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BARI Annual Report 2018-19

Bangladesh Agricultural Research Institute

Joydebpur, Gazipur-1701

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Foreword

This annual report includes the major findings of the experiments conducted by the scientists of different Crop Research Centers and Research Divisions of BARI during the year 2018-19. The major research areas include variety development of different crops, such as tubers (potato, sweet potato, aroids etc.), oilseeds (mustard, rapeseed, groundnut, sunflower, safflower, linseed, niger etc.), pulses (grasspea, lentil, chickpea, mungbean, blackgram, cowpea, pigeonpea etc.), horticultural crops (fruits, vegetables and flowers), spices (onion, garlic, turmeric, ginger, fenugreek, etc.) and cereals (millet, barley, sorghum, etc.). The area of research also include improvement of cropping systems, crop, soil, water and irrigation management, plant nutrition, disease and insect management, production economics, development of low-cost farm machineries, postharvest processing, and farm management. Besides, attention was focused on adaptation and mitigation of climate change, plant biotechnological research, improvement of floriculture and hill farming. Our scientists have also engaged in developing technologies which are appropriate as well as sustainable with a view to narrowing the ongoing gap between current food demand and its production in the country.

The annual report summarizes all the research activities of this year. But it is really very hard to accommodate all the findings of all the studies in such a single volume. So like previous years, only the major findings of the studies have been incorporated in this report. The readers can get the information about any of the studies in brief. In case, anybody wants to have all the generated data, he or she may go through the centre or divisional reports.

I sincerely thank and appreciate the scientists, editors and associates who have worked hard to publish the report. I hope this report will be very useful to the scientists, teachers, students, policymakers and other stakeholders who have engaged in agricultural research and development in Bangladesh.

Dr. Abul Kalam Azad
Director General, BARI

Bangladesh Map
Central Station
Regional Station
Research Centre
Sub Station
SP. Crop Station
North
INDIA
INDIA
INDIA
MYANMAR
BAY OF BENGAL
PANCHAGARH
THAKURGAON
NILPHAMARI
DEBGANJ
BURIRHAT
LALMONIRHAT
KURIGRAM
NASHIPUR
DINAJPUR
RANGPUR
MAHIGANJ
GAIBANDHA
JOYPURHAT
NAOGAON
SHIBGANJ
BOGRA
NAWAB GANJ
KAZLA
RAJSHAHI
NATOR
ISHURDI
SIRAJGANJ
PABNA
SHERPUR
JAMALPUR
TANGAIL
MYMENSINGH
NETRAKONA
SUNAMGANJ
SYLHET
HABIGANJ
MOULVIBAZAR
AKBARPUR
KISHOREGANJ
JOYDEBPUR
GAZIPUR
NARSINGDI
MEHERPUR
KUSHTIA
CHUADANGA
MANIKGANJ
DHAKA
N'GANJ
BRAHMANBARIA
RAJBARI
JHENAIDAH
MAGURA
FARIDPUR
MUNSHIGANJ
COMILLA
KHAGRACHARI (HILL TRACTS)
SARIATPUR
CHANDPUR
JESSORE
NARAIL
MADARIPUR
GOPALGANJ
BARISAL
LAXMIPUR
NOAKHALI
FENI
HATHAZARI
RANGAMATI (HILL TRACTS)
PAHARTALI
RAIKHALI
KHULNA
PEROJPUR
RAHAMATPUR
BAGERHAT
JHALAKATI
PATUAKHALI
CHITTAGONG
BHOLA
BARGUNA
BANDARBAN (HILL TRACTS)
COXS BAZAR
0 10 20 30 40 50 miles
0 20 40 60 80 km

BOARD OF MANAGEMENT

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Director General (Ex-officio)

Member

- Two eminent scientists, one in social science and other in the field pertaining to the speciality of the Institute (nominated by the Ministry or the Division dealing with agriculture)
- A representative of the Council (nominated by the Council)
- The Directors of the Institute (Ex-officio)
- Two senior scientists of the Institute (nominated by the Ministry or the Division dealing with agriculture)
- A representative of the DAE not below the rank of Director (nominated by the Ministry)
- Two representatives, one from the Ministry or the Division dealing with agriculture and the other from the Finance Division not below the rank of Deputy Secretary (nominated by the respective Ministry or Division)
- Two representatives, one from among the farmers and the other from among the non-Govt. Organizations (NGOs) performing functions similar to those of the Institute (nominated by the Ministry or Division dealing with agriculture)

The Director-in-charge of administration of the Institute acts as secretary of Board.

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01 TUBER CROPS

Tuber Crops Research Centre (TCRC), BARI deals with Potato, Sweet Potato, Aroids, Cassava and other minor tuber crops. Breeding, biotechnology, disease & pest management, soil & nutrient management, organic culture, postharvest processing are the major concern groups to improve tuber crops. Achievements during 2018-2019 on varietal improvement, biotechnology approaches, disease management, insect management, production technology, soil, water and nutrient management, postharvest technology, organic culture and technology transfer have been given below:

Varietal Improvement

Potato

Potato is one of the most promising crops in Bangladesh due to its high productivity, short duration and wide adaptability. Potato research and development of HYV potato was started regularly in 1960, its varietal improvement has only been limited to introduction and selection until the year 2000 due to lack of facility. Potato plants do not flower under the short day conditions of Bangladesh. In the recent years, hybridization has been made possible at the TCRC after long lasting efforts on variety selection under extended photoperiod and use of flower induction techniques. Several treatments like extension of photoperiod, brick planting, stem girdling, grafting on tomato and use of hormones, alone or in combination, have been found effective in inducing flowers and berry setting in potato. Hybridization was done at Debigonj and Joydebpur during 2018-19 using 168 and 109 genotypes/ varieties, respectively under 16 hours extended photoperiod to create variability, and for the selection of desirable genotypes. At Joydebpur, 77 out of 216 crosses and at Debigonj, 744 out of 2289 crosses produced berries. In total 360 g hybrid seeds were produced of which 320 g was at Debigonj and rest at Joydebpur.

Production of seedling tubers of the potato hybrid (F_1C_0) population

Hybrid seeds which were produced in 2017-18 at Gazipur and Debiganj were sown at Breeder Seed Production Centre, Debiganj on seedbed during 2018-19. Out of 602 crosses 549 were germinated. 10-15 single tuber were selected from each of 322 cross on the basis of desired characteristics. The harvested selected plants and tubers weighing 300 kg stored for next year observation.

Selection of potato hybrids in subsequent clonal generations (F_1C_1, F_1C_2 and F_1C_3)

Clonal selection after hybridization is a continuous process of early generation. During selection planted potato clones are subjected to selection as single plant, plant row and single plot in subsequent clonal generations. In F1C1, F1C2 and F1C3 generations 144 potato clones weighing 1393 kg were selected and stored at BSPC, Debigonj for further evaluation.

Preliminary yield trial with clonal potato hybrids

Eleven hybrid clones of potato were evaluated during 2018-19 along with four check varieties BARI Alu-7 (Diamant), BARI Alu-13 (Granola), BARI Alu-25 (Asterix) and BARI Alu-28 (Lady-Rosetta) at Debigonj and Gazipur. Combined analysis was done to see the genotype and location interactions. Significant influence was observed for different environmental factors of different locations on the expression of different characters of the potato hybrids. During final harvest, clone 15.117 gave the highest tuber yield (48.95 t/ha) at Gazipur. Clone 15.36 gave highest average yield (47.47 t/ha). Clone 15.156 gave significantly higher average yield (45.79 t/ha) than the four checks

followed by 15.117 (45.14 t/ha), 15.38 (44.87 t/ha), 15.139 (43.93 t/ha), 15.126 (43.66 t/ha) and 15.136 (42.34 t/ha). These seven clones (15.36, 15.117, 15.38, 15.139, 15.126, 15.136 and 15.156) can be selected for their higher tuber yield potentialities. In case of dry matter, the clones 15.156 (21.11%), 15.126 (20.99%) and 15.139 (20.83%) are suitable for processing purpose. No early mature clone was found than the checks BARI Alu-13 (Granola) and BARI Alu-28 (Lady Rosetta). Considering marketable tuber yield, dry matter, disease, insect and tuber characteristics (shape, size, colour, scoring) these seven clones (15.36, 15.117, 15.38, 15.139, 15.126, 15.136 and 15.156) can be selected for SYT.

Secondary yield trial with clonal potato hybrids

Six hybrid clones of potato were evaluated along with four check varieties BARI Alu-7 (Diamant), BARI Alu-13 (Granola), BARI Alu-25 (Asterix) and BARI Alu-28 (Lady Rosetta) at Debigonj, Gazipur and Jamalpur during 2018-19. Combined analysis was done to see the genotype and location interactions. The significant influence was observed for different environmental factors of different locations on the expression of different characters of potato. Clone 14.11 can be selected for next year trial due to its higher tuber yield (31.02 t/ha) potential as early bulker. No early mature clone was found than checks BARI Alu-13 (Granola) and BARI Alu-28 (Lady Rosetta). The highest average marketable yield (52.54 t/ha) was observed in clone 14.11 followed by clones 14.70 (48.36 t/ha), 14.10 (45.15 t/ha) and 14.44 (44.36 t/ha). Clones 14.11, 14.10, 14.44 and 14.70 can be selected for AYT due to their higher tuber yield potentialities. Average dry matter percent of 14.70 was 20.51% and found suitable for processing purpose. Clones 14.44 and 14.70 performed better than checks regarding taste, appearance and texture. Considering the marketable tuber yield, dry matter, organoleptic taste, disease, insect infestation and tuber characteristics (shape, size, colour, scoring) these four clones (14.10, 14.11, 14.44 and 14.70) can be selected for next year AYT.

Advanced yield trial of clonal potato hybrids

Three clonal hybrids of potato were evaluated with three check varieties BARI Alu-7 (Diamant), BARI Alu-25 (Asterix) and BARI Alu-28(Lady-Rosetta) at six locations during 2018-19 for seventh generation. Tuber yield at 65 DAP was recorded to identify the early bulker genotypes. Clone 13.7 can be selected for RYT due to its higher tuber yield (31.23 t/ha) potential as early bulker. No early mature clone was found than check BARI Alu-28(Lady-Rosetta). At final harvest, Clone 13.7 and 13.17 can be selected for RYT due to their higher tuber yield potential (47.75 t/ha) and (44.30 t/ha), respectively. No entry performed better than BARI Alu-28(Lady-Rosetta) in case of dry matter percent. Therefore clones were not suitable for processing purpose. Clones 13.7 performed best regarding taste, appearance and texture of boiled potato. Clones 13.7 and 13.17 can be selected for next year RYT Trial due to their performance regarding marketable tuber yield, organoleptic taste performance, disease and insect infestation and tuber characteristics (shape, size, colour, scoring) etc.

Participatory Variety Selection of Advanced Clonal Hybrids

Three clonal hybrids with three checks varieties were evaluated during 2018-19 at farmer's field under participatory variety selection to understand the performance as well as farmers opinion. In case of average yield of all locations the highest yield (44.34 t/ha) was recorded in 13.7 followed by 13.17 (43.36 t/ha), and the lowest average yield was found in check varieties BARI Alu-28 (Lady Rosetta) (28.95 t/ha). Considering tuber yield, tuber size, shape and colour, farmers of all locations showed their keen interest to the clones 13.7 and 13.17, but varied from location to location. Therefore, these two clones can be selected for next generation trial.

Development of Diploid Potato Inbred Line

Diploid potato germplasms as TPS was introduced from Michigan State University 2017-18 and planted in BSPC to get tubers. High yield tuber producing line was selected to plant in our crossing block both at BSPC, Debigonj and TCRC, Joydebpur. All together twenty two genotypes of diploid population were selected based on the performance of A and B population from the last year 2017-18. The selected genotypes/lines were planted on whole bricks and polybag followed by earthing up in non-replicated rows of 1m length at TCRC, Joydebpur, Gazipur and BSPC, Debigonj, Panchagarh by October 2018-November 2019.

Total planted genotypes were 20 in TCRC and addition two of 20 in BSPC.After flowering of that diploid plant in our extended photoperiod system, selfing was done in some lines which produced flowers and viable pollen.Day length was extended up to 16 hours with the help of HP sodium lights. Stolons and tubers formed on the bricks/polybag were removed time to time to accelerate flowering. Most of them did not flowered at all in both locations. Some them even produced flowers but there was no viable pollen to self them. Rest of them produced pollen and selfing was done but did not set berry. Only diploid self-compatible flowered genotypes were B-24 and B-27 from TCRC and BSPC, respectively. Among the two genotypes, Only B-24 genotypes at TCRC gave 15 TPS which will be used for next generation of selfing.

Regional Yield Trial of Clonal Hybrids of Potato

Two clonal hybrids of potato, namely 12.13 and 12.20 along with three check varieties BARI Alu-7 (Diamant), BARI Alu-25 (Asterix) and BARI Alu-28 (Lady Rosetta) were evaluated at six agro-ecological locations during 2018-19 cropping season in RYT. No early mature clone was found than check variety BARI Alu-28 (Lady Rosetta). The average yield for the highest was in clone 12.20 (50.19 t/ha) which was statistically similar with another clone 12.13 (49.15 t/ha). These two Clones can be recommended for release as commercial varieties due to their higher tuber yield potentiality. Average dry matter percent of two tested clones was not suitable for processing purpose. In case of organoleptic taste, the clone 12.20 performed best regarding taste, appearance and texture. Considering tuber yield, organoleptic taste performance, disease, insect infestation and tuber characteristics (shape, size, colour, scoring) these two clones can be recommended for release as commercial varieties.

Table 1. Tuber yield at 95 DAP of selected genotypes under RYT during 2018-19

Variety\ location	Bogura	Debigonj	Gazipur	Jamalpur	Jashore	Munshiganj	Mean
12.13	59.13 ab	34.84 k	43.02 efg	60.72 a	40.60 ghi	56.60 bc	49.15 a
12.20	49.07 d	41.43 f-i	56.80 bc	58.00 ab	41.35 f-i	54.50 c	50.19 a
BARI Alu-7 (Diamant)	42.42 f-i	24.68 m	35.96 jk	42.51 fgh	34.68 k	46.02 de	37.71 b
BARI Alu-25 (Asterix)	42.24 f-i	27.99 lm	39.24 hij	44.63 ef	35.35 k	38.95 ij	38.07 b
BARI Alu-28 (L.Rosetta)	36.32 jk	28.52 l	29.56 l	34.96 k	31.15 l	40.65 ghi	33.53 c
CV%				5.10			

Participatory Variety Selection of Clonal Hybrids

Two clonal hybrids with check varieties were evaluated at farmer's fields under participatory variety selection to understand the performance as well as farmers opinion 2018-19. On the average of all locations, both the tested hybrid clones produced higher yield than check varieties. The highest average tuber yield (44.77 t/ha) was recorded in 12.13 followed by 12.20 (37.03 t/ha) and lowest average yield was found in check varieties BARI Alu-28 (Lady Rosetta) (30.91 t/ha) (Table 2). Farmers were very much interested in both the clonal hybrids 12.13 and 12.20 for their yield, tuber size, shape, color but varied location to location. Therefore, these two clones can be recommended for the release as commercial varieties.

Table 2. Performance of clonal hybrids of potato for tuber yield under PVS at 95 DAP in farmers' fields during 2018-19

Variety/Hybrid clone	Tuber Yield (t/ha) at 95 DAP						
	Bogura	Debigonj	Gazipur	Jamalpur	Jashore	Munshiganj	Mean
12.13	54.32	43.07	-	20.13	51.11	55.22	44.77
12.20	44.50	39.69	-	18.63	37.12	45.22	37.03
BARI Alu-7 (Diamant)	42.95	22.45	-	21.22	31.16	44.11	32.38
BARI Alu-25 (Asterix)	38.94	31.51	-	23.35	35.74	38.04	33.52
BARI Alu-28 (L.Rosetta)	28.2	30.56	-	27.57	34.07	34.16	30.91

Preliminary yield trial of exotic potato varieties in first generation for table and processing purposes

Potato variety development through hybridization and selection is common and popular in potato growing countries. As, it is a crop of cooler region, long day condition is required for flowering. But, in Bangladesh such condition does not prevail in all locations. So, variety development through hybridization and selection is a tedious job and takes more time. In that case to release a variety within a short period through introduction is skillful. Six exotic potato varieties, namely Alcander, Delia Red, Diverse Zailengence, Twinner, Twister and Prada including four checks were evaluated during 2018-19 at Gazipur for yield. The variety Delia red gave the highest average marketable yield (26.03 t/ha). All the exotic varieties produced satisfactory marketable yield. This is the first-year trial. As the seed potato were collected from different countries they might not exposed their all characters completely. Therefore, no selection was done in this year. Seeds produced from this trial are kept for 2nd year trial for further confirmation.

Secondary yield trial of exotic potato varieties for table and processing purpose

Eleven exotic varieties along with four check varieties BARI Alu-7 (Diamant), BARI Alu-13 (Granola), BARI Alu-25 (Asterix) and BARI Alu-28 (L. Rosetta) were evaluated at six different agro ecological locations of Bangladesh (Bogura, Debiganj, Gazipur, Jamalpur, Jashore and Munshigonj) during 2018-19 for second generation trial. The significant influence was observed of different environmental factors of different locations on the expression of different characters of potato. At 65 DAP the highest yield was found (37.78 t/ha) with HZD 1249 at Jamalpur. But, Ottawa performed the best average yield (26.69 t/ha) over the locations which was statistically similar to the average yield of and AlRusset (25.84 t/ha). Exotic variety AlRusset gave the highest yield (49.19 t/ha) at Bogura. The highest average yield (34.38 t/ha) was also found in AlRusset which was statistically similar with Ottawa (32.05 t/ha). Dry matter percentage at harvest was the highest with check variety Lady Rosetta (24.96) at Munshiganj. Considering the average over locations, here check BARI Alu-28 (Lady Rosetta) again gave the statistically highest percentage of dry matter (21.58). In case of dry matter percentage, no entry performed better than checks. Therefore, no exotic variety was found good for processing. Seed tuber grade performance was satisfactory among the genotypes and over the locations. Finally Exotic variety AlRusset, Ottawa and HZD 1249 can be selected for AYT on the basis of field performance and Organoleptic taste.

Advanced yield trial with exotic potato varieties for table and processing purpose

Six exotic potato hybrids along with four check varieties BARI Alu-7 (Diamant), BARI Alu-13 (Granola), BARI Alu-25 (Asterix) and BARI Alu-28 (Lady Rosetta) were evaluated at six locations during 2018-19 in third generation. Mean highest yield (39.86 t/ha) and (37.57 t/ha) was observed in Margarita and Sun red respectively. All the tested genotypes yielded more than 30 t/ha except Cereza. At final harvest, dry matter percentage was the highest in the check variety Lady Rosetta (20.09%)

All other tested genotypes were lower in dry matter.

Participatory Variety Selection of Advanced Exotic Potato Varieties for Table, Export and Processing Purposes

Six exotic potato varieties, namely Actrice, Cereza, Messi, Margarita, Picobella and Sun red along with check varieties BARI Alu-7 (Diamant), BARI Alu-25 (Asterix) and BARI Alu-28 (Lady Rosetta) were evaluated at farmers' field of six different agro ecological environments/locations during 2018-19 cropping season in PVS. Yield of six tested new exotic varieties varied significantly from location to location. Some cases more than double yield was obtained. Farmer's perception also varied. For that reason the tested varieties need to be further evaluated for conformation.

Regional yield trial with exotic potato varieties

Two exotic potato varieties namely Colomba and Fortus along with check varieties BARI Alu-7 (Diamant), BARI Alu-25 (Asterix) and BARI Alu-28 (Lady Rosetta) were evaluated at six different agro ecological environment/locations during 2018-19 cropping season in RYT. The significant influence was observed of different environmental factors of different locations on the expression of different characters of potato (Table 3). The variety Colomba yielded the highest (44.51 t/ha) followed by Fortus (42.93 t/ha) at 95 DAP. So, considering the yield, performance in farmers' field trial, post-harvest, processing, disease and insect data both exotic germplasms were recommended for release as commercial varieties.

Table 3.Tuber yield at 95 DAP of selected genotypes of potato under RYT during 2018-19

Variety\ location	Marketable tuber yield (t/ha) at 95 DAP						
	Gazipur	Jamalpur	Jashore	Munshigonj	Bogura	Debiganj	Mean
Colomba	35.52	59.13	36.71	48.98	55.01	31.70	44.51 a
Fortus	41.07	50.16	36.44	50.63	44.50	34.80	42.93 b
BARI Alu-7 (Diamant)	35.96	42.51	34.68	46.02	42.42	24.68	37.71 c
BARI Alu-25 (Asterix)	39.24	44.63	35.35	38.95	42.24	27.99	38.07 c
BARI Alu-28 (L.Rosetta)	29.56	34.96	31.15	40.65	36.32	28.52	33.53 d
CV (%)				4.98			

Participatory variety selection of exotic potato varieties

Two exotic potato varieties namely, Colomba and Fortus along with check varieties BARI Alu-7 (Diamant), BARI Alu-25 (Asterix) and BARI Alu-28 (Lady Rosetta) were evaluated at farmers' field of six different agro ecological environments/ locations during 2018-19 cropping season in PVS. Yield of two tested new exotic varieties varied significantly from location to location. In some cases more than double yield was obtained compare to another location. Farmers' perception also varied.

Table 4. Performance of exotic potato varieties for tuber yield under PVS at 95 DAP in farmers' fields during 2018-19

Variety/Hybrid clone	Tuber Yield (t/ha) at 95 DAP					
	Bogura	Debigonj	Munshiganj	Jashore	Jamalpur	Mean
Colomba	38.01	29.51	27.13	31.85	25.51	30.40
Fortus	49.75	32.45	43.90	32.78	24.47	36.67
BARI Alu-7 (Diamant)	42.95	22.45	44.11	31.16	21.22	32.38
BARI Alu-25 (Asterix)	38.94	31.51	38.04	35.74	23.35	33.52
BARI Alu-28 (L. Rosetta)	28.2	30.56	34.13	34.07	27.57	30.91

Regional Yield Trial for Late Blight Tolerant Exotic Potato Varieties

Late blight caused by Phytophthora infestans is one of the most damaging diseases of potato in Bangladesh. The disease causes serious yield loss depending upon the stages of plant growth, susceptibility of the variety, aggressiveness of the pathogen and prevailing environmental factors. Cultivation of resistant varieties/cultivars is one of the best options against any plant disease. Some late blight resistant varieties have been introduced from abroad. After 3 years trial two exotic varieties found promising against late blight. The selected varieties need to be evaluated by the technical committee for release under Regional Yield Trial. So, the present study was undertaken to fulfill the NSB requirement for release a variety. The experiment was conducted with two late blight tolerant promising exotic varieties Alouette, Carolus and three checks BARI Alu-7 (Diamant), BARI Alu-8 (Cardinal) and BARI Alu-77 (Sarpomira) at RARS, Burirhat, Rangpur; TCRSC, Bogura; RARS, Jamalpur during 2018-19. All the locations showed significant variations for tuber yield at 65 DAP and 95 DAP. At 65 DAP, the mean yield over the locations was the highest in cardinal (33.08 t/ha) followed by Diamant (31.96 t/ha) and Alouette (30.79 t/ha). At 95 DAP Alouette produced the highest yield in all locations. Mean tuber yield over the locations was also the highest in Alouette (50.24 t/ha) (Table 5 and 6).

Table 5. Tuber yield (t/ha) of selected potato genotypes under RYT during 2018-19

Variety\ location	Tuber yield (t/ha) at 95 DAP			
	Bogura	Jamalpur	Rangpur	Mean
Aloutte	44.06	49.33	57.33	50.24 a
Carolus	41.05	34.95	37.22	37.74 b
BARI Alu-7 (Diamant)	35.47	42.51	44.02	40.67 b
BARI Alu-8 (Cardinal)	33.01	42.45	44.84	40.10 b
BARI Alu-77 (Sarpomira)	43.08	44.49	31.29	39.62 b
CV (%)	12.20			

Table 6. LB Reaction to Late blight diseases at 65 and 95 DAP

Variety/GP	Late blight Score (1-9) at 65 DAP		Late blight Score (1-9) at 95 DAP	
	Rangpur	Bogra	Rangpur	Bogra
	R1 - R2 - R3	R1 - R2 - R3	R1 - R2 - R3	R1 - R2 - R3
Alouette	0 - 0 - 1	0 - 0 - 0	0 - 0 - 1	0 - 0 - 0
Carolus	0 - 0 - 0	0 - 0 - 0	0 - 0 - 0	0 - 0 - 0
BARI alu-7	3 - 2 - 2	3 - 3 - 3	9 - 8 - 9	3 - 3 - 3
BARI alu-8	2 - 2 - 2	3 - 3 - 3	9 - 8 - 9	2 - 2 - 2
BARI alu-77	0 - 1 - 0	.3 - .4 - 5	4 - 5 - 5	1.8 -1.2- 1.5

Participatory Variety Selection for Late Blight Tolerant Exotic Potato Varieties

Two exotic table potato varieties namely, Alouette and Carolus along with check varieties BARI Alu-7 (Diamant), BARI Alu-8 (Cardinal) and BARI Alu-77 (Sarpomira) were evaluated at farmers' fields of three different agro ecological environments during 2018-19 cropping season in PVS. Yield of two tested new exotic varieties varied significantly from location to location. Alouette gave the highest yield (40.12 t/ha) followed BARI Alu-8 (37.06 t/ha) (Table 7 and 8).

Table 7. Performance of exotic potato varieties for tuber yield under PVS at 95 DAP in farmers' fields during 2018-19

Variety/Hybrid clone	Tuber Yield (t/ha) at 95 DAP			
	Bogura	Jamalpur	Burirhat, Rangpur	Mean
Alouette	48.53	26.50	45.32	40.12
Carolus	34.91	12.13	32.83	26.62
BARI Alu-7 (Diamant)	46.93	34.38	25.87	35.73
BARI Alu-8 (Cardinal)	47.17	36.56	27.44	37.06
BARI Alu-77 (Sarpomira)	33.34	28.43	30.38	30.72

Table 8. LB Reaction of different Germplasm at 65 and 95 DAP

Variety/GP	Bogura		Burirhat, Rangpur	
	Late blight Score (1-9) at 65 DAP	Late blight Score (1-9) at 95 DAP	Late blight Score (1-9) at 65 DAP	Late blight Score (1-9) at 95 DAP
	R1 - R2 - R3	R1 - R2 - R3	R1 - R2 - R3	R1 - R2 - R3
Alouette	1 - 1 - 1	1 - 1 - 1	0 - 1 - 0	0 - 1 - 0
Carolus	1 - 1 - 1	1 - 1 - 1	0 - 0 - 0	0 - 0 - 0
BARI Alu-7 (Diamant)	2 - 2 - 2	2 - 2 - 2	3 - 4 - 3	9 - 8 - 9
BARI Alu-8 (Cardinal)	2 - 2 - 2	4 - 2 - 4	4 - 4 - 3	9 - 8 - 9
BARI Alu-77 (Sarpomira)	1 - 1 - 1	1 - 1 - 1	2 - 2 - 2	5 - 5 - 5

Observation Trial with Clonal Hybrids and Exotic Varieties against Natural High Temperature Stress for Early Planting

Farmers in the northern part of Bangladesh cultivate potato using BARI released varieties which are not suitable for that climatic condition. Therefore, they do not get optimum yield and sufficient economic benefit. Another point is that farmers of north Bengal cultivate potato two times within the season. Although our released varieties are not suited perfectly in that region but they still cultivate by gaping one crop production to make up cropping pattern. Under this circumstances, early planting variety (early heat tolerant) development is an essential task. Therefore, development of early and heat tolerant variety and short duration (80 Days) were the objectives into consideration regarding this experiment. This experiment was taken to find out suitable genotypes for earlier cultivation in northern regions of Bangladesh prior to mid of November. Performance of eighteen genotypes of potato was evaluated along with four check varieties BARI Alu-41, BARI Alu-13 (Granola), BARI Alu-29 (Lady_rosseta) and BARI Alu-72 were evaluated at the breeder seed production center, Debigonj during *rabi* season 2018-2019 following a randomized complete block design with three replications. Marketable tuber yield at 65 days, non-marketable yield at 65 days, emergence, plant height, and canopy coverage was recorded to identify the early bulker varieties. Finally clone 12.13, BARI Alu-41, Alouette, Fortus and Taisiya can be selected for early material on the basis of field performance.

Screening of the Potato Variety for Export Potential

The present consumption of potato estimates 7.0 million tons, seed requirement 0.8-1.00 million tons and processing factory use 0.1 million tons. The rest >1.5 million tons was surplus. Farmers sometimes face serious losses due to glut in the market. So, they get discouraged in potato cultivation, which can't be entertained in a food

nutrition deficit country like Bangladesh. Therefore, we need to export this surplus potato to foreign country. Some of the exporters claimed that we have no sufficient technology for production of exportable potato. Suitable Variety is one of them. The requirement of export potato variety as well as production technology is different in our traditional table potato production. So, the present study is therefore undertaken to identify the suitable potato varieties for export with a view to sustainable potato production in the country. Twenty-four released potato varieties were evaluated at three different agro ecological environments/locations during 2018-19 cropping season for selecting export suitability of the variety. Tuber yield and grading by percent number and weight reveled that among the tested varieties varied significantly between the locations and within location. Post-harvest data collection is not yet been completed, which is one of most important criteria for selecting exportable potato variety. This is the first year trial; minimum three years data needs to select suitable variety (s) for export. After compilation of all locations dormancy and post harvest storage data final decision can be made.

Participatory Regional Yield Trials of CIP Potato Clones through Mother & Baby Trial Design In Bangladesh

CIP initiated an on-farm participatory selection of potato varieties/clones to see the performance and acceptance of new clones through participatory variety selection approach using Mother and Baby trial design (M&B). In this experiment, data are being compared from different locations, following the standardized methods already existed for the data collection in M&B design. Evaluations were carried out as per the recommendations pertaining to the design during 2018-19. Farmers or growers are the end users of these HYV potatoes. In that case choice of farmers or growers is very important. Farmers can accept or reject any variety after release. If they reject any variety after release all the efforts given for the release of this variety become a futile effort. This problem may be solved by including growers/farmers/end-users at the time of variety release procedure. Participatory variety selection procedure is one of the methods by which end-users are included in the selection procedure and they also gave their opinion on the variety release system. Hence, to fulfill this purpose, participatory variety selection trial was conducted in the farmer's fields to know the farmers reaction and opinion as well as their acceptance about the new potato varieties. Two CIP advanced potato clones with three check varieties were studied in the Regional Yield Trial during 2018-19 for growth, yield and postharvest processing qualities at six locations. Clone CIP-239 can be recommended for release as a commercial variety due to its higher tuber yield (36.85 t/ha) and early bulking. No early mature cone was found than check BARI Alu-28 (Lady Rosetta). The average highest yield (57.25 t/ha) was observed in clone CIP-225. Clone CIP-239 also gave higher yield (48.71 t/ha) than the three checks. These two Clones can be recommended for the release as commercial varieties due to their higher tuber yield potentialities. Average dry matter percent of two tested clones was not satisfactory for processing purpose. In case of organoleptic taste, it was found that CIP-239 performed best than checks regarding taste, appearance and texture followed by CIP-225. The average highest tuber yield (45.19 t/ha) was recorded in CIP-225 followed by CIP-239 (43.67 t/ha) at farmers' field. Farmers were very much interested for both the CIP clones for their tuber yield, size, shape, color, disease and insect infestation, but varied location to location. Therefore, these two clones can be recommended for the release as commercial varieties.

Collection and Multiplication of Biofortified CIP Germplasm

Potato is the third most important food crop in Bangladesh. In our country, about 10.2 million tons of potato were produced from about 0.499 million hectares of land with an average yield of 20.44 t ha-1 (BBS, 2017). Due to the development of suitable variety as well as different production package and also regular supply of inputs potato production increases day by day. The present consumption of potato estimates 7.0 million tons, seed requirement 0.8-1.00 million tons and processing factory use 0.1 million tons. The rest >1.5 million tons was surplus. To fulfill SDG goals we need to ensure food as well as nutritional security. Biofortification is a feasible and cost-effective means of delivering micronutrients to populations that may have limited access to diverse

diets and other micronutrient interventions (H.E. Bouis, A. Saltzman, 2017). The ultimate goal of bio fortification is producing nutritious and safe foods, sufficiently and sustainability. Micronutrient malnutrition is one of the major problems in many developing countries like Bangladesh. This study was under taken by TCRC during 2018-19 in collaboration with the CIP to reduce malnutrition of Bangladeshi people through the use of biofortified potatoes. Forty biofortified and ten late blight tolerant germplasm lines were collected from the CIP, Peru. Hundred plantlets of fifty genotypes were planted in pot after hardening with a view to produce mini tubers in the green house. At present those plantlets are at growth stage. Two set of these plantlets have also been used in aeroponic and hydroponic system in the green house for seed multiplication.

Morphological Characterization of Advanced Breeding Lines and Exotic potato Varieties

Morphological characterization is essential for recognizing, distinguishing and describing a variety. The central theme is identification of a variety through the use of some parameters of characterization. Precise information about the extent of genetic divergence and on characters used for discrimination among the population is crucial in any crop improvement program, because selection of plants based on genetic divergence has become successful in several crops. In recent years a number of newly developed advanced breeding lines have been added to the germplasm collection. Therefore, the parents to be used in breeding improved potato cultivars to grow in these contrasting growing conditions ought to be different. No information regarding the extent of genetic divergence in these newly acquired potato lines, is available under this condition. In view of the above,the present study has been undertaken to collect information on genetic divergence in the newly acquired genotypes so that useful parental materials for the breeding program could be selected. Five advanced clones of potato developed from own crossiong program of TCRC, eleven exotic varieties and 2 CIP clones were characterized at TCRC, Gazipur during 2018-19 following the DUS (Distinctness, Uniformity and Stability) descriptor which is approved by the National Seed Board of Bangladesh and descriptor of CIP, Peru. There were lots of variations in morphological characteristics in addition agro-morphic characters. Large variation was found among the genotypes and distinct characters were recorded which could help to find out the respective clones as well. Furthermore, lot of information were identified which could provide important information to the breeders.

Maintenance of Released Potato Varieties, Germplasm, Lines and TPS Parents

Any variety, line, genotypes and land raceses considerd as germplasm which are very impotant for breeding point of view. Number of germplasm is also important for genetic base of the population. If the number is high the genetic base is high and contained high genetic pool. Some of the materials contained some valuable genes which are important for future breeding work. In that case Maintenance breeding is very much important for conservation as well as preservation of gene pool in future use. It is also necessary for breeding programme in our country, where the variability of potato is very low because potato is not a crop in this region. Maintenance breeding is the routine work of TCRC for future use of valuable materials. Potato needs to grow every year and stored in cold storage in our climatic conditions. Each and every year all the germplasm grown under net house in BSPC, BARI, Debigonj and after harvest stored in cold storage. This year also conduct the same experiment for this same purpose A total of 276 varieties / germplasm each of 5- 500 kg seeds of potato were preserved in Breeder Seed Production Center coldstore, Debiganj, Panchagarh during 2018-2019. The preserved materials will be used in future for variety development programme.

Multipliation, Purification and Maintenance of indigenous Potato Varieties

Indigenous potato variety (IPV) contents higher proportion of amylopectin than EPV which make them sticky and testier. In spite of low yields, the IPV are popular among the growers and consumers mainly for containing higher percentage of dry matter and as such exhibit good keeping quality under ordinary temperature. Besides, IPV gives reasonable yield under low input condition and because of that, it fits well into the production system of small and marginal farmers. Due to

farmers and consumers acceptability particular attention should be given to the maintenance and improvement of IPV. That's why these materials should be maintained and purified through clonal selection over the year. After purification each year yield performance should also checked with view to how much progress of yield compared to previous year. These were the objectives for this trial. During 2018-19 cropping year, quality seeds of nine indigenous variety viz. Ausha, Challisha, Dohazari, Indurkani, Lalpakri, Patnai, Sadaguti, Shilbilati and Sindurkota were produced under net house condition. There are 322 Kg seeds preserved in cold-storage of BSPC, Debiganj, Panchagarh for next your use.

Sweet potato

Hybridization of sweet potato by polycrossing

To exploit heterozygosity among sweet potato genotypes polycross method has been used to generate half-sib sweet potato hybrid seeds with great variability regarding yield potentiality, dry flesh, earliness, carotene content, disease tolerance & good taste. In reality, there is only one breeding objective- a better variety. The experiment was conducted during 2018-19 at Gazipur A total of 1901 numbers of F_1 seeds were collected from twelve parents. Twenty two parents were included in this study. The highest number of F_1 seeds was collected from $H_{2.7}$/12 (393) followed by BARI SP-9 (292) and the lowest number of F_1 seeds from BARI SP-2 (17). These F_1 seeds will be sown in nursery bed next season for vine as well as tuber production and evaluation.

Secondary yield trial of CIP clones of sweet potato

A total of 30 genotypes derived from CIP were evaluated regarding their phenotypic characters, yield and yield contributing characters. There is a huge diversity present among these lines. Specially wide variation present in yield which varied from 27.03 t/ha to 0.74 t/ha and flesh color from white to deep orange with purple shade. The information has been useful for the optimal design of plant breeding programs, influencing the choice of genotypes to cross for the development of new populations or for direct selection. Considering all the characters that have taken in this experiment eleven (11) germplasm namely Moz 21.3, Moz 6.3, Moz 19.1, Moz 21.6, Moz 8.5, Moz 8.3, Moz 5.2, Moz 1.9, Moz 1.8, Moz 1.39, Moz 1.15 germplasm has been selected.

Secondary yield trial with CIP clones of sweet potato

Fifteen (15) sweet potato genotypes with contrasting beta carotene and mineral content that were provided by International Potato Centre (CIP) were evaluated at Gazipur & Bogra in order to get a variety contrasting with higher yield, high sugar & dry matter content, earliness, weevil resistance and better nutritional quality. Considering these criteria, only six (6) genotypes were selected out of nine (9) for the next year trial, eg. CIP 106082.1, CIP400039, CIP 189151.8, CIP 194281.2, CIP194281.2 and CIP440004.

Advance yield trial with f_1C_6 hybrid clone of sweet potato

A field trial was done to evaluate three (03) hybrid clones of sweet potato at five locations during 2018-19 cropping season along with BARI SP-4 and BARI SP-8 used as check. Among the three tested clones three (03) hybrid clones namely, $H_{9.7}$/12 and $H_{9.10}$/12 were selected based on marketable yield, dry matter content, carotene content, earliness and overall acceptability score

Regional yield trial with anthocyanin containing sweet potato

Considering all the qualitative and quantitative characters during 2018-19 it can be assumed that this newly introduced Antho 1 would be the promising one specially as a biofortified crop. But the best expected output will come not so rapidly, it needs more adaptation.

Regional yield trial with white fleshed sweet potato

Two white fleshed local cultivars were evaluted along with BARI SP-3 and BARI SP-10 used as check during 2018-19 cropping season at four locations (Gazipur, Bogura, Jamalpur, Jashore, Pahartali and) in RCB design with three replications. Red skinned and white fleshed local cultivar WFRS002 found promising regarding their marketable yield, dry matter content and overall acceptability score. Though the weevil infestation

found insignificant, there were less infestation in the field for all the materials as they are locally adapted.

Regional yield trial with f_1C_7 hybrid clones of sweet potato

Considering marketable yield, dry matter yield, carotene content, from the experiment conducted during 2018-19 overall acceptability score and otherfactors for hybrid clones namely, $H_{6.52}$/11and $H_{9.48}$/11 may be selected for next year evaluation for more confirmation

Regional yield trail of f_1C_8 hybrid clones of sweet potato

Among the four studied clones, three clones gave satisfactory yield performance namely, H_5.ej/10 and H_{16}.ej/10. Considering marketable yield, dry matter (%), carotene content, overall acceptability score and other factors three hybrid clones namely, H_5.ej/10 and H_{16}.ej/10 may be selected for next year evaluation.

Regional yield trial with f_1C_9 hybrid clones of sweet potato

In 2018-19 the highest tuber yield was found (34.75 t/ha) from $H_{9.6}$/09. $H_{16.2}$/09 hybrid clones also gave satisfactory yield (29.55) compared to both the checks. Moreover, $H_{16.2}$/09 clone stood first among the two (2) tested clones regarding dry matter content. Besides that, mean sensory evaluation showed that $H_{16.2}$/09 had an excellent combination of taste and texture even though high beta carotene content present on it. One more OFSP clone namely, $H_{9.6}$/09 ranks first regarding taste which would make this clone promising along with its high yield potentiality. Weevil infestation not varied significantly in both interaction and genotype mean over location. Considering all above criteria, one hybrid clones namely $H_{9.6}$/09 and may be recommended for release as varieties.

Aroids

Regional yield trial of mukhikachu (*colocasia esculenta* var. *Antiquorum*) lines

Four genotypes of Mukhikachu (*Colocasia esculenta* var. *antiquorum*) viz. MK 122, MK 129, MK 131, MK 176 along with a BARI released variety Bilashi and BARI Mukhikachu-2 as check were evaluated under regional yield trial during March to November 2018. The growth, yield components and yield were statistically significant. The highest corm yield (38.07 t/ha) was recorded in Bilsi at Jamalpur. Among the tested lines MK 176 produced the highest yield (34.50 t/ha) followed by MK 129 (33.90 t/ha) at Jamalpur whereas the lowest yield was produced by MK 129 (15.58 t/ha) at Gazipur.

Maintenance of aroids germplasm

Nineteen of Mukhikachu, fifty of Panikachu and one of each of Panchamukhi kachu, Poidnal kachu, Dudhkachu, Moulovikachu/Sahebikachu and Ghataman kachu germplasms collected from home and abroad in recent past years and conserved at TCRC field, Joydebpur, Gazipur.

Minor tuber crops

Regional yield trial of yam germplasm

Five yam germplasm namely HOM 20, HOM 47, HOM 39, HOM 9 and HOM 7 were evaluated at three different agro ecological environment/locations during 2018-19 cropping season in RYT. Combined analysis was done to see the genotype location interaction. The significant influence was observed of different environmental factor of different locations on the expression of different characters of yam.HOM-9 gave highest yield 10.31 kg per plant followed by HOM-7 (8.33 kg/plant) and HOM-39(8.01 kg/plant). So, HOM-9 could be advanced to release as variety considering the result.

Cultural Practices

Bulking behavior of promising potato varieties

The experiment was conducted at tuber crops research Centre (TCRC), Joydevpur during the *rabi* season of 2018-2019 to find out the suitable time of harvest for getting desirable yield of promising potato varieties. Four harvesting was done at 10 days interval started from 60 DAP and continued up to 90 DAP. Three promising potato varieties such as BARI Alu-46, BARI Alu-62 and BARI Alu-63 were included in the study. The highest tuber yield (29.21 t/ha) and maximum dry matter (18.36%) was found in BARI Alu-62. Yield and dry matter was increased with the increase of harvesting period. 90 DAP provided significantly

higher yield (34.91 t/ha) and dry matter (19.85%). However, significantly the highest yield (35.59t/ha) and rich in dry matter (21.37%) were found from the variety BARI Alu-62 harvested at 80DAP and which was followed by 90 DAP with the same variety. On the other hand, the lowest tuber yield was found in BARI Alu-46 (10.66 t/ha) when harvested at 60 DAP.

Effect of urea super granule (USG) on the yield performance of BARI Panikachu-1 (C*olocasia esculenta l.*)

The experiment was carried out at TCRC, Joydevpur during February to September 2018 to evaluate the efficiency of USG application in comparison with prilled urea for sustainable production of Panikachu (BARI Panikachu -1) production. There were six treatments, T_1= N_{350} (recommended N dose used as prilled urea), T_2=N_{350} (recommended N dose used as USG), T_3= N_{315} (10% reduction of recommended N dose as USG) T_4= N_{280} (20% reduction of recommended N dose as USG) T_5=N_{245} (30% reduction of recommended N dose as USG), T_6= control (native nutrient). The experiment was laid out in randomized complete block design RCBD with three replications. The stolon and rhizome yields were significantly influenced by the application of USG. The highest stolon yield (24.14 t/ha) and rhizome yield (22.51 t/ha) were found in T4 treatment ($N_{280}P_{180}K_{250}$ kg/ha + CD 5 t/ha), 20% reduction of recommended N dose as USG) with highest BCR (2.0). Application of USG was found more efficient than prilled urea. This is the second year trial and need to verify the result.

Sensory evaluation of sweet potato shoot as leafy vegetables

Fifteen sweet potato varieties viz., BARI Misty Alu-1, BARI Misty Alu-2, BARI Misty Alu-13, BARI Misty Alu-4, BARI Misty Alu-5, BARI Misty Alu-6, BARI Misty Alu-7, BARI Misty Alu-8, BARI Misty Alu-9, BARI Misty Alu-10, BARI Misty Alu-11, BARI Misty Alu-12, BARI Misty Alu-13, BARI Misty Alu-14, BARI Misty Alu-15 were evaluated in the study. Considering taste/ mouth feel, bitterness and presence of fiber most of the participants in organoleptic evaluation preferred much BARI Alu-11 (scored 4.40) as leafy vegetables. The second selection was BARI Misty Alu-10 (scored4.01) has very taste, no bitterness and fair presence of fiber and it is also palatable. BARI Misty Alu-8 (Scored 3.89) the third choice also has good taste, fair bitterness and moderate presence of fiber and generally good palatability. This is the first year experiment, organoleptic taste and chemical analysis will be done next year to verify the results.

Effect of planting date and spacing on the yield of early harvesting 'baby' potato tubers and their economics

The experiment was conducted at Breeder Seed Production Center, Debigonj during the *rabi* season 2018-19 consisted of four planting date and four spacing using Randomized Complete Block Design (RCBD) with three replications within the unit plot size of 3.0m × 2.4m. The test crop was BARI Alu-13 (Granola). There was no significant effect of spacing but planting date had significant effect on the yield and yield contributing characters. The highest tuber yield (27.8 t/ha) was found from the 4th planting date (i.e. 25th October). Interaction effect of planting date and spacing was highly significant and last planting date with closure spacing (D_4S_4) gave the highest tuber yield (31.8 tha^{-1}) while the lowest tuber yield (15.2 t ha^{-1}) was recorded from the first planting date with medium spacing (D_2S_2). However, the highest gross return (712,250/ TK/ha) was found from the 2nd planting (5th October) date maintaining the spacing 40 cm and 20 cm.

Intercropping of potato with different vegetables at Munshigonj region

An experiment was conducted during *rabi* season of 2018-19 at Tuber Crop Research Sub-Centre, Munshigonj to find out suitable intercrop combination of potato for higher profitability and economic return. The treatment combinations were six including (i) Sole potato (100%) and five intercrop combinations such as (ii) one row of potato and one row of Red amaranth, (iii) one row of potato and one row of spinach, (iv) one row of potato and one row of Raddish, (v) one row of potato and one row of cabbage and (vi) one row of cauliflower and one row of potato were evaluated in the present study. Significantly the highest potato yield (42.85 t/ha) were obtained from the sole potato crop. Potato yield was reduced (4-

13%) due to intercropping, but it was compensated by the return of associated intercrop. Moreover, potato equivalent yield (PEY) of the intercrop treatments was higher than those of sole crops. The highest (48.58t/ha) potato equivalent yield (LEY) was obtained from the treatment namely one row of potato+one row of cabbage. This treatment also gave the highest gross return (Tk 242900/ha), net return (Tk. 66700/ha) and benefit cost ratio (1.38).

Inter cropping potato with maize in Northern part of Bangladesh

An intercropping experiment was conducted at the Tuber Crops Research Sub-Center Research, Seujgari, Bogura during the *rabi* season of 2018-19.The experiment consisted of five treatments, viz.,T_1= Sole Potato, T_2 = 50% potato + 50% Maize (1:1), T_3 = 75% potato + 25 % Maize (2:1), T_4 = 25% potato + 75 % Maize (1:2), T_5 = Sole Maize. The highest potato equivalent yield (31.91 t/ha) was recorded in T_2 treatment. The highest gross return (2,40,240tk/ha) was obtained from T_2 treatment. The highest gross margin (94,640tk/ha) was obtained from T_2 treatment

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Effect of spacing on the yield of Mukhikachu

A field experiment was conducted at TCRSC, BARI, Seujgari, Bogura during *kharif*, 2017-18 to find out optimum spacing of mukhikachu. There were seven treatments viz. 60 cm × 35 cm (T_1), 70 cm × 25 cm (T_2), 70 cm × 30 cm (T_3), 70 cm × 35 cm (T_4), 80 cm × 25 cm (T_5), 80 cm × 20 cm (T_6) and 60 cm × 45cm (T_7). The maximum corm yield (29.17 t/ha) was recorded from the treatment T_2 which was statistically similar with T_6.

Organic Farming

Performance of some indigenous potato varieties under organic practices

An experiment was conducted to find out the yield potential of nine indigenous varieties under organic management practices at RARS, Burirhut, Rangpur during 2018-19. The highest tuber yield was found from the variety Lal Pakri (14.1 t/ha) which was followed by Indurkani (12.7 t/ha) and was statistically similar while the lowest tuber yield (4.3 t/ha) was recorded in Dohazari.Lal.

Evaluation of stolon producing taro genotypes under organic farming system

Three released variety of Panikachu (*Colocasia esculenta* L), namely BARI Pani Kachu-1, BARI Pani Kachu-2 and BARI Pani Kachu-3 along with a local line as check were evaluated to find the superior variety under organic cultivation system during 2018-19. This experiment was executed at 'Organic Block', TCRC research field, Gazipur over the period from February to August, 2018. Soil fertility and pest management was done following organic practices and standards. Cow dung, Trichocompost and Neem Oil Cake (NOC); each one was applied @ 8t/ha and different botanicals were used to reduce the pest attack. There was significant difference among the varieties in respect of most of the yield contributing characters and BARI Pani Kachu-1 showed better in most of the parameters. Accordingly, the highest stolon yield (19.1 t/ha) was found from the variety BARI Pani Kachu-1which was followed by BARI Pani Kachu-2 (14.1 t/ha) but it was statistically different.

Effects of different registered organic fertilizers on the yield and yield contributing characters of potato

This experiment was executed at the organic block under TCRC research field, Joydebpur during the year 2018-19 to assess the influence of organic fertilizers on the yield of potato. Performance of four organic fertilizers, namely ACI organic fertilizer, North Bengal Organic Fertilizer, Onnopurna organic fertilizer, Mega organic fertilizer with one potato varieties e.g. BARI Alu-36 were evaluated. ACI Organic Fertilizer with BARI Alu-36 gave the highest yield (26.27t/ha) which was statistically higher than other the treatments.

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Biotechnology and Seed Production

Production, distribution and *in vitro* maintenance of potato varieties/germplasm

In vitro plantlets of potato have been produced from virus free potato tubers of different potato varieties and genotypes using MS media under aseptic conditions during 2018-19. This study has been conducted at Tissue Culture Lab, TCRC, BARI, Gazipur. In vitro maintenance of potato germplasm was initiated through meristem and disease-free sprout culture from disease free potato tuber. Initially tubers were tested with ELISA for the detection of viruses. Only the virus free tubers were selected for in vitro clonal propagation. The virus free sprout was used as explants. Several subcultures were done in MS media. 1-2 nodes were used for in vitro multiplication and short-term conservation. The cultures were incubated at 21-22^{0}C temperature, 75-80% relative humidity, and 2500-3000 lux light intensity with a 16hours and 8 hours light and dark photoperiod, respectively. Usually bottle or test tubes having poly cap has been used as vessel. Subcultures were done in every 21-28 days interval before root induction from the arial nodes. The plantlets without

removing the culture lid were kept in the greenhouse for 3 days in a partial shade. Then the plantlets were removed from the culture vessel and washed properly to remove the adhered media in root zone of the plantlets. For hardening process plantlets were planted in a tray containing sand for 7 days proper management has been taken in this time. After 7 days the established plantlets were transplanted in 1M wide bed at a spacing of 10cm X 10cm in net house. The soil of the net house was properly fertilized. The plantlets were regularly irrigated and 0.5% urea solution was sprayed after first two weeks of establishment. Pest or pathogen was managed appropriately and other cultural management was done when necessary. The mini tubers were harvested when mature and stored in cold storage. Several subcultures were done for plantlets production and short-term conservation. A total of 25700 disease free plantlets of BARI released potato varieties were sent to Breeder Seed Production Centre, Debigonj for G_0 generation development. Moreover, 255.0 kg virus free mini tubers of BARI released varieties, 102.0 kg breeder seed of BARI released varieties have been sent to BSPC, Debigonj for multiplication.

Production of minituber (G_0) from *in vitro* plantlets at net house conditions

Mini tuber has been produced from virus free in vitro plantlets of potato at net house of TCRC, BARI during 2018-19. The production of mini tuber was conducted at TCRC, Joydebpur and BSPC, Debigonj during 2018-19. When the plantlets (grown in vitro) were about 6 cm height, they were transferred to the net house and were kept in a shady condition without removing the lids. The beds of the net house were properly ploughed and were covered with a mixture of sand, decomposed cow dung. The soil bad was sterilized properly to avoid damping off disease caused by soil borne pathogens of the transplant. After two weeks, the plantlets were transplanted in beds under net house. Beds were drenched with fungicides before planting. Three to four water sprays were given daily with a sprayer to keep the soil moist and maintained humidity for initial one week. Additional soil substrate was added on the nursery beds to bury lower nodes. The crop was allowed to mature and mini tubers were harvested. The mini tubers were kept i in the cold storage for using as a planting material in the next crop season for breeder seed production Number of minituber per plant 29.4, 25.2, 23.4, 30.4, 50.0, 30.4, 46.4, 36.0, 29.6, 24.2, 9.6, 25.8 and 9.6 was recorded from the varieties BARI Alu-41, BARIAlu-37, BARI Alu-63, BARI Alu-46, BARI Alu-35, BARI Alu-53, BARI Alu-40, BARI Alu-47, BARI Alu--, BARI Alu-56 and BARI Alu-50 and BARI Alu-73, BARI Alu-8 respectively. The maximum weight of mini tuber per plant was found from BARI Alu-46 (574.0 g) followed by BARI Alu-41 (472.6g), BARI Alu -37 (470.8g), BARI Alu -48 (439.4g), BARI Alu-40 (385.0g) ,BARI Alu -62 (356.6g), BARI Alu 8 (313.0g), BARI Alu-63 (305.8g), BARI Alu-72 (276.0g), BARI Alu-7 (267.0g), BARI Alu-49 (255.4g) and BARI Alu-47 (255.0g) , BARI Alu-36 (208.6), BARI Alu-53 (183.8).

Improvement of indigenous promising potato cultivars through meristem culture and their yield performance study with traditional cultivars

Meristem culture has become a powerful and successful tool for virus elimination from virus infected plants and has been successfully applied in potato. Tubers of five IPV (Shilbilati, Lalpakhri, Sadaguti, Jam Alu and Patnai) were collected from different locations of Bangladesh. To test the virus infection tubers from each cultivar were subjected to DAS-ELISA test. Virus infected tubers were chosen and used for sprouts production. The sprouted potato cultivars were planted in pots containing fine heat sterilized sand under greenhouse conditions. When potato plants grew sufficiently (about 30-40 days old shoot.) the meristem part was taken from leaf buds. For sterilization the excised plantlets were washed several times with normal water and then washed with 70% ethanol for 10 minutes and continued it 3 times. After sterilized with ethanol then keep it with 1% clH20for 10 minutes and finally rinsed 3 times with sterile distilled water under laminar air flow cabinet. Under a 50X magnification with stereoscopic microscope, the pedicel, immature leaves and the outer leaf primordial surrounding the meristem region were discarded one after another, using sharp microsurgical blades and pointed fine needle, until only the meristem region and one or two leaf primordial about 0.2—0.5 mm remain. Murashige and skoog medium free of hormone was

used as basal culture medium. After adjusting the PH to 5.7, the medium was solidified with 8g/l of difcoBacto agar and autoclaved at 120^0C for 20 minutes. The isolated meristems were quickly transferred to sterilized vial containing 15 ml MS medium. Cultures were kept at 25+20C and 16/8 light and dark photoperiod in the culture room. A total of fifty meristems were isolated and cultured from five indigenous varieties on basal MS media. Out of fifty meristems, ten were sub-cultured in MS media. DAS ELISA test has been conducted of these plantlets and virus free plantlets were not obtained, others plantlets have been sub-cultured and will be tested for DUS-ELISA.

Tissue culture of Cassava (*Manihot esculenta* crantz) germplasm

This study was conducted at tissue culture lab, TCRC in BARI during 2018-2019 to enrich the germplasm having regeneration efficiency and established a standard procedure of hardening. MS media supllimented with 1.0mg/lBAP showed the good response for shoot induction. After 5 weeks shoots were cultured in rooting media. MS media supplemented with 0.5 mg/l NAA produced 5-6 roots per plantlets. Plantlets of 38 genotypes were collected from Vietnam in 20 July 2017. In vitro plantlets were used as a explants source for micro propagation. Nodal segments were inoculated in freshly prepared MS medium with 1.0mg/l BAP for shooting and after shoot developed then transferred to MS with 0.5mg/l NAA for rooting. Out of 38 genotypes the following cultivars were sub-cultured and survived CA-8, CA-10, CA-12, CA-13, CA-14, CA-16, CA-31, CA-32, CA-33 and CA-53. Culture bottles containing plantlets were carefully opened and using sterile forceps, the plantlets then transferred onto a sterile aluminum foil paper and the stems cut into micro-cuttings with at least one bud then carefully cultured on media. The cultures were incubated in the growth room at a temperature of 25±2°C under an illumination of 2000 lux white light and a photoperiod of 16 hours light and 8 hours dark. Examination for growth was carried out every week and contamination were carried out every day. The following data were recorded after 5 weeks of cultured. No. of node/plantlet, no. of leaf/plantlet, no. of root/plantlet, ten vials each containing one explants were used for each genotype. Any bottle that was found contaminated was discarded. Multiplication was achieved through sub-culturing after every 5 weeks on MS media containing BAP and NAA. The rooted plantlets were then selected for next step hardening.

***In vitro* maintenance of CIP Bio-fortified potato germplasm**

Forty biofortified CIP potato germplasm having Zn and Fe content plantlets and ten late blight tolerant CIP germplasm were maintained in tissue culture lab for multiplication. This study has been conducted at Tissue Culture Lab, TCRC, BARI, Gazipur. Hundred plantlets of fifty genotypes were collected from CIP in February 2019. In vitro maintenance of those germplasm was initiated through sub-culture. Several subcultures were done in MS media.1- 2 nodes were used for in vitro multiplication and short-term conservation. The cultures were incubated at 21-22^0C temperature, 75-80% relative humidity, and 2500-3000 lux light intensity with a 16 h light and 8 hrs dark photoperiod. Usually bottle or test tubes having poly cap and aluminum foilpaper has been used as vessel. Subcultures were done in every 21-28 days interval before root induction from the arial nodes. The following data were recorded after 4 weeks of cultured. No. ofshoot, no. of node/plantlet, no of leaf/plantlet, no. of root /plantlet. A total of hundred plantlets of fifty genotypes without removing the culture lid were kept in green house for 3days.Then the plantlets were removed from the culture vessel and washed properly to remove the adhered media in root zone of the plantlets. Soon after washing, the plantlets were transplanted in sand. After seven days the the established plantlets have been planted in pot media containing sterilized 50%soil and 50% compost. Two plantlets have been planted in each pot. The plantlets were regularly irrigated and fertilizer has been applied after 30, 45 and 60 days of planting. A total of 1873 plantlets has been obtained from fifty biofortified CIP genotypes. Among those, 100 plantlets have been planted in green house for tuber production. The data represented in the table no.1 for in vitro regenerated plantlets after 4weeks of cultured and table no. 2 showed the data for pot cultured in green house condition after 60 days of planting. Among 50 genotypes, anthocianin was present in 46 genotypes. More than 4 stem/plant was recorded in 26 genotypes and maximum no. of

stem (9.5) was obtained in CIP-408. About 30 genotypes had more than 50 leaf/plant. The range of the plant height was recorded (33.5-97.0) cm.

Evaluation of seed production of minitubers derived from nutrient film techniques (NFT) and tissue culture

NFT and tissue culture derived minitubers of some varieties were planted to look at their seed production performances in TCRC, Gazipur during 2018-19 year. To run the experiment minitubers of BAR Alu-7, BARI Alu-40, BARI Alu-47, BARI Alu-56, BARI Alu-62, BARI Alu-73, MSZ109-10pp and Red marker#2 were taken as the materials. From them MSZ109-10pp and Red marker#2 were the MSU origin and the minitubere were NFT derived. Rest of the varieties were TCRC released varieties and the minitubere were conventional tissue culture derived. Materials were planted in TCRC, Gazipur research field on November 11, 2018 with three replications. Plot size was 3 m 2.4 m. The experimental design was RCBD. The whole experiment was under filter net which is called filed net-house. Filter was used to developed net-house using brick concrete pillar. Intercultural operations were done as needed. Fertilizers were applied based on the TCRC recommendation. The statistical software R was used to conduct the analysis. Significant variations from the varieties were observed for all the traits except canopy coverage at 60 DAP. Highest seed production was recorded from the variety of BARI Alu-73 (24.30 t/ha) followed by BARI Alu-7 (23.14 t/ha), BARI Alu-62 (21.76 t/ha) and 47 (20.13). Tuber production was highest from BARI Alu-47. Specific gravity found highest from BARI Alu-40 (1.04). β-carotene (I.U.) content was estimated from MSZ109-10pp and BARI Alu-7 only and found MSZ109-10pp (624 I.U.) contains more than double compared to BARI Alu-7 (261 I.U.).

***In vitro* propagation of stress tolerant potato varieties and standardization of nutrient film technique (NFT) protocol for quality seed production**

TCRC developed some stress tolerant varieties BARI Alu-46, BARI Alu-53, BARI Alu-72, BARI Alu-73 and BARI Alu-77 were tested against virus using a double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) and virus free tubers were placed in the tissue culture to get sprout first for plantlets. Simple MS media is suitable for in vitro propagation of the stress tolerant potato varieties. For root induction MS media supplemented with .05 mg IBA showed the excellent rooting behavior. Finally, 200 plantlets were produced at the end of May, 2019 from each of the variety. Plantlets are maintaining at tissue culture lab for further multiplication and use them in the NFT next year to produce minituber. NFT system will be installed next year in the greenhouse. Plantlets from tissue culture will be planted in wool rock in 10 cm apart on the tray where nutrient will run from the reservoir. Before producing seed tubers, NFT system will be installed in the greenhouse on a small scale to see the preliminary results from the stress tolerant varieties.

Fingerprinting of indigenous potato varieties of Bangladesh using SNP marker

Twenty one indigenous potato cultivars (IPVs) of Bangladesh have been selected for fingerprinting. This experiment has been executing jointly at Molecular biology lab, TCRC, BARI, Gazipur, and Michigan State University, USA. The genotypes have been characterized using SNP marker for fingerprinting. Twenty one IPVs popular cultivars were used for DNA extraction. Genomic DNA extracted from young leaves/tuber using Promega genomic DNA extraction kit following manufacturer's protocol. DNA samples from 21 IPVs have been analyzed using SNP primers. The 21 samples were assayed on the Potato V2 SNP array. The V2 array has 12808 SNPs. The tetraploid model was also used to take a first look at the phylogeny using hierarchical clustering. There were 3857 SNPs with < 10% No-Calls in all 28 samples (21 BGD samples plus seven reference samples). The results revealed that the 21 samples are clear duplications. Primarily, we are thinking that of the 21 samples are really only from 6 different varieties having some clones have different names in different parts of the country. Secondly, 20 of the 21 clones cluster away from the US materials. This indicates a South American origin of these lines. Only one clusters with the US/European germplasms.

Fingerprinting of BARI released cloned potato varieties using SNP marker

Fourteen BARI released clone potato varieties have been selected for fingerprinting. DNA of those cloned potato varieties have been extraction from

young leaves using Promega genomic DNA extraction kit following manufacturer's protocol. Both quality and quantity of the isolated DNAs has been tested using NanoDrop spectrophotometer 2000 (USA). Eighteen SSR primers have been designed for genotyping of the varieties. PCR amplification is going on using those primers. DNA of 14 different clone potato varieties along with farmer preferred ones have been isolated using DNA isolation kit. Both quality and quantity of the isolated DNA has been tested using NanoDrop spectrophotometer. BARI released clone potato varieties along with farmer preferred varieties have been analyzed using SNP marker. A complete result has not yet generated. The program will be going on. Final results have not yet finalyzed. Therefore, the study should be continued.

Molecular characterization of BARI released sweet potato varieties using SSR marker

The study has been conducted at Molecular Biology Lab, TCRC, BARI, Gazipur during 2018-19. A total of 15 sweet potato varieties have been selected for the present study. DNA has been isolated from fresh young leaves. Ten SSR primer pairs viz.IBSSR14, Ib318, IBSSR19, IBSSR02, IBSSR15, Ib 316, Ib255, IBSSR21, IBSSR27 and IBSSR18 have been identified and collected for PCR amplifications. DNA has been isolated from fresh young leaves using following the protocol of CTAB with some modifications. The quantity and quality of extracted DNA has been tested at 260 nm absorbance reading (Thermo Scientific, Nanodrop 2000) and under the UV light following agarose gel electrophoresis (1% gel containing 10 mg/ml ethidium bromide), respectively. Ten SSR primer pairs viz. IBSSR14, Ib318, IBSSR19, IBSSR02, IBSSR15, Ib 316, Ib255, IBSSR21, IBSSR27 and IBSSR18 have been identified and collected for PCR amplifications microsatellite analysis in the present study. This is on-going program. This experiment is not yet been completed. Final results will be presented after completion.

Combining of PVY and PLRV resistance genes in tetraploid potato

M2 and M3 populations developed at Michigan State University, USA and TPS materials of those population was imported in Bangladesh in 2016. The method was used at TCRC is Marker Assisted Breeding (MAB). All populations were grown from TPS that was collected from MSU in the year of 2016. It was germinated from TPS and planted when they were 20 days old after germination at RARS, Burirhat of Rangpur in 2016-17. PVY and PLRV infected plants also planted to spread the virus disease into the M1, M2, and M3 population. The plant was harvested and stored at BSPC, Debigonj for planting 2017-18. All the stored materials were planted in the TCRC research field on December 19, 2017. Form the evaluation at TCRC research field in 2017-18, some genotypes were discarded first, based on the presence of virus symptom of the planted genotypes in the field, second based on the virus particle presence in the genotypes by ELISA test and third selected some lines from rest of them based on the presence of resistance gene in the genotypes. PVY and PLRV markers were used to see the R-genes presence in the hybrid clones (Kasai et al. 2000; Mihovilovich et al. 2014). Selection was done based on the three categories, single resistance of PVY alone and PLRV alone and both resistance of PVY and PLRV. Selected genotypes were 3 for PVY resistance, 24 was for PLRV resistance and 18 was for both PVY and PLRV resistance. Selected lines were planted in the TCRC research field on November 11, 2018 and recommended doses of fertilizers were used to grow plants well. Plants were irrigated and late blight and other diseases were controlled by the recommended pesticides. There was no use of pesticides for controlling Aphid. Aphids were used as a vector of virus disease, PVY and PLRV transmission. The replicated experimental plot size was 1.2m x 1.0m and the replication was 3. Plants were visually inspected to see virus infection, present or absent. Those with not infected by the virus, ELISA test was used to be confirmed for their resistance of virus diseases PVY and PLRV. The breeding genotypes of M2, and M3 breeding populations had PVY and PLRV R-gene from MSR061-01 and Alca Tarma, respectively and they segregated in the population. They were resistance against PVY and PLRV. PVY and PLRV resistance lines fall into four categories of flesh colour. Those were dark yellow, light yellow, yellow and white. Most of them were light yellow and white. PVY and PLRY resistance also segregated for scab resistance. Here we found most of them were strongly resistance to

scab disease of potato. Some PVY and PLRV resistance lines produced yield more than 25 t/ha which is more than the infected PVY and PLRV control varieties Diamant and Asterix.

Chloroplast genome sequencing and QTL analysis of heat tolerant and late blight resistant potato varieties

Chloroplast and CpDNA isolation protocol optimization going on. By this time chloroplasr and cpDNA isolated from BARI Alu-73. DNA quality and quantity have been tested using NanoDrop Spectrophotometer 2000. Electrophoresis were performed using genomic and cpDNA with agarose 0.8% gel stained using ethidium bromide at 80 v for 1 h. Bands in agarose gel revealed the presence of cpDNA (Fig. 1). More optimization and standardization of the procedure for pure chloroplst and cpDNA isolation is required.

Potato hybridization is a part of breeding program to develop F_1 population under this project. When two parent plants are crossed, few desirable characters transferred to progeny. As a result, a lot of genetic variation is available in F_1 populations. This year under this project, we established crossing blocks at Tuber Crops Research Centre, BARI, Gazipur and Breeder Seeds Production Centre, Debigonj to support the previous year short-coming results. In previous year, a total of 22 successful crosses found. F_1 seeds will be successfully collected and stored through the year carefully in glass vacuum desiccator. Among them, all types of F_1 seed will be transferred in Breeder Seed Production Centre (BSPC), Debigonj, Panchagar for population development by seedbed germination procedure. Only two types i.e. TB-08 and TB-15 have transferred at TCRC field, Gazipur for population development.

Young leaves were collected from the variety BARI Alu- 7, 8, 25, 46, 53, 72, 73, and 77 and DNA was isolated using Thermo GeneJET Plant Kit. Quality and quantity of the DNA was measured by NanoDrop septrophotometer 2000. Eighteen SSR Primers were selected and tested for PCR. Reaction products were electrophoresed on horizontal 1% gel agaros gel using lX Tris-Acetic EDTA buffer. Electrophoresis was conducted at for 1h at 80 volts and bands were visualized with ultraviolet light (302 nm) using AlphaImager mini^{TM}. Twenty three SSR primers have been tested for molecular characterization of heat tolerant and late blight resistant potato varieties. Few of the primers showed high polymorphism among the varieties. There is distinct genotypic variation among the heat telerant and late blight resistant varieties (BARI Alu-46, 53, 72, 73 and 77). Results revealed that all the varieties devided into six clusters. However, there is no significant genetic different between the varieties BARI Alu-7 & 8. Almost same genetic make up is carring. Also, smilar genetic make up is carring between the varieties BARI Alu-25 and 53. BARI Alu-77 is mostly genetically different than other varieties. This result is almost resembling to phenotypic characters of these poatao varieties. This is the basic research for four years. Second year experiment is going on.

Characterization of R-genes for late blight disease of potato

Late blight disease resistance was evaluated in the field and detached leaf bio-assay. TCRC developed late blight resistant varieties BARI Alu-46, BARI Alu-53, BARI Alu-77. TCRC developed late blight resistant varieties including BARI Alu-57, Alouette and Carolus were planted in the greenhouse to collect leaf tissue for DNA extraction. DNA from the control varieties, BARI alu-7 and BARI Alu-25 were also quantified and purified to run the PCR. This genomic DNA was used to check their R-gene by molecular markers. Molecular markers were selected from the published papers where they have been found association with late blight resistance. Those are well known R-gene markers and used them in this experiment. In addition, varieties were evaluated by field trial in TCRC research field and RARS, Burirhat, Rangpur research field to know their resistance level. Late blight resistant varieties and two susceptible varieties Diamant and Asterix as a control were planted in the research filed of TCRC, Gazipur and RARS, Rangpur. Planting time was 29-11-2018 in RARS, Burirhat, Rangpur and 10-12-2018 in TCRC, Gazipur with three replications. Plant spacing was 60 cm x 25 cm and the plot size was 2.5 m x 2.4 m. Late blight resistant varieties developed and introduced in our country. Based on the field evaluation and detached leaf bio-assay (DLB) Alouette showed maximum resistance. BARI Alu-56 and 53 has break down their resistance against late blight. To check the

resistance of late blight disease, DLB was done with the isolate of Debigonj. From the data we found variations of late blight resistance among the treated genotypes. From the disease progressive, Alouette and Carolus showed strong resistance resistance over the period of DLB. Others did not show resistance at all after 10 dpi. Similar results were found from the field evaluation in both TCRC, Gazipur and RARS, Rangpur. From those evaluation, Alouette and Carolus showed resistance more than other varieties. BARI Alu-46 and 53 also found susceptible even though it was released as resistant varieties, but their resistance has broken down. For exploring R-gene in the resistant varieties, DNA was isolated, purified and quantified to run PCR with selective R-gene markers. PCR analysis is still going on.

In vitro regeneration of sweet potato (*Ipomoea balatas* L.) for future transformation

The experiment was conducted at tissue culture laboratory of TCRC during 2018-2019. Two BARI released popular varieties, BARI SP-4 and BARI SP-8 were used for this experiment. At the beginning of the micro propagation process, explants were collected from the plants grown in a green house. In vitro plantlets were established from nodal explants. 0.5 mg/l KN was used in BAP supplemented with MS media according to (0.0,.0.5. 1.0, 1.5, 2.0 mg/l). Among these combination MS+ 1.0mg/l BAP +0.5mg/l KN showed the best results for both varieties, BARI SP-4 and BARI SP-8. For regeneration study and development of transformation protocol internodes, petioles, leaf segments of in vitro plantlets will be tested in MS media supplemented with different concentration of BAP, TDZ and ZR. Petiole and leaf segment will be used as explants for callus induction. A simple, efficient and reproducible method for plant regeneration of sweet potato was developed in this study. MS basal media with combination of 0.5mg/l and 1.0mg/l BAP and 0.5mg/l kN. The minimum days required for shoot initiation (4 days) was noted in BARI SP-8 from MS with 1.0mg/l BAP and 0.5mg/l KN after 4 weeks of culture. The maximum (5) number of nodes were obtained from 1.0mg/l BAP and 0.5 mg/l KN for variety SP-8 after 4weeks of cultured. Leaf number was recorded the highest (4) in case of SP-4 from 0.5mg/l BAP and 0.5mg/l KN with MS and variety SP-8 showed maximum number (5) of leaf in 1.0mg/l BAP and 0.5mg/l Kn. To established this protocol further study should be needed for standardization

Development of 3R-gene GM potato variety for late blight resistance

Feed the Future-Biotechnology Potato Partnership (FtF-BPP) is a collaborative research project, started in 2015 for the first five years phage. The project brings together USAID, Michigan State University, the University of Minnesota, University of Idaho and the J.R. Simplot Company and Bangladesh Agricultural Research Institute (BARI) in a cooperative agreement to develop 3R-gene containing genetically modified (GM) potato variety for late blight disease resistance. The first phase of the project will be ended on September 30, 2020.

Resistance (R) genes to *Phytophthora infestans* have been found in many tuber-bearing wild species. Early potato breeding programs utilized some of these R genes to help control late blight. To date 68 Rpi-genes, from wild solanum species, have been characterized and about 20 of them have been cloned. Plant biotechnology (Genetic engineering and plant transformation) is an effective and efficient method to introduce multiple R genes into one preferred variety of potato for new late blight resistant variety. The durability and efficacy of three genes is expected to be much greater than one or two genes in a single variety. The 3R- genes referred to as (3)-R-genes *Rpi-mcq1, Rpi-blb2 and Rpi-vnt1.1* have been isolated from *Solanumm ochiquense, Solanum bulbocastanum and Solanumventurii,* respectively; prepared a construct and inserted it in Diamant potato varieties. MSU 3R Diamant Event-1, MSU 3R Diamant Event-2 and non-GM

Diamant have been developed through *Agrobacterium* mediated gene delivery system by J. R. Simplot Company, USA. The events are now under trial for efficacy test against late blight disease at Michigan State University, USA. A total of 12 plantlets from two transgenic events (06 plantlets/event) along with 600 minitubers (300 minituber/events) will be imported in Bangladesh on October 2019.

Practice trial (Mock trial of CFT) of late blight resistant potato genotypes

A practice trial (MOCK Trial) has been conducted at TCRC, BARI, Gazipur to evaluate late blight resistant genotypes and to develop core team members of FtF-BPP project for handling of confind field trial (CFT) on 3R-gene GM potato events during November 2019 to March 2020. Nutrient Film Technique derived minitubers of MSZ 219-13 confer resistant to late blight at US blue -13 phytophthora isolate was used as GM event having check US Diamant and Katadhin. The trial was established as a MOCK trial of CFT of 3R-Gene containing LBR DIA-MSU-UB events. Local Diamant potato variety was used in Spreader Rows around the perimeter. Phytophthora isolates were artifici ally inoculated to test the efficacy of late blight resistace. MSZ 219-13 did not show resistant against the phytophthora isolates of Bangladesh. All the tested varieties showed susceptible to late blight disease. Core team members received hands on training on conduction of CFT from this MOCK trial.

Performance of MSU developed potato genotype (MSZ 219-13) for late blight resistant

The experimental plants were planted in a split plot design with four (4) replications. Each block (replicate) was consist of 6 plots: 2 treatments (spray; non-spray), 1 experimental line, MSZ219-13 and 2 control lines Diamant and Katahdin. Each plot was comprised of 1 row of 8 plants each, or 8 plants per plot (32 plants per line total). Each plot was 2.4 m x 2.0 m. Plant spacing 0.6 m x 0.25 m within plots and 60 cm between plots. Spreader Rows were consis of local Diamant around perimeter, planted at the same time of the experimental planting. Isolation zone was establishing an isolation zone between regulated Trial site (including the spreader plants) and any other cultivated potato. This zone must be at least 20 meters on all sides of the Trial site. The isolation zone was left fallow during the trial.

Plant stand or emergence was slow in the MSZ219-13 variety compared to Diamant and Katahdin. Diamant and Katahdin took around 30 days to emerge all the tuber from the plot but MSZ219-13 took almost 45 days. Canopy coverage after plant emerged, Diamant varieties showed highest percent earlier than others, but katahdin after 70 days showed sharply decrease canopy coverage due to senescence. as the MSZ219-13 was slower germination rate, canopy coverage was also very slower than others. This year the weather was not good for the development of late blight disease of potato. artificial inoculation was given to the experimental plot using inoculum spray and the placement of detached infected leaves. after inoculation disease was seen and their infection was taken as percent. In the experiment, MSZ219-13 was treated as the late blight resistant variety, but was not. MSZ219-13 including two control varieties, Dimant and Katahdin did not show resistance. MSZ219-13 showed maximum resistance among them, but their resistance level was not optimum. all of them showed more than 50% susceptible to late blight disease.

Preparation of *phytophthora* isolates and its efficacy at laboratory and field conditions

Phytophthora isolates were collected from Mymensingh, Bogura, Debigonj and Rangpurin during December 2018- January 2019. The pea (BARI Motarshuti-3) amended agar media found better for growing Phytophthora infestansandpea amended agar with calcium carbonate and antibiotic ampicillin provided huge number of spores. Successful isolation of P. infestans was done from Mymensingh, Debigonj and Rangpur. The potato genotypes MSZ219-13 was resistant to the US for US-13 isolate but it did not show any resistance to our local isolate which was sprayed to get infection in the MOCK trial. The Detached Leaf Bioassay (DLBs) and artificial inoculation of P. infestans on Diamant, Katahdin and MSZ219-13 showed susceptible to late blight, but fungicide sprays had some positive effect to control the late blight disease.

Survey, isolation and molecular characterization of *Phytophthora infestans* in bangladesh under FtF-BPP project

The survey work was conducted for observing the status of late blight infection in Bangladesh during 2018-19. The severity of late blight found lowerin Mymensingh, Bogura, Debigonj and Rangpurin this year. The pea (BARI Motarshuti-3) amended agar media found better for growing Phytophthora infestansandpea amended agar with calcium carbonate and antibiotic ampicillin provided huge

number of spores.Successful isolation of P. infestans was done from Mymensingh, Debigonj and Rangpur. Preliminary results on characterization suggest that there is diversity in the populations of P. infestans found in Bangladesh and the isolates are not all Blue 13 as previous studies have suggested.Both A1 and A2 isolates were found in Dhaka and all isolates from outside Gazipur (Dhaka Division) were of the A1 mating type.Haplotype testing showed that the Bangladesh isolates were 1a which is similar to US-8, US-22, US-23, and US-24 and Blue 13 isolates but distinct from Pink 6 isolates which are 1b. Further analysis,twelve living cultures sent to University of Idaho for molecular characterization.In case of metalaxyl sensitivity test, all the isolates tested were metalaxyl insensitive.The Detached Leaf Bioassay (DLBs) and artificial inoculation of P. infestans on Diamant, Katahdin and MSZ219-13 showed susceptible to late blight, but fungicide sprays had some positive effect to control the late blight disease. More isolates will be collected from the different agro-ecological zones of Bangladesh for molecular analysis to investigate the diversity and esx types of P. infestans.

Production of potato seed at BSPC, Debiganj, Panchagarh during 2018-2019

Breeder Seeds Production Centre, Debiganj produced 25969 potato plantlets from different varieties along with 25700 plantlets from TCRC, Gazipur to produce minituber. A total of 4056 kg minituber produced during 2018-2019. From the minituber of last year (2017-2018) 32.05 and 152.05 Kg G_1 and G_2 seeds produced, respectively. A total of 255.94 tons breeder seeds have been produced during 2018-19 year.

During 2018-19, 120 acres of land were under seed potato production. Of which 70.0 acres were under nucleus seed (minituber) and breeder seed production program (303 field net house-FNH and 3 permanently built net house-PNH). Rest area was covered with foundation seed (open field), true potato seed (TPS) and research activities. The amounts of different classes of seed produced were shown in Table-1. Under PNH 23 varieties (Asterix, Cardinal, Diamant, Granola, Courage, Lady Rossetta, BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-46, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-50, BARI Alu-53, BARI Alu-56, BARI Alu-57, BARI Alu-62, BARI Alu-63, BARI Alu-72 and BARI Alu-77) and CIP clones were grown to produce nucleus seed (minituber) from in vitro plantlets . Twenty one (21) varieties (Diamant, Cardinal, Granola, Asterix, Lady Rossetta, Courage, BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-46, BARI Alu-53, BARI Alu-64, BARI Alu-72, BARI Alu-73, BARI Alu-74, BARI Alu-77, BARI Alu-78 BARI Alu-79, and BARI Alu-80) were grown under temporary field net house to produced breeder seed. For foundation seed production 17 varieties were grown in open field condition. Standard seed production procedure were strictly followed developed by TCRC. The amount of seed produced can be multiplied through an organized seed production network to fully overcome the needs of improved potato seeds of the country.

Seed potato production through Aeroponic system

Potato (*Solanum tuberosum* L.) productivity is highly constrained by limited supply of high quality seed tubers in Bangladesh. Production of TC-based seed potato starts with meristem tip culture technique. The resultant plantlets are grown in net-house for production of mini-tubers. This method is expensive and time consuming due to limited productivity. To overcome this situation Aeroponics is an excellent modern technique. Aeroponics system is a soilless culture system, where roots are kept in a dark environment, saturated with aerosol of nutrient solution. In 2018-19 cropping year, an Aeroponics experiment was set up in the greenhouse of Tuber Crops Research Centre, BARI, Gazipur in order to investigate its feasibility and optimization of production system. Result of this experiment was very promising. Total of 6121 mini-tubers were harvested (20.34 kg). Number of tubers per plant was 30.49 and 24.66, weight of tuber per plant was 70.31g and 99.05g and weight of individual tuber was 2.85g and 3.09g in structure 1 and structure 2. The highest average number of tubers per plant were recorded in BARI Alu-37 in structure 1 BARI Alu-46 in structure 2. However, the average weight of tubers per plant and the average weight of individual tuber were observed in BARI Alu-37 in structure 1 BARI Alu- 46 in structure 2. The

estimated net profit was BDT 24,620from the 2x(4.5x1.5x1.2m3)Aeroponics structures in a season. The results opened a new area for producing quality potato mini-tubers by Aeroponics system in Bangladesh. For commercial optimization of Aeroponics technique in Bangladesh, research should be continued with emphasis on optimization of cheap source of nutrients, effect of shoot and stolon pruning on yield and quality and effects of different hormones on plant growth and tuberization.

Soil, water and nutrient management

Soil is the most important natural resource of Bangladesh and judicial soil management is the most important for getting desired yield and keeps the soil with full potential for further cultivation. Due to high cropping intensity, soil resource of Bangladesh has been over exploited and soil fertility declines. Soil, water and nutrient management section is currently working on soil fertility and organic matter enrichment through INM and IPNS system of tuber crops cultivation.

Effect of zinc on biochemical parameters, processing quality and zinc bio-fortification in potato tuber

Zinc was evaluated on the quality of potato tuber and zinc concentration in tuber as bio-fortification at Non-calcareous Grey Floodplain soil of Debiganj and Grey Terrace Soil of Joydebpur during 2018. There were five treatments - T_1 (0 kg Zn/ha), T_2 (1.5 kg Zn/ha), T_3 (3 kg Zn/ha), T_4 (4.5 kg Zn/ha) and T_5 (6 kg Zn/ha). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Yield of potato was significantly ($p \leq 0.05$) influenced by the different levels of zinc. The highest potato tuber yield (55.1 t ha^{-1}) was found in T_3 at Debiganj followed by T_4 at Debiganj. The crop response to fertilizer application was positive and quadratic in nature. From the quadratic response function, the optimum dose of Zn was recorded as 3.5 and 4.0 kg ha^{-1} for Joydebpur and Debiganj, respectively. The highest dry matter content (21.1 and 20.5% for Debiganj and Joydebpur, respectively) was found in T_3. There was no cutworm infestation in T_1 and T_3. The highest TSS and specific gravity were recorded in T_4 while no scab infection was found in the plots. The other parameter will be incorporated after receiving the lab analytical report. This is the first year result and it will be continued to verify the findings.

Effect of foliar application of zinc and manganese on the yield and quality of potato (*Solanum tuberosum* l.)

Foliar zinc and manganese were tested on the yield and quality of potato and to find out suitable foliar dose of zinc and manganese for potato at Breeder Seed Production Centre (BSPC), Debiganj, Panchagarh under AEZ-3 (Tista Meander Floodplain Soil) during the *rabi* season of 2018-2019. The treatments comprised foliar application with four levels of Zn (0, 0.05, 0.10 and 0.15%) and four levels of Mn (0, 0.05, 0.10 and 0.15%). The experiment was laid out in a factorial randomized complete block design (RCBD) with three replications. The tuber yield of potato was significantly influenced by foliar application of different concentration of zinc and manganese. The highest tuber yield (40.4 t/ha) was obtained in 0.1% Zn and Mn .The highest dry matter content of tuber (21.2 and 21.6% for Zn and Mn, respectively) was found in T_3. In Zn, the minimum scab infection was found in T_4, which was very closely followed by T3. For Mn, T_3 showed the minimum scab infection. The other parameters will be presented after receiving the lab analytical data.

Response of potato to phosphorous in old himalayan piedmont plain soil

Phosphorus was evaluated on the yield and quality of potato and to assess the effect of P fertilizer on P uptake and fertilizer P recovery at Non-calcareous Grey Floodplain soil of Debiganj during 2018-19. There were seven treatments - T_1 (0kg P/ha), T_2 (20 kg P/ha), T_3 (40 kg P/ha), T_4 (60 kgP/ha), T_5 (80kg P/ha), T_6 (100kg P/ha) and T_7 (Farmer's practice, FP). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Yield of potato was significantly ($p \leq 0.05$) influenced by the different levels of phosphorus. The highest potato tuber yield (54.1 t ha^{-1}) was found in T_4. The crop response to fertilizer application was positive and quadratic in nature. From the quadratic response function, the optimum dose of P was recorded as 70.4 kg ha^{-1} for Debiganj. The highest dry matter content (21.3%) in potato tuber was recorded in T_4. There no scab

infection and cutworm infestation were recorded in the plots. The other parameter will be incorporated after receiving the lab analytical report. This is the first year result and it will be continued to verify the findings.

Effect of potassium sulphate on the yield and quality of potato through controlling scab disease

Potassium sulphate was tested as a source of sulphur in controlling *Streptomycesscabies* in potato and to find out the suitable dose and source of sulphur for potato at Grey Terrace soil of Joydebpur and Non-calcareous Grey Floodplain soil of Debiganj. The popular potato variety BARI Alu-7 (Diamant) was evaluated under different levels of sulphur fertilizer from potassium sulphate. The five different levels of sulphur were: T_1 (0 kg S/ha), T_2 (15 kg S/ha), T_3 (30 kg S/ha), T_4 (45 kg S/ha) and T_5 (60 kg S/ha). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Different sulphur levels and locations showed significant effect on the yield of potato over locations. The highest tuber yield (54.7 t/ ha) was found in T_3 at Debiganj, which was followed by T_4 (53.0 t/ha) in the same location. T_3 showed the maximum dry matter content in potato tuber. The minimum scab infection and cutworm infestation were also recorded in T_3. The post-harvest properties of soil will be presented after receiving the lab analytical data. This is the first year findings and it needs to continue to verify the first year result.

Integrated nutrient management for potato-aroids-t. A*man* rice cropping pattern

Organic manure and chemical fertilizers were tested to develop a suitable fertilizer package for potato-aroids-T.aman cropping pattern and to increase crop productivity and sustain soil health under integrated nutrient at Grey Terrace soil of Joydebpur and Tista Meander Floodplain soil of Bora. There were six treatments - T_1 (Control, native nutrient), T_2 (100% recommended dose of fertilizers, RDF), T_3 (Poultry manure, PM@ 3t ha^{-1} + rest from RDF), T_4 (Cowdung, CD @ 6 t h^{-1}+ rest from RDF), T_5 (125% RDF) and T_6 (Farmer's practice, FP). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The potato, aquatic taro and rice grain yields were significantly influenced by the integrated nutrient management in potato-aroids-T.aman cropping pattern. The highest potato tuber yield was found in 125% RDF. The maximum rhizome and rice grain yields were recorded in T4 (CD 6 t ha^{-1}+ rest nutrient from RDF) while the highest stolon yield was noted in T3 (PM 3 t ha^{-1}+ rest nutrient from RDF). The lowest infected tuber was observed in T_3 while the minimum cutworm infestation was noted in T_4. The highest gross margin (Tk. 928517 ha^{-1}) and MBCR (12.5) were found in T_3 followed by T_4. This is the first year findings and it will be continued to verify the result.

Integrated nutrient approach for yield storability and nutritional quality of sweet potato

Organic manure and chemical fertilizers were evaluated on the yield, quality component and storability of sweet potato under integrated nutrient management at Grey Terrace Soil, Joydebpur and Tista Meander Floodplain soil of Bora during 2018-19. There were six treatments - T_1 (Control, native nutrient), T_2 (100% recommended dose of fertilizers, RDF), T_3 (Poultry manure, PM@ 3t ha^{-1}+ rest from RDF), T_4 (Cowdung, CD @ 6 t h^{-1}+ rest from RDF), T_5 (125% RDF), T_6 (Farmer's practice, FP). Four levels of storage media were used such as (1) Sand, (2) Sawdust, (3) Soil and (4) Open floor. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The yield of sweet potato was significantly ($p \leq 0.05$) influenced by the integrated use of organic manure and chemical fertilizers. The highest root yield (36.7 t $ha^{-}1$) was obtained in T3 at Bogra, where poultry manure @ 3 t ha^{-1} along with reduced rate of recommended dose of chemical fertilizers were applied (Table 9). The highest marginal benefit cost ratio (MBCR) (59.4) was also observed in the same combination. The highest dry matter content (34.7 and 32.1% for Bogra and Joydebpur, respectively) was recorded in T1 while minimum weevil infestation (8.47%) was found in T_1 which was very closely followed by T_3. The maximum TSS (7.33ºBrix) was found in T_3. At 28 and 42 DASt, sawdust and sand showed the minimum weight loss at Joydebpur and Bogra, respectively. The sand and dust media showed the better performance regarding fiber and color, while

sand and soil scored better regarding sweetness. The treatment having organic manure showed the minimum weight loss. Therefore, PM 3t or CD 6 t/ha along with reduced rate of chemical fertilizer as IPNS basis can be recommended for sustainable sweet potato production.

Table 9. Interaction effects of integrated nutrient management and locations on yield attributes and yield of Sweet potato

Location	Treat	Root length (cm)	Root diameter (cm)	Root yield (t ha^{-1})
Bogra	T1	11.1	3.11	11.5 d
	T2	12.9	3.85	29.4 b
	T3	14.6	4.85	36.7 a
	T4	14.3	4.67	34.5 a
	T5	13.3	4.34	34.4 a
	T6	12.5	3.70	28.0 c
Joydebpur	T1	10.5	2.40	10.2 d
	T2	12.7	3.80	21.0 c
	T3	14.3	4.52	22.1 c
	T4	13.9	4.33	21.9 c
	T5	13.5	3.90	21.6 c
	T6	12.0	3.40	19.4 c
	CV (%)	5.00	10.2	7.30

Determination of fertilizer dose for promising released Panikachu variety

The experiment was carried out to update and optimize the fertilizer package of panikachu matching the soil and agro climatic condition and to maximize yield and quality of Panikachu at Grey Terrace soil of Joydebpur and Tista Meander Floodplain soil of Bora. There were six treatments - T_1 (farmer's practice), T_2 (-N), T_3 (-P) and T_4 (-K). The experiment was laid out in a randomized complete block design (RCBD) with four replications. The stolon and rhizome yields were significantly influenced by the different treatments. The highest stolon (20.5 t ha^{-1}) and rhizome (25.2 t ha^{-1}) yields were found in T_1 (farmer's practice) at Bogra where all nutrients were applied with cowdung. Among the locations, Bogra showed the highest stolon and rhizome yield. Optimum fertilizer rate for maximizing the stolon and rhizome yield will determined after receiving the lab analytical data of plant sample. This is the first year findings and it will be continued to verify the result.

Influence of water stress condition on some BARI released newly potato varieties

Five level of irrigations namely I_0 = No irrigation, I_1= One irrigation at 30 DAP, I_2= Two irrigations at 30 and 45 DAP and I_3= Three irrigations at 30, 45 and 60 DAP (Control) with three newly released potato varieties namely BARI Alu-36, BARI Alu-37and BARI Alu-40 were evaluated at the Tuber Crops Research Sub-Centre, Munshiganj during 2018-19 cropping season with a view to select variety(ies) that are high yielding and suitable for cultivation under water stress condition. Results showed that the best performance (34.20 t/ha) was obtained from BARI Alu-36 with no irrigation (V_1I_0) which was followed by BARI Alu-37 (V_2I_0) and BARI Alu-40 (V_3I_0) under same water stress condition. In water stress condition expected percentage of tuber size 28-55mm was also obtained from V_1I_0. In case of dry matter

percentage, maximum dry matter percentage was produced by treatment combination V_3I_0 which was followed by V_2I_0 and V_1I_0 under water stress condition. Therefore, considering the yield and other characters, BARI Alu-36 may be cultivated under water stress condition in our country.

Disease management

Survey of major potato diseases of Bangladesh

A survey was conducted to observe the incidence of potato diseases at Bogura and Joypurhut region in Bangladesh during 2018-19. Late blight disease incidence was relatively medium in Punat upazilla of Joypurhut and next in Kahalu upazilla of Bogura district and low in Joypurhut sadar, Gabtoli and Shibgonj upazilla of Bogura. Early blight disease was also observed and it was low in the surveyed area. The highest incidence of Potato Leaf Roll Virus was in Kahalu, Bogura. Medium incidence of common scab was observed in Punat, Joypurhut. No incidence of stem rot and black leg was observed in these areas and low incidence of bacterial wilt, mosaic, stem canker, black scurf, and PVY were observed.

Screening of different released varieties against post -harvest disease under natural storage conditions

Performance of different potato varieties was assessed to post harvest rottage at Joydebpur under natural storage conditions during 2018-19. The percentage of tuber rot due to disease was increased with the increase of time. Considering all criteria, BARI Alu-59 and BARI Alu-13 were found to be better for long shelf life under natural storage condition up to 180 days.

Validation trial of seed and soil treatments in controlling common scab disease of potato at Joydebpur

An experiment was conducted at TCRC, BARI, Gazipur to find out the effective management practices in controlling common scab of potato var. Diamant during 2018-19. A total of eleven (11) treatments were selected as different combinations of seed and soil treatments. The effect of treatments varied among them to reduce common scab of potato. The treatment T_{11} means apply stable bleaching powder (SBP) with at 25 kg/ha before seed sowing into the soil and seed treatment with Provax @ 0.2% found to be more effective to control common scab based on disease the incidence and severity.

Screening of potato varieties and germplasm against late blight

Late blight of potato, caused by *Phytophthora infestans* (Mont.) de Bary, is one of the most important diseases of potato (*Solanum tuberosum* L.) in Bangladesh. Field experiment was conducted under natural inoculum pressure in farmers' field, Khaturia, Domar, Nilphamari and RARS, BARI, Burirhat, Rangpur to evaluate 40 (forty) potato varieties/germplasm/cultivars against late blight disease during 2015-2016, 2016-17, 2017-18 and 2018-19 cropping season. None of the variety/germplasm was found immune. One variety like BARI Alu-46, two germplasm viz. Alouette and Carolus found highly resistant in every year. Recently (2018-19 cropping year) included germplasms like Twinner and Twister found highly resistant. Rest two late blight resistant varieties like BARI Alu-53 and BARI Alu-77 were highly resistant in cropping seasons 2015-16 and 2016-17 but from 2017-18 cropping season showed moderate resistance. Yield of BARI Alu-46, BARI Alu-53, BARI Alu-77, Alouette, Carolus Twinner and Twister was 30.87 to 49.47 t ha^{-1} , 23.33 to 29.88 t ha^{-1} , 17.79 to 29.37 t ha^{-1} , 35.11 to 53.79 tha^{-1} and 31.23 to 38.50 tha^{-1} , 36.43 t ha^{-1} and 33.56 t ha^{-1} respectively. In respect of resistance and tuber yield performance of promising germplasm Alouette and Carolus was far better than all others released late blight resistant varieties.

Screening of potato varieties against black scurf disease of potato

Fourteen potato varieties/germplasm, namely BARI Alu-13, BARI Alu-25, BARI Alu-29, BARI Alu-36, BARI Alu-41, BARI Alu-46, BARI Alu-62, BARI Alu-72, BARI Alu-8, Carolous, Fountain, Twisted, Twiner and Alouette were evaluated against Black scurf disease under natural inoculum pressure at TCRSC, Bogura during *rabi*, 2018-19. In the study, no varieties were found to be resistant. All the tested varieties showed moderate level of resistance to black scurf disease.

Effect of different organic matter for managing soil borne diseases (common scab and stem canker & black scurf) of potato

An experiment was conducted in the experimental field of TCRSC, Bogura during *rabi*, 2018-2019 to select effective organic amendment (s) for managing soil borne diseases (common scab and stem canker & black scurf) of potato. There were nine treatments viz., T_1= Application of Cowdung @ 5 t/ha, T_2= Application of Ash @ 5 t/ha, T_3=Cowdung @ 2.5 t/ha + Ash @ 2.5 t/ha, T_4= Application of Kazi Jaibo sar @ 1.0 t/ha, T_5= Application of Annapurna jaibo sar @ 1.0 t/ha, T_6= Application of Mustard oil cake @ 0.5 t/ha T_7 =Fara jaibo sar @ 1.0 t/ha, T_8 = Tobacco dust @ 850 kg/ha and T_9 = Control. Among the treatments T_4 had the lowest incidence and severity against black scurf and T_6 gave the lowest incidence and severity against common scab. All treatments offered higher yield than control.

Screening of different BARI released varieties against common scab disease of potato at Joydebpur

Twelve BARI released potato varieties including two checks as BARI Alu-7 and BARI Alu-8 were evaluated at Tuber Crops Research Centre, BARI, Joydebpur, Gazipur during 2018-19 under the field condition at Rabi season. Considering scab incidence and severity, BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-46, BARI Alu-53, BARI Alu-72 and BARI Alu-13 performed better to show lower common scab of potato.

Morphological and molecular characterization of *Ralstonia solanacearum* causing bacterial wilt and brown rot of potato

An experiment on the morphological and molecular characterization of *Ralstonia solanacearum* causing brown rot of potato was conducted in the Biotechnology Laboratory, TCRC, Joydebpur, Gazipur during 2018-19. Morphological characters of virulent and avirulent bacteria as *R. solanacearum* found on TZC media from the samples. Total 4 samples (one tuber and three stem samples) among 09 (nine) samples showed the 281-bp amplification with the specific primers and indicated infected with *R. solanacearum.*

Screening of potato varieties against common scab

There were twenty seven potato varieties and five germplasm were evaluated against common scab disease under natural inoculum pressure and artificially inoculated condition. During 2015-16 and 2016-2017 cropping season potato varieties/germplasm were tested under natural inoculum pressure at farmers' field, Khaturia, Domar, Nilphamari and in artificially *Streptomyces* spp. inoculated condition during 2017-18 and 2018-19 cropping season under poly shaded permanent net house of RARS, Burirhat, Rangpur. There were no varieties / germplasm was found immune against *Streptomyces* spp. BARI Alu-13 (Granola), BARI Alu-29 (Courage), BARI Alu-36 (4.26 R), BARI Alu-41, BARI Alu-46, BARI Alu-56, BARI Alu-59 (Metro) and BARI Alu-61 exhibit good level of resistance against common scab for both 2015-16 and 2016-17 cropping seasons and out of these BARI Alu-59 was minimum affected where common scab incidence viz. 1.11% and 3.94% and severity was 0.39 and 0.80 was in 2015-2016 and 2016-2017 respectively. Significantly highest (49.05 t ha^{-1}) and lowest (31.52 t ha^{-1}) tuber yield was harvested from BARI alu-40 (4.45 W) and BARI alu-29 (Courage) respectively in 2015-2016. In 2016-2017 cropping season, BARI alu-13 (Granola) yielded the significantly highest 48.0 t ha^{-1} and lowest yield (24.17 t ha^{-1}) was from BARI alu-60 (Vivaldi). During 2017-18 cropping season, the highest disease incidence (85.51%) and severity (25.51) was recorded in BARI alu-62 and the lowest disease incidence (29.67%) and severity (6.60) was recorded in BARI alu-56 under artificially *Streptomyces* spp. inoculated condition. But the least common scab incidence (5.05%) and severity (PDI-1.01) was recorded in germplasm Twinner while, incidence-27.44% and severity 6.11 (PDI) was in BARI alu-8 in artificially inoculated condition in 2018-19 cropping season.

Detection of potato viruses (PLRV, PVY, PVX, PVM AND PVS) in the supplied samples of different companies through DAS-ELISA

A total of 471 plantlet samples from different government and non-government organizations were tested during 2018-19 for the presence of viruses by using specific DAS-ELISA detection separate kits as PLRV, PVY, PVX, PVS and PVM

according to manufacturer's instructions (Bioreba AG, Switzerland). Out of the 471 samples, 415 had completely virus free and 56 had infected with different viruses. Among virus infected samples, one (01) sample had PLRV, two (04) had PVY virus infection, one (01) had PVX virus infection, 40 had PVX and 10 had mixed virus infection by PLRV, PVS, PVX and PVY.

Integrated management of virus diseases in poato

An experiment was conducted to evaluate nine treatment combinations for managing virus diseases of potato during 2018-19 at TCRSC, Seujgari, Bogura. Effect of treatment combinations were varied significantly. Among them, T_4 {Barrier crop + Rouging + Spraying of Admire (@ 0.5ml/L, 4 times at 10 days interval)} showed the lowest virus diseases incidence and produced highest yield and which was 53.24% higher than control.

Insect management

Screening of released potato varieties and advanced materials against potato cutworm (*Agrotis ipsilon*).

Sixteen (16) varieties and advanced materials of potato were evaluated against cutworm infestation during 2018-19, TCRC, BARI, Gazipur. Among them Five (5) varieties and advanced materials namely, Colomba, Hybrid clone 13.7, CIP 235, Carolus and Alouette were shown comparatively less infestation (0.64-0.95%) caused by potato cutworm than the other varieties /advanced materials including two check varieties Diamant and Asterix. Finally, considering the highest marketable yield and lowest percent of damage tuber weight**,** these five tested materials was showed better performance against potato cutworm and can be used as breeding program. Skin color of tuber has no effect on cutworm's infestation.

Field evaluation of different new insecticides against potato cutworm

Fifteen insecticides were evaluated against potato cutworm (*Agrotis ipsilon, Hufnagel*) infestation at Tuber Crops Research Centre, Gazipur. All the insecticides were more or less effective in controlling the potato cutworm. Among them eight insecticides such as Fast Kill 2.5 EC, Biodin 10 G, Cimix 55 EC, Pecker 8 ME, Tomcat 80 WDG, AC Mix 55 EC, Nighter 55 EC and Gem 20 EC treated plots were gave more than 80% reduction of tuber damage over control. Significantly the highest yield was obtained from Cimix 55 EC treated plot which was followed by Nighter 55 EC and Pecker 8 ME.

Development of effective integrated management package against sweet potato weevil in farmer's field

The experiment was conducted to evaluate the effect of IPM management package in controlling sweet potato weevil during 2018-19 at Torotpara farmer's field, Gazipur. Among the treatments, the lowest percent of tuber damage by weight (3.77 %) and maximum yield (24.70t/h) was found in pheromone + Soil recharge (T_2) treated plots which differed statistically from other treatments. In case of the lowest mean grade crown and tuber damage recorded in pheromone + Soil recharge (T_2) treated plots. The weevil population was significantly positively correlated with weekly average temperatures and rainfall respectively. Based on all parameters, treatment T_2 (Pheromone trap + Soil recharge) showed best result in controlling sweet potato weevil throughout the crop season eco-friendly, effectively and economically. The second best treatment was T_1 (pheromone trap + Earthing up 3 times). In general, with the increase of tuber size, weevil infestation increases. Weevil population build-up was high in tuber than crown.

Screening of released sweet potato varieties and advanced materials against sweet potato weevil (*Cylas formicarius* fab)

Fifteen (15) varieties and advanced materials of sweet potato were evaluated against sweet potao weevil infestation during 2018-19, TCRC, BARI, Gazipur. Among these six (6) genotypes namely $H_{9.10}$/ 12, Antho-1, $H_{9.48}$/ 11, $H_{16.ej}$ / 10, $H_{9.7}$/ 12 and $H_{6.52}$/11 were showed comparatively less infestation (1.03-1.92% by weight of tuber) caused by sweet potato weevil than the other varieties /advanced materials along with check variety BARI SP 4 and BARI SP 8. Finally, considering the highest marketable yield and lowest percent of damage tuber weight**,** these six tested materials was showed better performance against sweet potato weevil and can be used as breeding program. Flash color of tuber has no effect on weevil infestation.

Survey, monitoring and documentation of insect pests of potato at southern regions of Bangladesh.

A field survey was conducted at two locations viz., Amtoly, Borguna and Dacop, Khulna during 2018-19 to document the insect-pests of potato, their nature of damage and farmers practice about their management. More or less similar insect-pests were recorded at both locations. Several insect-pests viz. Leaf miner (Tuta absoluta), Aphid, White fly and Leaf hopper were found to attack the potato. Their also found Lady beetle as a natural enemy. Among the insect pests, Tuta absoluta causing damage compared to other pests Amtoly, Borguna and Dacop, Khulna locations.

Infestation of new insect pests infesting and their documentation of different tuber crops

Insects are highly adaptable organisms having ability to cope with different types of environmental changes, including climatic change in the world. Climatic affects the range, distribution, behavior, development, survival and reproduction of insect pests through changes in minimum and maximum temperature, precipitation and other factors. As a result, many new insect-mite pests were found in tuber crops and some minor pests turned into major pests (Table 10). So, identification and documentation of these insect pests is essential to develop proper pest management approaches for sustainable crop production and food security.

Table 10. New observation of insect pests infesting different tuber crops during 2012-18 at Gazipur location.

Sl. no.	Name of new insect pest	Infested crops	Infested plants parts	Nature of damage	Destructive stage of the pest	First reporting year
1.	Common cutworm (*Spodoptera litura* (Fabricius))	Potato	Larvae scrap the leaf and bore the tuber	The young larvae first feed gregariously and scrape the leaves. Older larvae spread out and may completely devour the leaves resulting in poor growth of plants and then they attack in tuber.	Larvae	2012
2.	**Hairy caterpillar (***Creatonotus gangis)*	Sweet potato	Leaf and vine	The young larvae first feed gregariously and scrape the leaves.	Larvae	2012
3.	Aphid (*Aphis gossypii*)	Pani kachu	Leaf and stem	The adults & nymphs suck sap from leaves and stem.	Nymph and adult	2012
4.	White grub (*Phyllophaga ephilida*)	Potato, Sweet potato and Mukhi Kachu	Tuber	Initially young grubs feed on mother tuber, roots of developing potato plants. After tuber formation, the older second instars and third instars grubs feed on the underground potato tubers by making large, shallow and circular holes into them and thus rendering them unfit for marketing.	Larvae	2014
5.	Mealy bug (*Pseudococcus solenopsis* Tinsley)	Storage potato	Potato sprout and tuber	Mealy bugs suck sap from potato sprout and potato tuber.	Adult and nymph	2014

Sl. no.	Name of new insect pest	Infested crops	Infested plants parts	Nature of damage	Destructive stage of the pest	First reporting year
6.	Mole cricket (*Scapteriscus abbreviatus* Scudder)	Potato	Seedling stage and tuber	Mole crickets can damage potato plants by feeding at night on above ground foliage or stem tissue and below ground on roots and tubers. Seedlings may be girdled at the stems near the soil surface, though some plants may be completely severed and pulled into a tunnel to be eaten.	Adult	2014
7.	Potato wireworm (*Limonius canus, L. californicus)*	Potato	Seedling stage and tuber	Wireworms bore into tuber and even tunnel up the stems of plants depending on the crop attacked. Injury is most severe to seeds and seedlings and can result in stand loss. Root feeding causes wilting, stunting, and distortion of seedlings that usually kills the plant.	Larvae	2014 (I have studied damage severity at 2015-16 & 2016-17)
8.	Leaf minor *(Tuta absoluta*)	Potato and Sweet potato	Larvae mine the sweet potato and potato leaf and tuber	Most distinctive symptoms are the blotch-shaped mines in the leaves. In case of serious infection, leaves die off completely. Mining damage to the plant causes its malformation. Damage to tuber allows fungal diseases (for example) to enter, leading to rotting tuber before or after harvest.	Larvae	2016
9.	Epilachna beetle (*Epilachna vigintioctopunctata* (Fabricius))	Potato	Grubs and adults scrap the leaf	The grubs and adults both are the damaging stages of this insect. They feed on the foliage. The grubs scrap away the chlorophyll from the leaves leaving only veins. The grubs or larvae of this beetle are very sluggish and move very slowly while feeding on leaves.	Grubs and adults	2017
10.	Sweet potato tortoise beetle (*Aspidimorpha difformis*)	Sweet potato	Leaf and vine	Adults feed on leaves, making small to medium-size holes. The larvae at first eat the leaf surface; later, they eat their way through the leaf.	Adult and Larvae	2017

Post-harvest Technology

Storage

Storage behavior of potato varieties and hybrid clones under natural condition

An experiment was conducted during March to August 2018. Tubers of exotic potato varieties and clonal hybrids of RYT, AYT and SYT were evaluated for storage behaviour under natural condition. Memphis, Taisiya and Cimaga under exotic varieties of RYT performed better storage performance in natural condition. For hybrid clones of RYT, 10.58 and10.68 were showed better storage performance. For CIP clones under RYT, CIP-225 and CIP-224 exhibited better storage performance. In case of exotic varieties of AYT, Zina Red showed better performance. Regarding AYT, the clonal hybrids of 12.7 and 12.20 showed good storage performance. Regarding secondary yield trial (SYT), the exotic varieties of Actrice showed good performance with the clonal hybrids of 13.3 and 13.5.

Processing

Studies on the processing quality (Chips and French fry) of potato cultivars and hybrid clones

Fifteen exotic varieties of SYT were studied for their processing quality in the form of Chips and French Fries during 2018-19. L. Rosetta and Fontane varieties showed excellent performance in both cases - chips and French fries. Six hybrid clone under SYT were also evaluated and 14.12 as well as 14.11produced better quality chips and French fries. Colomba, Fortus and CIP-225out of 6 clones exhibited better performance in case of chips at RYT level whereas Fortus showed better only for French fries. Six exotic varieties under AYT were evaluated and Picabella and messishowed better performance in chips andActrice and Margaritashowed better performance in French fries. Among the hybrid materials for AYT, 13.7 showed better and rest two 13.17 and 13.19 were good in both cases – chips and French fries.

Technology Transfer

Adaptive Trials with Newly Released Potato Varieties

Adaptive trials with new potato varieties divided into two set (Set-I: BARI Alu-13 (Granola), BARI Alu-35, BARI Alu-37 & BARI Alu-40 and Set-II: BARI Alu-8 (Cardinal), BARI Alu-28 (L.Rosetta), BARI Alu-36 & BARI Alu-4!) were conducted at thirty two (Set-I: 24 & Set-II: 8) districts to promote as well as to know the farmers acceptance about the new potato varieties with the partial financial support of KGF. All the tested varieties varied between and within location. In Set-1 the average highest yield over the location 35.62 t/ha was recorded in BARI Alu-40 followed by BARI Alu-37 (33.31 t/ha) and BARI Alu-35 (32.84 t/ha). BARI Alu-13(Granola) was the lowest yielder (26.18 t/ha). In Set-II the average highest yield over the location 38.81 t/ha was recorded in BARI Alu-41 followed BARI Alu-36 (34.23 t/ha) and BARI Alu-8(Cardinal) (31.22 t/ha). BARI Alu-28(L. Rosetta) was the lowest yielder (29.40 t/ha) (Figure-3). Framers reaction varied between the locations. All the tested varieties accepted by the farmers of different location. Their demand is timely supply of quality seed of the tested new varieties.

Promotion and Dissemination of Newly Released Climate Smart (Heat & Salt Tolerant) Potato Variety at Farmers' Field

Promotion and dissemination trials with Climate smart new potato varieties were conducted at eight districts to promote as well as to know the farmers acceptance about the new potato varieties with the partial financial support of KGF during 2018-19. In each district the trial was replicated 10 locations except Patuakhali, twenty trials were conducted at Patuakhali. The tested two varieties varied between and within location. Average yield over the location of BARI Alu-72 was 26.43 t/ha and BARI Alu-73 was 22.21 t/ha. The highest yield of BARI Alu-72 was observed in Barishal and of BARI Alu-73 was found in Satkhira, whereas lowest yield BARI Alu-72 was in Barguna and of BARI Alu-73 was found in Coxsbazer. Framers reaction varied between the locations. Both the tested varieties accepted by the farmers of different location. Their

demand is timely supply of quality seed of the tested new varieties.

Promotion and Dissemination of Newly Released Late Blight Resistant Potato Varieties

Hundred field trials were conducted on BARI released late blight resistant potato varieties viz. BARI alu-46 and BARI alu-53 at farmers' field of nine lateblight disease prone districts in Bangladesh (Rangpur, Panchagarh, Nilphamari, Lalmonirhat, Gaibandha, Bogura, Joypurhat, Rajshahi and Kurigram) during 2018-19 for promotion and dissemination with the partial financial support of KGF during 2018-19. Yield of BARI Alu-46 and BARI alu-53 ranged 27.66 to 47.35 t/ha and 25.31 to 43.97 t/ha, respectively. Incidence of common scab, virus and late blight were found very low compared to farmers' adjacent plots. Farmers were very happy to observe the performance of the varieties as late blight resistance and yield.

Adaptive trial of Newly Released Potato Varieties through Potato seed producing private company and NGO

Adaptive trials with new potato varieties BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-46, BARI Alu-53, BARI Alu-72 & BARI Alu-73 were conducted at six seed producing company and NGO during 2018-19 to promote as well as to know the Company/NGO acceptance about the new potato varieties with the partial financial support of KGF. The main objectives were how to incorporate new potato varieties in their seed production system. This was the second year trials. Considering the two years results some Company/NGO showed their interest about tested varieties. Their demand is timely supply of breeder seed of the tested new varieties.

02 PULSE CROPS

Hybridization of blackgram

Hybridization of blackgram was conducted for creating genetic variability with desired gene combinations within the existing germplasm during Kharif-II season, 2018 at Pulses Research Centre, Ishurdi, Pabna. Six parents with desired characters were used and a total of 254 successful crossed seeds were collected from fifteen cross combinations that will be sown during the next season for confirmation of blackgram. F_1 segregation generations.

Confirmation F_1 generation of blackgram

To ensure fertile crosses between the parents, confirmation is very much essential. Fifteen F_1s obtained from Kharif-I, 2017 were grown along with their parents at Pulses Research Centre, Ishurdi, Pabna during Kharif-II, 2018. On the basis of desired characters eleven accessions were selected as confirmed cross comparing between two parents and were harvested separately for the next year trial.

Growing and evaluation F_2 generation of blackgram

Eleven F_2 segregates were grown along with one check BARI Mash-3 to advance the generation at Pulses Research Centre, Ishurdi, Pabna during Kharif-II, 2018. A total of 33 single plants from eight F_2s segregations generations were selected and harvested separately which will be grown in the next Kharif-II season as F_3 segregation generation in the next season.

Growing and evaluation F_3 generation of blackgram

Eight F_3s were grown along with check to advance the generation at Pulses Research Centre, Ishurdi, Pabna during Kharif-II, 2018. 4-13 plants from different cross combinations were selected and harvested separately which will be grown in the next Kharif-II season.

Observation trial of blackgram

Six families selected from last year's F_5s generation were grown against check variety BARI Mash-4 during Kharif-II 2018 at Pulses Research Centre, Ishurdi, Pabna. The experiment was laid out in a RCB design with two replications and having a spacing of 40 cm between rows. Among the test entries significant differences were observed in for Plant height (cm), Pods per plant, 100 seeds weight (g) and yield (kg/ha). The highest yield (2190 kg/ha) was obtained from BBLX K2-012005-6 followed by BBLX K2-012002-11, BBLX K2-012002-7 and the lowest yield (1246 kg/ha) from BBLX K2-012001-5 followed by BBLX K2-012003-1 and BBLX K2-012006-10. Therefore, Nine genotypes BBLX K_2-012002-9, BBLX K_2-012005-8, BBLX K_2-012005-5, BBLX K_2-012002-4, BBLX K_2-012002-2, BBLX K_2-012003-9, BBLX K_2-012002-7, BBLX K_2-012002-11 and BBLX K_2-012005-6 where selected to evaluate in the next Kharif-II season in PYT trial.

Regional yield trial of blackgram

The experiment was carried out to determine the performance of four blackgram genotypes for yield and yield contributing characters at Ishurdi, Pabna; Barind, Rajshahi; Jessore, Madaripur, Jamalpur and Gazipur. The genotypes were BG-7, BG-4, BG-2 and BARI Mash-3 was as a check. In case of days to flowering and days to maturity over six locations, no genotype performed earlier than Check variety BARI Mash-3, but all genotypes flowered early at Jamalpur location and mature early at Joshore location. Among the all genotypes, BG-4 was bold seeded. The highest mean seed yield was recorded in BARI Mash-3 (1474kg/ha) followed by BG-4 (1355 kg/ha) and BG-2 (1338 kg/ha). Therefore, two genotypes BG-4 and BG-2 were selected for further evaluation in Participatory Variety Selection trial in the next season at different locations of Bangladesh.

Participatory variety selection of blackgram

The experiment was conducted at Ishurdi, Barind, Jamalpur, Gazipur and Madaripur during Kharif-II season of 2018. Three Blackgram genotypes viz., BBLX-08010-4-1, BBLX-08008-2-1 and BBLX-08010-2-1 with one check (BARI Mash-3) were evaluated. The highest plant height was found in BARI Mash-3 (50.2 cm) and the lowest in BBLX-08010-2-1 (46.9 cm) followed by BBLX-08008-2-1. The genotype BBLX-08008-2-1 gave the highest 100 seeds weight (4.54 g) followed by BARI Mash 3 and the lowest 100 seeds weight was found in BBLX-08010-2-1 (4.24 g). The highest yield was seed found in BBLX-08008-2-1 (1458 kg/ha) followed by BBLX-08010-2-1 and the lowest seed yield was found in BBLX-08010-4-1(1264 kg/ha). From this trial genotypes BBLX-08008-2-1 and BBLX-08010-2-1 were selected for further evaluation.

Hybridization of lentil

Hybridization of lentil was conducted for creation of genetic variability among the genotypes with desired gene combinations during rabi, 2018-19 at Pulses Research Centre, Ishurdi, Pabna. Six potential parents with desired traits were used followed by half diallel fashion and a total of 351successful crossed derived seeds were harvest from fifteen cross combinations.

Confirmation of lentil F_1 generation

A total of fifteen cross combinations were grown along with their parents in both sides at PRC, Ishurdi, Pabna during the rabi season 2018-19. A total of 37 individual F_1s plants have been confirmed with specific accession number and harvested separately from six cross combination during rabi 2018-19 and these individual single plants will be grown as a F_2s generation in the next season for advancement of segregating generations.

Growing and evaluation of lentil F_2 generation

In hybridization program the maximum segregation and wide genetic variability is accomplished in F_2 generation of any crop species. For attaining more genetic variability with desired gene combination five F_2s were grown along with BARI Masur-8 as a check variety at Pulses Research Centre, Ishurdi, Pabna during rabi 2018-19. A total of 49 individual plants were selected and harvested from five F_2 generation of lentil for advancement of segregating populations as F_3s segregates in the next season.

Growing and evaluation oflentil F_3 generation

Ten F_3s were grown along with BARI Masur-8 as check variety for advancement of the generation from F_3 to F_4 and with a view to select appropriate and desired combinations at Pulses Research Centre, Ishurdi, Pabna. A total of 55 single plants were selected and stored from the ten F_3s generation which will be grown and evaluated in the next season as F_4 generations of lentil.

Growing and evaluation of lentil F_4 generation

A total of 47single plants were selected from ten F_4s generation comparing with check variety BARI Masur-8 based on desired phenotypic characters for advancement the generation from F_4 to F_5. The individual single plants will be grown in an individual line as F_5s generation for the retention of wide variability in the next season.

Growing and evaluation of lentil F_5 generation

More genetic homozygosity is obtained in F_5 generations, that's why family is selected in this generation. To select appropriate and desired combinations eighteen F_4s were grown along with BARI Masur-8 as a check at Pulses Research Centre, Ishurdi, Pabna during 2018-19 as F_5s generation. Finally, 28 lines were selected as 28 families from seventeen F_5s generation which will be grown in the next season as observation trial.

Observation trial of lentil

Twenty-eight families selected from last season's F_5 treated as lines were grown with check variety BARI Masur-7 and BARI Masur-8 in rabi season of 2018-19 at Pulses research Centre, Ishurdi, Pabna following RCB design with two replications. Finally nine genotypes *viz:* BLX-12002-12, BLX 13004-3, BLX 13004-13, BLX-13001-1, BLX-12002-4, BLX-12002-6, BLX 13005-2, BLX 13005-20 and BLX 13005-26 were selected to evaluate under PYT in the next rabi season.

Preliminary yield trial of lentil

The experiment was carried out to determine the performance of ten lentil genotypes for yield and yield contributing characters at four different locations viz. PRC, Ishurdi, PRSS, Joydebpur, RPRS, Madaripur and RARS Jashore. during Rabi, 2018-19. Significant variations were observed for days to flower, days to maturity,plant height, pods plant^{-1}, and yield in kg ha^{-1}. Significant differecnce was observed among genotypes for days to

maturity and plant height. Among the genotypes, BLX-12009-6 showed earlier maturity. Overall Ishurdi and Jashore produced the highest seed yield and in Gazipur genotypes earlier.

Regional yield trial of lentil

The experiment was carried out to determine the performance of nine genotypes for yield and yield contributing characters and stability that were evaluated in four different locations viz. Ishurdi, Jamalpur, Rahmatpur and Jashore during Rabi, 2018-19. Significant variation was observed for days to flower, days to maturity, pods per plant, 100 seeds weight and yield in kg per hectare. Among the genotypes, yield performance was not better over the checks. Genotypes BLX-10001-1 and BLX-10002-20 showed earliness over the locations and might be incorporated in future breeding program as early maturing parent.

Participatory variety selection of lentil

The experiment was carried out for evaluation the performance of five genotypes for yield and yield contributing characters and also determination of yield stability at farmers' field of five different locations viz.Pabna, Joydebpur, Madaripur, Barisal and Jashore during Rabi, 2018-19. Significant variations were observed for days to flower, days to maturity, pods plant^{-1}, and yield in kg ha^{-1}. Among the genotypes, BLX-05002-3 was flowered earlier followed by 05002-6. Considering yield potentiality, early maturity and stability parameters, the advance line 05002-6 can be released as a variety.

Screening of lentil germplasm under relay condition

Six promising entries of lentil along with BARI Masur-6 as check were evaluated at Pulses Research Centre, Ishurdi, Pabna during Rabi season of 2018-19 which was laid out in RCB design with 3 replications to select suitable genotypes for relaying with T. aman rice. Significant differences among the genotypes were observed in case of all the yield contributing characters except days to flower. The entry BLX 01013 flowered (58 days) and matured earlier (114 days) followed by BLX 11014-10. The highest pods per plant were obtained from DPL-62 and the lowest in BLX 05009-7. Among the entries the highest yield was obtained from DPL-62 followed by BLX-01013 and BARI Masur-6.

Confirmation of chickpea F_1 generation

Eight cross combinations were grown along with their male and female parents in both site during rabi season 2018-19 at PRC, Ishurdi, Pabna. A total of 28 individual F_1s plants have been confirmed and harvested separately from 8 combinations and these single plants will be grown as F_2s generation in next season for advancement of chickpea segregating populations.

Growing and evaluation of chickpea F_2 generation

The maximum segregation and genetic variability is accomplished in F_2 generation of any hybridization program. With a close observation, selection of appropriate and desired combinations, ten F_2s were grown along with BARI Chola-10 as a check variety for comparing with the F_2 segregates at Pulses Research Centre, Ishurdi, Pabna during rabi 2018-19. A total of 88 individual plants were selected, harvested and seeds were stored separately from ten accession for advancement of segregating populations as F_3s generation in the next season.

Growing and evaluation of chickpea F_3 generation

A total of 60 individual F_3s plants from eight F_3 progenies were selected and harvested separately during rabi 2018-19 and these single plants will be grown and evaluated as F_4s generation in the next season for advancement of chickpea segregating populations.

Growing and evaluation of chickpea F_4 generation

A total of 36 single plants were selected from three F_4s generations comparing with check variety BARI Chola-10 based on desired phenotypic characters for advancement the generation from F_4 to F_5. The individual single plants will be grown in an individual line as F_5s generation for the retention of wide variability of chickpea in the next season.

Preliminary yield trial of chickpea

The experiment was carried out to evaluate the performance of five chickpea genotypes along with check BARI Chola-5 and BARI Chola-10 for yield and yield related traits in six locations during Rabi 2018-19. Considering mean data for both days to flower and maturity BARI Chola-10 was found earlier. From the mean data across location BCX-

13005-8 gave the highest pods per plant and the lowest from BCX-13002-3. The genotype BCX-13005-8 gave the highest mean seed yield followed by BCX-13004-4 and BCX-13002-2 where as the genotype BCX-13002-2 was also found more stable across the locations. Considering, stability parameters and higher yield, three entries BCX-13005-8, BCX-13004-4 and BCX-13002-2 were selected to evaluate in the RYT of next Rabi season

Participatory varietal selection of chickpea

The experiment was carried out to evaluate the performance of four chickpea genotypes along with check BARI Chola-5 and BARI Chola-10 for yield and yield related traits in six locations during Rabi 2018-19. Considering mean data for both days to flower and maturity ICCV 07102 was found earlier. From the mean data across location BARI Chola-10 gave the highest pods per plant. The genotype ICCV 07102 gave the highest mean seed yield and also found more stable across the locations. Considering stability parameters, higher yield and farmers preference ICCV 07102 are selected to release as a variety.

Candidate variety demonstration trial of chickpea

Four advanced lines along with BARI Chola-10 as a check variety were used in Candidate Variety Demonstration Trial of chickpea during rabi-2018-19 at Pulses Research Centre, Ishurdi, Pabna for evaluation of promising advance lines in large plots and also multiplication of seeds of these advanced lines. Among the advanced lines BCX-08009-9 produced the maximum yield followed by BCX-08001-3.

Evaluation and seed multiplication of chickpea exotic germplasm

An experiment was conducted for evaluation and seed multiplication of chickpea exotic germplasm during 2018-19 at PRC, Ishurdi, Pabna. A total of 44 genotypes were selected for further evaluation in replicated trial in the next season.

Program : Fieldpea (*Pisum sativum,* L.) Improvement hybridization of fieldpea

Hybridization of fieldpea was conducted to create genetic variability among the existing genotypes having desired gene combinations during rabi, 2018-19 at Pulses Research Centre, Ishurdi, Pabna. Six parents were used following half diallel fashion. A total of 263 seeds derived from 10 crosses were collected and these F_1s seeds will be grown in the next season for confirmation of F_1s generation.

Confirmation of fieldpea F_1 generation

Confirmation is essential to ensure fertile crosses between the parents. Ten F_1s obtained from rabi 2017-18 were grown along with their parents at Pulses Research Centre, Ishurdi, Pabna during rabi 2018-19. Finally, a total of 35 single F_1s plant were confirmed from six cross combinations, harvested separately which will be grown in the next season as F_2 generation.

Growing and evaluation of fieldpea F_2 generation

Maximum segregation is attained in F_2 generation and with a view to select appropriate and desired combinations, nine F_2s were grown along with BARI Motor-3 as a check at Pulses Research Centre, Ishurdi, Pabna during rabi 2018-19. A total of 57 individual plants of desirable charaters from nine F_2s were selected for next season trial as F_3 generation.

Growing and evaluation of fieldpea F_3 generation

A total of 52 single plants in F_3s generation were selected from ten accessions during rabi 2018-19 at Pulses Research Centre, Ishurdi, Pabna. The selected F_3s generation will be grown as F_4s generation in next season.After selection of segregates in F_2 it is essential to advance the generation into F_3 to attain more homozygosity. In Fieldpea about 75% homozygosity is accomplished generally in F_3 generation.

Growing and evaluation of fieldpea F_4 generation

A total of 23 single plants of fieldpea F_4s generation were selected from four accessions during rabi 2018-19 at Pulses Research Centre, Ishurdi, Pabna. The selected accessions will be grown as F_5s generation in the next season.After selection of segregates in F_3 it is essential to advance the generation into F_4 to attain more homozygosity. In fieldpea about 87% homozygosity is accomplished generally in F_4 generation.

Regional yield trial of fieldpea

The experiment was carried out to evaluate the performance of six fieldpea genotypes along with check BARI Motor-1 and BARI Motor-3 for yield and yield related traits in five locations during Rabi 2018-19. Considering mean data for both days to flower and maturity BFP 11016 was found earlier. BARI Motor-3 followed by Sekim local produced the highest numbers of pods/plant. Apart from these, maximum seed weight was observed in Sekim local. In case of yield performance over locations, Jhikorgacha local performed the best among the genotypes. Considering biplot analysis and yield data, the genotypes *viz.* BFP-11016, Jhikargacha local and BARI Motor-3 showed stable performance across the locations.

Program: Grasspea (*Lathyrus sativus*, L.) Variety improvement hybridization of grasspea

Hybridization on grasspea was conducted during rabi 2018-19 at PRC, Ishurdi, Pabna to create the genetic variability among the existing germplasm of grasspea. Six parents were used following half diallel fashion. A total of 239 successful crossed derived seeds were collected and harvested separately from fifteen cross combinations.

Confirmation of grasspea F_1 generation

Eleven cross combinations of grasspea were grown along with their parents during the rabi season 2018-19 at PRC, Ishurdi, Pabna. A total of 17 individual F_1s plants have been confirmed and harvested separately from six cross combinations and these individual single plants will be grown as F_2s generation in the next season for advancement of segregating generations.

Evaluation of grasspea germplasm

An experiment was conducted at Pulses Research Centre, Ishurdi, Pabna and RPRS, Madaripur during Rabi 2018-19 to find out the suitable and high yielding genotypes/variety of grasspea. Eight genotypes and two check variety *viz.* BARI Kheshari-2 and BARI Kheshari-3 were evaluated in this trial. Results revealed that all the yield contributing characters under study were significantly different among the genotypes. The highest mean yield (1753 kg/ha) obtained from BKX 0003-1 followed by BARI Khesari-3 and BARI Khesari-2 and the lowest (1373 kg/ha) in Narail local followed by Sirajgonj local.Considering yield and other desirable characters, 4 genotypes *viz.* BKX 0003-1, BGP 13010, BKX 0002-4 and BGP 13008 were selected for next year breeding trail.

Evaluation of grasspea lines (exotic germplasm)

A field experiment was conducted at RARS, Rahmatpur, Barishal during Rabi season of 2018-19 to evaluate the local and exotic germplasm of grasspea genotypes/lines. Eight selected grasspea local and exotic lines viz. IGYT-125, IGYT-120, IGYT-124, IGYT-122, IGYT-110, IGYT-115, IGYT-123, IGYT-216 and one check variety BARI Kheshari-3 were evaluated in the trial. Results showed that all the characters under this study were significantly different among the genotypes except final plant stand and plant height. The line IGYT-216 was found early maturing (101.33 days) among the grasspea lines. The highest seed yield (1255 Kg/ha) was produced by the entry BARI Kheshari 3 followed by IGYT-216 (1166.67 kg/ha) and the lowest seed yield (386.67 kg/ha) was obtained in IGYT-110.

Screening of grasspea germplasm under relay condition

The experiment was conducted at Pulses Research Centre, Ishurdi, Pabna, during rabi season 2018-19 to find out the suitable germplasm/s having higher yield of grasspea under relay condition using a randomized complete block design with three replications. Significant genotypic differences were detected for all recorded traits. The entry BGP 130010 flowered earlier than others and the entry BKX 0002-4 was matured earlier followed by BGP 130010 and Narail local. The highest yield was obtained from BGP 130010 (1692 kg/ha) followed by Narail local and BGP 13008. Three genotypes BGP 130010,Narail local and BGP 13008 were selected for next season breeding trial.

Preliminary yield trial of grasspea

The experiment was carried out to evaluate the performance of three grasspea genotypes along with check BARI Khesari-5 for yield and yield related traits in three locations *viz.* Pulses Research Centre, Ishurdi, Pabna; PRSS, Joydesbpur and RPRS, Madaripur during Rabi 2018-19. Different genotypes of grasspea showed significant or non significant variations among all the parameters across all the environments. Considering mean data for both days to flower and maturity BGP 13009 was found earlier. The genotype BGP 13010 gave

the highest mean seed yield (1542 kg/ha) and lowest (1036 kg/ha) by BGP 13008 across the locations. Compared to three locations, almost all the genotypes produced higher yield at Ishurdi. Considering yield, desired yield contributing characters and stability parameters, two genotypes BGP 13010 and BGP 13009 were selected for RYT trial in the next rabi season.

Candidate variety demonstration trial of grasspea

A Candidate Variety Demonstration Trial of grasspea during rabi 2018-19 was conducted at Pulses Research Centre, Ishurdi, Pabna using two entries, BKX 0003-1 and BKX 0002-4 along with BARI Khesari-3 and BARI Khesari-5 as check varieties for evaluation of promising advance lines in large plots and also multiplication of seeds of these advanced lines. Highest seed was obtained from BKX 0003-1and this line will be proposed as a variety in this year.

Evaluation and seed multiplication of grasspea exotic germplasm

An experiment was conducted to evaluate and seed multiplication of grasspea exotic germplasm during 2018-19 at PRC, Ishurdi, Pabna.As the germplasm set was received at the last hour of season at PRC, its sowing was very late.This experiment was a non-replicated trial. Only 41 accessions flowered and produced few seeds and most of the rest accessions didn't flowered, few flowered but no pod setting occurred, hence yielded nothing. Yield per plant range was recorded 5.0 to 78.0 g. Based on the morphological features in the field, yield per plant, 100 seeds weight, plant height and others yield contributing characters 41 accessions were selected for further evaluation in a replicated trial in the next season.

Evaluation of cowpea genotypes for southern region

An adaptive experiment was implemented at RARS, Rahmatpur, Barishal during Rabi season of 2018-19 to evaluate the adaptive quality of eight selected cowpea germplasms with one check variety in southern agro-climatic conditions. Eight selected cowpea germplasms viz.CPL-1-17, CPL-2-17, CPL-3-17, CPL-3-17, CPL-4-17, CPL-5-17, CPL-6-17, CPL-7-17, CPL-8-17 including one check variety BARI Felon 1 were evaluated in the trial. Results showed that all the characters under this study were significantly different among the genotypes except days to maturity, number of seeds/pod and hundred seeds weight. Germplasm. The germplasm CPL-8-17 had produced the maximums seed yield (1569.4 kg/ha) which was statistically identical with CPL-7-17 (1297.2 kg/ha) whereas the lowest seed yield was observed in the check, BARI Felon 1and CPL-6-17 (630 kg/ha, and 693.6 kg/ha respectively).

Program: Mungbean (*Vigna radiata* L. Wilczek) improvement hybridization of mungbean

For creation of genetic variability among the existing germplasm with desired gene pool a hybridization program was conducted at PRC, Ishurdi, Pabna during Kharif-I, 2019. Six parents were used having desired genetic combinations and a total of 668 successful crossed seeds were harvested from fifteen cross combinations and preserved these seeds for confirmation of F_1s in the next season. Hybridization is a process to create genetic variability for crop improvement program. It also helps to incorporate useful genes into the adapted and desirable varieties/lines of a crop. So, hybridization is carried out in most of the year for mungbean at Pulses Research Centre, Ishurdi, Pabna with a view to create genetic variability among the population.

Observation trial of mungbean

Eleven families selected from last year's F_5s generation were grown against check variety BARI Mung-7 and BARI Mung-8 during kharif-1, 2019 at Pulses Research Centre, Ishurdi, Pabna. The experiment was laid out in a RCB design with two replications and having a spacing of 40 cm between rows. Among the test entries significant differences were observed for all parameters except plant population/m^2. BMXK1-14001-12 flowered and matured earlier. The maximum plant height was obtained from BMXK1-14002-6. The maximum pods were recorded in BMXK1-14003-17. BMXK1-14002-23 was recorded as bold seeded. The maximum seed yield was recorded in BMXK1-

Participatory varietal selection of mungbean

Five promising genotypes viz: BMXK1-10011-3,BMX-1009-4, BMXK-010015 and two check BARI Mung-7 and BARI Mung-8 were evaluated in the trial. Among the three entries and two check varieties BMXK1-10011-3 gave the highest yield

(1451 kg/ha) with the maximum 100 seeds weight (5.65 g), pod length (9.13 cm) and with lowest number of plant population (31.7). On the other hand, BMXK-010015 gave the lowest yield (1142 kg/ha) with the lowest number of pods/plant (11.73).

Candidate variety demonstration trial of mungbean

A Candidate Variety Demonstration Trial of mungbean during kharif-I 2019 was conducted at Pulses Research Centre, Ishurdi, Pabna using five entries, $BMXK_1$-10012-2, BMX-08010-2, BMX-08011-2, $BMXK_1$-09015-2, BMX 010015 along with BARI Mung-7 and BARI Mung-8 as check varieties for evaluation of promising advance lines in large plots and also multiplication of seeds of these advanced lines. Highest seed yield was obtained from BMX-010015 and this entry out yielded the check varieties, BARI mung-8 and BARI mung-7 by 10% and 17%, respectively. Considering the yield performance, BMX-010015was selected as potential future advanced line which will be proposed as a variety in near future.

Screening of mungbean genotypes against water logging stress at vegetative growth stage

Water logging tolerance of mungbean was conducted during kharif-1 season of 2019 to find out waterlog tolerant genotype. Fifty mungbean genotypes were evaluated at waterlog and normal condition. Waterlog was imposed at 30 days after sowing by transferring the pots in a water tub where water was maintained about 5 cm above the soil surface of pots. After three days (72 h), pots were removed from waterlogging and kept in normal condition until maturity. Under waterlog condition the higher relative yield was found in G16, G8, G7, G20, G12 and G22 while that was lower in G2 and G28. Stress tolerance index (STI), Yield index (YI) and Relative yield (RY) of G20, G16, G22, G7, G12 and G8 were higher than others. So, on the basis of yield, dry matter production, STI, YI and RY, genotypes G20, G16, G22, G7, G12 and G8 could be selected for future research against waterlogging stress.

Effects of seeding method and seed rate on yield and yield attributes of field pea

A field experiment was conducted at PRSS, BARI, Gazipur during *rabi* season 2018-19 to find out the sowing method and optimum seed rate for newly released field pea variety (BARI Motor 3) for better crop growth and seed yield. The experiment was conducted in randomized complete block design with three replications. There were three sowing methods- line sowing at 40 cm and 50 cm, and broadcast sowing; and three seed rates *i.e.,* 70 kg/ha, 80 kg/ha and 90 kg/ha. It was observed that between line and broadcast sowing there was no significant difference. Among the seeding methods line sowing with 40 cm gave better yield and yield attributes over other treatments. Comparing with seed rates 90 kg/ha increased plant population seeds/pod and grain yield. SR @ 90 kg/ha X LS 40 cm performed better for of newly released field pea variety BARI Motor-3. However, this experiment will be continued for the next year for concrete conclusion.

Adaptation of advanced grasspea genotypes/ lines in saline soil

Grasspea is probably the most drought tolerant legume crop and it is also resistant to moderate salinity. An experiment was conducted at the Agricultural Research Station (ARS), BARI, Benarpota, Shatkhira during *rabi* season of 2018-2019 to evaluate the performance of different genotypes/lines under saline soil. There were 3 genotypes of grasspea (SEL-1348 , BKX-002-4 and Serajgonj local (E_3) where BARI khesari-3 was used as check variety. Highest seed yield (1.30 t/ha) was recorded in Serajganj local which was significantly higher than the rest of the varieties/lines. Similar trend was observed in case of straw yield (4.31 t/ha). BKX-0002-4 was the shortest durational one among the studied genotypes. The lowest level (5.25 dS/m) of soil salinity was recorded at the sowing time in BARI Khesari-3 and the highest level of salinity (10.35 dS/m) was recorded in the harvesting stage at SEL-1348.

Adaptation of different pulses as relay crop in the farmers' field of High Barind Tract

The experiment was undertaken to study the suitability of different pulses as relay cropping with T.aman in the farmer’s field of High Barind Tract to increase production and develop farmers' livelihood. The field trial was conducted at the farmer's field of FSRD site Bashantopur, Godagari, Rajshahi during Rabi 2016-17, 2017-18 and 2018-19. The study was designed by randomized

complete block design with three replications. There were three varieties of different pulses i.e. BARI Masur-6, BARI Motor-1, BARI Khessari-3. The yield and most of the yield contributing characters like Plants m^{-2}, Plant ht (cm), No. of seeds pod^{-1} and 100 seeds showed significant variation in those three years. Grass pea (BARI Khessari-3) performed best in three seasons in respect of yield (1.40 t ha^{-1} ,1.12 t ha^{-1} and 1.13 t ha^{-1} respectively) and incase of lentil equivalent yield (LEY), gross return, gross margin and benefit cost ratio (BCR) showed higher in lentil (BARI Masur-6) than grass pea because of higher market price of lentil during 2017-18 and 2018-19 but opposite scenario was showed in the previous year . In the 1st year, lentil (BARI Masur-6) showed the poorest performance in gross return, gross margin and benefit cost ratio (BCR) whereas pea (BARI Motor-1) showed the lowest performance during 2nd year and grass pea (BARI Khessari-3) showed the lowest performance during 3rd year.

Application of growth regulator for synchronizing ripening of mungbean

A field experiment was conducted at the research field of Pulses Research Centre, Ishurdi and PRSS, BARI, Gazipur during 2018-19 to find out the suitable growth regulator to synchronize ripening of mugbean. There were six treatments viz T_1= Glycel (Glyphosate, 3.70 L/ha), T_2=Gramoxone (Paraquat, 2.25L/ha), T_3=Jascot (Paraquat 20% and Glyphosate 41%), T_4= Bonmara (2, 4-D Amine, 2.80 L/ha), T_5= Ripen-15 (Ethephon, 1L/ha), T_6=Control. Treatments did not show significant effect on the yield contributing characters of mugbean. Among the growth regulator cycle, Gramoxone and Jascot performed better for desiccation the plants upto 00% but bonnora ripen had no effect on desiccant the plant. The highest gross return (Tk. 30420) was obtained from Ripen-15 (Tk. 30420) at Ishurdi and Gramoxon (Tk.28020) at Gazipur, but the highest MBCR (3.48 and 4.14 at Ishurdi and Gazipur, respectively) were got from Gramoxon.

Performance of different fieldpea varieties /germplasm relaying with T. Aman rice

A field experiment was conducted at Pulses Research Centre and Regional Agricultural Research Station, Ishurdi during *rabi* season of 2018-19 to find out the suitable cultivars on the growth and yield of Field pea under relay condition. The experiment was conducted in randomized complete block design with three replications. There were six cultivars, e.g. BFP 11016, Bagha local, BARI Motor-1, BARI Motor-3, Jikorgacha local and Sikim local. Among the fieldpea cultivars, the highest seed yield was obtained from Bagha local (1.1 t/ha) followed by BARI Motor-3 (1.0 t/ha) while the lowest seed yield (0.4 t/ha) was obtained from BFP 11016. However, this was the first year trial and will be continued for the next two years for concrete conclusion.

Effects of rice husk ash and previous crop straw on the performance of lentil in rice-based cropping system

A feasibility study is made to use Rice Husk Ash (RHA) as an admixture and previous crop straw as mulch (SM), and an attempt has been made to investigate the effects of RHA and RS on yield and yield components of lentil in rice-based cropping system. This field experiment started with lentil at Pulses Research Centre (PRC) during the rabi season of 2018-19. The other crops in the rotation were Mung bean and T.aman rice. In this report, only the results of lentil are presenting. There were seven treatments in the present experiment comprising Rice Husk Ash (RHA), Recommended Fertilizer Dose (RFD), SM and control. The addition of SM increased crop yield over other treatments and control. The tallest plant height, higher branches and pods likely contributed to increased seed and straw yield of lentil in SM treatment. However, there were no effects of RHA as an admixture with top soil on the performance of lentil. This experiment will run over the next year for drawing a concrete conclusion.

Effect of tillage systems and timing of weed control on weed flora and yield of mungbean

A field experiment was conducted at Pulses Research Centre (PRC) and Regional Agricultural Research Station (RARS) during Kharif-I season of 2018 to determine the critical period for weed competition during mungbean growth under different crop establishment options. Studies on weed dynamics in mungbean sown under two tillage systems were conducted at Pulses Research Centre Ishurdi, Pabna, Bangladesh. A commonly grown mungbean cultivar ʼBARI Mung-6ʼ was sown on 27th March of 2018 under strip planting system (SP) and conventional tillage (CT) and it

was subjected to different durations of weed competition [weeding at 15, 30, and 45 days after sowing (DAS) and season-long weed competition]. Season long weed-free plots (7 times weeding) were maintained under each tillage system for comparison. The broad-leaved and sedge weed densities were higher under season-long weed competition (43 m-2 and 138 m-2) compared to weed free at 45 DAS (34 m-2 and 112 m-2), 30 DAS (30 m-2 and 97 m-2) and 15 DAS (17 m-2 and 91 m-2). However, the maximum grassy weed density was recorded in SP plots under the season-long weed competition (475 m-2) and the lowest in CT plots under weed free at 15 DAS (113 m-2). The seed yield was significantly higher in the plots of season long weed-free (1.24 t/ha) while the lowest yield (0.83 t/ha) was recorded in plots under season-long weed competition. The seed yield loss relative to season long weed-free plots were higher in plots under season-long weed competition (32 %) followed by the plots under weed free at 45 DAS (29 %) and 30 DAS (20 %), and the lowest in weed free at 15 DAS (5 %). The results suggest that weeding at 15 DAS was effective in controlling weed and minimizing yield losses of mungbean compared with delayed weeding and longer durations of weed competition.

Effects of tillage and residue retention on the performance of mustard in mustard-mungbean-T.aman rice of northwest Bangladesh

Performance of mustard under three tillage treatments such as conventional tillage (CT), no-tillage (NT) and strip planting (SP) and two levels of residue retention-high residue (HR) and low residue retention (LR) were evaluated in rice-based system of Bangladesh. The field experiment was initiated in November 2015 and continuing for a longer term period at Pulses Research Centre Ishurdi, Pabna and Pulses Research Sub-Station, Joydebpur, Gazipur. The cropping sequence lentil-mung bean-t.aman was practicing since commencing of the experiment at Ishurdi, Pabna. However, the cropping sequence was changed to mustard-mungbean-T.aman in 2018-19. In the present report, only the Crop numbers 10 (mustard) of 2018-19 are presenting. The results showed that the application of SP and NT resulted in higher number of plant populations and plant height which may lead to increase seed yield of lentil by 11.4 % and 6.6 % over CT. This short-medium term effect was positive towards conservation agriculture over CT system from beginning of the experiment. Now nutrient management in CA system is warrant further research.

Effect of shoot picking on growth and yield of grass pea

The field experiment was carried out at Pulses Research Centre and Regional Agricultural Research Station, Ishurdi during *rabi* season 2018-19 to find out the effect of shoot picking for vegetable on growth, yield and economic return of grasspea. The treatments used for the experiment were T_1 = One time Vegetable harvest at 40 DAE (days after emergence), T_2=Two times vegetable harvest at 40 & 50 DAE, T_3 = Three times vegetable harvest at 40, 50 & 60 DAE, T_4 = Four times vegetable harvest at 40, 50, 60 & 70 DAE, T_5 = Two times vegetable harvest at 60 & 70 DAE and T_6 = Control. The highest seed yield (992 kg ha^{-1}) was obtained from one time shoot picking at 40 DAE. Four times vegetable harvest at 40, 50, 60 & 70 DAE (T_4) gave the maximum gross return (TK. 74750 ha^{-1}) and gross margin (Tk. 47550 ha^{-1}) followed by three times vegetable harvest at 40, 50 &60 DAE DAE (T_3). The highest BCR (2.75) was at four times vegetable harvest at 40, 50, 60 & 70 DAE and control gave the lowest BCR (1.38).

Phenology, growth and yield of lentil as influenced by sowing time and seed rate

A field experiment was conducted at Pulses Research Centre and Regional Agricultural Research Station, Ishurdi during rabi season 2018-19 to study the effect of sowing time and seed rate on phenology, growth and yield of BARI Masur-8. The experiment was laid with four sowing dates (01 November, 15 November, 1 December, 15 December 2019) in main plots and four seed rates (30 kg ha^{-1}, 35 kg ha^{-1}, 40 kg $ha^{-1}$and 45 kg ha^{-1}) in sub-plots replicated thrice in a split-plot design. Lentil sown on 01 November 2019 took 120 days from sowing to maturity which was decreased by 20 days on 01 December and 30 days on 15 December sowings. Lentil sown on 15 November at the seed rate of 45 kg ha^{-1} was produced the highest seed yield (3125 kg ha^{-1}) and the lowest yield (1417 kg ha^{-1}) was obtained from 30 kg ha^{-1} seed rate with 15 December sowing.

Efficacy of herbicides for controlling weeds in lentil field

A field experiment was conducted at Pulses Research Centre, Ishurdi, Pabna during 2018-19 to

find out the efficacy of herbicides on weed control and crop response in lentil. Eight treatments viz. T_1= Whip super 9EC (Pre-emergence), T_2= Weednil 5 EC (Pre-emergence), T_3= Panida 33 EC (Pre-emergence), T_4= Whip super 9EC (Pre-emergence and post-emergence), T_5= Weednil 5 EC (Pre-emergence and post-emergence), T6= Panida 33 EC (Pre-emergence) and Whip super 9EC (post-emergence), T_7= Panida 33 EC (Pre-emergence) and Weednil 5 EC (Post-emergence), T_8= Whip super 9EC (Post-emergence), T_9= Weednil 5 EC (Post-emergence), T_{10}= Hand weeding and T_{11}= Control (No weeding) were included in this experiment. Herbicides were applied at moist condition of soil after irrigation for proper seed germination that means pre-emergence condition and post emergence at 20 Days after lentil emergence. The experiment was laid out in a randomized complete block design with three replications. Among the treatments, application of panida in pre-emergence and whip super in post-emergence was effective method to control narrow leaf weed and sedge weed for achieving higher yield on the basis of BCR

Effect of different level of phosphorus and their integration with manures on different crops in the lentil-mungbean-T.aman rice cropping pattern

A field experiment was conducted at the research field of Pulses Research Centre, Regional Agriculture Research Station, Ishurdi, Pabna during 2017-18 and 2018-2019 to determine the optimum rates of phosphorus for lentil-mungbean-T.aman rice cropping pattern and to reduce the rate of P fertilizer application by inclusion of cowdung and poultry manure. There were 8 treatments viz T_1=P_0, T_2= P16 kg/ha, T_3=P 32 kg/ha, T_4=P 48 kg/ha, T_5=P 16 kg/ha+Cowdung 5 t/ha, T_6=P 16 kg/ha + Poultry manure 3 t/ha, T_7 = P 32 kg/ha + Cowdung 5 t/ha, T_8= P 32 kg/ha +Poultry manure 3 t/ha. The experiment was designed randomized complete block with three replications. Result showed that application of different level of P and manures proved effective in significantly enhancing the nodulation, yield attributes and seed yield of lentil during both the year. The tallest plant, number of branch and maximum number of pods per plant were recorded from the P fertilizer with cowdung and poultry manure treatments. Seed yield of lentil was significantly influenced by organic and inorganic sources of phosphorus during 2017-18 and 2018-2019. Maximum seed yield was found in the treatment T_5 and T_6 (P fertilizer with manure).This was significantly higher than the other treatments. The maximum numbers of nodules were recorded from the treatment T_8 (P 32 kg/ha with 3 t/ha poultry manure) in all the nodules collection dates which was significantly higher over the other treatment in both years. The lowest nodule values were obtained from the P control treatment. Average of two years, maximum net return TK. 175000/ha was obtained from the treatment T_6 (P 16 kg/ha with 3 t/ha poultry manure). The highest benefit cost ratio 3.88 and 3.96 were recorded from the treatment T_5 and T_6 (P fertilizer with manure). Therefore, it may be concluded that 16 kg/ha phosphorus fertilizer along with cowdung 5 t/ha or poultry manure 3 t/ha with a blanket dose of $N_{20}K_{20}S_{10}$ Zn_2 B_1 kg/ha may be considered as economically sound and optimum fertilizer dose for yield maximization of lentil production in High Ganges River Floodplain soil under lentil-mungbean-T.aman rice cropping pattern.

Integrated nutrient management for lentil+mustard mixed cropping system

A field experiment was conducted at the research field of Pulses Research Centre, Regional Agriculture Research Station, Ishurdi, Pabna during 2017-18 and 2018-2019 to find out the suitable fertilizer dose for lentil+mustard mixed cropping system in High Ganges Floodplain soil. The trial consisted of eight nutrient treatments such as T_1= MYG based on soil test, T_2= HYG based on soil test, T_3=IPNS with 5 t/ha for HYG, T_4=T_1 + 25% of T_1, T_5= T_2 + 25% of T_2, T_6=According to FRG 2012, T_7 = Farmers practice, T_8= Native fertility (Control).The experiment was designed randomized complete block with three replications. For mixed cropping system, 70% lentil + 30 % mustard seeds were sown. Result showed that application of different nutrient management proved effective in significantly enhancing the yield attributes and seed yield of lentil and mustard mixed cropping system in both the years. During 2017-18 and 2018-2019, the maximum number pods per plant and seed yield of lentil and mustard were recorded from the treatment T_5 (T_2 + 25% of T_2) and T_3 (IPNS with 5 t/ha for HYG) which was significantly different with the others treatments but it was lowest in control treatment due to variation for nutrient supply. Maximum Lentil

equivalent yield was found treatment T_5 (HYG based on soil test + 25% of T_2) followed by treatment T_3 (IPNS with 5 t/ha for HYG) in the year of 2017-18 and 2018-19. Average of two years, regarding the cost and return analysis, the highest net return TK. 172000/ha was obtained from the treatment T_5. The highest benefit cost ratio 3.89 and 3.70 were recorded from the treatment T_5 and T_3. Therefore, it may be concluded that treatment T_5 (35-50-62-40-3.75-1.25 kg N-P-K-S-Zn-B/ha) and T_3 (30-28-42-30-3-1kg N-P-K-S-Zn-B/ha + 5 ton cowdung/ha) may be considered as economically profitable and optimum fertilizer dose for yield maximization of lentil+mustard mixed crop production in High Ganges River Floodplain soil (AEZ # 11).

Fertilizer management for Grasspea relay cropping system with T.aman rice in High Ganges Floodplain soil

A field experiment was conducted at the research field of Pulses Research Centre and Regional Agriculture Research Station, Ishurdi, Pabna during 2017-18 and 2018-19 to find out the suitable fertilizer dose for grasspea relay cropping system with T.aman rice in High Ganges Floodplain soil. The trial consisted of six nutrient treatments such as T_1 = Native (control), T_2 = Farmers practice, T_3 = FRG 2012, T_4 = FRG 2012+$Zn_{2.0}$, T_5 = FRG 2012+$B_{1.0}$, T_6 = FRG 2012+$Zn_{2.0}$+$B_{1.}$The experiment was designed randomized complete block with three replications. Result showed that application of different nutrient management proved effective in significantly enhancing the yield attributes and seed yield of grasspea. During 2017-18 and 2018-19, the maximum number pods per plant and number of seeds per pod were recorded from the treatment T_6 (FRG 2012+$Zn_{2.0}$+B_1) and T_5 (FRG 2012+$B_{1.}$) which was significantly different with the others treatments, but statistically identical to T_4 (FRG 2012+$Zn_{2.0}$) while it was lowest in control plot due to variation for nutrient supply. Maximum seed yield of grasspea was found treatment T_6 (FRG 2012+$Zn_{2.0}$+B_1) followed by treatment T_5 (FRG 2012+$B_{1.0}$) in both the year. Average of two years, regarding the cost and return analysis, the highest net return TK. 115650/ha was obtained from the treatment T_6. The highest benefit cost ratio 2.36 and 2.28 were recorded from the treatment T_6 and T_5. Therefore, it may be concluded that treatment T_6 (20-20-18-10-2-1 kg N-P-K-S-Zn-B/ha) and T_5 (20-20-18-10-1 kg N-P-K-S-B/ha) may be considered as economically sound and optimum fertilizer dose for yield maximization of grasspea production relay with T.aman rice in High Ganges River Floodplain soil (AEZ # 11).

Productivity of black gram as influenced by integrated application of phosphorus and zinc under rainfed condition

The experiment was conducted at the research field of Pulses Research Centre and Regional Agriculture Research Station, Ishurdi, Pabna during 2018-19 find out optimum rates of boron for growth and yield of blackgram. The experiment was laid out in RCBD with three replications. The trial consisted of nine nutrient treatments such as such as T_1= P_0Zn_0;T_2= P_0Zn_2; T_3= P_0Zn_4;T_4= $P_{20}Zn_0$;T_5=$P_{20}Zn_2$; T_6= $P_{20}Zn_4$;T_7= $P_{40}Zn_0$;T_8= $P_{40}Zn_2$;and T_9= $P_{40}Zn_{4.}$The experiment was designed randomized complete block with three replications. The unit plot size was 4m×3m. Nutrients P and Zn was supplied from TSP and Zinc sulphate. No significant difference was observed in pod length and seed/pod among the treatment which respectively ranged from 4.0 - 4.36 cm and 5.73-6.33. The highest seed yield was recorded in treatment T_5 and T_9 (kg/ha) followed by T_9 (1271 kg/ha) T_7 (1213 kg/ha) and control (T_1) produced the least (824 kg/ha). No significant difference was observed in stover yield among the treatment. Application of B and P might influence the yield of blackgram to achieve higher yield without any statistical significance. From the results, it was obvious that application of B @ 2 and P 20 kg ha^{-1} increased the yield substantially over the control treatment (T_1).

Evaluation of different fungicide for controlling stemphylium blight disease of BARI released lentil variety

The experiment was conducted at Pulses Research Centre, Ishurdi, Pabna during 2018-19 to find out the effective and economic fungicide(s) as well as tolerant lentil variety in controlling stemphylium blight of lentil. Four fungicides and three variety were used in the experiment. BARI Masur-8 was totally disease free when sprayed with Nativo (Tebuconazole 25%+ Trifloxystrobin 25%). The highest seed yield was also obtained from the combination of Nativo and BARI Masur-8 (1803

kg/ha) which was statistically similar to combination of BARI Masur-8 and Folicur, Secure and Rovral sprayed plots. Economic analysis demonstrated that Folicur and BARI Masur-8 combination incurred the highest Marginal Benefit Cost Ratio (MBCR 2.6).

Screening of lentil germplasm against stemphylium blight

The screening trial was conducted with 27 accessions based on previous year's evaluation for Stemphylium Blight (SB) resistance of lentil at Pulses Research Centre (PRC), Ishurdi, Pabna. These accessions were screened in natural field environment and showed varying level of resistance. Lentil variety BARI Masur-1 (susceptible) was used as check throughout the experiment. The highest frequency of resistance to SB was found in ILL-4705, ILL-6314, ILL-6367 and BLX-06004-2 (0.0) and yielded 2058, 1863, 2337 and 2845(kg/ha) respectively. These lines were selected from three years trial among hundreds of lentil lines received from ICARDA and now they could be used in lentil breeding for stemphylium blight resistance.

Screening of chickpea germplasm resistant to botrytis gray mold

The experiment was conducted at Pulses Research Centre (PRC), Ishurdi, Pabna, during 2018-19 to find out the high yielding and Botrytis Gray Mold (BGM) disease resistant variety of chickpea. Twelve chickpea advanced entries were used for this experiment. Due to lack of disease development weather condition no incidence of BGM disease was occurred in previous season at PRC, Ishurdi but this year artificially sprinkler irrigation sprayed to create foggy weather condition for the development of BGM disease. The highest disease resistant was recorded (3.0) in ICCV 92944 and the lowest was observed from BARI Chola-1 followed by BCX 08008-1 and BCX 08009. The highest seed yield (2153 kg/ha) was recorded from ICCV 92944 followed by BCX 09015-7, BCX 06004-10, BCX 09010-6 and BCX 09010-2 and the lowest yield was found in BARI Chola-1.

Field screening of selected mungbean lines resistant to yellow mosaic visurs (YMV) and cercospora leaf spot (CLS)

An experiment was conducted at Regional Pulses Research Station (RPRS), Madaripur during Kharif-I, 2019 to evaluate the performance of mungbean genotypes for searching of Yellow Mosaic Virus (YMV) and Cercospora Leaf Spot (CLS) disease resistant and high yielding lines. Twenty one mungbean lines with a check BARI Mung-6 were evaluated in the trial. Results revealed that BD-6941 and BMMP-201508 gave the lowest MYMV score (3.33) where the line BMMP-201511 gave the highest (6.33) score. A wide variation of CLS disease reaction was observed among the genotypes. The highest yield (1500 kg/ha) obtained in BMMP-201518 and BMMP-201519 and the lowest (600 kg/ha) in BMMP-201516.

Field screening of native blackgram lines resistant to yellow mosaic virus and powdery mildew in natural condition

A field experiment was conducted at Regional Pulses Research Station (RPRS), Madaripur during Kharif-II season of 2018 to evaluate the germplasms of locally collected blackgram for searching of yellow mosaic virus and high yielding resistant genotypes. Significant difference were observed in every important parameters like scoring of BYMV, no of pods/plant, 100 seeds weight, and seed yield (kg/ha) etc. The line BD-6853 provided the lowest YMV score (2.00) and the highest (6.00) was in BD-6869. The line BD-6814 and BD-10047 gave the highest seed yield (1833 kg/ha) and the lowest (1267 kg/ha) in BD-10040.

Eco-friendly management of flower thrips and pod borers of mungbean through sesame intercropping

Effectiveness of sesame intercropping in mungbean in managing flower thrips and pod borer of mungbean was studied at Pulses Research Centre, Ishurdi, Pabna during kharif-I, 2019. Sesame intercropping in mungbean reduced flower infestation by thrips and pod borer infestation significantly. Among the intercropped treatments, mungbean : sesame at 2:2 row ratio arrangements was found the best in reducing flower thrips and pod borer infestation. Sesame intercropping showed equivalent performance in reducing pod borer infestation as like as insecticide spraying (Imitaf 20 SL @ 0.5 ml/l).

Significantly the highest mungbean equivalent yield (1391 kg/ha) was obtained from mungbean sprayed with insecticide and the second highest

yield (1259 kg/ha) was recorded from sole cropping of mungbean. Sesame intercropped treatments provided the lower yield compared to the sole cropping of mungbean. This might be due to lower market price of sesame. Considering environment friendly and to avoid the risk of crop failure, sesame intercropping in mungbean might be eco-friendly management approach against flower thrips and pod borers of mungbean providing higher yield and benefit.

Comparison of IPM package for major insect pests of mungbean from world vegetable centre with current recommended practice

Effectiveness of integrated management approaches using blue sticky trap, pheromone trap, bio and synthetic insecticides were evaluated against major insects like, flower thrips and pod borers of mungbean at Pulses Research Centre, Ishurdi, Pabna, Bangladesh during kharif-1, 2019. All of the management packages significantly reduced flower infestation, thrips population and pod borer infestation in mungbean. The highest percentage of reduction of flower infestation (80.40%) and thrips population (81.88%) was found in IPM package 3 i.e. installing blue sticky trap + two spraying of chlorfenapyr (Intrepid 10 EC) @ 1 ml/l + third spraying with chlorantraniliprole (20%) + thiamethoxam (20%) (Virtako 40 WG) @ 0.15 g/l followed by Recommended practice. Again, the highest percentage of pod borer infestation reduction (72.65%) was observed in IPM package 3 followed by IPM package 1: Installing blue sticky trap & pheromone trap + two spraying of azadiractin (Biomeem plus 1EC) @ 1 ml/l + third spraying with spinosad (Success 2.5 EC) @ 1.2 ml/l and Recommended practice (Imitaf spraying). The highest yield (1345 kg/ha) was also obtained from IPM package 3 which was statistically similar to all the IPM packages and Recommended practice. Although the IPM package 3 provided the highest seed yield and return but Recommended practice gave the highest benefit. Considering environment friendliness, the IPM package 1 i.e., installation of blue sticky trap & pheromone trap + two spraying of azadiractin (Biomeem plus 1EC) @ 1 ml/l + third spraying with spinosad (Success 2.5 EC) @ 1.2 ml/l would be the best package for controlling of major insect pests of mungbean with higher yield in the insects prone areas.

Response of promising mungbean varieties / entries against flower thrips and pod borers

Response of promising varieties/entries of mungbean against flower thrips and pod borers were studied at Pulses Research Centre, Ishurdi, Pabna, Bangladesh during kharif-I, 2019. Flower infestation, thrips population and pod borer infestation varied significantly among the varieties/entries. The lowest flower infestation was observed in BARI Mung-8 followed by BINA Mung-8, thrips population was BARI Mung-8 followed by $BMXK_1$08 011-2 and pod borer infestation was BARI Mung-8 followed by BMXK1 05008-2, respecctively. Significantly the highest seed yield (1914 kg/ha) was obtained from $BMXK_1$08 011-2 followed BINA Mung-8 (1657 kg/ha). Considering the insect pests reaction and yield potentiality the entry $BMXK_1$08 011-2 might be promising one to be a variety in future.

Population fluctuation of grasspea aphid, *aphis craccivora* koch in relation to sowing time and its effect on grain yield

The experiment was conducted at Pulses Research Centre (PRC), Ishurdi, Pabna during rabi season in 2018-19. Seven sowing dates with one week interval *viz.* 31th October, 2018 (T_1); 07th November, 2018 (T_2); 14th November, 2018 (T_3); 21th November, 2018 (T_4); 28th November, 2018 (T_5); 05 th December, 2018 (T_6) and 12 th December, 2018 (T_7), respectively were considered as seven treatments. BARI Khesari-3 was selected for this experiment. The percent twig infestation by aphid was higher (60.42%) in the late sown crop 5 th December, 2018 followed by crop sown on 12 December, 2018 (57.71%). Aphid infestation was lower in the crop sown on 14 November (19.38%) which was statistically similar to 07th November (22.92%). The variation in sowing time resulted in availability of different stages of crop at a time and the difference in aphid population might be due to succulent stage of late sown crop which was preferred by the aphid for its multiplication. However, highest seed yield (1040.28 kg/ha) was obtained from the crop sown on 14th November. The yield in 31th October (838.89 kg/ha) and 7th November (933.33 kg/ha) sown crop was reduced probably due to extra early sowing, but found higher than the crop sown on 28th November (813.89 kg/ha), 05th December (802.78 kg/ha) and 12th December (794.44 kg/ha). The reduction in yield in late sown crop on 05th December and 12th

December was probably due to heavy infestation of aphid along with delayed sowing.

Sustainability of ground water use for irrigation in northwest Bangladesh

The long-term (1997–2018) maximum WT (water table) depth data under different upazilas of Pabna, Natore and Rajshahi district at north west part in Bangladesh are analyzed using MAKESENSE model software to find out WT depth trend and prediction value of WT at different years that helps to take policy sustainable agriculture and judicial use of GW (ground water). It is clear that the rate of change of maximum water table depth varies 0.037 (myear^{-1}) to 0.39 (myear^{-1}) in the study areas. Minimum changes rate of WT at Ishurdi about 0.037 myear^{-1} (GT7639020) and maximum 0.39 myear^{-1} (GT8194048) at Tanore. The changes rate of Chatmohor and Tanore upazilla are higher compare to other upazillas. WT depth showed a declining trend, and falls below the lifting capacity (up to 8 m) of suction-mode pumps. If the present trend in the dry season is continued, suction-mode pumps may not operate at all due to the exceeding the suction limit. Minor irrigated crops could be adopted instead of the monopoly of the rice cropping pattern and adopted climate smart technology of agriculture.

Performance of pulses on different mechanical seeding systems

The experiment was conducted at Regional Agricultural Research station, BARI, Ishurdi, Pabna, to evaluate the pulses (lentil and mung bean) performance on different seeding system as well as seeding device performance where lentil at residual soil moisture with rice residue except mung been. Five seeding method like i) Broad casting with 4 times tillage, (Conventional) ii) Direct bed planting seeding iii) PTOS seeding iv) Strip tillage seeding and v) Zero tillage seeding system, with previous crop residue treatments were assigned in a RCB design with three replication. In bed planting, PTOS, strip tillage, zero, 49.31%, 53.08%, 67.54%, and 75.48% respectively, of lower fuel consumption was documented than conventional tillage seeding. The results clearly revealed that seeding operation by bed planting, PTOS, strip tillage, zero, seeding method was saved 48.1%, 52.91%, 65.89% and 72.81% of time, respectively than that of conventional broadcasted method. The performance of both pulse like lentil and mung bean on Bed planting seeding system is best compare to other seeding and tillage system. From the results, it is clear that most of the time, yield increased 4.00% to 12.62% for lentil and 17 % to 28% for mungbean in mechanical seeding system than conventional system. In mechanical seeding system like bed planting, PTOS, Strip tillage were more suitable than zero tillage seeding system. For lentil there were no need post sowing irrigation if seed was showing with in one weak just after T aman harvest having enough residual soil moisture. While, post sowing irrigation must be applied for ensure seed germination of mungbean cultivation. Bed planting seeding system supply extra facilities for irrigation and drainage system for mung bean.

Effects of row spacing on different lentil varieties under strip tillage system

Four row spacing (S_1= 25 cm, S_2= 30 cm, S_3= 35 cm, S_4= 40 cm) and three varieties of lentil (V_1= BARI Masur-8, V_2= BARI Masur-7, V_3= BARI Masur-6) were assigned in a Randomize Complete Block Design with three replications. The trend of seed yield was recorded in BARI Masur-8 > BARI Masur-7> BARI Masur-6 and seed yield was decreased with increasing row to row distance for all varieties. The results also supports the following clarifications that 30 cm row to row spacing for BARI Masur-8, 25 cm row to row spacing for BARI Masur-6 and BARI Masur-7 are more suitable row to row spacing distance at strip tillage seeding system.

Profitability, value addition and constraints to munngbean production in some selected coastal areas of bangladesh

Assessment of profitability, value addition and constraints to munbean production in two southern coastal districts- Barisal and Patuakhali was made through an extensive field survey during 2018-2019. The study revealed that few farmers of these areas used chemical as well as organic fertilizers. Total cost incurred for mungbean production was Tk.51850/ha of which 50% is variable cost and remaining 50 % was fixed cost. Average gross return was Tk. 54143/ha. Benefit cost ratio on variable cost basis was 2.09 but on total cost basis it was 1.04. Considering variable cost per kg production cost was Tk. 24.62/kg but on total cost basis it was estimated Tk. 49.05/kg. Highest value addition of fried mungbean was estimated for

Amrita consumers products and their price share was 69.57 %. Disease infestation, insect attack, uneven and heavy rainfall, flash flood, unavailability of cultivating machine and inadequate labour during harvesting were found to be the major constraints to mungbean production in the study areas.

Technology transfer activities of pulses

Technology transfer activities have been done through seed production & distribution, training & block demonstrations, field days and workshops, publication of booklets, leaflets, posters, broadcasting news in radio, TV etc. during 2018-19. Pulses Research Centre produced a total of 19239 kg seeds of them 514 kg nucleus seed, 8616 kg breeder seed and 10109 kg TLS seed of different pulse crops and distributed a total of 8930 kg of seeds to the farmers, BADC, research organizations, universities and NGOs. Under the financial support of Strengthening of oilseed and pulses research and development in Bangladesh project". A total of 20 scientists received three days long training on "Improvement strategies and production technologies of pulse crops in relation to changing climate". Twenty officers, 60 SAAO/SSA/SAs and 1350 farmers got daylong training on "Modern production technologies and seed preservation techniques of pulse crops. A total of 23 block demonstrations (1 acre each) of different pulse crops were established in 11 districts, 22 field days were organized with 1210 participants 4 leaflets were published under Strengthening of oilseed and pulses research and development in Bangladesh project". With the financial support of Harvest Plus (Bio-fortification) Project, 400 women farmers and 50 staffs received training on bio-fortified lentil (BARI Masur-8) and health issue. One leaflet have been published on Bio-fortified super early lentil variety BARI Masur-9. Comparing the varietal performance BARI Khesari-3, BARI Masur-8, BARI Chola-5 and BARI Chola- 9 and BARI Motor-3 were more acceptable varieties to the farmer. Scientists, Officers, Extension personnel, farmers and concern persons were very happy to receive different training to pulse crop improvement and their dissemination. Everybody expressed their satisfaction to observe the yield performance of improved varieties of pulse crops.

Rapeseed and mustard

Variety development

Development of BC_2S_5 generation in *Brassica rapa*

BARI Sarisha-14, BARI Sarisha-15, BARI Sarisha-9 (S_4) and Improved Tori-7 (S_4) were crossed with Local Tori-7 (LT-7) during *rabi* 2011-12 to develop F_1. Developed six F_1s were crossed with LT-7 to develop BC_1 and BC_2 during ra*b*i 2012-13 and 2013-14. BC_2S_1,BC_2S_2 BC_2S_3 and BC_2S_4 were developed during 2014-15, 2015-16, 2016-17 and 2017-18, respectively. BC_2S_4 seeds were sown on 25 November 2018 to develop BC_2S_5. Unit plot size was 3 rows 3m long.

Days to maturity of cross combinations were ranged from 85-87days. Seeds were stored to evaluate as well as advance BC_2S_6 generation in the next year.

Development of short duration inbred lines in *Brassica rapa*

The most adaptive variety Tori-7, high yielding varieties BARI Sarisha-9, BARI Sarisha-12 and Kalaynia, short duration local cultivar Din-2, short duration line BC-2193, low erucic acid lines SBC-4093, SBC-6823 and SBC-8693 were used as source populations. Selfed seeds from individual plant of source populations obtained from previous year were sown following plant to row method. Selfed seeds were sown along with Tori-7 as check. Seeding was done on 25 November 2018

Four hundred and fifty seven plants were selected from 111 rows for selfing for advancing S_5 to S_6 generation from eleven source populations. Total 2681 buds were selfed from which 1737 efective siliquae and 7417 seeds were obtained. Selfed seeds were stored for maintaining as inbred lines in the next year.

Growing of F_2 generation originated from 16 parents of *B. rapa*

Eight brown sarson parents and eight yellow sarson parents were utilized to produce single crosses from different varieties developed as well as advanced lines of rapeseed –mustard. Single crosses were made in 2013-14 following double crosses in 2014-15. Complex crosses were done in 2015-16 and 2016-17 to accumulate desirable genes into a single parent. F_1 generation were developed in 2017-18. The F_2 seeds along with the parents were sown on 22 November 2018.

A total of 62 single plants were harvested of which 16 were yellow seeded. The plants were selected on the basis of seed coat colour and yield per plant. The single plants with similar type were bulked together and remaining entries were stored for next year sowing as F_3 generation.

Evaluation of F_3 generation in *Brassica rapa*

BARI Sarisha-14, BARI Sarisha-15, BARI Sarisha-17 and BARI Sarisha-6 were used as female parents and S_6 generation of BARI Sarisha-9 and Tori-7 were used as male parents to develop single crosses during rabi 2014-15. F_1s were grown during rabi 2015-16 and crossed with BARI Sarisha-6 and BARI Sarisha-17 to develop three-way crosses. F_1 and F_3 were developed through selfing during 2016-17 and 2017-18. F_3 seeds of three-way crosses of eight cross combinations were sown on 25 November 2018 at Joydebpur.

No. of selfed plants from different cross combinations ranged from 14-32 and total 184 plants were selfed. One thousand four hundred and seventy six buds were selfed from 1476 plants to develop F_4 generation. One thousand two hundred and ten siliquae were obtained from which eight thousand five hundred and eighty nine seeds were obtained. Selfed seeds were stored to advance F_4 generation in the next season.

Evaluation of segregating generations of *Brassica rapa*

F_5 generation

Progenies of F_5 generation of two cross combinations having both yellow and brown seed coat colour were evaluated during rabi 2018-19 at Joydebpur. Progenies were sown following progeny to row method along with BARI Sarisha-14 as check in 4-rows 3m long plot with spacing 30cm and 5cm between rows and plants, respectively. Seeding was done on 25 November 2018. Single plant selection among progenies was done based on short duration (maturity duration upto 85 days), erect and compact type having desirable agronomic characters, disease and insect tolerance.

Five progenies having yellow seed coat colour of one cross combination and six progenies having brown seed coat colour of two cross combinations were evaluated. Considering earliness (maturity duration upto 85 days), erect and compact plant type, seed colour, seed size and siliqua shape, disease and insect tolerance, three progenies having yellow seed coat colour and three progenies having brown seed coat colour were selected.

F_6 generation

Progenies of F_6 generation of five cross combinations having both yellow and brown seed coat colour were evaluated during rabi 2018-19 at Joydebpur. Progenies were sown following progeny to row method along with BARI Sarisha-14 as check in 4-rows 3m long plot with spacing 30cm and 5cm between rows and plants, respectively. Seeding was done on 25 November 2018.

Thirty eight progenies having yellow seed coat colour of four cross combinations and six progenies having brown seed coat colour of one cross combination were evaluated. Considering earliness (maturity duration upto 85 days), erect and compact plant type, seed colour, seed size and siliqua shape, disease and insect tolerance, twenty families having yellow seed coat colour and three families having brown seed coat colour were selected.

Observation trial of *Brassica rapa* (Set-I)

Seventeen lines of *Brassica rapa* having yellow flower and yellow seed coat colour were selected last year from F_6 generation of different cross combinations along with selfing in netting. These lines along with check as BARI Sarisha-14 were evaluated with two replications under Observation Trial of *Brassica rapa* (Set-I) at Joydebpur during 2018-19. The lines were sown on 19 November 2018 in 3 rows of 3m long with spacing of 30 cm and 5cm between rows and plants, respectively. Data were taken on days to flowering, days to maturity, plant height (cm), no. of siliquae/plant, no. of seeds/siliqua, 1000-seed weight (g) and seed yield/plot. The plot yield was converted into kg/ha.

Three lines were matured within 85 days whereas check variety BARI Sarisha-14 took 86 days. Plant height ranged from 79-101 cm. Number of siliquae/plant ranged from 53-93. The highest number of siliquae/plant recorded in BS-14x-BS-15-1. No. of seeds/siliqua ranged from 14-36. The highest number of seeds/siliqua recorded in BC-2014-Y02. Thousand seed weight ranged from 3.0-3.89 g. Seed yield ranged from 1517-2756 kg/ha. The highest seed yield recorded in BC-100614(4)-9 (2756 kg/ha). Considering earliness, seed yield and other yield contributing characters, three lines BC-100614(4)-14, BC-100614(4)-9 and BC-2014-B08 were selected for the next trial.

Observation trial of *Brassica rapa* (Set-II)

Twelve lines of *Brassica rapa* having yellow flower and brown seed coat colour were selected last year from F_7 generation of different cross combinations. These lines along with one check as BARI Sarisha-9 were evaluated with two replications under Observation Trial of *Brassica rapa* (Set-II) at Joydebpur during 2018-19. The lines were sown on 19 November 2018 in 3 rows of 3m long with spacing of 30 cm and 5cm between rows and plants, respectively. Data were taken on days to flowering, days to maturity, plant height (cm), no. of siliquae/plant, no. of seeds/siliqua, 1000 seed weight (g) and seed yield/plot. The plot yield was converted into kg/ha.

Plant height ranged from 91-101 cm. The highest plant height was recorded in BS 6XSAU-1-3. No. of siliquae/plant ranged from 61-101. The highest number of siliquae/plant was recorded in BS-14 x -BS-15-10. Number of seeds/siliqua ranged from 11-28. Thousand seed weight ranged from 2.73-3.54 g. Seed yield ranged from 1480-2346 kg/ha. The highest seed yield recorded in BS BS-6 x-BS-

1-6 (2346 kg/ha). Considering earliness, seed yield and other yield contributing characters, five lines BS-14 x -SAU-1-4, BC-100614(Y)-4, BS-14 x -BS-15-10, BS-6 x-BS-1-6 and BS-14 x -SAU-1-1 were selected for the next trial.

Preliminary yield trial of *Brassica rapa* (SET-I)

The experiment was conducted at Joydebpur, Ishurdi, Jashore, Rahmatpur and Hathazari during *rabi* 2018-19 with 19 genotypes of *Brassica rapa*having yellow seed coat colouralong with two checks as BARI Sarisha-14 and Tori-7. The experiment was laid out in randomized complete block design with three replications. The plot size was 3m x 0.9m. Seeding was done on 18 November 2018 at Joydebpur, 03 November at Ishurdi, Pabna, 16 November at Rahmatpur, Barisal, 08 November at Jashore and 22 November at Hathazari, Chittagong in continuous sowing and row was 30 cm apart from each. Data were taken on days to flowering, days to maturity, plant height (cm), no. of siliquae/plant, no. of seeds/siliqua, 1000 seed weight (g) and seed yield/plot. The plot yield was converted into kg/hectare. The data were analyzed statistically.

Maturity duration ranged from 83-88 days. Plant height ranged from 74-99 cm. The lowest plant height was recorded in BC-110714(7)-7 (85 cm) after the checks. Number of siliquae/plant ranged from 57-158. The highest number of siliquae/plant was recorded in BC-110714(7)-8 and BC-100614(4)-6 (104) except the checks (158). Number of seeds/siliqua ranged from 14-37. The lowest number of seeds/siliqua was recorded in BC-110714(7)-8 and BC-110714(7)-4 next to the check-2. Thousand seed weight ranged from 3.0-4.01 g. The highest 1000-seed weight was recorded in check variety BARI-Sarisha.14. Seed yield ranged from 1521-2703kg/ha. The tested lines showed statistically different seed yield (kg/ha).

Considering seed yield and other yield atributing characters, eight lines like BC-100614(4)-6, BC-100614(8)-3, BC-100614(4)-8, BC-100-614(4)-5, BC-100614(8)-2, BC-100614(4)-2, BC-100614(4)-11 and BC-100614(4)-4 were selected for RYT in the next year.

Regional yield trial of *Brassica rapa*

The experiment was conducted at Joydebpur, Ishurdi, Jashore, Hathazari and Rahmathpur during rabi 2018-19. It consisted of seven advanced lines of *Brassica rapa*a long with two checks as BARI Sarisha-14 and Tori 7. The experiment was laid out in randomized complete block design with three replications. The plot size was 3m x 1.2m. Seeding was done on 18 November at Joydebpur, 08 November at Jashore, 03 November at Ishurdi, 22 November at Hathazari and 16 November at Rahmatpur 2018 in continuous sowing and row was 30 cm apart from each. Data were taken on days to flowering, days to maturity, plant height (cm), no. of siliquae/plant, no. of seeds/siliqua, 1000 seed weight (g) and seed yield/plot. The plot yield was converted into kg/ha. The data were analyzed statistically.

Maturity duration ranged from 78-87 days. Plant height ranged from 75-99 cm. The lowest plant height was recorded in Tori-7. Number of siliquae/plant and number of seeds/siliqua ranged from 61-85 and 13-27, respectively. The highest no. of seeds/siliqua was recorded in BC-120114 which was statistically similar with BARI Sarisha-14. The lowest number of seed/siliqua was recorded in Tori-7. Thousand seed weight ranged from 2.93-3.67 g. Seed yield ranged from 1504-2731 kg/ha. The highest seed yield was recorded in BC-100614(4)-7. The lowest seed yield was recorded in check Tori-7.

Maturity duration ranged from 82-85 days (Table 12a) and seed yield ranged from 1348-1895 kg/ha over locations (Table 12b). The line BC-100614(4)-7 produced the highest seed yield over locations and it also produced the highest seed yield at Joydebpur, Jashore and Hathazari locations.

Considering seed yield and other yield attributing characters, three lines BC-100614(4)-7, BC-100614(3)-1 and BC-100614(8)-4 were selected for Adaptive Trial in the next year.

Evaluation of segregating generation of *Brassica juncea*

F_6 generation (Set-I)

Progenies of fifteen cross combinations having both brown and yellow seed coat colour were evaluated in F_6generation (Set-I) during 2018-19 at Joydebpur. Progenies were sown following progeny to row method along with BARI Sarisha-11 as check. Seeding of fifteen crosses was done on

22 November 2018 in 3m long of 3-rows-plot with spacing 30cm and 5cm between rows and plants, respectively.

A total of 127 plants from thirteen cross combinations having brown seed coat colour and 27 plants from two cross combinations having yellow seed coat colour were selected considering erect and compact plant type, seed colour, seed size and siliqua shape.

F_6 generation (Set-II)

Six cross combinations having both and yellow black/brown seed coat colour were evaluated during 2018-19 at Joydebpur. Progenies were sown following progeny to row method along with BARI Sarisha-11 as check. Seeding of progenies of different cross combinations was done on 22 November 2018 in 3m long of 3-rows-plot with spacing 30cm and 5cm between rows and plants, respectively.

A total of fifty three progenies from three cross combinations having black/brown seed coat colour were evaluated and twenty three progenies were selected. Eighteen progenies from three cross combinations having yellow seed coat colour were evaluated and forteen progenies were selected. Considering erect and compact plant type, seed colour, seed size and siliqua shape, single plant selection method was followed.

Observation trial of *Brassica juncea*

Thirteen lines of *Brassica juncea* along with two checks as BARI Sarisha-11 and BARI Sarisha-16were evaluated with two replications under observation trial of *Brassica juncea* at Joydebpur during 2018-19. The lines were sown on 22 November 2018 in 3 rows of 3m long with spacing of 30 cm and 5 cm between rows and plants, respectively. Data were taken on days to flowering, days to maturity, plant height (cm), no. of primary branches/plant, no. of siliquae/plant, no. of seeds/siliqua, 1000 seed weight (g) and seed yield/plot. The plot yield was converted into kg/ha.

Maturity duration ranged from 95-102 days. BJ-2014-Y04was the earliest in maturity (102 days). Plant height ranged from 116-151 cm. The line BARI Sarisha -11 (ch) showed lowest plant height (116 cm). Number of siliquae/plant ranged from 98-157. Number of seeds/siliqua ranged from 10-14. Thousand seed weight ranged from 2.48-3.51 g. Seed yield ranged from 1639-2469 kg/ha. The highest seed yield recorded in BJ-2014-B13 and followed by BJ-2014-B08. Considering earliness, seed yield and other yield contributing characters, five lines BJ-2014-B08, BJ-2014-B13, BJ-2014-B14, BJ-2014-B10 and BJ-2014-B07were selected for the next trial.

Preliminary yield trial of *Brassica juncea L*.

The experiment was conducted at Joydebpur, Ishurdi, Jessore and Hathazari during *rabi* 2018-19. The experiment consisted of 11 lines of *Brassica juncea* having yellow seed coat colour except two along with checks BARI Sarisha-11 and BARI Sarisha-16. The experiment was laid out in randomized complete block design with two replications. The plot size was 3m x 1.2m. Seeding was done on 22 November at Joydebpur, 08 November at Jashore, 05 November at Ishurdi and 22 November at Hathazari 2018 in continuous sowing and row was 30 cm apart from each. Data were taken on days to flowering, days to maturity, plant height in cm, no. of primary branches/plant, no. of siliquae/plant, no. of seeds/siliqua, 1000 seed weight (g) and seed yield/plot. The plot yield was converted into seed yield/hectare. The data were analyzed statistically.

Days to maturity ranged from 97-102 days. Plant height ranged from 137-152 cm. Number of siliquae/plant ranged from 119-164. Number of seeds/siliqua ranged from 10-14. The highest number of seeds/siliqua was recorded in BJ-11536-(7)-2. Seed yield ranged from 1606-2129 kg/ha. The highest seed yield was recorded in BJ 2014 - Y 02.

Days to maturity ranged from 100-103 (Table 13a) and seed yield ranged from 1669-2123 kg/ha (Table 13b) over locations. The highest seed yield was recorded in BJ-10-10104(Y) over locations. Consudering seed yield and other yield contributing characters, two lines like BJ-10-10104(Y) and BJ-11536(12)-3 were selected for evaluation in RYT.

Regional yield trial of *Brassica juncea* L.

The experiment was conducted at Joydebpur, Ishurdi, Jashore, Hathazari and Rahmatpur during rabi 2018-19. It consisted of 8 advanced lines of *Brassica juncea* along with one check as BARI Sarisha-11. The experiment was laid out in

randomized complete block design with three replications. The plot size was 3mx1.8m. Seeding was done on 22 November at Joydebpur, 5 November at Ishurdi, 8 November at Jashore, 22 November at Hathazari and 22 November at Rahmathpur 2018 in continuous sowing and row was 30 cm apart from each. Data were taken on days to flowering, days to maturity, plant height, no. of primary branches/plant, number of siliquae/plant, number of seeds/siliqua, 1000 seed weight (g) and seed yield/plot. The plot yield was converted into seed yield/hectare. The data were analyzed statistically.

Maturity duration ranged from 103-105 days. Plant height ranged from 134-153 cm. Number of siliquae/plant ranged from 133-208. The highest number of siliquae/plant was recorded in BJ-11536-(12)-5. Number of seeds/siliqua ranged from 8-13. The highest number of seeds/siliqua was recorded BJ-11536-(12)-1. Thousand seed weight ranged from 2.77-3.84 g. Seed yield ranged from 1762-2206 kg/ha. BJDH-05 produced the highest seed yield (2006 kg/ha).

Regarding maturity duration over locations, days to maturity ranged from 105-106 days (Table 14a). Seed yield ranged from 1921-2335 kg/ha over locations (Table 14b). The line BJDH-05 produced the highest seed yield (2335 kg/ha) over locations.

Considering location wise seed yield and other yield contributing characters, two lines BJDH-05 and BJ-1111-(7)-7 were selected for adaptive trial in the next year.

Maintenance of CMS, maintainer and restorer lines of *Brassica napus*

The experiment consisted of two CMS lines like $CMSZ_1$ (248) and $CMSZ_2$ (279), two maintainer lines like Nap-248M and Nap-279M and one restorer line like Nap-14-01R. It was conducted at Gazipur during *rabi* 2018-19. Unit plot size was two rows three meter long. Seeding was done on 29 November 2018. CMS lines were crossed with maintainer lines. Maintainer lines and restorer line were selfed. Bagging was done to protect out crossing. Crossing and selfing were done by hand pollination.

Days to flowering and maturity for CMS lines ranged from 22-23 days and 97 days, respectively. In total 140 buds of 39 plants of two CMS lines were crossed with two maintainer lines. Two thousand twenty five nine hundred seeds were obtained from 135 siliquae. Seeds were stored for future breeding programme.

Days to flowering and maturity for Nap-248M, Nap-279M and Nap-14-01R were 22-24 days and 97 days, respectively. Seven hundred and seventy four buds were selfed from 92 plants. In total 5584 seeds were obtained from 703 siliquae. Seeds were stored for future breeding programme.

Development of hybrid variety in rapeseed

I. Identification of parental lines in *Brassica rapa*L.

Hybrid seeds of Golden Sapphire of *Brassica rapa* L. which was imported from India received from Supreme Seed Company were used as experimental material in this experiment. The experiment was conducted during *rabi* 2018-19 at Gazipur. S_5 seeds were obtained from hybrid seed (S_0) through selfing during last *rabi* 2012-18. S_5 seeds were sown on 29 November 2018 for growing S_5 population. Anthers in flowers were observed visually. Plants having prominent anthers along with pollen grain in flowers were identified as pollen fertile plants. On the other hand, plants having absent of anthers or rudimentary anthers without pollen grain in flowers were identified as CMS plants. Actually CMS plants were not identified in S_5 population. Pollen fertile plants in S_5 population were selfed for advancing S_6 generation. Bagging was done to protect out crossing. Selfing was done by hand pollination.

All of the plants in S_5 population of hybrid 'Golden Sapphire' were identified as pollen fertile plants. Results on selfing of pollen fertile plants in S_5 population of hybrid 'Golden Sapphire' are presented. Flowering ranged from 21-23 days and maturity ranged from 95-97 days. One thousand one hundred and twenty three buds were selfed from 105 plants. In total 1098 siliquae were obtained from which 8744 seeds were obtained. Seeds were stored for advancing S_6 generation in the next year.

II. Identification of parental lines in *Brassica napus* L.

Hybrid seeds of Yunyouzaerhao-2 and Yunyouzaerhae-10 of *Brassica napus* L. which

were collected from China were used as experimental material in this experiment. The experiment was conducted during *rabi* 2018-19 at Gazipur. S_5 seeds were produced from hybrid seed (S_0) of these two hybrid varieties through selfing during last rabi 2013-18. S_5 seeds were sown on 29 November 2018 for growing S_5 population. Anthers in flowers were observed visually. Plants having prominent anthers along with pollen grain in flowers were identified as pollen fertile plants. On the other hand, plants having absent of anthers or rudimentary anthers without pollen grain in flowers were identified as CMS plants. Pollen fertile plants in S_5 population were selfed for advancing S_6 generation. CMS plants were crossed with restorer line.

Almost all of the plants in S_5 population of hybrids 'Yunyouzaerhao-2' and 'Yunyouzaerhae-10' were identified as pollen fertile plants. Days to flowering and maturity ranged from 21-22 days and 97-100 days for Yunyouzaerhao-2. Days to flowering and maturity ranged from 22-23 days and 98-102 days for Yunyouzaerhae-10. Nine hundred and five buds were selfed from 112 plants. In total 864 siliquae were obtained from which 6856 seeds were obtained. Seeds were stored for advancing S_6 generation in the next year.

III. Development of short duration parental lines in *Brassica napus* L.

Two CMS lines [$CMSZ_1$ (248) and $CMSZ_2$ (279)], one Restorer line (Nap-14-01R), three short duration (87-88 days) of *Brassica napus* lines (Nap-0876, Nap-0869 and Nap-205), two varieties (BARI Sarisha-8 and BARI Sarisha-13) and one *Brassica napus* line (Nap-14-015) were used as experimental materials. The experiment was conducted during *rabi* 2018-19 at Gazipur. Seeds were sown on 29 November 2018. CMS lines were crossed with three short duration *Brassica napus* lines, and BARI Sarisha-8 and BARI Sarisha-13. Restorer line was crossed with BARI Sarisha-8 and BARI Sarisha-13 and Nap-14-015. Bagging was done to protect out crossing. Crossing was done by hand pollination.

Days to maturity for CMS lines ranged from 95-97 days and for *Brassica napus* lines/varieties ranged from 87-95 days. Four hundred and sixty five buds of 86 CMS plants were crossed with short duration *Brassica napus* lines/varieties. Four hundred and thirty three siliquae was obtained from which 3198 seeds were obtained. Seeds were stored for back crossing in the next year.

Days to maturity for restorer line was 97-98 days and for *Brassica napus* varieties/lines ranged from 93-95 days. Three hundred and twenty two buds of 44 restorer plants were crossed with short duration *Brassica napus* varieties/lines. Two hundred and ninety six siliquae were obtained from which 2072 seeds were obtained. Seeds were stored for back crossing in the next year.

IV. Development of test cross hybrid in *Brassica napus* L.

CMS line [$CMSZ_1$(248) was crossed with Restorer line (Nap-2014-01R-P_6) to develop test cross hybrids. Seeds of male parent were sown on 29 November 2018 and seeds of CMS lines were sown on 25 November 2018 for synchronization of flowering. Unit plot size was two rows of 3m long. The experiment was conducted at Gazipur.

Days to maturity of CMS lines was 97 days and restorer lines was 101 days. Forty seven buds of 28 plants were crossed. Forty four siliqua were obtained from which 355 seeds were obtained. Hybrid seeds of test cross was stored for evaluation in the next year.

V. Evaluation of test cross hybrids in *Brassica napus* L.

Two CMS lines, $CMSZ_1$(248) and $CMSZ_2$ (279) were crossed with Restorer lines, Nap-2014-01R-P_6 and Nap-2014-01R-P_{10} during last rabi 2017-18 to develop test cross hybrids. Developed two hybrids were evaluated during rabi 2018-19. Hybrid seeds were sown on 29 November 2018. Unit plot size was four rows of 3m long. The experiment was conducted at Gazipur.

Days to flower for test crosses was 21 days and maturity ranged from 97-100 days, respectively. Pollen fertile plants ranged from 84-99% and CMS plants ranged from 1-6%. Hybrid seeds of those two hybrids were produced for evaluation in the next year.

VI. Maintenance of parental lines of selected test cross hybrids in *Brassica napus* L.

Two CMS lines, $CMSZ_1$(248) and $CMSZ_2$ (279) were crossed with selected plants of Restorer line (Nap-2014-01R) during last rabi 2014-15 and 15

test cross hybrids were developed. These hybrids were evaluated during rabi 2015-16 and four test cross hybrids performed better. In order to maintain the restorer line of selected test cross hybrids, seeds of restorer lines were sown on 29 November 2018. Unit plot size was two rows of 3m long. Selfing was done to maintain the lines. The experiment was conducted at Gazipur.

Days to flower and maturity of selected restorer lines ranged from 21-24 days and 97-113 days, respectively. Eight to twenty eight plants were selfed from each line and 77-197 buds were selfed from these lines from which 502-1188 seeds were obtained. Selfed seeds of selected restorer lines were stored for maintenance in the next year.

Days to flower and maturity of restorer line ranged from 22-23 days and 113-116 days, respectively. Three to ten plants were selfed from each line and 16-138 buds were selfed. Fourteen to one hundred twenty eight siliqua were obtained from which 102-768 seeds were obtained. Selfed seeds were stored for maintenance in the next year.

Development of double low short duration genotypes through interspecific hybridization: evaluation of F_3 generation

Parent materials of the experiment consisted of two species (*Brassica rapa* and *Brassica napus*). BARI Sarisha-17 of *Brassica rapa*, Nap-0876 and Nap-0569 of *Brassica napus* [high erucic acid (30-45%) but short duration (80-85 days)]. Nap-14-001, Nap-14-004, Nap-14-007, Nap-14-010 and Nap-14-011of *Brassica napus* [low erucic acid (less than 2%), high yielding (2.0-2.5 t/ha) but long duration (100-105 days)]. BARI Sarisha-17, Nap-0876 and Nap-0569 were crossed with Nap-14-001, Nap-14-004, Nap-14-007, Nap-14-010 and Nap-14-011 during last rabi 2015-16. Developed 15F_1s were selfed during 2016-17 and 2017-18 to develop F_3 generation. Developed 15F_3s were sown on 25 November 2018. Selfing was done through bud pollination to produce F_4 generation.

No. of selfed plants from different cross combinations ranged from 9-22 and total 218 plants were selfed. Two thousand four hundred and ninety five buds were selfed from 218 plants to develop F_4 generation. Two thousand four hundred and fourty two siliqua were obtained from which 12180 seeds were obtained. Selfed seeds were stored to advance F_4 generation in the next season.

Trial of double low genotypes of *Brassica napus*L.

Five genotypes of *Brassica napus* along with BARI Sarisha-13 and BARI Sarisha-14 as checks consisted the experiment. The genotypes were evaluated at Joydebpur during *rabi* 2018-19 to know the performance of the genotypes and to develop 'double low' (Canola) variety. The genotypes were sown on 15 November 2018 in 3 rows of 3m long with spacing of 30 cm and 5cm between rows and plants, respectively. The seedlings were thinned after few days of germination 5 cm apart with three replications. Data were taken on days to flowering, days to maturity, plant height (cm), no. of primary branches/plant, no. of siliquae/plant, no. of seeds/siliqua, 1000-seed weight (g) and seed yield/plot. The plot yield was converted into kg/ha.

Maturity duration ranged from 87-109 days. Check variety BARI Sarisha-14 was the earliest (87 days) in maturity among the genotypes. Plant height ranged from 74-101 cm. Check variety BARI Sarisha-14 showed the lowest plant height (74 cm). Number of siliquae/plant ranged from 53-120. The highest number of siliquae/plant was recorded in BN-1410 which was statistically similar with other three genotypes. No. of seeds/siliqua ranged from 17-26. The highest no. of seeds/siliqua recorded in Nap-14004, although its yield was remarkably low. Thousand seed weight ranged from 2.83-3.87g. Seed yield ranged from 1468-2302kg/ha. The highest seed yield was recorded in Nap-14010 (2302 kg/ha) and lowest in check variety BARI Sarisha -14.

Considering seed yield and other yield contributing characters, genotypes Nap-14010, Nap-14011 and Nap-14001 were selected for further evaluation.

Crop Management

Development of fertilizer management for mustard- boro mixed cropping system

A field experiment was carried out during rabi season on 29-11-2018 at Joydebpur, Gazipur to find out the suitable fertilizer dose in Mustard-Boro mixed cropping system and to calculate the cost and return of mixed cropping system. The experimental areas belong to the Madhupur tract (AEZ 28). The experiment was laid out in Randomized Complete Block design with three

replications. It consisted of four treatments as follows: T_1=Boro recommended fertilizer dose as per FRG (Fertilizer recommendation guide) +10% excess fertilizer of BRDF, T_2 = Boro recommended fertilizer dose as per FRG (Fertilizer recommendation guide) +20% excess fertilizer of BRDF, T_3 = Boro recommended fertilizer dose as per FRG (Fertilizer recommendation guide) +30% excess fertilizer of BRDF and T_4 = Recommended dose of Boro rice. The seeds of boro rice and mustard are sown in broadcast method . At first the rice seed was sown during final land preparation, then one light pass by the tractor on the field, as the rice seed goes into the depth of the soil for delay emergence of rice seeds .After that mustard seeds were sown and laddering was done on the field. The experiment was set on 29 th November 2018 with the seed rate of mustard and boro rice 8 and 40 kg/ha. respectively . The unit plot size was 30 m^2. The lands were fertilized according to the treatment wise. 2/3rd Urea and all the fertilizers of entire amount were applied during final land preparation as basal and ½ of rest of the urea was applied as top dress at 25 days after broadcasting. Remaining urea was applied after the weeding and gap filling of the rice seedling. Plant protection measure and all other management practices were done for mustard and boro rice as and when necessary. Mustard was harvested on 2 nd February 2019, whereas boro rice on 26 April, 2019. From the evidence of research it was found that the highest rice equivalent yield (6.18 t ha^{-1}) was found in the treatment combination T_2 where Boro recommended fertilizer dose as per FRG (Fertilizer recommendation guide) +20% excess fertilizer of BRDF.were applied. Cost and return analysis revealed that the T_2 treatment gave the highest gross return (92700.00Tk. ha^{-1}) and gross margin (17660.00. ha^{-1}) compared to the other treatments combination.

Development of cropping pattern for increasing cropping intensity and productivity

The field experiment was conducted at the Central Research Station of BARI Joydebpur (AEZ 28) during 2017-2018 (July 2017 through June 2018). Soil analysis report is presented in Table 1a & 1b. Five cropping patterns were as follows: CP_1 = Mustard (var. BARI Sarisha-16) – Indian Spinach (BARI Puisak-1) -T. aus (var. BRRI dhan48) - T. aman (var. BRRI dhan62), CP_2 = Groundnut (BARI Chinabadam-8) + Spinach (Palongsakh- 2) –T.aus (var. BRRI dhan48) - T. aman (var. BRRI dhan62), CP_3= Groundnut (BARIChinabadam-8) + Red Amaranth (BARI lalsakh-1) –T.aus (var. BRRI dhan48)- T. aman (var. BRRI dhan57), CP_4 = Bushbean (BARI Jharshim-1) – Sesame (var.BARI Till-4) – Kangkong (BARI Gimakolmi-1)- T. aman (var. BRRI dhan57) and CP_5 = T. aman (var. BRRIdhan57)- Fallow – Boro (var. BRRIdhan28) – Fallow (Control). The highest gross margin (Tk.302500 /ha) and BCR (3.65) were obtained from CP_2 (Groundnut (BARI Chinabadam-8) + Spinach (Palongsakh- 2) –T.aus (var. BRRIdhan48) - T. aman (var. BRRI dhan62) and The second highest gross margin (Tk.277250 /ha) was found in CP4(Bushbean(BARI Borboti-1) – Sesame (var.BARI Till-4) – Kangkong (BARI Gimakolmi-1)- T. aman (var. BRRI dhan57) and the second highest BCR (3.44) was obtained from CP_1(Mustard (var. BARI Sarisha-16) – Indian Spinach(BARI Puisak-1) -T. aus (var. BRRI dhan48) - T. aman (var. BRRI dhan-62). So these four crops based cropping patterns will help for increasing cropping intensity, crop productivity and at the same time more employment opportunity will be created for male and female agricultural workers.

Disease Management

Efficacy of fungicides against *alternaria blight* of mustard

The experiment was conducted during 2018-2019 cropping season in the field at Oilseed Research Centre, BARI, Joydebpur to evaluate five fungicides in controlling *Alternaria blight* of mustard . Seeds of BARI Sarisha 14 was sown on November 2018. The experiment was designed in RCB with 3 replications where plot size was 3m x 2m with 30 cm row spacing. Fertilizers were applied @ 120:80:60:40:4:1 kg/ha of N:P:K:S:Zn and Boron from Urea, TSP, MP, Gypsum, Znic Sulphate and Boric acid respectively. Half of the urea and all other fertilizers were applied during final land preparation. The rest of the urea was applied at flower initiation stage. All intercultural operations were done timely to raise a good crop. Five different fungicides namely, Rovral 50WP (Iprodian), Amister top (Azoxytrobin + Difenoconazole), Antracol (Dithiocarbamate), Rai

(Azoxytrobin + Difenoconazole), and (Bioneem plus1EC) Bioneemplus (Azadirachtin) were sprayed. A control treatment was maintained for comparison. Rovral, Antracol, and Bioneemplus were sprayed @ 0.2 % and Amister top and Rai were sprayed @ 0.1% at 10 day intervals beginning from the first appearance of the disease and continued to 3 times.

All the fungicides significantly reduced the disease as compared to control . The highest disease reduction was recorded from Amister top (81.44) sprayed plot followed by Rovral (81.22%) and Rai (73.49 %) sprayed plots. The highest yield (1687 kg/ha) was obtained from Rovral sprayed plot followed by Amister top (1625kg/ha). The highest net profit of Tk. 16750 was obtained from the Amister top sprayed plot followed by Rai (Tk. 14090) and Rovral (Tk. 10560) sprayed plot .Considering benefit cost ratio the fungicide Amister top was found to be economic (2.64) followed by Rai (2.50) and Rovral (1.54).

Amister top and Rai were effective fungicides for controlling the disease and increasing yield of mustard.

Evaluation of *sclerotinia* stem rot resistance in rapeseed-mustard germplasm under inoculated condition

The experiment was carried out at ORC pot house, BARI, Gazipur , during 2018- 2019 to observed the reaction of 20 mustard germplasms against sclerotinia stem rot disease. Pathogen was isolated from infected crop and multiply on Potato Dextrose Agar (PDA) in the laboratory. Seeds were sown in plastic pots filled with sterile soil. Twelve days old seedlings were inoculated in cotyledon inoculation and fifty days old plants were inoculated in stem inoculation. The inoculated seedlings and plants were maintained in pot house condition. The genotypes namely, Nap-205, BS-15 and BS- 11 shows resistant reaction against S, sclerotiorum. The stem lesion were measured from 0.00 to 76.33mm.The smallest lesions was observed on Nap- 1007 (8.67mm) and the largest was in BC-100614(4)-7 (76.33mm) but they were statistically identical with BC-100614(4)-7, BC-100614(8)-4 , BC-05118, Nap-10017 ,Nap-11009 Nap-11008 and Nap-10012-1. The Cotyledon lesion were measured from 0.00 to 2.2 mm. The smallest lesions was observed on BS- 11 (0.2mm) and the largest was in BC-05115 (2.2 mm) but they were statistically identical. Among 20 germplasms only two genotypes namely Nap-205 and BS-15 showed resistant reaction against *Sclerotinia sclerotiorum* in both stem inoculation and Cotyledon inoculation technique.

Sesame

Variety Development

Disease management

Screening of sesame lines against stem rot disease

An experiment was conducted at Oilseed Research Centre, Joydebpur during 2017-2018 to find out resistant lines of sesame against stem rot disease caused by *Macrophomina phaseolina*. A total of twenty five lines were used in the experiment. A susceptible variety T6 was used in the experiment as check. The test lines were sown in two rows of two meter long and separated by a single row of susceptible variety T6 as infector row. Disease data were recorded following standard disease rating scale (1-9 scale) given by Dinakaran and Naina Mohammad(2001) before 10 days of harvest. Reaction of crop against the disease was graded on the following five grade, where1= 1-10 percent infection (R), 3=11-20 percent infection (MR), 5=21-30 percent infection (MS), 7=31-50 percent infection(S), and 9= 51-100 percent infection (HS)

Among the test lines only five lines (Ses-jp-83-1,Ses-84, Ses-85,Ses-35-2 and Ses-5) were found moderately resistant against the disease. Three line (Ses-65,Ses-34, and Ses-jp-964) were found moderately susceptible against the disease. Rest of the lines show highly susceptible to susceptible reaction to stem rot disease

Groundnut

Variety development

Maintenance and evaluation of groundnut germplasm

A total of two hundred one genotypes were grown in a non replicated trial at Gazipur to evaluate the collected materials for future use in the breeding program. The sowing date was 24 December 2018. Seeds were sown in two rows of 4 m long plot with

the spacing line to line 30cm and plant to plant 15 cm. Recommended doses of fertilizers were applied @ 10:70:50:30:4:2 kg/ha of N P K S Zn B respectively.

A total of two hundred one (201) groundnut germplasm accessions were evaluated at Joydebpur, Gazipur. The ranges for days to 1st flowering,days to maturity, plant height, mature pods/plant,100 karnel weight (g), Shelling % and plot yield were 52-66 days, 144-155 days, 22.6-77.2 cm, 7-34, 19.06-49.14, 41.5-87.45 and 600-2900 kg/ha respectively. The highest coefficient of variation (CV %) was recorded for the character mature pods/plant (27.73%) followed by plot yield(kg/ha). Minimum variation was observed in the character days to maturity. The seeds of the germplasm will be grown in the next year and stored for using in the future breeding program.

Creation of genetic variability in groundnut through hybridization

A total of 167 buds were pollinated at Joydebpur. On an average 25% crosses were successful and produced 42 pods. Crossed seeds were collected for growing as F_1 in the next Rabi season.

Two batches of five parental lines were sown on fourteen days interval in 27 December 2018 and 10 January 2019 at Joydebpur. The seeds of individual parents were planted in raised bed of 2 rows x 2m long with the spacing 50 and 20cm between rows and plants respectively. After the flower initiation, the crosses have been attempted. The unopened matured buds were emasculated at afternoon (12.00 pm to 2.00 pm) and the emasculated buds were pollinated in the following morning (6.00 am to 8.00 am).

Evaluation of segregating generations of groundnut

Seeds of twenty two combinations from F_1, twelve entries from F_2, eight entries from F_3, six entries from F_4 and three entries from F_6 respectively were sown on December 24, 2018 at Joydebpur. Unit plot size was 4m long with required number of rows. Recommended doses of fertilizers were applied and necessary steps were taken to grow the crop uniformly.

On the basis of number of mature pods per plant, cluster pod formation, dwarf canopy of the plant, pod surface and diseases and insect reaction a number of single plants as well as bulk populations from different cross combinations of different segregating generations were selected. A total of 59 single plants, 51 single plants, 36 single plants, 25 single plants and 13 single plants were selected from F_1, F_2, F_3, F_4 and F_5 generations respectively. The seeds from selected single plant of F_1 was collected and stored for advancing the generation as F_2 in the next season. On the other hand the seeds from single plant of F_2 was collected and stored according to the cross and generation will be advanced as F_3 generation. From the F_3 generation 36 plants were selected as single plant from 8 accessions and will be tested their performance as F_4 generation in the next season. From the F_4 generation 25 plants were selected as single plant from 6 accessions and will be tested their performance as F_5 generation in the next season. From the F_5generation 13 plants were selected as single plant from 3 accessions and will be tested their performance as F_6 generation in the next season.

Observation trial of groundnut

Nineteen genotypes including two checks Dhaka-1 and BARI Chinabadam-8 were evaluated at Joydebpur during Rabi 2018-19. Seeds were sown on 24 December, 2018 in RCBD design with three replications. Unit plot size was 2 rows 4 m long with the spacing of 40cm x 15cm between rows and plants, respectively. Recommended doses of fertilizers were applied @ 10:70:50:30:4:2 kg/ha of N P K S Zn B respectively.

Higher shelling percent were found in the ICGVS 15-1, 702-6-2-1 and 14-103. Maximum shelling percent were found in the genotypes ICGVS 15-1 (80%), 702-6-2-1 (76%)and 14-103 (76%).Highest yield (2545 kg/ha) was obtained from the genotype ISD 0414 followed by the genotype Choko 0314(2408 kg/ha), Jhaldhaka (2348 kg/ha), 702-6-2-1(2185 kg/ha), 14-103 (2063 kg/ha) and ISD 2914 which were 36%, 29%, 25%, 17%, 10% and 9% higher than the check variety BARI Chinabadam-8 respectively. Maximum mature pods per plant was observed from the entry ISD 0414 (30). Highest 100 kernel weight (g) was obtained from the genotype PK-1 followed by the genotype ICGVS 38-3 (50g) Considering the yield six genotypes ISD 0414,Choko 0314, Jhaldhaka,

702-6-2-1, 14-103 and ISD 2914 have been selected for PYT.

Preliminary yield trial of groundnut (Set-I)

The experiment was conducted with seventeen groundnut genotypes including 2 checks as Dhaka-1 and BARI Chinabadam 8 at Joydebpur in a randomized complete block design with 3 replications. Unit plot size was 6 rows 4m long with the spacing of 40cm between rows and 15 cm between plants. Recommended doses of fertilizers were applied @ 80:65:60:20:4 kg/ha of N P K S Zn respectively.

Significant differences were observed among the genotypes for all the characters except days to 1st flowering and days to maturity studied at Joydebpur. Maturity duration ranged from 147-154 days. Highest number of mature pods/plant (31) was obtained by the entry NCGV-0207.The range of hundred kernel weight 39-66g. Highest shelling percentage was recorded in the genotype TG-51 (78%). The Genotype NCGV 0207 produced the maximum pod yield (2530 kg/ha) followed by NCGV 0704(2505 kg/ha), TG 37(2460 kg/ha), ICGVS 35-1(2360 kg/ha), ICGV 91176(2249) and NCGV 0107(2124 kg/ha) which were 20%, 18%, 16%, 12%, 6% and 1% higher than the check variety BARI Chinabadam-8 respectively.

Regional yield trial of groundnut (Set-1)

The experiment was conducted at Joydebpur during *rabi* 2018-19 with 16 promising genotypes of groundnut including 3 checks Dhaka-1, BARI Chinabadam-8 and BINA Chinabadam-4. The experiment was laid out in Randomized Complete Block design having three replications. The plot size was 4m x 2m. Spacing was 15cm seed to seed and 40 cm row to row. Fertilizers were applied @ 12:32:43:54:1.8 kg/ha of N: P: K: S: and Boron from Urea, TSP, MP, Gypsum and Boric acid. Half of the urea and all other fertilizers were applied during final land preparation. The rest of the urea was applied at the initial stage of peg development.

Significant differences were observed among the genotypes for all the characters except days to 1st flowering and days to maturity studied at Joydebpur. Maturity duration ranged from 147-153 days. Highest number of mature pods/plant (30) was obtained from the entry ICGV-07219. The range of hundred kernel weight 38-54g. Highest shelling percentage was recorded in the genotype ICGV-91114 (76%).The Genotype ICGV 07219 produced the maximum pod yield (2519 kg/ha) followed by ICGV 06237 (2383 kg/ha), ICGV 06423(2328 kg/ha), ICGV 00338(2264 kg/ha), ICGV 07217(1931 kg/ha) and ICGV 06285(1923 kg/ha) which were 33%, 26%, 23%, 20%, 3% and 2% higher than the check variety BARI Chinabadam-8 respectively

Regional yield trial of groundnut (Set-2)

Twelve entries including two checks Dhaka-1 and BARI Chinabadam 8 were evaluated at Joydebpur. Unit plot size was 6 rows 4 m long with the spacing 40 cm x 15 cm between rows and plants respectively. Recommended doses of fertilizers were applied @ 10:70:50:30:4:2 kg/ha of N P K S Zn B respectively.

Significant differences were observed among the genotypes for all the characters except days to 1st flowering and days to maturity studied at Joydebpur. Maturity duration ranged from 147-156 days. Highest number of mature pods/plant (28) was obtained by the entry ICGV-95063. The range of hundred kernel weight 36-63g. Highest shelling percentage was recorded in the genotype ICGV--01080 (75%) and ICGV-96346(75%).The Genotype NCGV 02096 produced the maximum pod yield (2617 kg/ha) followed by ICGVS 36-1(2490 kg/ha), ICGV-04096(2440 kg/ha) and NCGV-0204(2357 kg/ha) which were 13%, 7%, 5% and 2% higher than the check varieties

Crop Management

Effect of seed priming on seed quality of groundnut (*Arachis hypogaea* L.)

The seeds of groundnut variety BARI Chinabadam-8 was subjected to seven seed priming treatments namely T_1- Control (no priming), T_2- seeds soaked in water for the period of 6 hr followed by shade drying, T_3- seeds soaked in water for the period of 12 hr followed by shade drying, T_4- seeds soaked in 1% boron solution for the period of 6 hr followed by shade drying, T_5- seeds soaked in 1% KCl solution for the period of 6 hr followed by shade drying, T_6- seeds soaked in 1% GA_3 solution for the period of 6 hr followed by shade drying, and T_7- seeds soaked in 1% $CaCl_2$ solution for the period of 6 hr followed by shade drying,. The

experiment was conducted at the laboratory of Oilseed Research Centre,f BARI in Randomized Block Design with three replication.. Prior to the experimentation, about 10 grams of each salt were dissolved in one litre of distilled water to prepare 1 per cent concentration solutions in sufficient quantities for seed soaking purpose. Subsequently seeds were soaked in respective salt concentrations in 1:5 ratios for 6 or 12 hours. Further they were decanted and surface dried for their original weight. The soaked seed and dried seed were utilized for this experiment. Among all the seed priming treatments, seed priming with soaking in water (osmo priming) was found to be the best priming treatment followed by priming using GA_3. Among all seed priming treatments soaking the seed for 12 hrs in water having more pronounced effect on germination behavior and vigour in groundnut seeds.

Intercropping radish with groundnut

A field experiment of intercropping radish with groundnut was conducted in Oilseed Research Centre, BARI, Gazipur during *rabi* season of 2018-19 to find out the optimum row arrangement of radish as intercropping with groundnut for higher productivity and return. Six treatments were T_1= One row of radish in between two normal rows of groundnut, T_2= Two rows of radish in between two normal rows of groundnut, T_3= Radish broadcast in between two normal row of groundnut, T_4= Two rows of radish alternated with two rows of groundnut, T_5= Sole groundnut and T_6= Sole radish. The experiment was laid out in Randomized Complete Block Design with three replications. The unit plot size was 4mx3.2 m. Both the seeds of BARI Chinabadam-8 and Local radish were sown on 3 December, 2018. Fertilizers @45-36-75-30-2-1-0.6 kg/ha NPKSZnB were applied at the time of final land preparation for both sole groundnut & intercrop. At harvest, the yield data was recorded plot wise. Collected data were analyzed statistically and means were adjusted by LSD test at 5% level of significance using CROPSTAT. Yield of individual crop was converted to groundnut equivalent yield (GEY) considering prevailing market price of the crops according to Islam et al.(2006). Marginal benefit cost analysis was also done. Although intercropping reduced groundnut yield but total productivity was increased due to addition of radish yield. Total productivity in terms of groundnut equivalent yield (GEY) (2.51t/ha) was obtained from T_4 treatment while the lowest (1.40 t/ha) in radish sole crop. However, highest benefit cost ratio (BCR) (4.31) was also recorded in T_4 treatment (Two rows of radish alternated with two rows of groundnut).

Disease Management

Efficacy of biocontrol agents and botanicals against different seed borne pathogen of groundnut in vitro

A lab experiment was conducted at Pathology Laboratory of Oilseed Research Centre, BARI, Joydebpur during 2018-2019 to identify the associated fungi with groundnut seed in farmers saved seed. Seed samples were collected directly from the farmers house at different locations of Faridpur, Rangpur, Cumilla and Mymensing districts of Bangladesh. The seed samples were stored at refrigerator until the use.

Seeds were treated with crude extracts of different plant species.Two hundred fifty gram leaves/cloves of the selected plants were blended separately in an electric blender with equal volume of water. The meshed leaves were squeezed through 3 folds fine cotton cloth. The filtrate thus obtained was used as crued extract for seed treatment by dipping seeds separately. One hundred seeds for each sample were dipper for 24 hr in each crude extract. The treated and untreated control seeds were tested by blotter incubation method (ISTA, 2001). In this method, three pieces of filter paper (Whitman no.1) were placed at the bottom of 9 cm diameter glass petridish after soaking in sterilized water. Seeds treated with plant extracts were taken randomly and placed on the moist filter paper in 10 replicated petri dishes setting 10 seeds per plate. The seeds were then kept at 25 ± 1^0C for incubation under 12/12 hour altering cycles of light and darkness in the growth chamber for seven days. After incubation the fungal growth on the seeds werer identified under the stereo-microscope following the dey of Mather and Kongsdal (2003). Pathogens were identified by their morphological characteristics like color, structure of mycelium, types of spores and fruiting bodies using a compound microscope. Percent incidence of different fungi and germination in each sample (treated and untreated) were recorded.

Plant extracts of five different species viz Marigold (*Tagetes erecta*), tulsi (Ocimum sanctum), Neem (Azadirachtaindica), Garlic (Allium sativum) Ginger (*Zingiber officinale*) and one bio-agent (*Trichoderma hargianum*) were tested against mycoflora associated with groundnut seeds by blotter incubation test. Individual as well as total incidence of seed-borne fungi was reduced after treatment with plant extracts and bio-agents. All the plant extracts showed the ability to control seed-borne mycoflora of groundnut and subsequently can increase germination percentages. Garlic extract and *Trichoderma herzianum* performed better among all the extracts tested. Five fungal genera viz. Aspergillus flavus, Aspergillus niger, Fusarium sp., Rhizopus stolonifer. and Penicillium sp were occurred in the control seed samples, whereas four (*Aspergillus flavus*, *Aspergillus niger*, *Fusarium* sp. and, *Rhizopus stolonifer*) of the five occurred in the seed samples that were treated with different treatments.From the above four district experiment results it may be concluded that Garlic extracts , Trichoderma harzianum and ginger may be used to treat groundnut seed for effective control of seed-born mycoflora.

Soybean

Variety Development

Maintenance and evaluation of soybean germplasm

A total of one hundred eleven entries were grown in a non-replicated trial at Gazipur to maintain and evaluate the materials for future use in the breeding program. The sowing date was 28 December, 2018. Seeds were sown in two rows of 4 m long plot with the spacing line to line 40 cm and plant to plant 10cm. Fertilizers were applied @ 25:35:55:18 kg per ha of NPKS, respectively from Urea, TSP, MP and Gypsum.

The ranges for days to flowering, days to maturity, plant height, pods per plant,100 seed weight and yield per plot were 58-87 days, 110-174 days, 18-85 cm, 5-77, 6-22 g and 14-1841 kg per ha respectively. The percent highest coefficient of variation (CV%) was recorded for the character yield per plot (65). Minimum variation was observed in the character days to flowering and maturity. The character plant height, pods per plant and hundred seed weight showed moderate variation.

Observation trial of soybean

Eleven entries including one check variety namely BARI Soybean-6 were evaluated in a RCBD design with two replications for seed yield and it's components at Gazipur during rabi 2018-19. The unit plot size was 2 rows of 4 m long and the spacing was maintained 40 cm between rows and 10 cm between plants. The sowing date was 28 December, 2018. Fertilizers were applied @ 25:35:55:18 kg per ha of NPKS respectively, from Urea, TSP, MP and Gypsum. Data on days to maturity and seed yield per plot were taken on the plot basis. The other yield contributing characters such as plant height, pod per plant, and 100 seed weight (SW) were recorded from 5 randomly selected plants of each plot. Recorded data were analyzed statistically.

The entry USDA 40 required minimum days to mature (110) while the USDA 95, USDA 107 and B2 took maximum days to mature (120-126). Highest plant height was recorded in USDA 53 (45 cm) followed by USDA 95 (43 cm). The most dwarf entry was VIETKHAI (32 cm). The entry USDA 92 produced the highest pods per plant (56) followed by USDA 53 (45). All the entries produced the higher seed yield compared to the check variety BARI Soybean-6 except the entry USDA 92. The entries USDA 40 produced 20% and USDA 53, USDA 95 and LG-92P-1825 produced 18% higher yield than the check variety BARI Soybean-6.

Preliminary yield trial of soybean

Ten entries including one check variety viz., BARI Soybean-6 were evaluated in a RCBD design with three replications for seed yield and it’s component at Gazipur and Cumilladuring 2018-19. The unit plot size was 4 rows of 4 m long and the spacing was maintained 40cm ×10cm apart. The sowing date was 28 December, 2018 at Gazipur and 06 January, 2019 at Cumilla. Fertilizers were applied @ 25:35:55:18 kg per ha of NPKS, respectively from Urea, TSP, MP and Gypsum.

In Gazipur location, GMOT 13 was the most dwarf (23cm) while USDA 53 and USDA 95 showed maximum plant height (44 and 46 cm). Maximum

number of pods per plant (42) was found in the entry USDA 53 and USDA 72 while minimum number in USDA 4 and BS 29 (30). The entry USDA 44 took maximum days to mature (127) followed by GC-83001-16 and USDA 95 (126) while the check variety BARI Soybean-6 took 115 days to mature. The entry USDA 4 took 114 days to mature which was minimum. USDA 53, USDA 72, USDA 95 and USDA 44 were produced the higher seed yield compared to the check variety BARI Soybean-6.

Regarding maturity duration over locations, days to maturity ranged from 110-124 days. Yield ranged from 1718-2678 kg/ha over locations. The entry USDA 53 produced the highest yield (2604 kg/ha) followed by USDA 72 (2604 Kg/ha) which were 18% and 15% higher than the check variety BARI Soybean-6 over locations.

Regional yield trial of soybean

Eight entries including two check varieties viz. BARI Soybean-5 and BARI Soybean-6 were evaluated in a RCBD design with three replications for seed yield and its component at Gazipur Noakhali and Burirhat location. The unit plot size was 6 rows of 4 m long and the spacing was maintained 40cm ×10cm apart. The sowing date was 28 December, 2018 at Gazipur and 15 January, 2019 at Noakhali. Fertilizers were applied @ 25:35:55:18 kg per ha of NPKS, respectively from Urea, TSP, MP and Gypsum.

In Gazipur location, SANTAROSE was the most dwarf (20 cm) while GMOT 17 and AGS 95 were the tallest (40 and 46 cm) in plant height. Maximum no. of pods per plant (48) was found in the entry KHSH 2004 while minimum number in BARI Soybean-6 (30). The highest seed yield was obtained by the entry SANTAROSE (1480 kg/ha) followed by GMOT 17 (1350 kg/ha) which were 36% and 24% higher than the check variety BARI Soybean-6. The entries LG-92P-11-76 took the maximum days to mature (128) while the check variety BARI Soybean-6 took 114 days to mature.

Over three locations, mean days to maturity ranged from 112-125 days and yield ranged from 1271-1873 kg/ha. On an average the entry SANTAROSE produced the highest yield (1873 kg/ha) which was 13% higher than the check variety BARI Soybean-6.

Crop Management

Performance of selected genotypes of soybean under rainfed condition

The experiment was laid out in field semi controlled condition at BARI, Joydebpur, Gazipur during 2018-19. Ten genotypes (AGS-95, Asset-95, BS-32, GMOT-95, BARI Soybean-6, BS-29, USDA-22, USDA-53, Shohag & BARISoybean-5) were used in the study. The experiment was laid out in Randomized Complete Block Design with three replication. Seeds were sown on 12 December, 2018. Soil moisture measured by soil moisture meter (Model –TDR 200). Drought treatment was imposed by restricting irrigation and plants were re-irrigated when they showed signs of wilting or leaf rolling. Slightly rainfall occurred in the month of November. Besides, no rainfall occurred during crop production periods. After germination, plants were counted and excess plants were removed to maintain optimum plants in each plot. The genotypes were harvested at maturity. Rainfed/drought stress showed significant influence on growth, yield contributing characters and yield. Among the different genotypes, Asset-95 gave the maximum 100 seed weight (9.95g) and the lowest (5.90g) from USDA-53 under rainfed situation. The highest seed yield (1105kg/ha) and stover yield (1995kg/ha) were obtained from Asset-95 genotype and the lowest seed yield (725kg/ha)and stover yield (1250kg/ha) from BARI Soybean -6. Among the different genotypes, Asset-95, BARISoybean-5, Shohag, USDA-22, USDA-53, AGS-95 and BS-32 performed better under rainfed condition.

Disease Management

Screening of soybean genotypes against soybean yellow mosaic virus

The experiment was conducted at Oilseed Research Centre, BARI, Joydebpur during *rabi* 2018-2019 cropping season. A total of twenty three lines/variety of soybean were tested. Twenty (22) soybean entries were evaluated under natural condition against soybean yellow mosaic virus disease using infector row method. The experiment was conducted in RCBD following 3 replication in continuous row method. Seeds were sown on 1

January 2018. A susceptible variety Shohag was used in the experiment as infector. Every test lines were sown in two rows of 2 m long separated by single row of susceptible infector (Shohag). Fertilizer management, cultural and intercultural operations were done as recommended by Oilseed Research Centre (ORC), BARI. Foliar disease data were recorded at the pod development stage using 0-8 scale. *Among* the 23 test lines only one line (AGS 205) showed Immune to Soybean yellow mosaic disease. Two lines (VIETKHAI and TAS-4)showed Highly Resistant and Seven lines(GMOT-43, LG -92p-1825, USDA-92,COLOMBUS, BD-4,UDSA-47,GMOT-13) showed resistant reaction to Soybean yellow mosaic disease. These lines will be further evaluated in the next season.

Management of soybean Yellow Mosaic Virus (SYMV) through vector control by insecticide spray

The experiment was conducted at Oilseed Research Centre, BARI, Joydebpur and RARS Barisal during 2018-2019 cropping season to evaluate some insecticides in controlling yellow mosaic virus disease of soybean. Seeds of BARI Soybean-6 was sown on December 2018. The experiment was designed in RCB with 3 replications where plot size was 2m x 2m with 40 cm row spacing. Fertilizer and other intercultural operations were done uniformly as per recommendation of ORC to raise a good crop. Five different insecticide namely, T_1 = Malathion 57EC @2ml/L of water,T_2 = Admire 200SL@0.25ml/L of water, T_3 = Aktara 25WP @ 0.2gm/L of water,T_4 = Tafgor 40EC @2ml/L of water and T_5 = Bioneem plus 1EC @1ml/L of water were sprayed. A control treatment was maintained for comparison. All insecticides were sprayed at 10 day intervals beginning from the first appearance of the disease and continued to 3 times. Disease data was recorded 10 days after last spray on the basis of 0-8 scoring scale. Data on number of pod/plant, number of seed/pod and yield per plot were recorded. Yield (kg/ha) data was computed on the basis of plot yield. The PDI value was transformed in to arcsin transformation for analysis. Disease incidence, severity, number of pod per plant, yield per plot, yield/ha both healthy and infected and seed yield (t/ha) were recorded. All the insecticides significantly reduced the aphid population as compared to control after spray but before spray they were statistically identical. Malathion sprayed plot observed the lowest aphid population. The highest disease reduction was recorded from Malathion (39%) sprayed plot followed by Aktara (33%) and Admire (31%) sprayed plots. The highest yield (1.93 t/ha) was obtained from Malathion sprayed plot. followed by Aktara (1.85 t/ha). Considering benefit cost ratio the insecticide Admire was found to be economic (8.33) followed by Malathion (7.39).

Insect Management

Screening of soybean entries against leaf roller and hairy cattterpillar under natural field condition

The experiment was conducted in the field of Oilseed Research Centre, BARI, Joydebpur, Gazipur, during *rabi* season of 2018-19. There were four plots and plot size was 4.0m X 5.0m.Eighteen (18) entries of soybean were evaluated against leaf roller and hairy caterpillar infestation. Of these 6 (six) entries, namely AGS-95, ASST-95, BR-14, BOOS, USDA-30, USDA-40 were selected for comparatively less infestation caused by leaf roller and hairy caterpillar than the other entries and check varieties BARI soybean-5 and BARI Soybean-6.

Sunflower

Varietal Improvement

Collection, evaluation and maintenance of sunflower

Forty two accessions of sunflower were grown at the research field of ORC, BARI Gazipur on 19 November 2018. BARI Surjamukhi-2 was used in this experiment as a check. Seeds were sown in 2 rows x 4 m long plot, where row to row distance was 50 cm and plant to plant distance was 25 cm. Fertilizers were applied @ 25:35:55:18 kg/ha of NPKS, respectively from Urea, TSP, MP and Gypsum. Half of the Urea and other fertilizers were applied at the time of final land preparation. The remaining half of the Urea was applied as top dress during flower primordial stage. Pollen of each entry within a plot was collected and bulked. Then crossing was done within the genotypes of that

plot. After crossing, bagging was done properly. Other intercultural operations were done when necessary to obtain optimum plant growth.

The ranges for days to flower, days to maturity, plant height (cm), stem diameter (cm), head diameter (cm), number of seeds/ head, seed yield/head (g) and 1000 seed weight (g) were 62-93, 92-137, 46.6-160.4 cm, 0.96-2.25 cm, 7.2-16.6 cm, 19-303, 1.2-21.0 and 25-80g respectively. The highest CV% was recorded for the character seed yield/head (51.0g) followed by number of seeds/head (48). Minimum variation was observed for the characters days to flowering and days to maturity.

Development of dwarf inbred lines in sunflower: advancing S_4 to S_5 generations

Seeds from eighty S_4single head of nine sunflower genotypes were grown at Gazipur. Seeds were sown on 19 November 2018 in ORC research field. Seeds were sown in head to row method of 4 m long plot where the spacing was 50 cm between the rows and 25 cm between the plants. Fertilizers were applied @ 90:35:80:30:3.6 and 1.8 kg/ha of NPKSZn and B, respectively, from urea, TSP, MP, Gypsum, Zinc sulphate and Boric acid. Half of the Urea and all other fertilizers were applied at the time of final land preparation. The remaining half of the Urea was applied as top dress during flower primordial stage. To obtain optimum plant growth other intercultural operations were done properly when necessary. Individual plants were selected for selfing and bagging were done properly to prevent out crossing. Pollen were collected and rubbed within the same head by hand brush during selfing. Data was recorded on average plant height (cm), head diameter (cm), seeds/head, and seed weight/head (g).

A total of 774 heads of nine sunflower genotypes were selfed. Number of plants selected and the average plant height, head diameter, seeds/head and seed weight/head of selected plants were recorded. As the objective of this study was to develop dwarf inbred lines of sunflower, the plants having height close to 100 cm had been selected to advance generation as S_6. A total of one hundred and seventy nine single plants were selected out of 774 selfed plants from nine sunflower genotypes. These selfed single plants will be evaluated as S_6 generations next year

Identification of parental lines for development of hybrid variety in sunflower

S_3seeds of CN001, CN002, CN003 and S_5 seeds of Hysun-33 were used as experimental material in this experiment. Seeds were sown on 27 November 2018 in ORC research field in two rows of 4 m long with the spacing of 50 cm between the rows and 25 cm between plants. Anthers in flowers were observed visually. Plants having prominent anthers along with pollen grain in flowers were identified as pollen fertile plants. On the other hand, plants having rudimentary anthers without pollen grains or absent of anthers in flowers were identified as CMS plants. CMS plants were crossed with selected pollen fertile plant (male parent) and selected male fertile plants were selfed. Data on total number of plants, number of pollen fertile plants, and number of CMS plants were recorded.

A cross between a CMS vs fertile plant SL2P4 X FL2P6 of CN001, SL1P5 X FL1P8 (P2) and SL1P5 X FL1P8 (P12 x P2) of CN002, SL2P2 X FL2P9 (P8 x P11) of CN003 and a self-fertilized plant FL2P9 (P1) of hybrid CN003 produced 100% fertile plant which might indicated that these would be a restorer plant of that hybrid.

Self-fertilized or cross between a pollen fertile and CMS plant of hybrid Hysun-33 produced 100% fertile plant which might indicated that these would be a restorer plant of that hybrid but none of the self-fertilized or cross between a pollen fertile and CMS plant of hybrid Hysun-33 could produce 100% sterile plant (Table 3b). Therefore further investigation is needed for getting a maintainer or restorer plant of this hybrid.

Development of synthetic and composite sunflower variety

I) development of synthetic sunflower variety

Eight inbred lines (P-S-2-OP1, P-S-2-OP2, P-S-2-OP3, P-S-2-OP4, P-S-2-OP6, P-S-2-OP8, P-S-2-OPa and P-S-2-OPb) and their 28 F_1diallel crosses (excluding reciprocals) were grown in a randomized complete block design with three replications at the research field of ORC, BARI Gazipur on 20 November 2018. Seeds were sown in 2 rows x 4 m long plot, where row to row distance was 50 cm and plant to plant distance was 25 cm. Fertilizers were applied @ 25:35:55:18 kg/ha of NPKS, respectively from Urea, TSP, MP

and Gypsum. Half of the Urea and other fertilizers were applied at the time of final land preparation. The remaining half of the Urea was applied as top dress during flower primordial stage. Other intercultural operations were done when necessary to obtain optimum plant growth. Data was recorded on days to 50% flowering, days to maturity, plant height (cm), stem diameter (cm), head diameter (cm), number of seeds/head, seed weight/head (g) and 1000 seed weight (g) from ten randomly selected plants. Combining ability analysis was carried out following Griffing's (1956) Model I (fixed effect model) and Method 2 (parents + one set of direct crosses) using PBTools software programme.

The analysis of variance showed the mean squares due to genotypes were highly significant for all characters studied (except for the character plant height), indicating a wide diversity among the parental materials.

The parental lines with best general combiner (P1, P2, P6 and P8) would be used in synthetic sunflower variety development. Besides, the crosses with significant desired SCA effect would be used in hybrid sunflower variety development.

ii) Development of composite sunflower variety

The seeds from composite-2 were grown at the research field of ORC, BARI Gazipur on 20 November 2018. Seeds were sown in 10 m x 10 m plot, maintaining row to row distance 50 cm and plant to plant distance 25 cm. The inbreds were allowed to intermate by open pollination in isolation. Fertilizers were applied @ 25:35:55:18 kg/ha of NPKS, respectively from Urea, TSP, MP and Gypsum. Half of the Urea and other fertilizers were applied at the time of final land preparation. The remaining half of the Urea was applied as top dress during flower primordial stage. Other intercultural operations were done when necessary to obtain optimum plant growth.

During the growing season, the undesirable types were discarded to achieve uniformity and homogeneity in various morphological characters. The data were taken from 10 randomly selected plants on days to flower, days to maturity, plant height (cm), stem diameter (cm), head diameter (cm), seeds/ head, seed yield/head (g) and 1000 seed weight (g). The plants were harvested in bulk as composite-3 and kept for growing as composite-4 in the next *rabi* season.

Development of dwarf high yielding sunflower variety through induced mutagenesis:

i) Evaluation of M3 mutants

Gamma radiation treated M3 seeds of sunflower inbred P-S-2 and SVS019001 and variety BARI Surjamukhi-2 were used in this study. All the M3 seeds (obtained from *rabi* season 2017-18) along with a total of 150 non-irradiated seeds from each genotype were sown at the research field of ORC, BARI Gazipur on 27 November, 2018 to generate M3 population. The seeds were grown in 4 m long plot maintaining 50 cm×25 cm row to row and plant to plant distance, respectively.

Fertilizers were applied @ 25:35:55:18 kg/ha of NPKS, respectively from Urea, TSP, MP and Gypsum. Half of the Urea and other fertilizers were applied at the time of final land preparation. The remaining half of the Urea was applied as top dressing during flower primordial stage. Other intercultural operations were done properly to obtain optimum plant growth. Plot of each treatment was covered with mosquito net to prevent outcrossing and selfing was done within the treatment. The entire M3 populations were grouped into tall (plant height above 110 cm), medium dwarf (plant height between 65-110 cm), dwarf (plant height less than 65 cm), big headed (head diameter greater than 17 cm) and branched mutants (more than one head) compared to the non-treated plants. Mature heads of each group were harvested separately and seeds from all tall plants and rest of the plots were bulked and kept for growing as M4 generation in the next rabi season.

A total of 124 single head from medium dwarf, dwarf, branched and big headed mutants were harvested and kept separately. The dwarf and medium dwarf mutant would be used for the dwarf sunflower variety development. The big headed mutant would be used for high yielding sunflower variety development. Whilst, the branched mutant could be a source of material for the development of hybrid sunflower. All the tall plants were harvested as bulked and kept.

The T3 (300GY) radiated inbred lines P-S-2 and SVS019001 did not show much variation compared to control population. Therefore, the seeds from

these inbred were harvested as bulk and stored. All the selected and bulked seeds will be grown in the next rabi season for further evaluation.

Molecular characterization of sunflower dwarf mutants by the expression analysis of *ent-kaurenoic acid oxidase1* (*HaKAO1*) gene sequence

Dwarf mutant created by Gamma Radiation and EMS of sunflower were grown in the field during rabi 2018-19, at the research field of ORC, BARI Gazipur. The leaves of 40 day old both wild and mutant plant were collected, clean with distilled water, cut into small pieces, immediately frozen in liquid nitrogen and stored at -80 °C for extraction of Total RNA.

Approximately, 0.1 g of frozen leaf tissue was ground in liquid nitrogen to a very fine powder with a pestle in a pre-chilled mortar. The ground material was transferred to a 1.5 ml micro centrifuge tube and Total RNA was extracted using Trizol Total RNA extraction kit according to manufacturer instructions. The quantity of RNA were determined by taking spectrophotometer readings at wavelengths of 230, 260, and 280 nm. According to Sambrook*et al.,* (1989) pure RNA has a A_{260}/A_{280} ratio of between 1.8 and 2.0. To The quality of RNA was determined by separating on 1.2% (w/v) TAE agarose gel and electro phoresed at 80 V for 1hr 15 min.

First strand cDNA was derived from 2 µg total RNA using the Revert Aid First Strand cDNA Synthesis kit (Thermo Fisher Scientific) according to manufacturer instructions.

The quantity and purity of extracted RNA were determined using a spectrophotometer. The absorbance ratio $A_{260/280}$ for all samples ranged between 1.85-2.01. The $A_{260/230}$ ratio of all samples (except one) ranged from 1.80-1.96.

Total RNA samples showed distinct bright bands of 28S rRNA and 18S rRNA with a ratio of approximately 1.5 to 2:0, in TAE agarose gel.

First strand cDNA was synthesized from approximately 2.0 µg of total RNA using the RevertAid First Strand cDNA Synthesis kit (Thermo Fisher Scientific) according to manufacturer instructions and stored at -80 °C. This cDNA will be used in analysis of *ent-kaurenoic acid oxidase1* gene and *FatA* and *SAD* gene sequence in mutant sunflower and its wild type.

Creation of mutant sunflower through EMS: Evaluation of M_2 mutants

EMS treated M2 seeds of sunflower variety BARI Surjamukhi-2 were used in this study. All T1 (0.6% EMS treated) and T2 (0.8% EMS treated) treated M2 seeds (obtained from rabi season 2017-18) were sown in head to row method at the research field of ORC, BARI Gazipur on 27 November, 2018 to generate M3 population. Along with a total of 150 non-treated seeds were also sown. The seed were grown in 4 m long plot in required number of rows maintaining 50 cm×25 cm row to row and plant to plant distance, respectively.

Fertilizers were applied @ 25:35:55:18 kg/ha of NPKS, respectively from Urea, TSP, MP and Gypsum. Half of the Urea and other fertilizers were applied at the time of final land preparation. The remaining half of the Urea was applied as top dressing during flower primordial stage. Other intercultural operations were done properly to obtain optimum plant growth. Plot of each treatment was covered with mosquito net to prevent out crossing and individual head was self-fertilized using rubbing.

In M2 segregating generation, EMS treated (from both of T1= 0.6% and T2= 0.8%) BARI Surjamukhi-2 seeds were categorized into branched (The plant possesses more than one head) and bigheaded (plant with head size more than 17 cm) mutant compared to non-treated control population. However in segregating population no dwarf plant (plant height less than 65 cm) was obtained. A total of 30 and 32 single head from big headed and branched mutants, respectively were harvested and kept separately for further evaluation. Rest of all the tall plants were harvested as bulked and kept for further investigation.

Crop management

Effect of different storage containers on the seed quality of sunflower

Experiment was conducted at the Central laboratory of Oilseed Research Centre, BARI, Joydebpur, Gazipur-1701 during the period from October to February 2018-19. Experiments were

laid out in Factorial Complete Randomized Design (CRD) with three replications. Seeds were stored in ambient condition. Five storage period and five container were used in this experiment. Storage periods are i. October, ii November, iii December, iv. January and v. February. Storage period commenced on 01 October and data were taken in every 01 month interval on different physiological observations. One sunflower variety (BARI Sunflower-2) was used for the experiment. Seeds were stored in different air tight packing system viz, Plastic container, Earthen pot, Polythene, Tin container and Gunny bag at room temperature (25+1°C) from October to February. Seed moisture percentage was noted in one month interval of each treatment. Seed moisture content was determined by the Farmpoint Moisture Analyzer. Seeds were placed on sand media in the plastic plat every month interval i,e. October, November, December, January, and February. The plastic pots were placed in room temperature up to 10 days for germination. Seedlings were counted every day up to the completion of germination at ten day. The following data were recorded: a. germination % b. root length (cm) c. shoot length (cm) d. vigor index. Germination percentage was calculated using the following formula (Krishnasamy and Seshu, 1990).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds tested}} \times 100$$

Seed vigour index was calculated by using the following formula (Baki and Anderson, 1973).

Seed vigour index = Germination (%) x (Mean shoot length + Mean root length)

Among the five containers, tin and plastic container were the best for sunflower seed storing due to higher germination (%), less abnormal seedlings, higher seed vigour with higher oil content and the gunny bag and earthen pot were not suitable as container for sunflower seed storage for long time.

Effect of different spacing on sunflower production in southern region of Bangladesh

The experiment was conducted at the research field of Oilseed Research Centre (ORC), BARI, Gazipur during the *rabi* season of 2018-2019 to identify the suitable plant to plant and row to row spacing of newly developed sunflower variety in Bangladesh. There were four treatments viz., T_1: 40 x 20 cm, T_2: 40 x 25 cm, T_3: 50 x 20 cm and T_4: 50 x 25 cm (recommended spacing). The crop variety was BARI Surjamukhi-3. The experiment was design in RCB with three replications. Seed were sown in 27 December 2018 at Gazipur. Full amount of triple super phosphate, muriate of potash, gypsum, zinc oxide, boric acid and half of urea were broadcasted in the experimental plot at the time of final land preparation as per treatment. The rest half of urea was applied in equal amounts at 25 & 50 days after emergence. Two times irrigation at 30 & 70 days after sowing were applied during the growing period. At every one month interval plant samples were collected to measure the SPAD value, light interception data and dry weight content. Percentage oil content was estimated for each treatment after harvesting the crop. Seed yield (2.0 t/ha) was recorded highest in T_3: 50 x 20 cm which was higher than rest of the treatments but not differed significantly among the treatments.

Effect of different fertilizer doses on sunflower production

Accurately quantifying the optimum fertilizer rate is essential to maximize profitability and minimize potential negative environmental impact. An experiment was conducted at the Oilseed Research Centre (ORC), BARI, Gazipur during the *rabi* season of 2018-2019 to identify the suitable fertilizer doses for newly developed sunflower variety of ORC. There were four treatments *viz.*, T_1: recommended dose (RD), T_2: 20% less than RD, T_3: 20% more than RD and T_4: 30% more than RD. The crop variety was BARI Surjamukhi-3. The experiment was design in RCB with three replications. Seed were sown in 27 December 2018 at Gazipur. Fertilizers were applied as per treatment combinations. Two times irrigation at 30 & 70 days after sowing were applied during the growing period. At every one month interval plant samples were collected to measure the leaf area, SPAD value, light interception data and dry weight content. Percentage oil content was estimated for each treatment after harvesting the crop. Data on yield and yield contributing characters were recorded and analyzed statistically using SPSS program. Seed yield (2.18 t/ha) was maximum in T_4: 30% more than RD and lowest (1.12 t/ha) in T_1: (RD).

Disease management

Survey, isolation and indenification of diseases in sunflower

A survey Programme was carried out in different sunflower growing areas of Labukhali, Potuakhali, Rahmatpur, Barisal Dumki, Potuakhali, Kuakata, Potuakhali and Khulna, Dakope during December 2018 to May 2019 cropping season. Plant samples (viz. leaf, stem and flower) were collected and brought in the plant pathology laboratory for identification of the disease and pathogen following standard method. The pathogens were isolated from the samples following the "Tissue planting method". The isolated fungi were identified based on morphological characteristics observed under a compound microscope comparing standard keys. Four species of fungi namely *Alternaria helianthi, Fusarium* sp, *Rhizopus* sp**.** and *Sclerotium rolfsii*. were isolated from the infected plant parts of Sunflower Which were caused the diseases of Alternaria leaf spot, leaf blight, Head rot and Collar rot diseases. Furthermore, study was needed for the more confirmation about the diseases of sunflower in Bangladesh.

Effect of some fungicides in controlling leaf blight of sunflower

The study of the efficacy of some fungicides against leaf blight (*Alternaria helianthi*) disease of sunflower was conducted in the field of Oilseed Research Centre (ORC), BARI, Joydebpur during 2018-2019 cropping season to select a suitable fungicides against leaf blight of sunflower.

Seeds of BARI Sunflower-2 were sown on 14 November 2018 .The experiment was designed in RCB with 3 replications where plot size was 3m x 2m. Irrigation and other intercultural practices were done as and when necessary. The spacing was 50 cm x 30 cm. Eight treatments including control were in this experiments. The treatments were: T_1 = Rovral (2g/L) , T_2 = Amistertop(1g/L) T_3 = Indofil(2g/L) , T_4 = Autostin(2g/L) T_5 = Tilt(2g/L), T_6 = Secure (2g/L) T_7 = Archar (2g/L) T_8= Defence (1g/L) T_8= Extra (2g/L) and T_{10} = Control. The crop was allowed to grow under natural infection. There sprays were applied on January 18, 28 and 10 February ,2019. In each plot 10 plants were randomly selected and targeted for data recording. Disease data were recorded before 10 days of harvest. Percent Disease Incidence (PDI), head diameter, No. of seed//head, 1000 seed weight(gm) and yield(kg/ha) were recorded. *Alternaria* Blight of sunflower scored according to 0-5 scale developed by Meah(1994). The scale was 0= leaves free from leaf spot (HR), 1= 0.1-6% leaf or pod area diseased (R), 2= 6.1-12% leaf or pod area diseased (MR), 3= 12.1-25% leaf or pod area diseased (MS), 4= 25.1-50% leaf or pod area diseased (S) and 5= above 50% leaf or pod area diseased (HS). All fungicides showed significantly better performance over control. The highest disease reduction (50 %) was obtained from Rovral treated plot followed by Amistertop(45%) and Indofil(39%) treated plot. The highest yield(2.3 t/ha)was also found in Rovral treated plot followed by Amistertop (2.2t/ha) and Indofil (2.1t/ha) treated plot. Control plot produced highest disease incidence(56%) and lowest yield (1.4 t/ha). Considering PDI, seed yield and yield contributing character Rovral was the best but, Amistertop and Indofil was also found decreasing the disease incidence and increasing seed yield of sunflower at par with Rovral.

Linseed

Maintenance and evaluation of linseed germplasm

Forty five linseed genotypes including check variety Neela were evaluated and maintained in the experimental field of Oilseed Research Centre, BARI, Gazipur during *rabi* 2018-2019. The highest CV% was recorded for the parameter 10 plant yield followed by plot yield (kg/ha). Collected seeds were conserved properly. The seed will be rejuvenates in the next year.

Observation trial of linseed

A total of eight linseed lines including released variety Neela were evaluated at ORC, BARI, Gazipur during *rabi* 2018-2019. Among the genotypes significant differences were observed for days to flower, plant height and number of pod/plants. The highest 10 plant yield and yield (kg/ha) was found in Lin-w-2017 as compared to Neela.

Crop Management

Screening of linseed genotypes against salinity at seedling stage

The experiment was conducted at the laboratory of Oilseed Research Centre, Bangladesh Agricultural Research Institute (BARI). Twenty five genotypes of linseed were used. The experiment assessed the germination and seedling growth of linseed genotypes at control, 4, 8 and 12dS/m NaCl salinity levels. The salt solution was prepared by calculated amount of NaCl in Hogland solutions. The pH of solution was maintained at 6. Plastic pots were used in the experiment with a diameter of 10 cm, height was 9 cm and arranged in a completely randomized design (CRD) with four replications. Each pot was supplied with 500 ml of the respective treatment solution having cotton gauge which covered the lid with small holes through which the roots can reach the solution. Seeds were sown on the lid of the plastic pots. The germination count was taken after 72 hours of sowing of seeds. A seed was considered to have germinated when both the plumule and the radicle emerged > 0.5cm. After 15 days, the shoot and the root length of ten randomly selected seedlings from each replicate were measured following a draftsman ruler. Following ISTA rules seed quality such as percent of germination, root-shoot length and total dry weight were recorded.

Germination percentage (GP) $= \frac{a}{b} \times 100$ Where: a = Number of seeds germinated

b = Total numbers of seeds used

The plants were then collected from the pots and the following parameters were measured, i.Root Length (cm), ii. Shoot Length (cm) and iii. Total dry matter/plant(mg). All the seedling traits showed a decreasing trend irrespective of the genotypes to salinity stress. Lin-703 showed the maximum root length, shoot length and total dry matter under saline condition. It was found that Lin-703, and Lin-803 was more tolerant to high salt concentrations than the others while Lin- Noakhali and Neela were the susceptible.

Niger

Variety Development

Maintenance and evaluation of niger germplasm

A total of twenty one niger genotypes including Shova as check were grown to evaluate and maintain at ORC, BARI during rabi 2018-19. The highest CV % was observed for the parameter number of branches per plant followed by pod per plant. Collected seeds were conserved properly to use for research work in the next year.

Safflower

Variety Development

Maintenance and evaluation of safflower germplasm

Seven Safflower genotypes including released variety BARI Saff-1 were grown to maintain and evaluation during *rabi* 2018-19. The maximum CV % were found for the parameter 10 plant yield (g) followed by number of pod per plant. Collected seed preserved properly. These seeds would be grown next year.

Observation trial of safflower

A total of five Safflower lines including released variety BARI Saff-1 were evaluated at ORC, BARI, Gazipur during rabi 2018-2019. The most dwarf genotypes were SAF-T-2017 and SAF-503 among the genotypes. The tallest entry was SAF-504. BARI Saff-1 produced maximum number of seeds and highest seed yield.

Post harvest and biochemical studies

Study on 5-aminolevulinic acid ameliorates salinity-induced growth, photosynthetic gas exchange and biochemical changes in *Brassica napus* L.

An experimental site was carried out during the period from 2nd week of Nobember, 2018 in net house of Central laboratory, Oilseed Research Centre (ORC), BARI, Gazipur. The physiological and biochemical characteristics of BARI Sarisha-16 (*Brassica napus* L) seedlings under salinity stress were investigated to ameliorate the effects of 5-aminolevulinic acid (ALA). Growth and physiological parameters of salt stressed mustard

seedlings treated with exogenous ALA were investigated; these parameters included shoot and root dry mass, leaf area, plant height, intercellular CO_2 concentration, stomatal conductance, net photosynthetic rate and transpiration rate. The contents of chlorophyll, proline, soluble proteins, malondialdehyde were evaluated. Results showed that the physiological characteristics of mustard seedlings under NaCl stress (12 dSm^{-1}) were inhibited. BARI Sarisha-16 seedlings treated with 12 dSm^{-1} NaCl and 30 mgL^{-1} ALA for every growth parameters recovered. Moreover, BARI Sarisha-16 seedlings treated with 30 mgL^{-1} ALA exhibited improved effectively physiological characteristics. Treatment with exogenous ALA increased plant height, leaf area, shoot and root dry mass, net photosynthetic rate, transpiration rate, intercellular CO_2 concentration and stomatal conductance). The treatment also increased the contents of chlorophyll, soluble proteins, and proline but decreased malondialdehyde content. These findings indicate that exogenous ALA treatment could improve or mitigation of growth and relieve the salt stress injury of BARI Sarisha-16 seedlings by increasing photochemical efficiency, osmotic regulation and biochemical activity.

Study on biochemical and antioxidant responses of selected mustard genotypes under salinity condition

The research work was conducted during the period from 1st week of Nobember, 2018 at Central laboratory of Oilseed Research Centre (ORC), BARI, Gazipur. Sixty five mustard genotypes were screened in pots under net house, ORC, BARI. After screening two mustard genotypes, BJ-1603 and BARI Sarisha-16 as newly identified tolerant genotypes, BARI Sarisha-14 as sensitive and BARI Sarisha- 11 as standard tolerant were grown in pots with three replications. In this study, physio-biochemical changes and antioxidant enzyme activities of mustard genotypes were evaluated, which may provide an insight into the mechanism of salt tolerance in mustard under salt stress. Different parameters such as shoot and root lengths, fresh weight (FW) and dry weight (DW)/plant, stomatal conductance (g_S), net photosynthetic rate (P_n), CO_2-assimilation rate (A), transpiration rate (Tr), total chlorophyll (Chl) content, malondialdehyde (MDA) content, potassium (K^+) and sodium (Na^+) content, leaf K^+/Na^+ ratio, and proline (Pro) contents, relative water content (RWC), as well as activity of antioxidative enzymes like superoxide dismutase (SOD), peroxidase (POD), catalase (CAT) ascorbate peroxidase (APX), glutathione reductase (GR), guaiacol peroxidase (GPX) and glutathione S-Transferase (GST) were studied. Salt treatments significantly decreased shoot and root lengths, FW, DW, P_n, A, Tr, g_S, Chl pigments and RWC while Pro, H_2O_2, superoxide, MDA and activities of SOD, POD, CAT, GR, GPX and GST enzymes increased in all mustard genotypes. In comparison with the tolerant genotype BARI Sarisha-11 as well as our selected genotypes had higher or similar trends of FW, DW, accumulation of Pro and MDA, Na^+, H_2O_2 and activities of SOD, APX, CAT, GR, GPX and GST. According to the results, the genotypes BJ-1603 and BARI-Sarisha 16 showed the better tolerance compared to salt sensitive genotypes against salt stress. Higher accumulation of Pro along with improved physiological and biochemical parameters in tolerant genotypes can confer tolerance by reducing oxidative damage through up-regulating antioxidant defense under salinity.

Onion

Varietal development

Collection, conservation and evaluation of onion germplasms

An experiment was conducted to select superior winter onion germplasm for higher yield and good keeping quality at Spices Research Centre, Shibganj, Bogura during 2018-2019. Twenty-five collected onion genotypes including BARI Piaz 4 and Ac Gaz 379 as check were used in this study. The experiment was laid out in alpha lattice design with three replications. Considering yield and other attributing traits the genotype Ac Bog 418 was found promising

Evaluation of collected onion germplasm for the development of base population

An experiment was conducted to select superior winter onion germplasm for higher yield and good keeping quality at Regional Spices Research Centre, BARI, Gazipur during 2018-2019. Twenty seven collected onion genotypes were characterized and evaluated in this study. The experiment was laid out in alpha lattice design with two replications. Considering yield and other attributing traits the genotype Ac Gaz397, Ac Gaz401, AcGaz384, AcGaz 390 were found promising.

Searching of male sterile and maintainer lines of onion

An experiment was conducted to search male sterile and maintainer lines of onion at Spices Research Centre, Shibganj, Bogura during 2018-2019. Only one F_1 was used in this study in the present season. Approximatly 20 kg bulbs from the F_1 were harvested to produce F_2 seeds in the next season.

Development of diverse onion germplasm through hybridization

An experiment was conducted to develop diverst onion germplasm through hybridization at Spices Research Centre, Shibganj, Bogura during 2018-2019. BARI Piaz 1, BARI Piaz 4 and AC Gaz 009 were used in this study. Diallel mating design was followed for crossing. A minimum amount of 10g seeds were harvested from each of the crosses.

Advanced yield trial of winter onion against thrips

The experiment was conducted at Spices Research Centre, Shibganj, Bogura during 2018-2019 to evaluate of onion lines against thrips infestation and to observe bulb yield potentiality. Two onion lines ON0326-1, ON0332 with BARI Piaz-1 and BARI Piaz-4 were used in this study. The experiment was laid out in randomized complete block design with four replications. It was observed that the highest plant height (52.50 cm) was recorded from ON0326-1 and the lowest (43.92 cm) was found from BARI Piaz-1. ON0332 gave the highest single bulb weight (39.28 g) followed by ON0326-1 (38.10 g) and the lowest was recorded from BARI Piaz-1(28.16g). In case of thrips infestation, it was observed that the minimum thrips population per plant (3.14) was recorded from ON0332 and the highest (23.65) was recorded in BARI Piaz-4. The highest bulb yield (18.74 t/ha) was found from ON0332 and the lowest (10.61 t/ha) was found from BARI Piaz-1. The highest bolting percentage and splitted bulb (20.16 and 36.28, respectively) was found from BARI Piaz-1 and the lowest (5.26 and 3.26%, respectively) was recorded from ON0332. In case of disease severity it was found that ON0326-1, ON0332 and BARI Piaz-4 were moderately resistant and BARI Piaz-1 was moderately susceptible to purple leaf blotch disease.

Regional yield trial of winter onion

The experiment was conducted at Spices Research Centre, Shibganj, Bogura, Spices Research Sub-center Lalmonirhat, Spices Research Sub-center

Faridpur and Regional Spices Research Center, Cumilla during December 2018 to April 2019 with a view to study the regional adaptability of the selected winter onion lines at different onion growing areas and to select promising winter onion line(s) for releasing variety. The experiment was laid out in randomized complete block design with four replications. Two advance lines of onion (ON0374, & ON0375) with BARI Piaz-1and BARI Piaz-4 were used as check in the study. In case of location the highest bulb yield (17.60 t/ha) was recorded at Bogura location and the lowest yield (13.96 t/ha) was recorded at Lalmonirhat location. In case of onion lines, the highest bulb yield (17.84 t/ha) was found from ON0374 and the lowest (11.74 t/ha) was recorded from BARI Piaz-1. Significantly the highest bolting percentage (13.52) was observed from BARI Piaz-1 and the lower (3.63) was found in ON0374. The Combined effect of location × onion lines gave significant effect on yield and other parameters. The highest bulb yield (21.04 t/ha) was recorded from ON0374 at Lalmonirhat location and the lowest (10.98 t/ha) was recorded from BARI Piaz-1 at Faridpur location.

Purification of BARI released onion varieties

An experiment was conducted to purify existing onion varieties at Spices Research Centre, Shibganj, Bogura during 2018-2019. BARI Piaz-1 and BARI Piaz-4 were used in this study. Approximately 250g seeds of both the variety were collected and conserved from the healthy true to type plants.

Cultural management

Effects of transplanting time on the yield and quality of onion

A field experiment was conducted during the winter season of 2018-2019 at Spices Research Sub-Centre, Bangladesh Agricultural Research Institute, Faridpur to determine the appropriate seedlings transplanting time on the yield and quality of onion bulbs. Varieties used in the trial were:BARI Piaz-1 and BARI Piaz-4. There were six levels of seedlings transplanting time such as T_1:November 15, T_2:November 30, T_3:December 15, T_4:December 30, T_5:January 14 and T_6:January 29. The experiment was laid out in a randomized complete block design of factorial concept with three replications. The results revealed that seedlings transplanting times, varieties and their combined effects had significant effect on the parameters studied with minor exception. The values for plant height, number of leaves per plant and incidence of bolting were gradually decreased with the passage of transplanting time. But yield attributes and yield were increased up to the third transplanting time. After that it was decreased destructively. However, due to minimum incidence of bolting, transplanting on December 30 exhibited the best performance for producing quality bulbs. Because of higher temperature and long day length, no bolting was occurred from January 14-29. For the same reasons, transplanting seedling on January 14-29 gave poor yield of onion. The variety BARI Piaz-4 performed better in respect of yield and yield attributes but it showed inferior quality. The combined effect of December 15 x BARI Piaz-4 gave the highest yield attributes and yield of onion followed by the combination of November 30 x BARI Piaz-4 and December 30 x BARI Piaz-4 while the values among the three treatments were statistically similar.

Performance study of selected spices, fruits and vegtables for roof top gardening

The experiment was conducted at Spices Research Centre, Shibganj, Bogura during 2018-2019 to study the performance of some selected spices, fruits and vegetable crops for different rooftop gardening, to ensure year round supply of fresh spices, fruits and vegetables, effective utilization of space and to increases the monetary value of land/apartment. Different spices, vegetables and fruit crops were used in this study and the study is on going.

Nutrient and water management

Yield potential of onion as influenced by nutrient management

The field experiment was conducted during three consecutive years 2016-17, 2017-18 and 2018-19 at the research field of Spices Research Centre, Shibganj, Bogura to determine the optimum dose of fertilizer for maximization of bulb yield of onion. In this trial BARI Piaz -4 was tested at different levels of fertilizer practices i.e. T_1 (Control), T_2 (STB dose), T_3

(STB + 15% extra of STB), T_4 (STB + 30% extra of STB), T_5 (STB + 45% extra of STB) and T_6 (Farmer's practice). All the treatments significantly influenced plant height, leaf length, number of leaves plant^{-1}, bulb diameter, marketable yield and total yield per hectare. The highest plant height (53.24 cm) was recorded from the treatment T_6 (Farmer's practice). BARI Piaz -4 from treatment T_5 (STB + 45% extra of STB) gave the best results with regard to number of leaves plant^{-1} (5.98), bulb length (7.21 cm), bulb diameter (5.52 cm) and single bulb weight (43.07g). The highest bulb yield was obtained from the treatment T_5: STB + 45% extra of STB (19.83 t/ha). Economic analysis of onion cultivation is shown in Table 3. The highest marginal benefit cost ratio (7.60) was also calculated from T_2 (STB dose). The lowest marginal benefit cost ratio 2.88 was obtained from T_6 (Farmer's practice) treatment. So considering MBCR, T_2 (STB dose) may be recommended for highest onion bulb production.

Effect of different levels of sulphur on growth and yield of onion

A field experiment was carried out at Spices Research Centre, Shibganj, Bogura during two consecutive years 2017-18 and 2018-2019 to evaluate the effect of different levels of S on growth and yield of onion. Five levels of sulphur viz. 0, 15, 30, 45 and 60 kg ha^{-1} were evaluated. Different levels of S significantly influenced plant height, number of leaves plant^{-1}, bulb diameter and total yield per hectare. The treatment T_3 (30 kg S ha^{-1}) gave the best results regarding plant height (50.57 cm), number of leaves plant^{-1} (7.68) at 75 DAT, bulb diameter (5.24cm) and total bulb yield (12.9 t ha^{-1}). The calculated optimum level of S from the regression curve for yield appeared to be 34.75 kg Sha^{-1}. So highest bulb yield was obtained from 35 kg S ha^{-1} along with a blanket dose of 100 kg N, 50 kg P, 75 kg K, 4 kg Z, 1.5 kg B ha^{-1} and 5 t cow dung ha^{-1}. Lowest growth and bulb yield were recorded from control T_1 (0 kg S ha^{-1}) treatment. However, the highest marginal benefit-cost ratio (12.77) was also found in treatment T_3 (S= 30 kgha^{-1}).

Insect pest and disease management

Identification of onion bulb associated fungi in storage and their management to reduce storage loss

The experiment was conducted at the field and store house of Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh during 2017-18 to identify post-harvest onion bulb associated fungi in storage and to find out the effective control measures to overcome the storage loss as well as to increase self-life of onion bulb. The field experiment was conducted for producing bulbs of BARI Piaz-1, BARI Piaz-2, BARI Piaz-3, BARI Piaz-4 and BARI Piaz-5 which were used in store house. Six treatments viz. Healthy and fresh Bulb, Bulb treatment with Cabriotop (0.3%), Bulb treatment with Provax 200 WP (0.25%), Bulb treatment with Amistar Top 325 SC (0.1%), Bulb treatment with Autostin DF (0.2%) and Control were used in store house. Aspergillus niger was the isolated storage fungi in onion bulbs. There were no effects of fungicides on rotted and sprouted bulbs of all varieties of onion for whole storage periods.Summer varieties viz. BARI Piaz-2, BARI Piaz-3 and BARI Piaz-5 showed around 50% rotted and sprouted bulbs at 32 DAI. But winter varieties viz. BARI Piaz-1 and BARI Piaz-4 showed 20 - 30% rotted and sprouted bulbs at 160 DAI. Among the winter varieties, BARI Piaz-4 was more stable to BARI Piaz-1. Among the summer varieties, sprouted bulbs were more than rotted bulbs, but rotted bulbs were more than sprouted bulbs in winter varieties.

Post harvest technology

Effects of pre and post harvest factors for quality seed bulb production of summer onion

A field trail was carried out during growing season *kharif* 2018 at the Spices Research Sub-Centre, BARI, Lalmonirhat, to study the effects of pre and post harvest factors for quality seed bulb production of summer onion. Three harvesting stage viz., H_1 (65 DAT), H_2 (75 DAT) & H_3 (85 DAT) and five curing levels viz., C_1 (5 days curing under shade house), C_2 (10 days curing under shade house), C_3 (15 days curing under shade house), C_4 (20 days curing under shade house) and C_5 (no curing) were used as treatment having a randomized complete block design with three

replications. Storage losses (sprouting, rotting percentage) was significantly higher with early harvesting. Similarly, without curing responded significantly higher on the storage losses. In case of quality (dry matter, TSS and marketability percentage) was registered in maximum under both delay harvesting and long time curing treatment. Among the treatment combination H_2 (75% leaf top fall) with C_4 (20 days curing under shade house) showed higher performance in quality parameter and reduced storage losses.

Study on drying kinetics and development of value added products from onion

This experiment was undertaken to study the drying behavior of summer onion by mechanical dryer under different condition (temperature and thickness) and prepared onion powder from fresh summer onion. Drying rate was increased with the increased of temperature and decreased with the increased of thickness. Dehydrated onion powder was developed in laboratory and its packaging and nutritional value also evaluated. Finally sensory evaluation of onion powder was conducted in comparison of fresh onion in curry.

Technology transfer

Validation trial of onion and garlic varieties in char land at lalmonirhat region

The trial was conducted at char gobordhan (Mohiskhocha), Aditmari unde Lalmonirhat district during November 2018 to March 2019. BARI Rashun-2 and BARI Piaz-1 were included in the study. The seed of two varieties with required chemical fertilizers had supplied to two farmers for 20 decimal land. The results revealed that comparatively better performance showed during growing season. The average yield of garlic and onion varieties were 16 and 32 kg/decimal, respectively.

Garlic

Varietal development

Evaluation of garlic germplasm

The experiment was conducted at Spices Research Centre, BARI, Shibganj, Bogra during *rabi* Season 2018-2019 to select the promising garlic germplasm for releasing a variety. Fourteen different garlic lines (GC0043, GC0047, GC0046, GC0045, GC001, GC005, GC0012, GC0018, GC0029, GC0030, GC0017, GC0042, GC0036, GC0040 and BARI Rashun-3 check as) were collected and evaluated based on their yield and other desirable characters. The experiment was laid out in RCB design with three replications. Among the lines, the highest yield (13.40 t/ha) was obtained from GC0047and the lowest (5.80 t/ha) was found from GC0012. Disease severity was also lower in GC0047. Significantly all the yield contributing characters found better from GC0046.

Advanced yield of garlic line

The study was conducted at the farm of Spices Research Centre, BARI, Shibgonj, Bogra during rabi Season 2018-2019 to select the promising garlic germplasm for releasing a variety. The experiment was laid out in RCB design with three replications. Six different garlic lines (GC0038, GC0044, GC0035, GC0027, GC0031and GC0013) including BARI Rashus-3 as check were evaluated based on their yield and other desirable characters. Among the lines, the highest yield (12.57 t/ha) was obtained from GC0044and the lowest (8.93 t/ha) was found from GC0031. Disease severity was also lower in GC0044. The signification variation was found in plant height, number of leaves/plant, bulb length, bulb width, clove length, clove width, yield /plant and yield t/ha. Considering all the characters, the lines GC0038, GC0035 and GC0044 were found promising and selected for next year trial.

Post harvest technology

Development of shelf stable value added products from garlic

This study was concerned with the dehydration kinetics of garlic in mechanical dryer at different temperature to develop processing techniques and to reduce post-harvest losses of garlic. Drying of garlic in a cabinet type mechanical dryer at low temperature (52 to 68ºC) for a specific moisture ratio showed that the least drying time was achieved at 68º C, followed by 60°C, while the highest drying time was required at 52°C to dry garlic cloves. Thus shelf stable products could be developed by mechanical drying with or without pretreatments. Studies on packaging materials

showed that for long time storage at room temperature (RT) aluminum foil, ALF-0.08mm, Poly bag PB-0.09mm and plastic pot PP- 1.75 may be used as packaging material, while for storage at refrigerated temperature (RFT) all films can be used. The chemical compositions of the fresh and dehydrated garlic products were determined and it was observed that the qualities of the products were satisfactory. Organoleptic taste testing showed that all the developed products were accepted by the panelists. The study thus shows that high quality shelf-stable garlic products can be developed utilizing available low cost dehydration processes and thereby, post-harvest losses of garlic can be reduced to an acceptable level

On-farm verification trial of garlic varieties

The experiment was conducted at MLT site Bauphal, and MLT site Kuakata during rabi season of 2017-18 with different types of BARI released Garlic varieties, e.g: B ARI Rashun -1, BARI Rashun- 2, BARI Rashun - 3 and Local Rashun, to observe their performance in farmers' field. Among the varieties at both locations Kuakata and Bauphal BARI Rashun -3 gave highest yield (5.3 t/ha) and (4.7 t/ha) respectively. Local Rashun gave the lowest seed yield (4.4 t/ha and 3.84 t/ha) at both location.

Chilli

Varietal development

Evaluation of winter chilli lines

The experiment was conducted at Spices Research Centre, Shibganj, Bogura during 2018-2019 with a view to identifying suitable winter chilli line (s) and to develop good breeding line(s) for improvement of chilli. Three chilli lines *viz*., C0716, C0724, C0725 and BARI Morich-3 were used in this study. The experiment was laid out in a randomized complete block design with five replications. In case of days to 50% flowering, it was observed that C0724 produced 50% flowers within 62 days. The highest days was needed to 50% flowering (84 days) by C0725. The minimum days were needed to produce 50% mature fruits (112 days) by C0724 and the highest days were needed to produce 50% mature fruits (127 days) by BARI Morich-3. It was observed that C0724 given higher number of fruits and the highest fruit weight per plant (217 and 385.22 g, respectively) and the lowest (125 and 177.12 g, respectively) was found from C0716. The highest single fruit weight (2.30g) was found in C0724 and the lowest single fruit weight (1.41 g) was found from BARI Morich-3. The highest fruit length (8.34 cm) was recorded from C0724 and lower fruit length (5.66 cm) was found from C0716. The lowest skin thickness (0.29 mm) was found from BARI Morich-3 which was followed by C0725 (0.33 mm), C0724 (0.34 mm) and the highest skin thickness (0.48 mm) was found from C0716. The line C0724 gave the highest green chilli yield (13.17t/ha) and the lowest was recorded from C0716 (7.08 t/ha).

Evaluation of summer chilli

The experiment was conducted at Spices Research Centre, Shibganj, Bogura during April-October 2018 with a view to identifying suitable summer chilli line (s) with good yield. Nine chilli lines viz., C0718, C0719, C0720, C0723, C0726, C0727, C0728, C0729, C0730 with BARI Morich-2 were used in this study as check.The highest plant height (100.16 cm) was recorded from C0719 and the lowest (80.90 cm) was found from C0723. In case of days to 50% flowering, it was observed that C0723 produced 50% flowers within 43 days and the highest days were needed to 50% flowering (63 days) by C0718. The minimum days were needed to produce 50% mature fruits (88 days) by C0723 and the highest days were needed to produce 50% mature fruits (111 days) by C0718. It was found that C0727 gave the highest number of fruits per plant and fruit weight per plant (262 and 362.10 g, respectively) and the lowest (88 and 170.48 g, respectively) were found from C0730. It was observed that C0727 gave the highest green chilli yield (12.82) followed by BARI Morich-2 (12.82 t/ha) and C0723 (12.43 t/ha) and the lowest (7.28 t/ha) was found from C0730.

Searching of CMS and maintainer lines of chilli

The experiment was conducted at Spices Research Centre, Shibganj, Bogura during 2018-2019 with a view to search the maintainer line of chilli and to identify male sterile line from segregating population of hybrid chilli. Ten hybrid chilli lines with A & B line were used in this study. A and B line was collected from World Vegetable Centre, Taiwan. Hybrid lines were collected from home

and abroad. For increasing more seeds collected seeds of A line and B line were sown again in the seed bed. Now it is vegetative stage. In case of Hybrid chilli lines ripe fruit were collected for next year study. Seeds of A line and B line collected separately for further study.

Screening of chilli lines against blossom drop

The field experiment was carried out at Regional Spices Research Centre, BARI, Joydebpur, Gazipur during the month from November 2018 to May 2019 to study the blossom dropping habit of different chilli lines and to select less or non-flower dropping chilli line. Twenty chilli lines were considered in the experiment. Seedlings of different lines were transplanted on November 14, 2018. Plot size was 3.0×1.0 m^2 maintaining 50 cm× 50 cm row and plant spacing. The highest blossom drop were recorded from C0633 (1108.67) and the lowest dropped bud (226.33), flowers (924.33) and fruits (26) were recorded from C0611-2, IAH163 and C0631, respectively .Maximum bud dropping (15-18) was found in three chilli lines (CO626,CO633, RT34) at low temperature of 10.8 and 12.5^0 C and that of six chilli lines (CO 634 , CO 635, RT-34, C0610, C0517-1, C0626) dropped maximum flowers (14-20) at different low temperature. Seven chilli lines (CO 517-3 , 610 , CO 611-1 , CO 628 , IAH 162 , CO 633, CO 635) dropped maximum buds (17-22) and that of rest thirteen chilli lines dropped maximum flowers at high temperature (33 and 34^0 C), respectively. Considering relative humidity, it was found that a high humidity (>70 %) caused blossom drop. Maximum bud (14-20) and flowers (17-22) was recorded in seven (RT 34, C0626, C0635, C0633, C0162, C0517-1, C0571-2) and four chilli lines (CO633, CO 634 , RT33 , C0635), respectively when >80-91.5% RH was prevailed. C0517-1 possessed of the highest reproductive efficiency (24.2 %) and C0517-1, C0517-3, C0610, CO590 may be considered as less blossom drop chilli lines

Collection and evaluation of chilli genotypes for their tolerance to drought stress

A field study was conducted out at the Regional Spices Research Centre, Gazipur during *rabi* season, 2018-19 to evaluate the effect of drought stress to morphological and leaf growth attributes of green chilli. The Split Plot Design was used in this experiment with drought stress as main plot (100%, 75%, 50% of field capacity, FC) and chilli genotypes as sub plot (CO631, CO632, CO634, CO636, CO637, CO639, CO640, CO641, CO642, CO643). The maximum decrease of growth and yield was recorded under the high level of water stress (50% FC) compared to optimum water supply (100% FC). CO632, CO643, CO636, CO637 and CO640 were the genotypes that could survive under drought stress and still provide the higher yield. Stomatal conductance and leaf area index showed more reduction in susceptible genotypes than the tolerant ones where as Fractional Interception of photosynthetically active radiation (FIPAR) was found minimal in tolerant genotypes.

Evaluation of chilli genotypes against thrips and mite

The field study was conducted at Spices Research Centre, Shibganj, Bogura, Bangladesh (geographic coordinates 25.0167° N, 89.3167° E) during Rabi season of 2018-19 to test the performance of different chilli genotypes against thrips and mite. Eleven different chilli genotypes (C01212, C01111, C01236, C01511050, C0587, C0INDCH-39, C01346, C0428, C0614, C0145 and C01245) along with BARI Morich-1, 2 and 3 were evaluated against thrips and mite. Out of eleven chilli genotypes screened against thrips and mites, none was found completely free from the attack of pests. The three genotypes, C0145, C01212 and C01236 recorded lowest number of thrips, mite and leaf curl were found resistant, three genotypes, C01346, C01245 and BARI Morich-2 were found moderately resistant, five genotypes, C01111, C01511050, C0587,BARI Morich-1 and 3 were found susceptible and three genotypes viz., C0INDCH-39, C0428 and C0614 were found highly susceptible to both thrips and mite. Thrips and mite populations are negatively correlated with Chlorophyll Concentration Index of leaf. Further resistant and moderately resistant genotypes showed thick and dark green colour leaves, very thin and light green colour leaves was observed in highly susceptible genotypes. The maximum fruit yield of chilli was also obtained from the genotype C0145 (16.73 t/ha) followed by the genotype C01212 (15.79 t/ha) and C01236 (14.29 t/ha).

Maintenance breeding of chilli

The experiment was conducted at Spices Research Centre, Shibganj, and Bogura during 2018-19 with a view to maintain the varietal purity through maintenance breeding. Two chilli varieties BARI Morich- 2(year round) and BARI Morich-3 (winter variety) were used in this study. Desired plants were selected according to the morphological characters of the mother parent. Red ripe fruits were collected from the specific characterized plants for maintaining varietal purity. After ripening seed were collected, processed and stored.

Hybridization of winter chilli

The experiment was conducted at Spices Research Centre, Shibganj, Bogura during 2018-19 with a view to creating variability and to exploit heterosis for future crop improvement program. Crossing was made by 4 x 4 full-diallel fashion. One chilli line (C0721) and BARI Morich-1, BARI Morich-2 and BARI Morich-3 were used in this study. F_1 seeds along with parents were collected and stored for future study.

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Advanced yield trial of winter chilli

The experiment was conducted at Spices Research Centre, Shibganj, Bogura during 2018-19 with a view to develop suitable winter variety for green chilli. Two chilli lines viz., C0721, C0722, and BARI Morich-3 were used in this study. The experiment was laid out in a randomized complete block design with five replications. In case of days to 50% flowering, it was observed that C0721 produced 50% flowers within 60 days followed by C0722 (65 days) and the higher days were needed to 50% flowering (72 days) by BARI Morich-3. The minimum days were needed to produce 50% mature fruits (121 days) by C0721. The highest days were needed to produce 50% mature fruits (130 days) by BARI Morich-3. It was observed that C0721 gave the highest number of fruits per plant and the highest fruit weight per plant (410 and 438.20 g, respectively) and the lowest of these parameters (280and 305 g, respectively) was found from BARI Morich-3. The maximum fruit length (8.79 cm) was recorded from BARI Morich-3 and lower fruit length (6.96 cm) was found from C0721. The line C0721 gave the highest green chilli yield (17.51t/ha) and C0722 gave the lowest (10.31 t/ha).

Regional yield trial of winter chilli

The experiment was conducted at Spices Research Centre Shibganj, Bogura, Spices Research Sub-centre, Lalmonirhat, Regional Spices Research Centre, Magura and Regional Spices Research Centre Cumilla during November 2018 to May 2019 to study the regional adaptability of the selected chilli lines at different chilli growing areas and to select promising winter chilli lines for releasing variety. Three advance lines of chilli (C0649, C0650 & C0701) with BARI Morich-3 were used as check in the study. The experiment was laid out in a randomized complete block design with four replications. Among the different locations, it was observed that the highest number of fruits per plant (404) was found at Lalmonirhat location and the lowest number (363) was found at Magura location. The highest green chilli yield (14.20) was recorded from Lalmonirhat location whili the lowest (12.82 t/ha) was recorded from Bogura location. Significantly the highest number of fruits per plant (407) was found from C0650 and the lowest (350) was found in C0649. The highest green chilli yield (14.95 t/ha) was recorded from C0650 followed by C0701 (14.52 t/ha) and the lowest (11.63 t/ha) was recorded from C0649. In case of combined effect of location and chilli advanced lines, it was observe that C0650 gave the maximum green chilli yield (15.51 t/ha) at Lalmonirhat location and the minimum yield (10.52 t/ha) was recorded from C0649 at Bogura location.

Regional yield trial of chilli in char land

The experiment was conducted at Mymensingh, Saghata (Gaibandha), Shariakandi (Bogura) and Sherpur during September 2018 to March 2019 with a view to studying the regional adaptability of

the selected chilli lines on different char land areas and to select promising winter chilli line for releasing variety. Two advance lines of chilli (C0666 & C0677) with BARI Morich-3 were used as check in the study. The experiment was laid out in a randomized complete block design with four replications. It was found that the maximum number of fruits per plant (534) was found at Saghata, Gaibandha location and the lowest number (449) was found at Sherpur, location. Saghata, Gaibandha location gave the highest dry chilli yield (4.25 t/ha) and the lowest (3.91 t/ha) was found at Sherpur location. The highest number of fruits per plant (552) was observed from C0677 and the lowest (431) was found in BARI Morich-3. The highest dry chilli yield (4.39 t/ha) was recorded from C0677 and the lowest (3.01 t/ha) was found from BARI Morich-3. It was found that C0677 gave the maximum dry chilli yield (4.63 t/ha) at Mymensingh location and the lowest (2.87 t/h) was observed from BARI Morich-3 at same location.

Characterization and evaluation of ornamental chilli germplasm

The research was carried out at the experimental field of Spices Research Centre, Shibganj, Bogura during *rabi* season, 2018-19 to identify chilli germplasm suitable for kitchen and roof top garden as ornamental and table purpose. The land was medium high and the soil was clay loam in texture. The unit plot size was 1.5m x 3m. Seven ornamental chilli germplasm were characterized and evaluated for their performance. The characterization was done according to "Descriptors for capsicum" by IPGRI, AVRDC and CATIE (1995). The yield and yield contributing characters varied significantly among the different ornamental chilli germplasm. The highest amount of fruit 1.254 kg/plant was harvested from the line OC18 because of its bigger sized fruit and heaviest single fruit weigh. The lower amount of fruit 0.124 kg /plant was harvested from the line OC06 which was identical to OC07 (0.180 kg/plant). Among the different germplasm the ornamental chilli line OC18 showed better performance in terms of yield potentiality. But the other lines also gave impressive result due to their different coloured fruit and attractive canopy structure.

Cultural management

Effect of NAA on blossom drop in chilli

A field experiment was carried out at Regional Spices Research Centre, BARI, Joydebpur, Gazipur during the month from November 2018 to April 2019 to standardize the optimum doses and time of spraying of NAA as foliar spray in reducing blossom drop. The experiment included four different levels of NAA *viz*., 0 ppm (D_1), 10 ppm (D_2), 20 ppm (D_3), 30 ppm (D_4) and 40 ppm (D_5) and three spraying time *viz*., 25 DAP(S_1), 10 days after 1st flowering (S_2) and 25 days after 1st flowering (S_3). Plot size was 3.0 m × 1.0 m and plot to plot distance was 50 cm. Seedlings of 35-40 days were transplanted on November 14, 2018 maintaining a spacing of 50 cm× 50 cm in RCB design (factorial) with three replications. Freshly prepared aqueous solution of NAA was sprayed three times according to treatments. Maximum number of flowers (120) were counted when no NAA was applied and that of minimum (54.58) with the application of 10 ppm (D_2) followed by 20 ppm (D_3). Application of 10 ppm NAA (D_2) of NAA and spraying at 10 days after 1st flowering (S_2) resulted minimum number of dropped flowers (55), buds (13) and fruits (1.5),respectively followed by 20 ppm (D_3) NAA . The highest plant height (123.5 cm) attained in D_2S_2 (application of 10 ppm NAA at 10 days after 1st flowering) which was statistically similar to D_3S_2 (118.4 cm) and D_2S_3 (113.3 cm), respectively. Maximum number of fruit (65.35) and heaviour fruits (133.6 g) were harvested with the application of D_2 (10 ppm) followed by 62.15 and 128.8 g , respectively in D_3 (20 ppm) at 10 days after 1st flowering (S_2).

Nutrient and water management

Effect of different sources of nitrogen on the growth and yield of chilli

An experiment was conducted at the research field of Regional Spices Research Centre, BARI, Gazipur during 2018- 2019 to evaluate the effect of different sources of N on growth and yield of chilli. The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications having five treatments combinations. Among the treatments application of DAP fertilizers had significantly influenced on plant height, days to anthesis, number of branches

plant^{-1}, number of fruits plant^{-1}, fruit size, fruit yield plant^{-1}, single fruit weight, fresh fruit yield, number of seed fruit^{-1}, 1000 seed weightand seed yield exceptfruit size, dry fruit yield and percentage germination days to fruit setting of chilli. The highest fresh fruit yield (7.96 tha^{-1}), dry fruit (1.76 t ha^{-1}) and seed (206.33 kg ha^{-1}) yield of chilli was obtained ($N_{100}K_{100}S_{20}Zn_3B_1$kg ha^{-1}) (N from DAP).

Effect of nitrogen and weather parameters on blossom drop in chilli

A field experiment was carried out at Regional Spices Research Centre, BARI, Joydebpur, Gazipur during the month from November 2018 to April 2019 to find out optimum doses of nitrogen to reduce blossom drop and relation between nitrogen and weather parameter (temperature and relative humidity) on blossom drop in chilli. Four different levels of nitrogen, viz., N_1= 50, N_2 = 100, N_3= 150 and N_4 = 200 kg/ha were considered in the experiment. The soil of the experimental field was sandy clay loam in texture having pH 6.0. Plot size was 3.0 m × 1.0 m and plot to plot distance was 50 cm. Seedlings of 35-40 days were transplanted on November 18, 2018 maintaining a spacing of 50 cm × 50 cm in RCB design with three replications. Significantly maximum number of dropped flowers (440) and buds (354.33) were recorded in N_4 (200 kg/ha) which was statistically similar to N_1 (50kg/ha). Minimum number of dropped flowers (314), buds (201.33) and fruits (22) were counted when 150 kg N/ha were applied. Maximum number of dropped bud and flowers (>14) were counted in maximum plants where 200 kg/ha N was applied as influenced by daily temperature and humidity. Maximum number of dropped flowers (22) were recorded in N_1 (50kg/ha) and N_4 (200kg/ha) plot influenced by low (15.2^{0}C) and high humidity (91.5%), respectively. The increase number of dropped bud and flowers were recorded with the increase doses of N (200kg/ha) which might be positively linked with low temperature and high humidity. Application of nitrogen = N_3 (150kg/ha) followed by N_2 (100 kg/ha) was found to be optimum to reduce blossom drop and positively linked with lower temperature and higher RH as well as produced maximum and heaviour fruits in chilli.

Insect pest and disease management

Management of chilli insect pests through trap crops

The field study was conducted at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh (geographic coordinates 25.0167° N, 89.3167° E) during *rabi* season of 2018-19 to evaluate the effectiveness of trap cropping Marigold, Carrot, Tomato, Groundnut and French bean with chilli for the management of chilli insect pests. BARI Morich-2 was trap cropped with Marigold, Carrot, Tomato, Groundnut and French bean. The treatments were T_1=Tomato trap cropped with onion; T_2= Groundnut trap cropped with chilli; T_3= French bean trap cropped with chilli; T_4= Carrot trap cropped with chilli; T_5= Marigold trap cropped with chilli and T_6= Sole chillii. Among the different trap crops tested, chilli trap cropped with marigold and tomato performed well by recording lowest population of sucking pests, leaf curl index, larval population of Helicoverpa armigera and Spodoptera litura with fruit damage. Whereas, the highest pest population of aphids, thrips, mite, leaf curl index, larval population of H. armigera and S. litura with fruit damage was observed in sole chilli crop. Mean yield data revealed that, the treatment chilli trap cropped with marigold recorded highest red ripe chilli yield of 11.70 t/ha and it was statistically similar to treatment, chilli trap cropped with tomato (11.30 t/ha) and chilli trap cropped with carrot (9.57 t/ha) whereas, trap crop yield was higher in chilli + tomato (22.80 t/ha) followed by chilli + French bean (12.62 t/ha) and chilli + carrot (12.05 lakh/ha). Among the different trap rcrops, the highest marginal benefit-cost ratio (24.53) was recorded from chilli + marigold, followed by chilli + tomato (20.71), chilli + carrot (17.86) and chilli + groundnut (10.76) whereas chilli +French bean trap crop recorded the lowest marginal benefit-cost ratio (7.99). Predators like coccinellids were found greatly distributed in the crop having different trap crops. Chilli trap cropped with marigold and tomato supported good activity of the predators. It appeared that growing trap crops in between the main crop and border of the main crops was found advantageous in the management of chilli pest's complex besides yield benefits.

Development of bio-rational based management approach against major insect pests of chilli

The field experiment was conducted at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh during *rabi* season of 2018-19 to develop a bio-rational based management approach against major insect pests of chilli. The treatments were six including control. Pheromone trap with spraying of Spinosad (Success 2.5SC) @ 1.2ml/L and Fizimite (Sodium lauryl ether) @ 1ml/L as well as soil application of recharge (Metarhizium anisopliae + Trichodarma) @3g/L resulted the lowest aphid (0.85 aphid/leaf), thrips (0.67 thrips/leaf), mite (0.95 mite/leaf) and fruit borer i.e Helicoverpa armigera (0.24 larvae/plant) and Spodoptera litura ((0.51 larvae/plant) with highest marginal benefit cost ratio of 3.84. Chilli fruit borer populations are negatively correlated with average temperature and rainfall but positively correlated with relative humidity. The highest percentage of aphid (85.42%), thrips (91.20%) and mite (85.45%) population reduction over control with maximum red ripe chilli yield (14.50 t/ha) was also obtained from Pheromone + Spinosad+ Fizimite + Soil recharge. So, Pheromone trapping with spraying of Spinosad (Success 2.5SC) and Fizimite (Sodium lauryl ether) as well as soil application of recharge (Metarhizium anisopliae + Trichodarma) may be recommended for effective management of insect pest's complex in chilli field

Management of choanephora blight of chilli

The experiment was conducted at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh during *rabi* season of 2018-19 to find out the effective control measures against Choanephora blight or wet rot disease of chilli. BARI Morich-2 was used in this experiment. Six fungicides, one bio-control agent and one untreated control were used as treatment. Amistar Top 325 SC (0.1%) resulted the lowest disease incidence (4.95%) which was followed by Trichoderma (0.5%) and Autostin (0.2%), and untreated control showed the highest incidence (20.45%). The highest single fruit weight (2.59 g), fruit length (6.71 cm), number of fruits/plant (350.11) and weight of fruits/plant (798.25 g) were recorded in Amistar Top 325 SC (0.1%) which was followed by Trichoderma (0.5%) and Autostin (0.2%), and the lowest of these parameters were found in the untreated control. Amistar Top 325 SC (0.1%) showed the highest fresh yield (15.49 t/ha) which was statistically dissimilar to other treatments, but followed by Trichoderma (0.5%) and Autostin (0.2%), and untreated control showed the lowest yield (8.39 t/ha) of chilli.

Post harvest technology

Efficacy of different seed drying and storage method on quality of chilli seed and its effect on chilli production

A lab followed by a field experiment was carried out at the field of Regional Spices Research Centre, BARI, Joydebpur, Gazipur during the month from May 2017 to October 2018 and November 2018 to April 2019. The experiment included three different levels of drying method, viz., D_1= Air drying, D_2 = Sun Drying, D_3= Bead drying and three Storing method, viz., S_1= Aluminium foil packet, S_2=Double polythylene packet, S_3 = Tin container and S_4 = Hermetic container (Bead box). Seeds were extracted from red ripe chillies of BARI Morich-3 and dried in netted wooden frame following Air and sun drying methods. Seeds were also dried with beads (D_3) and stored in Hermetic container (Bead box). Moisture % of seeds in different drying method, solar and air temperature (^{0}c) and relative humidity (%) was recorded from starting date of drying (9:15 am- 4:15 pm maintaining one hour interval) and continued till seed moisture attained in < 8-10 %. The initial moisture percentage of seeds was 14.5 and it decreased 13.9 (air dry), 11.5 (sun dry) and 12(bead dry) at the end of drying day. Days to drying was recorded 9, 6 and 4 in air, sun and bead drying method, respectively. The minimum moisture % was recorded in sun dried chilli seeds followed by drying with beads (8.0) before storing. The highest germination % was recorded in bead dried seeds (82) followed by sun (80) and air dry (75). The highest seed germination % was recorded in bead drying and stored in bead box and aluminium foil packet (83) and that of the lowest in air drying and stored in tin container (45). Sun dried seed and stored in bead box gave the longest root and shoot (4.5 cm and 3.0 cm) followed by stored in aluminium foil packet (3.59 cm and 2.78 cm), respectively. The highest number (73.0) chilli fruits were obtained from the seeds which dried in bead box and stored in aluminium packet and that

of heavier (134.11 g) fruits were obtained when sundried seeds were stored in bead box.

Ginger

Varietal development

Evaluation of ginger germplasm

The experiment was conducted at Spices Research Centre, BARI, Shibganj, Bogra during April 2018 to March 2019 to select the promising ginger germplasm for releasing a variety. Twenty different ginger lines (G0020, G0021, G0022, G0023, G0033, G0044, G0025, G0026, G0034, G0041, G0042, G0046, G0045, G0043, G004, G0010, G0036, G0031, G0040, and G0032) with BARI Ada-1 as check were evaluated based on their yield and other characters. The experiment was laid out in randomized complete block design with three replications. Significantly the highest plant height, number of tillers/plant, number of leaves/plant, weight of primary and secondary rhizome were observed in the line G0044. The highest yield (36.00 t/ha) was also obtained from G0044 and the lowest yield (19.15 t/ha) was found from G0021 line.

Regional yield trial of promising ginger lines

The experiment was conducted at Spices Research Centre, BARI, Shibgonj, Bogra and Spices Research Sub Center Lalmonirhat during April 2018 to March 2019. Four promising ginger lines (G005, G0028, and G001and G0027) were included in the study with BARI Ginger-1 as check. The experiment was laid out in randomized complete block design with three replications. Significant differences among the ginger lines were observed in both the location regarding different parameters. Significantly the highest rhizome yield was found from G005 in Bogra (30.20 t/ha) and Lalmonirhat (29,0 t/ha) while the lowest rhizome yield was found from BARI Ginger-1 in both location (20.10 t/ha and 19.89 t/ha respectively). Significantly higher plant height, number of tillers/plant, number of leaves/plant, weight of primary and secondary rhizome, dry matter (%) and yield along with better yield contributing characters were observed from the line G005. The highest dry matter (%) of 27.23 and 27.88 was found from G005 in Bogra and lalmonirhat location, respectively. The lowest dry matter 19.90 % and 19.98 % was obtained from BARI Ada-1 at Bogra and Lalmonirhat location, respectively.

Improvement of ginger through induced mutation

Ginger (Zingiber officinale Rosc.) is a monocotyledonous perennial herb in the family Zingiberaceae, grown mainly for its spicy and aromatic rhizomes. It is an important tropical horticultural plant valued for its aroma, flavor and medicinal properties. Ginger has basic antiseptic properties and is used as carminative and stimulant (Singh and Singh, 2000). It is obvious that ginger production in Bangladesh is based on a very narrow gene pool and improvement of ginger is greatly challenged as it is vegetatively propagated. Mutation breeding technique is one of the important accessories to mainstream plant breeding. With this technique 15-20% yield improvement and correction of the defects to a top cultivar are very easy and straight forward (Gaul, 1961). Pleotropic effects are very common and help fix the breeding lines even in M_3/M_4 generations. Genetic improvement of any yield attributes either qualitative or quantitative in nature, have been successful with this technique (Azad et al., 2010; Hamid et al., 2006; Shamsuzzaman et al., 1998 and Azam and Uddin, 1999. Therefore, genetic improvement of ginger can be done through induced mutagenesis. It serves as an important tool for creating usable genetic variability in crops (Iwo et al., 2011). It has the ability to change one or two characters without changing the entire characters in the genotype. Therefore, induced mutation in ginger through use of gamma-ray irradiation will proffer solution to creating or inducing desired attributes useful in ginger improvement. Therefore, an effort has been taken to induce variability for yield and yield related traits in the existing ginger cultivars of Bangladesh.

Cultural management

Development of ginger production technology under soilless culture using fertigation technique in Bangladesh

The experiments were conducted at Spices Research Center, Bogra during April 2018 to March 2019. The experiments were conducted to achieve the objectives. In experiment I. seven combinations of growth substrate 1) Coco-dust, 2) Sawdust 3) Rice bran, 4) 50% Coco-dust + 50%

sawdust 5) 50% Sawdust+ 50% rice bran, 6) 50% Coco-dust+ 50% rice bran and 7) Sandy loam soil (control) and three ginger varieties BARI Ada-1, BARI Ada-2 and BARI Ada-3 were compered. In experiment 11, two conventional methods 1) SRC recommended production practice and II) Farmer practice and three ginger varietys BARI Ada-1, BARI Ada-2 and BARI Ada-3 were studied. The main objective of the study was to determine the most suitable growth substrate for cultivation of ginger using fertigation technique and to produce disease free seed rgizome for higher yield. In experiment I, the study was conducted under the side- netted rain shelter equipped with an irrigation system to supply fertilizer solution at a regulated time schedule. Seven combinations of ginger substrates were evaluated. The treatments were arranged in randomized complete block design (RCBD) with six replications. Two polybag (plant) was used per treatment in each replication. The ginger plants were selected randomly and the rhizome were harvested 11 month after planting. Plants growth in Coco dust × BARI Ada-1 gave the best growth performance and yield compared to the other treatments. The highest rhizome yield 43.0 t/ha was obtained from plants grown in M_1V_1 (Coco dust × BARI Ada-1) followed by 36.4 t/ha in M_1V_2 (Coco dust × BARI Ada-2)). The lowest yield (8.1 t/ha) were found from M_7V_3 (Control × BARI Ada-3) treatment combination. In experiment II, the treatments also arranged in randomized complete block design with three replications. In this study, the highest rhizome yield (14.34 t/ha) was obtained from plants grown in P_1V_1 (SRC practices × BARI Ada-1 which was identical (13.12 t/ha) to P_1V_2 (SRC practices + BARI Ada-2) treatment combination. The lowest yield (6.93 t/ha) was found from P_2V_3 (Farmers practices × BARI Ada-3) treatment combination. The lowest rhizome yield in P_2V_3 (Farmers practices × BARI Ada-3) treatment combination might be due to highest disease infestation hat ultimately reduced the rhizome yield.

Insect pest and disease management

Integrated management of rhizome rot disease of ginger

The experiment was conducted in infected sick plot with rhizome rot disease at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh during 2018-19 to find the effective control measures of rhizome rot through an integrated management. Eight integrated treatments including control were used in this experiment. The test variety was used BARI Ada 2. The highest germination (97.83%) was recorded in Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP and the lowest germinaition (90.95%) was recorded untreated control. Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP resulted the lowest Rhizome rot incidence (15.45%) and control treatment showed the highest Rhizome rot incidence (45.88%). Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP showed the highest yield (28.15 t/ha) and control treatment showed the lowest yield (9.95 t/ha).

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Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP showed the highest yield (28.15 t/ha) and control treatment showed the lowest yield (9.95 t/ha).

Post harvest technology

Formulation of dehydrated fresh ginger and its post dehydration physico-chemical studies

This research was undertaken to develop processing techniques to reduce post-harvest losses and preserve ginger using low cost conventional technology based on dehydration process. The dehydration was carried out by pretreatment, osmotic dehydration and /or combined pretreatment /osmotic dehydration and air drying in a cabinet dryer. Drying of ginger in a cabinet dryer at low temperature (52 to 68ºC) for a specific moisture ratio showed that the least drying time was achieved at 68º C, followed by 60°C, while the highest drying time was required at 52°C to dry 5 mm ginger slice. Thus shelf stable products could be developed by mechanical drying with or without pretreatments. Studies on packaging materials showed that for long time storage at room temperature (RT) aluminum foil, ALF-0.08mm, Poly bag PB-0.09mm and plastic pot PP- 1.75 may be used as packaging material, while for storage at refrigerated temperature (RFT) all films can be used. The chemical compositions of the fresh and dehydrated ginger products were determined and it was observed that the qualities of the products were satisfactory. Organoleptic taste testing using 1-9 hedonic scale showed that all the developed products were accepted by the panelists. The study thus shows that high quality shelf-stable ginger products can be developed utilizing available low cost dehydration processes and thereby, post-harvest losses of ginger can be reduced to an acceptable level.

Turmeric

Varietal development

Regional yield trial of turmeric lines

The experiment was conducted at Spices Research Centre, Bogura; Regional Spices Research Centre, Magura, Joydebpur, Regional Agricultural Research station, Cumilla; and Spices Research Sub-Center, Lalmonirhat and Faridpur during May, 2018 to February, 2019. Three selected promising lines of turmeric (T075-1, T098, and T0119) with BARI Halud-5 as check were included in the study. The experiment was laid out in RCB design with three replications. The hundred percent emergence was recorded at 30 days after planting in T073-1 followed by T0119 (98.61) and T098 (94.46.)Different yield contributing characters of turmeric lines across all locations were found significant except number of tillers and mother rhizome. The highest number of leaves (22.93) and fingers (25.62), heavier mother rhizome (161.50 g), fingers (381.75 g), clump (541.78 g) and finally highest yield (25.13 t/ha) was obtained from T073-1. There were significant differences among the different characters at varied locations. The turmeric lines/varietal performances at Cumilla regarding different yield contributing characters were found best. The line× location effect of rhizome yield (t/ha) varied significantly. The results indicated that T073-1 gave the highest yield at SRSC, Lalmonirhat (27.33t/ha), RSRC , Joydebpur (27.0 t/ha), RSRC , Magura (25.33 t/ha) and SRSC, Faridpur (22.33 t/ha) followed by T0119 at RARS, Cumilla (27.0 t/ha) and SRC, Bogura (25.33 t/ha), respectively. The ranking of highest dry matter (%) was found in T073-1(28.8) followed by T0119 (27.4) while texture of tested lines varied 3.10-3.60 with deep orange yellow core color. T073-1 exhibited tolerance and T098 and T0119 exhibited moderately tolerance to leaf blight disease .

Post harvest technology

Value Chain Study of Turmeric in Selected Areas of Bangladesh

The study was undertaken to identify value chain actors and their functions and inter-relationship; determination of marketing and value chain system; value addition in different steps of value chain actor; marketing efficiencies; constraints of value chain and recommended intervention to overcome them. Primary data were used for this study. Primary data were collected from Panchagarh, Pabna, Rangamati and Jhenaidah districts depending upon the concentration of production and commercially marketing of turmeric and consuming area Dhaka and Chattogram. Data were analyzed using arithmetic mean, percentage, ratio, margin, profit, efficiency

ratio, and flow chart. Five major marketing channels were identified for domestic produced dry turmeric marketing. Channel-4 was the most important supply chain through which 24% domestic produced turmeric reaches to consumers. Out of five marketing channel, Channel-3 was more efficient than those of other channels. Eight actors like; farmer, local trader, trader, commission agent, wholesaler, processing industry, distributor, retailer and consumer were identified who were involved in the turmeric value chain systems. The study revealed that farmer added the highest amount of value Tk 3451.00 per quintal in non-processed turmeric followed by trader (Tk 2561.00), retailers (Tk 1744.00), local trader (Tk 1657.00) and wholesalers (Tk 1472.00), respectively. In the case of processed turmeric, processing industry added the highest amount of value and it was Tk. 11432 per quintal. Sixteen marketing problem were identified, among them price fluctuation, higher transport cost and lack of loan facilities were the major and common problem for most kinds of intermediaries involved in turmeric marketing in Bangladesh. It is therefore, recommended that loan facilities should be provided to the intermediaries and price fluctuation should be kept in reasonable limit by the government intervention. Natural gas and frequent supply of electricity should be ensured to turmeric processing industries for continuous production of processed turmeric. Technologies should be developed for the identification and removal of alpha toxin and heavy metal and to develop technique against the deterioration of colour of turmeric powder for enhancing export.

Coriander

Varietal development

Collection and evaluation of coriander germplasm

An experiment was conducted to select superior oriander germplasm for higher yield at Spices Research Centre, Shibganj, Bogura during 2018-2019. Thirty coriander genotypes including BARI Dhonia 1 and 2 as check were used in this study. The experiment was laid out in alpha lattice design with three replications. Considering yield and other attributing traits the genotype Cor 15, 20, 21 and 24 were found promising.

Technology transfer

Validation trial of BARI Dhania-1, BARI Kalozira-1, BARI Mouri-2 and BARI Methi-2 at char land

The performance trial was conducted at char bongram, Chilmari under Kurigram distric during October 2018 to Apri 2019. Four minor spics BARI Dhaina-1, BARI-Kalozira-1, BARI Methi-2 and BARI Mauri-2 were included in the study. The spices seed with required chemical fertilizers had supplied to four farmers for cultivati on for 30 decimal land. The results revealed that excellent crops condition occurred during growing season. The average yield of four minor spices were 4-5 kg/decimal.

Black cumin

Varietal development

Evaluation of black cumin germplasm

The trial was conducted at Spices Research Centre, BARI, Shibganj, Bogura during rabi season 2018-2019 to evaluate different black cumin germplasm collected from different sources and to identify the best germplasm with higher yield and other desirable characters. The land was medium high and the soil was clay loam in texture. The experiment was laid out in a Randomized Complete Block Design with three replications. Twelve different black cumin lines (viz. BC01, BC03, BC04, BC05, BC06, BC07, BC08, BC09, BC14, BC15-1, BC15-2 and BC16) were evaluated against BARI Kalozira-1 as check. Seed yield and other yield contributing characters were significantly different except capsule length, capsule diameter and 1000-seed weight. The higher amount of seed 1.306 t/ha was harvested from the line BC014 followed by BC009 (1.127 t/ha). The lower amount of seed 0.628 t/ha was harvested from the line BC015-2 followed by BC003 (0.767 t/ha) and BC005 (0.777 t/ha).

Cultural management

Effect of thinning and irrigation regimes on the growth quality and yield of black cumin

In this study, the effects of different thinning level under different irrigation regimes on the growth, yield and quality of black cumin were observed in a

field experiment. This experiment was laid out on two-factorial Randomized Complete Block Design with three replications during 2018-2019 at the Spices Research Sub-Cetre, BARI, Lalmonirhat. Three thinning level (T_1=1st thinning 25 days after sowing), (T_2=2nd thinning 35 days after sowing), (T_3=3rd thinning 45 days after sowing) and three irrigation regimes (I_1= vegetative stage + flowering stage), (I_2= Vegetative stage + casules stage), (I_3= Vegetative stage + flowering stage + casules stage) were used as treatment. Results showed that growth, yield component, yield and quality of black cumin were affected by different thinning level except plant height (cm) while the non-significant effects showed over growth, yield component and quality (plant population/LM) by different irrigation regimes. Most of the parameter responded in maximum in respect of second thinning among the different thinning level. The combination of second thinning and irrigation regimes (vegetative stage + flowering stage) produced the highest number of branching/plant (4.96), nu mber of capsules/plant (15.86), number of seeds/capsules (60.33), thousand seed weight (2.33 g) and yield (1.077 t/ha) which is flowed by combination of first thinning with different irrigation regimes. On the other hand, the treatment combination of first thinning with different irrigation regimes obtained maximum plant population due to effect of one time thinning than that of others treatment combinations.

Insect pest and disease management

Effect of fungicides, bio-agent and agronomical practices for the management of foot and root rot disease of black cumin

The experiment was conducted at Regional Spices Research Centre, BARI, Magura during November 2017-2018 and 2018-19 to find out the effect of fungicides, bio-agent and agronomical practices for the management of foot and root rot disease of black cumin. BARI Kalojira-1 was used as the test variety. The experiment was laid out in randomized complete block design with three replications and nine different treatments viz T_1: Autostin (carbendazim) @ 0.2% + raised bed, T_2: Cabriotop (pyraclostrobin 5%+ metiram 55% WG) @ 0.3% + raised bed, T_3: Trichoderma mixed compost @ 50 kg/ha + raised bed, T_4: Autostin (carbendazim) @ 0.2% + flat bed, T_5:Cabriotop (pyraclostrobin 5%+ Metiram 55% WG) @ 0.3% + flat bed, T_6: Trichoderma mixed compost @ 50kg/ha + flat bed, T_7: Trichoderma suspension @ 5ml/l + raised bed, T_8: Trichoderma suspension @ 5ml/l + flat bed and a control plot T_9. Significant differences regarding yield and yield attributes were observed among different treatments. The highest yield (1405.37 kg/ha in 2017 and 1384.6 kg/ha in 2018) was found from T_7 (Trichoderma suspension @ 5ml/l + raised bed) which was significantly higher than those of other treatments. The lowest yield (686.10 kg/ha in 2017 and 640.3 kg/ha in 2018) was found from control plot T_9. Significantly higher plant height, number of capsules/plant, number of seeds/capsule, less disease incidence with better yield contributing characters were observed from treatment T_7 (Trichoderma suspension @5ml/L + raised bed). The highest incidence of foot rot disease (40.57 % in 2017 and 33.26% in 2018) was from in T_9 (control) and the lowest disease incidence (4.20 % in 2017 and 7.32% in 2018) was observed in T_9: (Trichoderma suspension @ 5ml/l + raised bed).

Fenugreek

Varietal development

Evaluation of fenugreek germplasm

The trial was conducted at Spices Research Centre, BARI Shibganj, Bogura during *rabi* season of 2018-2019 to evaluate the fenugreek germplasm collected from different sources in terms of their yield potentiality and other desirable characters and to identify the best one(s). The experiment was laid out in a RCB design with three replications. Nineteen different fenugreek lines (FK01, FK07, FK08, FK09, FK012, FK014, FK016, FK017, FK018, FK021, FK023, FK024, FK025, FK27, FK028, FK029, FK030 and FK031) were evaluated against recommended variety BARI Methi-2. Seed yield and other yield contributing characters were significantly varied among the germplasm. The higher amount of seed 2.49 t/ha was harvested form the line FK25 followed by FK30 (2.35 t/ha) and FK28 (2.34 t/ha) and the lower amount of seed 1.21 t/ha was harvested from FK01. The experiment will be repeated in the next year for more confirmation of results.

Regional yield trial of fenugreek

The trial was conducted during rabi season of 2016-17, 2017-18 and 2018-19 to evaluate the performance of advance fenugreek lines at different agro ecological zone and to select the promising one for releasing a variety. The experiment was laid out in a Randomized Complete Block Design with three replications. Two advanced fenugreek line FK22 and FK15 were evaluated against recommended variety BARI Methi-2 as check. The trial was conducted at five different locations viz,. SRC, Bogura, RSRC, Gazipur, RSRC, Magura, SRSC, Faridpur and SRSC, Lalmonirhat. Seed yield and other yield contributing characters were significantly different among the germplasm in different location. Among the location, the higher amount of seed (2.97 t/ha) was harvested in Bogura location which was identical to Magura location (2.88 t/ha). The lower amount of seed (1.10 t/ha) was harvested in Gazipur location. Among the three variety/lines, the highest seed yield (2.2 t/ha) was obtained from the fenugreek line FK22 which was statistically identical to BARI Methi-2 (2.14 t/ha) and the lowest amount of seed 1.97 t/ha) was harvested from the line FK15 In case of combined effect of location and fenugreek variety/line, the highest amount of seed 3.24 t/ha was harvested from FK22 in Bogura. The lower amount of seed 1.04 t/ha was harvested from the line BARI Methi-2 in Gazipur. It was found that the advanced fenugreek line FK22 performed better in all location. Moreover, this line can be harvested 20-25 days earlier than the check variety BARI Methi-2.

Cultural management

Effect of stage of pinching on growth and yield of Fenugreek (*Trigonella foenum graecum* L.)

The experiment was conducted at Spices Research Sub-Centre, Faridpur during rabi season 2018-19 to determine the effects of different stage of pinching on growth and yield of Fenugreek. The experiment was arranged in Completely Randomized Block Design with three replications. Stages of pinching positively affected all the traits examined. Highest yield (2.73 t/ha) was found from pinching at 35 DAS and lowest yield (2.01t/ha) from no pinching treatment. Almost all parameters shows better result when plants were pinched at 35 days after sowing than plants pinching at 25, 45 days after sowing and no pinching.

Fennel

Varietal development

Evaluation of fennel germplasm

The trial was conducted at Spices Research Centre, BARI, Shibganj, Bogura during *rabi* season of 2018-2019 to identify the best germplasm with higher yield and desirable characters. The experiment was laid out in RCB design with three replications. Eleven different fennel lines with newly released variety (FN02, FN03, FN04, FN05, FN07, FN08, FN09, FN10, FN11, FN12, FN13 and BARI Mouri-2) were evaluated for yield and yield contributing characters. Seed yield and other yield contributing characters were significantly different among the germplasm. The highest plant height was recorded from FN04 (180.6 cm). The higher seed yield was obtain from BARI Mouri-2 (2.44t/ha) which was identical to FN10 (2.29) t/ha. The lowest seed yield was recorded from FN03 (1.91 t/ha).

Insect pest and disease management

Management of foot and root rot disease of fennel

The experiment was conducted at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh during *rabi* season of 2017-18 to find out the suitable control measures in controlling foot and root rot disease of Fennel. BARI Mouri 1 was used in the experiment. Four fungicides, turmeric powder, poultry refuse and one control were the treatment. Foot and root rot incidence of Fennel under different treatments ranged from 7.14 - 29.39%, while the lowest incidence was observed in Seed treatment and soil drenching with Provax 200 WP (0.25%) and the highest incidence was observed in untreated control. Seed treatment and soil drenching with Provax 200 WP (0.25%) gave the highest number of seeds per plant (6588), weight of seeds per plant (20.57 g) and seed yield (2.01 t/ha) which was followed by seed treatment and soil drenching with Cabriotop (0.3%) and seed treatment and soil drenching with Autostin (0.25%), and the lowest of these parameters were recorded in Control plots.

Dill

Varietal development

Evaluation of dill germplasm

The trial was conducted at Spices Research Centre, BARI, Shibganj, Bogura during *rabi* season of 2018-2019 to identify the best germplasm with higher yield and desirable characters. The experiment was laid out in RCB design with three replications. Three different dill lines (DL003, DL004 and DL005) with dill line DL001(proposed for a new variety) as check were evaluated for yield and yield contributing characters. Seed yield and other yield contributing characters were significantly different among the germplasm. The highest plant height was recorded from DL003 (140.36 cm). The lowest plant height was found in DL005 (122.61 cm). The highest number of umbels/plant (93.97) was observed in DL001 and the lowest was recorded from DL004 (80.98). In case of seed yield, DL001 performed best (2.22 t/ha).

Regional yield trial of dill

The trial was conducted during three consecutive years of 2016-2017, 2017-2018 and 2018-19 to evaluate the performance of advance dill lines at different agro ecological zone and to select the promising one for releasing a variety. The experiment was laid out in a RCB design with three replications. Two advanced dill line DL001and DL002 were evaluated against dill local line as check. The trial was conducted at five different location ie. Spices Research Sub Center, Faridpur (L_1), Regional Spices Research Center, Magura (L_2), Spices Research Center, Bogura (L_3), Spices Research Sub Center, Lalmonirhat (L_4), and Regional Spices Research Center, Gazipur (L_5). Seed yield and other yield contributing characters were significantly different among the germplasm in different location. Among the location the higher amount of seed 2.69t/ha was harvested by RSRC, Magura. The lower amount of seed 2.00 t/ha was harvested by SRSC, Lalmonirhat. Among the three lines the highest seed yield 2.46 t/ha was obtained from the dill line DL001 and the lowest seed yield 2.13 t/ha was obtained from the dill local line. In case of combined effect of location and dill line, Magura × DL001 gave the highest seed yield (2.86 t/ha) followed by Magura × DL002 (2.77t/ha). However, the DL001 line performed better in every location. The lowest (1.85 t/ha) seed yield was recorded from local line in Lalmonirhat location.

Insect pest and disease management

Management of alternaria leaf and umbel blight of dill

The experiment was conducted at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh during Rabi season of 2018-19 to find out the effective fungicides in controlling Alternaria leaf and umbel blight of Dill. DL001 was used in this experiment. Seven fungicides and one control were used as treatment. Alternaria leaf and umbel blight incidence of Dill under different treatments varied from 9.33-90.33%, while the lowest incidence was recorded in Seed treatment and foliar spraying with Amistar Top 325 SC (0.1%) and the highest incidence was obtained from control plot. Seed treatment and foliar spraying with Amistar Top 325 SC (0.1%) gave the highest number of seeds/plant (1811.43), weight of seeds/plant (18.37 g) and seed yield (1.98 t/ha) which were followed by Seed treatment and foliar spraying with Rovral 50 WP (0.2%) and Seed treatment and foliar spraying with Secure 600 WG (0.15%), and the lowest of these parameters were recorded in control plots.

Sickle fruit fenugreek (Firingi)

Varietal development

Evaluation of sickle fruit fenugreek germplasm

The trial was conducted at Spices Research Centre, BARI, Shibganj, Bogura during rabi season of 2018-2019 to identify the best germplasm with higher yield and desirable characters. The experiment was laid out in RCB design with three replications. Three different firingi lines (FRG003, FRG004 and FRG005) with dill line FRG001(proposed for a new variety) as check were evaluated for yield and yield contributing characters. Seed yield and other yield contributing characters were significantly different among the germplasm. The highest plant height was recorded from FRG005 (39.2 cm). The lowest plant height was found in FRG003 (34.2 cm). The highest number of podss/plant (521.73) was observed in FRG002 and the lowest was recorded from

FRG003 (320.33). In case of seed yield, FRG 002 performed best (0.54 t/ha).

Regional yield trial of sickle fruit fenugreek

The trial was conducted during three consecutive year of 2016-2017, 2017-2018 and 2018-19 to evaluate the performance of advance Sickle shaped fenugreek lines at different agro ecological zone and to select the promising one for releasing a variety. The experiment was laid out in a RCB design with three replications. Two advanced dill line FRG001 and FRG002 were evaluated against Sickle shaped fenugreek local line as check. The trial was conducted at five different location ie. Regional Spices Research Center, Faridpur (L_1), Regional Spices Research Center, Magura (L_2), Spices Research Center, Bogura (L_3), Spices Research Sub Center, Lalmonirhat (L_4) and Regional Spices Research Center, Gazipur (L_5). Seed yield and other yield contributing characters were significantly different among the germplasm in different location. Among the location the higher amount of seed 0.55t/ha was harvested by RSRC, Gazipur which was identical to SRSC, Faridpur (0.52 t/ha) and RSRC Magura (0.51 t/ha). The lower amount of seed 0.45 t/ha was harvested by SRC, Bogura. Among the three lines, the highest seed yield (0.56 t/ha) was obtained from the sickle shaped fenugreek line FRG002 and the lowest seed yield (0.44 t/ha) was obtained from the sickle shaped fenugreek local line. In case of combined effect of location and sickle shaped fenugreek line, Faridpur × FRG002 gave the highest seed yield (0.58 t/ha) followed by Gazipur × FRG002 (0.57t/ha) and Magura x FRG002 (0.56 t/ha). However, the FRG002 line performed better in every location. The lowest (0.41 t/ha) seed yield was recorded from local line in Bogura location.

Celery

Varietal development

Collection and evaluation of celery germplasm

The experiment was conducted at the research field of Spices Research Centre, Shibganj, Bogura during rabi season, 2018-19 to evaluate the performance of different celery germplasm and to select the promising one(s) for releasing a variety. The land was medium high and the soil was clay loam in texture. The experiment was laid out with a Randomized Complete Bock Design with three replications. Four celery germplasm collected from different region of Bangladesh were tested for the experiment. It was found that all the parameters except number of umbel lets per umbel and 1000-seed weight found statistically significant.The larger quantity of seeds 1.74 t/ha were harvested from the celery line CL007 followed by CL002 (1.61 t/ha). The smaller amount of seeds 1.42 t/ha were harvested from the line CL006. Beside this more germplasm were collected and seeds were multiplied in this year. The experiment will be repeated in the next year with the newly collected germplasm.

Cumin

Varietal development

Evaluation of cumin germplasm

The trial was conducted at Spices Research Centre, BARI, Shibganj, Bogura during *rabi* season of 2018-19 to evaluate the germplasm which collected from different sources and to identify the best germplasm with higher yield and other desirable characters for variety release. The experiment was laid out in RCB design with three replications. Twenty seven different cumin genotypes (CN001, CN003, CN016, CN017, CN019, CN020, CN021, CN022, CN024, CN026, CN028, CN030, CN031, CN034, CN035, CN036, CN038, CN039, CN040, CN041, CN042, CN043, CN044, CN045, CN046, CN047and CN048) were evaluated for yield and yield contributing character. Seed yield and yield contributing characters were significantly different among the germplasm.The maximum germination (85%) was recorded from CN026 and the minimum germination (45%) was recorded in C034 genotype. The highest number (95.46) of umbel/plant was recorded from CN026 and the lowest (38.59) was recorded in CN017 genotype. In case of disease severity, the lowest disease severity (10.30) was observed in CN026 and the highest disease severity (55.41) was recorded from CN041.The highest seed yield was obtained from CN26 (592.85 kg/ha) and the lowest seed yield was recorded from CN003 (56.70 kg/ha).

Regional yield trial of cumin

The trial was conducted during *rabi* season of 2018-19 to evaluate the performance of advance cumin lines at different agro ecological zone and to

select the promising one for releasing a variety. The experiment was laid out in RCB design with three replications. Four advanced cumin lines viz., CN026, CN028, CN031 and CN038 were evaluated in this study. The trial was conducted at five different location *viz*., SRC, Bogura; RSRC, Gazipur; RSRC, Magura; SRSC, Faridpur and SRSC, Lalmonirhat. But the trial of cumin in Regional Spices Research Centre (RSRC), Gazipur; RSRC, Magura; SRSC, Faridpur and SRSC, Lalmonirhat was totally destroyed by infection of Alternaria blight disease due to unfavorable of weather condition during vegetative stages. So no data was generated of those locations. Seed yield and other yield contributing characters were significantly different among the germplasm in SRC, Bogura. Among the four lines, the highest seed yield (587.85 kg/ha) was obtained from the cumin line CN026 which was statistically different from other lines and the lowest seed yield (407.18 kg/ha) was obtained from CN031.

Isabgul

Varietal development

Collection, conservation, cataloguing and evaluation of germplasm of Isabgul (*Plantago ovata Forsk.)*

The experiment was conducted at the research field of Regional Spices Research Centre, Magura during rabi season, 2018-19 to evaluate the performance of different isupgul germplasm and to select the promising one(s) for releasing as a variety. Two germplasm was collected from jhinaidah and kushtia of Bangladesh. The experiment was laid out in randomized complete block design with three replications. It revealed that plant height (35-40cm), leaves per plant (70-75), tillers per plant (6-8), spikes per plant (25-30), length of spikes (6-8 cm) and seed yield (700-800 t/ha) was more or less similar among the two line.

Ajowan

Cultural management

Effect of seed rate on growth and yield of ajowan

A field experiment was conducted at Spices Research Sub-Centre, Faridpur during rabi season, 2018-19 to find out the optimum seed rate for growth and yield of ajowan. The trial was set at high land of Low Ganges River Floodplain (AEZ 12). The experiment was laid out in a Randomized Complete Block Design with three replications and comprised of different five seed rate viz. 2.0, 2.5, 3.0,3.5 and 4.0 kg/ha. Seeds are sowing in line. The results revealed that different treatments had significant effect on yield and others parameters. The highest seed yield (1264.15 kg/ha) was recorded from the treatment of 4.0 kg seed/ha followed by the seed rate 3.5 kg/ha (1180.29kg). The lowest seed yield (632.73 kg/ha) was observed at 2.00 kg seed/ha.

Effect of harvesting time on seed quality of ajowan

A field experiment was conducted at Spices Research Sub-Centre, Faridpur during rabi season, 2017-18 and 2018-19 to find out the proper harvesting stage of ajowan to assure best quality for seed. The experimental field belongs to high land of Low Ganges River Floodplain (AEZ 12) with clay loam in texture. The experiment was laid out in a Randomized Complete Block Design with three replications. The experiment comprised of five harvesting stage viz., 120-127, 127-134, 134-141,141-148 and 148-155 days after emergence (DAE). The results revealed that different treatments had significant effect on quality attributes of ajowan seed. The ajowan umbels harvested at 127-134 and 134-141 days after emergence (DAE) gave better result to rest of the harvesting stages and recorded maximum sensory Scores and good for obtaining better quality ajowan seed with optimum fiber content.

Betel leaf

Insect pest and disease management

Development of bio-rational based management approach against sucking pests of betel leaf

The field study was conducted in seven years old standing betel vine boroj at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh (geographic coordinates 25.0167° N, 89.3167° E) during January 2018-December 2018 to study the population buildup of sucking insect pests as influenced by climatic factors and to evaluate the efficacy of different bio-rational based

management approach against sucking insect pests complex of betel leaf. BARI Paan-3 was used as test crop for this trial. The treatments were T_1= Sanitation + Alternate spraying of Spinosad (Success 2.5SC) @ 1.2ml/l and Abamectin (Biomax 1.8 EC) @ 1ml/l; T_2= Sanitation + Alternate spraying of Azadirachtin (Bioneem plus1EC) @ 1ml/l and Antatio wp (Bt + Abamectin 0.1%) @ 0.5g/l; T_3= Sanitation + Alternate spraying of Abamectin (Biomax 1.8 EC) @ 1ml/l and Fytoclean (Potassium salt of fatty acid) @ 5ml/l; T_4= Sanitation + Alternate spraying of Fizimite (Sodium lauryl ether) @ 1ml/l and Antatio wp (Bt + Abamectin 0.1%) @ 0.5g/l; T_5= Farmers practice : Spraying of Imidacloprid (Admire 200SL) @ 0.25 ml/l and T_6= Untreated control. Population of sucking pest (black fly, white fly, red mite and mealy bug) was found active throughout the year but the maximum (22.7, 17.2, 16.1 and 14 adult/vine) and minimum (3.2, 2.8, 2.6 and 1.5adult/vine) was recorded during the month of October and January. Multiple linear regression analysis showed significant variation and the R^2 value suggested that biotic factor contribute 57.9%, 50.9%, and 51.3% and 53.7% variation in black fly, white fly, red spider mite and mealy bug population. Among the five bio-rational based management approach, the highest mortality (80.56%, 84.73%, 82.44% and 90.96%) of black fly, white fly, red mite and mealy bug with the lowest number (3.11, 1.33, 1.28 and 0.64 adult/vine) of insect population was found in the Sanitation + Three alternate spraying of Fizimite and Antario treated plot and the highest number of those sucking insect was recorded from untreated control plot. However, the highest vine yield (18.61 t/ha) was also obtained from sanitation + alternate spraying of Fizimite and Antario and the lowest yield (9.11 t/ha) was recorded from untreated control plot that indicated better control of sucking insect pest compared to other treatments. So, Sanitation of belel leaf garden along with three alternate spraying of Fizimite (Sodium lauryl ether) @ 1ml/l and Antario wp (Bt + Abamectin 0.1%) @ 0.5g/l may be recommended for effective management of sucking insect pest's complex of betel vine boroj.

Bay leaf

Cultural management

Effect of layering time and IBA concentration on the success of air layering in bay leaf (*Cinnamomum tamala*)

The experiments was conducted at the Regional Spices Research Center, BARI, Gazipurduring May 2017 to September 2018 to evaluate the effect of layering time and IBA concentration on bay leaf propagation by means of air layering. Air layering was done in five times (mid April, mid May, mid June, mid July and mid August) with six levels of IBA concentration viz. 1000, 2000, 3000, 4000, 5000 ppm respectively and control (no IBA).IBA solutions were applied at distal phloem cuts of air layering in different times. Layering time and IBA concentration showed significant effect on rooting, success and survivability rate of layers. The number of successful rooted layer was significantly higher in July (76.67%) closely followed by Mayand August (73.33%**)**layering with 4000 ppm IBA application and the success was almost nil (3.33%) in April and September layering without IBA treatment. The final establishment rate wasmaximum in May layering (86.31%) with 4000 ppm IBA but no layers was survived in April, July and August layering without IBA application.

Insect pest and disease management

Assessment of chlorophyll loss due to infestation of gall mite on bay leaf

The field experiment was conducted at Spices Research Centre, Shibganj, Bogura, Bangladesh during May 2019 to analyse the percent loss of chlorophyll a and b induced by Aceria doctersi and to assess the damage potential of gall mite within the leaf galls of Cinnamomum tamala. The highest chlorophyll a (8.24 milligram/gm) and chlorophyll b (2.29 milligram/gm) content was recorded from control sample containing no gall tissue and the lowest chlorophyll a (2.18 milligram/gm) and chlorophyll b (0.64 milligram/gm) content was recorded from the sample containing ≥50 gall /1gm leaf sample. Eriophyid mite galls were negetively correlated with chlorophyll a (r= -0.98245**) and chlorophyll b (r= -0.95525**) content of bay leaf.

Cinnamon

Cultural management

Effect of time and IBA concentration on the performance of cinnamon layering

Experiments were conducted at the Regional Spices Research Center, Bangladesh Agricultural Research Institute, Gazipur during May 2017 to September 2018 to evaluate the effect of IBA concentration and time of cutting and air layering in Cinnamon. Air layering and cutting was done in five time (Mid April, Mid May, Mid June, Mid July and Mid August) with Six levels of IBA concentration Viz. 1000, 2000, 3000, 4000, 5000 ppm respectively and control (no IBA).IBA solutions were applied at the cut portion of cutting and distal phloem cuts of layering in different times. No root was emerged in cuttings and all cuttings were died after a few (30-40) days. Layering time and IBA concentration showed significant effect on rooting, success and survivability rate of cinnamon layers. The number of successful layer was significantly higher in July (8.0,80%) with 5000 ppm IBA followed by May and June(7.67,76.67%)layering with 4000 and 5000 ppm IBA application and the success was almost nil (0.33, 3.33%) in April and September layering without IBA treatment. The final establishment rate of cinnamon plant was maximum in May layering (6.33, 86.31%) with 4000 ppm IBA but no layers was survived in April, July and August layering without IBA application.

Eggplant

Genetic diversity of eggplant germplasm during winter season

The study was conducted at the experimental field of Olericulture Division, Horticulture Research Centre, BARI, Gazipur during 2018-19 to assess the extent of genetic diversity among 26 eggplant germplasm. The collected germplasm originating from different local and exotic sources were subjected to cluster analysis. The germplasm was constellated into five distinct groups with the range of 3 germplasm in cluster IV to 7 germplasm in cluster II. The inter-cluster distance in all cases was larger than the intra- cluster distance. Maximum inter-cluster distance (17.73) was observed between germplasm of cluster IV and V followed by cluster II and IV (16.39) and minimum was found between germplasm of cluster II and V (4.41). The highest intra cluster value (3.40) was observed in cluster I. Cluster III was responsible for second highest values *viz.*, number of marketable fruit (23.40), average fruit weight (187.00 g), fruit length (18.60 cm), fruit diameter (6.22 cm), fruit yield (4.37 kg/plant), fruit yield (56.84 t/ha), while second lowest vales for days to 1st harvest (101.33 days), FSB infested fruit (11.40 %), bacterial wilt infestation (6.00 %), little leaf (4.00 %), while cluster IV was exhibited highest mean value for average fruit weight (228.33g), fruit diameter (7.40 cm), fruit yield (4.64 kg/plant), fruit yield (60.36 t/ha). Considering the group distance and inter-genotypic crosses between the members of cluster II and IV and cluster IV and V would exhibit high heterosis and is also likely to produce new recombinants with desired traits. But in case of the cluster means values and yield contributing performance cluster III and cluster IV performed well. Therefore, inbreds belong to cluster III, cluster IV and cluster V will be given higher priority for crossing in future eggplant hybridization programme.

Evaluation of eggplant germplasm (RHRS Patuakhali)

Thirty-eight eggplant germplasm was collected from different location of Patuakhali region and planted at Regional Horticulture Research Station, Lebukhali, Patuakhali during *kharif-1* season 0f 2018 for preliminary evaluation. The germplasm showed wide range of variability among them. Among the germplasm SMP 39, SMP 42 the gave highest yield/plant and 1-6, 1-10, 3-11, 7-1, 7-2, 7-6, SMP 38, SMP 41, and SMP 51 gave moderate yield. Among them 1-6, 7-1, 7-2 and 7-6 were large fruited and green skin color. 1-10, 3-11, SMP 39, SMP 42 and SMP 51 were also large fruited and purple to purple black skin color. SMP 38 was long with white skin color and SMP 41 was large fruited and white skin color. As market demand of eggplant depends on shape, size and color, those lines could be trialed in separate groups for further plant evaluation for variety release.

Evaluation of eggplant lines for winter (RARS, Jamalpur)

Twelve eggplant lines were collected and evaluated at RARS, Jamalpur during winter season of 2018-19. The highest (124) number of fruits per plant was noted from the line SM Jam-009 and the lowest (12) number of fruits per plant was noted from the line SM Jam-015. Maximum yield (41.22 t/ha) was produced by the line SM Jam-015 and minimum yield (20.40 t/ha) was produced by the line SM Jam-014.

Preliminary yield trial of eggplant lines (Green type)

The study was conducted with 17 eggplant lines/ varieties at the farm of Olericulture Division, HRC, BARI, Gazipur during the winter season of 2018-19 to develop new green type high yielding OP variety having tolerance to eggplant fruit and shoot borer and bacterial wilt. The lines varied

significantly for their response to all characters (P<0.05). The line SM011 required minimum 88.67 days to first harvest as well as maximum marketable fruit number (95.00). Heavy sized fruit was harvested by BARI Begun-6 (178.00 g), followed by SM275 (176.67 g), SM262 (148.33 g), SM253A (146.33 g), SM291B (143.67 g). In case of bacterial wilt infestation at field level performance, zero percent incidences was observed in SM083B, SM253A, SM262, SM273, SM275. The range of fruit infection by eggplant fruit and shoot borer (EFSB) was 9.33 -19.00 %, while lowest in SM262 (9.33 %) statistically similar with SM272 (9.67 %), SM204, SM220, BARI Begun-6 (10.00 %). The yield range of eggplant lines was 38.72- 61.66 t/ha. The highest fruit yield was recorded from BARI released variety BARI Begun-6 (61.66 t/ha), which was statistically similar with SM273 (60.02 t/ha), SM351 (58.36 t/ha) SM083A (56.64 t/ha) followed by SM011 (52.13 t/ha), SM204 (52.11 t/ha), SM221B (50.79 t/ha), SM275 (50.58 t/ha). Considering earliness, tolerance to fruit infection by EFSB, bacterial wilt infestation, attractive fruit shape and fruit colour, the lines Considering earliness, tolerance to fruit infection by EFSB, bacterial wilt infestation, attractive fruit shape and fruit colour, last of all fruit yield, the lines SM273, SM351, SM083A, SM011, SM204, SM221B, SM275 were found promising were found promising. So these seven lines can be selected for further confirmation.

Pliminary yield trial of eggplant lines for winter

A study on the performance of twenty-two selected advance eggplant lines with BARI Begun-4 was conducted at the experimental farm of Olericulture Division, Horticulture Research Centre, BARI, Gazipur, during the winter season of 2018-19 to observe the performance of the selected lines. The line SM0286 took the minimum (98 days) days to first harvest and the lines SM0222B and SM 0222D took identical the maximum days (106). The maximum fruit number (33nos) was produced by the line SM0286 followed by SM0217, SM0236A, SM0286B and BARI Begun-4 where ranges were 30-33nos. while the minimum (22nos.) was from SM0232. The highest identical average fruit/plant were from the line SM0217A and SM0293 (156.67g) while the lowest was from the line SM0343 (94.67g). The identical longest fruits were produced from the line SM 0222B, SM 0232A, SM 0288, which ranges were (25.33-25.67cm) while the line SM 0232 produced the shortest fruit (6.23cm). The highest diameter fruit was recorded from SM0286 (7.77 cm), while the lowest was from SM0318 (3.73cm). The highest identical plant height at last harvest was SM0217A, SM0286 (105.33cm) and the lowest was from SM0236A (76.0 cm). Statistically identical fruit yield/ha was obtained from SM0217A (62.08t), SM0286 (62.09t) while the lowest was from SM0343 (30.66t). Minimum infestation by fruit and shoot borer was observed in SM236A (9.67%) followed by SM232 (12%), SM291 (12.3%) and the highest infestation was observed from SM0181B (16%). Considering earliness, high yield and pest tolerance, the lines SM232, SM232A and SM236A, SM257, SM222D were found promising and may be recommended for RYT.

Advanced yield trial of selected large fruit green colored eggplant lines (RHRS Patuakhali)

Five large fruited green colored eggplant lines were selected from preliminary evaluation and planted at Regional Horticulture Research Station, Lebukhali, Patuakhali during winter season of 2018-19 for advance yield trial. The germplasm showed wide range of variability among them. Among the germplasm lowest days required for germplasm SMP 52 and highest days required for germplasm 7-2. Plant height was minimum in 7-1 (89 cm) and maximum 150 cm in germplasm 7-2. Fruit length was found minimum 15.7 cm in BARI Begun-6 and maximum 25.883 cm in SMP 52. Fruit breadth was minimum 8.1 cm in 7-2 and maximum 12.33 cm in BARI Begun 6. Single fruit weight was minimum 408 in BARI Begun 6 and maximum 763.66 germplasm SMP 52. Number of fruits per plant ranged from 13.85 in 7-1 germplasm to 8.54 in SMP 52. Fruit weight per plant varied from 6.52 kg in germplasm SMP 52 to 4.09 kg in BARI Begun-6. Considering earliness, yield and yield contributing characters germplasm SMP 52 was found promising and may be recommended for variety release.

Advanced yield trial of selected purple colered eggplant lines (RHRS Patuakhali)

Nine purple colored large fruited eggplant germplasm was selected from preliminary evaluation and planted at Regional Horticulture Research Station, Lebukhali, Patuakhali during

winter season of 2018-19 for advanced yield trial. The germplasm showed wide range of variability among them. Among the germplasm 7-15 gave highest yield per plant and SMP 39, and SMP 51 gave moderate yield. Among them BARI Begun-6 are large fruited (113.66) and purple skin color. The lowest yield per plant with small sized fruit shown SMP 53.

Advanced yield trial of some selected white colered eggplant lines (RHRS Patuakhali)

Five white colored eggplant lines was selected from preliminary evaluation and planted at Regional Horticulture Research Station, Lebukhali, Patuakhali during winter season of 2018-19 for advance yield trial. There was wide range of variability among the genotypes. Longest fruit was found (25.43 cm) in SMP 48 and shortest fruit (11.71 cm) in SMP 54. Fruit breadth was minimum 4.45 cm in SMP 15 and maximum 7.62 cm in SMP 38. Maximum number of fruits/plant was 42.69 in SMP 54 and minimum 12.19 was in germplasm SMP 41. Average fruit weight ranged from 84.66 g (SMP 54) germplasm to 491g (SMP 41). Fruit weight per plant varied from 2.72 kg in germplasm SMP 15 to 5.96 kg in SMP 41. Considering earliness, yield and yield contributing characters germplasm SMP 41 and SMP 38 were found promising and may be recommended for RYT trial.

Regional yield trial of eggplant lines for winter

A study on the performance of four eggplant lines with BARI Begun-4 and BARI Begun-6 were conducted at the experimental farm of Olericulture Division, Horticulture Research Centre, BARI, Gazipur and RARS (Jamalpur), RARS (Hathazari), RARS (Akbarpur), RARS (Burirhat), RARS (Ishurdi), RARS (Jasshore), RARS (Rahmatpur), Bangladesh during the winter season of 2018-19 to develop new high yielding OP varieties. In case of days to 1st harvest, SM216 took the minimum days (97) and the line SM021 (104days) and BARI Begun-6 (104 days) took the maximum days. The highest identical marketable fruit/ plant were recorded from SM216 (47.67), SM233 (4.336) and BARI Begun-4 (42.67) while the lowest was from BARI Begun-6 (19.67).The highest identical average fruit weight was obtained from the line SM021 (216.67g) and BARI Begun-6 (212.33g) whereas the lowest was in SM233 (82.67g).The longest fruit was observed in SM217A (23.67cm) while the shortest was from SM233 (12.0cm), The maximum diameter of fruit was recorded in BARI Begun-6 (11.37cm) while the lowest was from SM233 (3.60cm). The tallest plant (114.33cm) was recorded in BARI Begun-6 while the shortest plant (80.0cm) was recorded from SM233.The highest per hectare fruit yield (66.50t) was from SM216 and the lowest were from SM233 (48.90t). Minimum infestation by eggplant fruit and shoot borer was observed in SM216 (10.33) while maximum infestation was showed in SM233 (14.33). Bacterial wilt infestation was minimum which ranges were 0.00-3.33%. The line SM216 showed elliptical shape with magenta purple color and SM012 showed oval shape with deep green white strip colour. Considering earliness, high yield and pest tolerance, the lines SM216 and SM021 were found promising and may be recommended as a new OP variety.

Heterosis studies in eggplant

A study on the performance of 30 F_1 crosses and their 20 parents of eggplant was conducted at the farm of Olericulture Division, HRC, BARI, Gazipur, Bangladesh during the winter season 2018-19. Better parent heterosis in eggplant was studied in 30 crosses of eggplant. In case of days to first harvest highest significant negative heterotic response for earliness was observed in the hybrid 21X18 (–8.70 %) followed by 253AX11 (-8.04 %). Highest better parent positive heterosis for number of marketable fruit and average fruit weight was observed from the hybrid 1X217 (56.52 %) and 206X233 (43.80 %), respectively. Positive significant heterosis for fruit length and fruit diameter were ranged from 5.88 to 83.33 per cent and 2.33 to 29.87 %, respectively. The highest significant positive heterosis for fruit yield per hectare was obtained from the cross 5X20 (73.91 %). Followed by 1X217 (48.86 %), 4X217A (68.63 %), 5X11 (48.88 %), 5X233 (38.67 %), 12X206 (43.29 %), 14X233 (39.33 %). In the present study the cross combination 1X217, 4X217A, 18X233, 21X18, 5X20, 5X216, 5X217A manifested the higher heterosis over better parent for plant yield and yield contributing characters.

Regional yield trial of eggplant hybrids

The study was conducted with five advance F_1's lines at the farm of Olericulture Division, HRC, BARI, Gazipur and RARS (Jamalpur), RARS

(Hathazari), RARS (Akbarpur), RARS (Burirhat), RARS (Ishurdi), RARS (Jasshore), RARS (Rahmatpur), Bangladesh during the winter season of 2018-19 to develop new high yielding hybrids having tolerance to eggplant fruit and shoot borer and bacterial wilt. The lines varied significantly for their response to all characters ($P<0.05$). The hybrid F_1 20x5 required minimum 100.33 days to first harvest. Maximum marketable fruit number was obtained by BARI Hybrid Begun-3 (36.00) which statistically similar to F_1 14x5 (33.50). Heavy sized fruit was harvested by F_1 13x12 (200.33 g), followed by F_1 1x5 (147.67 g), F_1 20x5 (159.67 g). The range of fruit infection by EFSB was 10.00 -19.00 %, while lowest in F_1 1x19 (10.00 %). In case of bacterial wilt (BW) infestation at field level performance, zero percent incidence was observed in F_1 1x19, F_1 13x12, BARI Hybrid Begun-3. The yield range of eggplant hybrids was 40.73- 65.29 t/ha. The highest fruit yield was recorded from the line F_1 13x12 (65.29 t/ha), followed by F_1 14x5 (59.79 t/ha), $F_1$1x5 (50.27 t/ha). Considering earliness, tolerance to fruit infection by EFSB, bacterial wilt infestation, little leaf infestation attractive fruit shape and fruit colour, the hybrids F_1 13x12, F_1 14x5 were found promising. So, these two hybrids viz., F_1 13x12, F_1 14x5 can be selected for releasing as new hybrid variety.

Screening of BARI released eggplant varieties against salinity

A pot experiment was conducted at the research field of Olericulture Division, HRC, BARI, Joydebpur, Gazipur during the winter season of 2018-19 to screen out salt tolerant eggplant variety (ies). Fifteen eggplant varieties *viz*.; BARI Begun-1 (BB1), BARI Begun-4 (BB4), BARI Begun-5 (BB5), BARI Begun-6 (BB6), BARI Begun-7 (BB7), BARI Begun-8 (BB8), BARI Begun-9 (BB9), BARI Begun-10 (BB10), BARI Hybrid Begun-2 (BHB2), BARI Hybrid Begun-3 (BHB3), BARI Hybrid Begun-4 (BHB4), BARI Bt Begun-1 (Bt1), BARI Bt Begun-2 (Bt2), BARI Bt Begun-3 (Bt3) and BARI Bt Begun-4 (Bt4) were included in this study. After transplanting into 15L pots, the plants were exposed to control, 4 and 8 dS/m salinity stresses and continued upto 30 days. The results revealed that soil salinity reduced plant height, number of leaves/ plant, fresh weight of shoot and root, number of fruits/plant, individual fruit weight and fruit yield/plant in all eggplant varieties. In control treatment, the highest fruit yield was recorded from Bt4, BB1, BB6 and BHB3. The varieties BB1, BHB3, BB6 and BB8 provided maximum fruit yield at 4 dS/m salinity while, BB1, BB2 and BB6 produced the highest yields at 8 dS/m salinity stress. From the current study it can be stated that BB1, BHB3, BB6 and BB8 were tolerant to 4 dS/m salinity stress, but none of the eggplant varieties found to be tolerant to 8 dS/m salinity stress.

Screening of BARI eggplant varieties against salinity tolerance (ARS, Satkhira)

Knowledge of salt tolerance in vegetable plants is necessary to increase productivity and profitability of crops irrigated with saline wastewaters. Eggplant (*Solanum melongena*) is moderately sensitive to salinity but more attention to salinity is required in the agricultural production of eggplant and its varieties. An experiment was conducted at the Agricultural Research Station (ARS), BARI, Benarpota, Satkhira during the winter season of 2018-19 to find out saline tolerant eggplant variety (ies). There were twelve eggplant varieties viz., BARI Begun-1, BARI Begun-4, BARI Begun-5, BARI Begun-6, BARI Begun-8, BARI Begun-9, BARI Begun-10, BARI Bt Begun-2, BARI Bt Begun-3, BARI Bt Begun-4, BARI Hybrid Begun-2 and BARI Hybrid Begun-3. Fruits yield (45.21 t/ha) was found highest in BARI Bt Begun-4 also significantly higher than rest of the varieties. In coastal saline areas, BARI Bt Begun-4 can be cultivated to get higher yield with maximum economic return.

Effect of different rootstock for higher eggplant production

A field experiment was conducted at Olericulture Division, HRC of BARI, Gazipur, Bangladesh, during the period from September 2018 to April 2019 to study the effect of different rootstock for higher eggplant production. Among the five treatments, it could be concluded that eggplant can be grafted on four rootstocks viz., BARI Begun-8 (BB8), EG203, S. sisymbriifolium (SS), F_1 (21x11) with desired scions- BARI Begun-5. In case of important yield and yield contributing characters viz., average fruit weight, fruit yield/ plant, fruit length and fruit width showed better performances when BB5 was grafted onto BB5/BB8 [186.67 g,

3.92 kg/ plant, 10.37 cm, 8.20 cm] and BB5/F_1 (21x11) [186.67 g, 3.98 kg/ plant, 10.17 cm, 7.90 cm]. Among the 4 grafted treatments, BB5/F_1 (21x11) (51.70 t/ha), BB5/BB8 (50.96 t/ha) and BB5/EG203 (45.61 t/ha) produced more than 45 t/ha. So, these three rootstocks may be selected considering higher yield. However, the study was conducted during winter season. So, to draw a complete conclusion it is needed to conduct this experiment during summer season.

Graft compatibility and yield potentials of newly developed bt eggplant varieties on cultivated solanum rootstock (RHRS, Shibpur, Narshingdi)

Graft compatibility and yield potentials of newly developed Bt Brinjal varieties on cultivated solanum rootstock was conducted at RHRS, Shibpur, Narshingdi during the winter season of 2018-19. The commercial cultivation of four Bt-Brinjal varieties *viz.* BARI Bt Begun-1, BARI Bt Begun-2, BARI Bt Begun-3 and BARI Bt Begun-4 which were grafted on two root stocks *viz.* BARI Begun-8 and BARI Begun-10. The non-grafted Bt Brinjal varieties were termed as control. Maximum plant height 55.88 cm was found in BARI Bt Begun-2 and minimum 36.11 cm in combination effect of root stock BARI Begun-8 grafted with BARI Bt Begun-3. Maximum fruit length, fruit breadth and individual fruit weight were found in control treatment BARI Bt Begun-4. Whereas number of fruits per plant maximum were found in Bt Begun-2 grafted with root stock BARI Begun-10. Main combination effect showed that bacterial wilt disease incidence was reduced significant on grafted plant. Maximum 38.10% bacterial wilt disease incidence was found in control rootstock BARI Bt Begun-3. But all controlled treatment such as BARI Bt Begun-1, 2, 3, 4 were found more susceptible in bacterial wilt than grafted plants. Root stock of BARI Begun-8 showed better performance than BARI Begun-10 against wilting because of this variety is more resistance of bacterial wilt. Maximum yield per plant 3.35kg, yield per plot 23.51kg and yield per hectare 22.38 t/ha were found in BARI Bt Begun-2 grafted with root stock BARI Begun-10.

Effect of bagging on EFSB for quality eggplant cultivation

Eggplant fruit and shoot borer (EFSB), *Leucinodes orbonalis*, is the most damaging pest of eggplant in South and Southeast Asia especially in Bangladesh. This study tested the technical feasibility of bagging eggplant fruits during production to protect them against EFSB. The experiment was randomized complete block (3 blocks) with conducted in 6 treatments: i) Imported brown bag ii) Local brown bag iii) Imported white bag iv) Butter paper bag v) HDPE bag vi) Open fruit (control). Fruits were bagged at fruit set time, and evaluated for days to 1st harvest, number of marketable fruit, aborted fruit (%), average fruit weight (g), fruit length (cm), Fruit diameter (cm), fruit yield per plant (kg), eggplant fruit and shoot borer (EFSB) infection (%), spotted/ scratched fruits (%), fruit skin colour and fruit yield (t/ha). Highest number of marketable fruits per plant was produced by imported white bag (12.33), which was followed by butter paper bag (10.67), local brown bag, HDPE bag, open fruit (10.33). Maximum aborted fruit was obtained from the imported brown bag (23.33%) and HDPE bag (20.00%). The highest average fruit weight (363.33 g) was obtained from fruits bagged with Imported white, while maximum fruit length and fruit diameter was also produced from imported white bag (15.27 cm and 11.23 cm, respectively). Zero percent damage by eggplant fruit and shoot borer was produced by imported brown bag, imported white bag and butter paper bag, while higher infection was observed in open fruit (control) (17.70 %), HDPE bag (11.70 %). Bagging eggplant fruit produced 38.78 to 58.20 t/ha, while open fruit (control) produced only 35.66 t/ha. The highest calculated fruit yield 58.20 tons/ha was estimated from imported white bag and other bagging fruits were local brown bag (46.74 t/ha), HDPE bag (45.00 t/ha), butter paper bag (43.23 t/ha). The bagging of eggplant fruits with imported white bag and butter paper bag were more effective in reducing damage by eggplant fruit and shoot borer than the other bagging treatments and the control. These two treatments produced higher number of consumers preferred fruit, without negative effects on the color of the skin, fresh weight and fruit abortion, thus resulting in higher economic gains.

Performance of Bt and non-Bt eggplant production under IPM package

The experiment was conducted at farmers' fields of Bogura and Gazipur during winter season 2018-19 to evaluate the impact regarding yield, input cost

and pesticide use etc. on Bt brinjal production as compared to the same non-Bt counterpart under recommended IPM package. Results revealed that Bt brinjal demonstrated 96.69% reduction of fruit damage over non-Bt brinjal variety. Marketable yield increased (85.85%) over non-Bt brinjal under same IPM package. Bt brinjal offered more economic benefit (4.31) as compared to non-Bt brinjal

Screening of eggplant germplasm resistant to bacterial wilt

The experiment was conducted with 17 eggplant accessions supplied by Olericulture Division, HRC, BARI, grown in artificially inoculated sick bed of HRC during November 2018-2019 cropping seasons. The sick bed was established by inoculating the soil with a mixture of *R. solanacearum* isolates, collected from wilted eggplant field of various regions during 2018 but the population was estimated before transplanting which was about $1.8X10^9$ cfu/ml. Seventeen eggplant accessions were screened for resistance to *Ralstonia solanacearum* grown under artificial epiphytotic conditions during 2018-2019 cropping seasons. One line such as 363 gave resistant reaction under field condition in Gazipur. Single line of eggplant (SM-393) showed moderately resistant reaction. Six lines showed moderately susceptible and two lines showed susceptible reaction where, seven lines gave highly susceptible reaction to *R. solanacearum*.

Screening of eggplant germplasm against root-knot nematode

The experiment was conducted at BARI, Gazipur during November 11, 2018. One-month old seedlings of fifteen eggplant germplasm were transplanted in three replications in nematode sick bed, having population of 2500-3500 RKN larvae per kg soil. Fifteen eggplant varieties/lines were tested in a nematode infested sick bed for their resistance to root-knot nematode. Among them five lines SM-392, SM-393, SM-318, SM-262 and SM-253 were found resistant, ten lines SM-253-A, 273, 337, Green Ball, 362, SM-361, 336, 286-B, 232-A and 363 gave moderately resistant to root knot nematode.

Screening of brinjal genotypes against salinity at germination and early seedling growth stage

The experiment was conducted at the laboratory of Plant Physiology Section, hrc, BARI during December 09, 2018 to December 22, 2018. The experiment consisted of nine brinjal varieties *viz.*, BARI Begun-1, BARI Begun-4, BARI Begun-6, BARI Begun-7, BARI Begun-8, BARI Begun-9, BARI Begun-10, BARI Hybrid Begun-2, and BARI Hybrid Begun-4, considered as factor A and three levels of salinity *viz.*, 0 dS/m, 8 dS/m, 12dS/m considered as factor B. Required number of petri dishes each with a diameter of 9 cm were used in the experiment and arranged in a completely randomized design (CRD) moistened with respective treatment in three replications. Three layers of Kitchen tissue paper were used in each petri dish for retaining required amount of water for imbibition of seeds. Twenty five equal sized seeds of each variety were selected and placed on sterilized petri dish lined with kitchen r paper. The germination count was taken after 72 hours of placing seeds. After 14 days shoot and root weight 10 seedlings were weighed by the electrical balance and this weight was considered as fresh weight of root and shoot, and these two weights were kept in an oven at 72°c for 1 weeks for recording dry weight of shoot and root. After 14 days, the shoot and the root length of ten randomly selected seedlings from each replicate were measured. Data was recorded on germination and germination prosperities (germination value, speed of germination, germination rate, germination rate of index, coefficient of germination) and seedling vigour index. All characters were expressed as percentage of control. Among nine brinjal varieties BARI Begun-7 and BARI Hybrid Begun-2 performed well at both 8 dS/m and 12 dS/m. Cluster analysis and discussion on germination properties and growth characters revealed that BARI Begun-7 and BARI Hybrid Begun-2 were salt tolerant and BARI Begun-1, BARI Begun-9 and BARI Hybrid Begun-4 were salt susceptible. However, further trial is needed for the confirmation of the result including more genotypes as per collection.

Tomato

Evalution of tomato germplasm (semi-determinate type) and seed increase at net house

A study on evaluation of tomato germplasm was conducted under the net house of Olericulture Division of HRC, BARI, Gazipur during the winter season of 2018-19. There were 11 entries included in this study for selecting superior semi-

determinate tomato lines and increasing of seed. All the lines showed difference in the most of the parameters studied. The line SL0419 contributed the highest per plant yield (3.10 kg) with good shelf life (16.00 days) having 29 days harvestable. The entries SL0420, SL0421, SL0422, SL0504, SL0507 and SL0514 contributed above 2.00 kg of fruit having good quality. There were seven tomato entries- SL0419, SL0420, SL0421, SL0422, SL0504, SL0507 and SL0514 may be considered as semi-determinate type and the lines may also be selected for further study.

Preliminary yield trial of resistant tomato lines/genotypes against different insect pests and diseases

A preliminary yield trial was conducted on WVC (The World Vegetable Centre-former AVRDC) tomato entries to study the yield, pest and diseases resistance and quality attributes at the experimental field and laboratory of Olericulture Division of HRC, BARI, Gazipur, Bangladesh during the winter season of 2018-19. There were 8 selected tomato lines (supplied from the WVC) viz.: SL0403; SL0404; SL0405; SL0406; SL0411; SL0413; SL0415; and SL0416 along with one local check BARI Tomato-19 included in this study. The findings of major parameters revealed that: days to 50% flowering was observed uniform and earlier than control that was confined in 52-60 days. It may be due to the genetic potentiality as the lines are inbreeds. In respect of fruit number per plant varied from 17 to 24, while the highest number of fruit (24) was counted in the line SL0SL0413 and the lowest number of fruits was counted in SL0411 (17). In the case of average fruit weight, the largest fruit was harvested from SL0403 (91.45g) followed by SL0405 (85.11g) and the smallest average fruit weight were obtained from SL0411 (64.56 g). The marketable fruit yield per plant varied from 1.05 to 1.98 kg. The highest marketable fruit yield per hector was obtained from the line SL0406 (67.06 ton/ha). The length and width of fruits, TSS, p^H, pericarp thickness and locules number per fruit of different lines varied significantly. The same line SL0413 exhibited the highest (10 days) shelf life at the temperature 26-27°C. Number of seeds per fruit showed significantly difference among the lines studied which ranged from 90 to 177. Most of the lines showed better performance in terms of pest and disease resistance. Based on the growth habit, diseases infection rating. In the case of quality attributes, the highest firmness (15.00 Newton) showed in the line SL0415 that indicated hardiness of fruit which may be good for distant transportation. Regarding other qualitative traits, the lines SL0403, SL0405, SL0411, SL0413, and SL0416 found to be promising and may be put into the regional yield trial in the following year to confirm the results.

Preliminary yield trial selected of $f_1$tomato lines (determinate)

A study on preliminary yield trial of four determinate hybrids was conducted at the experimental field of Olericulture Division of HRC, BARI during winter season of 2018-19 to evaluate the yield potentiality. The treatment T_1 produced the largest individual fruit weight (67.00g). The T_2 exhibited maximum yield per plant (2.94 kg) followed by 2.93 kg harvested from control. Maximum yield per ha was obtained from T_2 (69.58 t) followed (63.77 t) by the new hybrid line T_4. Considering the yield performance, other attributes and uniformity, the experiment may be conducted as regional yield trial with all entries to confirm the results.

Advanced yield trial of multiple (bacterial wilt and TYLCV) disease tolerant tomato lines

A study on the performance of five selected advance disease tolerant tomato lines with BARI Tomato -15 was conducted at the experimental field of Olericulture Division, HRC, BARI, Gazipur, Bangladesh during the winter season of 2018-19 to observe the performance of the selected lines. Significant variation was observed among the lines in respect of different characters studied. A wide range of variation in number of fruits (21-40) per plant was observed. Maximum fruit yield per hectare obtained from the line AVTO1317 (105.3 tones) followed by AVTO1316 and AVTO 1229 (102.6 and 97.4 tones), respectively. There was no bacterial wilt infestation found in all the lines. No virus infestation was found in the lines AVTO1317, AVTO1316, AVTO1229 and AVTO1218. The highest virus infestation was observed from BARI Tomato 15 (83%). The result revealed that considering high yield and disease tolerance the tomato lines viz. AVTO1317, AVTO1316 and AVTO1229 were found to be promising and may be recommended for RYT.

Regional yield trial for dual purpose processing/fresh market tomato inbred lines

A regional yield trial was conducted on four tomato inbred lines to study the yield, diseases resistance and processing attributes at the experimental field of Olericulture Division of HRC, BARI, Gazipur, Bangladesh during the winter season of 2018-19, alongside the study was conducted in more five RARS and RHRS (Burirhat, Ishwardi, Jamalpur, Akbarpur, and Jashore) of BARI. There were four selected inbred tomato lines (selected from the WVC supplied eight inbred tomato lines) viz.: SL0033=CLN3670B; SL0036= CLN3552C; SL0037=CLN3552B; and SL0038= CLN3125L-5x65 along with one local check BARI Tomato-19 was included in this study. The findings of major parameters revealed that: days to 50% flowering was observed uniform and earlier than control that was confined in 46-48 days. It may be due to the genetic potentiality as the lines are inbreeds. In respect of fruit number per plant varied from 36 to 49, while the highest number of fruit (49) was counted in the line control as because it was genetically good fruit bearer type and the lowest number of fruits was counted in CLN3552B (36). In the case of average fruit weight, the largest fruit was harvested from CLN3552B (91.67g) followed by CLN3552C (87.66g) and the smallest average fruit weight were obtained from CLN3670B (83.33 g). The length and diameter of fruits of different lines also varied significantly. The marketable fruit yield per plant varied from 2.42 to 2.66kg. The highest marketable fruit yield per hector was obtained from control (66.94 ton/ha) while other lines also exhibited statically identical quantity of fruit per hector. All the lines showed good resistance on EB, LB, TYLCVD, BW, FW, SB and TFB. In respect of postharvest attributes, all the lines specially control line showed satisfactory magnitude lightness, hue angle, TSS, firmness, dry matter percentage, P^H and vitamin-C for fresh product. The same lies also showed better performance in terms of lightness, hue angle, pulp percent, final product percent and viscosity too in processed product. Considering the growth habit, diseases infection rating, shelf life, qualitative traits and yield, the tomato entries CLN3670B and CLN3125L-5x65 may be released as dual purpose tomato varieties while; other entries may be used as breeding materials for further improvement of tomato variety.

Regional yield trial of T_y gene inserted tomato lines for yield and diseases resistance

A regional yield trial (RYT) of five selected potential tomato lines of WVC (The world vegetable Centre-former AVRDC with check BARI Tomato-15 was conducted at the experimental field of Olericulture Division of HRC, BARI, Gazipur during the winter season of the year of 2018-19 to assess the yield potentiality and disease resistance, alongside the study was conducted in more five RARS and RHRS (Burirhat, Ishwardi, Jamalpur, Akbarpur, and Jashore) of BARI. The highest fruit yield per plant was recorded from the line SL0008 (3.68kg) followed by BARI Tomato-15 (3.29 kg). The maximum fruit yield (76.12 tones) per hectare was obtained from the line SL0008. The same line SL008 also showed good shelf life (21 days). No virus and other diseases (BW, EB, LB and SB) infection was found to occur in the tomato plants of all lines except control. The entry-SL0008 may be suggested for realizing as new tomato variety while, other entries may be used as breeding materials for further improvement of tomato variety.

Regional yield trial of cherry tomato lines

A regional yield trial (RYT) of two selected cherry tomato lines of WVC (The World Vegetable Centre- former-AVRDC) with check BARI Tomato-11 was conducted at the experimental field of Olericulture Division, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during the winter season of the year of 2018-19 to assess the adaptability and yield potential, alongside the study was conducted in more five RARS and RHRS (Burirhat, Ishwardi, Jamalpur, Akbarpur, and Jashore) of BARI. The highest fruit yield per plant was recorded from the line SL0068 (3.17 kg) followed by control (2.38 kg). The maximum fruit yield per hectare (84.42 tones) was obtained from the line SL0068. Long shelf life was observed 25-26 days in both the cherry tomato lines. The magnitude of virus infestation showed that no virus infection was found in the tomato plants. The cherry tomato line SL0068 may be selected for releasing as cherry tomato variety and may also be suggested for growing in all agro-ecological zones of Bangladesh.

Hybridization in virus resistant tomato lines

An half diallel cross using 6 parents has been made at winter season in order to produce virus resistance hybrids for summer as tomato grown during summer is very much popular technology in Bangladesh and very often suffers to virus. AVRDC provided some lines through during NATP project contain Ty1, Ty2, Ty3, Ty4, Ty5 gene. Fifteen crosses and their 6 parents were evaluated replicated thrice. Initially the experiment has started on April and planted on May and due to unprecedented weather experiments was totally damaged at fruiting stage. Later the experiment was carried out at July to February. Data were recorded on days to 50 % plant flowering, number of cluster per plant, number of fruits per cluster, number of fruits per plant, single fruit wt. (g), yield (per plant yield and per hectare), plant height at last harvest, virus reaction at field condition, lycopene and **β**-carotene content (mg/kg). Significant heterosis was observed in number of fruits per plant, single fruit wt, fruit yield per plant. Very negligible number of plants found virus infected crosses made, but the parent like C 11, C 51, WP 7 were severely affected. The number of fruit was varied in different crosses, the highest number of fruits was recorded in the cross CLN-3324-A × CLN-3241-AA (64) with 20 cluster (the highest), while the lowest in the cross BARI TOMATO -17 × C51 (27) and parents BARI tomato 17 (22) with the lowest number of cluster (7). Early fruit harvest was made the cross CLN-3150-A-5 × C51 and the late harvest from the cross WP7 × CLN-3241-AA and the parents BARI tomato 17. Yield per plant was recorded in the cross CLN-3324-A × CLN-3241-AA) 5.5 kg/plant) while the lowest yield was recorded in the cross WP7 × C51 (1.39 kg/plant) and parent was C11 (1.30 kg/plant). Lycopene (mg/kg) content ranges 16-19 mg/kg and **β**-carotene (mg/kg) content ranges 5-6 mg/kg which was not varied significantly across the crosses. Considering the yield and quality characters the cross CLN-3324-A × CLN-3241-AA and CLN-3150-A-5 × CLN-3125-0-19, BARI TOMATO -17 × CLN - 3125-0-19 might be selected for RYT across the country.

Screening of hybrid tomato genotypes against salinity during germination and early seedling growth stage

The lab experiment was carried out at the Plant Physiology Laboratory of HRC, BARI, Gazipur during December 06, 2018 to December 19, 2018 to find out the salinity tolerant tomato genotypes during germination and early seedling growth stages. The response of 10 hybrid tomato genotypes *viz.*, V_1 = BARI Hybrid Tomato-4, V_2 = BARI Hybrid Tomato-5, V_3 = BARI Hybrid Tomato-7, V_4 = BARI Hybrid Tomato-8, V_5 = BARI Hybrid Tomato-9, V_6 = BARI Hybrid Tomato-10, V_7 = Rupashi hybrid, V_8 = Sonali Hybrid, V_9 = Bornali hybrid and V_{10} = Unnayan Hybrid against three levels of salinity *viz.*, 0 dS/m (S_0), 8 dS/m (S_1) and 12 dS/m (S_2) were studied in this experiment. BARI Hybrid Tomato -10 (V_6) and Unnayan Hybrid (V_{10}) were more salt tolerant than other varieties in view of germination, germination properties and early seedling growth characters. However, further trial is needed for confirmation of the result including more genotypes as per collection.

Effect of drought on tomato genotypes at germination and early growth stages

The experiment was conducted at the laboratory of Plant Physiology Section, HRC, BARI during December 22, 2018 to January 04, 2019. Ten tomato OP varieties (BARI Tomato-2, BARI Tomato-3, BARI Tomato-8, BARI Tomato-11, BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, BARI Tomato-17, BARI Tomato-18 and BARI Tomato-19) collected from Horticulture Research Centre, (BARI were used in the study. The experiment assessed the germination and seedling growth of tomato varieties at four polyethylene glycol (PEG) levels i.e. stress levels. In this experiment PEG 6000 was used for creating osmotic stress. The PEG concentrations used were 0% (distilled water, control), 5% PEG, 10% PEG and 15% PEG. Three layers of kitchen tissue paper were used in each petri dish for retaining required amount of water for imbibition of seeds. Twenty five healthy and equal sized seeds of each variety were selected and placed on sterilized petri dish lined with kitchen tissue paper. The germination count was taken after 72 hours of placing seeds. The 5 ml of distilled water (control) and 5 ml solution of PEG were added separately in the petri dishes. Number of seeds germinated was counted daily and data recording were continued up to 14 days. At the seedling age of 14 days, the shoot and the root length in mm of 10 randomly selected seedlings from each replicate were measured. Data

was recorded on germination and germination propertities (germination value, speed germination, germination rate, germination rate of index, coefficient of germination), seedling growth characters (shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, shoot length, root length, seedling vigour index. All characters were expressed as percentage of control. Among 10 tomato (OP) varieties BARI Tomato-18 performed best at 15% PEG. BARI Tomato-14, BARI Tomato-16, BARI Tomato-17 and BARI Tomato-19 also performed better at 15% PEG. BARI Tomato-11 was the worstt performer at 15% PEG. Cluster analysis and discussion on germination properties and growth characters revealed that BARI Tomato-18 might be drought tolerant and BARI tomato-14, BARI Tomato-15, BARI tomato-17 and BARI Tomato-19 might be moderately drought tolerant. However, further trial is needed for the confirmation of the result including more genotypes as per collection.

Effect of drought stress on growth and yield of BARI released tomato varieties

The experiment was conducted at the field of Plant Physiology Section, HRC, BARI (23.99307 N, 90.41094) during October 2018 to March 2019. Ten varieties of tomato (BARI Tomato-2, BARI Tomato-3, BARI Tomato-8, BARI Tomato-11, BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, BARI Tomato-17, BARI Tomato-18 and BARI Tomato-19) collected from Olericulture Division of HRC, BARI, Joydebpur, Gazipur, were evaluated at drought stress-i) non stress- water applied upto 100% of field capacity, ii) ii) moderately drought stress-water applied upto 70% of field capacity and iii) drought stress-water applied upto 50% field capacity. The moisture percent of soil was monitored upto experimentation by Soil Moisture Meter (Model:PMS-714, Taiwan). Drought was imposed after 2 weeks of transplanting in the pot. The range of minimum and maximum temperature was 11.70-19.95^{o}C and 22.20-32.95^{o}C, respectively and the crop received 108 mm rainfall during experimentation. The field capacity of pot soil was 32%. The study was evaluated under Completely Randomized Design (CRD) with three replications. Twenty five day-old seedling was transplanted in plastic pot (height- 29 cm, dia 32 cm at the top and 21 cm at the bottom; capacity 14 L) on 11 November 2018 which contained around 11.0 kg air dried soil (12.55 soil moisture). Fertilizers were applied to each pot @ Urea 2.25 g, TSP 3 g, MoP 3 g, Gypsum 2 g zinc sulphate 1.0, Magnesium Sulphate 1.0 g and Boric Acid 1.0 g during pot filling mixing with air dried soil Fertilizer was applied 4 times, at the rate of 4.0 -2.0-2.0 g of Urea, TSP and MoP per pot on 01 December 2018, 24 December 2018, 14 January 2019 and 04 February 2018 at 25 days interval. Weeding was done as per requirements. Ridomyl Gold was sprayed @ 0.2% at 15% interval. Final harvest of tomato was done 18 March, 2019. Data (from 5 plants) were taken on plant height, chlorophyll content (SPAD value), % relative water content, number of fruits/plant, individual fruit weight, %fruit set and fruit yield/pot. The SPAD value was taken by SPAD meter (SPAD-500 plus, Minolta Konica Inc, Japan). Relative water content (RWC) was measured using leaves (8th no. leaf from the tip of the plant) after imposing drought conditions. All the parameters are negatively affected by 70 and 50% FC due to less water availability. In respect of the parameters studied, it might be concluded that BARI Tomato-14, BARI Tomato-15, BARI Tomato-17, BARI Tomato-18 and BARI Tomato-19 performed better at less water availability condition (70% and 50% FC). These five varieties might be drought tolerant. The experiment will be conducted for the next year with these five selected varieties for the conformation of the result.

Effect of different levels of magnesium on the yield and quality of tomato

A field experiment was conducted at the research field of HRC, BARI, Gazipur during 2018-19 to estimate the effective doses of magnesium (Mg) for yield maximization of tomato (*Lycopersicon esculentum* L.). There were 4 treatments viz. T_1 = Control, T_2 = Mg 4.0 kg ha^{-1}, T_3= Mg 8.0 kg ha^{-1}, T_4= Mg 12 kg ha^{-1} along with the blanket dose of $N_{140}P_{45}K_{90}S_{18}Zn_4B_2$ kg ha^{-1} and cow dung 5 t ha^{-1}. The experiment was designed in randomized complete block with three replications. The results showed that the marketable yields of tomato ranged from 52.1 to 69.2 t ha^{-1}. The highest tomato yield was obtained from the treatment T_4. The lowest yield was found in control plot. The highest TSS (^{0}Brix 4.38) was found in T_4 treatment. The T_4 treatment exhibited the highest Mg uptake (291 kg ha^{-1}) by tomato. Considering the yield and quality

attributes 12 kg Mg ha^{-1} may be used for tomato production in terrace soils of Bangladesh.

Survey on pest status and incidence of tomato leafminer, tuta absoluta at panchagarh region of Bangladesh

The survey was conducted at farmers'' tomato fields at Bakshipara, Bhatiapara and Baragipara villages under Chaklarhat union, Panchagorh separately installing delta traps containing Tuta lures during August 2018 to July 2019 winter and summer seasons to find out the incidence, intensity and peak period of attack of tomato leafminer, Tuta absoluta(Meyrick) (Lepidoptera: Gelechiidae). From the results it was found that tomato leaf miner, Tuta absoluta damaged up to 85.4% plants, 20.50% leaves and 20.72% tomato fruits. The incidence was much higher in summer season than that of winter season. The peak period of Tuta attack was observed in March- April in winter and June-July in summer season and this introduced pest is appearing as a serious challenge to the farmers of Panchagarh area .

Evaluation of biorational based ipm packages for the management of tomato leafminer, tuta absoluta at farmers' fields in Bangladesh

The experiment was conducted at farmers' fields of Chaklarhat, Panchagarh during February to June 2019 to find out most effective biorational based IPM package(s) against tomato leaf miner, Tuta absoluta at farmers' field level. Total four packages, viz, $Package_1$ = Foliar spray of Bacillus thuringiensis (Biocure) @ 2g/L of water +Mass trapping through installation of Delta sex pheromone trap+ Application of Metarrhizium anisolpiae biopesticide in soil @ 5g/L of water, $Package_2$= Application of Metarrhizium anisopliae biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap, $Package_3$= Farmers' practice (Spraying with Chlorantraniliprole, Coragen 20SC @ 0.5ml/L of water) and $Package_4$ = untreated control were evaluated following Dispersed randomized complete block design with 5 replications. Results revealed that IPM package, Application of Metarrhizium anisopliae biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap performed best in reducing Tuta infestation, increasing marketable yield and highest marginal benefit cost ratio.

Effect of different mulches on growth and yield of tomato

The experiment was conducted during 2018-19 at Regional Agricultural Research Station, Rahmatpur, Barishal. The treatments of the experiment comprised five mulch materials *viz*. Sawdust (5cm thick), Cocodust (5cm thick), Rice husk (5cm thick), Water hyacinth (chopping and 10cm thick), Black Polythene with no mulch as control and BARI Tomato 15 as a variety. Mulching significantly increased the total number of fruit/plant of tomato over control plants. The highest number of fruit was recorded in chopped Water hyacinth mulch (28.74) and the lowest was in control i.e. no mulch (22.80). Similar trend was found in single fruit weight, being the highest in chopped Water hyacinth mulch (66.24g) lowest was in cocodust mulch (53.26g). The highest yield was recorded in chopped Water hyacinth mulch (94.96t/ha) followed by rice husk mulch (81.84t/ha) and the lowest was in control i.e. no mulch (62.86 t/ha).

Effect of vermicompost and other fertilizer on cultivation of tomato

The field trial was conducted at horticultural research field at Regional Agricultural Research Station, Rahmatpur, Barishal during 2018-19. The effect of organic and chemical fertilizer showed significant increase of the number of fruits per plant, individual fruit weight and yields in terms of fruit production in all the treatments in comparison to controlled one. In case of number of fruit per plant, the highest was observed in treatment T_2 (22.83) followed by treatment T_6 (22.04) and the lowest was observed in treatment T_3 (18.75). In case of individual fruit weight the highest was in treatment T_7 (91.73g) followed by T_6 (87.91g) and the lowest one was in treatment T_1 (61.41g). The highest yield per hectare was found in the treatment T6 (96.85t/ha) followed by T_7 (93.24t/ha) and T_5 (88.99t/ha). The lowest yield per hectare was observed in the treatment T_1 (62.24t/ha).

Influence of zinc and boron as foliar application on the growth, yield and quality of summer tomato

The experiment was conducted at the research field of HRC, BARI during summer season of 2018 to

evaluate the effect of foliar application of zinc and boron on growth, flowering and fruit setting of summer tomato and to determine the suitable foliar application doses of Zn and B for higher growth, yield and quality of summer tomato. The experiment was designed followed by RCB with three replications. Four foliar sprays with one control and one soil applied (check) treatments *viz*. T_1: Control; T_2: 9 ppm Zn (25-ppm $ZnSO_4$); T_3: 5 ppm B (25 ppm H_3BO_3); T_4: 4.5 ppm Zn (12.5-ppm $ZnSO_4$) + 2.5 ppm B (12.5 ppm H_3BO_3); T_5: 9 ppm Zn + 5 ppm B (25 ppm $ZnSO_4$ + 25-ppm H_3BO_3) and T_6: 4 kg Zn + 2 kg B as soil application (check) were used in the experiment. From one year study it was observed that foliar application of Zn and B application had significant effect on summer tomato production. Treatment T_4 with foliar application of 4.5 ppm Zn (12.5-ppm $ZnSO_4$) + 2.5 ppm B (12.5 ppm H_3BO_3) showed the best performance in terms of both yield and economic profitability. Maximum yield of 47.09 ton ha^{-1} was recorded with the treatment T_4. Also the higher fruit setting (16.7 fruit $plant^{-1}$), individual fruit weight (67.7 g) were found with T_4 treatment. Maximum gross margin (Tk. 1195562) was found in T_4 treatment followed by T_6 (Tk. 1113720) and T_3 (Tk. 1074130). Maximum BCR (2.74) and MBCR (31.82) were found from T_4 followed by T_6, respectively.

Screening of tomato germplasm resistant to bacterial wilt

The experiment was conducted with 20 tomato accessions/lines in artificially inoculated sick bed during November 7, 2018 cropping seasons. The sick bed was established by inoculating the soil with a mixture of *R. solanacearum* isolates, freshly collected wilted tomato plants from different regions of Bangladesh. Twenty tomato accessions were screened to find out bacterial wilt resistant source grown under artificial epiphytotic field conditions during 2018-2019 cropping seasons. Among the accessions, two accessions namely SL-0008 and SL-0406 gave highly resistant reaction against bacterial wilt. Seven accessions of tomato were showed resistant reaction, three accessions gave moderately resistant reaction, three accessions gave moderately susceptible, single accession was found susceptible, five accessions gave susceptible reaction and four accessions were highly susceptible to *R. solanacearum*.

Screening of rootstock against bacterial wilt for grafting tomato variety

The experiment was conducted with six different rootstocks supplied by Olericulture Division, HRC, BARI, grown in artificially inoculated sick bed of HRC during June 4, 2018 cropping seasons. The sick bed was established by inoculating the soil with a mixture of *R. solanacearum* isolates, collected from wilted eggplant field of various regions during 2018 but the population was estimated before transplanting which was about $1.77X10^9$ cfu/ml.Six different rootstocks were screened to find out suitable resistant rootstock for tomato grafting bacterial wilt resistant source grown under artificial epiphytotic field conditions during 2018-2019 cropping seasons. Among the six rootstocks, *Solanum sisymbriifolium* was highly resistant to bacterial wilt. Two rootstocks such as EG 203 and BARI Begun-8 gave resistant reaction against bacterial wilt with 10% mortality, respectively.

Screening of tomato germplasm against root-knot nematode

The experiment was conducted at BARI, Gazipur during November 11, 2018. One-month of old seedlings of twenty tomato germplasm were transplanted in three replications in nematode sick bed, having population of 2500-3500 RKN larvae per kg soil. Twenty tomato varieties/lines were tested in a nematode infested sick bed for their resistance to root- knot nematode. Among them, four lines (SL- 0011, SL- 0403, SL-0304 and SL-0404) showed resistant, four lines (SL- 0309, SL-0312, SL-0401and SL-0313) showed moderately resistant, five lines (SL-0012, SL- 0003, SL-0033, SL-0311and SL- 0402) showed moderately susceptible, six lines (SL-0036, SL-0310, SL-0008, SL-0038, SL-0405 and SL-0406) showed susceptible and a line (SL-0009) gave highly susceptible reaction to root knot nematode.

Management of TYLCV of tomato through chemical and cultural means

The experiment was conducted at Horticulture research field, BARI, Gazipur during winter 2018-19 cropping season to select suitable management practice (s) for Tomato Yellow Leaf Curl Virus (TYLCV) disease of tomato. BARI tomato-8 variety was used in the experiment. Five treatments viz: yellow polyethylene mulch, straw mulch,

barrier crops, neem seed oil and control (Admire) were evaluated. Among them, yellow polyethylene mulch reduced the maximum disease incidence and severity, and increased yield of tomato. Moderate disease incidence and medium yield was obtained from straw mulch treatment. Neem oil, barrier crop and control (Admire) gave similar results regarding leaf curl symptom development on upper leaves and per hectare yield of tomato. While in 2017, the maximum yield was recorded in yellow polyethylene mulch followed by straw mulch which is similar to this year results. Therefore, yellow plastic mulch may recommend controlling whitefly population and management of TYLCV disease in tomato.

Sweet Paper

Performance of newly developed sweet pepper hybrids

This study of two selected F_1's of capsicum ($F_1$1x2, $F_1$2x3) with a check was conducted at the farm of Olericulture Division, HRC, BARI, Gazipur during the winter season of 2018-19. The hybrid 2x3 took the minimum days to 1st harvest (66.25 days). The highest number of fruits per plant (28.40) was recorded from $F_1$1x2. The heaviest fruits (114.8g) were obtained from F_1 2x3. Fruit weight per plant was found maximum (2.54kg) in $F_1$1x2 followed by the $F_1$2x3 (1.42kg). The highest yield was produced by $F_1$1x2 (57.05 t/ha) due to higher yield contributing characters. Minimum infestation by fruit borer (1.02%) was observed in $F_1$1x2, This hybrid line also performed well against white fly and mite infestation. All the studied lines were differed in various colors, which are varied from red to yellow in matured stage. These two hybrids ($F_1$2x3, $F_1$1x2) were found promising for earliness, high yield, color variation and insect pest reaction. So, these two lines may be recommended for further evaluation for their yield and quality.

Effect of planting time and genotypes on growth and fruit yield of sweet pepper

Sweet pepper (Capsicum annum L.) is highly sensitive to temperature variation and high temperature promotes flower drops and reduce fruit yield. An experiment was undertaken to identify suitable planting time of sweet pepper and stable performed varieties for different plating times during the winter season of 2018 -19 at the farm of Olericulture Division, HRC, BARI, Gazipur. The experiment was randomized complete block design with 3 replications. Three planting dates (15 November, 30 November and 15 December) were allotted with 4 genotypes (V1-CA0005; V2- CA 0015; V3- CA0012; V4- BARI Mistimorich 1). Sweet pepper responded differently with the changes in planting dates irrespective of different characters. November 30 planting emerged best in terms of different and growth yield attributes. Among the genotypes, CA0005 emerged as superior in terms of more number of fruits (10.24), fruit weight (65.50 g) and yield (670.76 g/plant and 18.11 t/ha).The interaction effect showed that variety CA0005 transplanted on 15 December resulted in many fold improvement in the form of maximum number of fruits/ plant, fruit weight (86.93 g) and fruit yield (854.69 g/plant and 23.08 t/ha). The result revealed that 30th November was ideal for sweet pepper planting and the genotype CA0005 was the most suitable genotype with respect to the different planting dates.

Effect of seedling age on growth and yield of BARI released capsicum varieties

The experiment was carried out at Regional Horticulture Research Station, BARI, Shibpur, Narsingdi, during *rabi* season of 2017-2019. There were four treatments that were 21 days, 28 days, 35 days and 42 days age of transplanting seedling. The experiment was conducted in a randomize block design with three replications. Plant height (61.78 cm), individual fruit weight (110.50g), marketable fruit number (16.89) and yield (28.73 ton/ ha) was found higher in 21 days age of seedling which was followed by 28 days and 35 days age of seedling respectively. The lowest yield 5.79 ton/ha was recorded in 42 days age of seedling. From the result of this experiment, it may be concluded that 21 days age of seedling at transplants growth and yield was better performer than other age of seedling at transplants of BARI Mistimorich-1 variety.

Effect of packaging on storage life and quality of fresh cut green bell pepper

An experiment was conducted on fresh cut processing technique of green bell pepper in Postharvest Laboratory of Horticulture Research Centre, BARI, Gazipur. The study was conducted

with the financial assistance of NATP-2 CRG. Matured, shiny green, compact and defect free green bell pepper, knives, all used utensils were washed with sanitizers (200 ppm sodium hypochlorite). After wearing apron, hand gloves, cap and musk, green bell pepper was cut into pieces with sharp knives. Green bell pepper pieces were packed into different packaging techniques like i. without packaging (control); ii. polypropylene (PP) box iii. Styrofoam tray wrapped with cling film; iv. sealed low density polyethylene (LDPE) bag; v. vacuum LDPE bag. After packaging, all samples were stored at refrigerator (4±1°C and 50±5% RH). The effectiveness of the packaging in extending shelf-life with quality was evaluated by determining respiration rate, firmness, weight loss, external colour, some chemical parameters (ascorbic acid content, TSS and pH), total bacterial count (TBC) and sensory quality. The highest amount (around 4.33 log CFU/g) of TBC was observed in FC bell pepper packed in sealed LDPE bag which was similar with that of PP box and cling-wrapped ones at 8th day of storage period. It was 3.94 log CFU/g in control at 6th day and 2.96 log CFU/g in vacuum packed at 10th day. FC bell peppers packed in sealed LDPE bag, PP box and cling wrapped, condensation was produced inside the package helps microorganisms' growth. That's why higher amount of TBC was found in these packages even more than the control samples. However, in all samples TBC was below the maximum acceptable contamination values in FC bell pepper. Based on all sensorial, microbial and physicochemical characteristics control or unpacked fresh cut green bell pepper was acceptable up to 2 days, bell pepper packed in sealed LDPE bag, PP box and cling wrapped was acceptable up to 8 days and vacuum packed one was acceptable more than 10 days.

Survey and monitoring of anthracnose disease of capsicum

The anthracnose caused by *Colletotrichum* species is an important disease that primarily caused fruit rot in pepper. About 300 samples of the isolates representing three species of *Colletotrichum* were obtained from rotten pepper fruits in Bangladesh.The survey was conducted in Bogra, Gaibandha, Sirajgonj, Manikgonj, Faridpur, Mymensingh, Gazipur, Jashore and Khulna districts during Kharif and Robi seasons from July 2017 to February 2018 and July 2018 to June 2019 and samples were characterized according to morphology. Three hundred samples were cultured in PDA media. Among them, 37 isolates were preserved for future study which had positive reaction to *Colletotrichum gloeosporioides*, *C. capsici* & *C. truncatum*. Totally 121 samples of anthracnose pathogen were collected using FTA card for molecular characterization. Among them, 115 were identified as *Colletotrichum truncatum*, two samples were *Colletotrichum goleosporioides*, one was *Colletotrichum capsici* and the rest of the three were identified as others.

Cauliflower

Germination and seedling growth of cauliflower as affected by salinity

An experiment was conducted at the shade house of Olericulture Division, HRC, BARI, Joydebpur, Gazipur during December, 2017 to investigate the effect of salinity on germination and early seedling growth stage of cauliflower. Ten cauliflower varieties *viz*.; BARI Fuikopi-1 (C-01), BARI Fulkopi-2 (C-02), Sivan Cauliflower F1(C-03), Cauliflower F1 Hybrid (Fresh Marker) 70 Days (C-04), Cauliflower F1 Hybrid White 770 (C-05), F1 Hybrid Snow White (C-06), Hybrid Fulkopi (Snow Box) (C-07), Cauliflower F1 Hybrid (Candid Charm) (C-08), Cauliflower F1 Hybrid (Shira Giku) (C-09) and F1 Hybrid Hamazuki 33 (C-10) were included in this study. Four levels of salinity *viz*., control, 4, 8 and 12 dS/m were imposed at the very beginning of germination and continue upto 20 days. The results revealed that salt stress reduced the germination percentage (GP) and speed of germination (SG) in cauliflower seeds. Under different stress conditions, C-01, C-02, C-09 and C-10 gave the higher GP and C-01, C-09 and C-10 gave the higher SG as compared to other verities. The length of shoot and root and fresh and dry weight of seedlings at 20 DAS were also decreased at higher salinity. The longer shoot and root were recorded from C-01, C-06, C-9 and C-10 under 8 and 12 dS/m salinity levels. In case of fresh and dry weight of seedlings, C-01, C-03, C-06, C-09 and C-10 showed the overall higher values. Increasing salinity caused gradual decrease in seedling vigor index (SVI) and seedlings tolerance index (STI),

while percentage of shoot and root toxicity (ST% and RT%, respectively) were increased with increasing salinity with a few exception found at low salinity. The higher SVI as well as STI were recorded from C-01, C-09 and C-10 under different salinity levels. Most of the varieties showed negative ST(%) and RT(%) values at 4 dS/m salinity stress indicated their favourable growth at low salinity. At higher salinity levels, the ST(%) and RT(%) were minimum in C-01, C-02, C-09 and C-10.

Effect of packaging on storage life and quality of fresh cut cauliflower

An experiment was conducted on fresh cut processing technique of cauliflower in Postharvest Laboratory of HRC, BARI, Gazipur. The study was conducted with the financial assistance of NATP-2 CRG. Fresh, compact, defect free cauliflower, knives, all used utensils were washed with sanitizers (200 ppm sodium hypochlorite). After wearing apron, hand gloves, cap and musk, cauliflower was cut into pieces with sharp knives. Cauliflower pieces were packed into different packaging techniques like i. without packaging (control); ii. polypropylene (PP) box iii. Styrofoam tray wrapped with cling film; iv. 1% perforated low density polyethylene (LDPE) bag; v. sealed LDPE bag; vi. vacuum LDPE bag. After packaging, all samples were stored at refrigerator (4±1°C and 50±5% RH). The effectiveness of the packaging in extending shelf-life with quality was evaluated by determining respiration rate, firmness, weight loss, external colour, some chemical parameters (ascorbic acid content, TSS, acidity, pH, total sugar and reducing sugar), total bacterial count (TBC) and sensory quality. The highest amount (around 4.1 log CFU/g) of TBC was observed in FC cauliflower packed in perforated LDPE bag, sealed LDPE bag, PP box and cling wrapped while only 2.26 log CFU/g was found in vacuum packed ones at 20th day. FC cauliflower packed in perforated LDPE bag, sealed LDPE bag, PP box and cling wrapped, condensation was occurred inside the package. After 16th day of storage, this excess humidity inside packages helps microorganisms' growth. That's why higher amount of TBC was found in these packages even more than the control samples. Based on all sensory, physical and chemical parameters fresh cut control or unpacked cauliflower was acceptable up to 4 days, FC cauliflower packed in perforated LDPE bag, sealed LDPE bag, PP box and cling wrapped was acceptable up to 16 days and vacuum packed cauliflower was acceptable for more than 20 days.

Effect of different nitrogen levels on growth and yield of cabbage cauliflower and broccoli

An experiment was conducted in a split plot during the research field of HRC, BARI, Gazipur during summer time of 2018 followed by RCBD with 3 replications. The treatments were: three crops as- Cabbage, cauliflower and broccoli were considered as factor A and Four fertilizer levels as- $N_{1=}$ 100% RDN PU; $N_{2=}$ 100% RDN USG; N_3= 85% RDN USG and N_4 = 70% RDN USG were considered as factor B. From one year experiment it was observed that 100% RDN as USG produced the highest yield in cabbage, but in cauliflower and broccoli 85% RDN as USG produced higher yield. So, cauliflower and broccoli was highly responsive to USG in relation to prilled urea.

Standardization of Talc Base Formulation of *Trichoderma viride* for Disease Management of Cabbage

The experiment was conducted in Horticulture research field, BARI, Gazipur during November 2018-19 cropping season with cabbage (variety Atlas-70) for standardization of talc based formulation of *Trichoderma viride* and maize bran mixing ratio before application to control soil borne pathogens. Five ratio of talc *Trichoderma*: maize bran (1:2, 1:3, 1:4, 1:5 and 1:6) was tested. Control was maintained without any *Trichoderma* application. All *Trichoderma* treatment reduced disease incidence over control. The highest disease incidence was recorded in control treatment. Talc *Trichoderma* and maize bran ratio 1:5 reduced the maximum disease incidence (78.08%) over control. Length, diameter, biomass and single head weight of cabbage were not influenced by talc *Trichoderma* application. However, diameter, head weight and marketable yield were affected due to talc *Trichoderma* application. Cabbage diameter and single head weight was the highest in 1:5 ratio of talc *Trichoderma* and maize bran. Yield increased over control was 47.69% in 1:5 ratio of talc *Trichoderma* and maize bran muxture. Considering disease incidence and yield 1:5 ratio of talc *Trichoderma* and maize bran mixing may recommend for soil application.

Broccoli

Advanced yield trial of selected broccoli lines

The experiment was conducted at the research field of Olericulture Division, HRC, BARI, Gazipur during the winter season of 2018 - 19 with eight selected OP broccoli lines and BARI Broccoli-1 was used as check to evaluate their yield performance. The highest curd length (22.83 cm) was recorded from the line BOI 019 and the highest curd breadth (18.5 cm) was recorded from the BARI Broccoli-1. The highest only curd weight/ plant (1150 g) was obtained from the line BOI 021. Marketable curd weight/plant (900 g) and the highest per hectare curd yield (27.9 t) was obtained from the line BOI 018. The lowest only curd weight/ plant (297.3g) and marketable curd weight/plant (216.67 g) was obtained from the same line BOI 016 and the lowest per hectare curd yield (7.06 t) was recorded from the line BOI 017. All lines produced slightly cerate green color leaf except BOI 018 and BARI Broccoli 1.The line BOI 015, BOI 018, BOI 020, BOI 021 and BOI 022 was produced medium and compact curd while BOI 019 produced small curd. The line BOI 015, BOI 017, BOI 019, BOI 021 produced light green curd and BOI 016, BOI 020, BOI 022 and BARI Broccoli-1 produced green color curd. On the basis of uniform curd shape, compactness and yield the line BOI 018, BOI 021, BOI 022 and BOI 015 were selected to verify their yield performance and seed production potentiality in local climate.

Effect of GA_3 and main head removal on seed yield and yield attributes of broccoli

The experiment was conducted at the field of plant physiology section of HRC during the *rabi* seasons of 2016-17, 2017-18 and 2018-19. Here only in case of seed yield, three years' results were presented but in case of other's data the results of 2018-19 were presented. The experiment was laid out in Randomized Complete Block Design. The treatments consisted of four GA_3 concentrations (Factor-A) viz. G_0 = Distilled water (control), G_1 = GA_3 60 ppm, G_2 = GA_3 80 ppm and G_3 = GA_3 100 ppm and two head removal treatments (Factor-B) *viz.*, R_0 = no head removal and R_1= Head removal at marketable stage. The unit plot size was 2.00 m x 1.80 m (3.6 m^2) having 12 plants. The variety used in the experiment was BARI Broccoli -1. Twenty five, 24 and 23 day-old seedlings were transplanted on 27 November, 2016, 16 November, 2017 and 20 November 2018, respectively adopting a spacing of 60 cm x 50 cm. GA_3 was sprayed to the plants at 50 and 75 days after transplanting mixing with 2-3 drops of Trix solution every year. Cowdung, urea, TSP, MoP, sulphur, boron, and magnesium were applied @ 10 t, 240, 150, 150, 10, 2 and 2 kg/ha. The entire quantity of cowdung, TSP, sulphur, boron, magnesium, one-third urea and half of MoP were applied during land preparation. The remaining half of MoP and two-third urea was applied in three equal installments at 20, 40 and 60 days after transplanting. An additional dose of 50 kg N/ha, 50 kg K/ha and 10 kg P/ha was applied to the plants at 80 days after transplanting. Weeding was done as when necessary. A total of four irrigations were given to the crop. In the first year, head harvest was done at marketable stage from 19 January, 2017 to 27 January, 2017, in 2nd year 11 January, 2018 to 17 January, 2018 and 1n the final year, from 14 January, 2019 to 22 January, 2019 according to treatments. Seed harvest was done on 28 March, 25 March and 01 April of 2017, 2018 and 2019, respectively. The data were recorded on plant height, number of leaves/plant, leaf length, leaf breadth, plant spread and SPAD value. These data were taken on 01-03 February of 2017, 2018 and 2019. The data was also taken on primary flower stalks/plant, secondary flower stalks/plant, pods/plant, pod length, seeds/pod, 1000 seed weight, weight of seeds/plant and weight of seeds/plot after harvest. The plot yield was converted to per hectare yield. Data on SPAD value was taken by SPAD meter (Model: SPAD-502, Minolta, Japan). Plant height, length of the biggest leaf and plant spread were found maximum from the spraying of GA_3 60 ppm and minimum from control. However, there was no significant difference among GA_3 60 ppm, GA_3 80 ppm and GA_3 100 ppm in respect of plant height and length of the biggest leaf. No of leaves/plant and width of the biggest leaf were not influenced by growth regulator (PGR) treatments. Plant height, leaves/plant, length of the biggest leaf, width of the biggest leaf and plant spread were not significantly influenced by head removal treatments. The combination of GA_3 and head removal (G_1R_1) gave the maximum plant spread closely followed by G_1R_0 and G_0R_0 gave the minimum plant spread. Plant height, no of leaves/plant, length and width of

the biggest leaf were not significantly influenced by the combination of PGR and head removal treatment. GA_3 treatments had significant effect on all yield attributes and yield except Primary and secondary flower stalks/plant. Pods/plant, pod length, seeds/pod, 1000 seed weight, seed yield/plant and per hectare were found maximum from the spraying of GA_3 60 ppm and their values were minimum under control treatment. No head removal treatment gave higher primary (13.27) and secondary flower stalks/plant (46.20) than head removal treatment. On the other hand, head removal at marketable stage gave maximum pods/plant (869.69), seed yield/plant (19.18 kg) and seed yield (607.52 kg/ha).The results revealed that main head removal had positive effect on yield attributes and seed yield of broccoli. This might be due to removal of main head, several numbers of secondary shoots (heads) were produced around the main stem and they were not so compact as main head and also got more space which decreased competition among the flower stalks and thus produced more seeds. In case of control plants (without main head removal), no secondary head was produced and the flower stalks produced from main head were more compact which increased competition among the flower stalks for space, thus normal development of seeds was hampered. The lower seed yield obtained from no head harvested treatment could be also due to poor aeration and poor pollinator movement. The highest number of pods/plant was obtained from G_1R_1 (1042.2.0) followed by G_1R_0 (915.5) and its minimum value was recorded from control (G_0R_0) (Table 6). The combination G_1R_1 produced the maximum pod length (4.59) which was identical with that of G_1R_0 (4.53) Similar trend was also followed in respect of seeds/pod and 1000 seed weight. The highest number of seeds/ pod was obtained from G_1R_1 (13.35) followed by G_1R_0 (13.30) and its minimum value was recorded from control (G_0R_0).The maximum seed yield was recorded in G_1R_1 (20.09 g/plant and 649.6 kg/ha) followed by G_1R_0. G_1R_1 combination gave significantly maximum seed yield in all the years. The average seed yield of three years was also found highest from G!R1 (684.55 kg/ha) treatment combination. The cost and return analysis revealed that spraying of GA_3 @ 60 ppm in combination with head removal at marketable stage was superior to G_2R_1 and other combinations in terms of net income and BCR.

Bottle Gourd

Genetic diversity of bottle gourd germplasm

The study was conducted at the experimental field of Olericulture Division, HRC, BARI, Gazipur during 2018-19 to assess the extent of genetic diversity among 25 bottle gourd germplasm. The collected germplasm originating from different local and exotic sources were subjected to cluster analysis. The germplasm was constellated into five distinct groups with the range of 3 germplasm in cluster III to 6 germplasm in cluster II and cluster IV. The inter-cluster distance in all cases was larger than the intra- cluster distance. The highest intra cluster value (2.65) was observed in cluster IV. Maximum inter-cluster distance (12.24) was observed between germplasm of cluster I and V followed by cluster I and III (12.05) and minimum was found between germplasm of cluster I and IV (3.46). In case of the cluster means values and yield contributing performance cluster I, cluster IV and cluster III performed well. Cluster I had five germplasm and recorded the highest mean for number of fruit/plant (13.60), fruit yield /plant (24.72 kg), fruit yield (49.44 t/ha) and second lowest mean for days to 1st harvest (79.20). Cluster III had three germplasm and was responsible for lowest mean for days to 1st harvest (70.00), while second lowest vales for average fruit weight (1.83 kg), fruit diameter (12.23 cm). Cluster IV was constituted of six germplasm and exhibited highest mean value for average fruit weight (2.07 kg), fruit length (39.50 cm). Considering the group distance and inter-genotypic crosses between the cluster and cluster means, inbreds belong to cluster I, cluster IV and cluster III will be given higher priority for crossing in future bottle gourd hybridization programme.

Evaluation of winter bottle gourd germplasm (RARS, Ishwardi)

Six bottle gourd germplasm were evaluated at Regional Agricultural Research Station, Ishurdi, Pabna during *rabi* season of 2018-19 for yield performance. Six bottle gourd lines LS Isd-001, LS Isd-002, LS Isd-003, LS Isd-004, LS Isd-005 and LS Isd-006 were evaluated. The highest number of fruits per plant (18) was counted from LS Isd-006 and lowest (10) from LS Isd-005. The highest yield (45.23 t/ha) was obtained from LS Isd-006 and the lowest yield (25.54 t/ha) was found in LS Isd-005.

LS Isd-006, LS Isd-001 and LS Isd-004 were found promising irrespective of yield and other contributing characters. The study will be repeated in the next cropping season with more collection.

Evaluation of bottle gourd lines in summer (RARS, Jamalpur)

A study was conducted to evaluate bottle gourd (*Lagenaria siceraria*) lines in respect of yield and quality in summer at HRC field, RARS, Jamalpur during the *kharif-1* season of 2018. Seven bottle gourd lines *viz.* LS Jam-001, LS Jam-002, LS Jam-003, LS Jam-004, LS Jam-005, LS Jam-006, LS Jam-007 and BARI Lau-4 as check were evaluated to investigate the yield and yield contributing characters. Longer fruit (41 cm) was obtained from BARI Lau-4 whereas shorter fruit (11 cm) by LS Jam-002. LS Jam-006 produced wider fruit (21 cm) compared to narrower fruit (12 cm) . The highest number of fruits per plant (12) was produced by the LS Jam-004 whereas the lowest number of fruits (8) was noted from the LS Jam-005. The higher individual fruit weight (1.51 kg) noted in LS Jam-005 and lower (1.15 kg) in LS Jam-003. The more fruit yield per plant (16.55 kg), per plot (82.77 kg) and per hectare (27.59 t) was produced by the LS Jam-004 as against the less 10.49 kg per plant , 52.47 kg/plot and 17.49 t per hectare in LS Jam-007. The selected line will evaluated next year.

Advanced yield trial of selected winter bottle gourd lines

The trial was conducted at the experimental field of Olericulture Division, HRC, BARI, Joydebpur during winter season of 2018-19 to select superior lines with higher yield and better quality. Sixteen advanced lines of bottle gourd were included in the study. The line LS1568 produced the earliest fruiting with 60 days followed by LS 158 (72 days), LS 161 (73 days), LS 164 (75 days). The maximum number of fruits per plant was harvested from the line LS158, LS170 (12.0), while the heaviest fruits were obtained by the LS 155-2 (2.3 kg). The range of fruit length was 24 cm (LS162) - 44 cm (LS155-2), while the fruit diameter was 9.0 cm (LS164) – 16.0 cm (LS162, LS169). Though the lines LS 170 (54.00 t/ha), LS 158 (52.50 t/ha), LS171 (52.50 t/ha), LS 161 (52.25 t/ha), LS 155-2 (51.75 t/ha), LS154 (50.00 t/ha) were higher yielder, but considering earliness, yield potentiality, fruit color, acceptable fruit shape five advanced lines viz., LS154, LS 155-2, LS 162, LS 167, LS171 were found promising and may be selected for RYT for regional performances.

Regional yield trial of bottle gourd lines

A study on the performance of four Bottle gourd lines with BARI Lau-3 and BARI Lau-4 was conducted at 6 locations *viz.* Joydebpur, Rahmatpur, Jamalpur, Moulvibazar, Ishurdi and Burirhat during the winter season of 2018-19 to develop new high yielding OP varieties. In case of days to 1st harvest, LS151C took the minimum days (90.330) which was statistically similar to LS138 B4 (92.33 days). The highest no. of fruit/ plant (11.33) was found by BARI Lau-4 which was followed by LS146 A1 (10.17) while the lowest was from LS138 B4 (8.17).The highest average fruit weight was obtained from the line LS146 A1 (2.25 kg) whereas the lowest was in LS139 A1 (1.79 kg).The longest fruit was observed in LS151 C (39.00cm) while the shortest was from LS146 A1 (21.33 cm). The maximum diameter of fruit was recorded in LS146 A1 (20.33cm) while the lowest was from LS138 B4 (10.60 cm). The highest per hectare fruit yield was from BARI Lau-4 (59.81 t/ha), LS146 A1 (56.94 t/ha). Considering earliness, yield potentiality, fruit color, acceptable fruit shape two advanced lines viz., LS146A1 and LS 151C were found promising and may be repeated for next one-year RYT for confirmation.

Heterosis studies in bottle gourd

A study on the performance of 11 F_1 crosses and their 7 parents of bottle gourd was conducted at the farm of Olericulture Division, HRC, BARI, Gazipur, Bangladesh during the winter season 2018-19. Better parent heterosis in bottle gourd was studied in 11 crosses of bottle gourd. Considering days to 1st harvest (-5.92%), number of marketable fruit/ plant (22.22, average fruit wt. (15.78%), fruit yield/ plant (31.17%), and fruit yield/ hectare (31.17%) - hybrid F_1 B-3x B-4 performed higher better parent heterosis, while F_1 B-2xLS146 was better for number of marketable fruit /plant (11.11%), fruit yield /plant (16.40%), fruit diameter (30.95%), fruit yield/ hectare (16.40%) and F_1 LS 139A1x B-4 was better for fruit yield /plant (20.57%) and fruit yield/ hectare (20.57%). Beside these, other two hybrids viz., F_1 B-2x B-3 (23.81%), F_1 B-1xLS139 (23.53%) were good for bigger sized fruits. In the present study the

hybrids F_1 B-3x B-4, F_1 B-2xLS146, F_1 LS 139A1x B-4 manifested the higher heterosis over better parent for plant yield and yield contributing characters.

Development of IPM package for disease management of bottle gourd

The experiment was conducted at vegetable research field at HRC, BARI, Gazipur during the winter, 2018-2019 for disease management of bottle gourd. Three treatments, viz. T_1= i) IPM package I: Soil application of Tricho-compost @ 2.5 t/ha + Bordeaux paste at 12 inch from soil level + foliar spray of Tricho-leachate @ 0.2% at 15 days interval + Pheromone trap, T_2= ii) IPM package II: Soil application of Talc base *Trichoderma* @ 50 kg/ha + mustard oil extract cake @ 600 kg/ha + foliar spray of Tricho-leachate @ 0.2% 0.2% at 15 days interval + Pheromone trap and iii) Control (regular practices) were used. Among the treatment, IPM package II: Soil application of Talc base *Trichoderma* @ 50 kg/ha + mustard oil extract cake @ 600 kg/ha + foliar spray of Tricho-leachate @ 0.2% at 15 days interval + Pheromone trap reduced the maximum disease incidence of gummy stem blight and increased the yield of bottle gourd followed by IPM package I: Soil application of Tricho-compost @ 2.5 t/ha + Bordeaux paste at 12 inch from soil level + foliar spray of Tricho-leachate @ 0.2% at 15 days interval + Pheromone trap was also found satisfactory to control the disease.

Demonstration trial of bottle gourd production using tricho-compost and tricho-leachate as disease management tools

A demonstration trial was conducted with local variety (Lomba Hazari Lau) at farmer's field Bogura during *kharif* 2017-18. Two treatments such as (i) Soil application of Tricho-compost @ 2.5 ton per hectare + chemical fertilizer 80% + foliar application of Tricho-leachate @ 20ml/ liter of water and (ii) Farmers' practices (cowdung @ 2.5 t/ha + chemical fertilizers+ pesticides spray) were used. Soil incorporation of Tricho-compost and foliar spray Tricho-leachate reduced disease infestation and increased yield of bottle gourd. At harvest fruit rot was significantly reduced due to application of Tricho-compost and foliar spray of Tricho-leachate. Trcho-product applied plot, percent fruits damage was only 3.42%, while it was about 6.47% in farmer's practices. Percent disease index was 30.0 in Tricho-products applied treatment, while it was 57.8 in farmer's practices. Percent disease index (PDI) reduction over control was 48.05% in Tricho-product applied fields. Total and marketable yield significantly increased in Tricho-product applied plots. Marketable yield was only 17.92 t/ ha in farmer's practices, while it was 24.47 t/ha in Tricho-products treatment. Yield increased over control was 37.21%. Benefit cost ratio was 2.34 in Tricho-compost plot, while it was 1.74 in control plot. BCR increased over control was 33.71%.

Evaluation of bottle gourd genotypes for drought tolerance through yield-based selection indices

A field study was conducted during October 2018-March 2019 growing season (Winter) under limited irrigated (DS) and irrigated (NS) conditions at the Research Field of Plant Physiology Section, HRC, BARI. Seeds of each genotype were sown in poly bag (6 cm x 7 cm) on 28 October, 2018. Seventeen day-old seedlings were transplanted in the field on 14 November 2018. Drought was imposed after 3 weeks of transplanting in the pit (30 cm x 30 cm x 30 cm). Fifteen bottle gourd genotypes, namely BARI Lau-I (G_1), BARI Lau-2 (G_2), BARI Lau-3 (G_3), BARI Lau-4 (G_4), BARI Lau-5 (G_5), LS 167 (G_6), LS139A1(G_7), LS146A1 (G_8), LS153(1) (G_9), LS154 (4) (G_{10}), LS155 (2) (G_{11}), LS151C (G_{12}), LS158 (G_{13}), BADC Khet Lau (G_{14}) and Diana (G_{15}) were used for the study. Seeds of 13 genotypes G_1-G_{13} were collected from Olericulture Division, HRC and 2 genotypes G_{14} and G_{15} were bought from local market. The study was designed using a 15 × 2 factorial experiment involving 15 bottle gourd genotypes under drought stress (DS) and non-stressed condition (NS). A total of 30 treatment combinations were laid out using a split plot design with three replications totaling 90 experimental units (unit plots measuring 2 m× 2 m). Drought (irrigation) treatment was allocated in main plot and genotypes were allocated in subplot. One plant of each genotype was planted in the unit plot at a spacing of 2 m between rows and 2 m between plants. Drought was imposed after 3 weeks of transplanting in the pit (30 cm x 30 cm x 30 cm). Daily average maximum and minimum temperatures ranged between 32.95°C and 11.70°C during the growing season. In the current study, the

total rainfall received during the growing season was 108 mm, which was considerably lower than the long-term mean annual averages. The experiment was established on 14 November 2018 and terminated on 29 March 2019. Irrigation was started after two weeks of planting (vegetative stage) until maturity (reproductive stage). A total of 3 irrigations were applied to the plants under drought condition and 15 irrigations to the plants under non-stress condition. Irrigation (@ 44 L water/plant) was given to the drought stressed plant when the plants showed wilting symptom whereas non-stressed plants were given irrigation (@ 88 L/plant) at 7 days interval. Each plant subjected to drought conditions received only 132 1itre (7 mm) of water and each plant of control (NS) treatment received 1320 litre (70 mm) of water from supplemental irrigation. Irrigation was terminated when all plants had stopped producing tender edible fruits). Fruit yield (in kg) was measured and converted to tons per hectare (t ha^{-1}). Quantitative yield-based indices of stress tolerance such as: Mean Productivity Index (GMP), Stress Tolerance Index (STI), Yield Index (YI), Yield Stability Index (YSI) and Harmonic mean (HM) were calculated from Yns (yield under non-stress) and Yds (yield under droght stress). Among 15 bottle gourd genotypes, the genotypes G_{13}, G_{15} and G_5 produced higher yield in both non-stressed and stressed condition. Principal Component analysis, cluster analysis confirmed that G_{13}, G_{15} and G_5 were drought tolerant and G_3, G_6 and G_{11} were most susceptible to drought. However, further trial is needed for the confirmation of the result.

Bitter Gourd

Evaluation of local germplasm of bitter gourd in cumilla region

This study was undertaken with five local germplasm collected from Cumilla region for screening the bitter gourd germplasm available in Cumilla region having high yield potentiality as well as resistance to insect pest and disease. The germplasm includes MC CUM 001, MC CUM 002, MC CUM 003, MC CUM 004, and MC CUM 005 along with BARI Korola-2 as check. The experiment was laid out in RCB design with three replications. Results indicate that most of the germplasm performed better compared to check regarding fruit yield and other yield contributing character. MC CUM 001 produced the highest average fruit weight (270.89 g). The highest no. of fruit per plant (57.50) was found in MC CUM 003 followed by MC CUM 004 (51.17) which gave the highest fruit yield (28.34 t ha^{-1}). MC CUM 004, MC CUM 001 & MC CUM 002 may be selected as good yield performer for the next year evaluation. Collection will be continued to gather more germplasm for evaluation.

Observational yield in off season bitter gourd

Eight lines of bitter gourd were tested at the experimental field of Vegetable Division, HRC, BARI, Gazipur in the winter season of 2018-19 to select suitable genotype for off season production. Germplalsm varied significantly for their response to days to 1st female flower open (DFF) ($P<0.05$) while they were similar for node order of 1st female flower open (NFF), harvest duration, fruit length, fruits per plant, average fruit weight, yield per plant and yield per hectare and fruit fly infestation ($P>0.05$). DFF varied from 25-39 ($P<0.05$) while Ft/plant 8-14, yield/plant 0.9-1.7kg, yield/ha 5.2-9.3 tons, AvFtWt 99.8-139.3g, FL 18-29cm and FtflyIfest 18.2-30.6% ($P>0.05$). Among lines, 3 were early relative to DFF (25-31), 2 produced higher Ft/plant (13-14), 3 higher yield/plant (1.5-1.7kg), and 1 higher yield/ha (9.3 tons). Lower FtflyInfest was observed in two lines (18-20%) while others higher (22.9-30.6%). All the lines showed no reaction to viruses and powdery mildew infection (0.0% incidence). Considering all the characters studied, virus and PM reaction and visual observation of fruit shape, size and color one line (MC122), was found promising which may be advanced for making homozygous for off-season production.

Regional yield trial of bitter gourd hybrids

Four hybrids of bitter gourd were evaluated with one check variety Hybrid Tia was conducted at 4 location viz. Joydebpur, Jamalpur, Moulvibazar and Ishurdi in the summer season of 2018 to select suitable hybrids for release as variety. Hybrids showed significant variation for their response to most of the characters studied of which days to 1st female flower open (DFF) varied from 29-33, node order of first female flower open (NFF^v) 17-21, fruits/plant 16-29, yield/plant 2.53-3.50 kg, yield/hectare 17.72-24.47 tons, average fruit weight

(AvFtWt) 89.71-163.54g, fruit length (FL) 14.71-26.20 cm, and fruit diameter (FD) 4.25-4.60cm ($P<0.05$). All the hybrids, Hybrid 23, Hybrid 24, Hybrid 4 and Hybrid 8 performed better for major yield and yield contributing characters (fruits/plant: 25, 23, 29 and 26; yield/plant: 3.27, 3.50, 2.62 and 2.91kg; and yield/hectare: 22.86, 24.47, 18.33 and 20.40 tons respectively) compare to check variety (fruits/plant: 16, yield: 2.53 kg/plant and 17.72 tons/hectare). Bitterness of two hybrids was low and the rest medium. No virus and powdery mildew diseases were observed in these crosses. Considering all the parameters studied; visual observation of fruit color, shape and size; and visitor's choice; three hybrids hybrid 8, hybrid 23 and hybrid 24 may be released as hybrid variety of bitter gourd. Of these, two hybrids, Hybrid 23 and Hybrid 8 are already released as BARI hybrid karala 2 and 3 respectively.

Regional yield trial of off season bitter gourd

Five advanced lines of off season bitter gourd were evaluated with one check variety Hybrid Tia at 3 locations viz. Joydabpur, Patuakhali and Akbarpur in the summer season of 2018 to select suitable lines for release as variety. Lines showed significant variation for their response to most of the characters studied of which days to 1st female flower open (DFF) varied from 37.20-56.13, node order of first female flower open (NFF^v) 10-27.07, marketable fruits/plant 5.53-13.47, yield/plant 0.63-1.34kg, yield/hectare 5.53-13.47 tons, average fruit weight (AvFtWt) 96.94-152.47g, fruit length (FL) 14.35-24.32 cm, and fruit diameter (FD) 5.05-4.46 cm ($P<0.05$). All the advanced line, AVBG-143, AVBG-1324, 117-1-2-3 and 115-1(c)-9-12 performed better for major yield and yield contributing characters (fruits/plant: 51, 67, 64 and 43; yield/plant: 3.78, 6.69, 5.16 and 4.98 kg; and yield/hectare: 20.79, 36.79, 28.38 and 27.39 tons respectively) compare to check variety (fruits/plant: 36, yield: 4.82 kg/plant and 26.51 tons/hectare). Bitterness of two hybrids was low and the rest medium. No virus and powdery mildew diseases were observed in these crosses. Considering all the parameters studied; visual observation of fruit color, shape and size; and visitor's choice; three advanced lines AVBG-1324, 117-1-2-3 and 115-1(c)-9-12 may be released as off season variety of bitter gourd.

Extension of bitter gourd shelf life through modified atmospheric packaging at controlled storage condition

Commercially mature bitter gourds (*Momordica charantia* L.) stored by wrapping the individual fruits with cling film (12.7 µm thick) or packed in 1.0% perforated polyethylene packet and were stored at 18^0C with 85% RH at postharvest laboratory of Postharvest Technology Section, HRC, BARI, Gazipur. Storage of non-packed fruit at 18^0C resulted in extension of shelf life was nine days. Shelf life was two weeks in 1.0% perforated polyethylene packet. It played role in delayed appearance of chilling injury symptoms, however with incidence of some rotting. Cling film-wrapped fruits stored at 18^0C were marketable up to 21 days, had lowest fresh weight losses, less softening, reduced incidence of postharvest rots, less fruit yellowing and minimal changes in firmness, vitamin C and β-carotene content. Storage of individually wrapped fruits at reduced temperature (18^0C with 85% RH) therefore offers an effective method of prolonging the shelf-life of bitter gourd.

Response of bitter gourd to zinc, boron and magnesium application

A study was conducted at the research field of HRC, BARI, Gazipur during 2018 (2018-19) to determine the effective doses of zinc (Zn), boron (B) and magnesium (Mg) for yield maximization of bitter gourd (*Momordica charantia* L).There were 9 treatment combinations consisting of three levels each of Zn (0, 3, 4 kg ha^{-1}), B (0, 1.5, 2 kg ha^{-1}) and Mg (0, 4, 8 kg ha^{-1}) along with the blanket dose of $N_{120}P_{40}K_{85}S_{20}$ kg ha^{-1} and cow dung 10 t ha^{-1}. The experiment laid out in randomized complete block with three replications. The treatment combinations were $T_1 = Zn_0B_0Mg_0$, $T_2 = Zn_3B_{1.5}Mg_4$ kg ha^{-1}, $T_3= Zn_3B_2Mg_4$ kg ha^{-1}, $T_4= Zn_4B_{1.5}Mg_4$ kg ha^{-1}, $T_5= Zn_4B_2Mg_4$ kg ha^{-1}, $T_6= Zn_3B_{1.5}Mg_8$ kg ha^{-1}, $T_7= Zn_3B_2Mg_8$ kg ha^{-1}, $T_8= Zn_4B_{1.5}Mg_8$ kg ha^{-1} and $T_9= Zn_4B_2Mg_8$ kg ha^{-1}.The results showed that the marketable yields of bitter gourd ranged from 11.2 to 15.6 t ha^{-1}. The highest bitter gourd yield was obtained from the treatment T_9 (15.6 t ha^{-1}) followed by T_8. The lowest yield was found in control plot. The yield and quality attributes of bitter gourd showed best performance in T_9 followed by T_8 treatments. The highest net return (Tk.245229 ha^{-1}) was counted from T_9 treatment followed by T_8. The highest benefit cost ratio

(2.10) was also counted from the treatment T_9 and T_8 treatment. Considering the yield and benefit cost ratio T_9= $Zn_4B_2Mg_8$ kg ha^{-1} or T_8= $Zn_4B_{1.5}Mg_8$ kg ha^{-1} including $N_{120}P_{40}K_{85}S_{20}$ kg ha^{-1} may be used for bitter gourd production.

Off season observational yield trial of bitter gourd lines

Eight bitter gourd lines of indigenous sources were put into Observation Yield Trial at the experimental field of Vegetable Division, HRC, BARI, Gazipur in the winter season of 2018-2019 for selecting suitable genotypes for off season production. Lines varied significantly for their response to days to 1st female flower open (DFF) which ranged from 25-39 days ($P<0.05$). Lines were statistically similar for rest of the characters ($P>0.05$). Two lines were early relative to DFF (25-30 days) three relative to node order of 1st female flower open (22 nodes). DH was higher in four lines (29 days). One-line MC122 produced comparatively higher fruits (14) and yield (1.7kg) per plant; and gave moderately good yield (9.3 tons). Fruits of most of the lines were medium in length (18-24cm) except one MC131 (29cm). Three liens MC132, 124, 122 showed low bitterness and two MC130 and 131 medium. Lower fruit fly infestation was observed in two lines MC132 and 122 (18.2-20.5%). All the lines showed 0.0% incidence for virus and powdery mildew diseases. Considering yield and yield contributing characters, virus and PM reaction, fruit fly infestation; and visual observation of fruit shape, size and color two lines MC132 and 122 were selected for evaluation in Preliminary Yield Trial in off-season.

Heterosis in bitter gourd

The experiment was conducted at the experimental field of Vegetable Division, HRC, BARI, Joydebpur, Gazipur. Sixteen parents of bitter gourd and their 29 crosses were included in this study for estimating heterosis relative to a standard commercial check variety Hybrid Tia. None of the crosses exhibited maximum heterosis for all the characters studied. All the 29 crosses showed highly significant positive heterosis for fruits per plant which ranged from 14.3 to 285.4% in compare to standard check. Nineteen crosses (BT Cross-33, 34, 36, 37, 38, 41, 43, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, and 59) out of 29 showed outstanding heterosis (more than 100%) which ranged from 104.9 to 285.4%. Significant positive heterosis was noticed in two crosses BT Cross 34 and 54 (15.3 and 26.2% respectively) for yield per hectare and positive but non-significant heterosis in six crosses BT Cross-35, 36, 37, 39, 40 and 59 (ranged from 0.2 to 8.3%) for this trait. Based on the characters studied for standard heterosis; visual looking of fruit color, shape, size; and plant health five crosses BT Cross-34, 35, 36, 37 and 39 may be selected for testing in the regional yield trials.

Pumpkin

Evaluation of pumpkin germplasm

Six pumpkin genotypes were collected from PGRC on the basis of individual fruit weight was evaluated in Olericulture Division, HRC, BARI, Gazipur during the winter season of 2018 - 19 for identify the bigger size pumpkin. The genotypes varied for their response of some characters studied. Most of the genotypes beard their male and female flower earlier and lowest node. The flesh thickness, average fruit weight, fruits per plant, yield per plant and yield (ton/ha) was ranged from 3.5 to 5.5, 3.1 to 5.5, 1.8 to 3.0, 5.58 to 16.5 and 11.1 to 33.0 kg, respectively. The TSS ranged from 7 to 10. The genotypes were in different shapes such as round, high round, elliptical and bumble. The orange type flesh color was dominant among the genotypes. Fruit fly infestation and virus incidence was also observed in these genotypes. Based on the objective of the experiment, the lines BD 290 and BD 10063 was identified as a bigger size pumpkin and used for breeding purpose.

Evaluation of selected lines of pumpkin (RHRS, Cumilla)

Survey and collection of sweet gourd germplasm were conducted at different locations in Cumilla region. The local landraces and primitive crop cultivars/germplasm were mostly collected. A total of eighteen (18) germplasm were evaluated at RARS, BARI, Cumilla. Results revealed that most of the germplasm performed better compared to check regarding fruit yield and other yield contributing characters. CM Cum-007 was very early to induce flower as well as fruit. Flesh thickness (5.33 cm) was found the highest in CM Cum-019 and the lowest in CM Cum-006 (3.00

cm). The highest no. of fruit per plant (25.67) was found in CM Cum-005 followed by CM Cum-004 (24.00), CM Cum-001(20.33) and CM Cum-016(18.00). CM Cum-019 produced the highest average fruit weight (7.37 kg) as well as gave higher fruit yield (47.39 t ha^{-1}). But CM Cum-014 was the best yield giver (53.54 t ha^{-1}). In addition to that CM Cum-016 and CM Cum-007 was also found to give better yield performance. On the other hand, CM Cum-006, CM Cum-010, CM Cum-012 and CM Cum-017 showed comparatively poor yield.

Response of pumpkin to urea super granule, prilled urea and PKS fertilizer application

The experiment was conducted in the field of HRC, BARI, Gazipur during winter 2016-17 to 2018-19 followed by RCBD with three replication to evaluate the performance of USG to prilled urea in pumpkin production and to develop a fertilizer recommendation both with prilled urea and USG for pumpkin. Seven treatments were considered as- T_1: $N_{80}P_{35}K_{75}S_{20}$ +$Zn_4B_{1.5}$ (N as prilled urea); T_2: $N_{80}P_{35}K_{75}S_{20}$ +$Zn_4B_{1.5}$ (N as USG); T_3: 20% higher NPKS than T_1 + $Zn_4B_{1.5}$ (N as prilled urea); T_4: 20% higher NPKS than T_1 + $Zn_4B_{1.5}$ (N as USG); T_5: 20% lower NPKS than T_1 + $Zn_4B_{1.5}$ (N as prilled urea); T_6: 20% lower NPKS than T_1 + $Zn_4B_{1.5}$ (N as USG) and T_7: Native fertility. From three year studies, it was clearly observed that performance of USG is better than the prilled urea. In case of prilled urea 20% higher dose of recommended prilled urea and PKS performed better than the recommended prilled urea. But in case of USG, 20% less recommended dose of USG and PKS performed better followed by recommended dose of USG was sweet gourd production. Therefore, 20 % less recommended dose of NPKS (N as USG) with other fertilizers ($Zn_4B_{1.5}$) and 20% higher dose of NPKS (N as prilled urea) with other fertilizer doses ($Zn_4B_{1.5}$) could be suggested to produce quality sweet gourd.

Effect of side shoot removal and vine pruning on growth and yield of pumpkin

A study was conducted during 2018 to 2019 at Regional Agricultural Research Station, Jamalpur to investigate effect of side shoot removal and vine pruning on growth and yield of sweet gourd (Cucurbita *moschata* Duch. ex Poir). Seven different treatments viz T_1=Side shoot pruining up to 6^{th,} T_2=Side shoot pruning up to 9th, T_3=Side shoot pruining up to 12th,T_4=Maintaining three secondary vines after pruning, T_5=Maintaining four secondary vines after pruning, T_6=Maintaining five secondary vines and T_7=Control after pruning. In addition, character association with fruit and seed yield also done. Results of pruning revealed that T_5(4-vine) produced the highest fruit yield (fruit yield,12.09t/ha).However fruit size individual fruit weight and seed quality were better in T_5=Maintaining four secondary vines after pruning other treatments .On the other hand there four results analysis revealed that pruning had important effects on the yield and quality of fruit and seeds in sweet gourd.

Response of pumpkin to different irrigation frequency and nitrogen levels

The experiment was conducted at the experimental field of HRC, BARI, Gazipur during 2017-18 and 2018-19 to investigate the response of sweet gourd (cv. BARI Hybrid Misti Kumra-1) under different irrigation and nitrogen levels. The study was carried out in a split plot design with three replications. Three irrigation levels as I_1: Irrigation up to FC at 7 days interval after stand establishment (SE); I_2: Irrigation up to FC at 14 days interval after SE and I_3 : Irrigation up to FC at 21 days interval after SE were considered as main plot treatment and four doses of PU and USG as N_1:100 kg N ha^{-1} as PU; N_2: 100 kg N ha^{-1} as USG; N_3: 80 N ha^{-1} as USG and N_4:60 kg N ha^{-1} as USG were considered as sub-plot treatment. A significant response of sweet gourd to different irrigation and N levels was observed. Among the different treatments combinations, I_2N_3 (irrigation at 14 days interval with 80 kg N as USG) were relatively better yielding (35.08 ton ha^{-1}) followed by I_2N_1 (31.92 ton ha^{-1}) for sweet gourd production. But higher water productivity was obtained with I_3N_3 (Irrigation at 21 days interval with 80 kg N as USG) in 2017-18 and I_2N_3 in 2018-19 season. The results suggest that I_2N_1 (irrigation at 14 days interval with 80 kg N as USG) followed by I_2N_1 (100 kg N as PU) might be optimum irrigation and fertilizer levels for sweet gourd production on the basis of yield.

Ridge Goued

Advance yield trial of ridge goued lines

Five lines of ridge gourd were evaluated at Olericulture Division, HRC, BARI Gazipur during kharif season of 2018. Significant variation was found in the studied characters among the lines. The line LA1014-2-5 required minimum days for 1st female flower open (24.08 days) and beard female flower at lowest node (19.33). On the other hand, the line LA1001-1 required maximum days for 1st female flower open (37.84 days) and beard 1st female flower at highest node (32.33). The yield potentiality of these lines was below 20 ton/ha. Considering the yield and yield contributing characters the lines LA 1013-5-4, LA 1014-2-5 and LA 1018-2-2 found promising. Bitterness were absent in all the lines. 10 - 20% virus incidence was observed in all the lines at later stage. So, the lines were used for parental material for hybridization program.

Effect of salinity on ridge gourd genotypes

A pot experiment was conducted at the research field of Olericulture Division, HRC, BARI, Joydebpur, Gazipur during the *Kharif* season of 2018-19 to investigate the effect of salinity on different ridge gourd genotypes. Ten ridge gourd varieties / advanced line; BARI Jhinga-1 (RG-1), BARI Jhinga-2 (RG-2), P2 × P1 (RG-3), P2 × P6 (RG-4), P1-8 (RG-5), P2-1 (RG-6), P3-1(RG-7), P7-7 (RG-8), P6-10 (RG-9) and P8-1 (RG-10) were included in this study. The results revealed that soil salinity had negative impact on the physiological as well as yield and yield contributing parameters in all ridge gourd genotypes. At control condition, the number of fruits/plant were higher in RG-2 and RG-7 while, at 6 dS/m salinity, RG-7 produced the highest number of fruits/plant and at the highest salinity, RG-5 produced the maximum number of fruits/plant followed by RG-1, RG-2 and RG-10. Individual fruit weight (IFW) was the highest in RG-6 followed by RG-10 and RG-5 at moderate salinity but at higher salinity, IFW was the highest in RG-7, followed by RG-3 and RG-6. In case of fruits yield/plant, RG-6 produced the maximum yield at normal condition followed by RG-7 and RG-5. Similar trend of fruit yield were recorded at 6 dS/m salinity stress. However, at 12 dS/m salinity, RG-5 produced the maximum yield, followed by RG-1 and RG-2. Based on most of the parameter studied, RG-7, RG-6 and RG-5 were found to be tolerant at 6 dS/m salinity; while, only RG-5 found to be tolerant at 12 dS/m salinity stress.

Sponge Gourd

Evaluation of sponge gourd lines in summer

A study was conducted to evaluate sponge gourd (Luffa cylindrica) lines in respect of yield and quality at HRC field, RARS, Jamalpur during the summer season of 2018. Nine sponge gourd lines viz. LC Jam-001, LC Jam -002, LC Jam -003, LC Jam -004, LC Jam -005, LC Jam -006, LC Jam -007, LC Jam -008 and LC Jam -009 were evaluated to investigate the yield and yield contributing characters. The higher number of fruits per plant (89.00) was produced by the line LC Jam-006 whereas the lower number of fruits (27.00) was noted from the LC Jam-005. The higher individual fruit weight (140 g) noted in the line LC Jam-008 and lower (96 g) in the line LC Jam-007. The more fruit yield per plant (11.79 kg) & per hectare (47.15 t) was produced by the line LC Jam-001 as against the less 2.97 kg & 11.86 t in the line LC Jam-005, respectively.

Effect of drought on growth and yield of sponge gourd lines

A pot experiment was conducted at the research field of Olericulture Division, HRC, BARI, Joydebpur, Gazipur during the *Kharif* season of 2018-19 to investigate the effect of drought on different sponge gourd genotypes. A total of 10 sponge gourd lines/varieties; LC 1-1-3-1-5-9 (SG-1), LC 1-1-3-1-3-4-5 (SG-2), LC 1-7-8-1-4-1-3-5 (SG-3), LC 3-8-1-1-1 (SG-4), LC 13-1-3-1-2-3 (SG-5), LC 9-4-1-4-1-2-3-4-5 (SG-6), LC 9-4-1-4-4-5 (SG-7), LC 1-7-8-1-4-5 (SG-8), Monalisa (SG-9) and Sonali (SG-10) were included in this study. After transplanting into 15-L pots containing soil and recommended doses of manures and fertilizer, the plants were exposed to three levels of drought *viz*., Control= Irrigation as per requirement, 7 Days Drought (DD) = Irrigation at 7 days interval and 14DD = Irrigation at 14 days interval. The results revealed that drought stress had negative impact on the physiological as well as yield and yield contributing parameters in all sponge gourd genotypes. At control condition, the

numbers of fruits per plant were higher in SG-9 followed by SG-4 and SG-5. At 7DD and 14DD, the same line also provided the maximum number of fruits per plant. However, the genotypes SG-2, SG-3, SG-8 and SG-10 did not produce any fruits at 7DD and 14DD. IFW at 7DD was the highest in SG-2, followed by SG-9 and SG-5. At 14DD, IFW was the highest in SG-9 followed by SG-6. The line SG-9 produced the maximum fruit yield at normal condition followed by SG-4 and SG-5. However at 7DD and 14DD, SG-9 produced the maximum yield per plant, followed by SG-5. Based on most of the parameter studied, SG-5 and SG-9 were found to be tolerant at 7DD and 14DD.

Regional yield trial of sponge gourd lines

A regional yield trial of four sponge gourd genotypes were evaluated with a check variety (local) was conducted at 3 location viz. Joydebpur, Moulvibazar and Narshingdi during the *kharif* season of 2018 to study the regional adaptability and yield potentiality. The genotypes varied significantly for their response of different characters studied. Days to first female flower and node order of first female flower was ranged from 29.67 to 44.33 and 26.00 to 31.33 respectively. The line LC-1-7-8-1-4-3-8 flowered female flower earlier and the line LC-9-4-1-4-5-8 bearded female flower in the lowest node. The overall performances of three lines were good. Among the lines including check the lines LC- 9-4-1-4-5-8 ranked top for yield per plant and other characters but the color of the fruit of this line is white and very soft. So the consumer preference may be very poor than the other two lines. Thus considering all the parameters and visitor acceptance two lines LC-3-8-2-1-1-8-6 and LC-1-7-8-1-4-3-8 may be released as op variety. The line LC-3-8-2-1-1-8-6 already released as OP Sponge gourd variety.

Squash

Preliminary yield trial of selected squash lines

Five squash lines with one check variety (BARI Squash -1) were evaluated at the experimental field of Olericulture Division, HRC, BARI, Gazipur during the winter season of 2018 - 19 to select the high yield potential and lucrative variety. Significant variation was observed among the squash lines for different characters. The lines CP002, CP007, CP007-2 required minimum days (26.66 days to 29.27 days) for 1st female flowering and the line CP006 bear the 1st female flower in the lowest node (6.67). From the evaluated lines the check variety (BARI Squash-1) was superior for its individual fruit weight, yield per plant and TSS. Next to BARI Squash -1 two lines CP007 and CP007-2 was good for its lucrative shape, size and yield potential. In this respect, two lines CP007 and CP007-2 may be recommended for RYT.

Cucumber

Evaluation of cucumber germplasm at Narsingdi region

The experiment was conducted at the experimental field of Regional Horticulture Research Station, BARI, Shibpur, Narsingdi during Summer 2018 with eighteen genotypes of cucumber to evaluate their performance at Narsingdi region. Minimum days required to male flower initiate in CS Nar 007 (30 days) and CS Nar 008 (30 days) genotypes and maximum were in CS Nar 001, CS Nar 002 and CS Nar 014 (40 days). The Maximum days required to female flower initiate in CS Nar 001 (58 days) and minimum were in CS Nar 011 and CS Nar 018 (34 days) genotypes. The longest fruit (30.38 cm) and the heaviest fruit (699 g) were found from CS Nar 004. Maximum no. of fruit per plant (7.00), yield per plant (5.59 kg) and yield per hectare (37.08 t) were recorded from CS Nar 004 which was followed by CS Nar 001 and CS Nar 006, respectively. The smallest fruit length (11.33 cm), the lightest fruit (166.25 g), minimum yield per plant (553 g) and yield per hectare (4.19 t) was found from CS Nar 013. But the highest fruit width (10.03 cm) was found from CS Nar 005 and lowest from CS Nar 014 (4.48 cm). Maximum 1000 Seed weight was noted from CS Nar 008 (37 g) and minimum was from CS Nar 016 (7 g). Considering number of fruits per plant, yield per plant, yield per hectare, the genotypes CS Nar 004, CS Nar 001 and CS Nar 006 were showed higher yielder. Therefore, further trial will be conducted to verify their performance.

Inbred development in cucumber

The trial was conducted at the experimental field of Olericulture Division, HRC, BARI, Joydebpur during winter season of 2017-18. Thirteen several

progenies of cucumber lines were advanced to S_4 generations to develop variable cucumber inbred lines for op and hybrid variety development. The variations which found in the lines for days to 1st female flower 41.75 – 52.50 days, node order of 1st female flower 4.8 – 12.85, fruit length 11.35 – 19.80 cm, fruit breadth 3.75 – 5.25 cm, flesh thickness 1.08 – 1.58, individual fruit weight 120 – 278 g, fruits/plant 4.40 – 11.40 and yield/plant 0.71 – 3.19 kg. Maximum lines were free from hollowness and bitterness. The green type skin color is dominant among the different skin color. Most of the lines were virus free but the lines CS0-3, CS02-3, CS03-1 CS06-12-3 and CS40-7-3-3 showed virus symptom at later stage. From the overall performance of the lines: CS08-5-5, CS79-3-7, CS44-5-2-6, CS25-20-4 and CS 18-3-1 may be recommended for RYT and the lines may be used for hybrid variety development.

Teasle Gourd

Evaluation of teasle gourd germplasm at narsingdi region (RHRS, Cumilla)

Six teasle gourd germplasm were evaluated at the research field of Regional Horticulture Research Station of BARI, Shibpur, Narsingdi during February 2018 to August 2019 to evaluate their yield, quality and virus resistance. The germplasm MD Nar-003 had the highest number of marketable fruit (58.67) per plant whereas lowest (50.34) was recorded from MD Nar-001. The highest yield was obtained from MD Nar-003 (46.98 t/ha) while MD Nar-001 germplasm obtained lowest yield (30.44 t/ha). The germplasm MD Nar-003 is also free virus and insect infestation where other germplasm showed more susceptible to virus diseases and insect infestation. Considering yield, size, virus incidence and insect infestation germplasm MD Nar-003 is recommended for future breeding program showed the best among the germplasm.

Evaluation of selected teasel gourd germplasm

The study was carried out at the experimental field of Olericulture Division, HRC, BARI, Gazipur, Bangladesh to evaluate the teasel gourd germplasm for yield, quality and development of promising teasel gourd lines for variety development and future breeding program. Eleven genotypes were evaluated during the summer season of 2019. Observation on different morphological and yield attributing characters were recorded from three randomly selected plants from each germplasm. The line MD-6-2 required the longest days (115.67) and MD019 required the shortest days (106). The highest number of fruits/ plant was recorded in MD020 (53.33) while MD019 (4) produce the lowest fruit. Among the lines MD021 (90.0 g) produced the heaviest fruit while lightest fruit (41.33 g) was from MD-14-2.The highest fruit wt./ plant was recorded from MD021(4.60 kg) and the lowest weight was MD019 (0.16kg). The longest fruit was observed in MD-6-2 (9.13cm) while the shortest was MD-8-1 (6.43cm).The line MD022 (4.43cm) produced the widest fruit while MD-9-3 (3.57cm) produced the lowest wide fruit. In case of inner flesh thickness it was found that except MD-12-2, MD020 and MD-14-2 all the lines produced the longest identical inner flesh thickness which ranges were 0.44-0.64cm. In case of fruit color, most of the lines produced green color fruit except MD -13-2 and MD -6-2, which produced yellow orange colored fruit. Considering the yield contributing characters, color and size the lines MD020, MD021, MD022, MD-8-1 and MD-15-2 and may be selected for RYT.

Quality of tesale gourd as affected by minimal processing

An experiment was conducted on minimal processing of teasle gourd in postharvest laboratory of Postharvest Technology Section, HRC, BARI, Gazipur. Teasle gourd collected at commercially mature stage from contract grower's field, sorted to eliminate damaged, deformed or defective fruits and screened to select uniformly mature fruits. Selected teasle gourds, knives and all the utensils to be used were washed with sanitizers (Aqua's solution of 200 ppm sodium hypochlorite). After wearing apron, hand gloves, cap and musk, teasle gourds were prepared for ready-to-cook. Teasle gourds were sliced transversally into 0.5 cm thickness with a sharp stainless steel knife (sterilized again with ethanol) and dipped into different food additives (ascorbic acid , citric acid and calcium chloride), wash with normal water and non-wash. Surface water of teasle gourd slices were removed by air drying, samples were kept into polypropylene box, wrapped with cling wrap and stored at refrigerator (4±1°C). The suitability of the treatments was evaluated by determining total

acidity, vitamin C, colour properties and sensory quality (colour, flavor, total acceptance, freshness, marketability, cooking performance and consumer preference). In all quality parameters, ready-to-cook teasle gourd slices treated with 0.5% calcium chloride performed better and was suitable for minimal processing with 7 days of storage life at refrigerator (4±1ºC).

Pointed Gourd

Regional yield trial of pointed gourd hybrids

An experiment was conducted at 4 location viz. Joydebpur, Jamalpur, Ishurdi and Narsingdi during Rabi season of 2018-19 to evaluate the performance of six lines of hybrid point gourd viz. PG 014 X M_1, PG 018 X M_2, PG 008 X M_1, PG 009 X M_2, PG 008 X M_2 and BARI Hybrid potol1 (as check) were include in the experiment. The highest number of fruit per plant was obtained from PG 009 X M_2 (136.67) whereas the lowest was found PG 009 X M_2 (79.67).The line PG009xM_2 gave the highest number of fruits per plant (77.66). The highest yield (27.31 t/ha) was obtained from PG009xM_2 and the lowest yield (17.99 t/ha) was obtained from PG014XM_1. There four line PG 009 X M_2, can be recommended for future breeding program of pointed gourd.

Effect of time of vine planting and spacing on growth and yield of pointed gourd

A field experiment was conducted at Regional Agricultural Research Station, Ishurdi, Pabna during *rabi* season of 2018-19 to find out the optimum time of vine planting and plant spacing on growth and yield of pointed gourd. Four sowing time *viz*. (i) 15 October (ii) 1 November (iii) 16 November and (iv) 1 December and three plant spacing viz. (i) 1.50 m (ii) 1.00 m and (iii) 0.50 m were included in the experiment. No vine germination occurred in 1 December planting. Among three planting time, there was no significant difference regarding yield. In case of spacing, closer plant spacing (0.50 m) produced the highest yield (42.77 t/ha). On the other hand, 15 October planting with 0.50 m spacing produced the highest yield (44.03 t/ha) which was statistically similar to 1 November planting with 1.00 m spacing.

Demonstration trial of pointed gourd production using tricho-compost and tricho-leachate as disease management tools

Two demonstration trials on the effect of Tricho-compost and Tricho-leachate on pointed gourd were conducted at farmers' field in Jessore and Bogra district, respectively during 2018-19 cropping session. Vine cuttings were made from previous year crop and rooted during November-December and planted January-February in order to obtain a crop in the same year. The demonstration trials were laid out in 10 decimal, where half of the plot (5 decimal) was treated with Tricho-compost and the rest half maintained as untreated control. The unit raised bed size was 6.0 m x 1.50 m. and six plants of pointed gourd were planted in one unit bed. The treatments were (i) untreated control (farmers practices: cowdung at 2.5 t/ha + chemical fertilizers+ pesticide spray)and (ii) Soil application of Tricho-compost @ 2.5 ton per hectare + chemical fertilizer 80% + foliar application of Tricho-leachate @ 20 ml per liter of water. Tricho-leachate was sprayed on foliage disease at 15 days interval as preventive measure. Soil incorporation of Tricho-compost and foliar spray of Tricho-leachate reduced disease infection and increased yield of pointed gourd. Fruit damage reduction over control was about 46.35-48.55% and 35.16-38.72% in Bogura and Jashore, repectively. Marketable and total yield were higher in all farmers' fields regardless of locations. Marketable yield increased about 35.63-43.1% in farmer's fields of Bogura, it was increased about 22.73-34.34% in Jashore. Regardless locations, Benefit Cost Ratio for Tricho-products application treatments were 3.39-4.12, while it was 2.53-3.38 in farmers' practices. BCR increased over farmers' practices was 34.17-41.55% in Bogra and 21.92-32.9% in Jashore farmer's field.

Ash Gourd

Evaluation of ash gourd lines

Five collected ash gourd (*Benincasa hispida*) lines viz. BH Jam-001, BH Jam-002, BH Jam-003, BH Jam-004, BH Jam-005 and BARI Chalkumra-1 as check were evaluated at HRC, RARS, BARI, Jamalpur during the summer season of 2018. The line BH-Jam-005 had the maximum number of marketable fruits (11) per plant followed by the

BARI Chalkumra-1(10.40) and the minimum number of fruits (5.20) was observed in BH-Jam-004. The highest yield was obtained from BH-Jam-005 (43.31 t/ha) followed by BARI Chalkumra-1 (38.77 t/ha), while the line BH-Jam-004 produced the lowest yield (20.89 t/ha). So, the trial may be repeated next year for more conformation.

Regional yield trial of ash gourd lines

An experiment was conducted at 2 location *viz*., Joydebpur and Ishurdi during the summer season of 2018 to assess yield potentiality and quality of three ash gourd advance lines. The lines were BH 001, BH 002 and BH 029 along with BARI Chalkumra 1as check variety. The experiment was laid out in RCBD design with three replications. Wide ranges of variability were found in the studied characters among the lines. *The days to* 1st female flower opening earlier in BARI Chalkumra-1 (42.6 days) followed by BH029 (43.30 days), while late in BH002 (44.00 days) followed by BH001 (43.70 days). The number of fruits/plant was highest in BH001 (8.45) and lowest in BH029 (7.10). Individual fruit weight was higher in BH029 (1.48 kg) and lower in BARI Chalkumra-1 (1.09 kg). Fruit length was highest in BH029 (18.75 cm) and lowest in BARI Chalkumra-1 (15.45 cm). Fruit diameter was highest in BH029 (12.02 cm) followed by BARI Chalkumra-1 (10.38 cm) and lowest in BH001 (10.00 cm). The yield per plant was higher in BARI Chalkumra-1 (12.00 kg) followed by BH001 (11.67 kg) BH002 (11.23 kg) and lowest in BH029 (8.40 kg). Among the advanced line yield was highest in BH001 (38.91 t/ha) followed by BH002 (37.12 t/ha), which was significantly similar to BARI Chalkumra-1 (39.90 t/ha) and lowest in BH029 (27.99 t/ha). So, the line BH001 and BH002 may be evaluated for the next year.

Effect of prilled urea, USG and NEEM coated urea on the growth, yield and n-use efficiency of broccoli and ash gourd

The experiment was conducted followed by RCBD with three replication. There were 8 treatments as- T_1: Control; T_2: Recommended PU (broadcasted); T_3: Recommended USG (blended); T_4: Recommended Neem coated urea (broadcasted); T_5: Recommended Neem coated urea (blended); T_6: 85% recommended USG (blended); T_7: 85% Recommended Neem coated urea (broadcasted) and T_8: 85% Recommended Neem coated urea (blended). Broccoli in winter and Ash gourd in summer season. From one year result with broccoli, it was observed that USG as well as blended Neem coated urea (NCU) performed better than prilled urea. But in broadcasted condition NCU performance is not remarkable.

Watermelon

Evaluation of selected watermelon (*Citrullus lanatus Thunb*.) germplasm

A field experiment was conducted on watermelon at Olericulture Division, HRC, BARI, Joydebpur during winter season of 2018 -19 to evaluate the performance of six selected germplasms of watermelon (WM 056, WM 057, WM 058, WM 059, WM 60 and WM 061) with a view to recommending the best germplasms that will be the best breeding material. The six germplasms were selected from last year evaluation. Each plot measured 3m x 6m separated by 1m each between plots and between replicates. The bed was covered by black polythene mulch. The experiment was arranged in a randomized complete block design and replicated three times. The germplasm were severely affected by virus at fruiting stage and finally died. So, we did not get any data about yield and yield contributing character. Therefore, this evaluation may go over next year.

Advanced yield trial of selected musk melon lines

Six muskmelon lines were selected and a trial was conducted a trial at the research field of Olericulture Division, HRC, BARI, Gazipur during the *kharif-1* season of 2018 with a view to develop a new variety. Significant variation was observed in all traits. The line CM014-5-4-2 and CM015-2-3-4 took the longest identical days (104.67) to harvest while the line CM011-5-5-1 took the lowest days (90) to fruit harvest. The highest number of fruits/ plant (9.8) was recorded from the line CM011-5-5-1 and the lowest was from CM011-5-3-4 (8.13).The heaviest fruit was observed from the line CM015-2-3-4(4.23kg) whereas, the lowest fruit weight was recorded from CM011-5-5-1(2.83 kg). The line CM011-5-3-4 produced the longest fruit (39.67 cm) while the shortest fruit (35.33 cm) was recorded from

CM014-5-4-2 which was identical with the line of CMO14-5-1-1. There was no statistically difference showed among the line in fruit breadth.The line CM014-5-4-2 produce the highest fruit yield / plant (45.0 kg), the lowest was from CM015-2-3-4 (11.3 kg). The highest flesh thickness (3.53 cm) was obtained from CM-015-2-3-4 followed by CM011-5-1-1.The highest TSS (%) was recorded from CM014-5-1-1(5.6) followed by CM011-5-3-4(5.36) and CM011-5-5-1(5.23).In case of texture, 3 lines showed sandy and 3 lines showed crispy texture. Considering qualitative and quantitative parameters the line CM014-5-4-2 and CM011-5-5-1 may be selected for AYT through self-pollination towards achieving homozygosity.

Muskmelon

Evaluation of muskmelon germplasm

The present study was undertaken with five germplasm of muskmelon (*Cucumis melo* L.) which were collected and evaluated in Regional Agricultural Research Station, Cumilla during summer, 2018 to evaluate their performance. The significant differences were noted for all of the quantitative characters Number of fruit per plant was maximum in MCM CUM-005(12.7) and minimum in MCM CUM-001(2.59). The highest yield(t/ha) was observed in MCM CUM-005(35.06) followed by MCM CUM-003(28.09) while the lowest yield was found in MCM CUM-001(17.24). Maximum TSS was obtained in MCM CUM-002(5.07%) whereas minimum in MCM CUM-004(4.3%). According to the performance of all the genotypes MCM CUM-005 and MCM CUM-003 were found promising. Hence, further evaluation is needed with more collection and locally popular check for better comparison.

Evaluation of muskmelon at Narsingdi region

The study was conducted with thirty five muskmelon genotypes at the experiment field of Regional Horticultural Research Station, Shibpur, Narsingdi , BARI during 2017 to 2019 to evaluate their performance. The collected genotypes originated from PGRC and different location. Significant differences were noted for the whole of the quantitative characters. Cluster analysis separated the genotypes in five different groups. The distribution pattern that maximum number of genotype 12 was included in cluster I which was followed by Cluster III 11 genotypes whereas minimum 1 genotype was found cluster V. Cluster II was found 6 genotypes and cluster IV was obtained 5 genotypes. Yield contributing characters in 35 genotypes of muskmelon was analyzed by RCBD analysis. The highest yield per plant, yield per plot and yield t/ha were observed in CM 2276 (15.39kg/plant, 46.18 kg/plot and 36.94 t/ha respectively) whereas the lowest yield per plant, yield per plot and yield t/ha were found in CM 2293 (3.5kg/plant, 10.54kg/plot and 8.34 t/ha respectively). Considering, no. of fruit per plant, yield per plant, yield t/ha and TSS cluster II, III and IV will be given higher priority in future muskmelon development program.

Netted Melon

Evaluation of advanced netted melon germplasm

The study was conducted with 20 netted melon lines at Olericulture Division, HRC, BARI, Gazipur during 2018-19 with a view to develop a variety of netted melon. Among 20 lines, ranges of days required for net development (26-97 days), individual fruit weight (500-1550g) fruit length (10.0-15.09 cm), fruit breadth (9.50-13.0 cm), fruit cavity (35.0-72.0 cm^2), pericarp thickness (2.50-4.0 cm) were recorded. Based on the TSS of fruit, all lines were categorized in 3 groups. There was no lines below 5% of TSS, 18 lines showed 5-8% of TSS and 2 lines showed more than 8% of TSS. On the basis of individual fruit weight, 2 lines produced less than 600 g, 15 lines produced 600-1000 g and 3 lines produced more than 1000g. In case of pigmentation, 18 lines showed white and 2 were green. According to the intensity of net forming, all lines were categorized in 3 groups. Ten lines showed light netting, 1 line showed medium netting and 9 lines dense netting. On the basis of fruit flesh color, 20 lines showed orange color. From the study it may be concluded that on the basis of qualitative and quantitative characters 5 lines namely CMR-0012-2-1, CMR-0012-2-9, CMR-0012-2-18, CMR-0012-2-83, CMR-0012-2-91 and CMR-0012-2-92 were selected for further evaluation.

Country Bean

Evaluation of country bean germplasm

The study was conducted at the Olericulture Division, HRC, BARI, Joydebpur, Gazipur during winter season of 2018-19, twenty nine country bean germplasm were collected from different locations of Bangladesh to see their performance. Genotypes varied significantly for their response to all the characters studied. Based on time to 1st flowering, the genotypes DL (St)-034, DL (St)-029, DL (St)-033, DL (St)-022, DL (St)-024 and DL (St)-042 were early bearer. The genotype DL (St)-002 produced the maximum number of pods/plant (606), followed by BARI Sheem-1 (524), DL (St)-025 (488), DL (St)-004 (450), DL (St)-008 (438), while DL (St)-021 produced the minimum pods (97). The individual pod weight (IPW) was the highest in DL (St)-032 (18.2 g) and the lowest in DL (St)-015 (5.94 g). The highest pod yield was recorded from DL (St)-002 (5.26 kg/plant), followed by DL (St)-004 (5.16 kg/plant), DL (St)-043 (5.03 kg/plant), BARI Sheem-1 (5.02 kg/plant), DL (St)-025 (4.82 kg/plant), DL (St)-024 (4.58 kg/plant), whereas the lowest yield from DL (St)-021 (1.11 kg/plant). Considering higher yield, yield attributes and and quality of pods, the genotypes DL (St)-002, DL (St)-004, DL (St)-043, DL (St)-025, DL (St)-024, DL (St)-042 and DL (St)-034 may be selected for further evaluation to develop as country bean variety(ies).

Evaluation of country bean germplasm (RARS, Ishwardi)

Performance of twenty hyacinth bean lines collected from Ishurdi region were investigated at RARS, Ishurdi, Pabna during Rabi season of 2018-19. Variation was found in different parameter among the genotypes. Number of fruits per plant ranged from 40 to 225 and was maximum (225) in DL Isd-006 whereas, minimum (40) was in Dl Isd-018. The highest average fruit weight (20 g) was recorded from DL Isd-009 and the lowest (7 g) was in DL Isd-001 and DL Isd 020. The highest pod yield (26.60 t/ha) was recorded from the genotype DL Isd-010 and the lowest (4.18 t/ha) was in DL Isd-018. This was first year results. The study will be repeated in the next year.

Advanced yield trial of selected country bean lines

An experiment was conducted at the HRC field, Regional Agricultural Research Station, Jamalpur during 2018-2019 to observe the performance of yield and yield contributing characters of five hyacinth bean (Lablab purpureus) germplasm i.e. CB Jam-001, CB Jam-002, CB Jam-003, CB Jam-004 and CB Jam-005 with BARI Sheem-1 & BARI Sheem-6 as check. Maximum number of pod per plant (742) was observed from CB Jam-001 and minimum (278) from CB Jam-005. CB Jam-005 gained maximum individual pod weight (14.70 g) whereas minimum observed in CB Jam-003 (7.57 g). Maximum pod yield per plot (26 Kg) and per hectare (21 t) gained from CB Jam-001 and minimum per plot (16 Kg) & per hectare (14 t) obtained from CB Jam-003 and CB Jam-005, respectively.

Effect of plant growth regulators on the performance of summer country bean

The experiment was conducted at the research field of plant physiology section of HRC (23.99271 N, 90.41139 E) during the summer seasons of 2017 and 2018. The experiment was laid out in Randomized Complete Block Design. The treatments consisted of four NAA concentrations (15, 30, 45 and 60 ppm) and 3 CCC concentrations (200, 300 and 400 ppm) with distilled water as control. Two additional treatments, GA_3 20 ppm and GA_3 30 ppm were included in 2018. The unit plot size was 2.00 m x 1.80 m (3.6 m^2) having 2 plants. The variety used in the experiment was BARI Seem-7. Fourteen and 13 day-old seedlings were transplanted on 03 April, 2017 and 19 April 2018, respectively. The control plants were sprayed with tap water, whereas aqueous solutions of NAA, CCC and GA_3 were sprayed thrice on the plants i.e. 4 weeks after transplanting, at flowering and three weeks after flowering. Seedlings were raised in in poly bag (6 inch x 7 inch). First flowering was seen at 43 and 44 days after seed sowing during 2017 and 2018, respectively. Trix was added in the solutions as surfactant for uniform spread of chemicals and moisture on leaves. Cowdung, nitrogen, phosphorous, potassium, sulphur, calcium, magnesim, zinc and boron were applied @ 5 t, 25, 40, 60, 20, 4, 4 and 2 kg/ha. The source of nitrogen, phosphorous, potassium, sulphur, calcium, magnesim, zinc and boron was urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, calcium sulphate, magnesium sulphate, zinc sulphate and medicated boric acid. The entire quantity of cowdung, TSP, gypsum, calcium sulphate, magnesium sulphate,

zinc sulphate and boric acid, one-third urea and half of MoP were applied during land preparation. The remaining half of MoP and two-third urea was applied in three equal installments at 30, 60 and 90 days after transplanting. Weeding was done as when necessary. Pod harvest was done at marketable stage from 20 June 2017 to 12 August 2017 according to treatments. In 2018, 1st pod harvest was done on 24 June and continued upto 29 Aughust. A total of 7 times and 9 times pod harvests were done in 2017 and 2018, respectively. The data were recorded on stem girth, vine length, plant dry weight, SPAD value, number of pods/cluster, pod length, pod width, individual pod weight, number of pods/plant, %pod set and pod yield/plant. Plot yield was converted to per hectare yield. The data on SPAD value was taken on 20 July 2017 and 15 July 2018. All growth regulator treatments performed well over control in respect of all characters studied. Among all foliar agents, the response of NAA was found better. Stem girth, vine length, plant dry weight, SPAD value, no. of pods/cluster, pod length, individual pod weight, no. of pods/plant and %pod set were found maximum from NAA 60 ppm followed by NAA 45 ppm in both years. Maximum pod yield/plant was recorded with NAA 60 ppm followed by NAA 45 ppm and CCC 200 ppm, while minimum pod yield/plant was noticed in control in 2017.In 2018. NAA 60 ppm recorded maximum pod yield/plant which was identical with NAA 45 ppm. The cost and return analysis revealed that spraying of NAA 60 ppm was superior to NAA 45 ppm and other combinations in terms of net income and BCR.

Integrated management of white mold of country bean

A disease susceptible field ($24^0$75'01"N & $89^0$42'37") in Bri-kustia village under Chupinagor union of Shahjahanpur upazilla in Bogra was selected to test two IPM packages. IPM package 1 (a. Raising seedlings in poly bag; b. Land sub-merged for 22-25 days; c. Tricho-compost @ 2.5 t/ha applied in soil; d. Weeding two times; e. Rouging virus infected plants; g. Using sex pheromone complex; i. BioNEEM plus (0.1%) applied; j. Foliar spray of Tricho-leachate) and IPM package 2 (Package 1+ Application of bio-control agents (*Bacillus subtilis* strain BNC_{38} & *Pseudomonas* sp.) at 10%, 30%, 50% and 80% of the major stems flowering. Farmer's practice was maintained as control. Both of the IPM package reduced insect pest and disease infestation and gave better yield compared to control (farmer's practices). White mold disease reduction over control was 63.31% in package 1 and 68.83% in package 2. While both of the packages markedly reduced root-knot nematode and virus infection. Marketable yield increased in both of the IPM package. About 40.45% and 42.20% yield increased over control in IPM package 1 and package 2, respectively. Marketable yield was negatively correlated with white mold disease incidence. Benefit Cost Ratio was higher (2.61) in both of the IPM package applied field. BCR increased over farmers' practices was about 39.38 to 39.81% in IPM package using field.

Yard Long Bean

Preliminary yield trial yard long bean lines

The study was conducted at the central research farm of Olericulture Division, HRC, BARI, Gazipur during *Kharif* season of 2018 to evaluate yard long bean lines including BARI Borboti 1 as check. The test lines including check variety differed for their response to all the traits. In case of days to 50% flowering the lines VS 19 blossomed earlier (32 days), while the check variety (39 days) flowered last. The highest number of pods per plant was obtained from the line VS 43 (22.88), while the lowest was from VS 46 (12.32). BARI Borboti 1 produced the maximum weight of pods per plant (386.48 g) and the line VS 46 produced the minimum (145.62 g). The highest yield was found from BARI Borboti 1 (12.88 t/ha) which was statistically similar with VS 43 (12.11t/ha) and VS 21 (9.23t/ha).

Garden Pea

Influence of different levels of potassium on yield, nodulation, quality and nutrients uptake of garden pea

An experiment was conducted in the research field of HRC, BARI, Gazipur during *rabi* season of 2018-19 to estimate the suitable dose of potassium for nodulation, quality and yield maximization of garden pea (*Pisum sativum*). There were 5 treatments viz. T_1 = Control, T_2 = K 30 kg ha^{-1}, T_3= K 40 kg ha^{-1}, T_4= K 50 kg ha^{-1} and T_5= K 60 kg ha^{-}

[1] along with the blanket dose of $N_{15}P_{20}S_{10}Zn_3B_2$ kg ha^{-1}.The experiment was laid out in randomized complete block design with three replications. The results revealed that the green pod yield of garden pea ranged from 3851 to 4353 kg ha^{-1} in 2018 and 4900 to 6350 kg ha^{-1} in 2019. The seeds yield varied from 999 to 1456 kg ha^{-1}in 2018 and 1124 to 1679 kg ha^{-1} in 2019. The highest green pod and seed yield in both the years was found in T_5 followed T_4 treatment and the lowest both yields were found in K control plot. The maximum nodulation and nutrient & protein content (18.5%) were found in T_5 treatment followed by T_4 treatment. The highest K uptake was made in T_5 followed by T_4 treatment. The greatest net return was counted from the treatment T_5. The highest benefit cost ratio of 5.59 for green pod yield and 2.87 for seed yield of garden pea both were counted from the treatment T_5 followed by T_4 and the lowest were in T_1 treatment. Considering the yields, quality and economic, the application of 60 kg K ha^{-1} may be sound and suitable dose for garden pea yield maximization in grey terrace soils of Gazipur, Bangladesh.

Okra

Evaluation of okra germplasm

This experiment was conducted during April 2018 to September 2018 in the experimental field of ARS, BARI, Cumilla. A total of 13 (thirteen) germplasm of okra were collected from different upazilla of Cumilla district to evaluate them regarding high yield and tolerance to YVMV. The experiment was set in randomized complete block design with three replications. Results revealed that AE Com-009 produced highest yield (24.19 t/ha) and minimum yield was produced by AE Com-011 (7.39 t/ha). Among the thirteen germplasm, AE Com-005 (0%) showed no and AE Com-009 (8 %) showed minimum YVMV infestation while maximum infestation was recorded on both AE Com-002 and AE Com-003 (100%).

Advance ypeld trial of selected okra lines

The experiment was conducted with selected six okra lines at Olericulture Division, HRC, BARI, Gazipur during the summer season of 2018. An extensive screening program was done over the six lines were selected from last year (9 lines) studies with BARI Dherosh 2 as local check to evaluate their reaction especially against YVMV and fruit yield in open field condition. The experiment was laid out in RCB design with 3 replications. No insecticide was applied to allow free movement of white fly. Percent infection by YVMV plant were recorded at every 10 days intervals after 50 days of sowing up to 90 days. Only two lines viz. AE0122 and AE012 were found high tolerant to yellow vein mosaic virus (26 to 50%). But considering the yield and yield contributing characters the lines AE 0122 performed higher yield (15.89 t/ha). So, the lines AE 0122 and AE012 selected for RYT evaluation.

Radish

Evaluation of exotic radish germplasm

The study was conducted at the experimental field of Olericulture Division, HRC, BARI, Joydebpur, Gazipur during the months of October 2018 to February 2019 to observe the adaptability and yield performance. Four radish lines Mila (RS 001); Saxa-2 (RS 002); Long White Icicle (RS 003) and RS 004 originated from Australia were evaluated where BARI Mula-1 and BARI Mula-2 were used as check. The data, generally, show that, plant length ranged (22.7-66.4 cm). The highest recorded values of root length was 32.9 cm in RS 004 while, the lowest values was (9.2 cm) in RS 002. The highest root weight (620g) was obtained from RS 004, while the lowest (110g) was found in RS 001. Corresponding yield per hectare showed the similar trend where the highest 49.6 ton and the lowest 8.8 ton were produced by the lines RS 004 and RS 001respectively. Considering growth, yield and quality it revealed that the lines are not suitable for cultivation in Bangladesh condition.

Advanced yield trial of summer radish lines

The study was conducted at the experimental field of Olericulture Division, HRC, BARI, Joydebpur, Gazipur during the months of February 2019 to May 2019 to observe their growth and yield performance. Selected summer radish line RS 004 and commercial variety Everest, Quick-40 with BARI Mula-1 were evaluated. Plant length ranged 47.33-54.67 cm. The highest (452g) plant weight obtained from the variety Everest and the lowest (322g) from the line RS 004. Root length ranged from 22.50-17.00cm but no remarkable variation

was observed. The maximum (5.07 cm) diameter was measured from the variety Quick-40 and the minimum (4.13cm) from the line RS 004. The highest root weight (306g) was obtained from the variety Everest while the lowest (193g) was found in the line RS 004. The highest root yield 24.45 ton and the lowest 15.47 ton were produced by the variety Everest and the lines RS 004 respectively. Considering growth and yield the performance of tested line was not satisfactory.

Stem Amaranthat

Evaluation of stem amaranth lines

The study was conducted with 12 stem amaranth lines at the research field of Olericulture Division , HRC, BARI, Gazipur during *Kharif-1* season of 2019 with a view to develop winter, early and late summer and high fiber containing variety of stem amaranth. Days to 50% flowering was varied from 34 to 53.66. The line AM-0064 and AM-0042 took minimum days (34 days) and delay flowering was observed from AM-0047(53.66).The tallest plant was exhibited from AM-0017 (155.7 cm) followed by AM-0015 (147.33 cm), AM-0006 (106.33 cm) and smallest plant were observed from BARI Data-1 (83.43 cm).The longest leaf length (34.33 cm) was obtained by AM-0017, while the shortest leaf length by AM-0021(16.6 cm). The highest leaf breadth (13.33 cm) was obtained by AM-0017 which was identical with AM-0064, while the shortest leaf breadth by AM-0021(9.66 cm).The longest leaf petiole was obtained by AM-0047 (10.66 cm) which was identical with AM-0064 and AM-0017 while the shortest leaf petiole by AM-0042(7.33 cm).The heaviest stem was obtained from the line AM-0017 (378.1 g) which was followed by AM-0015 (340.1 g), AM-0053 (292.3 g), AM-0048 (258.17), AM-0021 (228.6 g), whereas the lightest stem was observed from AM-0006 (149.5 g).The longest stem length was obtained by AM-0017 (151.67 cm),while the shortest stem length by BARI Data 1(74.33 cm).The longest stem breadth (2.52 cm) was obtained by AM-0063, while the shortest stem breadth by AM-0006(1.47cm).Based on days to edible stage of stem all the lines categorized in 2 group. Five lines showed 40-45 days and 08 lines showed more than 45 days. In case of pigmentation, 04 lines showed pink lines, 04 were red and 05 were green. On the basis of branching nature, 05 lines had no branch, 03 showed few branches and rest 05 lines had all along branches. All the lines showed erect nature, stem were conspicuous. From the study it may be concluded that on the basis of qualitative and quantitative characters six lines AM-0015, AM-0017, AM-0047, AM-0048, AM-0053, AM-0063, were selected for RYT.

Evaluation of stem amaranth at Narsingdi region

Nine stem amaranth germplasm with one check variety were evaluated at the research field of Regional Horticulture Research Station of BARI, Shibpur, Narsingdi during October 2017 to January 2019 for their yield, quality and virus resistance. The germplasm AT Nar-008 showed maximum plant height (177.72 cm) and stem length (169.77 cm). Minimum plant height (53.10 cm) and stem length 46.23 cm) was recorded from germplasm AT Nar-002. No. of leaves/plant was obtained highest (34.41) from AT Nar-004 and lowest (11.27) from AT Nar-006. Single plant weight was found highest (385.61 g) from AT Nar-005 and lowest (154.67 g) from AT Nar-002. Both yield/plot (15.75 kg) and yield (52.50 t/ha) was recorded highest from the germplasm AT Nar-004. On the other hand, lowest yield/plot (5.14 kg) and yield (17.33 t/ha) recorded from the germplasm AT Nar-002. Days to harvest found minimum (43-46 days) from the germplasm AT Nar-004 and maximum (63-67 days) from the germplasm AT Nar-008. Germplasm AT Nar-004 showed less susceptible to anthracnose disease and also very low aphid infestation compare with other germplasm and check variety. So, PYT may be conducted at next year.

Evaluation of stem amaranth line (RARS, Jamalpur)

A study was conducted to evaluate stem amaranth (Amaranthus tricolor) lines in respect of yield and quality at HRC field, RARS, Jamalpur during the summer season of 2018 . Seventeen stem amaranth lines viz. AM Jam-001, AM Jam -002, AM Jam -003, AM Jam -004, AM Jam -005, AM Jam -006, AM Jam -007, AM Jam -008, AM Jam -009, AM Jam -0010, AM Jam -0011, AM Jam -0012, AM Jam -0015, AM Jam -0016, AM Jam -0018, AM Jam -0019, AM Jam -0020 and BARI Data-1 as

check. Days to flowering late (61 days) in the line AM Jam -007 and AM Jam -0018 and early (43) in AM Jam -001. The maximum individual stem weight (342 g) noted in the line AM Jam -003 and minimum (103 g) in the lineAM Jam -0015. The highest yield per plot (51.3 kg) & per hectare (34.37 t) was produced by the line AM Jam -003 and second highest yield per plot (50.10 kg) & per hectare (33.57 t) was produced by the line AM Jam -002 as against the less 15.45 kg & 10.35 t was produced by the line AM Jam -0015 respectively. So, the line AM Jam-002 and AM Jam-003 may be advanced for next year evaluation.

Evaluation of stem amaranth germplasm (RARS, Akbarpur)

Nine stem amaranth germplasm *viz*. AS-Akb-001, AS-Akb-002, AS-Akb-003, AS-Akb-004, AS-Akb-005, AS-Akb-006, AS-Akb-007, AS-Akb-008 and AS-Akb-009 were evaluated at RARS, Akbarpur during the summer season of 2019 to evaluate the yield potentiality of stem amaranth lines. Maximum stem diameter (for both base and middle-27.87mm and 23.62mm) was recorded in AS-Akb-005 and minimum (for both base and middle-20.64mm and 23.62mm) was recorded in AS-Akb-008. The highest stem diameter both at base and middle was produced by the line AS-Akb-005 that lead to the higher stem yield. Considering taste and cooking quality AS-Akb-005 was found very good among the lines.

Intercropping of crucicerous vegetables with red amaranth at various organic fertilizers

Low production from the unit plot is a common blame against organic cultivation among the stakeholders, therefore a study has been carried out at Olericulture Division, HRC, BARI in order to find the suitable dose of organic fertilizers for cabbage, kohlrabi intercropped with red amaranth and to utilize land equivalent ratio (LER) for harvesting maximum vegetables. The two factors experiment was set in a RCB design where crops and organic fertilizers were the factors with three replications. Two sets of experiments one with cabbage and red amaranth and other with Kholrabi and red amaranth under different organic fertilizers applications. The treatments were BAOFER-BF (150 g, 100g and 50 g), Vermi-compost- VC (150 g, 100 g and 50 g), VC + BF (75 +75g, 50+ 50g, 25 +25 g). Data were recorded on the head wt. of cabbage , yield amaranth as single crop and intercrop, yield of kohlrabi including there SPAD value. It was revealed that the heaviest amount of cabbage were harvested in BF (150 g), VC (150 g) and VC + BF (75 +75 g) both in intercropped, which was significantly varied with sole crops followed by BF 100, VC 100 g, BF + VC 50+ 50g. The SPAD value was significantly differed with control to treatments. Cabbage yield per hectare were the highest in VC+ BF (75 + 75g) followed by BF 150 g. For kohlrabi the heaviest size were recorded in BF (150 g), VC (150 g) and VC + BF (75 +75 g) both in intercropped, which was significantly varied with sole crops followed by BF 100, VC 100 g, BF + VC 50+ 50g both intercropped and sole crops while the smaller size kohlrabi were harvested in control plot. Considering the yield parameters and LER it might be suggested that cruciferous crops like cabbage and kohlrabi can be cultivated with red amaranth by application of 150 BF and VC soley or in combination.

Spinach

Screening of spinach genotypes against salinity

An experiment was conducted at the Olericulture Division, HRC, BARI, Joydebpur, Gazipur during November, 2018 to January, 2019 to investigate the effect of salinity on germination and vegetative growth of spinach. Eight spinach gemplasm viz; SO-47, SO-48, SO-50, SO-51, SO-52, SO-53, SO-54, SO-55 and BARI Palongsak-1 (BPS-1) were included in this study. Four levels of salinity *viz*., control, 4, 8 and 12 dS/m were imposed at the very beginning of germination and continued upto 30 days. The results revealed that salt stress reduced the germination percentage (GP) and speed of germination (SG) in spinach seeds. The number of leaves per plant of most of the spinach genotypes was remained statistically unchanged at different salinity levels; while leaf length and breadth were reduced with increasing salinity. The length of shoot and root of most of the spinach genotypes were decreased as the concentration of salinity increased. Similarly, the fresh and dry weight of shoot and root of different spinach genotypes at final harvesting were found to be decreased as the concentration of salinity increased. At 4 and 8 dS/m salinity stresses, the maximum fresh and dry

weight of shoot /plant were recorded from SO-50, SO-51, SO-55 and BPS-1 and in case of fresh and dry weight of root, the higher values were recorded from SO-52, SO-53, SO-55 and BPS-1

Lettuce

Performance of selected spinach germplasm against salinity under pot culture

The experiment was conducted at the research field of Plant Physiology Section, HRC, BARI (23.99297 N, 90.41227 E) during December 2018 to January 2019. Seven genotypes of spinach (SO-0048, SO-0047, BD-4333, BD-4323, BD-4339, BD-1062, and BARI palongshak-1) collected from Olericulture Division of HRC. and Plant Genetic Resources centre, Joydebpur, Gazipur were used in the study during 2016-17 and 2017-18. The genotypes BD-4333, BD-4323, BD-4339, BD-1062, SO0047, SO0048 and BARI Palongshak-1 were screened out of 21 spinach germplasm for the last two years based on germination and early seedling growth stages. These seven genotypes performed better at 8 dS/m during germination and early seedling growth stages in 2016-17 and 2017-18. In 2018-19, the selected three genotypes SO0047, SO0048 and BARI Palongshak-1 were again studied. Here, average result of three years is presented. The NaCl concentrations used were 0 (control), 8 dS/m and 12 dS/m. The salinity was measured by soil EC Meter (HI 9833, direct soil conductivity & temperature meter, HANNA instruments) and EC Meter (Model 6061, Made in Taiwan).The study was evaluated under Completely Randomized design (CRD) with three replications. Spinach was grown in plastic pot (length 25 cm, dia 25 cm at the top and 12.5 cm at the bottom; capacity 10 L) which contained around 10 kg air dried soil. Fertilizers were applied to each pot @ Urea 2.25 g, TSP 1.5 g, MOP 1.70 g, Gypsum 1.5 g and Boric Acid (medicated) 1.0 g during pot filling mixing with air dried soil (7.5 % moisture). Weeding was done as per requirements. In each pot, 10 seeds were sown on 04 December, 2018. The seedlings were emerged within 6-7 days after sowing. The pots used during the present study had five small holes at the bottom. At the bottom of the pot, some pieces of broken bricks were kept and the brick pieces were covered with a small piece of mosquito net. Thinning of seedling was done at 15 days after sowing by keeping five plants in each pot. Salinity treatment was imposed at 4 leaf stage. Salt solution was prepared by dissolving calculated amount of commercially available NaCl with tap water. The salt solution was applied with an increment of 2.5 dS m^{-1} in every alternate day till respective salinity level was attained. Treatment solution was applied in excess so that the extra solution dripped from the bottom of the pots. The experiment ended in 12 January 2019. The root and shoot sample were collected prior to harvest. The collected sample was oven dried at 72^0C, for 1 week. For root sampling, plastic pots were soaked in water, soil was washed with water and the roots were recovered by passing the soil water suspension through a 2mm mesh sieve.

Data on plant height, no of leaves/plant, leaf length of the biggest leaf, leaf width of the biggest leaf, spad value, shoot fresh weight, root fresh weight, seedling fresh weight, shoot length, root length, seedling length, shoot dry weight, root dry weight, seedling dry weight were recorded. SPAD value was recorded by SPAD meter. The genotypes showed significant variation with regard to plant height, number of leaves/plant, leaf length, leaf width, SPAD value, total dry matter/plant and leaf yield/pot. The genotype SO-0047 performed better at both 8 and 12 dS/m in respect of all the characters studied. Therefore, it can be inferred that SO-0047 are salt tolerant and can be recommended for cultivation in saline area of Bangladesh.

Effect of GA_3 and growing condition on emergence and seedling growth of lettuce seed

The experiment was carried out at the Research Field of Plant Physiology Section, HRC, BARI during 05 December 2018 to 30 December 2018. The treatment consisted of two GA_3 concentrations (control-0.0 and 10 ppm) and four growing conditions viz. G_1 (Seeding in poly bag and placed in low light place, shaded by bamboo chatai with black polythene), G_2 (Seeding in poly bag and placed in bright light place, kept open), G_3 (Seeding in seed bed and placed in low light place, shaded by bamboo chatai with black polythene) and G_4 (Seeding in seed bed and placed in bright light place, kept open).The field was dived in 24 unit plots. The area of unit plots 1.0 m^2 (1 m x 1 m). Poly bags (7 cm x 6 cm) were kept in twelve unit plots. Thirty poly bags were taken for each

unit plot. The medium of poly bag was prepared by mixing sandy loam soil and well rotten cowdung in 1:1 ratio. The rest 12 plots were prepared like seed bed. Only three kg well rotten cowdung was applied to each unit plot. Required amount of lettuce (BARI Lettuce -1) seeds were divided into two parts; one part was soaked in control (distilled water) for 12 hours and another part was soaked in GA_3 10 ppm solution for 12 hours. After soaking seeds were air dried. Then air dried seeds were sown in the field on 5 December 2019 maintaining spacing of 20 cm x 5 cm. Twenty seeds were son in each line. After sowing twelve plots were covered by bamboo-chatai and black polythene and the rest 12 plots were kept open. The experiment was laid out in Split-Plot design. Growth regulator treatments and growing condition treatments were allocated in main plot subplot, respectively. Watering was done to poly bags and seed bed daily by water can with fine meshed nozzle until germination. The experiment was daily surveyed and some traits were measured. Emergence was started after 6 days of sowing. After 15 days data on emergence was taken. Data on shoot length, root length, shoot fresh weight, root fresh weight, SPAD value were recorded on 30 December 2018. SPAD value was recorded by SPAD meter.

The root and shoot sample were collected and were oven dried at 72^0C, for 72 hours. For root sampling, the desired plants were well watered and uprooted cautiously. Soaking of lettuce seeds in GA_3 10 ppm gave higher seed emergence percent, seedling fresh weight, seedling dry weight, seedling length and seedling dry weight and seedling vigour index than those of distilled water (control) and seed growing condition, G_1 recorded maximum seed emergence percent, seedling length and seedling vigour index.T_1 x G_1 combination gave maximum seed emergence percent, seedling length and seedling vigour index. The experiment will be continues next year.

Organic Practice

Evaluation of brinjal genotypes under organic condition

A study has been carried out at the organic research field of olericulture division of BARI to find out suitable variety of Brinjal for low input organic practices. Thirty one brinjal lines were tested in RCB design with three replication. The organic field were fertilized at the rate of 15 t/ha (7.5 t CD + 7.5 PR) in each year since 2006. The raised bed (70 cm) were prepared and each pit (70 cm apart) was made fertilized by CD + PR and 100 g BAOFER followed by straw mulching. Thirty-five old seedlings were planted and followed by irrigation to established the planting. Data were recorded on days to fifty percent plant flowering, number of fruits per plant, single fruits wt. fruits size, color, yield per plant, nutritional quality (anthocyanin). It was revealed that most of germplasm produced fifty percent plant flower ranges 55- 58 days while flower appeared late in two germplasm. The heaviest fruits was recorded in the 6 germplasm ranges from 230- 310 g which found statistically at par. Considering the color and shape variation of the fruits 5 types of color were recorded namely white, green, light green with white mottled at the bottom, deep purple and pink in combination with round, egg, long shape. Anthocyonin was measured of the germplasm which was ranged 90-122 microgram/ 100 g which was compared with conventional farming produced one. From this experiment there are 5 lines found potential to grown under organic condition and 8 lines found distinctly differed in all traits observed. These eight lines will be cross further under magic breeding method.

Evaluation of nutritional quality of organic and conventionally grown vegetables

A study have been carried out olericulture division, HRC, BARI to investigate the richness of nutritional properties of organically and conventionally grown vegetables during 2018 - 2019. Spinach, cabbage , tomato, brinjal, bottle gourd, carrot, cauliflower, capsicum, country beans, broccoli were assessed, and these are all BARI released variety except carrot. The crop was grown both organic and conventional conditions and sample were prepared at edible maturity stage followed by freeze drying. AOAC method was followed to analysed the sample from accredited laboratory (WAFFEN, Tejgoan, Dhaka) for proximate analysis (protein, fat, moisture, ash, carbohydrate, and fiber. It was revealed that invariably organic product contained more amount (ranges 10-25 % higher) of nutritional elements than conventionally grown one except few exception. The result is comply with other internationally published data as well.

Effect of organic substrate and container for safe and quality production of microgreen vegetables

A study was carried out at organic waste recycle laboratory of olericulture division to optimize the media and container for growing microgreen vegetables during 2018 -2019. Five treatments, namely; vermicompost- VC (75, 50 and 25 %), BAOFER (75, 50 and 25 %) and control were employed following CRD with three replication. Initially radish and broccoli were used a to micro green. Data were recorded on plant height, fresh weight and dry weight of microgreen, and analyzed statistically. It was revealed that the VC or BAOFER applied at the rate of 50 percent has not created phytoxicity and produced the highest amount of foliage. The harvested product then sent to accrediated lab for nutritional analysis (for total phenol) after freeze drying. It was revealed that total phenol did not varied significantly in all treatment. Therefore, it may be concluded from this experiment that VC or BAOFER 50 % combine with soil is suitable for growing radish and broccoli microgreen.

Comparison of amaranth (*Amaranthus lividus*) genotypes in organic and conventional farming

An experiment was conducted in the experimental field of olericulture division, HRC, BARI, Gazipur 2018 -2019 to investigate the variation of Amaranth genotypes in organic and conventional Farming. The experiments consists of 9 varieties under organic and conventional condition those are, 'BARI Data-1, AM(ST)-008, AM(ST)-011, AM(ST)-012, AM(ST)-020, AM(ST)-023, AM(ST)-025, AM(ST)-030, and AM(ST)-031-3', the genotypes were tested under organic (15 t/ha of cowdung application per year), recommended dose under conventional condition, control for both cases. Data was calculated on average total stem weight (g), stem length (cm), stem breadth (cm), number of leaf per plant, leaf weight (g), leaf length (cm), leaf breadth (cm), fresh weight (g), dryweight (g). The highest total stem weight was recorded the genotype AM(ST)-030 (RD) (3097.5 g), and variety AM(ST)-020 (RD) showed the lowest total weight (1250 g). Stem length was recorded the highest in AM(ST)-030 (RD) (83.17cm), and the lowest was AM(ST)-025 (RD) (44.7 5cm) which was differed significantly. Stem breadth of the genotypes was significantly varied. The highest leaf number was AM(ST)-030 (RD) (28.33), and the lowest was AM(ST)-025 (RD) (13.83). The highest fresh weight was AM (ST)-030 (RD) (119.16g) and the lowest was AM(ST)-012 (RD) (35 g). So, it can be said that genotype AM(ST)-030 (RD) is better than other genotypes.

Evaluation of nutrition dense pumpkin

Eleven pumpkin germplasm collected form hill districts and old stock (before 2000) of PGRC, BARI Gazipur and made a field evaluation in order to increase the collected seeds and test the nutrition during winter 2017-18. The genotypes were NDP 001, NDP 002, NDP 003, NDP 003, NDP 004, NDP 005, NDP 006, NDP 007, NDP 008 and NDP 009 and BARI Mistikumra-1, BARI Mistikumra 2 as a check. Data were recorded on days to first female flower, number of fruits per plant, single fruit wt and percent lycopene and B-carotene. It was revealed that female flowering took around 55-60 days except NDP 003 (did not produced female flower at winter), number of fruits ranges from 1-6 while single fruits wt. was recorded 585-2000g. fruits were round to oval shape with prominent ridge to flat skin. TSS was recorded ranging from 7- 11.4 (° brix). Flesh thickness was ranging from 1.5 to 3.68. Lycopene and B-carotene were assessed by color meter which was ranging 17-20 and 5-8 respectively. Dried sample were sent accredited lab for further nutritional analysis. Considering the exiting data 3 lines found superior in term of yield contributing characters and lycopene and B-carotene.

Effect of mulching and fertigation on yield and quality of tomato and brinjal

Mulching is used to cover soil surface around the plants to create congenial condition for the plant growth along with fertigation. Therefore a study has been carried out to find out suitable method for weed control and water management using various mulch (straw, water hyacinth and black plastic) and fertigation method was adapted by drip irrigation method in tomato, brinjal and pumpkin. The design of the experiments was split plot where fertigation was in main plot and mulching was in subplot. It was revealed that straw mulching plots plants were affected by phytoxycity and growth were hampered invariably while water hyacinth mulch did not affect similar to straw. Plastic mulch was effective for all crop grown under organic condition. Yield

contributing character like, number of fruits, single fruit wt., SPAD value, yield per plant were recorded. For tomato three varieties (BARI tomato 2, 11, and 19) plastic much produced the highest number of fruits per plant and fruits size were also bigger than those of water hyacinth and straw mulch. Yield per plant were recorded the highest in plastic mulch as compared to other two mulch. For Brinjal BARI begun-5, 8 and 10 were planted and the straw mulch could not produced any fruits while water hyacinth mulch did 2-3 small size fruits but for plastic mulch expected number and size of fruits were harvested during the growing time. The highest number of fruits were recorded at BARI begun 8, while the lowest was in BARI begun 5 but not significantly differed. Therefore, it might be concluded that plastic mulch was effective for growing tomato and brinjal with drip irrigation under organic condition.

Intercropping of crucicerous vegetables with red amaranthat various organic fertilizers

Low production from the unit plot is a common blame against organic cultivation among the stakeholders, therefore a study has been carried out at Olericulture Division, HRC, BARI in order to find the suitable dose of organic fertilizers for cabbage, kohlrabi intercropped with red amaranth and to utilize land equivalent ratio (LER) for harvesting maximum vegetables. The two factors experiment was set in a RCB design where crops and organic fertilizers were the factors with three replications. Two sets of experiments one with cabbage and red amaranth and other with Kholrabi and red amaranth under different organic fertilizers applications. The treatments were BAOFER-BF (150 g, 100g and 50 g), Vermi-compost- VC (150 g, 100 g and 50 g), VC + BF (75 +75g, 50+ 50g, 25 +25 g). Data were recorded on the head wt. of cabbage, yield amaranth as single crop and intercrop, yield of kohlrabi including there SPAD value. It was revealed that the heaviest amount of cabbage were harvested in BF (150 g), VC (150 g) and VC + BF (75 +75 g) both in intercropped, which was significantly varied with sole crops followed by BF 100, VC 100 g, BF + VC 50+ 50g. The SPAD value was significantly differed with control to treatments. Cabbage yield per hectare were the highest in VC+ BF (75 + 75g) followed by BF 150 g. For kohlrabi the heaviest size were recorded in BF (150 g), VC (150 g) and VC + BF (75 +75 g) both in intercropped, which was significantly varied with sole crops followed by BF 100, VC 100 g, BF + VC 50+ 50g both intercropped and sole crops while the smaller size kohlrabi were harvested in control plot. Considering the yield parameters and LER it might be suggested that cruciferous crops like cabbage and kohlrabi can be cultivated with red amaranth by application of 150 BF and VC soley or in combination.

Indigenous Vegetables

Collection, evaluation and conservation of underutilized indigenous vegetables

Twenty eight types of underutilized indigenous vegetable were put under observational trial to assess their performance in respect of yield, seed production and agronomic practice for growing different time of the year during 2018-19. The yield potentiality of Bathua - green (16 t/ha), Bathua - red (14 t/ha), Thankuni (8.50 t/ha), LafaShak (18.0 t/ha), Pudina (9.60 t/ha), Nunia (14.26 t/ha), Malancha (8.65 t/ha), Helencha (10.5 t/ha), ShialmutraShak (17.5 t/ha), Shaknotey (18.20 t/ha), Katanotey (16.48 t/ha) and Pat Shak (5.24 t/ha). However, further studies are required for the standardization of their production practices. More indigenous medicinal herbs have been collected and are being multiplying for further study.

Preliminary yield trial of selected underutilized indigenous vegetables

Seven types of underutilized indigenous vegetables were put into PYT at the research field of Olericulture Division of Horticulture Research Centre (HRC), BARI, Gazipur during 2018-19 to standardize production protocol for growing different time of the year. Different parameters viz.: Plant height, number of branches per plant, number of leaves per plant, leaves' length and width, days to harvest, days to flowering, plot and per hectare yield were recorded and analyzed. The yield potential of Bathua- green (15.64 t/ha), Bathua- red (14.25 t/ha), Thankuni (8.50 t/ha), Lafashak (18.45 t/ha), Pudina (9.60 t/ha), Telakucha (7.58 t/ha) and Chukur (5.78 t/ha) was obtained. Further study need to be performed to standardize the production practices.

Performance of different colored vegetables in winter and summer

This experiment was conducted during April 2018 to September 2018 and during November 2018 to March 2019 in the experimental field of RARS, BARI, Cumilla to evaluate the performance of colored vegetable and to popularize the colored vegetable among the consumers. There were five treatments *viz*., green yard long bean, red yard long bean, green indian spinach, red stem amaranth and green stem amaranth in kharif season. Results revealed that among the vegetables green indian spinach showed maximum yield (43 t ha^{-1}). The lowest yield (1 t ha^{-1}) was recorded from red yard long bean due to severe infestation of aphid and YMV. Red stem amaranth 40 t ha^{-1} showed better yield performance over green stem amaranth 24 t ha^{-1}. For rabi season there were eight treatments viz. red cabbage, red radish, red and orange Capsicum, red amaranth, red radish $F_{1,}$ red turnip and green cabbage. Results revealed that the maximum yield (93.75t ha^{-1}) was obtained from green cabbage while red cabbage yielded as 63.0 t ha^{-1} and the lowest yield (16.25 t ha^{-1}) was recorded from red radish. Orange capsicum showed better yield performance over red capsicum. Yield gap between orange and red capsicum was also 2.40 t ha^{-1}. Red radish F_1 showed better yield performance over red radish. Low yield potentiality was observed in red radish, red amaranth and red capsicum.

Development of cost effective nutrient composition for soilless cultivation

The developed chemical composition is a unique plant nutrient solution for hydroponic crop cultivation. In this composition HNO_3, CaO and KOH is used instead of KNO_3 and Ca $(NO_3)_2$ as N, K and Ca sources. This cut the solution price ten times than the present one. Besides some portion nitrogen is supplied from di- ammonium phosphate. This composition has the ability to maintain constant pH level in between 5.5-6.5 by buffering the solution and give healthier plant growth. The composition presents all the nutrients necessary for plant growth in the form of NH_4^+, NO_3^{--}, K^+, Ca^{++}, Mg^{++}, SO_4^{--}, H_2PO4^-, Fe^{++}, Mn^{++}, Zn^{++}, Cu^{++}, $MoO^{2-}{}_4$. Proportion of elements may vary with crop type and growth stage.Various auxilary agent like humic acid, Si (Silicon) etc may optionally be added to this comosition depending on the crop.

Evaluation of selected drumstick lines (on and off-season)

A study on evaluation of selected seven drumstick entries was conducted at the experimental field of Olericulture Division of HRC, BARI, Gazipur during the season of 2010-12 onward and this year (2018-19). The drumstick entry: MO 0025 found to be as seasonal natured having good quality with individual pod weight (61.53g) having 16.25kg yield per plant, while four lines viz MO 0001(1), MO 0007, MO-0008, MO-0011 and MO-0012 are considered as off-seasonal promising lines having 40-50g, average individual pod weight. Yearly average per plant yield indicated that the lines MO 0001(1) exhibited maximum yield (13.75 kg) followed by line MO 0012 (15.23 kg). These off-season lines are capable to produce flower two to three times in a year. No major pest and diseases found to attack in the Moringa lines. For further use, five plants of entry have been multiplied.

Collection, characterization and evaluation of wild s*olanum spp*. Root stocks- resistant to bacterial, fusarium wilt and rootknot nematode

An experiment was carried out at the experimental field of Olericulture Division of HRC, BARI, Gazipur, Bangladesh during October 2017 to July 2017-18 to characterize, evaluate and estimate tolerance level collected rootstocks against BW, FW and RKN. Based on horticultural traits and seedling growth attitude, the entries WSM004, WSM005, WSM006 and WSM007 may also be used as alternate rootstocks. The entries- WSS002, WSM004, and WSM005 were found to be resistant against BW. This first year results, the experiment may be repeated with included some other parameters like- seed yield per plant, number of seeds per fruit and seed vigour, etc.

Hydroponics

Effect of aeration on growth of four lettuce cultivars in hydroponics

An experiment was conducted in the glass house of HRC, BARI during the period from January to April 2019 to investigate the effects of aeration on growth of four lettuce cultivars viz., BARI lettuce-1, Grand rapid, Manik F1 and Cabbage lettuce in hydroponic systems. Among the tested lettuce varieties, Manik F1 produced highest shoot fresh

weight (133.8 g) which was followed by BARI lettuce 1 (115.8) and the lowest value was found in Cabbage lettuce. Lettuce plants grown with aeration yielded 34% higher fresh weight than plants grown without aeration. In combined effect of variety and aeration, it was found that BARI lettuce 1 produced maximum fresh weight of shoot (162.2 g) followed Manik F1. Other growth characteristics were contributed to the greater performance of these two varieties of lettuce. Therefore, it can be conducted that, BARI lettuce-1 and Manik F1 can be grown in deep water culture with aeration for higher shoot yield.

An experimental study on suitable type of water for growing hydroponic lettuce

The study was carried out in the polyhouse of Olericulture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI). In the experiment, a vertical A-shaped frame which is suitable to grow a large number of plants in a small area was used for growing lettuce. An A-shaped frame was constructed using total six steel's tray of 167.2 cm × 12.5 cm placing three tray at each inclined side of the A-shaped frame. The hydroponic system was Deep Water Culture System. Lettuce (*Lactuca sativa* L.) is a short growing period (30 days after transplanting) leafy vegetable and cash crop. Three types of water – rain, ground and distilled water were used to prepare respective water solutions mixing with stock solution according to Cooper's ratio 0.01. Crop coefficient, Kc the ratio of ETc to ET_o, was calculated. The ETc of lettuce in hydroponic system was estimated by direct method. ET_o was determined by CROPWAT software. The best water was selected mainly by counting the number of adjustment of nutrients with water, EC = 1-1.5 for 14 days after transplanting, DAT and 1.5-2 for 15-30 DAT and pH = 6.5-7.0 during the total length of growth stage. Each type of water used showed similar suitability in terms of pH and EC management but ground water is the most suitable in terms of production, availability, and cost. The considerable Crop coefficient, Kc was found as 0.73 for Lettuce. The cost effectiveness is satisfactory (BCR = 1.2). The study will be helpful for hydroponic farmer to select suitable water type and to estimate irrigation water requirement (IWR) and nutrient solution requirement for each crop cycle easily. The cost-benefit ratio, CBR will inspire people to be a hydroponic farmer. Hydroponic farming has a great potentiality in Bangladesh.

Year round production of vegetable crops through hydroponic culture

The experiment was conducted at the plastic house of Olericulture division of the HRC, BARI, Joydebpur, Gazipur during October 2017-November,18 to assess the year round production feasibility. The growing season were T_1=Oct.-Jan., T_2 =Feb.-May and T_3=Jun-Sept. In cucumber, plant height were minimum in T_1 (176.84 cm) and maximum in T_3 (191.17 cm). Minimum day's to1st female flowering was in T_3 (56.97 days) and maximum in treatment T_1 (61.63 days). There was no significant difference in harvest among the three planting times. The maximum yield was obtained from T_3 (2.52 kg) and minimum in T_2 (2.12 kg). In case of bitter gourd plant heights were higher in T_2 (422.93 cm) followed by T_1 (411.26 cm) and the lowest in T_3 (376.26 cm). Days to 1st female flowering open was earlier in T_3 (52.57 days) and late in T_2 (59.90 days). There is no significance difference in harvest; first harvest is recorded from T_3 (62.18 days). No. of fruits/plant was higher in T_2 treatment (10.03) while lower from T_3 (9.03). Fruit length was higher in T_2 (19.44 cm) and lower in T_3 (17.64 cm). The highest yield/plant was obtained from T_2 (2.62 kg), followed by T_1 (2.39 kg) and the lowest yield was obtained from T_3 (2.23 kg).

Production of selected vegetable crops through hydroponic culture

The experiment was conducted at the poly house on the rooftop of RHRS, BARI, Lebukhali, Patuakhali during the winter season of 2018-2019. . In case of netted melon, plant height varied from 175 cm to 191 cm. Days to harvest varied from 72 to 90 days. No. of fruits per plant was 1-2. Average fruit weight was 1.51 kg and maximum fruit weight was 2.1 kg. Maximum TSS was 13.5%. In the capsicum bed, plant height varied from 32 cm to 45 cm. Days to first harvest varied from 70 to 74 days. No. of fruits per plant was 14-18. Average fruit weight was 75.2 g and maximum fruit weight was 80 g. In an average 1.2 kg marketable capsicum could harvested from a single plant. In case of cherry tomato, plant height varied from 1.5 m to 2 m. No. of fruits per plant was 290-362. Average fruit weight was 11.58 g and maximum fruit weight was 13 g. Harvesting time lasted up to on an average 61 days.

Mushroom

Evaluation of different oyster mushroom strains

Yield potentialities of five strains of oyster mushroom were studied at the Olericulture Division, HRC, BARI, Joydebpur, Gazipur during the months of January-May 2019. The objective of this study was to evaluate the performance of different mushroom strains and to select suitable ones with good yield and quality. A wide variation was observed in yield and yield attributes in different varieties. Among the varieties, the highest numbers of fruiting body was found in Pleurotus ostreatus (Po2) followed by Pleurotus florida (Flo). Yield per packet was recorded the highest (314 g) in Pleurotus ostreatus var. Husky (HK) followed by Pleurotus ostreatus (Po2) (305 g) and the lowest (214 g) in Pleurotus sajor-caju (Psc). The strain Po2 produced the largest sized fruiting bodies.

Others

Feasibility of inter-cropping leafy vegetables under eggplant cultivation

An experiment was conducted during kharif and rabi season of 2018-2019 to find out the suitable crop combination for increasing total productivity, return and to maximize land utilization through intercropping system. Five treatments viz. Brinjal + Red amaranth, Brinjal + Leaf amaranth, Brinjal+ Jute as patshak, Brinjal + Indian spinach and sole of base crops (brinjal) were used in kharif season. In rabi season all treatments were same except T_4 where spinach was used in combination with brinjal instead of indian spinach. Results showed that different intercropping combination did not influence significantly on yield and yield contributing characters of brinjal. The yield of brinjal comparatively lower in intercropping but total productivity increased due to additional yield of leafy vegetables. The increase in total productivity in terms of brinjal equivalent yield (BEY) was 5.43 to 23.16 t/ha (Kharif) and 45.15 to 123.13 t/ha (Robi) in intercrop combination compared to base crop. All the intercropping combinations were higher in terms of brinjal equivalent yield, gross return and benefit cost ratio (BCR) over sole crops. Among the intercropping combinations, Brinjal + Indian spinach (summer) and Brinjal + Spinach (winter) was the most feasible and profitable in respect of brinjal equivalent yield (27.62 and 24.41 t/ha respectively), gross return (Tk. 1105000 and 610250/ha respectively), gross margin (Tk. 782487 and 392673/ha respectively) and benefit cost ratio (3.42 and 2.80 respectively). The results revealed that all intercropping treatments were suitable as compared to sole treatments but Brinjal + Indian spinach (in summer) and Brinjal + Spinach (in winter) intercropped combination was found more productive and profitable in respect of brinjal equivalent yield and monetary return.

Varietal Development

Evaluation of existing superior jackfruit lines

Performances of five jackfruit genotypes were studied at the Agricultural Research Station, Pahartali, BARI, Chattogram. Earliest flowering was observed in AH Pah-004 (Mid December) and the latest flowering was observed in AH Pah-001 and AH Pah-005, respectively (Late January). Maximum harvesting duration was observed in AH Pah-004 (Late April–Late July). Maximum number of fruits per plant (132) was produced by AH Pah-004, where minimum number (40) of fruits was produced by AH Pah-005. The heaviest fruit was observed in AH Pah-002 (8.310 kg) and the lightest fruit was observed in AH Pah-005 (3.110 kg) followed by AH Pah-004 (3.320 kg). Maximum yield of fruits per plant (401.22 kg) was produced by AH Pah-004, where minimum yield (110.34 kg) was produced by AH Pah-005. Maximum number of bulbs (121) was observed in AH Pah-001 where, minimum number of bulbs (37) was observed in AH Pah-004. Individual bulb weight was noticed higher (54.41g) in AH Pah-002 compared to lower (16.00) individual bulb weight was noticed in AH Pah-001. The highest bulb length and breadth was produced in AH Pah-003 (7.35 cm and 4.69 cm, respectively). Edible portion was recorded the highest (54.00%) in AH Pah-004 followed by AH Pah-001 (44.77%), where the lowest edible portion (36.10%) was recorded in AH Pah-005. TSS was noted the highest (21.50%) in AH Pah-004, which was closely related to AH Pah-001 (21.00%). The bulbs of AH Pah-004 are excellent in taste. Considering flowering, fruit characteristics and qualitative characteristics, the genotype AH Pah-001 and AH Pah-004 were found promising. The experiment will be continued in the next year for added evaluation.

Performance of BARI developed jackfruit varieties at Joydebpur

An experiment was carried out at the Fruit Research Farm of the HRC, BARI, Joydebpur, Gazipur to observe the performance of BARI developed jackfruit varieties viz. BARI Kanthal-1 (a regular bearing high yielding jackfruit variety, which is harvested after the Mid May to June); BARI Kanthal-2 (an off-season regular bearing jackfruit variety which is harvested during the month of January to March) and BARI Kanthal-3 (a year round regular bearing jackfruit variety, which is harvested during the month of September to June). Saplings of jackfruit varieties were planted in July, 2018. Prior to plant saplings of jackfruit, the land was ploughed with power tiller. Drainage system was developed. Pit was prepared and initially 20 Kg cow dung, 400 g TSP, 200 g MoP and 50 g gypsum were incorporated with the upper soil of pit. Total number of grafted saplings was 36. Spacing was 5 X 4.5 m. Pit size was 1m x 1m x1m. The experiment was laid out in a Randomized Complete Block Design (RCBD). Initial plant height at August 30, 2018 of BARI Kanthal-1, BARI Kanthl-2 and BARI Kanthal-3 were recorded 103.4, 39.8 and 44.0 cm, respectively and at July, 2019 plant height of BARI Kanthal-1, BARI Kanthl-2 and BARI Kanthal-3 were recorded to be 176, 178 and 175 cm, respectively. At the same time, base girth increased from 3.57 cm in August, 2018 to 8.92 cm in July, 2019 in case of BARI Kanthal-1; 2.07 cm in August, 2018 to 9.47 cm in July, 2019 in case of BARI Kanthal-2 and 1.97 cm in August, 2018 to 9.78 cm in July, 2019 in case of BARI Kanthal-3. Number of branches and number of leaves increased simultaneously. Male inflorescences were observed in BARI Kanthal-1.

Evaluation of exotic jackfruit germplasm

Six exotic year round and six red jackfruit germplasm were collected from Thailand and Vietnam with the help of local nursery men and were planted at Fruit Research Farm in the month of July, 2018. Spacing was 5 X 4.5 m. Plant height, base girth, number of branches, date of first male inflorescence initiation and number of male inflorescence were recorded in Augustt 2018 and July 2019. The average plant height was observed to be 63.7 cm in 2018 and 191.0 cm in 2019. Six germplasm were observed to produce male inflorescence from the second week of November, 2018 which was the sign of off-season and year round behaviour. Male inflorescences were observed from the first year of planting, but female inflorescences were not found.

Evaluation of jackfruit germplasm

From an evaluation of fourteen jackfruit germplasm viz. AH Joy-039(2), AH Joy-073(2), AH Joy-074(1), AH Joy-074(3), AH Joy-099, AH Joy-115, AH Joy-202, AH Joy-203, AH Joy-208, AH Joy-209, AH Joy-212, AH Joy-215, AH Joy-217 and AH Joy-218 to identify the superior ones at the Fruit Research Farm of HRC, BARI, Gazipur; wide range of diversity was observed in the tree characters, number of fruits per plant, fruit characters and pulp characters of jackfruit. Maximum plant height was recorded to be 7.2 m in AH Joy-208 and minimum plant height in AH Joy-115(3.8 m). Base girth ranged from 56 to 150 cm. Trunk height varied from 0.6 to 1.8 m. Number of fruits ranged from 5 to 25. Fruit characteristics of jackfruit germplasm also varied largely. The fruit weight ranged from 2.6 to 11.35 kg. Fruit length varied from 18.5 to 49.0 cm whether diameter from 16.0 to 29.0 cm. Maximum and minimum bulb weights were recorded to be 7.075 in AH Joy-218 and 1.12 kg in AH Joy-039(2), respectively. Number of bulb per fruit varied from 40 to 283. Maximum and minimum edible portion were manifested to be 59.8 and 25.5 % in AH Joy-218 and AH Joy-099, respectively. TSS was noticed to vary from 17.0 to 24.0 ^{o}Brix. With respect to the number of fruit per plant, fruit weight, edible portion, TSS and pulp quality; germplasm AH Joy-099, AH Joy-115, AH Joy-217 and AH Joy-218 were found auspicious. Among these superior germplasm, AH Joy-202 is the best in size and shape of fruit, bulb weight, pulp colour, sweetness etc. which might be released as variety. The experiment will be continued for further evaluation.

Evaluation of off season jackfruit germplasm

The selected off-season jackfruit germplasm were evaluated at the Regional Agricultural Research Station, Akbarpur, Moulvibazar. The earliest harvest was done from the line AH Akb-001 in the month of January, followed by the line AH Akb-08 in the month of March. The highest number of fruits was observed in AH Akb-001 (159) followed by AH Akb-008 (45) Maximum percentage of edible portion was observed in AH Akb-001 (42.1%) followed by AH Akb-016 (40.6% and minimum in AH Akb-008 (36.25%). The highest TSS was found in AH Akb-001 (30.6%) followed by AH Akb-008 (22.0%) and AH Akb-016 (20.6%). Considering the earliness, yield and yield contributing characters, the line AH Akb-001 performed better. This line can be suggested for further procedure to release as a variety.

Evaluation of jackfruit germplasm in the hilly region

Evaluation of existing eleven jackfruit germplasm was done at fruit research farm of HARS, Khagrachari to identify superior small sized jackfruit germplasm with high yield potentiality and edible qualities. Yield and yield components of the jackfruit germplasm revealed that number of fruits per plant ranged from 25-118. AH Kha-005 produced maximum number of fruits (118) followed by AH Kha-004 (84) and minimum number of fruits was recorded in AH Kha-011 (25). Among the eleven germplasms, five produced more than 60 fruits per plant indicating high yielding potentiality. Single fruit weight ranged from 2.55-4.38 kg, where AH Kha-004 produces the highest (4.38 kg) individual fruit weight followed by AH Kha-011 (4.10 kg) and the lowest individual fruit weight was found from AH Kha-005 (2.55 kg). TSS content of the fruit varied from 14-22, where AH Kha-005 and AH Kha-007 produced the highest TSS (22%). Yield (kg/plant) was noted the highest (367.92 kg) in AH Kha-004 and the lowest in the line AH Kha-011 (102.50 kg). The edible qualities varied from (34.33-53.0 %) where AH Kha-005 showed the highest (53.0%) followed by AH Kha-010 (52.67%) and the lowest was observed in AH Kha-009 (34.33%). Considering

fruit characteristics i.e, taste, juiciness, sweetness, colour of pulp, fruit number and yield of the germplasm, AH Kha-005, AH Kha-007 and AH Kha-010 were found to be suitable superior small sized jackfruit germplasm with high yield potentiality and edible qualities.

Evaluation of late jackfruit germplasm

The study was carried out at the Citrus Research Station, Jaintapur, Sylhet to evaluate one late jackfruit germplasm of around 20 years old with a view to develop a late season jackfruit variety. Plant height was recorded 8 m, whereas its base girth was 1.0 m. The plant flowered first on 1st week of March and first harvesting started on 1st week of August, which is considerably late in the fruiting season. Number of fruits was recorded 56 which yielded 294 kg fruit per plant. In case of qualitative fruit characters, ellipsoid shaped, greenish colored fruit, semi-hard textured and off-white was found. No insect infestation was observed but fusarium fruit rot disease was recorded in the rainy season which was controlled by applying carbendazim (Bavistin 2g/L). The accession AH Jai-201 may be selected as a suitable late season variety of Jackfruit. It also retains fruit up to the end of the season providing the longer harvesting period. Therefore, farmers can be benefited by its nutritions and also selling fruits in the late season. Thus it may be recommended for high rainfall area of Jaintapur.

Inter-varietal hybridization of mango

A hybridization programme of mango was conducted at RHRS, Chapai Nawabganj. A total of 1200 flowers from 240 panicles were emasculated and pollinated. Total number of fruit retention at 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 days after pollination were 100, 70, 53, 32, 18, 10, 8, 5, 2, and 2, respectively. Two hybrid fruits were obtained from the cross BARI Aam-3 x BARI Aam-11 and Langra x BARI Aam-3. These mango hybrid fruits were harvested at mature stage and stones of the fruits were sown in soil for germination in the hybrid seedling plot. After germination, these one year hybrid seedlings will be transplanted in the main field and will be evaluated in the following seasons.

Inter-varietal hybridization of mango

A hybridization programme was conducted at RARS, Burirhat, Rangpur. A total of 3087 flowers from 374 panicles were emasculated and pollinated. Two hybrid fruits were obtained from the crosses between BARI Aam-3 x BARI Aam-4. These mango hybrid fruits were harvested at mature stage and stones of the fruits were sown in the soil for germination in the main field. After germination, these hybrid seedlings will be evaluated in the following seasons.

Hybridization in mango (set III and set IV)

The mango varieties, namely Langra, Haribanga, BARI Aam-3, BARI Aam-4 and BARI Aam-11 are renowned for their emblematic taste and high TSS content. Due to their size and taste these varieties are popular and have a great demand throughout Bangladesh. To mitigate the growing demand of colored mango as well as to improve the export potentiality, a hybridization programme was conducted following half-diallel fashion at the Fruit Research Farm, Horticulture Research Centre, BARI, Gazipur to develop superior hybrids with desirable characters of mango. The cross combinations were; Harivanga x BARI Aam- 4, Harivanga x BARI Aam- 3, Langra x BARI Aam-3, Langra x BARI Aam-4, Harivanga x BARI Aam- 11, BARI Aam-3 x BARI Aam-4. A total of 832 flowers from 90 panicles were emasculated and pollinated. Ten fruits were obtained only from BARI Aam-3 x BARI Aam-4. Developed hybrids were harvested at proper maturity stage. Afterwards, the harvested fruits were retained in the lab for ripening. After ripening the stones were collected and were sown into the poly bag with soil for germination in the net house. The germinated seedlings will be planted and evaluated in the following seasons for variety development.

Evaluation of Green Sweet (kachamitha) mango germplasm at hill valley in Chittagong hill tracts

An experiment was conducted on the existing six years old mango orchard with MI Rai-005, MI Rai-006, MI Rai-007, MI Rai-008 germplasm and BARI Aam-9 (kachamitha mango as control treatment) at hill valley of Hill Agricultural Research Station of Raikhali, Kaptai in Rangamati Hill District to find out the best kachamitha mango germplasm. The highest number of fruits per plant (241) was found in MI Rai-008 and the lowest number of fruits per plant (36) was in MI Rai-006. The heaviest individual fruit weight (250 g) was recorded in MI Rai-008 and the highest edible

portion (80.3%) was found in MI Rai-005 on the other hand the lowest fruit weight (110 g) was found in MI Rai-007. Maximum TSS (11%) was found in BARI Aam-9 but gave the lowest edible portion (76.8%). The genotype MI Rai-008 was found very well in organoleptic test. MI Rai-008 was noticed superior among all other germplasms under the study in Chittagong Hill Tracts.

Evaluation of superior mango genotypes

Two genotypes of mango, namely MI Pah-002 and MI Pah-003 were evaluated at the Agricultural Research Station, Pahartali, Khulshi, Chattogram. Earliest flowering and earliest harvesting were observed in MI Pah-002 and the latest in MI Pah-003. Maximum number of fruits (67) per plant was produced by MI Pah-003 and minimum (48) was produced by MI Pah-002. The heaviest fruit (389 g) was observed in MIPah-003 and the lightest fruit (220 g) was observed in MI Pah-002. The highest edible portion (72.30 %) was achieved from MI Pah-003 and the lowest edible portion (68.23 %) was achieved from MI Pah-002. Maximum Total Soluble Solids (TSS) (18.8 %) was observed in MI Pah-003 and the minimum TSS (18.0 %) was observed in MI Pah-002. The highest yield per tree (26.50 kg) was produced by MIPah-003 and the lowest yield per tree (19.32 kg) was produced by MI Pah-002. In respect of sweetness, MI Pah-002 and MI Pah-003 ranked the highest score (2.4). Maximum fiber (2.4) was found in MI Pah-002 while minimum fiber was noted in MI Pah-003 (2.5). On the basis of earliness, fruit size, yield and quality, the germplasm MI Pah-002 and MI Pah-003 were found promising.

Evaluation of exotic mango germplasm

An exotic mango germplasm (MI Raj-001) collected from Saudi Arabia was characterized at the Fruit Research Station, BARI, Binodpur, Rajshahi. The Germplasm MI Raj-001 had 4.5 m of plant height and 45 cm of base girth. The tree was intermediate type of habit. In bagging condition, in the germplasm MI Raj-001, the average fruit length, breadth, fruit weight, skin weight, edible portion and TSS were 12.09 cm, 10.22 cm, 620.2 g, 76.2 g, 76% and 17.5%, respectively. Further, in non-bagging MI Raj-001 mango germplasm, the fruit length, breadth, fruit weight, skin weight, edible portion and TSS were 10.91 cm, 8.44 cm, 517.5 g, 69.5g, 74% and 19.2%, respectively. Whereas, in bagging BARI Aam-4 (check variety), the average fruit length, breadth, fruit weight, skin weight, edible portion and TSS were 13.1 cm, 11.9 cm, 689.2 g, 78.5 g, 77% and 22.0%, respectively. Further, in non-bagging BARI Aam-4 (check variety), the fruit length, breadth, fruit weight, skin weight, edible portion and TSS were 11.2 cm, 10.03 cm, 610.4 g, 73.8 g, 76% and 23.3%, respectively. The plant of MI Raj-001 produced 70 fruits this year. Maturity period of the fruit was 2nd week of July. The fruit had very attractive yellowish maroon colour at ripen stage. The growth condition and fruit characteristic of the germplasm was satisfactory. However, the germplasm may be recommended for releasing as a variety.

Performance of BARI released mango varieties in the Chattogram hill tracts

An experiment was conducted on the existing eleven years old mango orchard with BARI Aam-1, BARI Aam-2, BARI Aam-3, BARI Aam-4 and BARI Aam-8 at hill valley of Hill Agricultural Research Station at Raikhali in Rangamati Hill District to verify their performances. Máximum plant height (798 cm), fruits per plant (341) and yield (24.8 t/ha) were observed in BARI Aam-8. The heaviest fruit (421g), the highest edible portion (74.1%) were found in BARI Aam-4. Maximum TSS (21.3%) was recorded in BARI Aam-3. The lowest number of fruits per plant (124), edible portion (64.9%) and fruit yield (5.8t/ha) were found in BARI Aam-1. Based on the number of fruits per plant and fruit yield with higher TSS (%), individual fruit weight, fruit volume, edible portion, BARI Aam-8, BARI Aam-3 and BARI Aam-4 were noticed superior among all other varieties under study in Chattogram Hill Tracts. BARI Aam-1 was suggested as suitable early sweet variety and BARI Aam-4 for late variety.

Evaluation of mango germplasm

A study was conducted on mango germplasm at the Horticulture Research Field, BSPC, BARI, Debiganj, Panchagarh. The experiment was carried out with 19 mango germplasms as treatments. A wide variation was observed regarding individual fruit weight, fruit length and width and TSS of different germplasm tested. Maximum average individual fruit weight was recorded in MI Deb-011 (654 g) followed by MI Deb-015 (605.3 g), whereas maximum TSS (23%) was obtained from

the germplasm MI Deb-017 with the average individual fruit weight of 314 g. Considering the total soluble solids (TSS) and individual fruit weight, the germplasm MI Deb-017 and MI Deb-011 performed the best. In the case of combined effects of TSS and individual fruit weight, MI Deb-017 had superior performance. The other germplasms like Nobanposonda, Khirsapad, Kishanbhog, MI Deb-001 and MI Deb-017 need further evaluations.

Characterization and evaluation of late mango germplasm

An experiment on characterization and evaluation of late mango germplasm was conducted at the Fruit Research Station, Rajshahi. The experiment included only one late mango germplsm (MI Raj-002) which flowered two times in a year. First flowering occurred in the month of February and harvesting in the mid-season (June) and second flowering occurred in the month of May and harvesting in the late season (September). The germplasm MI Raj-002 produced 186 in number and 46 kg of fruits in the mid-season (February-June) of production. In case of late season production, the tree bored 155 fruits in number and 27 kg of fruits. The individual fruit weight of MI Raj-002 was 270 g in the main season and 182 g in the late season (May- September, 2018). TSS percentage of main season fruit was 17, while it was 21 in late season fruit. The overall performance of the germplasm MI Raj-002 was satisfactory. The germplasm has the capability of two times production in a year. Fruit quality in terms of TSS% and flavor is good though it has some fibers in pulp but it is palatable. Considering two times production and good flavor, it can be considered as a promising germplasm. The experiment should be carried out for the next year for further investigation.

Performance of green sweet mango (Kanchamitha) germplasm at hilly region

An experiment was performed for the evaluation of one green sweet mango (Kanchamitha) germplasm (MI Kha-001) at the Hill Agricultural Research Station, Khagrachari. The full blooming period was mid January. The tree habit was spreading to intermediate type. Harvesting period was 7 to 16 May, 2019. The average individual fruit weight was recorded 256 g which was an acceptable size. Length and diameter of the fruit was recorded 14.1 and 6.7 cm, respectively. Weight of skin was 28.0. Pulp weight was found 196.0 g. Total Soluble Solids (TSS) was noted 9.4%. Edible portions were found 76.56%. Overall growth conditions of the germplasm were found satisfactory. Considering the fruit characters and edible quality, MI Kha-001 was considered as a promising mango germplasm for using at unripe condition.

Hybridization in litchi

Hybridization in litchi was carried out at the Fruit Research Farm of HRC, BARI, Joydebpur, Gazipur to incorporate some important characters like earliness, lateness, colour, regular heavy bearing habit in the desired variety or cultivar. Cross combinations for hybridization were: Kathali x BARI Litchi-2, Kadmi x BARI Litchi-4 and Kathali x BARI Litchi-4. Initial fruit set was recorded to be 40, 35 and 64 in Kathali x BARI Litchi-2, Kadmi x BARI Litchi-4 and Kathali x BARI Litchi-4 cross combination, respectively. Number of fruits were harvested only from Kathali x BARI Litchi-4 cross combination which was 30. Saplings were raised from the seeds and would be planted in the research field to get desired hybrid(s).

Evaluation of litchi genotypes

Performance of seven litchi germplasm and BARI Litchi-4 were evaluated at the Regional Agricultural Research Station, Ishurdi, Pabna. Large sized fruit was obtained from LC Ish-001 whereas, average fruit weight was noted maximum (25 g) in BARI Litchi-4. The highest edible portion (75.45%) was recorded from BARI Litchi-4. TSS (%) is almost similar among the harvested fruits of litchi cultivars.

Evaluation of promising local banana race at Hathazari

The experiment was conducted with one promising local banana cultivar at the Regional Agricultural Research Station, Hathazari, Chattogram. Different physio-morphological characters and yield contributing characters of local banana race were studied. Base girth varied from 73- 98 cm. Plant height varied from 4.53 to 5.9 m. The bunch without peduncle in this investigation varied from 8.6 to 15.3 kg. Individual finger weight ranged from 74.15 to 154 g. The edible portion is one of

the important factors for selecting a cultivar. In present investigation, it varied from 82.6% to 84.52%. The total soluble solids (TSS) is the indicator of sweetness in desert banana. From this investigation we obtained around 24% TSS. The colour of local banana were bright yellow at ripening stage. Colour of fruit at ripening stage is the most important criterion for a good cultivar both for local consumption as well as for export market. Colour of local banana was bright yellow at ripening stage. These plants produced sweet fruits and had excellent flavor and taste. No dropping tendency was found. Considering the qualitative characters of fruits, there were not much differences.

Evaluation of seeded banana germplasm at Jamalpur region

An experiment was carried out for fruit characteristics of seeded banana (*Musa* sp.) at the Horticulture Research Centre, RARS, BARI, Jamalpur. Eight local *viz*. SB-01, SB-02, SB-03, SB-04, SB-06, SB-09, SB-10 & SB-13 and two exotic viz. SB-ISD-01 and SB-ISD-05 genotypes were included in the study. Significant differences were observed among all the local and exotic lines in respect of all vegetative growth, flowering characters, harvesting time, yield and yield contributing characters and post-harvest quality of seeded banana. The line SB-10 produced the tallest plant (4.58 m) and SB-13 the shortest plant (3.31 m). The line SB-02 exhibited the highest bunch weight (19.07 kg) and number of hands per bunch (11.04). The highest average weight of individual hand (2.26 kg) was found in SB-01. The length and breadth of bunch were noted maximum in the line SB-01 and SB-10 (62.00 cm and 40.22 cm), respectively. Number of fingers per hand was noted the highest in SB-02 (14.63). SB-10 exhibited the biggest finger (199.87 g) as against the smallest finger in SB-02 (122.96 g). The line SB-02 gave maximum yield (43.88 t/ha), while SB-09 exhibited minimum yield (25.05 t/ha). The lines; SB-02, SB-01, SB-06, SB-04 and SB-03 gave higher yield. Considering number of seed per finger, hardness of seed, edible portion, TSS content and shelf life SB-06 and SB-10 were found promising and SB-06 was the best one under Jamalpur condition.

Regional yield trial of banana lines

Six local and exotic table banana genotypes were evaluated to identify the suitable genotype at the Horticulture Research Centre, RARS, BARI, Jamalpur. There were significant variations among the genotypes in terms of all vegetative growth, flowering characters and harvesting time and yield and yield contributing characters and postharvest quality of banana. The highest number of hands per bunch was recorded in ITC-1441 (11.01) and the least in Kabri (7.22). ITC-1441 got the highest number of fingers per hand (16.17) whereas Kabri got the lowest (12.34). ITC-1320 produced the highest fruit yield (41.14 t/ha) whereas, Kabri produced the lowest yield (16.35 t/ha). Kabri exhibited the highest edible portion (82.52%) as compared to lowest in ITC-1441 (72.66). The highest TSS (21%) was found in Kabri closely followed by ITC-1441 and Dud Sagar (21.00 and 20.00 %), respectively whereas; BARI Kola-1 produced the lowest TSS (18.11%). Dud Sagar exhibited the highest shelf life (7 days) as compared to the lowest shelf in ITC-1320 (3.00 days). Considering qualitative characters, Dud Sagar, ITC-1441 and ITC-570 were found as promising genotypes.

Regional yield trial of banana lines

Six genotypes of banana were evaluated to select the suitable lines as well as their regional adaptability of banana at the Fruit Research Farm of Horticulture Research Centre, BARI, Gazipur. Significantly wider variation was observed among the lines/varieties in respect of all vegetative, yield and yield contributing characters except number of leaves at shooting. BARI Kola-1 showed the shortest plant (186.7 cm) and Dud Sagar produced the tallest plant (307.00 cm) followed by Kabri (281.30 cm). BARI Kola-1 required shortest period (332.7 days) to harvest whereas Kabri required the longest period (367.3 days) followed by Dud Sagar (356.7 days). The highest bunch weight was produced by ITC-1320 (25.11 kg) followed by BARI Kola-1 (23.45 kg) and the lowest by Dud Sagar (12.38 kg). The highest number of hands per bunch was recorded in ITC-1320 (12.00) and the lowest number of hands in Dud Sagar (8.00). The highest number of fingers per bunch was also found in ITC-1320 (203.7), whereas it was noted the lowest in Dud Sagar (109.0). The highest fruit

yield was recorded in ITC-1320 (62.79 t/ha) and the lowest in Dud Sagar (30.95 t/ha). The highest percentage of edible portion was recorded in Kabri (77.51) followed by ITC-1441 (74.36) and Dud Sagar (72.90). Maximum TSS was found in Kabri (33.67 %) followed by ITC-1441 (25.33 %) and minimum in ITC-570 (18.03 %). Based on the results obtained from the experiment, it may be concluded that the germplasm, ITC-1441, Kabri and Dud Sagar performed better in terms of yield and quality. Though the highest yield was recorded from ITC-1320 (62.79 t/ha) but its quality was very poor because ripen fruits were droped out from hands or bunch. The experiment should be repeated with the germplasm ITC-1441, kabri and Dud sagar for more confirmation.

Regional yield trial of table banana germplasm

A study to see the regional adaptability of a selected superior line MS Jes-001 with a check variety BARI Banana-3 to develop suitable variety was conducted at the Fruit Research Farm of Horticulture Research Centre, BARI, Gazipur. The germplasm MS Jes-001 produced taller plant (357.00 cm) as compared to BARI Banana-3 (340.81 cm). MS Jes-001 produced heavier bunch (21.42 kg) compared to lighter bunch in BARI Banana-3 (19.75 kg). Mmaximum number of fingers per bunch (246.92) was recorded from MS Jes-001 and minimum fingers were recorded in BARI Banana-3 (186.53). BARI Banana-3 resulted in maximum finger weight (112.97g) as compared to minimum finger weight in MS Jes-001 (87.23 g). The mean finger length of MS Jes-001 (12.44 cm) was recorded higher than that of BARI Banana-3 (11.34 cm). Mean higher fruit yield was noted from MS Jes-001 (53.55 t/ha) compared to lower yield in BARI Banana-3 (49.35 t/ha). Considering yield and yield contributing characters the germplasm MS Jes-001 was found promising.

Clonal selection of banana cv. Sabri

Seventeen sabri banana germplasm was collected from Ishurdi region and planted at Regional Agricultural Research Station, Ishurdi, Pabna to evaluate and identify the suitable lines. Maximum number of leaves was obtained from MS Isd-008 and MS Isd-009 (15), whereas MS Isd-015 produced minimum leaves (11). MS Isd-005 got the highest bunch weight (20.55 kg) and number of hands per bunch (10)). MS Isd-010 got the highest number of fingers per hand (26.10) whereas, MS Isd-014 got the lowest (13.70) number of fingers. However, the highest fruit yield (51.38 t/ha) was obtained from MS Isd-002 followed by MS Isd-004 (45,50 t/ha) and the lowest yield (24.25 t/ha) in MS Isd-016. MS Isd-017 exhibited the highest edible portion (84.80%). TSS was manifesed maximum in MS Isd-012 (21.83%) followed by MS Isd-011 (21.80%).

Evaluation of banana (cv. Sabri kola) germplasam

The experiment was conducted at the Regional Agricultural Research Station, Burirhat, Rangpur with a view to find out a suitable banana (Sabri kola) germplasm for releasing as a variety. Five banana (sabri kola) germplasm viz. MS Bur-001, MS Bur-002, MS Bur-003, MS Bur-004 and MSBur-005 were included in the study. All the banana germplasm produced flower this year. The results revealed that the germplasm MS Bur-005 gave the highest yield (31.39 t/ha), which was followed (28.13 t/ha) by MS Bur-003, while the lowest yield (18.02 t/ha) was observed in MS Bur-002. The experiment should be continued in the next year for further evaluation.

Clonal selection of banana cv. Amritsagor

More than five hundred Amritsagor germplasm was collected from ten different locations and planted at the research field of Regional Horticulture Research Station of BARI, Shibpur, Narsingdi to evaluate and identify the suitable lines/variety and know regional adaptability of banana. This is second year evaluation of only 42 lines under 10 accessions considered for evaluation. Selected germplasm will be evaluated more precisely. Maximum number of leaves was obtained from MS Nar-005 (12.44) whereas MS Nar-042 produced minimum leaves (8.17). MS Nar-005 got the highest bunch weight (18.14 kg), number of hands per bunch (8.53) and the heaviest hands (3.11 kg). MS Nar-022 had the highest number of fingers per hand (18.04) whereas, MS Nar-042 had the lowest (13.67) number of fingers per hand. MS Nar-005 produced the highest fruit yield (45.35 t/ha) closely followed by MS Nar-022 (43.93 t/ha) and MS Nar-017 produced the lowest yield (37.50 t/ha). MS Nar-005 exhibited the highest edible portion (77.96%). TSS was noted maximum in MS Nar-001 (20.12%) followed by

MS Nar-017 (20.03%). MS Nar-034 exhibited the highest shelf life (8.08 days) as compared to the lowest shelf life in MS Nar-040 (5.98 days)

Evaluation of plantain germplasm

The experiment was conducted at the Regional Agricultural Research Station, Burirhat, Rangpur to find out a suitable plantain germplasm for releasing as a variety. Ten germplasm including BARI Kola-2 were included in the study. All the germplasm gave fruit this year. The results revealed that BARI Kola-2 resulted in the highest yield (42.67 t/ha), which was followed (32.58 t/ha) by MP Bur-017, while the lowest yield (17.25 t/ha) was noticed in MP Bur-019. Considering the yield, BARI Kola-2 produced higher yield (42.67 t/ha), which was followed (32.58 t/ha) by MP Bur-017, while the lowest yield (17.25 t/ha) was recorded in MP Bur-019. The experiment needs to be continued for further verification of the results.

Hybridization of BARI Peyara-2 with Sowrupkathi Peyara

Hybridization is one of the best ways to develop a superior variety to both of the parents by either manipulation or transfer of one or few characters. Hence, this experiment of hybridization between BARI Peyara-2 and Sowrupkathi Peyara was undertaken in RHRS, Lebukhali, Dumki, Patuakhali to incorporate some important characters of Sowrupkathi peyara like taste, soft seed and attracted fragrance in BARI Peyara-2. Three plants of each germplasm have planted in pot with proper care on April 2018. Firstly, BARI Peyara-2 was set as female parent and Sowrupkathi Peyara as male parent and reverse parents have also be selected for reciprocal cross.

Evaluation of colour fleshed guava germplasm

The experiment was conducted at the Regional Agricultural Research Station, Hathazari, Chattogram from November 2017 to observe the performance of some color fleshed guava germplasm collected from different parts of Chattogram region. The objective was to find out the superior line(s) of colour fleshed guava. The highest individual fruit weight was found in PG Hat-004 (297.0 g) and the highest TSS was found in PG Hat-007 (9.23). The lowest percentage of disease and insect infestation was found in PG Hat-008 (5%) and the highest infestation was recorded in PG Hat-005 (11.5%). The highest number of fruits/plant (175.00) and fruit yield (22.08 t/ha) were noticed in PG Hat-004 and the lowest values in PG Hat-008 (7.90 t/ha). The results of present findings are in agreement with Patel *et al*. (2011), Singh *et al*. (2013), Babu *et al*. (2007) and Singh *et al*. (2016).

Clonal selection of guava

The experiment was conducted at the Regional Agricultural research Station, Hathazari, Chattogram from November 2017 to observe the performance of some Kanchannagar guava germplasm collected from different parts of Chattogram region. The objective was to find out the superior line(s) of Kanchannagar guava. The highest individual fruit weight was manifested in PG Hat-11 (182.33g) and the highest TSS was noted in PG Hat-009 (10.67). The lowest percentage of disease and insect infestation was noted in PG Hat-020. The highest number of fruits/plant (175.00) and fruit yield/plant (22.08 t/ha) were recorded in PG Hat-011.

Evaluation of exotic lemon germplasm

An exotic lemon germplasm, collected from Greece, was planted at the Fruit Research Station, Binodpur, Rajshahi in 2012 to study its performance comparing with BARI released and existing local lemon varieties. The plant height, base girth, number of primary branches were 3.5 m, 30 cm and 3, respectively. The plant produced 43 fruits. Growth condition of the genotype was good. The plant growth and fruit characteristics were satisfactory. This was the fourth-year result. Further study is needed for final conclusion.

Collection and evaluation of lime (*Citrus aurantifolia*)

An experiment was undertaken at RARS, Rahmatpur, Barishal with six (6) lime (Kagzi) germplasm collected from southern region of Bangladesh to find out superior ones for releasing as variety. Wide variations in growth, flowering and fruit characteristics among the germplasm were noticed. Among the germplasm, the highest plant height was attained in CA Rah-01 (5.4 m) and the lowest one was in CA Rah-06 (2.5 m). Maximum base girth was found in the germplasm CA Rah-001 (32 cm) and minimum base girth was measured in CA Rah-04 (13 cm). Maximum total

number of fruits was counted in CA Rah-02 (520) and minimum number of fruits per plant was noticed in CA Rah-04 (100). In case of individual fruit weight, the heaviest fruit was harvested from CA Rah-02 (48.5 g) and the lightest fruit was obtained from CA Rah-06 (31.4 g). The number of chamber per fruit varied from 8.8 to 9.4. Seed content per fruit ranged from 12 to 16.6, where maximum seeds were counted in CA Rah-04 and minimum seeds were counted in CA Rah-03. The highest yield per plant was calculated in the germplasm CA Rah-02 (25.22 kg) and the lowest yield per plant was recordedd in CA Rah-04 (3.85 kg). The quantitative and qualitative variations in the evaluated lime germplasm (kagzi) indicate that there is an ample scope of crop improvement in the southern region as well as all over the country.

Evaluation of mandarin germplasm in controlled condition under net house

The experiment was conducted at the Citrus Research Station, Bangladesh Agricultural Research Institute (BARI), Jaintapur, Sylhet with six mandarin germplasms/lines viz., CR Jai-011, CR Jai-013, CR Jai-014, CR Jai-015, CR Jai-016 and CR Jai-018 along with BARI Komala-3 as check to find out suitable lines with higher yield and quality. A wide variation was observed in respect of yield and yield contributing characteristics. The highest number of fruits per plant (25) was found in CR Jai-018 and the highest yield per plant (4 kg) was found in CR Jai-015. Maximum fruit weight was recorded in CR Jai-015 (200.45 g) with large fruit size (6.9×8.1 cm). Total soluble solids (TSS) was recorded the highest (13.8%) and titratible acidity (TA) was recorded the lowest in CR Jai-015 (0.72%). Fruit surface was noticed smooth in BARI Komala-3 and CR Jai-015, whereas others germplasm had pitted skin. Strong adherence of albedo to pulp was found in CR Jai-014, whereas others were medium to weak. The superior germplasm CR Jai-015 may be proposed for releasing as a variety in terms of fruit quality and quantitative characteristics.

Performance of exotic sweet orange (C*itrus sinensis*) germplasm

A study was conducted with four exotic sweet orange germplasm to see their performances with BARI Malta-1 as check at the Citrus Research Station, Jaintapur, Sylhet. Significant differences were recorded among the germplasm in terms of growth, yield and yield contributing characteristics. Plant height ranged from 126 cm to 184 cm. Maximum fruit weight (455 g) was recorded in CS Jai-051 while minimum (235 g) fruit weight was recorded in BARI Malta-1. The highest TSS (11 %) was recorded in CS Jai-003 while BARI Malta-1 attained TSS of 9.7%. Fruit colour at maturity in exotic sweet orange germplasm CS Jai-051, CS Jai-003, CS Jai012, CS Jai209 and BARI Malta-1 was found pale green, bright yellow and greenish yellow, respectively. Among the germplasm, CS Jai-003 and CS Jai-051 were recorded promising and can be released as new sweet orange (Malta) variety. But final conclusion about these two varieties can be made after 2-3 years of further evaluation.

Evaluation of citron (*Citrus medica*) germplasm

The experiment was conducted with four citron germplasm *viz*. CM Jai-059, CM Jai-060, CM Jai-061 and CM Jai-062 to study their performances at CRS, Jaintapur, Sylhet. The highest plant height (234.3 cm was recorded in CM Jai-062, while the lowest plant height was recorded in CM Jai-060 (102.5 cm). Variation was found in quantitative fruit characters. CM Jai-062 bore relatively biggest (831.2g) fruits whereas CM Jai-060 had the smallest (291.6g) fruits. Maximum number of fruits was recorded in CM Jai-062 (31.67), while the lowest number fruits was demonstrated in CM Jai-061 (24.67). Maximum yield (26.32 kg/plant and 16.45 t/ha) was recorded in CM Jai-062 as against mínimum yield in CM Jai-059 (8.26 kg/plant and 5.16 t/ha). The chemical analysis of fruits showed that the germplasm CM Jai-062 had the highest albedo TSS (6.9%) followed by CM Jai-060 (6.6%) while the lowest albedo TSS was recorded in CM Jai-059 (2.2%). Maximum edible portion was recorded in CM Jai-062 (79.43%) while minimum edible portion was recorded in CM Jai-059 (70.30%). In conclusión, CM Jai-062 was selected as the best germplasm in terms of fruit weight, yield/plant, yield/ha, TSS and edible portion.

Evaluation of citron germplasm

The experiment was conducted at HRC, RARS, Jamalpur. Seven germplasm of citron (*Citrus medica*) was included in this study. A wide variation was observed in citron germplasm. CM Jam-007 was found superior with the highest plant

height of 3.85 m, base girth (28.3 cm) and individual fruit wt. (446 g). Rind weight was found the highest in CM Jam-007 (350 g) and the lowest in CM Jam-005 (190 g). Considering growth and yield contributing characters, it can be concluded that the line CM Jam-007 exhibited superiority over rest of the germplasm. The experiment will be continued for further evaluation.

Evaluation of lemon (Colombo) germplasm

The present study to evaluate the lemon (Colombo) germplasm was conducted at the research field of HRC, RARS, Jamalpur. Three lemon (Colombo) germplasm were evaluated in this study. A wide variation was observed in case of different growth characteristics of the lemon germplasm. CL Jam-002 was found superior with highest plant height of 3.11 m, canopy size (3.65 x 3.70 m), number of branches (6.2), number of fruits per plant (129) and yield per hectare. (33.86 t), whereas the line CL Jam-001 exhibited the lowest performance. Considering growth and yield contributing characters, it can be concluded that the germplasm CL Jam-002 performed better. The experiment will be continued for added evaluation.

Evaluation of pummelo in the hilly region of Rangamati

An experiment with ten germplasm of pummelo was conducted at the existing eleven years old pummelo orchard collected from different parts of Chittagong Hill Tracts at the hill valley of Hill Agricultural Research Station of Raikhali in Rangamati Hill District for the evaluation of superior pummelo lines in the hilly region. The tallest plant (440 cm) was observed in CG Rai-008 and the shortest (335 cm) plant in CG Rai-011. The highest fruit length (16.5 cm) was obtained from CG Rai-047 whereas the lowest (12.2 cm) fruit length was obtained from CG Rai-007. The highest individual fruit weight (1450 g) was achieved in CG Rai-047 and the lowest (620 g) fruit weight was achieved in CG Rai-007. Máximum number of fruits per plant (62) was observed in CG Rai-008 followed by CG Rai-052 (58), whereas the minimum number of fruits per plant (9) was noted in CG Rai-011. The earliest flowering (mid February) was recorded in CG Rai-006 and the latest (mid March) in CG Rai-047. The genotype CG Rai-006, CG Rai-009, CG Rai-047 and CG Rai-052 were supposed to be a superior germplasm, which can be evaluated for the next few years to draw a conclusion.

In-situ evaluation of year round pummelo germplasm

The study was conducted at the Hill Agricultural Research Station, BARI, Khagrachari. One off-season pummel germplasm (CG Kha-001) was selected for the evaluation along with a normal season control. Principally, year round bearing occurred in the germplasm. Maximum numbers of mature (23) and immature (95) fruits were found in the month of October and November, respectively. Average fruit weight was 1.54 kg. Maximum edible portion and TSS were noted 49.6% and 9.43%, respectively. The average number of fruits per month (11.67) was collected from CG Kha-001. Considering the fruit characteristics, edible quality, TSS, percent edible portion and yield potentialities, the germplasm CG Kha-001 was found promising.

Evaluation of late-season pummelo germplasm in the hilly region

The study was conducted at the Hill Agricultural Research Station, BARI, Khagrachari with one 12 year old off-season/late season pummelo germplasm (CG Kha-001), which was selected for the evaluation along with a check variety (BARI Batabilebu-5). Harvesting time ranged from December to January. High yielder (107 fruits/plant and 154.1 kg/plant) compared to the check variety (18.33 fruits/plant and16.04 kg/plant). Fruits of the proposed line are pyriform shaped and large sized. Average individual fruit weight was 1450 g with excellent light yellow colour of rind, where check variety produced less fruit weight of 875 g. Pulp is very sweet in taste, soft juicy, light pink in colour, having pleasant aroma and bitterness free. Meange edible portion is high (67. 55%). Mean TSS is comparatively high (9. 30%) than that of check variety (9.05%). Fruit retention percentage was very high. Seeds were small in size (weight of 100 seed is 40.44 g). The variety was less susceptible to insect-pests and diseases. The plant can survive in drought condition. So, the line CG Kha-001can be proposed for releasing as a late variety. Thus it will help in extending the availability period of pummelo as well as may increase the export of sweet pulp citrus.

Evaluation of sweet orange germplasm in the hilly region

The experiment was conducted to study the performance of sweet orange germplasm collected from different locations of CHT and planted at HARS, Khagrachari. Two germplasm *viz*. CS Kha-001, CS Kha-002 and a check variety BARI Malta-1 were evaluated to identify promising sweet orange germplasm in respect of fruit bearing, fruit quality and yield potentiality. Flowering time ranged from February to march in case of CS Kha-002 and BARI Malta-1 but in case of CS Kha-001 it was in March. Harvesting time was late (November) in case of CS Kha-001. All the germplasm produced profuse fruits per plant. Number of fruits per plants was noted the highest (228) in BARI Malta-1, while the lowest (77) number of fruits was recorded in CS Kha-002. Individual fruit weight also varied from 139.32-204 g. The biggest (204 g) fruit was recorded in CS Kha-002 and the smallest (139.32) fruit was observed in BARI Malta-1. Weight of fruits per plant was noted the highest (31.76 kg) in BARI Malta-1 while in case of CS Kha-001 it produced yield of 28.06 kg/plant and the lowest (15.71 kg) yield in CS Kha-002. Number of seed ranged from 10-25. TSS ranged from 7.5 to 8.5 % Brix and the mean was 7.93% Brix. Considering fruit characteristics i.e. taste, juiciness, sweetness, colour of pulp, fruit number and yield, BARI Malta-1 was found excellent but in context of attractiveness, less incidence of insect-disease, considerable yield potentiality and edible qualities CS Kha-001 also found promising.

Collection and evaluation of lemon (Colombo) germplasm at narsingdi region

The experiment was conducted to evaluate five lemon (Colombo) germplasm at the research field of HRC, BARI, Shibpur, Narsingdi. Significant variation was observed in the case of growth, yield contributing characters, yield and fruit quality of the germplasm studied. The highest plant height (4.24 m) and base girth (0.27 m) were noted from the germplasm CL Nar-005. Maximum number of fruits/plant (85.13) and yield (15.41 t/ha) were obtained from CL Nar-005. Among the germplasm, CL Nar-005 was found free from diseases whereas the other lines suffered from gummosis. Leaf miner was common in case of all the germplasm. Irrespective of germplasm, pulp colour was found white. But high juicy content and strong fruit aroma was found in CL Nar-005. The highest edible portion (61.47 %) was noticed in CL Nar-005.

Development of population for gynodioecious papaya variety

Development of gynodioecious population for obtaining 100% productive plants with a view to increase farm income through papaya cultivation was performed at the Fruit Research Farm of Pomology Division under HRC, BARI, Gazipur. Four sets of plants namely S5 progeny of CP Joy-005, CP Joy-009; BC3 progeny and newly collected CP Joy-022 were included in the study. Among the four sets; S5 progeny of CP Joy-005 produced 70, 30 & 0 percent andromonoecious, female and male plants, respectively; S5 progeny of CP Joy-009 produced 60, 35 and 5 percent andromonoecious, female and male plants; the BC3 progeny produced 55, 42 and 3 percent andromonoecious, female and male plants, respectively and CP Joy-022 produced 80, 20 and 0 percent andromonoecious, female and male plants, respectively. Considering the number of fruits per plants, 25, 20, 24 and 23 fruits were recorded in CP Joy-005, CP Joy-009, BC3 and CP Joy-022, respectively. Fruits of S5 progenies and CP Joy-022 showed light to bright yellow flesh colour but in BC3 it was light red to red colour. TSS (%) of fruits were 11.50, 10.00, 12.00 and 11.00 in CP Joy-005, CP Joy-009, BC3 and in CP Joy-022, respectively.The results of the study revealed that the objective of the experiment (100% productive papaya plant) achieved successfully in the last year and also in the current year. So, we can propose the germplasm CP Joy-005 as a gynodioecious papaya variety this year or we can advance the generation for another one year for final confirmation (i.e. no male plant in the advanced population).

Purification of shahi papaya

An experiment was carried out at the Fruit Research Farm of HRC, BARI, Joydebpur, Gazipur to purify the Shahi papaya variety. Seedlings of purified Sib-mated seeds were transplanted in the main field on the last week of November 2018 and the Sib-mating process (selfing of five flowers from each plant) for this year was started on 28 April 2019 and continued up to 07 July 2019. From

April-July 2019, a total of 304 flowers were Sib-mated, among those 254 fruits have been set. By comparing standard Shahi papaya characters and our last ten (10) year's experiment results, we can conclude that the original Shahi papaya characters have partially regained and we need to maintain it through sib-matting every year to retrieve the original characters. Otherwise, the original characters will be degenerated again.

Performance of hybrid papaya in Cumilla region

A field experiment was conducted to evaluate the performance of hybrid papaya with respect to yield and quality. Three varieties *viz*., Red Lady, Top Lady and Shahi were considered as treatments replicated three times in RCBD design. Result of the study revealed that Red lady gave maximum number of fruit per plant (38.3), average fruit weight (1.73 kg), yield of fruit per plant (62.3 kg) and flesh thickness (3.3 cm). But the highest percentage of total soluble solids (11.30) was recorded in Shahi followed by Top lady whereas minimum percentage of TSS (10.93) was obtained in Red lady. Fruit size and cavity were recorded the highest in Top lady. Thus, it is concluded that Red lady is the best variety of papaya for getting higher yield but Shahi was found better in respect of TSS.

Purification of shahi pepe

An experiment was carried out at the Fruit Research Station, BARI, Binodpur, Rajshahi to purify the Shahi pepe variety. Seedling of purified selfed seeds were transplanted in the main field on 08 March 2018 and 10 flowers in each plant were selfed (Sib mating) from June to August 2018. The results showed that the plant and fruit characteristics of Shahi pepe (BARI Papaya-1) under this experiment were not relevant to that of the original Shahi pepe in the characters under consideration. However, the study on purification of Shahi pepe should be continued for the subsequent years to regain the characteristics of original Shahi pepe.

Collection and evaluation of sour type ber germplasm

A study was conducted at the Fruit Research Station, Binodpur, Rajshahi with sour ber lines. Fruit weight was recorded highest in ZM Raj-002 (10.46 g) followed by ZM Raj-005 (10.22 g) and ZM Raj-006 (10.14 g) whereas, the lowest fruit weight was observed in ZM Raj-008 (6.18 g). Total soluble solids (TSS) were recorded the highest in ZM Raj-002 (19.60%) followed by ZM Raj-010 (16.60 g), while that was recorded the lowest in ZM Raj-008 (14.40%). Again, ZM Raj-002 gave the highest yield (13.66 t/ha) and the lowest yield (10.24 t/ha) was noted in ZM Raj-010. Among all the ten sour type ber lines, ZM Raj-002, ZM Raj-005 and ZM Raj-006 were found to be very promising for late season.

Collection and evaluation of local ber germplasm

A study was conducted at the Fruit Research Station, Binodpur, Rajshahi with ten local and exotic ber varieties. Fruit weight was recorded the highest in BARI Kul-3 (38.7 g) followed by BARI Kul-2 (34.6 g) whereas, the lowest fruit weight was observed in Umboli Kul (15.7 g). Total soluble solids (TSS) was recorded the highest in Umboly Kul-1 (17.4 %) followed by Apple Kul and BARI Kul-1, while that was noticed the lowest in BARI kul-2 (12.4%). BARI Kul-3 gave the highest yield (25.27 t/ha) and it was noted the lowest in Umboli Kul (10.25 t/ha). BARI Kul-1, BARI Kul-2 and BARI Kul-3 have already been recommended for growing in Bangladesh. Among the other lines, Local Kul (Late) was found to be very promising for late season.

Evaluation of ber germplasm

An experiment was conducted to identify suitable ber germplasm (*Zizyphus mauritiana*) at HRC Fruit Orchard, RARS, Jamalpur. Thirty eight accessions were included in the study. Wide range of variation was noted regarding quantitative and qualitative fruit characters. ZM Jam-124 had maximum individual fruit weight 19 g and ZM Jam-143 got minimum fruit weight 5.70 g. Yield per plant varied from 9.00 (ZM Jam-177) to 22.00 kg (ZM Jam-122 and ZM Jam-244. Edible portion varied from 85.00 (ZM Jam-133) to 95.38 % (ZM Jam-145). TSS varied from 13 (ZM Jam-232) to 22 % (ZM Jam-122, ZM Jam-145 and ZM Jam-188). Some lines viz. ZM Jam-122, ZM Jam-124, ZM Jam-127, ZM Jam-140, ZM Jam -151, ZM Jam-178, ZM Jam-196, ZM Jam -205, ZM Jam -223, ZM Jam-239 and ZM Jam-244 showed promising characters regarding soury sweet taste which is our target. Some lines viz. ZM Jam-124, ZM Jam-169,

and ZM Jam-186 showed promising characters regarding late bearing habit. Some lines viz. ZM Jam-122, ZM Jam-188, ZM Jam-223, and ZM Jam-244, showed best performance regarding organoleptic taste. The experiment will be continued in the next year for further evaluation.

Collection and evaluation of bullock's heart genotypes

A study was carried out at RARS, Ishurdi to find out the superior genotypes of bullock's heart (*Annona reticulata*L). Thirteen genotypes were identified and fruits were collected from the plants in different locations of Ishurdi upazila. Data were collected in respect of fruit length, fruit breadth, as well as quality parameters like pulp content, edible portion, TSS and yield per plant. The genotypes AR Isd-001, AR Isd-002, AR Isd-004, AR Isd-005, AR Isd-009 and AR Isd-013 were found superior among the germplasm studied

Evaluation of cashewnut germplasm

Eight cashew nut germplasm were evaluated at RARS, Hathazari. Flower initiation was early in the line AO Hat-002 (28.01.17) and late flower Initiation was in line AO Hat-007 (27.02.17). Individual nut wt. with flesh was the highest (55gm) in AO Hat-008 and the lowest (18 g) in AO Hat-004. Individual flesh wt. was the highest (50 g) also in AO Hat-008 and the lowest (16 g) in AO Hat-004. Nut wt. was maximumn (12gm) in AO Hat-006 and the minimum (2 g) in AO Hat-004 and AO Hat-005, respectively. Maximum nut yield per plant (8 kg) was found in AO Hat-006 followed by AO Hat-001 (6.5kg) among 08 cashew germplasm and minimum nut yield per plant (1.6 kg) was found in AO Hat-003. Five germplasm (AO Hat-002, AO Hat-004, AO Hat-005, AO Hat-006 and AO Hat-007) had pink flowers and cream-colored flower was observed in 3 germplasm (AO Hat-001, AO Hat-003 and AO Hat-008). Considering nut yield and yield contributing characteristics the germplasm AO Hat-006 was found the best.

***In-situ* evaluation of bael germplasm**

An experiment comprising three bael germplasm was performed at Chapainawabganj sadar and Shibganj upazila to find out a good germplasm of bael for the commercial cultivation. BARI Bael-1 was used as check. Age of both the germplasm, AM Cha-001 & AM Cha-002 was 31 years, while BARI Bael-1 was 12 years old. Maximum individual fruit weight (960 g) was found in AM Cha-002 while it was recorded minimum (718 g) in BARI Bael-1. Maximum number (130) of fruits per plant was found in the germplasm AM Cha-001 while minimum number of fruit was harvested (75) from BARI Bael-1. Fruit length varied from 10.1 (BARI Bael-1) to 11.8 cm AM Cha-002, whereas fruit breadth ranged from 10.83 cm (BARI Bael-1) to 13 cm (AM Cha-002). Fruit thickness was the highest in AM Cha-002 (12.75 cm) and the lowest thickness in BARI Bael-1 (10.5 cm). The highest yield (124.8 kg) was found in the germplasm AM Cha-002 while minimum yield was recorded (54 kg) from BARI Bael-1. Considering TSS (38), pulp percentage (74.67), fiber percentage (1.23), mucilage(less) and eating quality(Excellent), the germplasm AM Cha-001 was found superior.

Evaluation of bael genotypes

An experiment was conducted at the Regional Agricultural Research Station, Burirhat, Rangpur with a view to developing high yielding variety of bael. Seventy two genotypes of bael were evaluated in this study. Out of 72 genotypes, 49 genotypes produced flowers and fruits during this season but 23 genotypes data were reported. Rest of the genotypes produced smaller fruit in size. Flowering time of different genotypes was observed in all genotypes from 1st week of May to 1st week of June. Early flowering (1st week of May) was observed in the genotype AM Bur-012, AM Bur-013 and AM Bur-052 and late flowering (1st week of June) was observed in the genotype AM Bur-060, AM Bur-063 and AM Bur-071. Harvesting was done from 2nd week of March to 1st week of May. Maximum number of fruits per plant (37) was obtained from AM Bur-028, whereas minimum number of fruits (5) was found in AM Bur-011, AM Bur-020, AM Bur-060 and AM Bur-063. The genotypes AM Bur-001 produced the highest fruit yield (25.40 kg/plant), while minimum fruits yield (3.00 kg/plant) was recorded from the genotype AM Bur-060. Considering weight of pulp, colour, flavour, stickiness texture, grittiness, bitterness and sweetness and TSS and quality it can be concluded that the genotypes AM Bur-001, AM Bur-003, AM Bur-037 and AM Bur-038 were found promising. The trial should be done in the next year for further evaluation.

In-situ evaluation of bael germplasm in Jaintapur

The experiment was conducted at CRS, Jaintapur, Sylhet, during three consecutive years 2016-17, 2017-18, and 2018-19. Four germplasm of bael were included in the study *viz*., AM Jai-001, AM Jai-002, AM Jai-003 and AM Jai-004. The plants were of variable ages ranged from 7-10 years. A wide variation was observed in the case of different characters of the germplasm tested. The highest number of fruits (135) was recorded in AM Jai-001 with maximum TSS (38.5%). Maximum fruit weight was resulted in AM Jai-002 (1245.67 g) with large sized fruit (15×12.7 cm^2). Maximum edible portion (83.61%). was recorded in AM Jai-001 while minimum (59.13%) edible portion was recorded in AM Jai-004. The germplasm AM Jai-001 was noticed as the best one in terms of TSS (%), number of fruits/plant and edible portion and may be released as a new variety.

In-situ evaluation of bael germplasm

An in-situ evaluation with three bael (*Aegle marmelos*) germplasm was done at Nandina, Jamalpur sadar. to find out a good one for commercial cultivation. Maximum individual fruit weight (950 g) was found in AM Jam-002 while minimum (850 g) individual fruit weight was recorded in AM Jam-003. Considering TSS (38.5%), pulp percentage (75.85), fiber percentage (1.25), and eating quality (excellent), the germplasm AM Jam-001 was noticed superior. In the case of TSS (38.5%), pulp percentage (75.85), fiber percentage (1.25), grittyness (absent) and eating quality (excellent), the germplasm AM Jam-001 was found superior.

Evaluation of star gooseberry genotypes in chattogram

An experiment was conducted at the Agricultural Research Station, Pahartali, Chattogram for the evaluation of five eleven-year-old star gooseberry genotypes with a check. Maximum number of fruits per plant (4744), TSS (10.1) and fruit yield per plant (19.92 kg) and very good organoleptic taste were recorded in PD Pah-003.Maximum individual fruit weight (4.7 g) was noted in PD Pah-004. Number of ridges (7) and edible portion (95.91%) were noticed maximum in PD Pah-002, whereas minimum number of fruits per plant (2872) was noted in PD Pah-004. Individual fruit weight (4.0 g), edible portion (95.00%) and TSS (7.9%) were recorded in PD Pah-001 and poor organoleptic taste was found in PD Pah-004. The lowest fruit yield per plant (9.20 kg) was recorded in PA Pah-005. Based on the TSS, fruit yield per plant and organoleptic taste, PD Pah-003 was observed to be superior and may be recommended as a new variety.

Evaluation of gooseberry (*Phyllanthus acidus)* germplasm

Four gooseberry lines *viz*. PA Akb-001, PA Akb-002, PA Akb-003, and PA Akb-004 were evaluated at the Regional Agricultural Research Station, Akbarpur, Moulvibazar. The highest number of fruits per plant (3519) was found in PA Akb-004. Considering the quantitative characteristics of fruits, the line PA Akb-003 was found much lucrative and larger in size than those of all other lines. The line PA Akb-003 was found better; the experiment should be continued for further research.

Evaluation of phalsa germplasm *(Grewia asiatica)*

One germplasm of Phalsa (GA Raj-001) was evaluated at the Fruit Research Station, BARI, Binodpur, Rajshahi. The germplasm (GA Raj-001) was a small spreading tree having plant height of 10.1 m and base girth of 1.2 m. The yellow flowers were borne in dense cymes in the leaf axils during March to May. The fruit was round, drupe and become dark purple when ripe. The flesh color was light greenish white. The length and breadth of the fruit were 1.3 cm and 1.2 cm, respectively. Fruit flavor was slightly astringent. Considering 100 fruits, the weight of fruit, seed and flesh was 70.5 g, 8.1 g and 49 g, respectively. The edible portion and TSS were 70% and 27.1%, respectively. Number of seeds per fruit was 1-2 and opaque type, brown, round or hemispherical seed showed low seed shattering tendency. The growth condition and fruit characteristic of the germplasm was satisfactory. This was the fourth-year result. The germplasm has been recommended for releasing as a variety.

Evaluation of phalsa (*Grewia asiatica l.*) in hilly area of Rangamati

An experiment on the evaluation of phalsa in the hill valley was conducted at the established minor fruits orchard of Hill Agricultural Research Station, Raikhali, Rangamati Hill District. Máximum plant height (630 cm) was recorded in GA Rai-003. Maximum yield per plant (7.8 kg), fruit length (9.25 mm), TSS (25.5 %) and fruit yield (3.2 t/ha) were found in the genotype GA Rai-002. On the otherhand, the highest 100 fruit weight (60.2 g) was measured in the genotype GA Rai-003. Every fruit contained two seeds in all the genotypes. Considering the performance of number of fruits per plant, fruit length and fruit yield the genotype GA Rai-002 was noticed promising from the third year of experiment.

Collection and evaluation of custard apple germplasm

Fruit characteristic of four custard apple germplasm were studied in the laboratory of Fruit Research Station, BARI, Binodpur, Rajshahi. The result indicated that wide range of diversity existed in fruit weight, pulp weight, TSS, pulp content and skin weight etc. The weight of a matured fruit varied from 120.5 to 129.4 g. The highest fruit weight (129.4 g) was observed in AS Bin-001 followed by AS Bin-002 (122.6 g) and the lowest fruit weight was observed in AS Bin-004 (120.5 g). Maximum (60%) edible portion was measured in AS Bin-002. TSS varied from 23.3 to 24.3 % but there was no significant difference among the lines. This was second-year result, AS Bin-002 showed better performance on the basis of fruit weight, skin weight, no of seeds/fruit, edible portion and TSS value. Further study is needed for developing suitable variety.

Collection and evaluation of Indian dillenia germplasm

Indian dillenia (*Dillenia indica*) is a fruit of highly medicinal values. It is also one of the stress tolerant fruit trees which can tolerate a bit of salinity and drought. Moreover, very minimum management is needed for growing the tree. By considering this in mind, a study was carried out at Horticulture Research Center, Regional Agricultural Research Station, Jashore to evaluate the Indian dillenia germplasm available in Jashore region. One promising germplasm was evaluated at the Horticulture Research Center, RARS, Jashore. The tree was about 10 years old having 8.7 m plant height and 1.2 m base girth. The plant was on flower on 15 May 2018 and matured as ripen on 18 October 2018. The total number of fruits produced by the genotype was 175. The average individual fruit weight was 478 g. Number of segments/fruit and also the average number of seeds/ fruit were 16 and 22, respectively. However, the yield/plant of 87.65 kg was recorded from the genotype. Though, only one germplasm had been evaluated but this is an excellent germplasm in terms of yield and quality. This is the second year of the study therefore; it needs to be repeated for further confirmation of the data before proposing as a variety.

Evaluation of indian dillenia germplasm in hilly region

The experiment with three Indian dillenia germplasm was evaluated at the Hill Tracts Agricultural Research Station, Ramgarh. The line DI Ram-003 produced maximum number of fruits (539/plant) followed by DI Ram-005 (533/plant) and heavier fruit (744.3 g/fruit) was produced by the line DI Ram-005. Maximum fruit yield (396.5 kg/plant) was recorded from the line DI Ram-005 followed by DI Ram-003 (215.1 kg /plant). Considering yield and yield contributing characters the line DI Ram-005 was recorded superior.

Evaluation of golden apple germplasm in the hilly region

Four golden apple germplasm were evaluated at the Hill Tracts Agricultural Research Station, Ramgarh. The line SD Ram-001 produced maximum number of fruits (4247/plant) and heavier fruit (100 g/fruit) was produced also by the line SD Ram-001. Maximum fruit yield (424.7 kg /plant) was obtained from the same line SD Ram-001 and the lowest yield (182.4 kg/plant) was recorded in SD Ram-004. Considering yield and yield contributing characters the line SD Ram-001 was appeared superior. So, the line can be released as variety.

***In-situ* evaluation and collection of superior Burmese grape genotype**

In-situ evaluation of seven Burmese grape germplasm was performed at the farmers field of

Shibpur, Narsingdi. . Wide variation was observed in the case of growth, yield contributing characters, yield and fruit quality of the germplasm. The highest plant height, base girth, canopy spreading were noted from the germplasm BS Nar-002. Maximum leaf size (lamina length) was noticed in BS Nar-004 and BS Nar-001. Maximum number of fruits/plant and fruit yield/plant were obtained from BS Nar-002. BS Nar-002 was also free from disease whereas the other germplasm suffered from powdery mildew and sooty mold. Chafer beetle was common in case of all the germplasm. The heaviest (23.14 g) fruit was obtained from BS Nar-002, while the lightest (15.35 g) fruit from BS Nar-007. Maximum edible portion was also recorded in BS Nar-002 (56.87 %) as compared to minimum in BS Nar-007 (41.36 %). Fruit size was the highest in BS Nar-002 (3.82 × 3.75 cm) followed by BS Nar-003 (3.41×3.26 cm). Flesh color and texture for all the germplasm were off white and juicy. Maximum edible portion (56.87%) and percent TSS (21.36%) were noticed in BS Nar-002.

Survey, collection and evaluation of jamun germplasm

An experiment was conducted at the Fruit Research Station, BARI, Binodpur, Rajshahi to evaluate nine jamun lines for superior traits (survey on different area in Rajshahi, Nator and Pabna). Wide variations were observed among the germplasm. The highest fruit weight of 15 gm was obtained from SC Raj-014 followed by SC Raj-013 (13 g). Maximum edible portion (86.67 %) was obtained from SC Raj-014 and SC Raj-016 followed by SC Raj-005 and SC Raj-015 which was 85 %, whereas minimum edible portion (72.50%) was found in SC Raj-004. Maximum TSS (18 %) was obtained from SC Raj-013. Maximum yield per plant was recorded in SC Raj-005 (50 kg) followed by SC Raj-001 (47 kg). Minimum fuit yield per plant was recoded in SC Raj-006 and SC Raj014 (20 kg). Considering fruit quality, percent TSS, flesh type, edible portion and fruit yield SC Raj-013 and SC Raj-014 in superior than other lines. This is third year experiment. So, this survey should be continued to collect superior germplasm.

Evaluation of jamun in the hilly area of Rangamati

An experiment with nine jamun genotypes was conducted on five years old jamun genotypes established in minorfruit block of the Hill Agricultural Research Station, Raikhali, Rangamati Hill District. Maximum fruit length (2.79 cm) and breadth (2.26) were found in SC Rai-010 and SC Rai-008, respectively. Individual fruit weight (8.8 g), yield per plant (58.7 kg) flesh thickness (0.82 mm), were also maximum in SC Ra-i008, maximum edible portion (86.0%) was found in SC Rai-010 and maximum TSS (14.0 %) was recorded in SC Rai-009. Fruits of all the genotypes were black in color, oblong in shape with flat fruit apex. The organoleptic test of SC Rai-008 and SC Rai-009 were supposed to be superior and might be released as variety in Bangladesh for commercial cultivation.

Evaluation of wood apple in hilly area of Rangamati

An experiment to evaluate four woodapple germplasm in hill valley at Hill Agricultural Research Station (HARS), Raikhali, Rangamati was conducted. Maximum plant height (576 cm), base girth (74 cm) and canopy (680 × 630 cm) were found in FL Rai-003 germplasm. Maximum individual fruit weight (460 g), fruit length (8.6 cm), fruit breadth (8.9 cm) and skin thickness (0.4 cm) were recorded in the germplasm FL Rai-003. Maximum number of fruits (179), fruit yield per plant (82.3 kg) and edible portion (59.0 %) were also found in FL Rai-003 germplasm and it was very well in organoleptic test.The FL Rai-003 was found as suitable for cultivation in hilly areas and might be released as woodapple variety in Bangladesh for commercial cultivation.

Evaluation of avocado germplasm

A sutudy was carried out at the Fruit Research Farm of Horticulture Research Center, BARI, Gazipur during to evaluate the avocado germplasm. Seven germplasm were evaluated in this study. Vegetative growth, flowering time and number of fruit set were studied. Growth of all germplasm was satisfactory. Plant height of studied germplasm ranged from 1.75 to 7.10 m. Average plant height and base girth were found to be 3.73 cm and 33.71 cm, respectively. Out of seven germplasm, PAJoy-003, PAJoy-004 and PAJoy-006 produced flower on late January to first week of February. Finally two germplasm PAJoy-003 and PAJoy-006 produced 4 and 11 fruit, respectively.

Evaluation of persimmon germplasm set-I

A study was carried out at the Fruit Research Farm of Horticulture Research Centre, BARI, Gazipur to evaluate the growth, flowering and fruiting behavior of persimmon germplasm. The plant and fruit characteristics, time of flowering, fruit shape and colour, harvesting time and number of fruit per plants and seed characteristics of persimmon germplasm were studied. The tallest plant (5.00 m) with maximum number of branches (4.0) was recorded in the germplasm DKJoy-002. The shortest plant (3.65 m) with minimum number of branches (3.0) was found in DKJoy-001. Maximum number of fruits (46) per plant was obtained from DKJoy-002. Individual fruit weight was 70 g in DKJoy-001 and 62 g in DKJoy-002. The highest TSS (14.0) was recorded in the germplasm DKJoy-001. Both of the germplasm produced globose shaped orange colour fruit which had deep orange pulp. Seeds were flat and brown in colour having very soft pulp texture in both of the germplasm. Seeds are also covered with musceligeneous substances. Both the accessions were infested by chafer bettle which was controlled by spraying cypermethrion at the time of new vegetative flush.

Evaluation of collected dragon fruit germplasm at Patuakhali Region

An experiment was conducted in RHRS, Lebukhali, Dumki, Patuakhali to find out the performance of collected dragon fruit germplasm suitable for commercial cultivation in southern region of Bangladesh. A total of 22 germplasm were collected from different location of Bangladesh. But after evaluation it was found that there were mainly three cluster means of three gemplasm including BARI Dragon Fruit-1. The other two germplasm accession was HU Pk-001and HU Pk-002. Maximum number of fruit was recorded in the genotype HU Pk-002 followed by BARI Dragon fruit-1. But in terms of individual fruit weight, total fruit yield and TSS, BARI Dragon fruit-1 was noticed superior over other two germplasm. Considering flowering time and fruit bearing habit, fruit characteristics i.e., taste, sweetness, edible portion the germplasm BARI Dragon Fruit-1 and HU Pk-002 might be considerd for commercial cultivation after study with economic analysis and market potentiality.

Life cycle events of dragon fruit genotype at Narsingdi region

The experiment was conducted for evaluation of six dragon fruit genotypes at RHRS, Shibpur, Narsingdi. Maximum plant height (367.06 cm) was observed in HU Nar -04 and minimum plant height (289.56 cm) was recorded in HU Nar-03. First flower initiation took place in the last week of April, 2017 and the range of flash number was recorded to be 6 to 8. Range of bud to flower setting was measured 15 to 18 days and flower to fruit setting was measured 6 to 7 days. The highest length of flower was recorded in HU Nar-04 (31.00 cm). Average fruit weight ranged from 143.27-340.23 g. Maximum fruit yield per pillar was recorded in HU Nar-04 (6.42 kg) whereas minimum yield was recorded in HU Nar-05 (2.29 kg). Maximum edible portion and TSS were recorded to be 77.72 % and 14.5% in HU Nar-01.

Evaluation of dragon fruit germplasm

The study was conducted at the Citrus Research Station (CRS), Jaintapur, Sylhet with two germplasm of dragon fruit viz., HC Jai-001 and HU Jai-002. Nnumber of side branches was found maximum (19) in HU Jai-002 and minimum (15) in HC Jai-001. Flowering duration was recorded from 24 to 28 May between the germplasm. Higher number of fruits was obtained from HU Jai-002 (21). HU Jai-002 produced larger fruit (397 g) with maximum (81.11%) edible portion. HU Jai-002 was found better regarding fruit weight, edible portion (%), TSS (%) with extraordinary white flesh. Further evaluation may be done for releasing it as a variety.

Collection and evaluation of cowa germplasm

The experiment to evaluate the cowa germplasm was conducted at RARS, Rahmatpur, Barishal.. Growth and reproductive characteristics of eleven cowa germplasm (viz. GC Rah-01, GC Rah-02, GC Rah-03, GC Rah-04, GC Rah-05, GC Rah-06, GC Rah-07, GC Rah-08, GC Rah-09, GC Rah-10 and GC Rah-11) were evaluated. Wide variations in growth characteristics among the germplasm were found. Among the germplasm, the highest plant height was attained in GC Rah-07 (498 cm) and the lowest plant height was observed in GC Rah-10 (240 cm). Maximum number of fruits per plant was found in GC Rah-03 (1600) and minimum number of fruits was counted in GC Rah-11 (270). The

highest individual weight of fruit was found in GC Rah-03 (45.75 g) and the lowest individual fruit weight was noticed in GC Rah-02 (32.50 g). Maximum fruit yield per plant was found in the germplasm GC Rah-03 (73.20 kg) and minimum fruit yield per plant was observed in GC Rah-11 (9.59 kg). The germplasm GC Rah-03 was found superior to all other germplasm.

Evaluation of burmese grape germplasm

The experiment was conducted at the Citrus Research Station, BARI, Jaintapur, Sylhet. Ten years old five lotkon germplasm were included in the study. A wide variation was observed in case of growth, yield contributing characters, yield and fruit quality of the germplasm studied. Maximum plant height was recorded in BS Jai-005 (8.9 m) while mínimum plant height was noted in BS Jai-004 (5.5 m). Maximum number of fruits/plant (2730), yield/plant (48.32 kg) and yield/ha (27.3t) were obtained from BS Jai-003. BS Jai-003 was also free from disease whereas the others suffered from powdery mildew and sooty mould. The largest fruit was recorded in BS Jai-003 (3.2×3.5 cm) followed by BS Jai-001 (3.2×3 cm). Maximum edible portion (35.03%) and per cent TSS (13.8%) were found in BS Jai-003. The germplasm BS Jai-001 and BS Jai-003 were recorded promising to be released as a variety of lotkon.

Collection and evaluation of water chesnut germplasm

Three lines of water chestnut (TrapabispinosaRoxb) such as TB Jam-001, TB Jam-002 and TB Jam-003 were evaluated at the Regional Agricultural Research Station, Jamalpur. Stem length ranged from 1.80 to 2.60 m in different germplasm.. Fruit length ranged from 2.9 to 4.3 cm in different germplasm.The highest yield per hectare was observed in TB Jam -002 and the lowest in TB Jam-003. TB Jam-002 also performed the best with respect to growth and yield parameters such as stem length, leaf length, leaf breadth, petiole length, individual fruit wt., fruit length, fruit breadth and yield. The experiment will be continued for further evaluation.

Collection and evaluation of citrus root stock germplasm

Five lines of root stock such as Rangpur lime, Rough lemon, Kalamanchi, Cleopetra mandarin and Trifoliate orange were evaluated at the Regional Agricultural Research Station, RARS, Jamalpur.Trifoliate orange was found superior with the highest plant height of 2.94 m, base girth (15.38 cm) and canopy size (2.22 m x 2.38 m) and the lowest plant height, narrow spreading found in Rangpur lime. Number of branches ranged from 3.0to 5.2 and profuse bearing was found in Kalamanshi root stock. Kalamanchi, Cleopetra mandarin and Trifoliate root stock lines are in fruit bearing stage and Rangpur lime and Rough lemon root stock lines are in vegetative growth stage. The experiment will be continued for complete evaluation.

Project: Propagation technique

Effect of time of grafting on BARI developed jackfruit varieties

An experiment was conducted at the Fruit Research Farm, HRC, BARI, Joydebpur, Gazipur to study the effects of time of and variety of jackfruit on grafting success. There were two factors in the experiment viz., time of grafting (March, April, May, June, July, August, September, October, November, December, January and February) and variety of jackfruit (BARI Kanthal-1 and BARI Kanthal-2). Time of grafting and variety alone, and in combination influenced the success of grafting and days required to sprouting. The highest grafting success (83.4%) was recorded in January grafting with BARI Kanthal-1 followed by that of February grafting with BARI Kanthal-1 (80.4%) and the lowest success was obtained from September grafting with BARI Kanthal-2 (26.7%). Considering grafting success January and February were the suitable time for cleft grafting of jackfruit. The experiment will be conducted next year for further confirmation.

Effects of time and variety on grafting in litchi

An experiment was conducted at the Fruit Research Farm of HRC, BARI, Joydebpur, Gazipur to study the effects of time and variety as scion on grafting in litchi. Scion of 3 litchi varieties namely BARI Lichu-2, BARI Lichu-3 and BARI Lichu-4 were taken for grafting in the months of July to June. Seedlings of BARI Lichu-1were raised in 20 ×15 cm polybags in 2017 and those seedlings were used as rootstock. Similar rootstocks in respect of size

and diameter were taken for the experiment. Ten grafts were prepared in each replication. There were two factors in the experiment viz., time and variety as scion of litchi. Time of grafting and variety alone and in combination influenced the success of grafting. The highest success was achieved in May grafting with the scion of BARI Lichu-4 (87.4%) followed by June grafting with BARI Lichu-4 (83.5.0 %). The lowest success was observed in BARI Lichu-3 in November (27.4%).

Effect of cutting length and time of cutting on the success and growth of dragon fruit propagation

In order to find out the suitable cutting length and time of cutting for the successful propagation of dragon fruit, the study was carried out at the research field of Regional Horticulture Research Station, BARI, Shibpur, Narsingdi. The experiment consisted of three different stem cutting lengths i.e. 10, 20 and 30 cm and seven months of cutting operation started from October, 2017 to April, 2018. In the case of days to bud break, the shortest period (62 days) was required by the cutting length of 30 cm, while the longest period (72.90 days) was recorded in the cutting length of 10 cm. The longest new shoot (12.50 cm) was recorded in the cuttings of 30 cm length after 30 days of cutting operations as against minimum (8.48 cm) in the cuttings of 10 cm length. Those were the longest (42.40 cm) in the cuttings of 30 cm length after 90 days of cutting operations as against minimum (24.55 cm) length in the cuttings of 10 cm length. The longest roots were also found in 30 cm cutting (11.32 cm) after 30 days of cutting operations as against minimum (10.21 cm) roots was recorded in the cuttings of 10 cm length.

Project: Cultural Management

Growth, yield and quality of mango as influenced by fertilizer and irrigation

Influence of fertilizer and irrigation on the yield and quality of mango was studied at the Fruit Research Farm of Horticulture Research Centre, BARI, Joydebpur, Gazipur to find out the effects of fertilizer and irrigation on growth and yield of mango. Three different levels of fertilizer (100 % of the fertilizer dose (Cowdung: 25 kg; N: 230.41 g, P: 50.00 g, K: 100.00 g, S: 35.97 g, Zn: 3.60 g, B: 3.40 g), 175 % of the fertilizer dose, 250 % of the fertilizer dose) and control along with two levels of irrigation (irrigations one at flowering stage and another one at pea stage of fruit and irrigations at an interval of 10 days up to maturity of fruit) were included in the study as treatments. Number of fruit per panicle was noticed the highest at harvest time in the treatments 175 % (1.21) and 250 % (0.60) of the fertilizer dose. Control plants always exhibited minimum number of fruits per panicle and it was noticed 0.39 at harvest. Maximum number of fruits were recorded from the plants treated with 250 % of the fertilizer dose combined with irrigations at an interval of 10 days up to maturity as compared to minimum in control. Fertilizer dose at 250 %, exhibited maximum number of fruits (190.00) and yield (71.30 kg) per plant compared to minimum fruits and yield (108.30/plant and 37.95 kg/plant, respectively) in the treatment combination of no fertilizer and two irrigations one at flowering stage and another one at pea stage of fruit.

Organic production of mango

A study with three organic fertilizers i.e. vermicompost, tricocompost and cowdung along with the control (no fertilizer) was performed in order to produce safe and quality fruit at the Fruit Research Farm of Horticulture Research Centre, BARI, Gazipur. No significant variations were obseved among the treatments with respect to plant height, base girth, canopy spread (N-S, E-W), length of terminal shoot, number of leaves per terminal shoot, length of panicle and number of secondary branch per panicle. Number of fruit set per panicle on 10.03.19 was recorded maximum (27.50) in tricocompost compared to that of control (22.17). During harvest on 22.07.19, except control, all the treatments exhibited superior but identical number of fruits per panicle. Fruits of all the treatments were harvested on 22 July 2019. All the treatments resulted in higher but identical number of fruits per plant compared to minimum fruits in control. Edible portion (79.7%) and TSS (17.87%) were noticed maximum in vermicompost compared to control (73.1%). Tricocompost produced higher number of fruits (187.67), whereas vermicompost resulted in bigger fruits and higher yield (61.9 kg/plant) compared to control.

Effect of integrated fertilizer management on growth and yield of mango (Cv. Harivanga)

An experiment was conducted at Khoragach, Mithapukur, Rangpur under Regional Agricultural Research Station, Burirhat, Rangpur with a view to find out the optimum doses of organic and inorganic fertilizer. Six levels of fertilizer were used in the experiment. Fertilizer levels were T_0 (control), T_1 (cowdung 15 kg + urea 300g + TSP 150 g + MoP 50 g+zypsum50 g+$ZnSo_4$ 5 g+boron 15 g), T_2 cowdung 20 kg+urea 350 g+ TSP 200 g+MoP 100 g+zypsum 100 g+$ZnSo_4$ 10 g+boron 20 g), T_3 (cowdung 25 kg+urea 400 g+ TSP 250 g+MoP150 g+zypsum150 g+$ZnSo_4$ 15 g+boron 25 g), T_4 (cowdung 30 kg+urea 450 g+ TSP 300 g+MoP 200 g+zypsum 200 g+$ZnSo_4$ 20 g+boron 30 g) and T_5 (cowdung 35 kg+urea 500 g+ TSP 350 g+MoP 250 g+zypsum 250 g+$ZnSo_4$ 25 g+boron 35 g). Maximum number of fruits per plant (290) was obtained from T_3, which was statistically similar to that of T_5 and T_2, whereas minimum number of fruits (50) was found in T_0. The highest fruit yield (75.43 kg) per plant was recorded in T_3, which was statistically similar with T_2 and T_5, while the lowest yield of fruits (54.80 kg) was found in T_0 treatment. From the result it was observed that the highest fruit yield (75.43 kg) per plant was recorded in T_3, which was statistically similar to T_2 and T_5 treatment, while the lowest yield of fruits (54.80 kg) was found in T_0 treatment. It was the first year trial. The trial should be continued in the next year.

Development of a fertilizer management package for dragon fruit cultivation in Bangladesh

A study was carried out at Horticulture Research Center, Regional Agricultural Research Station, Jashore to develop fertilizer management package for dragon fruit cultivation in Bangladesh. Five packages with different combinations viz; P_1 (urea 217 g, TSP 500 g MoP 200 g and 2 kg Manure@ once a month), P_2 (urea 110g, TSP 250g , MoP 100g and 2 kg manure @ every 4 months), P_3 (urea 435g, TSP 1 kg, MoP 400 g and manure 10 kg every 2 months), P_4 (urea 435 g, TSP 1 kg, MoP 400 g/2 months and 5 kg manure @ every 4 months) and P_5 (urea 72 g, TSP 88 g, MoP 40 g /4 months and 20 kg manure/year) were included in the experiment. Initial soil analysis was done. Most of the parameters under study did not vary significantly among the treatments except canopy spread. However, the treatment P_3 produced the tallest plant (3.72 m) and the shortest plant was found in the treatment P2 (3.10 m). Maximum number of fruits/pillar (55) was observed in the treatment P_4 followed by the treatment P_3 (49) and lowest number of fruits was noted from P_5 (17). Individual fruit weight was found maximum (255.80 g) in the treatment P_3 and minimum (202.87 g) in P_3 .The treatment P_2 produced the fruit with the highest edible portion (72.32 %) closely followed by the treatment P_3 (70.71 %) while, minimum in P_5 (65.22 %). The highest yield (28.92 t/ha) was obtained from the treatment P_3 which was closely followed by the treatment P_4 (28.67 t/ha) and on the other hand, the lowest yield was found in the treatment P_5 (9.85 t/ha). Although, most of the parameters under study did not variy significantly among the treatments. Considering growth, yield, yield contributing characters and qualitative characters the treatments P_3 and P_1 performed better over the other treatments. However, in the first year P_1 performed better but in the second and third year P_3 performed better. Therefore, we can recommend P_3 (urea 435g, TSP 1 kg, MoP 400 g and manure 10 kg every 2 months) as fertilizer management package for dragon fruit cultivation in Jashore region.

Manipulation through grafting and pruning for dwarf shape of BARI released mango variety

A study on manipulation through grafting and pruning for dwarf shape of BARI released mango variety was conducted at RHRS, Chapai Nawabganj. The experiment was laid out in RCBD design with three replications having 4 X 5 m plant spacing. The study comprised of seven treatments. The first grafting in all the treatments was done in 29 May 2018. It was second grafting according to the treatment was done in the four treatments in 29 May 2019. Among the remaining three treatments, Cutting main stem 5 inch above grafting was done this year in the treatment T_5 while normal grafting was done in the treatment $T_1$and single grafting at the height of 5 inch was done in T_2 treatment last year.

Effect of bagging on litchi

The experiment was conducted at Regional Agricultural Research Station, Ishurdi, Pabna in

2019 to find out the effective and economic fruit bagging technology to protect fruit from insect and sunburn disorder. Five different bags viz., Brown paper bag (double layer), white bag (single layer), nylon bag (60 mesh), cloth bag and control were used in five litchi varieties such bombai, madrazi, kadmi, china-3 and BARI Litchi-4. Fruits by bagging produced quality fruit over control. Among the bags white bagging is the most economic and also effective technology. In case of variety, fruit cracking was not controlled by bagging

Study on the pollen viability of litchi during preservation

An experiment was carried out at the Pomology Division, Horticulture Research Center, BARI, Gazipur to study the pollen viability of litchi during storage. Male flowers of BARI Litchu-2 were collected at anther dehiscence stage; time between 8 and 10 a.m. Collected pollens were stored at 4 different storage conditions such as; at room temperature (25-30^{0}C) in petridish, at room temperature in desiccator, refrigerator (5-70C) and deep freeze (-20±20C). Fresh pollen showed 43.37% viability, which had 26.68% viability after 7 days of storage in petridish. After 7 days of storage, 31.43% viable pollen was noticed when pollen was stored in desiccator at ambient temperature. Pollen viability under refrigerated condition lasted up to 60 days and it was observed 23.18%. At deep freeze (-20±20C) condition, pollen remained viable up to 60 days, which was 32.02%. Pollen viability was tested through in-vitro germination for all the storage conditions. Pollen stored in Deep freeze remained viable up to 60 days, which exhibited 29.84% germination at the same condition. Pollen viability and in-vitro germination were investigated in this study. Maximum pollen viability was recorded from the fresh sample. Duration of pollen viability was obtained up to 60 days when pollen kept in refrigerator. Pollen viability was tested by in-vitro germination for all the storage conditions and pollens stored in deep freeze condition exhibited higher percentage of germination, which remained viable up to 90 days. In this study, second year observation is going on and more trial is required for final recommendation.

Effect of foliar application of zinc on growth, yield and fruit quality of Guava (*Psidium guajava* L.)

An experiment to find out the optimum level of zinc for better growth, yield and fruit quality of guava and to increase fertilizer uptake was performed at the fruit research field of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. BARI Guava-2 was used as variety in the experiment. The experiment was laid out in a randomized complete block design with 3 replications. Six treatments were considered in the study with different levels of Zn as T_1: Control- no ZnSO4 solution, T_2: 0.30% ZnSO4 solution, T_3: 0.40% ZnSO4 solution,T_4: 0.50% ZnSO4 solution,T_5: 0.60% ZnSO4 solution,T_6: 0.70% ZnSO4 solution. In winter season, plant growth in terms of number of leaf per branch (29), length of leaf (12.06 cm), width of leaf (6.37 cm), length of shoot (52.28 cm) and shoot diameter (0.55 cm) was recorded maximum in plant, which were treated with 0.50% ZnSO4 solution and minimum number was noted from the control (no ZnSO4 solution). The highest fruit yield (28.73 kg plant-^{1}) due to the highest individual fruit weight (393.16 g) and maximum number of fruits per plant (73) was found in the treatment T_4 (0.50% ZnSO4 solution) and it was followed by T_5 and T_6 treatments. The lowest fruit yield was observed in T_1 (Control- no ZnSO4 solution) (15.77 kg plant-^{1}). Maximum TSS (%) was noted from the treatment T_4 (10.53) and the minimum TSS (%) was recorded in T_1 (9.30). The highest increase in terms of all the growth parameters of BARI Guava-2 over control was noted from the treatment T_4 (0.50% ZnSO4 solution). Foliar spraying of Zn might increase plant growth as well as yield and quality of guava.The experiment should be continued in the next year for further evaluation.

Effect of day-length enhancement and night-breaking by artificial lighting on off season fruit production of dragon fruit in Bangladesh

Effect of day-length enhancement and night-breaking by artificial lighting on dragon fruit were studied for off season fruit production at the research field of Regional Horticulture Research Station, BARI, Shibpur, Narsingdi. BARI Dragon fruit-1 was used in this experiment. The day length

prolongation was done by supplemental lighting from 4:00 p.m. to 10:00 p.m. and the night-breaking from 10:00 p.m. to 2:00 a.m. by different artificial lighting. No additional light was used at untreated control plant. Fast flower bud became visible at 03-03-2018 and fruit was harvested at 01-05-2018 in dragon fruit plants under artificial day length enhancement. In control plants fast flower buds became visible at normal flowering time which was 22-05-2018 and fruit was harvested at 03-07-2018. Minimum days to first flower bud opening from light application were observed in day length enhancement (123 days) while it was maximum in control (203 days). During off season formation of flower buds, bloom of flowers and harvest of fruit was done in the plants under artificial lightning. While plants under untreated control failed to produce any flower buds and fruits during the off season.

Standardization of pot culture method for BARI Komala-1

The experiment was initiated at the Citrus Research Station, BARI, Jaintapur, Sylhet on March 2016. One year old BARI Komala-1 grafts were used for the study. The experiment comprises of three pot size (14", 16", 18" diameter) and four potting media (a. Soil:FYM=3:1; b. Soil:FYM=1:1; c. Soil:FYM:Ash=1:1:1 and d. Soil:FYM:Coir pith=1:1:1). Fifty gram of TSP and ten gram of gypsum were added in every pot. The highest plant height (180.00 cm) was recorded in T_{12} (18" tub filled with Soil:FYM:Coir pith=1:1:1) whereas the lowest (88.33 cm) plant height was recorded in T_{11} (16" tub filled with Soil:FYM:Coir pith=1:1:1). The highest fruit weight (199.37 g) was found in T_{12} while the smallest fruit (132.32 g) was noticed in T_1. Maximum yield per plant (4.78 kg) was found in $T_{12,}$ whereas minimum (1.73 kg) yield was obseved in T_2. Maximum edible portion (79.43%) was recorded in T_9 and per cent total soluble solids (TSS) were recorded the highest (12.4%) in $T_{5.}$ From the study, T_{12} (18" tub filled with Soil:FYM:Coir pith=1:1:1) has been appeared as the best treatment in terms of fruit quality and quantitative characteristics.

Standardization of pot culture method for BARI Malta-1

The experiment was initiated at the Citrus Research Station, BARI, Jaintapur, Sylhet on March 2016. One year old BARI Malta-1 graftages were used for the study. The experiment comprising three pot size (14", 16", 18" diameter) and four potting media (a. Soil:FYM=3:1; b. Soil:FYM=1:1; c. Soil:FYM:Ash=1:1:1 & d. Soil:FYM:Coir pith = 1:1:1). Fifty gram of TSP and ten g of Gypsum were added in every pot. The highest plant height (151.66 cm) recorded in T_{11} (16" tub filled with Soil:FYM:Coir pith=1:1:1) whereas lowest (89.66 cm) in T_1 (14" tub filled with Soil:FYM=3:1). Number of fruits per plant (28) and yield per plant (4.23 kg) were recorded maximum in $T_{12.}$ Edible portion was recorded maximum (72.4%) and per cent total soluble solids (TSS) were recorded the highest (12.6%) in T_{12}. The treatment T_{12} (18" tub filled with Soil:FYM:Coir pith=1:1:1) was appeared as the best one in terms of fruit quality and quantitative characteristics.

To standardize the fertilizer dose for dragon fruit in Bangladesh

Effect of fertilizer and irrigation on the yield and quality of dragon fruit was studied at the Regional Horticulture Research Station, BARI, Shibpur, Narsingdi. Four doses of fertilizers i.e. 100 % (540 g N, 315 g P, 250 g K) ,150 %, 200 %, 250% and control (no fertilizer) along with four types of split application i.e. S1: six months interval, S2: four months interval, S3: three months interval and S4: two months interval. Each pit (pillar) was fertilized additionally with 75 kg FYM, 450 g gypsum, 100 g borax and 50 g ZnSO4 per year was included in the study as treatment. It was observed that higher doses of fertilizers had positive effect on the plant growth and reproductive behaviour compared to control (no fertilizer). Considering growth, flowering and fruiting the plants treated with 250 % of the fertilizer dose applied in three to four split applications exhibited superior result.

Performance of fruit bagging on different mango varieties grown at sylhet region

Strawberry (*Fragaria x annanassa* Duch.) is responsive to micronutrient like zinc (Zn) and boron (B) fertilizers. An experiment on strawberry was conducted in the fruit research field of Horticulture Research Centre, BARI, Gazipur to evaluate the effect of boron (B) and zinc (Zn) on yield, yield attributes and quality of strawberry. Sixteen treatment combinations were tested in this trial comprising four levels each of B (0, 1, 2 and

3 kg ha^{-1}) and Zn (0, 2, 3 and 4 kg ha^{-1}) with blanket dose of $N_{115}P_{40}K_{110}S_{25}$ kg ha^{-1} and 5t cowdung ha^{-1}. The experiment was set up in a split-plot design with three replications. Results showed that treatment combination of T_{11}= B_2Zn_3 (under scriptrepresent kg ha^{-1}) produced the highest strawberry fruit yield (15.8 t ha^{-1}) followed by Zn_2B_4 treatment. The lowest fruit yield (9.36 t ha^{-1}) was found in control (Zn_0B_0) treatment. The highest plant height, maximum mean number of fruits per plant, highest fruit length and diameter were recorded from the same (T_{11}) treatment. The highest TSS (^{0}Brix7.10) was also recorded from the same (T_{11}) treatment. The combined application of Zn and B was superior to single application. Hence, the results recommend that combined application of B and Zn @ of 2 and 3 kg ha^{-1}, respectively along with blanket fertilizers of $N_{115}P_{40}K_{110}S_{25}$ kg ha^{-1} can support to get higher yields of strawberry in terrace soils of Bangladesh.

Effect of bagging on the fruit quality of litchi

Different bagging materials (perforated polythene bag, brown paper bag, net bag) were evaluated at RARS, Akbarpur for the control of litchi fruit borer infestation in the variety BARI Litchu-2. All the bagging materials gave protection against the fruit borer infestation over unbagged control fruits. The maximum pulp weight (11.25 g) and the highest percentage of TSS (17.62%) were found in the treatment where litchi fruits were bagged with brown paper bag. Considering the fruit borer infestation, weight of fruit, length of fruit, pulp weight, % TSS among the three bagging techniques, bagging of litchi fruits with brown paper bag was effective for the control of litchi fruit borer. This is second year of experiment. It needs to be continued for further confirmation of the results

Management practices to overcome fruit cracking of mango cv. Bari Aam-3

An experiment on management practices to overcome fruit cracking was conducted at the Regional Agricultural Research Station, BARI, Akbarpur, Moulvibazar for producing quality mango of BARI Aam-3 variety. Five treatments were included in this study such as T_1: spraying with boron two times; T_2: Use of black plastic mulch; T_3-Spraying with boron two times and use black plastic mulch, T_4 : T_3+fruit bagging and T_5: control (Normal management practices). Mangoes are susceptible to different insect-pest and diseases. In this experiment, BARI Aam-3 was selected in order to produce quality mango fruits. Balanced fertilizers were used in the month of July and black plastic mulch was used in the month of April. Finally, the mango fruits were bagged on 50 days after fruit set. In this experiment, the highest fruit cracking (40.74 percent) was recorded from control treatment and the lowest cracking was noted from T_4 (17.64 percent) treatment. Anthracnose infection was recorded the highest (62 percent) from T_5 and the lowest (8 percent) infection was demonstrated by T_4. The highest (22%) TSS was recorded from T_3 and T_4 as against the lowest (21%) TSS in T_1, T_2 and T_5. From the experimental results, it is concluded that treatment T_4 performed the best considering fruit cracking results, insect infestation, anthracnose infection, qualitative parameters and quantitative characters. This is the first-year experiment. It will be continued next two years for final conclusion.

Effect of split application of fertilizer on the harvesting time, yield and quality of ber

The study was carried out at the HRC Fruit Orchard, RARS, Jamalpur. The treatments were: Factor-A: fertilizer dose: F_1: Recommended dose(1222 g Urea, 1000g TSP,1000g MOP, 281 g gypsum,15 g boron and 30 Kg cowdung), F_2: 150% of the recommended dose and F_3:200% of the recommended dose; Factor-B: split application of fertilizer: S_1: Total amount of fertilizer in one installment (at vegetative stage), S_2: Total amount of fertilizer in two installments (at vegetative stage + just after fruit set) and S_3:Total amount of fertilizer in three installments (at vegetative stage + just after fruit set+1 month after fruit set) and Factor-C: Variety: V_1: BARI Kul-1 and V_2: BARI Kul-2. A wide range of variations was observed in the treatments and treatment combinations in terms of parameters studied. Considering yield contributing characters and yield of ber, 200% of the recommended dose produced the highest yield (30.35 kg/plant). On the other hand, considering yield contributing characters and yield of ber, total amount of fertilizer in two installments (at vegetative stage + just after fruit set) produced the highest yield (37.56 kg/plant). On the basis of variety, considering yield contributing characters

and yield of ber, BARI Kul-2 produced the highest yield (41.28 kg/plant). In consideration of combined effect of fertilizer dose, split application of fertilizer and variety in terms of the plant characters, yield contributing characters and yield of ber, 200% of the recommended dose, total amount of fertilizer in two installments (at vegetative stage + just after fruit set) and BARI Kul-2 produced the highest yield (69.05 kg/plant). In consideration of combined effect of fertilizer dose, split application of fertilizer and variety in terms of the plant characters, yield contributing characters and yield of ber, 150% of the recommended dose, total amount of fertilizer in two installments (at vegetative stage + just after fruit set) and BARI Kul-1 produced the highest yield (34.75 kg/plant).

Development of fertilizer management package for dragon fruit cultivation in Bangladesh

An experiment was conducted at the Horticulture Research Centre, Regional Agricultural Research Station, Jamalpur to develop a fertilizer management package for Dragon fruit (*Hylocereus* spp) cultivation in Bangladesh. BARI Dragon fruit-1 variety was used in the experiment. Two plants per pillar were transplanted in April, 2014 maintaining 2.0 x 2.0 m spacing. The experiment comprising five treatments of the following doses of fertilizers: Package-1: Urea:100g/month, TSP:100g/month, MoP: 100g/month and 2kg Manure/month; Package-2: Urea: 50 g/4 months, TSP: 50 g/4 months, MoP: 50 g/4 months and 2kg manure/4 months; Package-3: Urea: 200 g/2 months, TSP: 200 g/2 months, MoP: 200g/2 months; Package-4: Urea: 200 g/2 months, TSP: 200 g/2 months, MoP: 200 g/2 months and 5kg manure/4 months and Package-5: Urea: 100 g/4 months, TSP : 100 g/4 months, MoP: 50 g/4 months and 15 kg manure/year. The results revealed that there were significant differences in all the parameters under study except days to first flowering among the treatments as influenced by different fertilizer packages. The tallest plant (272 cm) was observed in T_1 treatment. The highest number of fruits per plant (15.63) was noted in T_4 treatment. The biggest fruit (205 g) was observed in the T_4 treatment. The longest fruit (9.08 cm) was observed in treatment T_4. The highest TSS (13.87%) was recorded in T2 treatment. Maximum edible portion (58%) was observed in T_2. Minimum edible portion (50 %) was found in T_4. The highest fruit yield (3.21 kg per plant) was observed in treatment T_4 .On the other hand, the lowest fruit yield (1.75 kg/plant) was found in (T_2) treatment. The results revealed that application of fertilizers according to; Package-4: Urea: 200 g/2 months, TSP: 200 g/2 months, MoP: 200 g/2 months and 5 kg manure/4 months would be optimum for higher yield of dragon fruit in Bangladesh. So, the experiment will be continued in the next year for the confirmation of the result.

Project: Soil and water management

Effect of boron and zinc application on yield attributes, yield and quality of strawberry

Strawberry (*Fragaria X annanassa* Duch.) is responsive to micronutrients like zinc (Zn) and boron (B) fertilizers. An experiment on strawberry was conducted in the fruit research field of Horticulture Research Centre, BARI, Gazipur to evaluate the effect of boron (B) and zinc (Zn) on yield, yield attributes and quality of strawberry. Sixteen treatment combinations were tested in this trial comprising four levels each of B (0, 1, 2 and 3 kg ha-1) and Zn (0, 2, 3 and 4 kg ha-1) with blanket dose of $N_{115}P_{40}K_{110}S_{25}$ kg ha-^{1} and 5 t cowdung ha-^{1}. The experiment was set up in a split-plot design with three replications. Results showed that treatment combination of T_{11}: B_2Zn_3 (under script represents kg ha-^{1}) produced the highest strawberry fruit yield (15.8 t ha-1) followed by Zn_2B_4 treatment. The lowest fruit yield (9.36 t ha-1) was found in control (Zn0B0) treatment. The highest plant height, maximum mean number of fruits per plant, the highest fruit length and diameter were recorded from the same (T_{11}) treatment. The highest TSS (^{0}Brix 7.10) also recorded from the same (T_{11}) treatment. The combined application of Zn and B was superior to single application. *Hence,* the *results recommended that* combined application of B and Zn @ of 2 and 3 kg ha-^{1}, respectively along with blanket fertilizers of $N_{115}P_{40}K_{110}S_{25}$ kg ha-^{1} can *support to get* higher yield*s* of strawberry in terrace soils of Bangladesh.

Project: Insect Pest Management

Suceptibility of different litchi varieties to litchi mite (*Aceria litchi* keifer)

An experiment was conducted at the Fruit research station, BARI, Binodpur, Rajshahi on nine varieties/cultivars of litchi viz; Bombai, BARI Litchi-1, China-3, Bedena, Dinajpuri, Mojaffarpuri, Green, Madrajee, and BAU Litchi-1 on the incident of litchi mite (*Aceria litchi*), its extent of damage to litchi leaves and inflorescence. The highest infestation of 22.34% in leaves was recorded in Bombai variety, which was identical to Bedena, BAU Litchi-1, BARI Litchi-1, Madrajee, Green, China-3 and followed by Mojaffarpuri and the lowest 12.26% infestation was found in Dinajpuri. Among the tested varieties almost all the varieties/cultivars were susceptible to litchi mite. But Dinajpuri variety exhibited the lowest infestation (12.26%).

Efficacy of different control measures against litchi mite (*Aceria litchi*keifer)

The experiment was conducted at the Fruit research station, Binodpur, Rajshahi to know Litchi mite (*Aceria litchi*), its extent of damage to litchi leaves and inflorescence and the effectiveness of different management practices for controlling litchi mite. To control the litchi mite, there were five treatments such as T_1: Two pruning of infested foliage 1st on June after harvesting fruits and 2nd on August + Spraying of Abamectin 1.8 EC (Vertimec 1.8 EC @ 1.5 ml /l of water in February before opening flower). T_2: Two pruning of infested foliage 1st on June after harvesting fruits and 2nd on August + Spraying of wettable Sulphur (Thiovit 80 WP @ 2 g/l of water in February before opening flower). T_3 : Two pruning of infested foliage 1st on June after harvesting fruits and 2nd on August + Spraying of Dimethoate 40 EC (Tafgor 40 EC @ 2 ml/l of water in February before opening flower). T_4 : Two pruning of infested foliage 1st on june after harvesting fruits and 2nd on August, T_5 : Untreated control, Among all the treatments, T_1 : pruning of infested foliage + one spray of Abamectin 1.8 EC (Vertimec 1.8 EC @ 1.5ml /liter of water) resulted in the lowest leaf infestation (4.01%) and showed 86.38% infestation reduction over control. Whereas, the highest leaf infestation (29.46%) was observed in T_5 (Untreated control). Leaf infestation ranged from 6.98–10.98% in other treatments. In case of per cent infested inflorescence the lowest infested inflorescence (2.88%) was also observed in T_1 treated plant with 68.42% infestation reduction over control followed by T_2 (3.02%) and T_3 (3.65%). The highest value in per cent infestation of inflorescence was recorded in T_5 (9.12%). The MBCR was noted the highest in T_1 (5.75) followed by T_4 (3.40) and T_2 (3.25) over control. All the varieties are susceptible to litchi mite. Pruning of mite infested leaf and inflorescence as well as spraying of Abamectin might be promising in controlling litchi mite. The highest MBCR 5.75 was found in T_1 (Prunning + Vertimec spray). However further investigation is needed for final conclusion.

Efficacy of different types of bagging for management of oriental fruit fly (*Bactrocera dorsalis)* attacking guava

A research work on the fruit fly (*Bactrocera dorsalis*) of guava was conducted at the Fruit Research Station, BARI, Binodpur, Rajshahi to know incidence, nature and extent of damage and effect of different control measures. There were 5 treatments viz T_1 : Bagging by polythene bag (Perforated), T_2 : Bagging by butter paper bag (Perforated), T_3 : Bagging by brown paper bag (Perforated), T_4 : Bagging by mosquito net and T_5 : Control (untreated) against guava fruit fly to evaluate their effectiveness. The per cent infestation was recorded the highest (81.23%) in the untreated control. The least zero percent infestation was found in plant treated by all type of bagging except bagging by mosquito net which caused 40.68% infestation. To control the guava fruit fly, all types of bagging showed good result with 100% infestation reduction over control except bagging by mosquito net showed 49.91% reduction. The highest MBCR (5.6) was observed in T_1 followed by the treatments T_2 (3.8) and T_3 (3.8). All types of bagging except bagging by mosquito net were noticed to be very effective. The highest MBCR 5.6 was manifested in T_1 (Bagging by polythene bag).

Efficacy of different types of baggs for management of mango fruit fly (*Bactrocera dorsalis*) attacking mango

A research work on the fruit fly (*Bactrocera dorsalis*) of mango was conducted at the Fruit

Research Station, BARI, Binodpur, Rajshahi to know the incidence, nature and extent of damage and effect of different control measures. There were 8 treatments viz T_1: Bagging by polythen bag (perforated), T_2 : Bagging by butter paper bag (Perforated), T_3 : Bagging by brown paper bag (Perforated), T_4 : Bagging by mosquito net, T_5 : Bagging by mosquito net (Bag banded by Bokrom), T6 : Bagging by China brown paper bag, T_7 : Bagging by China white paper bag and T_8 : Untreated control against mango fruit fly to evaluate their effectiveness. All types of bagging showed 0 % infestation except bagging by mosquito net which caused 24.82% infestation, on the other hand the highest 61.12% infestation was found in untreated control. Except bagging by mosquito net (59.39%), all other bagging performed the best result with 100% reduction of fruit infestation. Bagging by polythene bag showed the highest MBCR (1.9). All types of bagging except bagging by mosquito net found very effective. The highest MBCR 1.9 was found in T_1 (Bagging by polythene bag). However further investigation is needed to have the final coclusion.

Survey and documentation of different insect pollinators/ visitors in different fruit crops during flowering period

The present study deals with the pollinators on selected fruit crops like, wax jambu, wood apple, longan, pummelo, phalsa, ber, olive, hog plum/ golden apple and guava. In Wax Jambu, the average population was the highest (2.98) of Honey bee in decreasing order of Syrphid fly (0.79) and Flower fly (0.62). In Wood apples, the average population was the highest (3.21) of Honey bee in decreasing order of Flower fly (2.24) and Syrphid fly (1.06). In Longan, the average population was the highest (4.87) of Honey bee in decreasing order of Flower fly (2.89), Syrphid fly (0.92), Blow fly (0.85) and House fly (0.41). In Pummelo, the average population was the highest (2.11) of Honey bee in decreasing order of Carpenter bee (1.02) and Syrphid fly (0.98). In Phalsa, the average population was the highest (1.43) of Honey bee in decreasing order of Sawfly (0.92), Flower fly (0.60) and Carpenter bee (0.47). In Ber, the average population was the highest (3.10) of wasp in decreasing order of Honey bee (2.04), Flower fly (0.92), Blow fly (0.81) and House fly (0.62). In Olive, the average population was the highest (9.92) of Flower fly in decreasing order of Blow fly (5.64), House fly (1.24), Honey bee (1.02) and Wasp (0.52). In Hog plum, the average population was the highest (1.05) of Flower fly in decreasing order of Syrphid fly (0.87). In Guava, the average population was the highest (1.12) of Flower fly, in decreasing order of Honey bee (1.02), Blow fly (0.81), House fly (0.67) and Carpenter bee (0.23). Nine fruit crops were observed and two to five types of pollinators/visitors were found for each crops.

Development of management approach against litchi fruit borer *(Conopomorpha sinensis)*

Two separate experiments were conducted at the Fruit Research Station, BARI, Rajshahi to select fruit borer (*Conopomorpha sinensis*) tolerant litchi variety and to develop cost effective guidelines for managing this pest during 2018-2019. For litchi varietal susceptibility test, trees of three common cultivated varieties *viz*. BARI Litchi 1, Bombai and China 3 with five replications were opened for fruit borer infestation up to harvest and were kept without any chemical treatment. Besides, for litchi fruit borer management, six treatment packages including untreated control were undertaken in RCBD design with three replications. Treatment packages were such as **T_1:** Netting of whole tree with mosari net starting from pea stage; **T_2:**Netting of whole tree with mosari net starting from marble stage; **T_3:** Sanitation + Three sprays: 1st with Imidacloprid @1ml/L at pea stage, 2nd and 3rd with Spinosad (Success 2.5 EC) @1.2 ml/L at marble and early ripening stage; **T_4:** Sanitation + Three sprays: 1st with Emamectin benzoate (Heclaim 5% SG) @1g/L at pea stage, 2nd and 3rd with Lufenuron (Heron 5 EC) @1ml/L at marble and early ripening stage; **T_5:** Sanitation + Three spray of Emamectin benzoate (Heclaim 5% SG) @1g/L at pea, marble and early ripening stage and **T_6:** Untreated control. Least borer infestation was observed in China 2 variety. Netting the whole plant with mosari net starting from pea stage performed better results which reduced 89% and 95% borer infestation at developing and ripening stage, respectively over control followed by three sprays: 1st with Imidacloprid @1ml/L at pea stage, 2nd and 3rd with Spinosad (Success 2.5 EC) @1.2 ml/L at marble and early ripening stage including sanitation. Farmers may follow any of the tow guidelines for managing litchi fruit borer: # Netting

the whole plant with mosari net starting from pea stage; or #Three sprays: 1st with Imidacloprid @1ml/L at pea stage, 2nd and 3rd with Spinosad (Success 2.5 EC) @1.2 ml/L at marble and early ripening stage including sanitation.

Project: Disease Management

Survey and collection of pathogen isolates of panama disease of banana

In Bangladesh, the most common and widely damaging disease of banana is panama caused by *Fusarium oxysporum* f. sp. *cubense* (FOC). The survey area was covered at Bogra, Rangpur, Faridpur, Jessore and Comilla only with the objectives to collect the isolates, purify and preservation of the panama causing fungus for characterization in banana production. Panama disease was found in the every area surveyed. Incidence of panama disease ranged from 5 to 90%. The highest disease incidence (90%) was found in Chapa at Chupinagar, Shahjahanpur, Bogra ($24^0$77'04"N,$89^0$50'45"E) and the lowest disease incidence (5%) was recorded in Sabri/Anupom and Plantain varieties at Gabtoli, Bogra ($24^0$51' 54.061"N, $89^0$24' 57.306"E). In case of Chapa, the disease incidence ranged from 20 to 90% and in Sabri from 5 to 60%. The infected roots investigated and the pathogen was identified. Isolates of *Fusarium oxysporum* f. sp. *cubense* were isolated, purified, stored in slants and refrigerated. This information will be needed for further study by using molecular tools.

Identification of post harvest diseases of fruits and vegetable

Disease samples of capsicum, brinjal, tomato, cauliflower, cucumber, country bean, banana, straw berry, beal, grape and orange were collected from vegetable and fruit research field of Horticulture research centre, BARI, Gazipur. Disease symptoms appeared on fruits. *Fusarium* sp. & *Alternaria* sp. were identified from capsicum; *Fusarium* sp., *Alternaria* sp. & *Diplodia* sp from brinjal; *Chladosporium* sp., *Odiodendron* sp, *Candida* sp. & *Alternaria* sp. from cauliflower; *Fusarium sp.* from cucumber; *Colletotrichum* sp. from country bean, *Fusarium sp.,Chladosporium* sp & *Colletotrichum* sp. from banana; *Fusarium sp.*, *Chladosporium* sp, *Pestalotia* sp. & *Aspergillus* sp. & *Penicillium* sp. *Rhizopus* sp. from straw berry and *Fusarium* sp., *Chladosporium* sp. & *Diplodia* sp., *Aspergillus sp.*, *Penecilium sp.* from grape and orange. *Fusarium* sp., *Alternaria* sp., *Diplodia* sp., *Chladosporium* sp., *Odiodendron* sp, *Candida* sp., *Colletotrichum* sp., *Rhizopus* sp., *Aspergillus sp.*and *Penecilium sp.*were identified from vegetables and fruits. However the study was in 2nd year. Further study is necessary confirming the result.

Management of gummosis disease of citrus

The experiment was conducted with Colombo lebu at datergaon, Shibpur, Norsingdi. The experiment was laid out randomized complete block design with three replications. Eight to ten years aged, 15 disease infected plants were selected for the experiment and one tree was considered one replication. Treatments were (i) Tricho-compost + Bordeaux paste, (ii) Tricho-compost + Bordeaux mixture, (iii) Tricho-compost + Secure, (iv) Tricho-compost + Coalter and (v) control. Tricho-compost @ 1 kg/plant was applied in root zone of the plant. All the treatments ruduced the length and diameter of lesion but remarkable reduction was observed after thrice application of Tricho-compost + Bordeaux paste and Tricho-compost + Coalter treatment. The length reduced about 46.95 to 50.93% and diameter reduced about 20.56 to 26.11%, respectively in Tricho-compost + Bordeaux paste and Tricho-compost + Coalter treatments after three applications. Tricho-compost + Bordeaux paste and Tricho-compost + Coalter gave good results among the treatments.

Project: Post-harvest Management

Characterization of oils extracted from the pulp of avocado fruits

A sutudy was carried out at the Fruit Research Farm of Horticulture Research Center, BARI, Gazipur to evaluate the avocado germplasm. Two germplasm was evaluated in this study. TSS%, pH value, Vitamin-C, Total sugar and β-carotene content of avocado were studied. The oil, the principal constituent of the pulp was in concentration of 20-21% in the studied avocado sample, BARI Avocado-1 contained the saturated fatty acid of 34.83% and the unsaturated fatty acid of 65.15%. BARI Avocado-1 produced highest β-

carotene (54.29 µg/100g) and TSS value (11.40%). Vitamin C content also two folds higher (7.06 mg/100g) than the accession PA-Joy-001 (3.53 mg/100g).

Effect of edible coating on storage life and quality of strawberry

An experiment was conducted on fresh cut processing technique of strawberry in Postharvest Laboratory of Horticulture Research Centre, BARI, Gazipur. The study was conducted with the financial assistance of NATP-2 CRG. Strawberry was selected based on uniformity of size, the absence of physical damage and fungal infection, and >80% of the surface showing red colour. All used utensils were washed with sanitizers (200 ppm sodium hypochlorite). After wearing apron, hand gloves, cap and musk, strawberries (Fragaria x ananassaDuch.) were coated with (a) 1.5% chitosan solution; (b) 1.5% chitosan+1% $CaCl_2$ solution; (c) Aloe vera gel; and (d) Aloe vera gel+1% $CaCl_2$ and (e) control strawberry was washed with tap water. Surface coating and water was air dried. Treated strawberries were kept into polypropylene box and stored at refrigerator (4±1°C and 50±5% RH). The effectiveness of the treatments in extending fruit shelf-life was evaluated by determining respiration rate, firmness, weight loss, external colour, some chemical parameters (ascorbic acid content, TSS, total sugar reducing sugar, acidity and P^H) total bacterial count (TBC) and sensory quality. Initial TBC of strawberry was 2.11 log CFU/g. After coating and storage in refrigerator, it was lowered slightly and then it was increased during storage. The highest amount (8.13 log cfu/g) of TBC was observed in control strawberry while it was only 3.10 log cfu/g in strawberry coated with AV gel+$CaCl_2$ at 9th day of storage. However, TBC in all coated strawberry was below maximum acceptable contamination values but it was higher in control strawberry at 9th day of storage. At 7th day of storage, in case of overall acceptability, control/uncoated strawberry secured 4.4 scores that indicate unacceptable by the consumer's preference, while more than 5 scores were obtained by all type of coated strawberry. However, strawberry coated with Aloe vera gel with or without $CaCl_2$ obtained 5.5 scores whereas the rest of the coated strawberry scored less than 4.5 at 9th day of storage in case of overall acceptability.

Effect of packaging on the shelf life of jamun fruit (S*yzygium cumini)*

An experiment was conducted on shelf life extension of jamun fruit (*Syzygium cumini)* through packaging in postharvest laboratory of Postharvest Technology Section, Horticulture Research Centre, BARI, Gazipur. Fresh bright purple coloured firm jamun fruits, free from blemishes, apparent disease, insect and mechanical damage were first hydro-cooled for 60s using normal tap water and kept on perforated plastic basket to remove surface water. Air cooling helped in surface drying as well as prepared the fruit for further experimentation. The fruit were packaged in different packaging such as 1% perforated polythene, non-perforated polythene, paper bag, pp box with cling wrap and in open condition and kept in room temperature. The effectiveness of the treatments was evaluated by determining total acidity, vitamin C, total sugar, fruit rotten % and sensory quality (colour, flavor, taste, total acceptance, freshness, marketability and consumer preference). Shelf life of jamun fruit was depended on the nutritional quality and sensory attributes. In all quality parameters, pp box with cling wrap performed better and was suitable for packaging of jamun fruit with 5 days of storage life at ambient condition.

Collection and evaluation of tuberose (*Polianthes tuberose* L.) genotypes

Six tuberose genotypes with BARI Tuberose-1 as check variety were evaluated at the Floriculture Research Field of HRC, BARI, Gazipur during 2018-2019 to know the variability in tuberose genotypes. A wide variation was exhibited in the qualitative parameters like flower type, bud and petal colour, floret arrangement on spike and fragrance. The genotype TR-001, TR-004 and TR-005 produced heavy scented flowers. The quantitative data revealed that, BARI Tuberose-1 required minimum days (17.2) to reach 50% germination of bulbs and also to reach 50% spike initiation (89.7 days). TR-001 produced the longest spike (87.5 cm). The longest rachis (43.2cm) and the maximum number of florets/spike (48.3) were recorded by TR-004. The maximum number of flower sticks/ha (2, 65,000 sticks) were recorded in TR-003. The largest (3.5 cm) and the heaviest bulbs (32.0 g) were recorded by TR-001. BARI Tuberose-1 remained fresh for the longest time (14.8 days) in the field and also in the vase (7.2 days). The highest percentage of florets (67.5%) was opened by the genotype TR-004.

Collection and evaluation of aster genotypes

A study on the performance of five aster genotypes was conducted at Floriculture Field of HRC, BARI, Gazipur during 2018-2019. Marked variations for all qualitative and quantitative characters were observed. Based on flower colour, flower number, flower size and durability of flower, the genotypes A-001 and A-004 were identified as good genotype.

Collection and maintenance of rose

Rose belongs to the family Rosaceae, is one of the natures beautiful creations and is universally known as the Queen of Flowers. Rose is a symbol of love, adoration and innocence. It may be used for planting in beds, borders, as ground covers, growing in pots and for cut flower production. Roses are also grown for their multiple uses like production of petals, extraction of perfumes, for medicinal uses and for sale as cut flowers. At present, it has become the most important commercial flower. It can be grown in Bangladesh for easy cultivation and wider adaptability. Therefore, ten genotypes were collected and maintained at the Floriculture Farm of HRC, BARI, Gazipur and RARS, Jashore. Variation was observed among genotypes in respect of vegetative and floral trials.

Collectionand maintenance of cactus

Cactus belongs to the family *Cactaceae* and it is suitable for growing in pots for indoor decoration. Cactus cultivation has become a fascinating hobby among amateur gardeners and these desert plants which are mostly unknown have become the subject of greatest care and delicate handling. Despite of their numerous thorns and spines, they have a beauty of their own. Their hardy nature and easy cultivation in shallow soils are additional features for their popularity. Therefore, a study on the performance of twenty threecactus genotypes were collected and maintained at Floriculture Field of HRC, BARI, Gazipur. Wide variation in respect of vegetative and floral traits was observed. Among the genotypes, Cac-011 exhibited distinctly large flower than the others. Flower durability varied from 2.0 to 6.0 days. The genotypes Cac-015 and Cac-016 produced higher number (14.0 and 12.0 respectively) of flower whereas Cac-008 produced lowest number of flower (2.0).

Collection and maintenance of succulents

Succulents are the xerophytic plants and members of the family Agavaceae, Euphorbiaceae Crassulaceae and Liliaceae etc. with swollen fleshy parts, curious forms, diversity of shape and colour. They can store water to survive in the drought condition. Succulent cultivation has become a fascinating hobby among amateur gardeners and

these desert plants which are mostly unknown have become the subject of greatest care and delicate handling.Their soft nature and easy cultivation in shallow soils are additional features for their popularity. Seventeen lines of succulents were collected and maintainedat Floriculture Division, Horticulture Research Centre, BARI during 2018-19for decorative and commercial purposes.

Collection and maintenance of carnation genotypes

Carnation (*Dianthus caryophyllus* L.), a member of family Caryophyllaceae is one of the leading cut flower crops in the world florist trade and ranks with in top ten cut flower of the world. It is half hardy perennial with branching stems and timid joint, leaves are linear, glaucous, in opposite or decussate pairs. It grows in all over as cut or bed flowers. Due to variation of colour, long flower stalk and shape, as well as it's long distance transportation and remarkable ability to rehydration during export it has made a world demand in flower industry. In Bangladesh, the agro-ecological conditions are conducive to the survival and culture of carnation. Bangladeshi farmers cultivate a number of flower crops that do not give them high return. Carnation was introduced to Bangladesh recently and it is gaining popularity. It has great a potential for local as well as export market. Four genotypes of carnation were collected and maintained at Floriculture Division, Horticulture Research Centre, BARI during 2018-19. Significant variations on different qualitative and quantitative parameters were observed among the genotypes under study.

Collection, evaluation and maintenance of lilium

Lilium is a perennial ornamental crop belongs to Liliaceae family. They grow in border, beds, pots and are excellent cut flowers of magnificent appearance and beautiful colours. This lucrative flower has recently been introduced in Bangladesh due to its high demand and profitability. Lilium genotypes showed wide variation in all qualitative and quantitative parameters studied. Among the collected liliumgermplasm, 28 attractive coloured and two types of flowers *viz*. Asiatic lilium and Oriental lilium have been found. Among them 14 germplasm are suitable for cut flower and 5 are suitable for pot culture. Regarding fragrance, Oriental type lilium produced strong scented flowers whereas Asiatic types have no fragrance. The longest stalk and rachis (80.0 cm and 26.0 cm, respectively) and also the maximum number of florets/stick (10.5) were produced by the genotype Lil-001. The maximum vase life was observed in Lil-007 and Lil-010 (12.0 days) whereas the minimum in Lil-016 and Lil-019 (6.0 days). The heaviest stalk and the heaviest bulb (60 g and 6.1 cm, respectively) were produced by the genotypes Lil-007.

Studies on variabilities of local dendrobium orchids

An investigation was carried out to find variability and identify morphological characteristics of 15 local Dendrobium orchid germplasm at the Orchidarium of Floriculture Division, HRC, BARI at Joydebpur, Gazipur. The results indicated the existence of wide variability among the genotypes on their physio-morphological characters along with yield and yield attributes. Considering flower colour, flower size, flower number and flower durability, D-001(*D. formosum*), D-004 (*D. parshii*), D-011 (*D. longicornu*) and D-013 (*D. densiflorum*) may be selected as promising ones.

Performance of exotic ornamental gourds lines

Ornamental gourd belongs to Cucurbitaceae family which includes the melon, squashes and pumpkins. They are usually hard shelled, durable, non-edible types suitable for storage vessels, dippers, bird houses and ornaments as value additive materials. Seventeen ornamental cucurbit lines were collected and evaluated at the research field of Floriculture Division, Horticulture Research Centre, BARI and RARS, Burirhat, Rangpur during the Rabi season of 2018-2019 to observe the adaptability as well as yield and storage duration. Wide variability was observed among the lines. The range of number of fruit per plant was 3.1-6.7; fruit weight range from 125-300 g. The range of fruit size was 4.0-12.0 cm. Fruit yield varied from 0.5-2.3 kg per plant. Storage duration was good ranging from 152-308 days. Considering attractive fruit colour, shape, size and storage duration, all the line may be selected for detail study.

Collection and maintenance of tulip

The tulip (*Tulipagesneriana*) is a perennial, bulbous plant belongs to family Liliaceae.Tulips are excellent for cut flowers, growing in beds, borders and pots and also for indoor gardening. Tulip flowers come in a wide variety of colours

therefore it is widely used as garden flowers and also in flowering arrangements.They are suitable for naturalization in grass under the trees and shrubs. It is the top most flowering genotype of the Netherlands and occupies fourth position among the top ten cut flowers in the global floriculture trade. In India, tulips thrive well in the temperate regions and other similar hilly regions but do not grow satisfactorily in the plains. However, there is scope of growing tulips for the production of quality cut flowers and bulbs in the tropical regions also. Sixgermplasm were collected from Netherlands used for the study. Variations were observed in respect of flower colour, leaf colour, leaf size and flower durability.

Hybridization of adenium flower

Adenium (*Adeniumobesum*) is one of the most important indoor decorative succulent plants in Bangladesh. Breeding of adenium is a fascinating aspect. Different attractive colours, various shape, size and large number of flowers are of demand to the users. So, there is a great scope for developing hybrid varieties in our country. In view of the importance of this crophybridization program on adenium was conducted in the flowering season December-January, 2018-2019 at Net House of Floriculture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur. Crossing was done between two adenium genotypes (AO-001 and AO-002) and pods were successfully produced. Seeds sown in pot containing cocodust medium and healthy plantlets were produced.

Hybridization of lily flower

Lilies belongs to the family Amarylldaceaeare most important and popular flowering annuals grown around Bangladesh to create colourful, temporary seasonal displays in flower beds as well as landscape gardening used in vases, bouquets, as cut-flower, and in a wide range of floral arrangements. They deserve special importance due to easy culture, wide adaptability to soil and climate and less prone to disease and pests. Recently, the demand of these flowering plants is increasing due to their attractive colour, prolonged flower durability and economic value. Most lilies produce very beautiful flowers those are large and come in a range of colour including whites, yellows, oranges, pinks, reds and purples. The commercial cultivars of lilies have the flower colour that is always not suitable to meet the demand of amateurs. It needs to develop lilies with flowers having mixed colours. To do the same it needs a comprehensive crossing programme among different parents with variable flower colour to develop new varieties. However, research works on hybridization of lily flower is scanty in Bangladesh.Therefore,an investigationon hybridization of lily was conducted in the flowering season March-April 2018-2019 at Net House of Floriculture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur. After crossing, pods were successfully produced within 25-30 days.The time taken 25-30days for seed formation.Seeds sown in pot containing cocodust medium.Healthy plantlets and finally new variants were produced.

Hybridization of gladiolus flower

Gladiolus is one of the most important cut flower in Bangladesh. Breeding of gladiolus is a fascinating aspect. Different attractive colours, various shapes and large number of florets are demand to the users. So, there is a great scope for hybrid varieties in our country. In view of the importance of this crop,a hybridization program on gladiolus was conducted in the flowering season November 2017 to May 2019 at Floriculture Farm, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur. Four crossing were done among five attractive gladiolus genotypes and pods were successfully produced. A large number of cormels were produced from a single cross.

Effect of substrates on yield and quality of gerbera in soilless culture

An experiment was conducted at the Floriculture Division of Bangladesh Agricultural Research Institute, Gazipur during winter season of 2018-19 to study the effect of different substrate on growth, flowering, yield and quality of gerbera. Four different potting substrates like soil, cocodust, perlite and sawdust were used in seven combinations. The treatment combinations were T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1), T_6: Cocodust + soil (1:1) and T_7: Cocodust + sawdust (1:1). Data on plant growth and flower character like plant height, leave number, plant spread, sucker number, days to flowering, flower number, stalk length, stalk weight, stalk diameter, vase life and flowering duration were recorded. Among the various

substrates, cocodust and perlite (T_5) (1:1) as well as cocodust (T_2) singly performed best followed by Cocodust + soil (1:1) T_6in respect of growth, floral and quality characteristics of gerbera. Contrasting to this, gerbera grown on soil (T_1) alone performed poor result.

Effect of artificial light on growth and flowering of standard chrysanthemum

An observational trial was conducted in the UV polyfilm shade house of Floriculture Research Field, HRC, BARI, Gazipur during October 2018 to February 2019 to extend the flowering time. Cuttings of white coloured chrysanthemum collected from previously grown suckers and planted in the seed bed in the first week of October, 2018 for root initiation. These chrysanthemum seedlings were transplanted in the pot under UV polyfilm shade house on November, 2019. After 15 days of transplantation the plants were given artificial illumination everyday by the use of LED (Light Emitting Diodes) light up to 45 days old seedlings after transplantation. The treatments of the experiment are T_1=Control, T_2=One hr. extended light, T_3=Two hr. extended light, T_4= Three hr. extended light and T_5= Four hr. extended light.Chrysanthemum plants responded well to the artificial light and delayed the flowering time.

Effect of planting materials on growth, flowering and bulb production of lilum

An experiment was carried out at Floriculture Division of Horticulture Research Centre, BARI during 2018-19 with three planting materials viz. stem cutting with node, scales of bulb and bulbils of lilium used in this experiment. The soil media for all the planting materials were prepared by 50% soil and 50% cocodust. After cutting of 20 cm of stem with 8-10 nodes were placed in plastic pot containing the soil media. Bulbils were collected in from the leaf axils and planted in the same soil media in plastic pot. After completion of flowering of plant, the bulbs produce bulblets.These bulblets were collected and planted in the soil media. Scales from main bulb were collected and planted in plastic pot. Among three planting materials, stem cuttings did not survived. Scales of bulb and bulbils plants are now in vegetative condition. The growth parameters showed better result in scale but the seedling survivality was higher in bulbil plant after transplanting.

Effect of nitrogen, phosphorus and potassium on growth and flowering of lilium

The present investigation was conducted at the Floriculture Research Field of Horticulture Research Centre, BARI, Gazipur during 2017-2018. The experiment was laid out in a randomized complete block design with five treatments N:P:K (120:45:65), N:P:K (145:55:80), N:P:K (160:65:95), N:P:K (185:75:110), N:P:K (205:85:125) along with control N:P:K (0:0:0) to study the effect of nitrogen, phosphorus and potassium on growth, flowering and bulb production of lilium. The unit plot size was 1.80 m × 3.0 m. Spacing was maintained at 20 cm from row to row and 20 cm from plant to plant.Plant protection was taken as and when necessary. The flower quality like stalk length, rachis length, floret per stalk and vase life N:P:K (145:55:80) performed better than other treatments. N:P:K (160:65:95) was better when considerd flower diameter only.

Effect of combined application of nitrogen, phosphorus, potassium and sulphur on yield and yield attributes of gypsophila flower

The present experiment was conducted at the research field of Floriculture Division, HRC, BARI, Gazipur during 2018-19 to determine the suitable doses of N, P, K and S for maximization of gypsophila yield. There were 15 treatment combinations comprising four levels of nitrogen (0, 70, 100 and 130 kg ha^{-1}), four levels of phosphorus (0, 20, 40 and 60 kg ha^{-1}), four levels of potassium (0, 60, 90 and 120 kg ha^{-1}) and four levels of sulphur (0, 10, 20 and 30 kg ha^{-1}) along with a blanket dose of $Zn_3B_{1.5}$ kg ha^{-1} and cow dung 5 t ha^{-1} over the treatments. The experiment was laid out in randomized complete block design with three replications. The results showed that the seed yield of gypsophila ranged from 800 to 1003 kg ha^{-1}. The highest seed yield (1003 kg ha^{-1}) was obtained from the treatment T_{10}=$N_{100}P_{40}K_{60}S_{20}$. The lowest seed yield was found in control plot. Most of the cases, the performance of yield parameters was found better in T_{10}=$N_{100}P_{40}K_{60}S_{20}$ treatment. The maximum number of flower bunches (190000) was recorded in T_{10}=$N_{100}P_{40}K_{60}S_{20}$ treatment. Considering the flower bunch price of gypsophila(Tk. 10 $bunch^{-1}$), the highest net return (Tk. 933313 ha^{-1}) and the highest benefit cost ratio (1.97) was counted from the treatment T_{10}. The lowest net return and benefit cost ratio was

calculated from the control (T_1) treatment. On the basis of yield and benefit cost ratio, the treatment which receiving combined 100 kg N ha^{-1}, 40 kg P ha^{-1}, 60 kg K ha^{-1} and 20 kg S ha^{-1} along with a blanket dose of $Zn_3B_{1.5}$ kg ha^{-1}may be suitable dose for gypsophila flower production in terrace soils of Gazipur.

Effect of silver thio-sulphate on quality and vase life of lilium

An experiment was conducted at the Postharvest Technology Laboratory of Horticulture Research Centre, BARI, Gazipur during 2018-2019. Six combination of silver thio-sulfate and sugar were used as treatments viz STS 3.0mM + 20 g/l Sugar, STS 3.0mM + 40.0 g/l Sugar, STS 4.0mM + 20.0 g/l Sugar, STS 4.0mM + 40.0 g/l Sugar, STS 5.0mM + 20.0 g/l Sugar, STS 5.0 mM + 40.0 g/l Sugar including control (only water). Genotype Lilium-010 was used for the study. Flowers were cut with sharp knife from 12cm apart above the ground. Flower sticks were collected when first two florets of a flower stick showed color. Vase life was calculated as when half of florets of the stick became unattractive. The weight of flower sticks was measured before placing them into pulsing and vase solution. Maximum vase life was found when Lilium flowers were treated with 3 Mm Silver thio-sulfate with 20 g/l sugar (15.4 days).

Lilium bulb preservation influenced by various temperature and storing media

Lilium enjoys a universal acceptance and there is hardly any other bulbous flower which can match its beauty, colour and fragrance. Bulb preservation is an important issue for the continuation of the lilium cultivation. The lilium bulbs are normally preserved in cold storage (2-5^{0}c temp.) for 6-8 weeks but -1^{0}c to -1.5^{0}c is necessary for longer storage. It is very much needed to find out the optimum storage temperature with appropriate storing media for commercial cultivation of lilium flower. Therefore, the study was undertaken to find out the optimum temperature and storing media for lilium blub preservation. Bulbs of Lil-001 (Creamy white colour) were used as materials. There were two factors viz. storage temperature (2.1-2.5^{0}c, 6.5-7.5^{0}c & 8.0-10°c) in cold storage of BADC, Kashimpur, cool room of Postharvest Division, BARI and constant temperature and humidity chamber, HRC, BARI, respectively) and storing media like cocodust (100%), sawdust (100%) andcocodust + Sawdust (50:50). The humidity of BADC cold storage was 85 to 91%, cool room of Postharvest Division was 70 to 75% and constant temperature and humidity chamber was 75 to 90%. CRD factorial design was followed. ANOVA and mean comparison by LSD were followed using R-software. Considering various parameters like sprout initiation, root and shoot length, weight changes of bulb (%), quality of bulb, cool temperature (2.1-2.5^{0}c) with media sawdust is suitable for lilium bulb preservation.

Success of cactus grafting as influenced by rootstocks and scion

Grafting is a usual method and has a major role in cactus propagation. Cacti are easy to be grafted and it's possible to graft almost any two cacti successfully. Some specific reasons for grafting include: saving plants severely rotted or diseased, ensuring better growth and flowering by grafting scions of slow growing species into fast-growing stocks, developing unusual forms, adding more aesthetic value etc. To get successful grafting, it's important to ensure grafting compatibility. The rootstock and scion should be compatible in terms of physiology and structure. So it should be necessary to study the grafting compatibility between rootstock and scion. Although, grafting is a common technique to propagate cacti species, to the best of our knowledge, little or no research has been done to explain cacti grafting. Thus, the objective of this study is to find out the best grafting combinations among the *Hylocereus* and *Echinopsis*Cacti rootstocks with *Gymnocalycium* scion. Two types of rootstocks i.e. *Hylocereus* and *Echinopsis*and three types of scion i.e. *Gymnocalycium* ruby red, *G.* ruby yellow and *G.* ruby reddish yellow were used in this experiment. In case of *Hylocereus* rootstock, success rate of grafting was highest in *Hylocereus* with *G.* ruby red (75%) than other grafting combinations. On the other hand, *Echinopsis*with *G.* ruby yellow (60%) was most successful among the other grafting combinations.

Cost return Analysis of Gerbera Cultivation in Selected Areas of Bangladesh

In Bangladesh gerbera has been introduced and gaining popularity day by day being cultivated by some progressive farmers. As gerbera cultivation requires huge investment its costs and return are required to know. From Jashore and Savar, data

were collected randomly from 26 farmers using pre-designed structured questionnaire. It was found in the study that there were several types of gerbera flowers produced by the gerbera growers some of which names as stated by them were Balance, Stanza, Brilliance, Duni, Rosalin, Instance, Salvador, Artist, BARI Gerbera -1, BARI Gerbera - 2 etc. Average land size of gerbera cultivation area of the respondent farmers was 51.79 decimal ranging from 132 to 17 decimal. As opined by the respondent farmers, a gerbera plant produce quality flower in first three years. Hence, three years data have been considered in this study. Gerbera cultivation requires massive investment for construct polyhouse (shed). In this study, it was estimated that on an average Tk42 Lakh per hectare was required for establishment of a polyhouse. Farmers incurred a handsome amount of money to purchase tissue culture seedling that was calculated Tk. 26.5 Lakh per hectare, which share was 52% of first year operating cost and 29% of both establishment and first year operating cost. The price of a single plant was Tk. 80 to 90 imported from Pune, India. It was calculated that return and cost per hectare in first year were Tk. 6,793,715 and 9,297,967 in second year Tk.9,058,287 and 2,460,307 in third year Tk9,058,287 and 2,460,307 respectively. In three years, per hectare return, cost and net return was estimated approximately Tk. 249 Lakh, 142 Lakh and 106 Lakh respectively. BCR is calculated 1.75 (nondiscounted) and 1.62 (discounted @15%). Net present value per hectare with a discount rate 15% was estimated Tk. 71 Lakh. IRR was calculated 66%. Gerbera flowers were mainly marketed in the wholesale markets at Agargaon and Shahbag in Dhaka and Cheragipahar in Chittagong. However, now a day plastic flowers of gerbera imported from China have been shrinking the market of real gerbera that left the gerbera growers in anxiety. Therefore, it is suggested that import of plastic flower should be banned to save environment and gerbera growers of Bangladesh. In order to get seedling in reasonable price tissue culture laboratory is suggested to establish in Jashore.

Adaptive trial of gladiolus varieties at farmers field

The aesthetic value of flowers in the daily life is increasing with the advancement of civilization. Gladiolus is used as cut flower in Bangladesh. The major production belts of this flower in the country are Jashoresadar, Sharsha, Chowgacha, Kushtia, Chuadanga, Satkhira, Khulna, Chittagong, Mymensingh, Dhaka, Savar, Narayangonj and Gazipur regions. Now a days, farmers are cultivating different cultivars of gladiolus in different locations. However, yield potential of those cultivars is not known and some of them are not performing well in our country. BARI has developed 6 varieties of gladiolus which have high potential in yield and other characters but these varieties are not widely cultivated in Bangladesh. Therefore, quick dissemination and popularization of BARI released gladiolus variety is urgently needed. Widespread and effective demonstration of them at farmers' fieldwill lead to ensure availabilityof gladiolus flowers in Bangladesh. Trials were conducted at Rangpurand Jamalpurduring Rabi season of 2018-2019 to observe the performance of gladiolus varieties and to popularize among the farmers. The varieties BARI Gladiolus-3, BARI Gladiolus-4 and BARI Gladiolus-5 showed better performance and produced higher yield at all locations. The demand of BARI Gladiolus-3 and BARI Gladiolus-5 were more in Jamalpurbecause of consumer's choice, economic value and early flowering habit of those varieties. But the demand of BARI Gladiolus-3 and BARI Gladiolus-4 were more in Rangpur.

Adaptive trial of tuberose varieties at farmer's field

Tuberose (*Polianthes tuberose* L.) is an important cut flower in Bangladesh from aesthetic as well as commercial point of view. It is suitable for use in herbaceous borders, beddings, pots and for cut flowers. Sometimes it is used for loose flower also. Apart from ornamental value, tuberose is extensively utilized in medicines for headache, diarrhoea, rheumatism and allied pains. Due to its increasing demand, farmers have started growing tuberose as a field crop under different management practices. Good variety, proper spacing, optimum size of bulbs, fertilizer requirement, irrigation schedule, use of growth regulators, optimum time of planting etc. are some of the important factors that may help to increase the yield and quality of tuberose. The major production belts of this flower in the country are Jashoresadar, Sharsha, Chowgacha, Kushtia, Chuadanga, Rangpur, Bogura, Satkhira, Khulna, Chittagong, Dhaka, Savar and Gazipur regions. Now a days, farmers are cultivating different

cultivars of tuberose in different locations. However, yield potential of those cultivars is not known and some of them are not performing well in our country. BARI developed tuberose variety that need to be popularize among the farmers. To do so, on-farm trial is one of the ways to demonstrate better performance of the variety. Therefore, trials on BARI Tuberose-1 with promising line (PT-001) as check were conducted at Burrirhat (Rangpur) during 2018-2019 The experiment was laid out in RCB design with two dispersed replications. The unit plot was 1500 m^2 areas with plant spacing of 30 × 20 cm. Bulbs of BARI Tuberose-1 along with check (PT-001) were used as planting material. Manure, fertilizer, insecticide, fungicide, netted bag, secateurs etc. were supplied for making availability of inputs among the farmers in time. The experimental field was well prepared by adding 10 t cowdung and fertilized @ 435 kg urea, 400 kg TSP, 300 kg MoP, 12 kg boric acid and 8 kg $ZnSO_4$/ha. Cowdung, TSP, MoP, boric acid and $ZnSO_4$ were applied as basal and urea was top-dressed in two equal splits at 30 days after planting and spike initiation stage. Farmers are interested to cultivate the new variety of BARI Tuberose-1 for getting higher yield over local variety at all locations. They also preferred BARI Tuberose-1 because there was no incidence of pest and disease recorded in the field. On the other hand, benefit cost ratio was also higher in BARI Tuberose-1.

Adaptive trial of marigold variety at farmer's field

Marigold gained popularity amongst gardeners and flower growers on account of its easy culture and wide adaptability. Its habit of free flowering to produce marketable flowers, wide spectrum of attractive colour, shape, size and good keeping quality attracted the attention of flower growers. BARI developed summer marigold variety that needs to be popularizing among the farmers. To do so, on-farm trial is one of the ways to demonstrate better performance of the variety. Trials were conducted on BARI Marigold-1 at Burrirhat (Rangpur) during 2018-2019. The experiment was laid out in RCB design with two dispersed replications. The unit plot was 1500 m^2 areas with plant spacing of 40 × 40 cm. Cuttings of BARI Marigold-1 was used as planting material. The experimental field was well prepared by adding 10t cowdung and fertilized @ 350 kg urea, 300 kg TSP, 275 kg MoP, 12 kg boric acid and 8 kg $ZnSo_4$/ha. Cowdung, TSP, MoP, boric acid and $ZnSO_4$ were applied as basal and urea was top-dressed in two equal splits at 30 days after planting and flower initiation stage.Farmers are interested to cultivate the new variety of BARI Marigold-1 for getting higher yield over local variety. They also preferred BARI Marigold-1 because there was no incidence of pest and disease recorded in the field. On the other hand, benefit cost ratio was also higher in BARI Marigold-1.

08 CEREAL CROPS

Research progress

Plant breeding division of Bangladesh Agricultural Research Institute (BARI) works of different cereal crops namely maize, barley, sorghum and millets. Among them maize (*Zea mays* L.) has become an emerging crop in Bangladesh with the highest productivity. Simultaneously, barley (*Hordeum vulgare*) is a stress tolerant and saline adaptive *rabi* crop which is best suitable to cope with salinity in south coastal region of Bangladesh. For varietal improvement of maize, plant breeding division works for collection and characterization of inbred lines, development and evaluation of inbred lines, production of hybrids, evaluation of experimental hybrid, maintenance and breeder seed increase of parental lines and seed production of BARI released maize varieties. Development of stress tolerant (drought, heat, salt, waterlogged) maize varieties are also strengthened. Emphasis is also given to speciality corn (popcorn, sweet corn and baby corn) and nutritionally rich maize hybrids (Pro-vitamin A). At the same time, the division has been working for barley, sorghum and millets variety improvement for saline and drought prone areas. Therefore, collection and evaluation of germplasm, hybridization of barley, maintenance and seed production is the main activities for variety improvement for minor cereals. The endmost objective are to develop stress resilient high yielding, early and dwarf and nutritionally enrich maize varieties as well as climate resilient maize. On the other hand, emphasis has been given on varietal improvement of barley, sorghum and millets for saline and drought areas. Actually plant breeding division, BARI is constantly working for high yielding and adversely tolerant varieties. To popularize and disseminate released varieties and developed technologies among farmers and private agencies different activities such as block demonstration, adaptive trials, farmers training, workshop, field days, publications etc. were conducted.

Maize improvement

A: Collection, characterization and maintenance of germplasm

Maintenance and seed increase of promising inbred lines of maize

Inbred lines are the primary units of high yielding desirable hybrid development. So, maintaining seed purity is the primary task and must be done it very attentively. The quality of hybrid seed production greatly depends on seed purity in field condition and post harvesting period. Inbred lines are homozygous genotypes produced by repeated selfing with selection over generations.

Fifty seven field corn and eighteen baby corn inbred lines of maize were maintained through selfing by hand pollination. Total of 13.3 kg seeds seed from field corn and 7.98 kg seed from baby corn were harvested and preserved separately for future breeding program.

B: Development of source population and inbred lines

Development of base population in maize

Maize breeding is focused in achieving high yielding with stable performance of hybrids. So, development of elite inbred line is the first step and it basically depends on source population development. A mixture of forty nine superior hybrids of 7th cycle seeds were planted (dwarfness and earliness) in isolation. The materials were then allowed for random mating, simultaneously some selfing were also done in some selected plants. About 300 plants were selected based on objectives at flowering stage. For next cycle selection and inbred line development from desirable plants, finally 100 selfed ears were selected separately based on their objectives and preserved them carefully for next year selection.

Advancing S_1 to S_7 generation of field corn, popcorn, baby corn and sweet corn

S_1 to S_2: Waxy corn

Generation advancing through selfing by hand pollination for inbred line development is a routine work in maize breeding. The balanced bulk S_1 seeds of two waxy corn (Waxy corn 2008 & Waxy corn 932) were advanced from S_1 to S_2 generation. Among them 58 and 56 selfed ear harvested from Waxy corn 2008 and Waxy corn 932, respectively, and preserved separately for advancing them from S_2 to S_3 generation.

S_2 to S_3: Field corn

The S_2 seeds of field corn hybrid (IM8119) were advanced from S_2 to S_3 generation. Variations were found among the lines for different traits. The selected S_2 plants were selfed by hand pollination and finally 93 selfed ear were harvested. Selected selfed seeds were preserved separately for advancing them from S_3 to S_4 generation in the next year.

S_3 to S_4: Sweet corn

The balanced bulk S_3 seeds of two sweet corn lines (20 lines from Dream sweet 2 and 20 lines from Dream sweet 3) were advanced to S_4 generation through selfing by hand pollination. Variations were found among the S_3 lines for different traits under studied and finally 66 and 78 selfed ears were harvested from Dream sweet-2 and Dream sweet-3, respectively, and kept them separately for advancing the population to S_4 generation in the next year.

S_4 to S_5: Baby corn and field corn

The balanced bulk S_4 seeds of baby corn hybrid (18 lines from Baby star) and field corn hybrid (42 lines from IM8013) were advanced to S_5 generation through selfing by hand pollination. Variations were observed among the S_4 lines for different traits under studied. Selected 102 and 97 selfed ears were collected from baby star and IM8013, respectively, for advancing them from S_4 to S_5 generation in the next year

S_5 to S_6: Field corn, popcorn and sweet corn

The S_5 seeds of 250 field corn, 47 popcorn and 26 sweet corn lines were advanced to S_6 generation. Variations were found among the lines for different traits under studied. Selected S_5 plants were selfed and S_6 seeds from selfed plants were collected and advanced them from S_5 to S_6 generation in the next year.

S_6 to S_7: Field corn, popcorn and sweet corn

The S_6 seeds of four field corn hybrids (Arun-4, 981, Pioneer 30V07 and 981), one popcorn hybrid (Popcorn Nepal) and two sweet corn hybrids (Seeda new and BARI Sweet corn-1) were advanced to S_7 generation in order to develop superior inbred lines. This is the final stage of inbred development through recycling. Considerable variation found among the lines for different traits under studied and selected plants were selfed by hand pollination. In total, 18.47 kg, 3.19 kg and 6.24 kg selfed seed were harvested from field corn, popcorn and sweet corn, respectively, and preserved them for future breeding program.

C: Evaluation of inbred lines

Evaluation of inbred lines of field corn through line × tester method

Twenty two lines were crossed with 2 testers, namely CML 429 and CML 425 following Line × Tester mating design in *rabi* 2017-18 and the resulting 44 crosses along with the lines, testers and three checks BARI Hybrid maize-9, 981 and Elite were evaluated in a alpha lattice design with two replications, during *rabi*, 2018-19 at Gazipur. Among them three lines *viz.*, BMZ 55, BMZ 53, BMZ 4 were best for earliness, four lines viz. BMZ 68, BMZ 15, BMZ 53, BMZ 55 for dwarfness and three lines *viz*. BIL 79, BIL 182 and Pinacle 17 were good for having desirable GCA effects for higher yield. Two crosses namely CML 451 x CML 429 (11.3 t/ha) and BIL 79 x CML 429 (12.76 t/ha) were selected based on their SCA effect for grain yield, yield contributing characters and mean values which could be used for commercialization of hybrids further evaluation.

D: Evaluation of single cross hybrids

Combining ability and heterosis in maize (3 Sets)

In Set I, eight inbred lines were crossed in a 8×8 diallel fashion excluding reciprocals in rabi 2017-18 and resulting 28 F_1's along with 2 local checks BARI Hybrid maize-9 and 981 were evaluated during rabi 2018-19 following alpha lattice design

with 3 replications. Among the eight parents, parent P_3 and P_7 were the best general combiner for yield; parents P_1, P_2 and P_6 for earliness and parents P_3 and P_8 for dwarfness. Among the crosses, seven crosses namely $P_1 \times P_7$, $P_2 \times P_7$, $P_2 \times P_8$, $P_3 \times P_4$, $P_3 \times P_5$, $P_4 \times P_6$ and $P_6 \times P_8$ showed positive and significant SCA effect for yield. Considering BARI Hybrid maize-9, as a check finally three crosses i.e. P1×P7 (13.23 t/ha), P3×P4 (12.46 t/ha) and P3×P5 (12.94 t/ha) were selected based on their positive and significant heterosis values also with their desirable traits and need to be further evaluated in multilocation.

In Set II, seven elite maize inbred lines were crossed in a 7×7 diallel fashion excluding the reciprocals and parents in *rabi* 2017-18 and resulting 21 F_1's were evaluated along with four checks namely BARI Hybrid maize-9, 981, Elite and NK-40 in a alpha lattice design with two replications at BARI, Gazipur in *rabi* 2018-2019. Parents P_1, P_4 and P_7 were selected as a best combiner for yield; parents P_2 for earliness and P_3 for dwarfness. Among the 21 crosses, four crosses i.e. $P_1 \times P_5$, $P_1 \times P_7$, $P_2 \times P_4$ and $P_4 \times P_6$ showed significant and positive SCA effects for yield. Two crosses namely $P_1 \times P_7$ (12.8 t/ha) and P_1 x P_5 (11.8 t/ha) showed high mean yield as well as higher heterosis and can be utilized for developing high yielding hybrid after verifying in different agro-ecological zones.

In Set III, seven elite maize inbred lines were crossed in a 7×7 diallel fashion excluding the reciprocals and parents in *rabi* 2017-18 and resulting 21 F_1's were evaluated along with four checks, namely BARI Hybrid maize-9, 981, Elite and NK-40 in a alpha lattice design with two replications at BARI, Gazipur in *rabi* 2018-2019. Parents P_5, P_6 and P_7 were selected as a best combiner for yield; parents P_1 and P_3, for earliness and dwarfness, respectively. Among the 21 crosses, five crosses viz. $P_1 \times P_4$, $P_1 \times P_6$, $P_2 \times P_5$, $P_3 \times P_7$ and $P_5 \times P_7$ showed positive and significant SCA effect for grain yield. Two crosses namely $P_5 \times P_7$ (13.2 t/ha) and P_5 x P_6 (12.2 t/ha) showed high mean yield as well as higher heterosis and can be utilized for developing high yielding hybrids after verifying in different agro-ecological zones.

Evaluation of selected single cross hybrids of field corn

Twenty three single cross field corn hybrids were evaluated along with two commercial checks following alpha lattice design with two replications viz. BARI Hybrid maize-9, and 981. Significant differences were observed among the genotypes for all the characters studied except 1000 grain weight. Considering yield, short stature and earliness five hybrids i.e. Pinacle 12 × BMZ 9 (9.98 t/ha), BIL 79 × E 34 (9.95 t/ha), BMZ 9 × Pinacle 3 (9.92 t/ha), CML 465 × CML 480 (9.67 t/ha) and Pinacle 3 × CML 451(9.09 t/ha) were found promising and selected for further evaluation across different locations in the next year.

Evaluation of promising field corn hybrids at different location (5 Sets)

In Set I, fourteen promising crosses and four check varieties (BARI Hybrid maize-9, 981, Elite and NK-40) were evaluated following alpha lattice design with 2 replications for genotype environment interaction (GEI) and stability to select promising one(s) at three locations namely Gazipur, Dinajpur and Burirhat during rabi 2018-19. The AMMI (additive main effects and multiplicative interaction) model was used to analyze the genotype-environment interaction over three locations. The result of the study revealed that environment of Gazipur was poor but Dinajpur and Burirhat were suitable for hybrid maize cultivation. Considering yield potentiality and stability parameter, three hybrids namely, E5 (12.11 t/ha), E7 (11.98 t/ha) and E9 (12.21 t/ha) showed higher yield as well as stable across location and need to be evaluated further in large plots before release as commercial hybrids across different agro-ecological zones in Bangladesh.

In Set II, twenty locally produced baby corn hybrid and one commercially used baby corn hybrid (Baby Star) as a check were evaluated following RCBD with 2 replications for genotype environment interaction (GEI) and stability to select of promising one(s) at five locations namely Gazipur, Rangpur, Dinajpur, Jashore and Hathazari during rabi 2018-19. The AMMI (additive main effects and multiplicative interaction) model was used to analyze the genotype-environment interaction over five locations. The result of the study revealed that among the five environments Dinajpur and Rangpur were most suitable and Gazipur was poorest environment for baby corn cultivation. Considering the mean and stability parameters of yield, three crosses viz. BCP 271-18×BCP 271-6 (28.2 g), BCP 271-18×BCP 271-16 (34.4 g) and BCP 271-20×BCP 271-6 (28.0 g)

exhibited high baby cob yield per plant and were also stable over the environments, whereas two crosses namely BCP 271-15×BCP 271-19 (703 g) and BCP 271-16×BCP 271-6 (574 g) were found high green fodder yield per plant and stable over the environments.

In Set III, thirteen locally developed hybrids including two check varieties BARI Hybrid maize-9, and 981 were evaluated following alpha lattice design with 3 replications during *rabi* 2018-19 at five locations *viz*. Jashore, Gazipur, Jamalpur, Rangpur & Dinajpur to select best stable hybrids among the imported and locally bred hybrids. The Eberhart and Russel (1966) model was used to analyze the genotype-environment interaction over five locations.The environment of Jashore and Jamalpur were poor; but Gazipur, Rangpur and Dinajpur were rich for hybrid maize production. Considering the mean and stability parameters of yield, fourhybrids namely E3, E5, E6 and E9 were found stable with low yield and three hybrids E2 (11.69 t/ha), E4 (10.65 t/ha) and E7 (10.82 t/ha) showed higher yield but were sensitive to change in growing environment and showed good performance in specific environment. Finally, these three hybrids (E2, E4 and E6) were selected for further evaluation in larger plot under wider agro-ecological zones of Bangladesh for confirmation.

In Set IV, seven single cross hybrids and four checks viz., BARI Hybrid maize-9, 981, Elite and NK-40 were evaluated following RCBD with 3 replications for genotype environment interaction (GEI) and stability to select of promising one(s) at five locations namely Gazipur, Jamalpur, Dinajpur, Jashore and Hathazari during rabi 2018-19.The AMMI model (additive main effects and multiplicative interaction) and GGE biplot were used to analyze the genotype-environment interactions. The result of the study revealed that Dinajpur and Jashore were the most favorable environments for grain yield and Gazipur was the most unsuitable for hybrid maize production. Considering the mean and stability parameters of yield the hybrid 9MG-22 × 9MS-4 (11.2 t/ha) was high grain yielder and stable over environments where as hybrid 9 MG-22× 9 MS-16 (9.27 t/ha) showed desirable yield but not stable for all environments. These two hybrids were selected for further evaluation in larger plot under wider agro-ecological zones of Bangladesh for confirmation.

In Set V, ten hybrids along with two checks viz., BARI Hybrid maize-9 and 981 were evaluated following alpha lattice design with 3 replications for genotype environment interaction (GEI) and stability to select of promising one(s) at three locations namely Dinajpur, Gazipur and Jashore during rabi 2018-19. The genotype-environment interaction over three locations were analyzed using Eberhart and Russel (1966) model to select hybrid having higher yield and other potential attributes. The result of the study revealed the environment of Dinajpur was the most suitable and Gazipur was the most unsuitable for hybrid maize production. Considering the mean and stability parameters of yield six hybrids i.e E-1 (13.37 t/ha), E-2 (13.16 t/ha), E-4 (14.29 t/ha), E-8(13.07 t/ha), E-9(13.25 t/ha) and E-10 (14.35 t/ha) exhibited the higher grain yield and are stable across the environments. These six hybrids were selected for further evaluation in larger plots under wider agro-ecological zones of Bangladesh for confirmation.

Evaluation of short stature maize hybrids

Nine selected single cross short stature maize hybrids along with five commercial check hybrids viz. BARI Hybrid maize-9, BARI Hybrid maize-16, 981, Elite and NK-40 were evaluated in RCBD with two replications at Nashipur, Dinajpur. Based on heterosis and mean performances, three hybrids F-14×M-10 (13.4 t/ha), F-14×M-15(12.4 t/ha), F-30×M-10(12.95 t/ha) were found promising and needs to verify them at different locations in the next year.

E. Stress Breeding-Abiotic stress tolerant variety development

Evaluation of promising maize hybrids for Haor areas

Fourteen selected single cross maize hybrids and three local checks viz. BARI Hybrid maize-9, BARI Hybrid maize-7 and Sunshine were evaluated following RCBD with three replications at farmer’s field in Goroi, Nikli, Kishoregonj during rabi 2018-19 to select suitable hybrids for haor areas. Considering yield potentiality, entry E11 (10.05 t/ha) was found promising. But considering yield potentiality, earliness (128 days) and plant height (196 cm) entry E2 (9.13 t/ha) was found promising for the haor areas. So, hybrid E2 could be released as commercial cultivation for haor areas of Bangladesh to avoid flash flood after verifying in large plot in the next year.

F. Development of new hybrids

Exploitation of hybrid vigour and selection of parents based on combining ability and *per se* performance has been used as an important breeding approach in crop improvement. Inbred lines are pre requisite for hybrid development and their worth is considered by their performance in combination with different inbred lines. Combining ability is one of the powerful tools in identifying the best combiner that may be used in crosses either to exploit heterosis or to accumulate fixable genes. Combining ability of inbred lines provides information about genetic nature of quantitative traits and for selection of most appropriate parents to be used for heterosis breeding. Line x tester method, diallel mating design also provides an opportunity to evaluate the genotypes during development of inbred.

Development of single cross maize hybrids though line×tester method in isolation (2 Sets)

One hundred and eighty six inbreds were crossed in isolation with two testers (BIL 79 and BIL 157) in two different locations i.e. Bogura and Narshingdi, respectively, in rabi season of 2018-19. Resulting 372 F_1s (each set containing 186 crosses) will be evaluated in the next rabi season of 2019-20 with different objectives. A total of 141.69 kg seed from set I and 96.57 kg from set II were produced from two different locations.

Production of single cross field corn hybrids through diallel mating design (2 Sets)

Two sets of crosses were made following 6×6 (set I) and 7×7 (set II) diallel fashion at Gazipur during rabi 2018-19. In set I, 15 crosses produced 5.6 kg seeds and in set II, 21 crosses produced 8.3 kg seeds. The seeds produced in each set will be evaluated in the next rabi season of 2019-20 for selecting promising hybrid(s).

Development of selected single cross hybrids of short statured, lodging tolerant, excess soil moisture and saline tolerant popcorn and baby corn (6 Sets)

The seeds of selected single crosses from last year's trials need to further increase for verifying them in wider agro-ecological zones. Therefore, to produce sufficient amount of seeds from the selected crosses were produced by hand pollination were needed. Six sets of single crosses produced total 12.6 kg baby corn and 98.43 kg field corn, respectively.

G. Maintenance and seed increase of parental/inbred lines

Inbred lines regarded as potential parental components of hybrids. So, maintaining of inbred lines without genetic change is an important and careful task. The goal of inbred line maintenance is to maintain the performance, appearance and genetic integrity of the original lines. Production of highly homogeneous, homozygous inbred lines has provided maize researchers with a large array of uniform, reproducible genotypes

Maintenance and seed increase of the parental lines of BARI maize hybrids (2 sets)

A total of 5.12 kg and 23.94 kg seeds were produced from two sets of parental inbred lines. Set I consisted of twenty one parental lines (BIL 20, BIL 22, BIL 28, BIL 29, BIL 31, BIL 77, BIL 79, BIL 106, BIL 113, BIL 114, BIL 210, BIL 211, BIL 212, BIL 213, BIL 214, BIL 215, BIL 216, BIL217 and BML 36, BML 59, BML 71) and set II consisted of nine parental lines (BIL 110, BIL 157, BIL 214, BIL 215, BIL 216, BIL217 and BML 36, BML 59, BML 71) of BARI released hybrid varieties were grown at Gazipur and Dinajpur (Nashipur), respectively. At flowering stage, healthy, disease free plants were selected and selfed by hand pollination. Mature selfed ears were harvested separately and dried properly. Undesirable ears were discarded. A final selection was done after harvest based on grain color, row arrangement and texture and preserved for future breeding purpose

Seed production of the parental lines of BARI maize hybrids

Parental lines are pre-requisite for hybrid seed production. So, maintenance of parental lines is very important to maintain the quality of the respective inbred lines. It is very much necessary to increase large scale seed production of the parental lines for large scale hybrid (F_1) seed production to meet the local demand and to supply seed to interested public and private partners for commercialization.

A total of 1960 kg breeder seeds were produced from ten parental lines of eight BARI released hybrids at fourteen locations namely Hathazari, Jashore, Jamalpur, Ishurdi, Gazipur, Burirhat, Cumilla, Bogura (Sewsgari, OFRD), Rahmatpur, Nashipur, Rajshahi, Kishoregonj, Dinajpur, and

Thakurgaon locations with proper isolation (time/space). Among them 9 kg seeds from BIL22, 677 kg from BIL28, 265 kg from BIL79, 50 kg from BIL110, 115 kg from BIL157,6 kg from BIL211, 12 kg from BIL213, 5 kg from BIL215, 606 kg from BML 59 and 215 kg from BML 71 were produced at different locations.

H. Seed Production of BARI released hybrids

High quality seed is the basic and vital input for enhancing maize production and productivity. To popularize the released varieties among farmers, seed production of released varieties is a pre-requisite for demonstration at farmer's field. So, the experiment was undertaken to increase seed stock of the BARI released hybrid varieties of maize to be used for demonstration and experimental uses.

Seed production of BARI Hybrid maize

A total of 5491 kg hybrids seeds of six BARI maize hybrids viz. BARI Hybrid maize-7, BARI Hybrid maize-9, BARI Hybrid maize-12, BARI Hybrid maize-13, BARI Hybrid maize-15 and BARI Hybrid maize-16 were produced at Bogura, Gazipur, Jashore, Debigonj, Thakurgaon, Dinajpur (Nashipur) and Dinajpur (Rajbari) locations with proper isolation (time/space) and maintaining female and male ratio of 4:2. At flowering stage, the plants from female rows were detasseled before pollen shedding and ears were collected from female plants only. Finally harvested ears were sorted, processed and stored for next year use.

Seed production of promising maize hybrids

Parents of ten promising maize hybrids were grown at different locations namely Ishurdi, Jamalpur, Narsingdi, Thakurgaon and Nashipur of Bangladesh during rabi 2018-19 in isolation (time/space). Total 168.98 kg seeds were obtained from nine promising hybrids line and stored for further evaluation in the next rabi season.

I: Maintenance and seed production of Open-pollinated varieties

Normally composite varieties are comparatively lower yielder than hybrid maize variety. Inspite of this, its advantage over hybrid is that farmers can keep their own seed and low inputs requirement in cultivating the crop.

Maintenance and seed production of BARI composite maize varieties

A total of 607 kg seeds of one composite variety (Khoibhutta) was produced at Gazipur and Labukahli with proper isolation (time/space) maintaining female and male ratio of 2:1. At flowering stage, male flowers (tassel) from female lines were detasseled and ears were collected from the female plants and the harvested ears were sorted, processed and stored them for next year use.

J: Maize Biotechnology: Molecular breeding

Comparative study on oxidative stress tolerance mechanism in maize (c_4) and barley (c_3) under drought condition

This experiment was conducted with two barley varieties (BARI Barley-5 and BARI Barley-7) as C_3 crop and two maize varieties (BARI Hybrid maize-5 and BARI Hybrid maize-7) as C_4 crop to find out antioxidative capacity between C_3 and C_4 crop. In both crops, reactive oxygen species like superoxide (ROS) ($O2^{\bullet-}$) and H_2O_2 were found to be increased enormously under drought, being remarkable higher in barley. Although superoxide dismutase (SOD) activity increased in BB-5, was abundance in maize in both specific and isozymes analysis. Similar results were found for catalase (CAT). However, peroxidase (POD) activities in creased in only BMH-7. On the other hand, ascorbate peroxidase (APX) activity increased in BMH-7, BB-5 and BB-7). GPX activity was increased in BMH-7, BB-5 and BB-7. Considering all, abundance rather induction was responsible for lower ROS in maize.

K. Technology transfer activities

Comparative yield trial of local and imported maize hybrids at different locations

Twenty five imported hybrids and four BARI released hybrids (BHM-7, BHM-9, BHM-12 and BHM-13) were evaluated following alpha lattice design with 3 replications for genotype environment interaction (GEI) and stability to select of promising one(s) at six locations viz. Gazipur, Jashore, Jamalpur, Rangpur, Hathazari and Dinajpur during rabi 2018-19.The AMMI model (additive main effects and multiplicative interaction) and GGE biplot were used to analyze

the genotype-environment interactions. The result of the study revealed the environment of Jamalpur and Hathazari were poor and Dinajpur was found highly suitable for hybrid maize cultivation followed by Jashore. Considering the yield potentiality and stability parameter, 25K60 exhibited as high yielding and also stable over all environments but Pacific 224 and 987 exhibited high yield but unstable over locations.

Adaptive Trial of drought and Heat Tolerant BARI Maize Hybrids

Six BARI Hybrid Maize (BHM) varieties (BHM-7, BHM-9, BHM-12, BHM-13, BHM-14, BHM-15 and three advanced lines HTMA-19, HTMA-21 and ZH-15445 were evaluated along with three imported commercial hybrids viz. Pacific 981, Elite, and NK-40 during rabi, 2018-19 at four locations i.e Faridpur, Pabna, Jamalpur and Bogura to observe the performance of BARI Hybrid Maize (BHM) varieties/lines with imported hybrids and to popularize among the farmers. Among the BHM varieties and advanced lines, BHM-7 (10.43 t/ha), BHM-12 (10.81 t/ha), HTMA-19 (10.25 t/ha) and BHM-13 (10.87 t/ha) gave higher yield. Among the imported varieties, Elite (11.50 t/ha) and Pacific 981 (12.36 t/ha) performed good. The highest yield was obtained from Sherpur, followed by Pabna and Faridpur. Among BARI released maize varieties BHM-12 and BHM-13 showed the highest grain yield in all locations. Highest benefit cost ratio was obtained from Pacific 981(1.95) followed by Elite (1.86) and BHM-12 or BHM-13 (1.72).

Adaptive yield trial of promising maize hybrids

Sixteen advanced lines of hybrid maize, namely P1, P2, P3, P4, P5, P6, P7, P8 P9, P10, P11 ($F_{30}xM_{15}$), P12 ($F_{40}XM_{10}$), P13 ($F_{30}xM_1$), P14 ($F_{14}XM_{10}$), P15 (BHM-16), P16 (Elite) were evaluated following RCB design with three replications at Pouli village under Sadar thana of Manikganj district during rabi season of 2018-19 to observe the yield performance of BARI developed advanced lines of hybrid maize. Among the lines P15 (13.21 t/ha) gave the highest yield followed by P9 (12.73 t/ha) and P12 (12.47 t/ha). The highest gross return (Tk. 213950.00 ha^{-1}) and gross margin (Tk.134040.00 ha^{-1}) was also obtained from P15 (BARI Hybrid maize-16).

On farm trial of BARI developed maize hybrids

An adaptive trial was conducted using four BARI released hybrid maize varieties viz., BARI Hybrid Maize-7, BARI Hybrid Maize-9, BARI Hybrid Maize-12 and BARI Hybrid Maize-13 and five imported varieties *viz*. Pacific 981, NK-40, Elite, Miracle and Kaveri 7720 at Cumilla, Tangail, Manikganj and Kushtia during 2018-19. The objective was to compare the performance of BARI Hybrid Maize (BHM) varieties with imported varieties and to popularize BHM varieties among the farmers. Among the tested varieties, BHM-7 (9.49 t/ha), BHM-9 (11.10 t/ha) and BHM-13 ((9.21 t/ha) showed satisfactory result. While Miracle (14.0 t/ha) and Kaveri 7720 (11.92 t/ha) gave higher grain yield. The highest yield was obtained from Manikganj followed by Cumilla, Kushtia and Tangail.

Demonstration of BARI Hybrid maize for Cumilla areas

A Demonstration trial was conducted using BARI Hybrid Maize-9 (BHM-9) with one check variety NK- 40 following RCB design with two replications at the farmers' field of Haripur in Dauadkandi upazilla and Amrataliin Barura Upazilla under Cumilla district during the rabi season of 2018-19 to evaluate the performance of BHM-9 and to disseminate and popularize BARI released hybrid maize variety among the farmers and private agencies. Among the two hybrids BHM-9 (9.53 t/ha) showed the highest grain yield followed by NK-40 (8.95 t/ha).

Training, field days on the performance of BARI released maize & minor cereals varieties

Plant Breeding Division, BARI has been working to generate new varieties and appropriate technology for development of maize, barley and minor cereal for farmers. Farmers, Government, and NGO personnel were trained to make them familiar with the new maize and minor cereals (Barley, Sorghum and Millets) varieties, modern crop management practices, seed preservation techniques and mechanization in cultivation. For quick dissemination of new varieties and improved production technologies, a number of technology transfer programs have been initiated during 2018-19 by the plant breeding division.

Plant Breeding Division BARI arranged 1 batch training for SAAO, SSA, SA (each with 30 Participants), 31 batches (930 Participants) training

for farmers on hybrid maize production technology, 2 Batches (60 Participants) training for upazilla and district level officers of DAE, and NGO officers, scientist, 1 batch (30 participants) training for BADC and private seed company personnel, 7 Batches (210 Participants) training for farmers on minor cereal crop production technology. Fourteen field days on maize and four field days on minor cereal were conducted by plant breeding division at different areas of Bangladesh.

Barley, Millets and Sorghum Improvement

A. Barley variety development

Hybridization of barley

Hybridization has played an important role in creating genetic variability and it brings together desired qualitative characters found in different plants into one plant. It transfers desired character/s from other varieties to the considered one. Two sets of varietie line were crossed in a half diallel fashion to develop early, dwarf and high yielding hull-less barley variety.

Set-1: Ten parental genotypes (variety and advanced lines) were crossed following half diallel fashion. Among 45 cross combinations, all the crosses have successfully produced seeds which are preserved for confirmation trial in the next year.

Set-2: Seven parental genotypes were crossed in a half diallel fashion. All the crosses successfully produced seeds and a total of 956 seeds were harvested and preserved for next year confirmation trial.

Confirmation of F_1 generation of barley

The study was conducted to understand the genetic control of grain yield and its component traits in barley. This study was conducted with 8 parental lines and 16 crosses to confirm the F_1 population and to identify the better cross combinations through family block design. Among the 16 crosses, 8 crosses were found promising based on positive heterosis for yield per plant and were selected for next generation evaluation.

Performance of F_2, F_3, F_5 and F_6 generation of barley

Success of a hybridization program depends on carefully handling of segregating materials. The main objectives of handling segregating generations is to grow and select the desirable families and individual plants in different filial generation for further evaluation. Individual plants were selected from four filial generations (F_2, F_3, F_5, and F_6) to observe earliness, short stature, hull-less and high yield. In F_2 generation, 72 plants from 20 crosses, in F_3 generation 3 plants from 3 crosses, in F_5 generation 9 plants from 9 crosses and in F_6 generation 4 plants out of 2 crosses were selected.

Evaluation of barley lines for early and high yield

Twenty one previously screened hull-less barley lines were received from ICARDA and were evaluated along with two standard check variettes namely BARI Barley-7 and BARI Barley-8 following RCBD with 2 replications at Gazipur to select better performing early, dwarf and high yielding hull-less barley lines. Significant variations were observed for all the traits among the tested entries except plant height and no. of tillers/plant. Considering short stature, yield and yield contributing characters eight lines (INBYT-18- E5, INBYT-18-E6, INBYT-18 -E14, IBON-18 L-24, IBON-18 L-53, INBON-HI/18 L-9, INBON-HI/18 L-84 and INBON-HI/18 L-90) were selected from the 21 barley lines for next year trial.

Preliminary yield trial of hull-less barley

Six genotypes of barley were evaluated along with one check variety (BARI Barley-7) following RCBD with three replications for genotype environment interaction (GEI) and stability to select the best barley lines at three locations namely Gazipur, Jamalpur and Ishwardi. The AMMI (additive main effect and multiplicative interaction) and GGE Biplot model was used to estimate the genotype-environment interaction and their graphical presentation. Genotype-environment interactions were significant for all the traits except plant height, no. of tillers/plant and no. of grains/spike. Considering mean and stability parameters of yield three genotypes i.e E2 (2.51 t/ha), E6 (2.33 t/ha) and E7 (2.45 t/ha) are high yielding but responsive to environmental changes and one genotype namely E4 (2.11 t/ha) found stable over all environments and need to be evaluated further in large plots.

Regional yield trial of hull-less barley

Seven hull-less barley lines were evaluated with one check variety BARI Barley-7 following RCBD

with three replications at Gazipur, Jamalpur, Patuakhali and Ishwardi for identification of suitable environment for high yielding stable barley lines. Among the Genotype E2 (2.97 t/ha), E3 (2.91 t/ha) and E5 (2.93 t/ha) were considered as high yielding and stable.

Large plot observation trial of barley

Four hull-less barley lines i.e INBON-L-21/15, BHL-29, Esmaralda M-104/12 and Atalpha12 were evaluated along with one check variety BARI Barley-6 following RCBD with three replications for genotype environment interaction (GEI) and stability to select the best barley lines at three locations namely Gazipur, Jamalpur and Ishwardi. The AMMI (additive main effect and multiplicative interaction) and GGE Biplot model was used to estimate the genotype-environment interaction and their graphical presentation. Genotype-environment interactions were significant for all the traits. Considering the mean and stability parameters of yield, Esmaralda M-104/12 (2.12 t/ha) and BARI Barley-6 (2.04 t/ha) exhibited higher yield but location specific while genotype Atalapha12 (1.78 t/ha) was comparatively medium yielding genotype but stable in all environments.

International barley observation nurseries-high input

The experiment was conducted with 138 barley lines including two checks (BARI Barley-5 and BARI Barley-7) at Gazipur to select better performing exotic barley lines. Considering yield and yield contributing traits 7 lines (E3 (2.58 t/ha), E11 (2.20 t/ha) E19 (2.56 t/ha), E24 (2.25t/ha) E41 (2.25t/ha) E55 (2.24 t/ha) and E69 (2.25 t/ha)) were selected for further evaluation.

Screening of barley varieties and lines in southern belt

Seventeen barley lines including nine BARI released varieties were tested for saline tolerance at three locations i.e. Amtoli, Borguna; Kolapara, Patuakhali and Dakope, Khulna. Salinity level increased with growing period, where 11.72 dS/m, 10.76 dS/m and 8.02 dS/m were recorded at last week of March, 2019. Among the materials, the highest number of spikes was harvested/m^2 from Atalpha/12 in Amtoli (241.5) and Kolapara (279.0), while INBON L-21/15 (217.0) from Dakope. For number of grains/spike, BARI Barley-9 produced the highest number of grains (47.0) followed by BHL-27(46.8) at Amtoli whereas at Kolapara, BHL-28 and Esmaralda produced the highest number of grains/spike (52.0). At Dakope, BARI Barley-7 produced the highest grains/spike (50.0) followed by BARI Barley-8 and BARI Barley-6 (46.9) and BARI Barley-2 (46.5). For grain yield/m^2 at Amtoli, BARI Barley-3 produced the highest yield (218.0 g) while BARI Barley-1 at Kolapara and BHL-27 at Dakope produced the highest yield (187.5g). Considering yield and yield contributing characters, Atalpha/12, BHL-27, INBON L21/15 and BARI Barley-6 were selected for further evaluation.

B: Millets and Sorghum Variety Development

Regional yield trial of finger millet

Five finger millets genotypes were evaluated following RCBD with three replications at four environments, namely Gazipur, Jamalpur, Rangpur and Ishwardi for identification of high yielding and stable finger millets genotypes. Among the genotypes E1 (4.36 t/ha) and E3 (4.06 t/ha) were found desirable and considered as high yielding and stable.

Preliminary yield trial of pearl millet germplasm

Four exotic pearl millet germplasm i.e. IP3706, IP5711, IP5793 and IP13523 were evaluated at three locations *viz.* Jamalpur, Gazipur, and Rangpur to find out the suitable genotypes for advanced yield trial. Considering grain yield across the locations IP3706 produced the highest yield (3.05 t/ha) followed by IP5793 (2.84 t/ha) and IP5711 (2.78 t/ha), whereas IP13523 produced the lowest (2.72 t/ha) yield. However, these four lines are statistically similar considering yield and selected for advanced yield trial in the next year.

Multilocation trial of ICRISAT sorghum lines

Eight advanced sorghum lines were evaluated to observe the performance of grain yield and other yield contributing characters across three different locations viz. Gazipur, Noakhali and Shatkhira. The trial was damaged at Satkhira in seedling stage and at Noakhali in reproductive stage by unfavorable environment and could not harvest. Considering the mean yield and other desirable characters three lines E6 (1.42 t/ha), E7 (1.31 t/ha) and E8 (1.31 t/ha) were found suitable at Gazipur.

Regional yield of trial of proso millet gerplasm

Tenproso millet genotypes were evaluated along with one check variety (BARI Cheena-1) following RCBD with three replications at three location viz. Rangpur, Gazipur and Jamalpur. Among the lines four proso millet genotypes i.e., BD1411 (2.41 t/ha), BD 777 (2.39 t/ha), BD764 (2.34 t/ha) and BD780 (2.31 t/ha) were selected for large plot yield trial in the next year.

Observation trial of proso millet germplasm under irrigated and non-irrigated conditions

The experimental materials consisted of 35 pre-selected proso millet lines along with one check variety BARI Cheena-1 (Tushar) following alpha lattice design with two replications at Gazipur. Among the tested lines, 14 promising germplasms (BD-761, BD-791, BD-1398, BD-1399, BD-1400, BD-1405, BD-1436, BD-1437, BD-1446, BD-1454, BD-1459, BD-1486, BD-1487 and BD-1488) were selected based on earliness, short stature, higher yield and yield per plot which varied from165-345 g in irrigated condition and 107-225 g in non-irrigated condition.

Preliminary evaluation of foxtail millet germplasm

Evaluation of foxtail millet lines are important to identify a particular genotype and maintain seed purity by rouging off type plant. The experiment was conducted with eighty germplasm received from PGRC, BARI. Among the germplasm only twenty four germplasm germinated. Considering yield and other yield contributing characters BD-862 (70 days) and BD-1063 (85 days)were selected for earliness and BD-1259 (220g), BD-1264 (200g), BD-1256 (180g) and BD-1284 (180g) for high yield for next year trial.

Regional yield trial of foxtail millets

Four genotypes *viz.*, Ise-375, Ise-376, Ise-710 and Ise-1820 along with two checks, BARI Kaon-1 and BARI Kaon-2 were evaluated following RCBD with three replication in four different locationsvizGazipur, Jamalpur, Burirhut and Ishwardi (Pabna). Among the tested foxtail millet lines E1 (2.90 t/ha) showed high yield but not stable and E4 (2.72 t/ha) and E5 (2.72 t/ha) showed moderate yield and were stable in all locations and selected for variety selection.

C: Buckwheat and Oat Variety Development

Evaluation of buckwheat germplasm

In Bangladesh, buckwheat is locally known as dhemsi and nutritionally enriched minor pseudo cereals. The experiment was conducted using four buckwheat genotypes with one local check collected from Bogura following RCBD with three replications at Gazipur during *rabi* 2018-19. Among the germplasmE3 was found promising due to its higher growth and yield attributes and higher seed yield (268.8 g) and selected for further evaluation.

Maintenance and seed increase ofoat

One genotype of oat BD-4271 received from PGRC, BARI was used to multiply seeds. As a self-pollinated crop this line was maintained by natural selfing and a total of 11.0 kg seed was produced and preserved for future breeding program

D: Seed Production

Breeder seed production of barley

Quality seed is important to maintain the purity of a variety and for demonstration of the varieties for popularization to farmers. Seeds of nine barley varieties *viz*., BARI Barley-1, BARI Barley-2, BARI Barley-3, BARI Barley-4, BARI Barley-5, BARI Barley-6, BARI Barley-7, BARI Barley-8 and BARI Barley-9 were produced at four locations namely Gazipur, Burirhat, Ishwardi and Debigonj to maintain the purity, distribution and demonstration of these varieties. Total 738.0 kg breeder seed of 9 barley varieties were produced.

Breeder seed production of millets

Seeds of BARI Kaon-1, BARI Kaon-2, BARI Kaon-3, and BARI Cheena-1 (Tusher) varieties were produced at Gazipur, Jamalpur, Debigong and Ishwardi. Total 314.0 kg breeder seed of Kaon and Cheena were produced at four locations. One hundred kg truthfully level seed (TLS) of BARI Kaon-2 was collected from Jamalpur for distribution to the farmers and demonstration.

Seed increase of selected pearl millet germplasm

Seeds of five pearl millet lines were produced at Gazipur, Jamalpur, Burirhat and Ishwardi. Total 24.9 kg breeder seed of pearl millet lines were

produced at four locations to maintain the purity, distribution and demonstration.

Seed increase of selected sorghum germplasm

Seeds of five sorghum lines were produced at Gazipur, Jamalpur, Burirhat and Ishwardi. Total 70 kg breeder seed of sorghum lines were produced at four locations to maintain the purity, distribution and demonstration.

E: Minor Cereals Biotechnology: Molecular biology

Oxidative stress tolerance mechanism in kaon (foxtail millets) under drought condition

Oxidative stress tolerance in three Kaon (Foxtail millet) varieties, BARI Kaon-1(BK-1), BARI Kaon-2 (BK-2) and BARI Kaon-3 (BK-3), was studied in drought condition by analyzing both specific and in-gel activities of ROS metabolizing enzymatic isozymes analysis of SOD, CAT, POD, APX and GPX. 25%FC and 12.5% FC were treated as mild (DR1) and severe stress (DR2), respectively. ROS ($O_2^{\bullet-}$ and H_2O_2) were found to be accumulated remarkably under drought in all the Kaon varieties, being comparatively lower in BK-3. All the varieties maintained almost similar level of SOD activity under stress. On the other hand, CAT, POD and GPX activities increased with stress severity in BK-3. Contrary, higher APX were found in BK-1 and BK-3. These data suggested improved oxidative stress tolerance capacity in BK-3.

Purification of glutathione *S*-transferase, glyoxalase-I and catalase from panicle of barley

In this study, an attempt was taken to purify glutathione *S*-transferases (GSTs; EC 2.5.1.18), glyoxalase I (Gly I; EC 4.4.1.5) and catalase (CAT; EC 1.11.1.6) from fresh barley panicle of BARI Barley-6. Crude protein was precipitated with 65% $(NH_4)_2SO_4$ and dialysis overnight. The concentrated protein was applied to a DEAE cellulose column chromatography and was elite with 0-20.2 M KCl. Total 121 fractions were collected each containing 5 ml of solution. The peak fractions of GST and Gly-I were purified by affinity chromatography containing *S*-hexyl glutathione- agarose. Active GST and GLY-I from affinity chromatography were tested in SDS-PAGE. Both proteins were purified and ran with a single band. GST had specific activity of 5.23µmol min^{-1} mg^{-1} protein, along with purification fold of 25.89 while Gly-I had specific activity of 10.26 µmol min^{-1} mg^{-1} protein, along with purification fold of 7.6. On the other hand, for CAT purification a hydroxyl and phenyl sepharose column chromatography was used. In SDS-PAGE, it also ran with single band with specific activity of 37.3 µmol min^{-1} mg^{-1} protein, along with purification fold of 3.6. However, protein concentration was very poor. Therefore, it has more scope to increase the concentration.

Screening of barley and sorghum lines against salinity in laboratory condition

Ten barley lines and seven sorghum genotypes were screened for salinity tolerance in pots containing three treatment of NaCl solution in a completely randomized design with three replications. In Barley, BHL-27, Atalpha/12, Esmaralda M-104/12 and INBON L21/15 and in sorghum, IS-29468, IS-21891 and IS-9745 showed better performance at 8 dSm^{-1} and 12 dSm^{-1}salt concentration, respectively. So, these four barley and three sorghum lines were selected for further evaluation at higher (16 ds/m) salinity.

Screening of drought tolerant barley lines at seedling stage under pot condition

Eight hull-less barley lines along with two standard checks BARI Barley-7 and BARI Barley-9 were evaluated to select better performing drought tolerant hull-less barley linesat greenhouse lab of BARI, Gazipur, during *rabi* season 2018-19. Among the lines, BARI Barley-7 had the highest dry weight (19.50 g) followed by BARI Barley-9 (19.18 g) and BHL-26 (17.51g) while it was found lowest in BHL 27 (10.67g). SPAD reading indirectly estimated the nitrogen status of plants so, the highest nitrogen status showed by BHL-26(38.76) and lowest nitrogen status showed by BHL-29 (34.72). BHL-26 had the highest leaf area (151.80) followed by BHL-25 (144.52). INBON L-21/15 produced the lowest leaf area (144.53) followed by BARI Barley-7 (84.53). Considering all, BHL-25 and BHL-26 were selected for further evaluation in field condition.

Screening of barley genotypes against spot blotch

Seventeen barley genotypes including nine BARI released varieties were screened against spot blotch

disease caused by *Bipolaris* under natural condition to find out resistant genotypes. Among the 17 tested genotypes only two genotypes i.e Atalpha and BHL-30 showed resistance reaction against barley spot blotch. Five genotypes (BB-2, BB-3, BB-5, BB-6 and BB-7) were moderately resistant, three genotypes (BB-1, BB-9 and BHL-27) were moderately susceptible, another three genotypes (BB-8, BHL-25 and BHL-26) showed susceptible reaction and one genotype BB-1 was highly susceptible to spot blotch disease during crop season. Resistant and moderately resistant genotypes were selected and will be screened again in next rabi season for reconfirmation.

F: Technology Transfer- Minor Cereals

Adaptive trials with barley genotypes in southern belt and Barindareas

Three barley varieties *viz*. BARI Barley-6, BARI Barley-7 and BARI Barley-8 and four advanced lines viz. BHL-25, BHL-26, BHL-27 and BHL-29 were evaluated at the farmer's field of Basantapur, Godagari, Rajshahi,Koyra, Khulna and Subarnachar Upazilla under Noakhali. Among the tested lines/varieties, BHL-27 (2.19 t/ha) produced the highest yield in Rajshahi under drought condition and BARI Barley-7 (1.37 to 2.13 t /ha) gave better yield performance and followed by BHL-25(1.27 to 2.06 t/ha) in saline soil of Koyra, Khulna and Noakhali. The trials need to be evaluated further for confirmation.

Adaptive trials with BARI Barley varieties in Char areas

Two barley varieties viz. BARI Barley-6 and BARI Barley-7 were evaluated at the farmer's field of Bhuapur (AEZ-8), Tangail, Saghata, Gaibandha and Sariakandi, Bogura to observe the performance and to popularize BARI Barley varieties in Char areas. Among the tested varieties, BARI Barely-6 (1.74 t/ha) and BARI Barely-7(1.64 t/ha) are more promising varieties than the local (1.39 t/ha). Considering the performance BARI Barley-6 may be recommended for large scale out among farmers in char areas of Tangail, Gaibandha and Bogura.

Adaptive trials with BARI foxtail millet varieties in Southern belt

An adaptive trial was conducted using three released Kaon varieties *viz*., BARI Kaon-1, BARI Kaon-2 and BARI Kaon-3 following RCBD with four dispersed replications in farmer's field of Subarnachar upazilla. The initial soil salinity level (15 DAS) were below 1 dS m^{-1}. Among the tested varieties the highest grain yield was observed in BARI Kaon-2 (1.66 t ha^{-1}). However and the lowest yield was observed in BARI Kaon-3 (1.22 t ha^{-1}). In case of gross return, BARI Kaon-2 gave the higher gross return (TK 66,400 ha^{-1}) as well as gross margin (TK 49,998 ha^{-1}) compared to other two varieties. So, foxtail millets can be cultivated in the saline char area of Noakhali where lands remain fallow after harvesting of T. Aman. Millet should be included in cropping pattern Fallow-Fallow -T. Aman.

Up-scaling of BARI foxtail millet varieties in Char, Barindand Hilly areas

The trial was conducted using three released kaon varieties *viz*., BARI Kaon1, BARI Kaon-2 and BARI Kaon-3 in the farmer's field of Melandah, Jamalpur and Bhuapur, Tangail under charland, Basantapur, Rajshahi under barind area and Dolupara and Tukhungpara hill valleys in Bandarban to disseminate, popularize and to select the best performed variety of BARI Kaon under farmer's field condition. Among the kaon varieties, considering the yield potentiality and economic point of view, BARI Kaon-3 was found promising in Jamalpur location but BARI Kaon-2 was better in Rajshahi, Tangail and Bandarban district.

Demonstration trial of BARI Cheena-1 variety in Barind areas

A demonstration trial lwas conducted using one BARI released proso millet variety, namely BARI Cheena-1 with three dispersed replications in farmer's field of Basantapur, Godagari, Rajshahi (High Barind area) to disseminate and popularize the variety. Result showed that BARI Cheena-1 gave 1.21 t/ha yield in Rajshahi region and farmers are interested to grow BARI Cheena-1 in this region.

09 AGRONOMY

Yield and quality of newly released sweet potato varieties as influenced by integrated nutrient management

The experiment was carried out at the research field of Agronomy Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during rabi seasons of 2018-19 to find out the suitable nutrient management of sweet potato for higher productivity. The treatments were T_1=STB fertilizer dose (100-40 -100 NPK kg/ha) × BARI sweet potato-8, T_2= STB fertilizer dose (100-40 -100 NPK kg/ha) +20%NPK × BARI sweet potato -8 T_3= STB fertilizer dose (100-40 -100 NPK kg/ha) + Vermi compost (3 t/ha) × BARI sweet potato -8, T_4= STB fertilizer dose (100-40 -100 NPK kg/ha) + Poultry manure (3 t/ha) × BARI sweet potato -8, T_5=STB fertilizer dose (100-40 -100 NPK kg/ha) × BARI sweet potato -12, T_6= STB (100-40 -100 NPK kg/ha) fertilizer dose+20%NPK × BARI sweet potato -12 T_7= STB(100-40 -100 NPK kg/ha) + Vermi compost (3 t/ha) × BARI sweet potato-12, T_8= STB(100-40 -100 NPK kg/ha) + Poultry manure (3 t/ha) × BARI sweet potato -12. The experiment was carried out in randomized complete block design with three replications. The unit plot size was 3 m × 3 m. Fertilizers were applied as per treatments in the form of Urea, Triple super phosphate (TSP), Muriate of potash (MoP) Gypsum, zinc sulphate and Boric acid, respectively . One third of urea and all other fertilizers were applied during final land preparation. Remaining 2/3 urea were top-dressed in two equal splits at 30 and 60 DAS, respectively followed by irrigation. Light irrigation was given after planting for uniform establishment. Vines of sweet potato were planted on 30 November 2018 with spacing 60 cm × 30 cm. The crop was harvested on 29 March 2019. Quality characters of tubers such as firmness, total sugar and β-carotene were analyzed after harvest. Significant variations were observed in tuber yield of sweet potato as affected by nutrient management. Higher tuber yield (31.67 t/ha) was recorded in T_6 = STB fertilizer dose (100-40 -100 NPK kg/ha) +20% NPK × BARI sweet potato -12 which was followed by T_8 =STB (100-40 -100 NPK kg/ha) + Poultry manure (3 t/ha) × BARI sweet potato-12. Quality characters like dry matter, starch, and β-carotene content were higher at application of organic manures. The highest gross return of Tk 253333.33/ha was observed in T_6 followed by T_8 and the highest BCR (4.85) was also obtained from T_8 followed by T_7 treatment. Results showed that T_6 = STB fertilizer dose+20%NPK × BARI sweet potato-12 treatment resulted higher yield and less TSS but T_8 =STB (100-40 -100 NPK kg/ha) + Poultry manure (3 t/ha) ×BARI sweet potato -12 gave reasonable good yield and the highest TSS.

Phenology and yield performance of bt. brinjal as influenced by planting date

The experiment was conducted at Agronomy field of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during 2016-17 to 2017-2018 to evaluate the performance of Bt. brinjal as influenced by date of planting. Planting of 35 days old seedling was started from 15 November 2017 and continued to 15 March 2018 as one month interval using treatments in two consecutive years. The trial was set up in randomized complete block design with three replications. The unit plot size was 8 m × 6 m. Plant spacing was 100 cm x 80 cm in raised bed. The crop was fertilized with cowdung 10 t/ha and 140-20-100-10-4-3 kg/ha of NPKSZnB, respectively. Cowdung was applied at the time of final preparation. One third N was applied at 10-15 DAP, at first fruiting and mid of harvesting, respectively. Half K was applied at 10-15 DAP and rest half N was applied at first fruiting stage and full dose of cowdung, P, S, Zn and B were applied at the time of final land preparation. BARI Bt. Begun-2 variety was used in the experiment. Crop management was done as per

requirement. Fruit yield showed negative and significant correlation ($r= -0.765$ at $p<0.01$) with total rainfall during growing season. Functional relationship of growing degree days (GDD) for flowering on the fruit yield of Bt. Brinjal can be explained 79% by the functional model of $Y= -7656+10.10X- 0.003X^2$ ($R^2 = 0.79$). From the two year experimentation it can be concluded that earlier planting (November) was better for growth and phenological development producing higher fruit yield of Bt. Brinjal (54.70 t/ha in 2017-18and 53.69 t/ha in 2016-17).

Effects of mulching and poultry manure on the yield of tomato at hilly region

An experiment was conducted at the Regional Agricultural Research Station, Hathazari, Chattogram, 2018-19 to study the effect of different mulch materials on the yield and quality of tomato. Rice straw mulch was found superior than that of grass mulch, and black polyethylene mulch in producing higher yield of tomato. Higher number of fruits per plant and maximum yield was recorded with rice straw mulch with 3 t/ha poultry manure which was 28.58% higher than the control (without mulch). BARI Tomato 8 in combination with rice straw and 3 t/ha poultry manure produced highest yield (63.45 t/ha).

Effects of seedling age and plant spacing on the yield performance of transplanting hybrid maize in southern region of Bangladesh

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during Rabi seasons of 2017-18 and 2018-19 to find out the suitable combination(s) of seedling age and plant spacing for increasing the yield of transplanting hybrid maize in southern region of Bangladesh. The treatments of the experiment consisted of two factors viz., Factor A: Plant spacing: 2 (S_1 = 45 cm × 25 cm, and S_2 = 60 cm × 25 cm); Factor B. Factor: A. Seedling age: 3 (A_1 = Transplanting of 14 days, A_2 = 21 days and A_3 = 28 days old seedlings). The experiment was laid out in randomized complete block design with three replications. All the studied parameter of transplanting hybrid maize affected significantly except cob length and cob diameter due to different plant spacing. The number of grain/cob, 100-grain weight and grain weight/cob were higher in wider spacing (60 cm × 25 cm) but the closer spacing (45 cm × 25 cm) gave the higher yield of grain because of higher plant population. The seedling age had significant effect at all the studied plant characters except the plant population. Transplanting of 14 days and 21 days old seedlings showed statistically similar plant height, ear height, cob length, cob diameter, number of grain/cob, 100-grain weight, grain weight/cob and yield. Establishment of 14 days and 21 days old seedlings in soil were better as compared to that of 28 days old seedlings that increased the yield of transplanting maize. The interaction effect of spacing and seedling age of transplanting maize created significant variation in plant population and 100-grain weight. Transplanting of 14 days to 21 days old seedlings with closer spacing of plant (45 cm × 25 cm) can be practiced for increasing the yield of hybrid maize in southern region of Bangladesh.

Effect of seedling age on yield of transplanted sunflower under zero tillage condition in southern region of Bangladesh

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during Rabi season of 2018-19 to find out the optimum age of sunflower seedling for getting higher yield under zero tillage condition in the southern region of Bangladesh. The treatments of the experiment were five ages of sunflower seedlings viz., A_1 = 7 days old seedling, A_2 = 14 days old seedling, A_3 = 21 days old seedling, A_4 = 28 days old seedling under zero tillage conditions, and A_5 = Direct seeding under conventional tillage condition. The seedlings were transplanted under zero tillage condition just after harvest of T.aman rice. The experiment was laid out in randomized complete block design with three replications. The variety of sunflower was BARI Sunflower-2. Seedlings of sunflower (A_1, A_2, A_3 and A_4) were transplanted on 2 December 2018 under zero tillage condition but direct seeding (A_5) was done under conventional tillage condition on 17 December 2018 (i.e. 15 days after zero tillage planting). Experimental results showed that the seedling age had significant effect on plant height, head diameter, number of seed/head and seed yield. Field duration became the lowest (97 days) in 28 days old seedling. The highest field duration (134 days) was found in direct seeding. Field duration reduced gradually with increasing the age of seedlings. Transplant of 14 days seedling gave the highest yield of seed (2017 kg/ha) followed by 7 days seedling (1987 kg/ha). Besides, 21 days

seedling produced the yield of 1660 kg/ha. The lowest yield was recorded in 28 days old seedling followed by direct seeding (1552 kg/ha). Experimental results further reveled that transplant of 14 days, 7 days and 21 days old seedlings increased the seed yield 30.01%, 28.08% and 6.95%, respectively over the direct seeding of sunflower under conventional tillage condition. Sunflower could be cultivated through transplanting of 14 days old seedling under zero tillage condition in southern region of Bangladesh. However, the experiment should be repeated in the next years for final recommendation.

Effect of integrated weed management on barley and soil microbes

The experiment was conducted at the experimental field of Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during *rabi* season of 2018. Treatments consist ofT_1= Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4 days after sowing (DAS), T_2= Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4DAS + one hand weeding (uprooting) at 25 DAS, T_3= One hand weeding at 25 DAS, T_4=Weeding by BARI weeder at 25 DAS and T_5= No weeding. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 5 m× 4.4m. Fertilizers were apply @ 85-25-45kg/ha N P K was applied in the form of urea, triple super phosphate and murate of potash, respectively. Half of N and all other fertilizer were applied as basal during final land preparation and rest N was applied at 35 and 60 DAS in equal split. Weeding operation was done as per treatments. BARI Barley-6 was used as test crop. Seeds were sown on 22 November 2018 with a spacing of 20 cm × 10 cm. Weed samples were collected from each plot at 25 and 40 DAS using a quadrate and dry weight was recorded to evaluate the efficacy of different weed control treatments. The intensity of weed infestation and the relative density were calculated following the formula of Mian and Rahman (1968); and Shetty and Rao (1979).To record dry matter weight and leaf area, one linear meter of plant was sampled at 30, 45, 60 and 75 DAS. Different plant parts of the collected samples were separated and then oven dried at 80^0C for 72 hours. Leaf area was measured by an automatic leaf area meter (L13100 c, LICOR, USA). The crop was harvested on 9 March 2019. At the time of harvest yield, yield contributing characters were recorded. Data on weed density, weed dry weight, yield and yield parameters were analyzed statistically with the help of MSTAT-C programme and means were adjusted by LSD test at 5% level of significance. Economic analysis was performed considering the prevailing market price of barley. Results showed that Shyama (*Echinochola crusgali*) was observed as a major weed in barley field. Number of weed/m^2 and weed control efficiency (WCE) was affected by different treatment. Yield components and yield of barley also significantly influenced by different treatment. The highest weed populations (118 and 56 weeds/m^2) were recorded in control plot at 25 and 50 DAS, respectively. The lowest (20 and 6 weed/m^2) were recorded in T_2 at 25 and 50 DAS. The highest WCE (weed control efficiency) was 83.05 and 96.65% at 25 DAE and 50 DAE respectively in T_2 treatment. The highest plant height (97.07 cm) was obtained from control plot. The maximum number of spikes /m^2 (418.33), spike length (11.17 cm), number of spikelet/spike (48.67), 1000-grain weight (38.87 g) and grain yield (3.94 t/ha) of barley were obtained from T_2 treatment. The highest gross return (Tk.79400/ha) and BCR (1.84) were also obtained from T_2treatment. The result revealed that application of herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4 DAS + one hand weeding (uprooting) at 25 DAS would be effective to control weeds for obtaining higher yield of barley.

Response of fertilizer and weed management on okra

The experiment was conducted at the research field of Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during *kharif* season of 2018. Treatments consist of T_1 = STB+ Two hand weeding at 25 DAE and 50 DAE, T_2 = STB +25%NPK+ Two hand weeding at 25 DAE and 50 DAE, T_3 = STB +50%NPK+ Two hand weeding at 25 DAE and 50 DAE, T_4 = STB +25%NPK+ weeding at 25 DAE + earthing up at 50 DAE, T_5 = STB +50%NPK+ weeding at 25 DAE + earthing up at 50 DAE, T_6 = STB +PM@3 t/ha + Two hand weeding at 25 DAE and 50 DAE, T_7 = Control (Native nutrient) + Two hand weeding at 25 DAE and 50 DAE, T_8 = Control (Native nutrient)+No weeding. The experiment was laid out in a randomized complete block design with three

replications. The unit plot size was 4 m× 4 m. Fertilizers were applied @ 90 kg N, 30 kg P, 60 kg K, 15 kg S, 2 kg Zn and 1kg B /ha was applied in the form of urea, triple super phosphate, murate of potash, gypsum, zinc sulphate and boric acid, respectively. One fourth N and all other fertilizer was applied as basal during final land preparation and rest N will be applied at 20, 40 and 60 days after sowing in equal split. Weeding operation was done as per treatments. BARI Dharos-2 was used as test crop. Seeds were sown on 9 March 2018 with a spacing of 50 cm × 40 cm. Weed samples were collected from each plot at 25 and 50 DAE using a quadrate and dry weight was recorded to evaluate the efficacy of different weed control treatments. The intensity of weed infestation and the relative density were calculated following the formula of Mian and Rahman (1968); and Shetty and Rao (1979). Harvesting started on 30 April 2018. Yield was recorded on whole plot basis. Excess rainfall was occurred during total cultivation period which partially damaged the crop. About 878 mm rainfall occurred during total growing period. Data on yield and yield parameters was recorded and analyzed statistically with the help of MSTAT-C programme. Means were adjusted by LSD test at 5% level of significance. Cost and return analysis was performed considering the prevailing market price of okra and other inputs. Results showed that Shyama (*Echinochola crusgali*) was observed as a major weed in okra field. Numbers of weed/m^2 and weed control efficiency (WCE) were affected by different treatments. Plant height, number of branches/plant and yield of okra also significantly influenced by different treatments. The highest weed population (52/m^{2}and 162/m^2) was recorded in control plot at 25 & 50 DAS, respectively. The lowest (32 and 31 weed/m^2) were recorded in T_3 at 25 and 50 DAS. The highest WCE (40.26 and 90.15% at 25 DAE and 50 DAE respectively) was found in T_3 treatment. The maximum height (119.66), number of branches/plant (4.66) and fruit yield (11.60 t/ha) were obtained from T_3 treatment. The highest gross return (Tk.232000/ha) and BCR (2.95) also obtained from T_3 treatment. The result revealed that application of STB fertilizer+50%NPK+ Two hand weeding at 25 DAE and 50 DAE would be most effective to control weeds for obtaining higher yield of okra.

Effect of weed management on growth and yield of cowpea

A field experiment was conducted at Regional Agricultural Research Station, Hathazari, Chattogram during the 2018-19 *rabi* season to assess the integrated effect of planting pattern and low dose herbicide mixtures on weed, growth, yield attributes and yields of cowpea, and to determine the economic feasibility of different weed management practices in cowpea, There were 5 treatments viz., T_1=One hand weeding at 20 days after emergence (DAE), T_2=Two hand weeding at 20 and 40 DAE, T_3=Gramoxone (15 Days before emergence), T_4=Roundup (15 Days before emergence) and T_5=No weeding (weedy check). The highest number of pods per plant, number of seeds per pod, hundred seed weight and grain yield (1409 kg/ha) were obtained from T_2=Two hand weeding at 20 and 40 DAE. The highest BCR and MBCR were obtained from Treatment T_1 where one hand weeding at 20 days after emergence (DAE) was practiced.

Carbon sequestration through residue management and crop productivity in potato-maize-t.aman cropping pattern in long term basis

The experiment was conducted at agronomy research field in 2017-2019. Treatments were viz. T_1=Full residue of potato, maize and 1/3 of rice + 100% recommended fertilizer dose (RFD) of T.aman, T_2=Full residue of potato, maize and 1/3 of rice + 90% RFD of T.*aman*, T_3=Full residue of potato, maize and 1/3 of rice + 80% RFD of T.*aman*, T_4=Residue removed + 100% RFD of T.*aman*, T_5=Control (Without crop residue and fertilizer). Experiment was conducted in a RCB design with three replications. Potato (var. BARI Alu -8) was sown on 23 November 2017 and harvested on 20 February 2018. Maize (var. BARI Hybrid Maize-9) was sown on 2 March 2018 and harvested on 12 June 2018. T. *aman* (var. BRRI dhan62) was transplanted on 7 July 2018 and harvested on 24 September 2018. Nutrients were applied as per treatments of recommended doses. Dry matter weight was recorded and organic carbon in residue and grain was analyzed in the laboratory following the standard procedure. Chemical properties of initial and after one year cropping soil were estimated. Carbon input from individual crop and total carbon input from pattern were calculated. Carbon input was computed with

multiplication of dry matter by organic C% concentration (like 54.60%). [e.g. 4.02 t/ha × 0.546=2.20 t/ha C input]. One hectare ≈considered 2250 tons' soil (0-15 cm depth and bulk density=1.5g/cc). The soil weight is multiplied by soil organic C percent (like 1.33%). [e.g. 2250 t/ha ×0.0133=29.92 t/ha organic C]. Carbon added from plant residue was also calculated. Organic carbon balance in the soil was estimated. Changes of other soil properties after one year cropping cycle was estimated. Potato tuber yield was higher in all treatments (18.06-19.88 t/ha) except T_5 (8.85 t/ha). Potato yield was found lower due to rainfall just after sowing. Germination failed and gap filling was done. Grain yield of maize was the highest in T_1-T_4 treatments (4.25-4.53 t/ha) but the lowest in control (T_5) (1.74 t/ha). There was no effect of potato residue incorporation among the treatments of T_1-T_4 but the lowest yield in T_5 due to no application of nutrient and residue incorporation. The highest grain yield of rice was obtained from control treatment (T_5) (3.76 t/ha) followed by T_3 (2.65 t/ha) while the lowest in T_4 (2.25 t/ha). Among the other treatments of residue incorporation of potato and maize, T_3 (80% RFD of T.*aman)* gave higher grain yield of rice (2.65 t/ha) while the rest treatments (T_1-T_2) produced lower grain yield (2.39-2.42 t/ha). Residue incorporation of potato and maize led to lodging the rice plant during grain filling stage and ultimately reduced grain yield. Organic C input from potato showed variation among the treatments while control treatment (T_5) gave the lowest values. Similarly, organic C input from maize showed variation among the treatments while control treatment (T_5) gave the lowest values. Variation of organic C input from rice was also observed among the treatments while T_1 gave the highest values except rice grain. Total organic C input from Potato-Maize –T. *aman* rice cropping pattern was noticed higher value in T_1 (10.66 t/ha) but the lowest in T_5 (6.57 t/ha) while other treatments showed intermediate values (9.73-9.84 t/ha). The results indicated that residue incorporation in Potato-Maize –T. *aman* rice cropping pattern increased organic C input. The highest total organic C adding from the pattern was estimated from T_1 (4.70 t/ha) followed by T_2 (4.06 t/ha) but the lowest in control T_5 (0.58 t/ha). The results revealed that incorporation of crop residue enhanced organic C addition in soil. Change of organic C in soil after one year cropping cycle has been presented below. Treatments, T_1, T_2 and T_3 showed positive balance of organic C in soil while T_1 showed the highest value (0.11%) but T_4 and T_5 gave negative balance. C sequestration was estimated the highest in T_1 (3.83 t/ha) followed by T_2 (3.37 t/ha) and T_3 (2.93 t/ha) while others (T_4 and T_5) showed negative values. The results expressed that addition of crop residues as well as organic C in soil enhanced C balance or C sequestration in soil. Changes of total N in soil in Potato-Maize-T. *aman* rice cropping pattern has been given. Treatments, T_1, T_2 and T_3 showed positive balance of total N in soil while T_1 showed the highest value (0.028%). Negative balance of total N in soil was noticed in T_4 and T_5. Addition of crop residues enhanced slightly positive balance of total N in soil. The other nutrients also showed positive balance in T_1, T_2 and T_3 over initial values. Addition of crop residues into soil improves soil nutrient status. The results expressed that addition of crop residues as well as organic C in soil enhanced C balance or C sequestration in soil. The experiment need to be repeated several years for estimation of long term effect.

Physiological aspects of hybrid maize squash intercropping

The experiment was conducted at the research field of Agronomy Division, BARI, Joydebpur during rabi season of 2018-19 and to find and observe the physiological basis of yield formation and productivity. The soil of the experimental field of Joydebpur was silty loam in texture with pH 5.8 belonging to Chhiata series under AEZ-28. The soil was low in organic matter and deficient in total nitrogen, exchangeable potassium and available sulphur. Available phosphours was low in Joydebpur. Six treatment combinations evaluated were: T_1= Maize normal row (75 cm ×25 cm) +1 row squash (Pt to pt 100 cm) in between two maize rows with 275-85-135-55-5-2 kg/ha of NPKSZnB, T_2= Maize normal row (75 cm ×25 cm) +1 row squash (Plant to plant 100 cm) in between two maize rows with 300-95-150-60-6-2 kg/ha of NPKSZnB kg/ha, T_3 = Maize paired row (37.5/150/37.5 cm×25 cm)+ two row squash (Plant to plant 80 cm) between two paired row of maize with 275-85-135-55-5-2 kg/ha, T_4= Maize paired row (37.5/150/37.5 cm×25 cm)+ two row squash (Plant to plant 80 cm) between two paired row of maize with 300-95-150-60-6-2 kg/ha of NPKSZnB kg/ha, T_5 = Sole maize (75 cm ×25 cm) T_6 = Sole

squash (100 cm × 80 cm). The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 5.0 m x 4.5.0 m. The hybrid maize (var. BARI Hybrid maize-9) and squash (Bulum house) were used in this intercropping experiment. Seeds of maize and squash were sown on November 19. The seeds were treated with provox at the rate of 3 g per kg of seed. The 1/3 amount of all fertilizer were used for maize and rest amount of fertilizer were used for squash. In case of maize the full amount of P, K, S,Zn, B and $^{1}/_{3}$N were applied as basal in the form of triple super phosphate, muriate of potash, gypsum, zinc sulphate, boric acid and urea, respectively. The remaining N was top dressed in two equal splits at 30 and 60 days after sowing (DAS) maize rows. In case of squash except urea and MoP, full amount of other fertilizer were applied in pit and urea and MoP were applied in two equal split at 7 and 20 days after transplanting as ring method. Three irrigations were applied at 30, 60 and 90 DAS. Two hand weeding were done at 20 and 40 DAS to keep the crops reasonably weed free. Light availability was measured by par Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). Yield components of maize and squash were taken from randomly selected 10 plants from each plot. Maize was harvested at 145 DAS. Squash harvesting started from 65 DAS. Yields of both the crops were taken from whole plot. Equivalent yields were computed by converting yield of intercrop on the basis of prevailing market price of individual crop using the formula of Bandyopadhaya (1984). Data on yield and yield components of both the crops were analyzed statistically and the means were adjudged using LSD. Economic analysis was also done. The highest yield of maize and squash was observed in sole plot. In intercropping system T_4 and T_2 gave the identical highest yield of maize and squash gave the highest yield maize planted in paired row with two rows of squash in between maize rows. T_4 gave the highest maize equivalent yield (17.32 t/ha), gross return (TK.207840/ha) and benefit cost ratio (2.05). The results revealed that Maize paired row (37.5/150/37.5 cm×25 cm) + two row squash (Plant to plant 80 cm) between two paired row of maize with 300-95-150-60-6-2 kg/ha of NPKSZnB kg/ha might be economically feasible for maize-squash intercropping system.

Jute intercropping as vegetable with hybrid maize under different planting systems

The field experiment was conducted at Agronomy research field, Joydebpur and Regional Agricultural Research Station, Jamalpur of Bangladesh Agricultural Research Institute during kharif season of 2018 to find out suitable combination of maize and jute (vegetable) intercropping system for higher productivity, nutritional security and monetary advantage. Treatments were: T_1= Hybrid maize normal row (MNR) (60cm ×20cm) +1row jute (33%), T_2= MNR (60cm ×20cm) +2 row jute (66%), T_3= MNR (60cm ×20cm) +3 row jute (100%), T_4= MNR (60cm ×20cm) + jute broadcast (100%), T_5= Sole maize (60 cm × 20 cm) and T_6= Sole jute as leafy vegetable (20 cm × continuous sowing). The experiment was laid out in a randomized complete block design with three replications and the unit plot size was 6m × 5m. Hybrid maize (BARI Hybrid maize-9) and jute (Binapatshak-1) were used in both locations. Seeds of both crops were sown on 10 March, 2018 at Joydebpur and on 5 March, 2018at Jamalpur. The seeds of both crops were treated with provex @ 3 g/ kg seed in both locations. Fertilizers were applied @ 250-76-121-72-5-1 kg/ ha of N, P, K, S, Zn, B (BARC, 2012) as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid for sole maize and intercrop. One third of N, whole amount of TSP, MoP, gypsum, zinc sulphate and boric acid were applied as basal. Remaining 2/3 N was top dressed at 20 and 40 days after sowing (DAS) of maize. In intercrop, extra N (40 kg/ ha) was applied in at 20 DAS as side dress to jute. Sole jute was fertilized at the rate of 30- 5-20 kg/ ha of N, P, K. Two third of N and all other fertilizers were applied as basal. Rest N was applied at 20 DAS in both locations. Light availability or Photo synthetically active radiation (PAR) was measured only at Joydebpur location by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). LP-80 has an 80 cm long sensor, which is usually used for below canopy measurement. Another optional quantum sensor can be used for above canopy measurement through a cable connection. So, simultaneous measurement of PAR at above and below canopy is possible with this instrument. The respective sensors were simultaneously installed above and below of the canopy (10 cm above the soil surface) for incident PAR (PARinc) and transmitted PAR

(PARt), respectively. The PAR was measured at 5-day intervals from 25 to 40 DAS at around 11:30 am to 13:00 pm. Four readings each of PARinc and PARt were recorded at different spots of each plot. The proportion of intercepted PAR (PARint) was calculated using the following equation and expressed in percentage (Ahmed et al., 2010):

Light availability {PARint (%)} = $\frac{\text{PARinc} - \text{PARt}}{\text{PARinc}} \times 100$

Data on yield contributing characters of maize were taken from randomly selected 5 plants from each plot. Yields of both crops were taken from whole plot area in both locations. Maize was harvested on 28 June 2018and jute/patshak was harvested on 20 April 2018 at Joydebpur. On the other hand, maize was harvested on 3 July 2018 and patshak was harvested on 15 April 2018 at Jamalpur. In both locations, maize equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below: Maize equivalent yield = Yim + (Yij×Pj)/ Pm;

Where, Yim = Yield of intercropped maize, Yij = Yield of intercropped jute, Pm = Market price of maize and Pj = Market price of jute.

Land equivalent ratio (LER) was obtained according to Willey (1979) as follows:

$$\text{LER} = \frac{\text{Yield of maize as intercrop}}{\text{Yield of maize as sole crop}} + \frac{\text{Yield of jute as intercrop}}{\text{Yield of jute as sole crop}}$$

Collected data of both the crops were analyzed statistically and the means were adjudged by using 5% level of LSD test. Economic analysis was also done considering local market price of harvested crops. Light availability on jute decreased with the increase of shade produced by maize canopy over the time up to 40 DAS (at harvest of jute). The lowest light availability on jute was observed at 40 DAS in T_4 (MNR+ jute broadcast) treatment followed by T_3 treatment and the highest light availability was observed in sole jute treatment followed by T_1 treatment. The maximum grain yield of maize was in sole crop and it was decreased 1-7 % at Joydebpur and 2-9 % at Jamalpur due to interspecific competition for growth resources among maize and jute (leafy vegetable) intercropping. Maize equivalent yield (MEY) of intercropping treatments showed better performance than sole maize. The highest MEY (16.40 t/ ha at Joydebpur and 16.69 t/ha at Jamalpur), gross margin (Tk197700/ha at Joydebpur andTk203370/ha at Jamalpur) and benefit cost ratio (3.08 and 3.10 at Joydebpur and Jamalpur, respectively) were observed in T_4= MNR (60cm ×20cm) + jute broadcast (100%) treatment followed by T_3. The highest Land equivalent ratio (LER) (1.78 at Joydebpur and 1.72 at Jamalpur) was also found in the same treatment. The results revealed that T_3= MNR (60cm ×20cm) +3 row jute (100%) and T_4= MNR (60cm ×20cm) + jute broadcast (100%) might be agronomically feasible and economically profitable for maize and jute (leafy vegetable) intercropping system at Joydebpur and Jamalpur.

Performance of intercropping garden pea with sorghum

The field experiment was conducted at Agronomy research field, Joydebpur and RARS, Burirhat, Rangpur, Bangladesh Agricultural Research Institute during rabi season of 2018-2019 to find out suitable combination of sorghum and gardenpea intercropping for higher productivity and monetary advantage. Treatments included in the experiment were: T_1= Sorghum normal row (SNR) +1 row gardenpea (GP) (100%Sorghum+44% GP),T_2=SNR +2 row GP (100% Sorghum +88% GP),T_3= Sorghum paired row (SPR) +2 row GP (100%Sorghum+38% GP),T_4=SPR +3 row GP (100%Sorghum+56% GP), T_5=SPR +4 row GP (100%Sorghum+75% GP),T_6=Sole sorghum (60 cm × 20 cm) and T_7=Sole GP (30 cm × 15 cm). The experiment was laid out in a randomized complete block design with three replications and the unit plot size was 6m × 5m. Local sorghum variety and BARI Motorshuti -3 was used in the experiment for both locations. Sorghum and gardenpea seeds were sown on same day. Seeds were sown on 22 November 2018 at Joydebpur and 15 November 2018 at Burirhat. The seeds of both crops were treated with provex @ 3g/ kg of seed in both locations. Fertilizers were applied at the rate of 120-48-75-30-3-1kg/ha of N, P, K, S, Zn, B as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid for sole maize and intercrop. One third of N, whole amount of TSP, MoP, gypsum, zinc sulphate

and boric acid were applied as basal. Remaining 2/3 N was top dressed at 25 and 45 days after sowing (DAS) of sorghum. In intercrop, extra N (40 kg/ ha) was applied in 2 splits at 25 and 45 DAS to sorghum. Sole gardenpea was fertilized @ 48- 24-30-12-1 kg/ ha of N, P, K, S and Zn. One third of N and all other fertilizers were applied as basal. Rest N was applied in 2 splits at 20 and 40 DAS in both locations. Light availability or Photo synthetically active radiation (PAR) was measured only at Joydebpur location by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). LP-80 has an 80 cm long sensor, which is usually used for below canopy measurement. Another optional quantum sensor can be used for above canopy measurement through a cable connection. So, simultaneous measurement of PAR at above and below canopy is possible with this instrument. The respective sensors were simultaneously installed above and below of the canopy (10 cm above the soil surface) for incident PAR (PARinc) and transmitted PAR (PARt), respectively. The PAR was measured at 10-day intervals from 30 to 60 DAS at around 11:30 AM to 13:00 PM. Four readings each of PARinc and PARt were recorded at different spots of each plot. The proportion of intercepted PAR (PARint) was calculated using the following equation and expressed in percentage (Ahmed et al., 2010):

Light availability {PARint (%)} = $\frac{\text{PARinc} - \text{PARt}}{\text{PARinc}} \times 100$

Data on yield contributing characters of sorghum were taken from randomly selected 5 plants from each plot. Yields of both the crops were taken from whole plot area in all the locations. Sorghum was harvested on 4 April, 2019 and gardenpea was harvested 2 times on 20 and 28 January, 2019 at Joydebpur. On the other hand, sorghum was harvested at Burirhaton 5 April, 2019 and gardenpea was harvested 2 times on 25 January and 2 February, 2019. In both locations, SEY was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below: Sorghum equivalent yield = Yis + (Yigp×Pgp)/ Ps;

Where, Yis = Yield of intercropped sorghum, Yigp = Yield of intercropped gardenpea,

Ps = Market price of sorghum and Pgp = Market price of gardenpea.

Land equivalent ratio (LER) was obtained according to Willey (1979) as follows:

$$\text{LER} = \frac{\text{Yield of sorghum as intercrop}}{\text{Yield of sorghum as sole crop}} + \frac{\text{Yield of jgardenpea as intercrop}}{\text{Yield of gardenpea as sole crop}}$$

Collected data of both the crops were analyzed statistically and the means were adjudged using $LSD_{(0.05)}$ test. Economic analysis was also done considering local market price of harvested crops.

Light availability on gardenpea decreased with the increase of shade produced by sorghum canopy over the time up to 60 DAS or up to harvest of gardenpea. The lowest light availability on gardenpea was observed at 60 DAS in SNR + 2 row gardenpea (T_2) followed by T_1 treatment and the highest light availability was observed in sole gardenpea (T_7) followed by T_3 treatment. The maximum grain yield of sorghum was observed in sole crop and it was decreased 6-10 % at Joydebpur and 5-11 % at Burirhat due to interspecific competition for growth resources among sorghum and gardenpea intercropping. Sorghum equivalent yield (SEY) of intercropping treatments showed better performance than sole sorghum. The highest SEY (10.93 t/ha at Joydebpur and 12.06 t/ha at Burirhat), gross margin (Tk 69100/ha at Joydebpur and Tk 82400/ha at Burirhat) and benefit cost ratio (BCR) (2.72and 3.16 at Joydebpur and Burirhat, respectively) were observed in T_5= SPR + 4 row GP (100% Sorghum + 75% GP). The highest Land equivalent ratio (LER) (1.32 at Joydebpur and 1.33 at Burirhat) was also found in the same treatment. The results revealed that T_5= SPR +4 row GP (100%Sorghum+75% GP) might be agronomically feasible and economically profitable for sorghum + gardenpea intercropping system at Joydebpur and Burirhat region.

Intercropping spinach and red amaranth with brinjal under different planting system

An experiment was conducted at the Agronomy research field of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, during 2018 to 2019 to find out the suitable crop combination of spinach and red amaranth with brinjal for increasing total productivity, economic return and maximize land utilization through intercropping system. The soil was silty clay loam with pH 6.3 belonging to Agro Ecological Zone (AEZ) 28. The treatments were:

T_1 = 2 row Spinach (50%) in between two row of brinjal (100%), T_2 = 3 row Spinach (75%) in between two row of brinjal (100%), T_3 = 2 row red amaranth (50%) in between two row of brinjal (100%), T_4 = 3 row red amaranth (75%) in between two row of brinjal (100%),T_5 = Sole brinjal (80 cm × 60 cm), T_6 = Sole spinach (Line to line 20 cm) and T_7 = Sole red amaranth (Line to line 20 cm). The experiment was set up in a randomized complete block design with three replications. The unit plot size was 4.2 m × 3.2 m. The sole crop of brinjal and intercropped treatments were fertilized with cow dung @ 5 t/ha and 120-31-120-13-3-1.5 kg/ha N-P-K-S-Zn-B. For sole brianjal and intercrop full amount of all other fertilizer except N and K were applied in pit before one week of transplanting brinjal. N and K were applied in three equal splits at 21, 40 and 60 days after transplanting (DAT) brinjal as ring method followed by irrigation. Sole spinach fertilized with 50-13-18-5 kg/ha N-P-K-S. Half of N and all other fertilizers were applied at the time of final land preparation and rest N was applied at 10 days after emergence (DAE) of spinach and sole red amaranth fertilized with 78- 18- 35- 4kg/ha N-P-K-S. Half N and all other fertilizers were applied at the time of final land preparation and rest N will be applied at 10 DAE of red amaranth (FRG, 2012). Brinjal (Var. BARI Begun-8) was use as main crop and red amaranth (var. BARI Lalshak-1) and spinach (var. BARI Spinach-1) were used as intercrops in this study. The sole crop of brinjal was planted at a spacing of 80 cm × 60 cm. In intercropping system two rows of spinach (50%), three rows of spinach (75%), two rows of red amaranth (50%) and three rows of red amaranth (75%) were intercropped in between two rows of brinjal. After establishment of brinjal seedling (12 days after planting) spinach and red amaranth seeds were sown as per treatments. Brinjal (Thirty days old seedling) was transplanted on 29 November, 2018 and seed of spinach and red amaranth sown on 11 December 2018, respectively. Brinjal was harvested four times and it was harvested on 04 March, 2019, 18 March, 2019, 03 April 2019 and 21 April, 2019. Spinach and red amaranth were harvested on 21 January, 2019. Four irrigations were done in the experimental field. First was applied at just after transplanting (brinjal) and sowing (component crop) of the crops for proper germination. Second, third and fourth irrigation was applied at 45, 60 and 90 days after transplanting (DAT) of brinjal. Weeding was done as can when necessary. Sex pheromone trap was used for control of brinjal, shoot and fruit borer from active vegetative stage up to fruit developing stage. For brinjal data on yield and yield contributing characters were taken and analyzed statistically. The yield component data of brinjal was taken from 10 randomly selected plants prior to harvest from each plot. For brinjal, spinach and red amaranth at harvest, the yield data was recorded plot wise. The collected data were analyzed statistically using MSTAT-C package and means were adjudged by LSD test at 5% level of probability. Brinjal equivalent yield (BEY) was converted by converting yield of intercrops on the basis of market price of individual crop according to formula. Results showed that different intercropping combination significantly influenced yield and yield contributing characters of brinjal. The yield of brinjal comparatively lower in intercropping but total productivity increased due to additional yield of spinach and red amaranth. Increased total productivity in terms of brinjal equivalent yield (BEY) was 26.97 to 35.17 t/ha in intercrop combination compared to sole brinjal 21.14 t/ha (main crop). All the intercropping combinations showed better performance in terms of brinjal equivalent yield, gross return and benefit cost ratio (BCR) over sole crops. Among the intercropping combinations, 3 row Spinach (75%) in between two row of brinjal (100%) was the most feasible and profitable intercropping system in respect of brinjal equivalent yield (35.17 t/ha), gross return (Tk. 5,27,585 /ha), gross margin (Tk. 3,74,296 /ha) and benefit cost ratio (3.44).

Long term effect of four crop based cropping pattern on soil health and crop productivity

The experiment was conducted at the research field of Agronomy Division BARI, Joydebpur, Gazipur (AEZ 28), during *rabi* season of 2017-18 to increase cropping intensity and productivity in rice based cropping pattern along with observing soil health. Four treatments of cropping sequence were: CP_1 = Mustard-Mungbean-T. *Aus*-T.aman; CP_2= Potato-Mungbean-T. *Aus* – T.*Aman*; CP_3 = Garden pea-Mungbean-T. *Aus*-T.*Aman*; CP_4 = Potato-Lalshak–Maize-T.*Aman*. The unit plot size was 5 m x 4m. Potato tubers (cv. Diamant) were planted in rabi season with 60 cm × 25 cm spacing and recommended fertilizers (@ 330-200-280-100-8-6 kg/ha urea-TSP-MP-gypsum-zinc sulphate-boric acid respectively). Mustard (BARI Sarisha-14) was

grown during *rabi* season. Mustard was sown with 30 cm x 5 cm spacing and fertilizers were applied @ 280-170-90-160-6-10 kg/ha urea-TSP-MP-gypsum-zinc sulphate-boric acid respectively. Garden pea (BARI Motorshuti-3) was grown during *rabi* season with 30 cm x 5 cm spacing and recommended fertilizers were applied (@ 30-80-40-50-7 kg/ha urea-TSP- MP- gypsum-boric acid respectively). Red amaranth (BARI Lalshak-1) was broadcasted during early *Kharif*-I season. Mungbean was grown during *Kharif*-I season with recommended fertilizer (Urea-TSP-MP @ 40-80-35-115 kg/ha) and sown in continuous line with 30 cm row to row spacing. Maize (BARI hybrid maize 15) was sown during *kharif* season with recommended fertilizers (Urea-TSP- MP-Gypsum-Boron @ 250-130-90-125-8 kg/ha) 60 cm × 20 cm spacing. Transplanted aus (Parija) rice was transplanted (twenty five days aged seedling) with 15cm × 15 cm spacing and fertilized with urea, TSP, MoP @ 135-55-85 kg/ha respectively. T.*Aman* (BRRI dhan 62) rice was grown during *Kharif* II season and was transplanted with 20cm x 15cm spacing. All intercultural operation was done as per recommendation and requirement. The results showed that four crops may be grown successfully one after another in a sequence in all the cropping patterns. The highest REY was recorded from the cropping sequence CP_4 (37.99 t/ ha). The highest gross margin was obtained from CP_3 (Tk. 541506/ha) followed by CP_1 (Tk. 532128/ha). The highest BCR was found in CP_1 (5.96) followed by CP_3 (5.77) and it might be due to lower cost of production. Soil nutrient status remains almost unchanged. Long term experimentation is mandatory to find out changes in soil nutrient status due to intensive cultivation.

Estimation of nutritional security from different cropping pattern

The experiment was conducted at the research field of Agronomy Division BARI, Joydebpur, Gazipur (AEZ 28), during *rabi* season of 2017-18 to increase cropping intensity and productivity in rice based cropping pattern along with maintaining nutritional security. Four treatments of cropping sequence were: CP_1 = Lentil-Maize-T. aman; CP_2= Lentil-Red amaranth-Mungbean-T. aman; CP_3 = Wheat-Red amaranth-Mungbean-T. aman; CP_4 = Wheat-Mungbean-T. aman. The experiment was laid out in a RCB design with 3 replications. The unit plot size was 5 m x 4m. Lentil (BARI lentil 6) was grown during *rabi* season. Full amount of fertilizer applied (Urea-TSP- MP-Gypsum-Boron @ 40-80-35-50-8 kg/ha) were applied at the time of final land preparation. Lentil was sown in continuous line with 30 cm row to row spacing. Wheat (BARI Gom 30) was sown during *rabi* season with fertilizer doses urea-TSP-MP-gypsum-boron @ 160-140-100-115-6 kg/ha and sown in continuous line with 20 cm row to row distance. Red amaranth (BARI lal shak-1) was broadcasted during late *rabi* season. Mungbean was sown during *Kharif*-I season with recommended fertilizer (Urea-TSP- MP @ 40-80-35-115 kg/ha) in continuous line with 30 cm row to row spacing. Maize (BARI hybrid maize 15) was sown during *kharif* season with recommended fertilizers (Urea-TSP- MP-Gypsum-Boron @ 250-130-90-125-8 kg/ha) 60 cm × 20 cm spacing. T.aman (BRRI dhan 62) rice was grown during *Kharif* II season and was transplanted with 20cm × 15cm spacing. Intercultural operations were done as per recommendation and requirement. The highest REY (28.56 t/ ha) and gross return (Tk. 513920 /ha) gross margin was also obtained from CP_2 (Tk. 430680 /ha). The maximum BCR was found in CP_2 (6.17). The highest amount of calorie was obtained from CP_1 (7802460 calorie/ha). The highest amount of calorie gained per taka cost was found in CP_4 (75.87 calorie/taka) followed by CP_1 (74.94 calorie/taka). Although CP_2 produce the height BCR, CP_4 is the best in terms of cost per calorie due to the lower cost of cultivation. CP_1 produce the second highest calorie per taka and also the highest total calorie content. So CP_1 (Lentil-Maize-T. aman) may be recommended for nutritional security of Bangladesh.

Relay intercropping of different gourds with brinjal

A field experiment was conducted to find out the suitable combination of relay intercropping of different gourds with brinjal for higher productivity and economic return at the Regional Agricultural Research Station, Jamalpur during *rabi* and *kharif* 2017-2018. The experiment was laid out in randomized complete block design (RCBD) with three (3) replications and seven treatments. The treatments were T_1= Sole brinjal, T_2= Brinjal + relay sweet gourd, T_3= Brinjal + relay ridge gourd, T_4= Brinjal + relay bitter gourd, T_5= Brinjal+ relay

sponge gourd, T_6= Brinjal + relay snake gourd, T_7= Brinjal + relay ash gourd. Highest brinjal yield was observed in brinjal + relay snake gourd combination which was statistically similar to sole brinjal and brinjal + relay ash gourd combination. In relaying intercropping sysytem different gourds yield was perform satisfactory, less cost and less total duration time.

Performance of potato - potato / maize / mung - t. aman rice cp against potato - maize - t. aman rice cropping pattern

An observation trial was conducted at Kisorganj, Nilphamari, RARS, BARI, Burirhat, Rangpur with compare to farmer existing cropping pattern to find out the suitability of the cropping pattern in the region and the productivity to increase the production per unit area per unit time during *rabi* season 2017-18 and 2018-19. The tuber yield of only two potato crops was recorded 47.53 t/ha from New CP. and 25.50 t/ha from FP CP and extra yield as come from mungbean which yield was 780 Kg / ha and extra benefit for soil fertility with incorporated of soil.

Nutrient management on potato realay with maize cropping in Rangpur region

A field trail was conducted at RARS, Burirhat, Rangpur with five cropping pattern and the better pattern and the best fertilizer dose and economic return after potato harvest of these areas through relay cropping pattern during *rabi* 2018-19.The yield of potato was recorded 47 to 49 t/ha^{-1} due to same fertilizer use. But, after potato harvest, the highest maize grain yield (12.10 t/ha^{-1} and 11.73 t/ha^{-1} of BARI hybrid maize-9) was shown full potato dose + 100 % Maize fertilizer dose and full potato dose + 80% Maize fertilizer dose. The lowest grain yield (7.80 t/ha^{-1}) was recorded from Full potato dose + only N (1 Kg cm^{-1}) farmer's fertilizer dose.

Improvement of cropping intensity through realy yard long bean in maize+ bush bean (Khaissa) intercropping

A field trail was conducted at RARS, BARI, Burirhat, Rangpur to observe the performance of relay yard long bean in maize-bush bean intercropping to increase the total productivity. To improve the cropping system through relay yard long bean in maize + bush bean during Rabi season 2018-19. There I no significant difference in maize equivalent yield from maize paired row+4 row french bean relayed with yard long bean, maize single row+2 row french bean relayed with yard long bean and maize single row +Single row franch bean with relay yard long bean. The lowest maize equivalent yield (11.50 t/ha) was recorded from sole maize.

Development of alternate cropping pattern against Tomato-Fallow- T. *aman* rice in medium high land of Dinajpur

The experiment was carried out at the research field of Agricultural Research Station, Rajbari, Dinajpur during *rabi* season of 2017-18 to develop an economically sustainable and profitable cropping pattern over existing pattern. Three alternate cropping patterns Tomato-T.*Aus*-T.*Aman*, Tomato-Summer onion-T.*Aman*, Tomato-Indian Spinach-T.*Aman* were introduced against the existing cropping pattern Tomato-Fallow-T.*Aman* rice. The experiment was carried out in RCB design with three dispersed replications. Grain yield of rice, fruit of tomato, bulb of summer onion and leaves of Indian Spinach were satisfactory. The highest rice equivalent yield was obtained from the alternate cropping pattern Tomato-T.*Aus* rice-T.*Aman* rice. The gross return and gross margin were higher in the alternate cropping patterns compared to existing cropping pattern due to additional yield of T. *Aus* rice, Summer Onion and Indian Spinach. So, crop cultivation in alternate cropping pattern would help to increase total production, farmer's income, employment opportunity and livelihood improvement.

Development of vegetable based cropping pattern for increasing cropping intensity and ensuring nutrition

In the context of developing vegetable based cropping patterns and ensuring nutrition, a field experiment was conducted at the Regional Agricultural Research Station, Jessore, Bangladesh during 2018-19 consecutive years. The objectives of this study were i) to find out the suitable cropping pattern based on vegetable for higher productivity and nutrition and ii) to estimate economic return of vegetable based cropping patterns. The cropping patterns were as follows: CP_1= Transplanted *Aman* rice (BRRI dhan75) - Spinach (local)-Gardenpea (BARI Motorshuti-3)-

Mungbean (BARI Mung-6)-Transplanted *Aus* rice (BINA dhan19); CP_2=T. *Aman* rice- Spinach-Gardenpea-Yardlong bean (Aduri)-T. *Aus* rice; CP_3= T.*Aman* rice-Cauliflower (Snowball)-Spinach-Yard long bean-T. *Aus* rice; CP_4= T. *Aman* rice-Coriander (BARI Dhonia-1)-Gardenpea-Mungbean-T. *Aus* rice; CP_5= T. *Aman* rice-Cauliflower-Spinach-Mungbean-T. *Aus* rice; CP_6 =T. *Aman* rice-Cabbage (Atlas70)-Spinach-Yard long bean-T. *Aus* rice and CP_7= T. *Aman* rice-Cauliflower-Mungbean-T. *Aus* rice (Farmer's practice). These cropping patterns (CP_1, CP_2, CP_3, CP_4 & CP_5) are composed with five crops; and last cropping pattern CP_6 is used as farmer's practice (control) to compare with the other five cropping patterns. The results showed that five crops may be grown successfully one after another in a sequence in all the nutrition enriched crop and vegetable based cropping patterns. The average highest REY 31.8 t/ha^{-1} was recorded from the cropping sequence T. *Aman* rice-Cauliflower-Spinach-Yard long bean-T. *Aus* rice (CP_3) which was followed by T. *Aman* rice-Cabbage (Atlas70)-Spinach-Yard long bean- T. *Aus* rice (31.3 t/ha) and T. *Aman* rice-Cauliflower-Spinach -Mungbean - T. *Aus* rice (27.3 t/ha^{-1}). The average lowest REY (14.2 t/ha^{-1}) was obtained from the cropping sequence T. *Aman* rice-Spinach-Gardenpea -Mungbean-T. *Aus* rice (CP_1).

Estimation of temperature co-efficient of wheat for adjusting proper sowing time

The field experiment was conducted at Agronomy research field, Joydebpur, Gazipur, RARS, Jamalpur and ARS, Rajbari, Dinajpur of Bangladesh Agricultural Research Institute, during rabi of 2018-2019 to observe the growth behavior and yield of wheat as influenced by prevailing air temperature as well as other weather elements based on sowing time. The treatments were five sowing dates: D_1= 10 November, D_2 =20 November, D_3 = 30 November, D_4=10 December and D_5=20 December. The soil was silty clay in texture at Joydebpur (AEZ-28), silty loam at Jamalpur (AEZ-9) and sandy loam at Rajbari (AEZ-1). The experiment was laid out in a RCB design with three replications and the unit plot size was 5m × 4m in all locations. Wheat seeds were sown as per treatment in line with maintaining 20 cm row to row spacing. Fertilizers were applied @ 120-30-90-15-3-1 kg/ ha of N-P-K-S-Zn-B respectively (BARC, 2012), in the form of urea, TSP, MoP, gypsum, zinc sulphate and boric acid. Two third of urea and full doses of other fertilizers were applied at the time of final land preparation. The remaining one third of urea was top dressed at CRI stage followed by irrigation at all locations. Data on growth parameters like leaf area and dry matter accumulation were measured at different dates with 15 days interval at Joydebpur location. To record dry matter weight and leaf area, one linear meter was sampled at 15, 30, 45, 60, 75, 90 DAS and at harvest. Different plant parts of the collected samples were separated and then oven dried at 80^{0}C for 72 hours. Leaf area was measured by an automatic leaf area meter (L13100 c, L1COR, USA). Daily air temperatures were recorded for computing the growing degree days (GDD). The GDD was calculated using the following formula:

$$GDD = \sum \frac{T\max + T\min}{2} - T_{base}$$

Where, T_{max} and T_{min} are daily maximum and minimum air temperatures, respectively. T_{base} indicated base temperature of wheat (5^{0}C). The GDD can be summed over days to indicate the amount of heat for growth that the crop has received over the period of the growing season (Kumar et al., 2008).

For estimation of physiological maturity and grain growth study, five spikes were harvested from each plot after anthesis starting from 5 days after anthesis at four days interval. It was continued up to 32 days after anthesis (DAA). The harvested spikes were oven dried at 70°C for 72 hours. Twenty grains of each spike were separated from the middle of each spike and then weight was taken. The crop was harvested at physiological maturity. Yield contributing characters were recorded from one linear meter at the time of harvest. Yield data were recorded by harvesting ten square meter area excluding border. Collected data was analyzed statistically following MSTAT-C software package and means were compared using LSD test at 5% level of significance. Sowing date showed great influence on total dry matter (TDM) production, leaf area index (LAI), physiological maturity, yield and yield components of wheat. The 30 November sowing produced the maximum TDM and LAI followed by 20 November sowing.

These parameters finally contributed to higher grain yield than earlier and later sowing date. The 30 November sowing took the longest period (105 days, 106 days sand 109 days at Joydebpur, Jamalpur and Rajbari, respectively) to attain the physiological maturity with the highest GDD (1639, 1638 and 1640 at Joydebpur, Jamalpur and Rajbari, respectively) and 20 December sowing took the shortest period (95 days, 96 days and 98 days at Joydebpur, Jamalpur and Rajbari, respectively) to attain the physiological maturity with the lowest GDD (1530, 1528 and 1525 at Joydebpur, Jamalpur and Rajbari, respectively). It was also observed that 30 November sowing produced the higher grain yield (4.90 t/ha, 4.99 t/ha and 5.03 t/ha at Joydebpur, Jamalpur and Rajbari, respectively).The results revealed that 20-30 November sowing produced higher grain yield might be due to favourable air temperature for growth and development. Late sowing after November 30 produced lower grain yield due to high temperature prevailed at the later growth stage (March) of wheat at Joydebpur, Jamalpur and Rajbari region. The results revealed that physiological maturity period as well as crop duration of wheat was reduced as influenced by higher temperature. The 20 November to 30 November sowing would be the optimum sowing date for wheat in relation to air temperature and early or late sown caused about 17-36% yield reduction. Temperature co-efficient of wheat was estimated at 2.41 t/ha per increasing 1^0C air temperature and the effect of temperature on grain yield of wheat was estimated at 81-84%.

Drought tolerance and root system analysis of some selected sesame genotypes

The experiment was conducted in pot house of Agronomy division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh during the period from March, 2019 to June, 2019 (*Kharif* season).This experiment, was conducted to screen out the best genotype(s) among the previously selected genotypes. On the basis of drought tolerance capacity, selected 4 genotypes (three-tolerant and one susceptible) from 88 genotypes were used in this experiment. These are; BD-7015, BD-7018, Jp-202, Jp-158.The experiment was set in pot with five replications. The pot was filled with 14 kg air dried soil including cowdung at a ratio of 4:1. The experimental pots were fertilized with 1.54, 0.45, 1.54, 0.14, 0.07, 0.035 g urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum, zinc sulphate and boron, respectively corresponding to 220, 65, 220, 20, 10, 5 kg/ha^{-1} urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum, zinc sulphate and boron. Six healthy seeds per pot were sown on 11 March 2019. Post sowing irrigation was applied for ensuring seed germination. Drought were imposed at 21 days after emergence. Drought stress was induced by withholding water completely. The treatment was continued until symptom of wilting persisted throughout the night. After that they were re-watered. In normal condition water was applied when it was needed. All the intercultural operations was same except irrigation both in normal and drought condition. Five plants from each genotype were selected to record data. Different formula was used to calculate the result. The result revealed that all four genotypes of sesame showed better performance in rain fed condition but BD-7018, Jp-158, Jp-202 showed promising result in drought and normal condition. Among them, genotype BD-7018 showed better performance against all parameter under drought. This genotype also produced highest yield under drought. On the basis of above result it could be concluded that genotypes BD-7018, Jp-158, Jp-202 can be recommended for cultivation in drought region. BD-7015 was less suitable for cultivation under drought condition.

Limited water management in sweet gourd cultivation

The experiment was conducted at the research field of Agronomy Division, BARI, Joydebpur during rabi season of 2018-19 to develop irrigation scheduling for sweet gourd in dry/upland area of Bangladesh and also to reduce the cost for irrigation water in sweet gourd cultivation. Treatments were as T_1 = Four irrigations at 10 DAT + 35 DAT +55 DAT +75 DAT,T_2 = Limited water use with two inlet at 10 days interval upto 25 days before harvest,T_3 = Limited water use with three inlet at 10 days interval upto 25 days before harvest, T_4 = Limited water use with two inlet at 15 days interval upto 25 days before harvest,$T_{5=}$ Limited water use with three inlet at 15 days

interval upto 25 days before harvest and T_6 = No irrigation (control).The experiment was laid out in a RCB design with 3 replications. The unit plot size was 4m × 4m. BARI Misti kumra-1 was used in this experiment. Thirty days old seedlings of sweet gourd were transplanted on 29 November, 2018 and pipe was setting on 27 November, 2018. Fertilizers @ 80-36-100-24-2-2 kg/ha NPKSZnB and cowdung applied 5 t/ha were applied in field. Chemical fertilizers were used in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. All of organic manure and PSZnB were applied in pit at 7 days before transplanting of sweet gourd seedlings while urea and MoP were side dressed in two equal splits at 15 and 35 DAT. The results revealed that the highest sweet gourd yield (28.92 t/ha) was recorded in T_1 (Four irrigations at 10 DAT + 35 DAT +55 DAT +75 DAT upto harvest) treatment. Among the limited water treatments, T_5 (Limited water use with three inlet in 15 days interval upto 25 days before harvest) treatment produced the highest yield ((27.41t/ha).This treatment showed more chlorophyll content and dry matter accumulation. Higher IWUE (0.24) was recorded in T_5 (Limited water use with three inlet at 15 days interval upto upto25 days before harvest) and the lowest (0.09) in T_1 (Four irrigations at 10 DAT + 35 DAT +55 DAT +75 DAT) treatment. The highest gross return (Tk. 289200.00 ha^{-1}), gross margin (Tk. 179699.00 ha^{-1}) and BCR (2.64) were obtained from T_1 (Four irrigations at 10 DAT + 35 DAT +55 DAT +75 DAT upto harvest) treatment. Though the highest BCR was recorded in T_1 treatment but it required higher irrigation water. Whenever T_1 and T_5 produced identical yield, respectively. Morever, T_5 required less water as compared to T_1.On economic point of view, farmers can take limited water use with three inlet at15 days interval upto 25 days before harvest for efficient utilization of water. From the study it concluded that limited water use with three inlet at 15 days interval upto 25 days before harvest (T_5) would be most effective for irrigation water use efficiency and maximize the yield.

Response of growth regulator to groundnut in charland area

The experiment was conducted at the charland area of Jamalpur during *rabi* 2017 to find out the suitable growth regulator for groundnut in char land. Treatments included in the experiment were: T_1=Flora (Nitrobenzene, ACI), T_2=Nafa (Entefa), T_3=Maxsulphar (Sulfer-80%, Mcdonald), T_4= Alba (Avamectin-1.8 EC, SAMP Limited), T_5 = Calsol and T_6=Control (without growth regulator). Growth regulator were applied Flora (2 ml/L), Nafa (2.5 ml/L), Maxsulphar (2 ml/L), Alba (0.5 ml/L), Calsol (3 ml/L) as foliar spray at 35 and 45 days after sowing (DAS). Several yield and yield contributing characters e.g. plant height, no. of pod/plant, no. of effective pod/plant, no. of uneffective pod/plant, root length, 100 seed wt. and yield were analyzed. Growth regulators showed significant effective to groundnut in charland area from Flora, Nafa, Maxsulphar and Alba application due to formation of nodulation, chlorophyll synthesis and supply of plant growth agent. Control treatment performs better some growth regulator treatments.

Performance of proso millet in charland area

The experiment was conducted at the charland area of Jamalpur during rabi 2018 to know the yield performance and popularize proso millet in charland areas. Treatments included in the experiment were: V_1= BARI Cheena-1, V_2= Local-1 and V_3= Local-2. Yield level of different proso millet varieties/cultivar were similar except BARI Cheena-1 (V_1). All the proso millet varieties/cultivar might be cultivate in char land after another year continue the programme because of poor management practices, low price, availability of its seeds, less risk and water requirement, easily grown without modern technology.

Performance of foxtail millet in charland area

The experiment was conducted at the charland area of Jamalpur during *rabi* 2018 to know the yield performance and popularize foxtail millet in charland areas. Treatments included in the experiment were: V_1= BARI Kaon-1, V_2= BARI Kaon-2, V_3= BARI Kaon-3 and V_4= Kaon (local). The highest yield was performed in BARI Kaon-2 which is statistically similar BARI Kaon-1and Kaon (local) cultivar. All the foxtail millet varieties/cultivar might be cultivate in char land after another year continue the programme because of poor management practices, low price,

availability of its seeds, less risk and water requirement, easily grown without modern technology.

Sorjan based integrated farming systems for increasing agricultural productivity under tidal flooding ecosystem in southern region of Bangladesh

This research programme was conducted at RARS, BARI, Rahmatpur, Barishal with the special allocation revenue budget for research and innovation under the Ministry of Agriculture during 2018-19 to increase agricultural productivity and profitability through sorjan based farming systems under tidal flooding ecosystem in southern region of Bangladesh. Under this research programme, new sorjans were prepared and existing sorjans were renovated in the project areas. Results of the sorjan based integrated farming systems research showed that a large number of summer and winter vegetable and fruit crops have been possible to cultivate under modern sorjan system though using its different production spaces. In 2018-19, a total of 2349 kg vegetables were produced from sorjan system of RARS, Rahmatpur, Barishal (Total sorjan area 2820 sq.m.) and worth Taka 52830. At the same time, 108 kg fruits were produced (worth Tk. 6110). Besides, sugarcane, fish, milk, fodder, cowdung and biogas produced the gross income of Tk. 323169 (Tk. 1145989/ha). The total gross income of the sorjan based integrated farming systems (sorjan area 2820 sq.m.) was Tk. 382067 (Tk. 1354848/ha). In a baseline survey conducted in 2017-18 showed that gross return from a traditional sorjan system was (Tk 183768/ha) and the increased gross return of the sorjan farming system was Tk. 1171080/ha over the traditional sorjan system. On the other hand, gross return from single rice crop was Taka 75000/ha (based on 5 t/ha T.aman rice yield and Tk. 15/kg grain). The sorjan farming systems can increase Tk. 1279848/ha over the single rice cropping. The research findings further indicated that sorjan farming systems are more profitable than that of traditional sorjan systems or single rice cropping in southern region of Bangladesh. However, the research works should be continued for at least five years for final recommendation.

Integrated vegetables and fish cultivation through plastic drum based floating system in flooded ecosystem of Bangladesh

The experiment was conducted under "Research, Extension and Popularization of Vegetables and Spices Cultivation on Floating Bed" project (BARI Part) at RARS, Rahmatpur, Barishal on year round basis starting from April, 2018 to increase the total productivity and net return through vegetable cum fish farming under floating agriculture system in the flooded ecosystem of Bangladesh. The floating cage was made with plastic drum and GI pipe. The unit floating cage size was 7.01 x 5.18m (23ft long x 17 ft wide). The floating cage and trellis were used for cultivation of fish and creeper vegetables, respectively. The experimental results revealed that plastic drum based floating cage system can be used for cultivating creeper vegetables as well as fish. The total production of vegetables was 419.30 kg (worth Tk. 6777) and fish production 245.00 kg (worth Tk. 29400). The total gross return from the plastic drum based floating system was Tk. 36177. The plastic drum based floating cage system could be used for integrated vegetables and fish cultivation in the flooded ecosystem of Bangladesh. However, the trial should be continued for at least three years for final recommendation.

Performance of garlic varieties at char land in Rangpur

A field trail was conducted at Mohipur Char, RARS, BARI, Burirhat, Rangpur with three varieties and two fertilizer doses to find out the better yield to compare local variety at char land during Rabi season 2018-19. The highest bulb yield (15.0 t/ha) was recorded from BARI Rasun 2 and recommended fertilizer dose. However, considering of all things, the BARI Rasun 2 and recommended fertilizer dose were better variety and fertilizer dose with compeer to other varieties in chair lands.

Performance of potato varieties at char land in Rangpur

A field trail was conducted at Mohipur char, RARS, BARI, Burirhat, Rangpur with five potato varieties to find out the better yield to compare local variety in char land in this experiment during Rabi season 2017-18 and 2018-19. The highest tubers yield 32 to 36 t $ha^{-1}$was given in the all

tested varieties in 2017-18 and 59.5 t/ha of BARI Alu-8 and 52,4 t/ha of BARI Alu-36 were recorded of 2018-19. However, considering of all things, the new potato varieties were given in the char land. BARI Alu-46 was showed late blight free with compare to other varieties.

Performance of BARI hybrid maize at char land in Rangpur

A field trail was conducted at Mohipur char RARS, BARI, Burirhat, Rangpur with seven varieties of BARI hybrid maize to find out the yield performance compare to other Hybrid verities in char land during Rabi season 2017-18 and 2018-19. The yield performance of BARI hybrid maize-12, 13, 14 and 15 and local hybrid (Elit) were performed significantly same yield in 2017-18. This grain yield ranged from 10.00 - 11.00 t/ha. The lowest yield was obtained from BARI hybrid -7. The tallest plant was BARI hybrid-9 and12in 2017-2018.The yield performance BARI-9, 21 and Elit were given significantly same yield in 2018-19.

Demonstration of mustard varieties in chalon beelarea at farmers' field

Block demonstration of BARI sarisha 14 was executed at Dobila, Tarash of Sirajgong in Chalan Beel during the *rabi* season of 2018-2019 to evaluate the performance of mustard variety, BARI sarisha 14 under farmers' field condition and to popularize it among the farmers Two farmers were selected at each location for conduction of demonstration with BARI sarisha 14. Land area was 1 bigha per farmer at chalan beel area. Seeds were sown broadcast on November 11, 2018 and crop was harvested on 07 March 2019 at Chalan Beel area. The crop was fertilized with 160-46-120-36-4 kg/ha NPKSZn (Fertilizer Recommendation Guide -2012, BARC). One half of nitrogen and full quantity of PKSZn were applied as basal in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. Remaining half nitrogen was applied at the time of flower initiation (20-25 days after seeding) as top dressing. Three irrigations were given at 12 days after sowing (DAS), after top dressing and at 50 DAS. The crop was kept weed free up to 20 DAS by two hand weedings at 10 and 20 DAS. Plant population/m^2 at harvest was taken from randomly selected 3 places. Yield and yield attributes were recorded. The grain yield of BARI sarisha 14 was noticed 1275 kg/ha in Chalan Beel area. Farmers' showed moderate interest to cultivate mustard (BARI sarisha 14) in Chalan Beel area of Sirajgonj.

10 IRRIGATION AND WATER MANAGEMENT

Background

Irrigation and Water Management Division is one of the full-fledged research divisions of Bangladesh Agricultural Research Institute. The division is associated with conducting research on various aspects of irrigation and water management practices for upland crops, water management techniques for saline soils, adaptation to impacts of climate change, micro-irrigation systems, and development of irrigation systems for hilly areas. It generates information through conducting research on water quality, agricultural drainage, as well as on pumps and tube wells for both surface and groundwater. It has developed and disseminated several water saving irrigation technologies for drought and salinity prone areas of Bangladesh. It is contributing to enhance crop productivity and sustainability in water management through proper scheduling of irrigation practices for major crops, providing innovative solutions to save water for irrigating crops, and disseminating the developed technologies among the beneficiaries (end users). As of yet, the division has developed and demonstrated about 49 irrigation and water management technologies. A considerable number of these technologies have been used by the farmers in different parts of Bangladesh.

Effect of deficit irrigation on yield and water productivity of different maize varieties in southern areas

This study was conducted at the Regional Agricultural Research Station, BARI, Rahmatpur, Barishal to determine the experimental evidence of the effects of deficit irrigation on yield and water productivity of different maize varieties during 2017-2018, 2018-2019, and 2018-2019. The experiment consisted of five irrigation treatments, viz. Farmer's practice (I_1), Full irrigation at 20-25 days after sowing (DAS) (I_2), 50% irrigation at 20-25 DAS and 50-60 DAS (I_3), 75% irrigation at 20-25, 50-60 and 75-80 DAS (I_4), 50% irrigation at 20-25, 50-60, 75-80 and 110-120 DAS (I_5). These irrigation treatments were tested on three maize varieties namely BHM-9 (V_1), BHM-7 (V_2) and NK-40 (V_3). The yield and yield contributing parameters were affected significantly by irrigation and variety. The treatment with 50% irrigation at 20-25, 50-60, 75-80 and 110-120 DAS produced the highest grain yield of 10.83 and 11.87 t/ha whereas the variety NK-40 produced the highest grain yield of 10.73 and 10.03 t/ha in 2018-19 and 2017-18, respectively. In case of interaction treatments, the highest grain yield of 11.87 t/ha was obtained from I_5V_3 in year 2018-19 and the highest (11.17 t/ha) grain yield was observed in I_5V_2 treatment in previous year. The average benefit cost ratio (BCR) was observed highest (2.92) for I_3V_1 (50% irrigation both at initial and vegetative (20-25 DAS and 50-60 DAS) stages; BHM-9) treatment. The water productivity (WP) was obtained highest for I_3 (50 % irrigation both at initial and vegetative (20-25 DAS and 50-60 DAS) stages) treatment 2.02 kg/m^3 and 2.73 kg/m^3, respectively for first and second years, due to less irrigation water application whereas the lowest WP was observed at farmer's practice.

Assessment of water use on the growth and yield of white grained hybrid maize

The experiment was conducted at the experimental field of IWM Division, BARI, Gazipur and farmer’s field of Godagari, Rajshahi during 2016 - 2017, 2017-18 and 2018-19 to assess the water use on the growth and yield of BARI hybrid maize-13. Six levels of irrigation were applied for the experiment with four replications. Treatments were T_1= Rainfed, T_2= One irrigation at vegetative (25-30 DAS) stage, T_3= One irrigation at pre-flowering (55-65 DAS) stage, T_4= One irrigation at grain filling (90-100 DAS) stage, T_5= Two irrigations each at pre-flowering (55-65 DAS) and grain filling (90-100 DAS) stages, T_6= Three irrigations each at vegetative (25-30 DAS), pre-flowering and grain filling stages. The results showed that most of the

yield contributing character values were found higher in treatment T_5 for both the locations where two irrigations at pre-flowering and grain filling stages were applied. The treatment T_6 produced the highest yield in 2016-17 at Gazipur (6.80 t/ha) and Rajshahi (5.80 t/h). But during 2017-18 and 2018-19, treatment T_5 achieved the highest yield at both the locations. The lowest yield (4.77 t/ha, 6.57 t/ha and 9.32 t/ha) and (4.28 t/ha, 5.60 t/ha and 5.32 t/ha) were found in treatment T_1 at Gazipur and at Rajshahi where no irrigation was applied. Among the one irrigation treatments, treatment T_3 did well at both the locations. The highest BCR was obtained from treatment T_5 at in most of the growing seasons. Hence, irrigation at pre-flowering and grain filling stages were found to be effective for BARI hybrid maize-13.

Irrigation effect on cowpea production in Chattogram region

The study was conducted at the research field of Regional Agricultural Research Station, Hathazari, Chattogram during the rabi season of 2018-19 to identify the critical stages of irrigation and optimize irrigation in cowpea production. Five treatments were applied: T_1 (rain-fed i.e. local practice), T_2 (irrigation at 3 weeks interval), T_3 (irrigation at flowering stage), T_4 (irrigation at pod formation stage), T_5 (irrigation at flowering and pod formation stages). The highest yield (2.2 t/ha) and highest water stress coefficient (K_s= 1 to 0.6) were found at higher frequency irrigation (T_2). The maximum irrigation (182mm) was applied at T_2. In rain-fed condition (T_1), cowpea yield was lowest (1.2 t/ha). Crop production function of cowpea was $Y=1.08+0.006X$, R^2 =0.89 at 95% confidence interval. The sustainability of cowpea in low water stress co-efficient (up to 0.05) indicated that field crop was drought tolerant. Irrigation at pod formation stage yield was higher than flowering stage in case of only one irrigation facilities. The flowering stage (K_y= 1.15) was more sensitive to deficit irrigation than pod formation stage (K_y= 0.93). Based on the economic analysis, irrigation at three weeks interval was more beneficial (BCR=1.47).

Potentiality of biochar to enhance productivity of tomato cultivated under deficit irrigation

This study was conducted at the research field of Irrigation and water Management Division (IWM) of Bangladesh Agricultural Research Institute (BARI), Gazipur during 2017-2018 and 2018-2019 to examine the potentiality of biochar in improving productivity of tomato cultivated under deficit irrigation regimes, and the effects of biochar on some soil properties. BARI Tomato-14 cultivar was used for the experiment. There were six different irrigation treatments comprising three level of irrigations and two soil conditions [full irrigation (FI), 75% of FI and 50% of FI with biochar (T_1 to T_3) and without biochar (T_4 to T_6)]. It is observed that plant height at different growth stages was lower in deficit irrigation (full irrigation > 75% irrigation > 50% irrigation). However, plant height was significantly higher in treatments with biochar compared to the non-biochar treatments (T_1>T_4, T_2>T_5 and T_3>T_6). In contrast to the plant height, root length was found higher in non-biochar treatments (T_4, T_5, T_6) than that of their parallel biochar treatments (T_1, T_2, T_3). Again, both wet and dry biomass weights were found highest in T_1, where the lowest values of both of these attributes were found in T_6. Moreover, the number of fruit per plant, unit fruit weight and the marketable yield in different treatments followed the usual trend, higher in biochar treatments, and reduced significantly as lesser amount of irrigation was applied. About 3-4%, 6-7% and 9-10% higher marketable yield of tomato was observed in T_1, T_2 and T_3 compared to T_4, T_5 and T_6, respectively. As less amount of irrigation water was applied in deficit irrigation treatments, water productivity (WP) showed an increasing trend with the increase in irrigation deficiency. Nonetheless, an improvement of WP by around 4-6%, 8-11% and 11-12% was observed in T_1, T_2 and T_3 compared to T_4, T_5 and T_6, respectively. It was also observed that the soil moisture content dropped sharply in non-biochar treatments under deficit irrigation regimes compared to the treatments with biochar. Overall, biochar addition in the soil helped improve the growth and yield of tomato grown under deficit irrigation regimes, as well as the water holding capacity, N-status and heterotrophic respiration of the soil.

Effect of irrigation on growth, flowering and corm production of gladiolus in winter season

The experiment was conducted at the experimental field of IWM Division, BARI, Gazipur during 2018 -2019 to evaluate the effect of different irrigation systems and scheduling on the performance of gladiolus. Nine irrigation treatments were designed

for the experiment with four replications. Treatments were T_1 = Drip irrigation at 3-days interval with recommended N doses, T_2 = Drip irrigation at 3-days interval with 20% less N than recommended doses, T_3 = Drip irrigation at 3-days interval with 40% less N than recommended doses, T_4 = Shower irrigation at 7-days interval with100% of FC, T_5 = Shower irrigation at 7-days interval with 80% of FC, T_6 = Shower irrigation at 7-days interval with 60% of FC, T_7 = Flood irrigation at 10-days interval, T_8 = Flood irrigation at 15-days interval, T_9 = Flood irrigation at 20-days interval. Results revealed that the drip system of irrigation i.e. (T_1, T_2, T_3) showed best performance than shower (T_4, T_5, T_6) and flood irrigation (T_7, T_8, T_9) system. Spike yield (22.42 t/ha), weight of single spike (84.07 cm), spike length (105.1 cm), rachis length (54.46 cm), yield of corms (1.04 t/ha) and cormel (0.94 t/ha), weight of single corm per plant (43.71 gm), diameter of corm (6.2 cm), number of cormels per plant (33.50) and weight of cormels per plant (12.33 gm) were found maximum with drip irrigation system (T_1, T_2, T_3). Maximum plant growth, spike yield attributes and flower production was obtained with gravity drip irrigation at 20% less N than recommended dose which were competitive with other two drip irrigation treatments along with shower irrigation with 80% of FC and flood irrigation at 10-days interval. However, maximum corm and cormel growth attributes was obtained from drip irrigation with recommended N along with the above treatments stated for spike yield. Whereas, the minimum plant growth, spike yield attributes, corm and cormel yield parameter were achieved with shower irrigation with 60% of FC along with shower irrigation with 100% of FC, flood irrigation at 15-days interval and flood irrigation at 20-days interval. The results of the study showed that the lowest irrigation water use, highest water productivity, and water and N savings through drip irrigation system, or shower irrigation with 80% of FC, or 10-days interval flood irrigation promotes flower growth and quality characters and corm production of gladiolus in comparison with optimal, or scarce water applied through shower or flood irrigation system.

Yield and water productivity indices of different onion varieties under sprinkler irrigation

To evaluate the performance of four onion varieties under sprinkler irrigation and their sensitivity to water stress, a study was conducted at the experimental field of IWM Division, BARI during the winter season of 2018-2019. The experiment comprised of five irrigation treatments with sprinkler system based on 60%, 80%, 100%, 120% and 140% of crop water use (ETc) laid out in split-plot design with three replications. Irrigation water was applied at a fixed 6-day interval with sprinkler system throughout the crops growing season. Onion sensitivity to water stress was determined using a yield response factor (Ky) derived from the linear relationship between relative evapotranspiration deficits (1-ETa/ETm) and relative yield decrease (1-Ya/Ym). Statistical analysis revealed that plant height was not much affected by the level of irrigation while leaf number, bulb diameter, bulb unit weight and total bulb yield was affected significantly ($P<0.05$) by the irrigation regimes. Among the four onion varieties, the highest plant height, bulb diameter and unit bulb weight contributed to the highest yield of 24.53 t/ha for BARI Piaj-4 (V_4) followed by 22.04 t/ha for Taherpuri King (V_3) under 120% water regime. Taherpuri super (V_2) produced the second lowest yield of 17.73 t/ha which was comparable to the lowest yield of 16.57 t/ha produced by the variety BARI onion -1 (V_1). Value of Ky determined for the whole growing season was found higher for V_4 (Ky: 1.18) and V_3 (Ky: 1.16) than other two varieties (0.85 for V_1 and 0.87 for V_2) indicating that both varieties V_4 and V_3 are highly sensitive to water stress. This fact is also evident by the water productivity (WP) with higher value obtained under higher water regimes (120% ETc) in case of V_4 and V_3; but for other varieties, higher WP was obtained from 80% ETc water regime. The amounts of water used for evapotranspiration under different irrigation regimes ranged from 151 to 253 mm, 153 to 256 mm, 158 to 260 mm and 161 to 262 mm, respectively, for V_1, V_2, V_3 and V_4 with minimum at 60% ETc and maximum at 140% ETc water regime. Though seasonal evapotranspiration was higher under wetter water regimes, yield was lower and consequently WP was the lowest. Considering Ky as a limiting factor, application of irrigation at 80% ETc was a marginal for V_1 and V_2 and 100-120% ETc for V_3 and V_4, beyond that yield losses are insupportable.

Performance of fertigation system on bottle gourd cultivation

An experiment was conducted at the research field of Irrigation and water Management (IWM) Division, Bangladesh Agricultural Research

Institute (BARI), Joydebpur, Gazipur during the rabi season of 2017-18 to determine the performance of bottle gourd (var. BARI Lau- 3) under fertigation systems. Six different irrigation treatments T_1= Ring Basin irrigation at 7 days interval with recommended fertilizer doses, T_2= Fertigation at an alternate day with recommended fertilizer doses, T_3= Fertigation at an alternate day with 20% less N and K than recommended doses, T_4= Fertigation at an alternate day with 35% less N and K than recommended doses, T_5= Fertigation at an alternate day with 50% less N and K than recommended doses were selected. The highest yield of 37.20 t/ha was obtained from treatment T_4 by applying 35% less N and K than recommended doses through drip system followed by treatment T_5 (33.02 t/ha) by applying 50% less N and K than recommended doses through drip system. Ring basin method required 404 mm of water during the season whereas only 107 mm water was needed in drip method. The economic analysis revealed that the highest benefit cost ratio (2.99) was obtained from treatment T_4 by applying 35% less N and K than recommended doses through drip system followed by treatment T_5 (2.67) by applying 50% less N and K than recommended doses through drip system. During the rabi season of 2018-19 the experiment was conducted but after two harvest the plants were damaged due to heavy rainfall and wind speed.

Determination of relationship between soil salinity and irrigation water salinity

This study was conducted under the poly shed house of Irrigation and Water Management Division, Bangladesh Agricultural Research Institute (BARI), Gazipur from May 2018 in pot to determine the relationship between soil salinity and irrigation water salinity. Three types of soil (Sandy loam, Clay loam and loam) were used with different levels of salinity where no crop was considered. Artificial salinity was prepared by using raw salt mixing with water through the trial and error method. To measure in situ soil salinity, direct soil EC meter was used. Irrigation water with different salinity level (4, 8, 12 and 16 dS/m) were applied up to field capacity at 15 days interval and soil salinity were measured at two depths (0-15 and 15-30 cm). The results demonstrate that soil salinity showed mostly increasing trend with time after applying different levels of saline irrigation water at 0-15 cm and 15-30 cm depth. Clay loam soil showed higher soil salinity compared to loam and sandy loam soil. A linear relationship was observed between irrigation water salinity and soil salinity at the end of the study for both depths. Though soil salinity at shallow depth rose higher than deeper depth but this trend was opposite at the end of the study for the highest level of saline water. However, further continuation and monitoring for this study is needed to get the final result.

Cropping systems intensification in the salt affected coastal zones of Bangladesh and west Bengal, India (ACIAR-KGF Project)

The coastal areas of Bangladesh are affected by varying degrees of salinity, long duration and late harvest of Transplanted Aman (T. Aman) rice. The cropping pattern in the coastal areas is mainly Fallow-Fallow-T. Aman. Therefore, the project "Cropping Systems Intensification in the Salt Affected Coastal Zones of Bangladesh and West Bengal, India; LWR/2014/073/ACIAR-KGF" aims to sustainably increase cropping intensity and productivity in the coastal zones of Bangladesh particularly in the rabi season through integrated soil, water and crop management. The major objectives of the project were (i) developing a sub-regional scale understanding of the surface water and groundwater resources, (ii) developing a detailed understanding of the salt and water dynamics of the case study polders, (iii) developing detailed understanding of crop production responses to various improved crop water management strategies, including early sowing, and (iv) identifying superior cropping options and polder water and salt management strategies through field evaluation and co-learning with farmers. The collaborative division of Irrigation and Water Management (IWM) under BARI set up field experiments in rabi season of 2018-2019 at project sites involving 8 farmers including male and female. The specific sub-objectives of these experiments were to (i) develop and evaluate the IWM technologies, and (ii) introduce and transfer the irrigation technologies among the farmers through the use of fresh water (FW) and saline water (SW) irrigation for rabi crops at the salt-affected areas of Bangladesh. The experiments were conducted at the farmers' field in the village of Tildanga at polder 31 in Dacope, Khulna and Sikandorkhali at polder 43/1 in Amtali, Barguna under the ACIAR-KGF project. The experiments

were on the conjunctive use of FW and SW for wheat/barley/mustard, controlled moisture and cracks of soil for maize/sunflower and surface drainage cum furrow irrigation technique for sunflower/maize. The observed results indicate that farmers cannot go for early rabi crops due to long duration traditional T. Aman rice, waterlogging, and salinity of water and soil in the field. Results showed that the use of FW at early growth stages and SW at later growth stages had significant difference. The technique of FW at early stage and SW at later growth stages of wheat/barley/mustard) produced significantly greater yield at around 2.2, 2.4 and 1.2 t/ha wheat, barley and mustard, respectively than other irrigation techniques. The effect of location had significant difference on the crops yield. At Amtali, wheat, barley and mustard yield were found significantly greater than Dacope coastal regions. The effects of rice straw significantly affected the crop growth and increased the yield of maize and sunflower by 22% and 4.3% compared to treatments of without straw mulching. Sunflower seed yield and grain yield of maize were ranged from 1.53 t/ha to 2.34 t/ha and 7.16 t/ha to 8.04 t/ha, respectively from the surface drainage techniques. The technique of single row raised with 15 cm drain obtained 2.34 t/ha sunflower seed yield and 8.04 t/ha maize grain yields are significantly greater than other drainage treatments. On average, the changes exact salinity (ECw) of field soil water varied from around 2 to 15 dS/m at Tildanga and 2 to 9 dS/m at Amtali during the crop growing season. The osmotic potential was around -200 to -700 kPa at Amtali and -200 to -1500 kPa from December 2018 to March 2019 and highest osmotic potential observed in February in both locations. Soil water contents substantially decreased in upper soil layers (0-15 cm) at mid February which affected the crop growth stages. The water salinity of the pond, canal and river ranged from around 1.5, 2 and 5 dS/m (November 2018) to 3.5, 4 and 20 dS/m (April 2019). The irrigation water (low saline) was not available to the pond/canal from February to March at Sikandorkhali village in Amtali during the crop growing season 2019. However, the technique of FW (low sanity of: ≤2 dS/m) at early growth stages and SW (2 ≥ salinity ≤ 4 dS/m) at later growth stages of wheat/ barley/mustard could be an alternative option for intensifying cropping system in the coastal saline zones of Bangladesh. The straw mulching and frequent irrigation could be used in coastal heavy soils to reduce soil salinity/osmotic potentials and increased crop yields in no-tilled systems. The use of single row raised bed with drainage technique would be optioned for sunflower/maize cultivation where salinity and waterlogging problem in the coastal areas of Bangladesh.

Conjunctive use of fresh and saline water in irrigation for wheat, barley and mustard in coastal areas of Bangladesh

Conjunctive use of fresh water (low-saline) and saline water (medium saline) for irrigation is a strategy to irrigate rabi crops in the coastal salt affected areas of Bangladesh where fresh water is not available. In this study, the objectives were to assess the effect of fresh water (FW) and saline water (SW) irrigation on the crop performances, and the scope of fresh and saline water irrigation for rabi crops. Three field experiments were laid out in a randomized complete block design with four irrigation treatments for wheat, barley and mustard, and replicated thrice during 2018-2019. These field experiments were conducted in farmers' fields at Sikandorkhali village, Amtali upazila in Barguna and Tildanga village, Dacope upazila in Khulna districts. Standard crop management practices and irrigation scheduling of different crops were followed. Results showed that the use of FW at early growth stages and SW at later growth stages had significant difference. Treatment T4 (FW at early stage and SW at later growth stages of wheat/barley/mustard) produced significantly greater yield at around 2.2, 2.4 and 1.2 t/ha wheat, barley and mustard respectively than other treatments. The effect of location had significant difference on the crops yield. At Amtali, wheat, barley and mustard yield were found significantly greater than Dacope coastal regions. The highest salinity of field soil water (EC_w) and osmotic potential were occurred in mid to end of the February 2019 in all treatments in the soil profiles (0-60 cm). The exact soil salinity (EC_e) varied from around 2 to 13 dS/m at Tildanga and 2 to 7 dS/m at Amtali. On average, the osmotic potential was found -200 to -700 kPa at Amtali and -200 to -1300 kPa from December 2018 to March 2019 and highest osmotic potential observed in February 2019 at both locations. Soil water contents substantially decreased in upper soil layers (0-15 cm) at mid February which affected the crop growth stages. The water salinity of the pond, canal

and river ranged from around 1.5, 2 and 5 dS/m (November 2018) to 3.5, 4 and 20 dS/m (April 2019). The irrigation water (low saline) was not available to the pond/canal from mid-February to March during the crop growing season which hampered the crop production. However, the use of FW (low sanity of: ≤2 dS/m) at early growth stages and SW(2 ≥ salinity ≤ 4 dS/m) at later growth stages of wheat, barley and mustard could be an alternative option for intensifying cropping system in the coastal saline zones of Bangladesh.

Controlled moisture and cracks of soil on salinity, crop growth and yield of maize and sunflower in no-tilled systems of coastal soils

Crack formation in clay soils presents a major difficulty for movement of water, conserving soil moisture and the accumulation of salts on the soil surface through capillary from saline groundwater which restricts the crop growth and yield in no-tilled systems of coastal saline soils of Bangladesh. Therefore, the field experiments were conducted at the salt-affected areas of Bangladesh. The objectives of the study were to: (i) evaluate the effect of straw and irrigation frequency on crop growth and yield in maize and sunflower, and (ii) determine the combined effect of straw and irrigation frequency on the salinity, osmotic potential and moisture of soils. The experiment was carried out in farmers' fields with eight treatments and was replicated three times during the dry (rabi) season of 2018-2019. There were two rice straw treatments (with or without straw), and 4 irrigation frequencies (at intervals of 5-7, 10-12, 15-17 or 20-25 days). Maize and sunflower seeds were sown by dibbling in no-tilled systems. The results showed that rice straw significantly affected the crop growth and yield, increasing the yield of maize and sunflower by 22% and 4.3% compared to treatments of without residue. The irrigation treatments also significantly affected crop yields. There was no interaction between straw levels and irrigation. The causes of these effects appeared to be improved water relations: rice straw and more frequent irrigations both reduced the salinity and osmotic potential of soils compared with treatments without straw while the soil moisture was greater in rice straw treatments and increased with the increased soil layers. Therefore, it is concluded that straw mulching and irrigation management practice could be used in coastal saline of heavy soils to reduce soil salinity, osmotic potentials thereby increasing crop yields in no-tilled systems.

Improving surface drainage cum furrow irrigation technique for sunflower and maize cultivation in coastal saline soils

Waterlogging and poor surface drainage are becoming a major constraint to the production of rabi crops in southern coastal saline soils of Bangladesh. Surface drainage is essential for establishment of rabi crops after the harvest of transplanted Aman rice. Hence, two field experiments were investigated to evaluate the rabi crops of sunflower and maize performances at two locations of Dacope and Amtali during 2018-2019. The specific objectives of this study were (i) to find out the effect of surface drainage cum furrow irrigation technique on crop growth and yield, (ii) to find out the effect of the surface drainage technique on salinity, osmotic potential and moisture contents of soils during crop growth periods. Four drainage treatments were imposed at all sites with three replications. The treatments consisted of (i) single row raised bed (furrow 15 cm drain), (ii) double row raised bed (furrow 20 cm drain), (iii) triple row raised bed (furrow 20 cm drain), and (iv) random field ditches (scattered)–Pothole. Sunflower seed and maize grain yield were ranged from 1.53 t/ha to 2.34 t/ha and 7.16 t/ha to 8.04 t/ha, respectively. The technique of single row raised bed with 15 cm drain obtained 2.34 t/ha greater sunflower seed yield than other drainage treatments. The treatment T_1 (single row raised bed with 15 cm drain) obtained (8.04 t/ha) significantly greater yield than other drainage treatments. On average, the changes exact salinity (ECw) of field soil water varied from around 2 to 12 dS/m at Tildanga and 2 to 9 dS/m at Amtali during the crop growing season. The salinity results indicated the salt accumulation was slightly lower in the treatment of single row raised bed planting and drainage technique than the other drainage techniques. The osmotic potential was found around -200 to -1100 kPa at Tildanga and -200 to -800 kPa at Amtali. Soil water contents substantially decreased in upper soil layers (0-15 cm) at later growth stages which affected the crop growth. However, the drainage technique would be optioned for sunflower and maize cultivation in the coastal areas of Bangladesh where salinity and waterlogging problems prevail.

Assessment of groundwater quality for irrigation in the northwest region of Bangladesh

The present investigation is aimed at understanding the temporal and spatial variability of groundwater quality for its use in irrigation purpose in the northwest region of Bangladesh. The groundwater samples from selected STWs and DTWs were collected during November – December of 2018 in pre-irrigation season and during March – April of 2019 in post-irrigation season. Water quality indices, namely sodium adsorption ratio (SAR), exchangeable or soluble sodium percent (SSP or %Na), residual sodium carbonate (RSC) and Kelly's ratio (KR) were calculated for the water samples of separate bore wells. Besides, the composite influence of different water quality parameters on the overall quality of water was also assessed using water quality index (WQI). The upper limit of SAR of 0.99 (less than 10), SSP 38.06% (less than 60%), RSC 2.54 and KR of 0.64 (<1) implies that all the groundwater samples were suitable for irrigation. According to the WQI values, all the samples were found to be "good" except few were found "poor" in post-irrigation season. Thus, the majority of the area is occupied by good water in both pre- and post-irrigation seasons.

Prediction of groundwater level using a discrete space-state model as an alternative to physically based groundwater modelling

Reliable and accurate prediction of groundwater level is an essential component of sustainable water resources management and designing remediation plans. Groundwater simulations and predictions are often performed by employing physically based models, which are not applicable in many parts of the world especially in developing countries like Bangladesh due to data limitations. On the other hand, data-driven statistical methods have proven their applicability in modeling complex and nonlinear hydrological processes with a view to forecasting short-term and long-term groundwater levels. The purpose of this effort was to develop a non-physical based approach by utilizing a discrete Space-State model as a prediction tool for future scenarios of groundwater level forecasting. In Space-State modelling approach, a model is identified to accurately compute a dynamic system with response to an input. The present study utilizes the prediction focused approach of the system identification process in which the overall goal is to create a realistic dynamic system model. The performance of the proposed approach was evaluated for groundwater level data at three observation wells of Tanore upazilla in Rajshahi district, Bangladesh. Historical weekly time series of water level data from the three observation wells for 39 (1980-2018) years was used to develop the time series model, which was used for future water level predictions for a period of the next 22 years (up to 2040). The results of the present study indicated the potential applicability of the proposed discrete Space-State modelling approach in forecasting future groundwater levels in the observation wells of the study area.

Sustainable groundwater utilization for crop production in Rajshahi district

This study was conducted in nine upazilas of Rajshahi district to investigate the groundwater level trend for sustainable groundwater use of crop production. Monthly water table data, data for irrigated crops, irrigated area, wetted area and meteorological data have been collected from Barind Multipurpose Development Authority (BMDA) and Bangladesh Meteorological Department (BMD). After collecting all relevant data, water table dynamics were analyzed with a model named "MAKESENS" and in excel. Results showed that groundwater abstraction as well as irrigated area decreased for the current year. But long term trend of water table depth indicates that water level decreased with time significantly in almost all upazilas and went below threshold level in the last few years for some upazilas. Future predictions based on the present declining trend demonstrates that if this abstraction is continued then groundwater level will go below threshold level as well as suction limit of shallow tube wells in most upazilas. Then withdrawing groundwater in this way will not be sustainable at all. So, some effective irrigation techniques will be needed to adopt in order to avoid over exploitation and consequently to promote the sustainable use of groundwater for crop production.

Dissemination of BARI developed water saving irrigation technologies for enhancing crop production in drought prone, coastal and hilly areas of Bangladesh

This project was conducted during the rabi season of 2018-2019 to disseminate BARI developed water saving irrigation technologies in three

distinct water stress regions; drought prone (Rajshahi and Naogaon), salinity affected (Patuakhali) and hilly (Khagrachari) region. Three different types of water efficient irrigation technologies were disseminated among the farmers, namely alternate furrow irrigation (AFI), drip fertigation and deficit irrigation (DI). At Tanore upazilla of Rajshahi, AFI technology was used to cultivate potato. AFI technology was found to increase the yield of potato by around 12% compared to the flood irrigation method, whereas it also increased the water use efficiency (WUE) by 84%. AFI technology was also tested to cultivate tomato at Godagari upazilla of Rajshahi. Where farmers' practice had 35.5 t/ha of yield, use of AFI technology increased it to 40.7 t/ha. Irrigation water use was also significantly lower (about 45%) in AFI, resulted greater water productivity than that of the farmers' practice. Wheat was grown using deficit irrigation (DI) technology at Shapahar, Naogaon. Here, two irrigations at CRI and grain filling stage was found to be the most effective one saving about 26% water but only sacrificed yield around 5%, eventually improved water productivity by 29% compared to the three irrigation treatments. In salinity affected Kuakata of Patuakhali district, maize was cultivated using AFI technology. On an average 7.53 t/ha yield of maize was found in every furrow irrigation (EFI), where under AFI it was 7.32, losing only 3% yield. But, significant amount of water was saved (around 24%) in AFI, thus water productivity was also found greater (30% higher) than that of the EFI. Similar result was also obtained in case of sunflower, where AFI technology saved about 30% of irrigation water that led to an improved (38% more) water productivity. Performance of drip irrigation was tested in watermelon cultivation at Kuakata. Where yield of watermelon was 35.7 t/ha in drip irrigation, ring basin and flood irrigation had only 28.9 t/ha and 25.6 t/ha, respectively. Drip irrigation also saved water use by around 11% and 18% than ring basin and farmers' practice. Drip fertigation method was found even more efficient in hilly area of Khagrachari, where marketable yield was 34% higher than that of the control treatment. Approximately 93% higher water productivity in drip fertigation method suggests that it could have significant effect on vegetable farming in hills, if properly practiced. Cabbage and cauliflower was also cultivated in hill, where both crop showed significantly higher water productivity under AFI technology (around 26% and 29% respectively) suggest that this could be a great option for crop production in this area. All the results obtained from this project suggests that BARI developed water saving irrigation technologies have potential to judicially utilize the limited water resources in the stress prone areas. Therefore, effective and large scale dissemination of these technologies can significantly increase crop productivity of the drought, saline and hilly areas, finally can contribute to the country's food security under climate change.

11 FMP ENGINEERING

Evaluation and improvement of four-wheel tractor operated zero till drill for cereal crops

Conservation agriculture (CA) based tillage technology permits direct seeding in untilled soil with moderate level of crop residue. Power tiller is the common tillage tool in Bangladesh agriculture but recent days four wheel (4W) tractors are being introduced in farming works along with transportation works. Sowing is one of the key factors that influence the success of any crop establishment and productivity. Maximum crop production and seeding operation need to complete within the recommended period avoiding slowness, time consume, costly operation and decreasing turnaround time. The research work has been under taken to evaluate the performance of 4W tractor operated zero till drill and improvement of the seeder for completing seeding operation in a single pass. Five zero till drills were imported from India. One of them was send to OFRD, Rajshahi for evaluation of field performance with maize (NK40) and wheat (BARI Gom-30) at Godagari and Poba upazilla of Rajshahi district. The zero till drill was operated with 4W tractor with 2.05 to 2.40 km/h forward speed. Effective field capacity and efficiency of zero till drill varied from 0.31 to 0.36 ha/h and from 81.64 to 84.13 % respectively. The planting depth (4-5 cm) of maize and seeding depth (2-3 cm) of wheat were found desirable. The yield of maize in zero till plot was 6.00 t/ha. The yields of wheat in zero till plots were found in the range of 4.20 to 4.75 t/ha. The experiment will be conducted in the next year (2019-20) to verify the performance in more areas and improve if necessary.

Design and development of a power tiller operated vegetable seedling transplanter

Current vegetable seedling transplanting method is manual that means need to make a hole in the soil then put the seedling at the proper depth and finally fill-up the hole. All of these works are laborious, time-consuming and costly. Three-dimensional projection of the transplanter was drowned by Solidworks-2016. A power tiller operated vegetable seedling transplanter was designed and fabricated with locally available iron materials at Farm Machinery and Postharvest Process Engineering Division of Bangladesh Agricultural Research Institute, Gazipur during 2018-19. The transplanter consisted of dibbler, dibbler pressing sprocket, chain, press wheel, seat, depth adjusting wheel, etc. The machine can transplant seedling two rows at a time and distance between the rows is adjustable up to 40-100 cm. Seedling spacing was adjusted and irrigation water was supplied at a time. The experiment will be continued in the next year for better field performance.

Development and adoption of two-wheel tractor operated potato planter

A power tiller operated cup type potato planter was developed in Bangladesh Agricultural Research Institute (BARI) which can plant whole tuber potato seeds automatically in furrows at predetermined regular intervals. An experiment was taken to improve the potato planter and evaluate the performance. During 2017-18, some modification of the planter was done. Mould casted metallic cups of 40 mm size were used instead of plastic cup. There were 10 cups instead of 13 pairs of potato cups fixed on a 40 mm flat belt, forming an endless loop. According to the design criteria, potato cups were positioned 110 mm apart from each successive cup which was changed to 90 mm with transmission ratio 1.15 in the improved model. Forward speed of 2.4 km/h was the best in respect of uniformity of spacing and missing seeds. Potato planter was evaluated at ten locations of Bogura and Jashore and there was a special program at Panchagarh during 2018-19. Similar yield was

found in machine planted field and manual planted field in all location with BARI Alu 36 and BARI Alu-41 except Jashore with BARI Alu-36. Total 7.11 ha area was planted with potato planter in different districts of Bangladesh. The experiment will be continued in the next year.

Improving the performance of mechanized seeding through innovations in seed metering and delivery system

A precision metering system for adoption in two-wheeled tractor operated maize planters was developed. The project tested three types of conventional maize seed meters used in Bangladesh (BARI, WRC and VMP) and an imported precision seed meter (CPM) at low, medium and high rotational speeds and inclination angles of seed meters. The tests were conducted using seeder test rig and soil bin facility of the FMPE Division, BARI. Two tests were conducted – one at steady state (zero vibrations) and the other at dynamic state (running prototype seed boxed on a PTOS to take in vibrations). Data collected were singles, doubles, multiples, missings, bridgings and gaps. The CPM seed meter outperformed other seed meters for the maize varieties tested (NK40, Elite and BHM9) giving a minimum of 92% single seeds that went up to as high as 97% depending on the operational settings. The CPM is a highly desirable seed meter that can used on seeders to improve precision of maize planting. The performance of the CPM seed meter did not change significantly due to vibrations compared to the other seed meters. Under the vibrations, the CPM seed meter resulted in 93–97% singles, <3% doubles and ≤5% gaps which indicates its suitability for maize seeding. Comprehensive field testing and fine tuning of the precision seeder for maize, wheat, pulse and oil seed crops in different soil and copping conditions are thus suggested.

Appropriate conservation machinery for rice based cropping pattern in the southern delta of Bangladesh

The field experiment was conducted at Dhamshar, Wazirpur, Barishal; Holdibari, Kolapara, Patuakhali and Charwapda, Subarnachar, Noakhali and Baratia, Dumuria, Khulna during 2018-19 for testing, adoption and popularization of different conservation machinery such as zero till planter (ZT), strip till planter (ST), and power tiller operated seeder (PTOS) along with conventional tilling and of sowing method (CT). Mungbean (BARI Mung-6) was planted in Barishal and Patuakhali and soybean (Shohag) was planted in Noakhali during the Rabi season of 2018-19. Jute of variety Nabin was planted in Baratia, Dumuria, Khulna during the Kharif-1 season of 2018-19. The average effective field capacities of ZT, ST, PTOS and power tiller were found to be 0.11, 0.10, 0.12 and 0.09 ha/h and the average tilling depths were 3.10, 4.27, 4.69 and 5.55 cm, respectively. CA planting methods (ZT, ST, PTOS) saved 60-65% fuel (Diesel) than power tiller. CA planting methods saved 36-39% planting cost of mungbean, 53% planting cost of soybean and 50% planting cost of jute than CT. Significantly the highest grain yields of mungbean were found for PTOS. ST and ZT did not perform well for mungbean yields in both Barishal and Patuakhali. Significantly highest grain yield of soybean was obtained from PTOS followed by dibbling and CT methods in Noakhali. Significantly the highest dry stalk and fiber yields were found from ST planted jute followed by PTOS and CT. Yields of jute fibre and jute stalk from PTOS were significantly lower than ST but significantly higher than CT.

Improvement and validation of BARI seeder for grain crops under different cropping patterns and soil conditions

Timely tilling and seed sowing are a major challenge in crop production specially after harvesting of aman rice. Improve seeder (Reduced, strip and zero tillage) required single pass for completion of land preparation and sowing of seeds in line whereas power tiller required 2-3 passes for land preparation. The improved seeder was found suitable for planting different types of crops such as wheat, maize, lentil, mungbean, sunflower, cowpea, etc. During rabi 2018-19, 4.22 ha of wheat maize, mustard and lentil were planted by the improved seeder in Godagari and 8.04 ha of wheat and lentil were planted in Tanore, Rajshahi. Maize, mungbean and sunflower were planted about 1.32 ha of land in Kalapara and 2.66 ha of maize, mungbean and cowpea were planted in Dumki, Patukhali by the improved seeder. Slightly higher depth of tillage and field capacity were found in silty loam soil in Patuakhali than clay

loam soil in Rajshahi. So, the field performance of seeder was found satisfactory in both Rajshahi and Patuakhali. There were four treatments (PTOS, strip tillage, zero tillage and conventional method) in field experiments of Rajshahi and Patuakahli. Significantly the highest crop yields were found from reduced tillage (PTOS) than strip tillage, zero tillage and conventional methods. PTOS is effective in crop planting method in all project locations. In four project locations (upazila), 120 operators and farmers were trained through four practical trainings. Awareness of 160 farmers were created through four field days in the project locations. Farmers of Rajshahi liked strip tillage but in Patuakhali they liked full tillage for planting of crops.

Energy use analysis of CA tillage systems for rice-maize cropping pattern

Sufficient supply of the right amount of energy and its effective and efficient use are necessary for an improved agricultural production. Conservation agriculture (CA) based management could considerably help smallholder farmers and make considerable contributions to food security. System-based evaluation of the CA in respect of energy and economics is important. Therefore, a study was undertaken to assess productivity, quantify energy flow and financial profitability of CA tillage methods for Rice-Maize cropping pattern. Treatments were- conventional Tillage (CT) T. Aman-CT maize, CT machine transplanted T. Aman-CT maize, CT T. Aman-Strip Tillage (ST) maize, CT T. Aman-Zero Tillage (ZT) maize, STMT T. Aman-ST maize, Strip till followed by manual transplanting (STMT) T. Aman-ZT maize, unpuddled tillage (UPT) T. Aman-ST maize, UPT T. Aman-ZT maize. Crops were cultivated in the cropping pattern during last Rabi season of 2017-18 and 2018-19. Yield of maize and T aman for different treatments were not significantly varied. Direct energy consumption was accounted for only a small proportion of the total energy consumption during maize cultivation. Indirect energy of maize shared lower amount in CT than ST and ZT. Direct energy of T. aman rice cultivation was the highest in CT and the lower ST and ZT. The highest energy output-input ratio was found for unpuddled T.aman-ZT maize cropping systems. The highest input cost and return was recorded in CT T. aman-CT Maize cropping pattern but the highest BCR was found in Unpuddled T.aman-ST maize cropping pattern. Thus, the experiment will be continued in the next year for completion of the cycle.

Less tillage and optimum water use of wheat and mungbean with residue retention of a rice-based cropping system using farm machinery

An experiment was carried out at RARS, Rahmatpur, Barishal to evaluate the performance of different tilling and seeding machines, to reduce turn-around time of a rice based cropping system and to determine the effect of different water stress on wheat in different cultivation practices. There were two treatments. Tillage and seeding practices are in the main plot and irrigation at sub plots. The tillage and seeding treatments were: T_1= Conventional tillage (Power tiller for tillage & broadcasting), T_2= Power tiller for tillage & Power operated seeder for sowing seeds and T_3= High speed rotary tiller for tillage & power operated seeder for sowing seeds. The four irrigation treatments were: I_1 = Farmer practice, I_2 = 100% irrigation at CRI stage, I_3 = 100% irrigation at CRI stage, 50% irrigation at 55-60 DAS and 50% irrigation at 75-80 DAS and I_4 = 100% irrigation at CRI stage, 75% irrigation at 55-60 DAS and 75% irrigation at 75-80 DAS. The cropping pattern was wheat-mungbean-aus rice-aman rice. The wheat variety used BARI Gom-30. By testing the tilling and seeding operations, it was found that high speed rotary tiller along with power operated seeder was more effective than power tiller with broadcasting techniques. The performance of power tiller along with power operated seeder gave higher performance than power tiller with broadcasting techniques. From interaction it was observed that the grain/spike, 1000 grain weight and grain yield sequentially high at T_3 treatment. In case of irrigation treatments I_4 gave higher results at 1000 grain weight and grain yield. The water productivity was high at I_2, due to less irrigation water applied than other treatments. Among the water stress treatments (I_3 and I_4), I_3 gave higher water productivity than I_4.

Use of farm machinery for increasing cropping intensity and crop productivity in southern region of Bangladesh

This research work was executed is four districts in Faridpur (Sadar upazilla), Rajbari (Baliakandi

Upazilla), Barishal (Babuganj Upazilla) and Patuakhali (Sadar Upazilla). The research area of the project was farm machineries and the crops were wheat, pulse, oilseed, spices and jute. The main objectives of the research was to reduce the turn-around time, production cost and postharvest loss, increasing cropping intensity of the single cropped southern region and to develop entrepreneurship of the local manufacturers. The two treatment of the research work were; T_1- Farmer practice (power tiller operated tilling system and broadcasting of seeds) and T_2- Tilling by high speed rotary tiller (to reduce turn-around time) and seeding operation by newly developed multi crop seeder (for quick seeding operation). Design of the research work was randomized complete block. For all crops (wheat, pulse, oilseed and spices) the yield was obtained highest at T_2 (tilling by high speed rotary tiller and seeding by multi crop seeder) than farmer practice (T_1). The grain yield was observed highest (1.47 t/ha) at the treatment T_2 for BARI Masur-6. The grain yield was observed highest (3.90 t/ha) at the treatment T_2 for BARI Gom-28. The grain yield was found highest (1.80 t/ha) at the treatment T_2 for BARI Mury-6. The grain yield was found highest (1.49 t/ha) at the treatment T_2 for BARI Felon-1. The grain yield was found highest (1.10 t/ha) at the treatment T_2 for BARI Sorisha-14. For increasing cropping intensity of southern region HSRT and multi crop seeder have better option in this changing climatic condition.

Performance evaluation of a battery operated rotary type low cost weeder for upland weed management

The overall goal of this experiment was to reduce the production cost and drudgery of labor in weeding purpose and use of renewable energy for upland crop production. The specific objective of this experiment was to remove weeds by using power operated weeder rather than manual, mechanical and chemical use of weeding to reduce time, save money and environment. Weeder was designed and fabricated considering methodological steps. The performance of battery operated weeder was acceptable for wide row crop. Field trial on maize, chili and eggplant was conducted at FMPE research field of Bangladesh Agricultural Research Institute, Gazipur. Weeding indices of battery operated weeder for maize, chili and eggplant were 92.52%, 95.85%, 92.79% respectively which was similar to chemical weeding. Again effective field capacities of battery operated weeder for maize, chili and eggplant were 0.046 ha/h, 0.022 ha/h, 0.046 ha/h respectively. Plant damage ratio was very limited for maize which was only 0.50% but it grow a little up to 2.8% for chili and eggplant. Cost of weeding by battery operated weeder was almost half compare to BARI weeder and just about one third compare to manual weeding but equivalent to chemical weeding. But there eas no significant difference in yield among three methods except eggplant. Adaptive trail in farmers' field can help this technology more acceptable among the farmers.

Design and development of prilled urea applicator for up-land crops

An experiment was executed at the research field of Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal during Rabi season (2018-19) to develop prilled urea applicator for increasing fertilizer use efficiency and to increase crop production with saving of fertilizer and environment pollution. There were three treatments (T_1: Prilled urea broadcasting (Farmers' Practice), T_2: Prilled urea deep placement by applicator and T_3: N, P, K deep placement by applicator). The design of the experiment was randomize complete block with three replications. The variety of potato was BARI Alu-41. The fertilizer use efficiency of urea was more in deep placement treatments than broadcasting. The highest yield was found (34.40 t/ha) at T_3 treatment followed by T_2 (32.75 t/ha) and T_1 (27.43 t/ha). The yield increase was higher in deep placement treatments (T_3: 25.4% and T_2: 19.4%) than broadcasting of urea. The benefit cost ratio (BCR) was greater in T_3 (1.15) and T_2 (1.04) than T_1 (0.77).

Development and adoption of two-wheel tractor operated potato harvester

A two-wheel tractor driven potato harvester was developed and improved with locally available materials at Farm Machinery and Postharvest Process Engineering Division of BARI, Gazipur to facilitate small farmers to harvest their potatoes at low cost. The harvester was a semi-automatic

digging machine consisting of digging blade, conveyer flat chain, guide plate and power transmission arrangement. The dimension of the potato planter was 900 mm × 850 mm × 950 mm. Field performance of potato harvester was evaluated at Regional Agricultural Research Station, Jashore, Tuber Crop Research Substation, Bogura, ten farmers fields in Bogura and Jashore and Breeder Seed Production Station, Panchagarh during the Rabi season of 2018-19. Field performance of potato harvester was better than manual method at different locations of Bogura and Jashore. The highest field capacity was obtained at Gazipur (0.12 ha/h) followed by at Bogura (0.109 ha/h) and Jashore (0.107 ha/h). Potato harvester required 21 labour per ha compared of 60 labours per ha in traditional manual method. Total cost of potato harvesting by the potato harvester was Tk. 12023 per ha but manually harvesting method the cost was Tk. 29,600 per ha. Lifted tuber was found 94% for potato harvester whereas for manual method it was 66%. Damage tuber was 2% higher in manual harvesting method than the mechanical harvesting method. The experiment will be conducted next year.

Improvement of coconut dehusking machine

Flat type blades were designed instead of spike type teeth, reduce the gap between the rollers from 45 to 40 mm, added rubber finger/lug instead of presser handle and added helical bar on the rollers for reducing breakage of coconut. An improved coconut dehusking machine was fabricated with locally available materials at Farm Machinery and postharvest Process Engineering Division, Bangladesh Agricultural Research Institute, Gazipur. The overall dimensions of the dehusker was 920×750×1120 mm and its weight was 258 kg. The machine has to be placed on plain surface, open space and shady place. The motor has to be started by means of OFF-ON switch, machine is running. Later one operator has to be placed one by one coconut between the two rollers and immediately press the coconut upper surface by rubber lugs. Coconut is dehusked of two blades rollers those are rotating opposite direction. The husk is pushed out out in the basket through delivery path. The price of the machine was Tk. 100000.00. The capacity of dehusker was 300 nuts per hour at the speed of 27 rpm of the machine roller. The breakage percentage of coconut was found to be 4. The dehusking cost of the device was found to be 0.28 Tk./nut. It was also estimated that benefit cost ratio was 1.28. Therefore, coconut dehusking by the dehusker could be profitable to traders when the annual use of the dehusker exceeds 750 hours. The machines would be useful for commercial purpose in coconut growing areas and coconut oil industry, wholesale and retail market for shelling coconuts.

Development of a power operated sunflower thresher

A study was conducted for solving the problem faced by the farmers in separating the seeds from the sunflower. Farmers use the manual methods due to unavailability of suitable machinery for sunflower threshing. The aim of the experiment was to design and develop a power operated machine which would separate the seeds from the sunflower. An orthographic projection was drawn with SolidWorks 2016 Software. The sunflower seed thresher was then fabricated at FMPE Divisional workshop with available local materials during 2017–18. The developed sunflower thresher was modified during 2018-19. The space between the pressing rollers (38mm to 35mm) were reduced. The cover of the machine was redesigned to primary hopper. A threshing fan was incorporated in the improved version to separate the dust part from the grains. The capacity of the power operated sunflower thresher was 115 and 197% higher compared with pedal thresher and manual threshing respectively. Capacity of the thresher varied with moisture content. Capacity of the thresher was varied from 89 to 125 kg/h within 31 to 62% moisture content (wb). The experiment will be continued in the next year.

Design and development of a sunflower seed dehuller

Sunflower is one of the principle oil-seed crops which is nicely fitted with the existing cropping pattern and adapted well in the coastal agro-climatic conditions of Bangladesh. Dehulling of sunflower seed is an important process prior to its oil extraction. Manual dehulling of sunflower seeds is a time consuming and tedious operation. Therefore, an experiment was conducted to design and fabrication of sunflower seed dehuller. An

orthographic projection was drawn with SolidWorks 2016 Software. The dehuller was then fabricated at FMPE Divisional workshop with available local materials during 2017-18. The sunflower seed dehuller was modified during 2018-19. The disks were made of wood which were previously made of steel metal. Dehulling was done with the friction of two wood made disks instead of metallic disk. The weight of the dehuller was reduced from 80 kg to 71 kg. The capacity of the dehuller was 20.56 kg/h. Capacity of the machine increased compared to last year. Whole kernel recovery was 11.06% and broken kernel was 16.63%. Though the observed capacity was increased in improved model but still the capacity and efficiency are lower than the expectation.

Design and development of a small scale millet dehuller

Millets are considered as minor cereals of Bangladesh and commonly grown in marginal land areas (saline coastal areas and chars). Its production contributes to the food security, nutrition and income of the resource poor farmers in these marginal areas. Dehulling of the millet is traditionally done manually using mortar and pestle. In order to reduce the cost and drudgeries, a millet dehuller was fabricated and tested at the FMPE Division, BARI, Gazipur. The batch type dehuller was feed with either 125 g, 167 g, 208 g and 250 g of millet grains at 9% moisture content and dehulled for either 90 s or 120 s (single pass only). The dehulling efficiency was as high as 99% up to the feed rate of 167 g. At these low feed rates, higher dehulling time did not improve the dehulling efficiency any further. Although, total milling recovery and head grain recovery were a bit low at these low feed rates, any higher feed rate would not be preferable as it reduces the dehulling efficiency. The dehulling time did not have any considerable effect on total milling recovery or head grain recovery at any of the feed rates. So, considering a higher throughput capacity, 90 s dehulling time would be preferable over 120 s.

Design and development of a chilli seed separator

Bangladesh produces 306 thousand tons of chilli per year in an area of 58000 ha. Until today, chilli seeds are separated manually. Conventional method requires operators to cut chilies into small pieces and then squeeze manually by bare hands to remove the seeds. Other practices include, sun drying of red ripe chili followed by hammering with wooden stick or, separating seeds from husk by hand. The mechanical method of chilli seed extraction is a better solution to this problem. Therefore, a power operated chilli seed separator was designed and fabricated at FMPE Division, BARI. Extracting capacity of machine was 7-10 times than manual extraction. It saved time of 4.5 times than manual method. The cleaning efficiency for dry chilli was 67.62% and 76.39% for fresh ripe chilli. Power extraction of chilli seeds was 5-6% cost effective. No seed injury was observed as well as no significant effect was found in germination or seedling emergence due to machine extraction. The experiment will be continued to the next year for improvement of its performance.

Design and development of power tiller operated onion harvester

The research work was carried out to bring out the reliable solution for harvesting of onion. The harvesting of onion is the labour intensive operation. The attempt was made to design the harvester for the low power capacity especially power tiller. The size of the harvester was decided with respect to the agro technical features of the crop. The working width of the harvester was worked out to be 30 cm. The depth of operation for the onion crop was up to 5cm. The width and depth ratio was 12:1 which is fit to the design. The estimated capacity of the harvester in respect of the working in the soil was worked out to be 1 ton/h. The drawbar power requirement for effective working of the harvester was optimize from the travel speed, the total soil load and the discharge of soil mass and the capacity of soil. The estimated power requirement for the onion harvester was to 11 to 13 hp. The estimated total weight of the machine was calculated as per the proposed engineering drawing comes to be 20 kg. The estimated cost of the onion harvester was worked out to be Tk 12000. This experiment will be continued next year.

Design and development of a low cost power driven tomato and potato grader

Tomato and potato are sold without grading in the markets of Bangladesh. Potato is graded manually

and there is no mechanical grader available in the country. A rotating cylinder type tomato and potato grader was developed in Farm Machinery & Postharvest Process Engineering Division, Bangladesh Agricultural Research Institute in 2017-2018. An electric motor of 1 kW was used to rotate cylinder at 17 rpm. Few modification was done during 2018-19 as machine inclination was increased from 15 to 20 º angels, increased the gap between tray and cylinder, etc. Four graded tomatoes were obtained from the grader through four outlets of three cylinders. The average capacity of the grader for tomato and potato are 1260 kg/h and 1504 kg/h respectively. During 2017-18, injury of potato and tomato reduced from 30 to 6% and 11 to 3% respectively. Now, injury of potato and tomato reduced 0.5% and 0.24% respectively. The benefit-cost ratio of the grader was found to be 1.54 and the payback period was 1.2 year. Therefore, the tomato and potato grader is economically profitable for custom hire business or industries.

Design and development of a cream separator

A prototype of cream separator machine was designed and fabricated at Farm Machinery and Postharvest Process Engineering (FMPE) Division, BARI, Gazipur during 2017–2018. The machine was made of a motor, SS rod, SS sheet, and SS bar, etc. Two types of milk sample named control (fresh milk) and treated (fermented) was prepared for churning in the machine for testing. The control milk (cow milk) sample produced ghee of 0.08 kg (1.6% of total milk) from 0.26 kg (5.2%) cream which was derived from 5 kg milk sample after 15 minutes of churning. The treated sample yielded 0.140 kg ghee from 0.160 kg butter which was also derived from 5 kg of milk sample. The fresh milk fat was determined at 3.30% while the amount down to 1.57% when churned in the machine and the separation the efficiency found 52%. However, for the treated milk sample the separation efficiency was 85%, while the fat down from 3.25% to 0.47%. This control sample need 58 kg milk to prepare 1 kg ghee while the treated milk need only 36 kg. This year another type of cream separator was developed, because capacity of previous machine was low compared with the current one. Current cream separator capacity was to produce 10.25 kg cream (Ghee 6.2kg/h) from 180 kg fresh milk per hour. About 3.36% of Ghee can be obtained from fresh milk. The average machine capacity was 180 kg/h. Therefore, the experiment will be continued in the next year.

Preparation of maize stalk fodder for cattle

Shortage of feed supply of the cattle during the dry season or flood period is an important issue which could be partially solved by maize stalk. An experiment was conducted to prepare maize stalk fodder for cattle during 2018-19. The BARI chopper was improved for chopping maize stalk in smaller size (7-8mm). Total chopping cost per hour was 0.23 Taka per kg. The chopped maize stalk in both fresh and dried conditions with different combinations were served to the cattle and found that smaller sized chopped piece of both dried and fresh maize stalk could be feed in both raw and mixing with salt, wheat bran and water with little molasses. Maize stalk block also prepared with different combinations and found that block made by liquid Gur was better in both physically and cattle likeness during 2017-18. Total cost of block per kg was 13.85, 31.35, 28.85 and 36.35 Taka for MS block 1(Molasses+ maize stalk), MS block 2 (Sugar + maize stalk), MS block 3 (Liquid Gur + maize stalk) and MS block 4 (Solid Gur + maize stalk), respectively. Chopped and dried maize stalk were preserved in polybag, open place and stored in room were liked by the cattle up to six months of the storage. Flatten and dried maize stalk were not liked by the cattle due to their long size and hardness. Changes in colour of stored stalk were found of open floor and store room stored stalks. Fungal growth was observed which caused the changes in colour. Chopped maize stalk and maize stalk block 3 stored in polythene bag in airtight condition could be store up to nine months.

Development of soymilk making machinery

Soybean provides a cheaper and high protein rich substitute to animal protein. In Bangladesh, uses of soybean for these food items are restricted due to unavailability of suitable machines. The design of the soymilk production and pasteurization plant would assist in increasing soybean in human consumption. The experiment was conducted to develop soymilk making machinery to increase consumption of soybean as human foods during 2018-19. A blender and a pasteurizing unit was

designed and developed for making soymilk. Capacity of the blender and pasteurizing unit was 2 liters and 6 liters, respectively. The operational time 50 seconds was selected with 69.69% blending efficiency to prepare soymilk for each batch. Time for heating the interlayer water up to 100 ^{0}C was 39 to 41 minutes. Time for reaching milk temperature up to 100 ^{0}C required five minutes only. The soymilk was prepared with 20 minutes pasteurizing. The experiment will be continuing in the next year to improve the machine performance and finalize the soymilk making parameters.

Improvement and validation of postharvest machinery for reduction of postharvest loss of fruits in the hilly region of Bangladesh

The study was conducted to know the status of coffee and cashew nut processing machinery in Bandarban, Khagrachari and Rangamati Hill districts during during 2018-19. Good quality of cashew nut is produced in the hilly region mainly in Bandarban district. But there is no good shelling machine available in this region. The performance test of coffee pulping cum grinder with fresh harvested coffee and dry coffee was evaluated. One litre of water was required for pulping of 500 g fresh harvested coffee. The pulping capacity of the pulper was 8.5 kg per hour. Dehulling capacity of the pulper was 23 kg per hour. Structural configuration and operation technique of coffee grinder and cashew nut sheller were modified. Manual and power operated higher capacity coffee cherry pulper was developed and fabricated with locally available materials. The overall dimension of the pulper is 950×649×910 mm. The hand operated cashew nut sheller was modified into both the hand and pedal operated sheller for easy operating and increasing capacity. The capacity of the sheller was 2.97 kg/h. One batch field demonstration was done at Khagrachari. Three batches (20 participants per batch) trainings were conducted at Bandarban (2 upazila) and Khagrachari (one upazila). Farmers and traders showed positive response on use of coffee and cashew nut processing machinery. Research on fine tuning and upscaling of coffee and cashew nut processing machinery is continued in next year.

Integration of postharvest technologies and best practices in the value chains of fruits and vegetables

The structural improvement of carrot washing machine, and modification and fabrication of leafy and fruit vegetable washing machine were done at Farm Machinery and Postharvest Process Engineering Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during 2018-2019. Washed (sanitizer-CCA and NaOCl) and unwashed carrots were packed in jute sack, plastic crate, CFB carton with polyethylene lining, polyethylene bag and perforated polyethylene bag stored in commercial cold storage of ASKEO MSP Centre Limited, Ashulia, Saver, Dhaka at 0-1°C and 97-99% rh for long term storage. The better yellow colour of peel of carrot was found in washed carrot by CCA than washed of NaOCl. In case of The hue angle (h°), unwashed carrot was found highly significant followed by washed carrot by sanitizer at significant level of 5%. The aerobic bacterial count (APC) count and total coliform count (TCC) were recorded as 5.6 log CFU/g and 3.8 log CFU/g, in unwashed carrot samples in 0 month of storage during March 2019. However, no E. coli nor any salmonella were detected in the samples. Yeast and mold count was recorded as 4.7 CFU/g at 0 month storage. When carrot was washed with NaOCl followed by water wash, 1.3 log CFU/g of APC count and approximately 1.0 log CFU/g reduction of TCC counts, and 1.5 log CFU/g of Y & M counts were observed. On the other hand, higher reduction of APC, and TCC counts was observed with CCA washed carrot compared to NaOCl washed carrot. Similar reduction of yeast and mold counts were observed in CCA or NaOCl washed carrot. The CCA washed carrot showed higher total phenolic content than that of NaOCl washed carrots. The total carotenoid content of the harvested matured unwashed and washed carrot samples were significantly ($P<0.05$) different on day 0. The ascorbic acid (vitamin C) content of unwashed and washed carrot was significantly ($P<0.05$) lower for non-sanitized carrot. The total soluble solids (TSS) ranged from 8.7 – 9.3 %. The TA (citric acid) values ranged from 0.07 – 0.11% on day 0. In all the chemical parameter analyzed, unwashed carrot showed higher values compared with washed carrots. Carrot washing machine was improved adding

larger wheel, auto delivery mechanism and replacement of pump. The leafy and fruit vegetable washing machine was developed for washing of brinjal, mango and banana. The capacities of the machine were 990-1260 kg/h for mango, 1864 kg/h for banana, 1020 kg/h for brinjal and 516 kg/h for red leaf.

Design and development of a jackfruit peeler

Bangladesh produced 1.0 million ton jackfruit and price of jackfruit remain very low during harvesting season. The unripe fruits could be used in vegetable curries and pickles. Main problem of such consumption was difficulty in peeling. The main aim of the research was to develop a jackfruit peeler and to solve the problems. A power operated jackfruit peeler was designed and fabricated in the workshop of FMP Engineering Division of BARI Gazipur during 2017-18. The peeler was modified to improve the performance during 2018-19. The peeler was made with locally available materials. The peeler is electric power operated machine where power transmitted to the cutting blades and jackfruit was rotated. Capacity of the mechanical peeling was 3.7, 3 and 6 times higher than the manual peeling for unripe jackfruit, papaya and sweet guard, respectively. The experiment will be conducted in the following year to evaluate the performance of the peeler for different fruits and vegetables.

Development and application of a low cost mechanical lifter for safe handling of agricultural products

A lifter is designed and fabricated for the purpose of lifting materials like sack, basket, crate and carton from ground to truck for loading purpose and vice versa. It is a simple mechanical device used to raise element or object from ground level to a certain height to perform a specific work with maximum load and minimum efforts. A low cost mechanical lifting equipment was developed for reducing the drudgery of the laborer and safe handling of agricultural products. Mechanical lifter was designed by coupling principles of hydraulic power and mechanical power of electric motor. There is a horizontal base frame which is supported by 4 number of rubber tyre wheels. It is a walking type lifting device. The main component are (i) main frame (ii) stacker with fork (iii) hydraulic pump (iv) electric motor (v) counterbalance assembly (vi) push/pull handle with accessories. Primary target of weight (100 kg) and lifting height from 3 to 2.5 m; i.e., up to the floor of transportation truck. Dimension of lifter is 6.096×0.854 m. The experiment will be continued for laboratory and field evaluation.

Up-scaling and application of solar photovoltaic pump for smallholder irrigation and household appliances in the central coastal region of Bangladesh

Base line survey was conducted in six Upazila such as Kalapara and Galachipa of Patuakhali district, Borguna Sadar and Amtali of Borguna district and Charfassion and Lalmohon of Bhola district. In each Upazila, 30 farmers were interviewed with pre-tested interview schedules. Among 166 interviewed farmers, 75.90 % had primary education, 15.07 % were illiterate, 2.41% had secondary, 3.61% were had higher secondary and rest 3.01 % were qualified up to degree and higher studies. The average literacy in the study areas was 96.76%. The average area of farm house, homestead and vegetable cultivation was found 183, 41 and 48 decimals, respectively. The vegetables-based cropping pattern was 10-15%. The main source of irrigation water in the study areas was surface water (Canals and ponds). About 1.91 m deep fresh water was always found available in the water sources throughout the dry season. There was no solar pump in the study areas. Average solar home system (SHS) package was found as $40W_p$ panel capacity with at least three DC tube light and a single DC fan. Matching the demand of farmers, solar pump and SHS were designed fabricated for and irrigation and operation of household appliances at FMPE Division, BARI, Gazipur. The new solar pump was made with 51 mm diameter centrifugal pump directly coupled with 900 W dc motor. The performance of the solar pump was tested and average discharge was found to be 180 L/min. Six solar pumps along with SHS were installed for field trials in the six Upazila along with 1300 W_p solar panel for each pump. Two field experiments were conducted in the research field of FMPE Division, BARI, Gazipur for testing of solar pump drip irrigation system during rabi season of 2018-19. The tested crops were tomato (Roma VF) and brinjal (BARI Begun-

8). Significantly the highest tomato and brinjal yields were found from drip irrigation than furrow irrigation method. There were no significantly differences of yields among three days five days, seven days intervals of water application in drip irrigation method. Drip irrigation saved about 50% and 45% water than furrow irrigation for irrigation in tomato and brinjal, respectively. This experiment will be continued for next year.

Development of handy solar dryer for drying of potato chips

Bangladesh produces about 30 Lac tons of excessive potato. This excessive potato can be partially utilized by preparing and consuming potato chips locally. A handy solar dryer was developed for drying of small-scale fruits and vegetables especially potato chips. The dryer was fabricated at FMPE Division, BARI using MS frame, plastic sheet, CI sheet, dc blower, solar panel, plastic net, etc. The temperature in the dryer (45-50 ^{o}C) was about 10°C above ambient temperature. The capacity of the dryer was to dry 2.5 kg of potato chips in 6-7 hours. Blanched sample of processing varieties of potato produced good quality potato chips. But table potato produced dark colour potato chips. Non-blanched potato slices produced inferior quality in terms of colour and shrinkage. Potato chips dried in the open sun took at least two sunny days for drying. If bad weather exits, potato chips are infected by fungus and damaged. Ten potato varieties such as BARI Alu-7 (Diamant), BARI Alu-8 (Cardinal), BARI Alu-25 (Asterix), BARI Alu-28 (Lady Roseta), BARI Alu-29 (Courage), BARI Alu-35, BARI Alu-41, BARI Alu-68, BARI Alu-70 (Destony) and BARI Alu-71 (Dolly) were tested for suitability of chips making. BARI Alu-25 (Asterix), BARI Alu-28 (Lady Roseta) and BARI Alu-70 (Destiny) were found suitable for good quality chips preparation. The handy solar dryer may be used for drying of small quantity of potato chips as well as other fruits and vegetables in household level.

Development and performance evaluation of a solar assisted cabinet dryer for vegetable seeds

A solar cabinet dryer was designed and fabricated at Farm Machinery and Postharvest Process Engineering Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during 2018-19 for drying of 10-15 kg of moist vegetable seeds. It is an indirect solar cabinet dryer that consisted of drying chamber, collector and auxiliary heating source (electric heater). The dryer was designed to generate desirable temperature (<45°C) from solar radiation suitable for vegetable seed drying. The dryer was tested with harvested semi dry moist okra seeds (9.72 kg). After drying, final weight of okra seeds was 9.305 kg. Inside air temperature of the drying chamber varied from 31.3 to 44.4 °C (first day) and 30.2 to 44.7 °C (2nd day). Ambient relative humidity varied from 41 to 68% (first day) and 42 to 57% (second day), where the relative humidity in the drying chamber varied from 36 to 50% (first day), and 32 to 53% (second day). Collector outlet air relative humidity was found lower than the ambient air relative humidity. The global solar radiation varied from 120 to 928 W/m^2 during testing period (January 2019). Semi dried Okra seeds dried in the dryer attained final moisture content of 8% (wet basis) from an initial moisture content of 12% (wet basis) after15 hours of drying. There were significant differences between top and bottom layers by statistical t-test. The dryer was tested with red amaranth seeds (9.27 kg). Drying chamber inside air temperature varied from 40.6 to 42.8 °C. The highest (848 W/m^2) and lowest (211 W/m^2) solar radiation was measured at 12:20 am and 4.00 pm respectively. Dryer relative humidity was about 50% lower than the ambient relative humidity. The moisture content was reduced from an initial moisture content of about 20.78% (wb) to the final moisture content of about 7% (wb) in 6 hours. The capacity of the dryer was 10-15 kg/batch. Germination rate of red amaranth seeds after drying up to 7% moisture content (wb) was 78%.

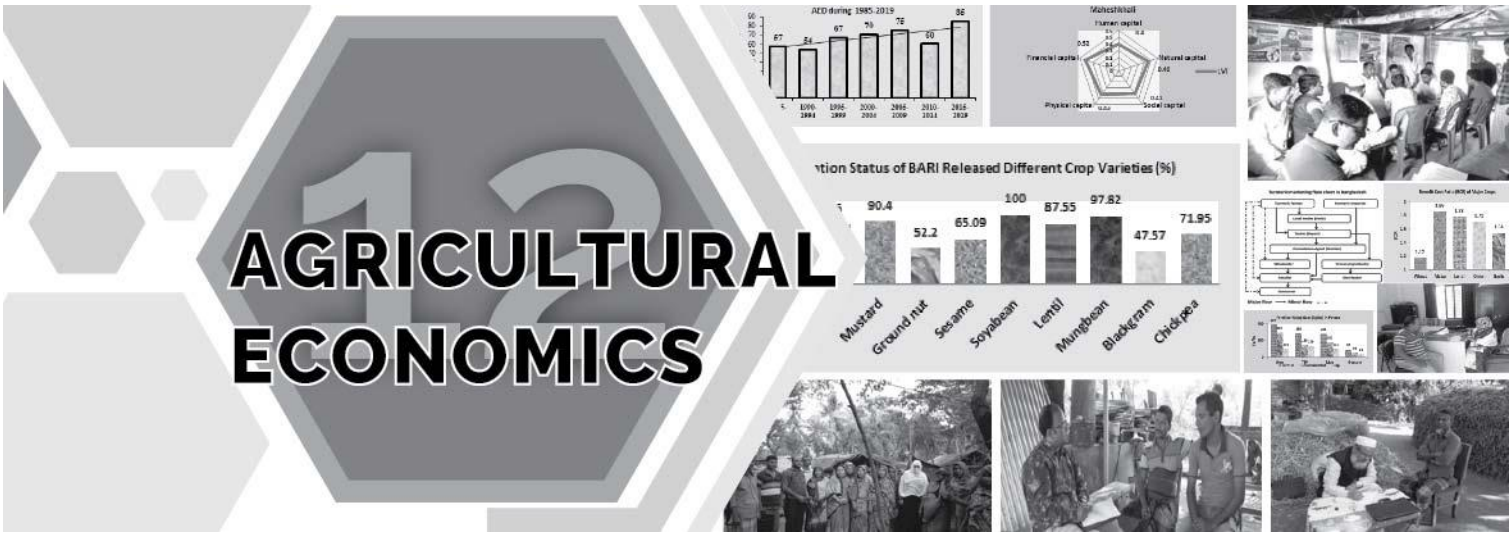
Development of solar energy powered air ventilated natural onion storage system

This experiment was conducted to increase the storage life of onion using solar powered forced air ventilated storage system rather than traditional storage method to reduce storage loss. Onion were stored at four different methods to know the storage behavior of onion bulbs. BARI Piaj-1 were kept in bulk at ambient conditions (25˚C ± 3˚C and 75% RH) in solar powered forced air ventilated storage system for 60 days of storage period. Physiological

weight loss, total soluble solids (TSS), decay and moisture content were measured at an interval of 15 days. Forced air ventilated storage system observed significantly the lowest decay (6.275%) and it was closed to traditional storage system (7.45%) but net and jute bag storage system found the highest decay (8.067%) and (8.64 %) respectively. Forced air ventilated storage system was observed significantly the highest moisture content (76.59%) than traditional storage system (71-72%). The physiological loss ranged from 2 to 5% in forced air ventilated storage after 60 days of storage period. The physiological weight loss of onions stored under traditional method was more than 5%. This was a first year experiment and it will be continued to the next year.

Present status of using dies, jigs and figs by local manufacturers in Bangladesh

Tool, die and mold making is a process to convert materials into a required shape using machine tools. The principal advantages of this process are its quickness and economy and the practically absolute interchangeability of all punches made from the same die. Local manufacturers are using indigenous tools for producing the machinery. Thus, this study was taken to determine the status of the tool and die available in the local manufacturing workshop. The survey was done at 20 different agricultural machinery manufacturers and 20 foundry workshop located at different parts of Bangladesh during 2018-19. Education level of 94% and 98% of the workers in the agricultural machinery manufacturers and foundry workshops were below SSC. All surveyed agricultural machinery manufacturers used lathe machine, drill machine, welding machine and grinding machine as key working machine. All agricultural machinery manufacturers used templates used in their 40% production. Use of dies, jigs and figs were found as 60%, 20% and 20% in agricultural machinery manufacturing. Agricultural machinery manufacturers collected the highest amount (59%) of raw materials from Nawabpur and Dholaikhal of Dhaka followed by local spare parts shop (13%). Agricultural machinery sold mainly to farmers and dealers by the manufacturers. Most encouragingly found that 2% agricultural machinery were sold by on-line marketing. Most of the foundry workshop have collected their 37% raw materials from the locally collected scrap market (37%) followed by supplier (30%). Foundry workshop usually did not sell their product directly to the farmers. They mainly sold to their dealers. The manufacturers were demanding technical training, specialized land for workshop, chemical laboratory and heat treatment plant for foundry and development of dies, jigs, figs for each machine from research institute as the priority need. This study will be continued in the next year in others manufacturer to find status of the manufacturers in Bangladesh.



Cost and return analysis of selected crops in Bangladesh

This study was conducted to analyze the cost and return of wheat, maize, lentil, onion and garlic cultivation in selected growing areas. A total of 2700 farmer were randomly selected for the study. Profit function was used to estimate the cost and return of the selected crops. It was observed that farmers in the study areas used highest 358 man-days human labour per hectare in onion cultivation followed by 268 man-days in garlic, 124 man-days in maize cultivation, 81 man-days in wheat cultivation and 65 man-days in lentil cultivation. The highest total cost was incurred in garlic cultivation (Tk. 239535) and the lowest cost was estimated in lentil cultivation (Tk. 54919). Highest net return was found from onion cultivation (Tk. 142446) followed by garlic (Tk. 128951), maize (Tk. 95110), lentil (Tk. 42992) and wheat (Tk. 13465) cultivation. Per hectare average BCR was estimated 1.17, 1.86, 1.78, 1.71 and 1.54 for wheat, maize, lentil, onion and garlic cultivation respectively. For producing one kg of wheat, maize, lentil, onion and garlic about Tk. 19, Tk. 10, Tk. 36, Tk. 15 and Tk. 32 respectively was required.

Adoption and profitability of BARI released garlic varieties in Bangladesh: a farm level study

The study was conducted in three garlic growing districts namely Rajbari, Natore and Dinajpur to know the adoption status of BARI garlic varieties, its farm level profitability and constraints of the farmers. A total of 300 farmers taking 100 farmers from each district were randomly selected for this study. Data were collected through a pre-tested interview schedule during January-March, 2019. The study revealed that the highest proportion (45%) of farmers adopted BARI Rosun-2 and the lowest proportion (14.67%) of farmers adopted BARI Rosun-1 variety. The other two varieties namely BARI Rosun-3 and BARI Rosun-4 were not adopted in the study areas. Some local and exotic varieties namely Italy, Patna and Barma were cultivated by some farmers. Higher yield, higher profitability, and less insect-pests infestations were the prime reasons for choosing BARI Rosun-2 and BARI Rosun-1at farm level. Besides, human labour, education, farm size, training on garlic cultivation, availability of quality seed, and influence of extension personnel had significant influence on BARI variety adoption. Farmers did not applied the recommended doses of manures and fertilizers due to lack of adequate knowledge on scientific recommendations. Human labour, seed, and rental value of land were the main cost items in garlic production. The highest yield was reported to be 7.65 ton per hectare at Rajbari followed by Natore (7.26 t/ha.) and Dinajpur (6.98 t/ha). Natore farmers received the highest net return (Tk 69631/ha), whereas the lowest return was received by Dinajpur farmers (Tk 38613/ha). Undiscounted BCR on variable cost and total cost basis were 1.31 and 1.24 respectively. Low market price at peck season, non-availability of improved or hybrid seed, unfavorable weather condition, and lack of technical knowledge were the major constraints to garlic cultivation. The study suggested to ban excessive import, introduce hybrid variety, provide hand-on training on production technologies, and ensure low price of inputs for higher adoption of BARI released garlic varieties at farm level.

Study on cropping pattern at south-western saline region of Bangladesh

The study was conducted in two district namely Satkhira and Khulna to know the scope and existing cropping pattern at south western region of Bangladesh where high salinity exist and

challenged to crop production during July,2018 to June,2019. Among the selected farmers about sixty six percent farmers were small farmer. Average farm size was 0.83 ha. Most of the land of saline area covered by a single crop (T. Aman). Average total cost of T. Aman rice was Tk.92,189.40 per hectare. Most of the cost involved for cost on labor for T. Aman rice cultivation. If the farmer cultivate the land by share from owner then farmer give half of the crop to his land owner. Study found that T. Aman-mustard-mungbean cropping pattern gain the highest net return (23,919.77 Tk./ha) at three crops cropping pattern followed by T. Aman-mustard-sesame (20,879.77 Tk./ha) cropping pattern. T. Aman-sunflower gave highest return Tk. 24,032.59 per hectare. Most of the farmers were eager to cultivate new crops.

Study of pesticide use on bitter gourd production at Jashore district

The study was designed to assess the extent of pesticide use and profitability of bitter gourd production at farm level in selected areas of Jashore district. Average farm size was 0.79 ha and average bitter gourd cultivated area per farmer was 0.07 ha. Most of the farmer cultivated local variety which called Gajkorola and some farmer cultivate hybrid korola such as Gonggajoli, Tia and BARI korola-1 variety. About ninety nine percent farmer spray insecticide in their fields to protect crops from different insect, paste and disease. Thirty nine percent farmer used pheromone trap for crop protection. A farmer averagely used 13 times spray in their fields and its range was 2-30 times in a season. On an average, the total cost of production of bitter gourd was Tk.321127/ha for IPM farmer and Tk.340043/ha for non IPM farmer. Among the cost item cost of labor was highest Tk.134800/ha (41.98%) for IPM farmer and Tk.132400/ha (39%) for non IPM farmer that means excess labor need to cultivate, nurturing, spraying and harvesting of bitter gourd. Average yield was 14.82 ton/ha and average price was 27.67 Tk./kg. Gross return was Tk. 410069/ha and net return was Tk.78943/ha for IPM farmer and Tk.70027/ha for non IPM farmer. Benefit cost ratio was 1.24 and 1.21 for IPM and non IPM farmer respectively that means bitter gourd production was profitable. Cent percent farmer said that IPM technology was time consuming method.

Socioeconomic impact of bagging technology for value addition in mango in the Chittagong hill tracts

The study was conducted at eight selected villages in the Chittagong Hill Tracts to gather information on the socio-economic impact of bagging technology on farmer's income and to know the factors affecting for adapting mango bagging technology during 2018-19. Findings revealed that BARI Aam-4, BARI Aam-8, BARI Aam-3, Mallika and Arshina were reported to be the most preferred varieties for bagging because of reduced pest attack, attractive color and higher market prices. The price received of bagged mango was 74% higher than non-bagged mango. The difference of average gross margin between bagged and non-bagged mango was recorded at Tk.22790 per ton implies that the bagging mango was more profitable than non-bagged mango due to its higher market price. About 15.7% annual gross income increased due to adopting bagging technology while it was 25.13% increased income from mango selling. About 96% of the respondents mentioned that they were able to control fruit fly through bagging technique and 92% of them confirmed that the fruit was safe and free of toxicity. The price of bagged mango, training, research contact, extension contact, risk taking behavior and willingness of farmers influence to adopt bagging technology significantly. This technology should be disseminated in the hilly areas with maintaining proper time and method.

Marketing of vegetables at traders' level with special reference to postharvest loss and food safety

The study was conducted in six vegetable growing districts namely Jamalpur, Mymensingh, Jessore, Rajshahi, Bogura, and Rangpur to assess the *knowledge, attitude and practice (*KAP) of traders on postharvest practices and losses, and investigate vegetable market chains for identifying market opportunities for producing and marketing safe produces to the consumers. Four summer vegetables namely brinjal, bitter gourd, yardlong bean and teasel gourd were considered for this study. *Data and information were collected from* 320 farmers, 68 Farias, 103 Beparis, 12 Paikers, 100 retailers, and 177 consumers. Most intermediaries have adequate knowledge on

different postharvest practices in relation to reduce postharvest losses and keep vegetables safe for the consumers, and in most cases they claimed to practice it. A huge amount of vegetables move from farmer to consumer through two major channels: (i) Farmer-Faria-Bepari-Paiker- urban retailer- urban consumer; and (ii) Farmer-Faria-Bepari-local retailer-local consumer. The total postharvest loss of brinjal, bitter gourd, yardlong bean, and teasel gourd are 13.32, 18.03, 16.47, and 6.40% respectively at traders' level. The annual financial loss incurred at national level are Tk.3433.05 million and Tk. 2596.40 million when vegetables move through the above two channels respectively. The trader's level postharvest losses were taken place at various stages in the supply chain such as sorting, cleaning, loading & unloading, packaging, and transportation. The highest marketing cost of selected vegetables was for urban retailer (Tk.610/quintal) followed by Bepari (Tk.608/quintal). The highest net margin was received by urban retailers for different vegetables. Middlemen traders received reasonable net margin (Tk.93.0-Tk. 889.0/quintal) from vegetable marketing. Local marketing channel (Chain-II) performed much better than urban channel (Chain-I) since the producer's share and marketing efficiency were higher and price spread was lower in the local channel. Return on operating capital for different intermediaries are also higher in local channel. The study suggested different stakeholders to adopt good agricultural practices in producing vegetables, certify available safe vegetables for developing consumers' confidence, and ensure premium price of the safe vegetables for encouraging farmers towards safe vegetable production. It also suggested government to construct different infrastructures such as pack house, concrete floor, drainage, water & sanitation facility, and rest room for the distant traders at the market premises. Development of awareness among producers, traders and consumers toward safe vegetable production, marketing and consumption is equally emphasized in this study.

Value addition and supply chain analysis of vegetable in Chattogram district

The study was carried out in 6 villages under three Upazilas namely Hathazari, Rangunia and Sitakundu in Chattogram District during 2018-19 with a view to analyze the existing supply chain, post-harvest losses, gap of the chains and constraints of vegetables marketing covering with 270 samples in all locations. The selected vegetables are: brinjal, tomato, okra, cucumber, country bean, asparagus bean, cauliflower, cabbage, sweet gourd, snake gourd, bitter gourd and teasle gourd. Results revealed that per household average cultivable land was recorded at 1.18 ha where vegetable cultivation was 0.22 ha in all locations. About 21 vegetables were cultivated in three locations where brinjal was got the highest ranked in Hathazari and Rangunia while country bean was the highest in Sitakundu. The cent percent farmers collected seed from local market and about 75.5% farmers were satisfied about the seed quality. The comparatively large plot size was estimated by 0.0.28 ha for country bean irrespective of all locations followed by brinjal 0.24 and tomato 0.11 ha.. The selling price of vegetable at different market places significantly differed from one place to another. The identified supply chain ''farmer-local market-consumer'' and ''farmer- bepary - whole seller'' was the common in all areas. The highest portion (87.5%) of market share was belonged to farmer to local market and consumer. About 68.4% farmers claimed that pre and post-harvest loss was occurred mainly due to insect and disease attack. All most all farmers were done value addition activities in vegetables except processing. Lack of proper coordination among the actors was the main gap of the chains. No permanent selling places, higher market taxes, market syndicate, transportation problem (in Sitakundu areas), multi handover of ownership of the market, lack of knowledge of marketing and market linkage, and 10% deduction vogue of the total weight (in Sitakundu) were the major constrains for marketing. All the stakeholders have to join hands to improve the supply chain which should be started from farmers to consumers. Thus, government support to group farmers in order to achieve a better focus on quality and customization of activities would be useful in the existing chains.

Supply chain analysis of major vegetables produced in hilly and coastal regions of Bangladesh

The study was conducted in hilly and coastal region of Bangladesh for understanding the input distribution system, profitability of different production practices, supply chain and marketing

system and different drawbacks of production and marketing of selected vegetables. The study area covered three hill districts namely; Rangamati, Khagrachari and Bandorban and three coastal districts namely; Patuakhali, Satkhira and Cox's bazar where vegetables production is very limited due to different stress. Brinjal and yard long bean were selected from hilly areas and bitter gourd and cucumber were selected from coastal areas. The study was conducted during the period of 2017-2018. Primary data were collected through face to face interview and ssecondary data were collected from different published sources. Multistage simple random sampling technique was used and total sample size was 1140 for the study. The study revealed that vegetables production and marketing both for farmers and traders were found profitable. Three production techniques were found in both regions such as; homestead, plain land and Jhum cultivation in the hilly areas and plain land, sorjon method and gher based cultivation in coastal area. The net return of brinjal and yard long bean in plain land cultivation was Tk. 1, 92,265/ ha and Tk.82362/ha respectively in hilly region and the BCR was found 1.88 and 1.53 respectively. The net return of Jhum cultivation was found Tk.70,113/ha and the BCR was found 2.02.On the other hand, the net return of bitter gourd and cucumber was Tk. 2,24,530/ ha and Tk. 1,57,893/ha and the BCR was found 2.08 and 1.82 respectively in plain land of coastal area. The profitability of sorjon cultivation and gher based agriculture system was Tk. 91023/ha and Tk. 1,29,115/ha respectively and the BCR was 1.37 and 1.76 respectively. Five supply chains of vegetables were identified in hilly area, of which four chains were dominant and 93.25% vegetables moved by those chains. On the other hand, four supply chains were identified in coastal areas of which three chains were dominant by which 94.43% vegetables moved from producer to consumer. Supply chain-I: Farmer-cum-retailer > Local Consumer is the most efficient chain for vegetables marketing in both hilly and coastal region of Bangladesh. Because no intermediaries were involved in the chain and farmer himself done retailing to the consumer. Highest marketing margin was found in supply chain-IV in hilly areas which was Tk. 647.60/qt. for brinjal. and Tk. 645.81/qt. for yard long bean whereas In coastal areas, it was also found highest in supply chain-IV which was Tk. 777.41/qt. for bitter gourd and Tk.554.65/qt. for cucumber. Farmers faced different production problem in the hilly areas such as; scarcity of irrigation water and quality seed, low yield, Insect & pest attack, poor technical knowledge and production practices, less use of farm machinery etc. and in coastal belt, farmers also faced unavailability of fresh irrigation water, incidence of salinity in the soil, intrusion of salinity due to heavy rainfall and drought, scarcity of quality seed, poor yield, poor technical knowledge etc. for vegetables cultivation. Businessmen also faced some marketing problems such as; price fluctuation, high transportation cost, lack of market information, poor road & transport, unethical subscription, absence of permanent retail place and lack of storage facilities etc. Training programme on modern technology and post-harvest handling, improvement of transportation and communication system, development of salt tolerant variety and wider expansion of existing modern technology in coastal region and linking farmers with the extension personnel and researcher were the major recommendation of this study.

Profitability, value addition and constraints to mungbean production in some selected coastal areas of Bangladesh

Assessment of profitability, value addition and constraints to munbean production in two southern coastal districts- Barisal and Patuakhali was made through an extensive field survey during 2018-2019. The study revealed that few farmers of these areas used chemical as well as organic fertilizers. Total cost incurred for mungbean production was Tk.51850/ha of which 50% is variable cost and remaining 50 % was fixed cost. Average gross return was Tk. 54143/ha. Benefit cost ration on variable cost basis was 2.09 but on total cost basis it was 1.04. Considering variable cost per kg production cost was Tk. 24.62/kg but on total cost basis it was estimated at Tk. 49.05/kg. Producer share was 66 % for husked mungbean and for fried packed mungbean it was 19.8 % only. Disease infestation, insect attack, uneven and heavy rainfall, flash flood, unavailability of cultivating machine and inadequate labour during harvesting were found to be the major constraints to mungbean production in the study areas.

Production, marketing and post-harvest loss of cucumber in selected areas of Bangladesh

The present study was undertaken to estimate the production, marketing and post harvest loss of Cucumber. The data were collected from 180 farmers and 45 intermediaries of Rajshahi, Rangpur and Bandorbon district of Bangladesh. Purposive sampling technique was used to select the cucumber producers and convenience sampling was used for selecting intermediaries. Production of cucumber is profitable in the study areas. Per hectare net margin of cucumber was Tk.632576.49. Total marketing cost of cucumber was highest for bepari (27.5%) and lowest for paikers (13.75%). There were 6 marketing channels in the cucumber marketing. The net marketing margin was highest for retailers (Tk.3.47) and lowest for paiker (Tk. 0.84). Insect and disease were the major causes of cucumber post harvest loss in the survey area. Due to post harvest losses of cucumber farmer have to incur financial loss Tk. 441.92 per decimal of cucumber cultivation. Farm level cucumber post harvest loss was found 9.93% per farm of which 6.17% was due to full damages and the rest 3.76% was due to partial damages of cucumber. Total harvested amount, selling place and type of vehicle were some of the important factors for cucumber post harvest loss in the survey area.

Value chain study of turmeric in selected areas of Bangladesh

The study was undertaken to identify value chain actors and their functions and inter-relationship; determination of marketing and value chain system; value addition in different steps of value chain actor; marketing efficiencies; constraints of value chain and recommended intervention to overcome them. Primary data were used for this study. Primary data were collected from Panchagarh, Pabna, Rangamati and Jhenaidah districts depending upon the concentration of production and commercially marketing of turmeric and consuming area Dhaka and Chattogram. Data were analyzed using arithmetic mean, percentage, ratio, margin, profit, efficiency ratio, and flow chart. Five major marketing channels were identified for domestic produced dry turmeric marketing. Channel-4 was the most important supply chain through which 24% domestic produced turmeric reaches to consumers. Out of five marketing channel, Channel-3 was more efficient than those of other channels. Eight actors like; farmer, local trader, trader, commission agent, wholesaler, processing industry, distributor, retailer and consumer were identified who were involved in the turmeric value chain systems. The study revealed that farmer added the highest amount of value Tk 3451.00 per quintal in non-processed turmeric followed by trader (Tk 2561.00), retailers (Tk 1744.00), local trader (Tk 1657.00) and wholesalers (Tk 1472.00), respectively. In the case of processed turmeric, processing industry added the highest amount of value and it was Tk. 11432 per quintal. Sixteen marketing problem were identified, among them price fluctuation, higher transport cost and lack of loan facilities were the major and common problem for most kinds of intermediaries involved in turmeric marketing in Bangladesh. It is therefore, recommended that loan facilities should be provided to the intermediaries and price fluctuation should be kept in reasonable limit by the government intervention. Natural gas and frequent supply of electricity should be ensured to turmeric processing industries for continuous production of processed turmeric. Technologies should be developed for the identification and removal of alpha toxin and heavy metal and to develop technique against the deterioration of color of turmeric powder for enhancing export.

Climate change and gender based vulnerability nexus: an evidence from cyclonic storm surges in Dhalghata, Moheshkhali of Bangladesh

Dhalghata Union of Maheshkhali Island is the most vulnerable in response to cyclonic storm surges. Women and girls are at most risk due to their differentiated role in the family and society and very weak coping strategy. The present study explored the vulnerability of women's livelihood in Sapmarar Dail village of Dhalghata through adopting sustainable livelihood framework which based on five livelihood assets. In order to assess the level of vulnerability, the present study applied livelihood vulnerability index (LVI) where assets are grouped into 10 major components and some other sub-components. Two Focus Group discussions (Men and women) along with questionnaire survey were done to collect necessary information. The maximum households (77%)

were in marginal farm size category. Salt production was the primary sources of income of 68% of the respondents in Dhalghata. The 31% of the respondents were illiterate following by 10% who can sign only. Beside this 54% of the respondents completed their secondary level of education. Most of the households were male headed (98%). As they are living just beside the Bay of Bengal so 91% of the respondents were well informed about the impact of climate change. Among the climate change related extreme events cyclonic storm ranks highest vulnerability concern for the women of Dhlaghata following by iron in drinking water, salinity intrusion, tornado etc. The overall LVI of Dhlaghata is 0.44. It means that women livelihoods here are moderately vulnerable to cyclonic storm surges. The index was highest in financial capital and lowest in human capital. Among the components land, finance and incomes, knowledge and skills are the most vulnerable components whereas social involvement and livelihood strategies are the least vulnerable components among the major components for women in Dhalghata. In order to reduce women's vulnerability special attention is prerequisite for Dhalghata. Employment opportunities for the women and provision of healthy social safety net programs can be the best option to reduce their vulnerability within the shortest period of time. The study indicated that the LVI technique can be used to understand vulnerability in special geographical regions and can formulate policy by comparing actual scenarios.

Impact of wheat research on adoption of technologies, return and competitiveness in Bangladesh

BARI has released good number of high yielding varieties and improved management technologies of wheat crop. The Department of Agricultural Extension (DAE) has been involved in developmental programs for the technology transfer of this crop through its countrywide networks. This impressive information indicates the immediate need of strengthening the current efforts of improved variety adoption at farm level. Although the released varieties have been found to be suitable for farmers and created additional employment, income and saved foreign exchange for the country, a large number of farmers throughout the country are still reluctant to adopt improved management technologies on wheat crop that need to be evaluated properly. Realizing the importance and demand of wheat, Bangladesh government has given emphasis on research and extension of this crop and invested huge money for attaining their self-sufficiencies in the country. Therefore, the present study has been conducted to prepare data base on the adoption of wheat technologies at farm level and to find out the factors affecting their adoptions and sustainability, to estimate the financial and economic returns and competitiveness of wheat cultivation in Bangladesh along with its impact on the livelihood of the farmers and to estimate the returns to investment (IRR, NPV, BCR) in wheat research and development in Bangladesh. Both primary and secondary data were used in this study. Primary data were collected through household survey, while secondary data were collected from various published sources. The household survey was conducted by 7 wheat growing districts namely, Dinajpur, Rajshahi, Faridpur, Jamalpur, Tangail, Kushtia, and Madaripur for the study. The study used different statistical tools for analyzing collected data. Financial and economic profitability analysis, an ex-post evaluation with the help of economic surplus model under both closed and small-open market economy situations was also adopted to estimate the rate of returns (BCR, IRR & NPV) of the investment in wheat in Bangladesh. The finding of the field survey revealed that in the year 2016-17 the farmers adopted wheat varieties such as BARI Gom-21 (Shatabdi) , BARI Gom-23(Bijoy), BARI Gom-24 (Prodip), BARI Gom-25, BARI Gom-26, etc. Among those adopted varieties, BARI Gom-24 (Prodip) was highly adopted variety (32%) followed by BARI Gom-26 (30%) and BARI Gom-25 (18%), BARI Gom-21 (Shatabdi) (10%), BARI Gom-23 (Bijoy) (6%) and other occupied 4% of the total wheat areas in Bangladesh. For economic analysis under import parity prices of wheat, the estimates of DRCs for wheat crops were observed to be less than unity implying that Bangladesh had comparative advantage in wheat production for import substitution. Due to adoption of BARI high yielding varieties over the sonalika year over year, change in consumer surplus and producer surplus were Tk 190,756/- million and Tk 65,591/- million. It is seen that consumers benefited 3.24 times higher than

producer. Therefore, change in total surplus stands Tk 256,347/- million. Investment in wheat research and extension was Tk 1,5203/- million. Hence, net present value (net benefit) was found to be Tk 241,144/- million at 2016 price. Internal rate of return (IRR) was calculated 53% at current price. Benefit cost ratio (BCR) was calculated as 17 (seventeen) indicating that society (country) gained 17 times return as against the investment in wheat research and extension over the years mentioned. Therefore, the investment on R&D of wheat is found to be encouraging in Bangladesh.

Impact of mungbean research and extension in Bangladesh

An ex-post rate of return analysis was considered to estimate the internal rate of return (IRR) to BARI-released improved varieties of mungbean that have been replaced the local varieties. The growth rate of area, production and yield before the release of improved mungbean varieties were 22.19, 23.30 and 1.11% respectively. After the release of improved varieties of mungbean, the area and production were increased dramatically but their growth rates were not satisfactory for various reasons. The IRR to total investment in both mungbean research and extension was calculated at 57%. The potential relative yield of BARI Mung-6 over the local varieties was 66% higher. Under various assumptions about the magnitude of the benefits and the research and extension expenditures, the IRR ranged between 45% and 67%. This indicates that the funding of mungbean research and extension was a good investment.

Adoption and impact of BARI developed machinery at farm level in Bangladesh

Farm machinery is an integral part of farming in Bangladesh as labors are shifted from agricultural operations to industry. The study was carried out to determine the impacts of adoption of BARI multi-crop seeder and BARI bed planter on productivity, farm income and livelihood of the farmers/service providers in Thakurgaon, Faridpur and Rajshahi districts through collection of primary data from 83 adopters, 160 non-adopters and 30 service providers. Propensity score matching method was used to assess the impacts of BARI multi-crop seeder and BARI bed planter adoption. Asset pentagon approach was also used to find out the change of livelihood of farmers and service providers. It was found that the rate of adoption of BARI multi-crop seeder and BARI bed planter was 9% and 15% at farm level respectively. Probit model showed that experience of the farmer, farm size, training, and extension contact enhanced the adoption of BARI multi-crop seeder and experience of the farmer, farm size, and extension contact were important variables that had an effect on the likelihood of farmers to adopt BARI bed planter. BARI multi-crop seeder adoption on average increased wheat productivity and farm income by 347 kg/ha and 37 to 41% respectively for adopters compared to non-adopters. BARI bed planter adoption on average increased lentil productivity and farm income by 128 kg/ha and 25 to 36% respectively for adopters compared to non-adopters. Again, all kinds of adopters' assets were also increased to some extent due to adoption of BARI multi-crop seeder and BARI bed planter. Ninety one percent, 79%, 69%, and 69% of the respondents responded that the number of mobile phones, chair, table and furniture were increased due to income earned from BARI multi-crop seeder in wheat farming. In the case of bed planter, electricity use increased by 95%, mobile phone increased by 90%, and furniture improved by 83%. Most farmers mentioned that non-availability of machine in peak period, problem of seed meter were the major problems in cultivating wheat and lentil by using BARI multi-crop seeder and BARI bed planter. Most of the respondents opined that the non-availability of machine due to lack of capital of the respondents and complicacy of receiving subsidy to purchase machine. The study recommended to provide training to the farmers/operators for more efficient operation and demonstration program should be continued until adequate awareness is created among the farmers. Agricultural extension agents can play a crucial role in this regard.

Assessment of fertilizer using gaps between farmers' practice and recommended dose in selected areas of Bangladesh

The study documented current farm practices related to soil nutrient management; determined the fertilizer using gaps between farmers' practices and scientific recommendations; explored barriers towards the adoption of recommended fertilizer application; and identified the factors affecting fertilizer using gaps. A total of 750 different

categories of farmers from Rajshahi, Thakurgaon, Mymensingh, Khulna, and Barguna districts were selected adopting stratified random sampling technique and interviewed them for collecting baseline data and information. Descriptive statistics were used to analyze the collected data. The study revealed that only 6% farmers had received nutrient management related training and 94.5% farmers did not test their soil due to lack of awareness (37.0%). About 23% farmers claimed to know about the optimum doses of fertilizer. They identified nutrient deficiencies by observing leaf color (78.2%) and physical growth of crop (70.3%). Most farmers applied fertilizers without maintaining scientific recommendations. They used much higher amounts (10.9-58.2 kg/ha) of all nutrients (NPKS) in potato cultivation, whereas used much lower amounts (7.1-18.8 kg/ha) in Kharif maize cultivation. Except maize, they applied much higher dose (1.0-29.5 kg/ha) of P in different crops compared to recommendations. However, the optimum dose of nutrients was used only for Aus rice. In farm categories, women managed farm households and small & marginal farmers used much lower dose of nutrients compared to medium and large category other farmers. The major barriers of applying balanced fertilizer dose were lack of relevant knowledge and skills; higher price of fertilizers; lack of training on soil nutrient management; complexity to apply recommended fertilizer doses; lack of extension advisory services; non-availability of soil testing facilities, and put less importance on recommended dose. These problems could be overcome if technical assistance and financial support are made available by the government. This support could be channeled into five areas: awareness creation, technology development, strengthening extension services, assurance of input quality and supply, and financial support.

Economic assessment of climate change adaptation strategies in maize farming

The study assessed the economic impact of climate change adaptation strategies adopted in maize farming in the selected maize growing areas of Chuadanga, Jhenaidah and Rajshahi district. A total of 180 maize growers, taking 60 farmers from each district, were selected on the basis of having minimum 6 years' experience in maize farming. Descriptive statistics and different farm management analytical tools such as gross margin and net margin analysis, partial budgeting and a log linear form of fixed effect model were used. The average gross margin was estimated at Tk. 74634/ha under the threshold climate, whereas it was Tk. 34,528/ha at non-adapted period. The most common strategy followed in maize farming was the adoption of stress tolerant varieties (Strategy-1) (43%). The farmers of Chuadanga (65%) and Jhenaidah (58%) adopted this strategy, whereas shifting of Rabi maize to Kharif-1 maize (Strategy-6) was mainly adopted by Rajshahi farmers (35%). All options moderately increased the value of returns to land and these are significantly higher than the threshold level. Cost benefit analysis revealed that the value of BCR is higher than one for all the adaptation strategies which implies that the investment is feasible as the benefits exceed the cost. The cost-effective analysis (CEA) for the same adaptation is also supportive because Tk. 100 ensures 8.64 kg to 10.08 kg maize. Strategy-1 is slightly more risky but has greater return, so farmer can adopt this strategy for getting higher return. The estimates of climatic variables such as temperature and rainfall are significant. The scores of the adaptation options provide strong significant evidence that the adaptation strategies undertaken by the maize farmers are correlated with farm profit and responsiveness to climate shocks.

13 PLANT GENETIC RESOURCES

Exploration and collection of plant genetic resources during 2018-19

Multi-crop exploration and collection program undertaken in 89 upazilas of 38 districts in Bangladesh during 2018-19. Seven hundred and fifty-nine (759) germplasm of 77 crops were collected from Bandarban, Chattogram, Jashore, Faridpur, Gazipur, Jamalpur, Khulna, Moulavibazar, Noakhali, Pabna, Patuakhali, Rangpur, Sariatpur, Barishal, Borguna, Rajbari, Rajshahi, Sylhet, Cumilla, Dhaka, Magura, Jalokathi,Lalmonirhat, Pirojpur, Jhenaidah, Mymensingh, Cox's, bazar, Tangail, Bogura, Chandpur, Chuadanga, Dinajpur, Gaibandha, Meherpur, Naogaon, Nilphamari, Satkhira and Sirajganj; including 14 germplasm from China, India and Thailand.The germplasm were 16 cereals, 69 pulses, 40 oilseeds, 393 vegetables, 92 spices, 23 fruits and 126 other crops.These germplasmswere collected from Home garden, field, threshing floor, farm store, cultivated habitat, market etc. The samples were collected as seeds, seedlings, fruits from individual plant or population. Passport data like collector's number, local/ cultivar name, date of collection, donor's name, name of village, union, upazila and district also GPS reading of the locations were recorded. The samples were registered in germplasm collection register and conserved in active collection following appropriate procedures.

Collection and characterization of important plant genetic resources in Bangladesh: BARI component (ID: 128)

Exploration and collection program were conducted on different important plant genetic resources.Nine exploration areas (Khulna, Jashore, Borishal, Patuakhali, Pabna, Rangpur, Chattogram, Bandarban and Noakhali) were undertaken and 200 landraces and GIs' (Pumpkin, Cucumber, Bitter gourd, Brinjal, Mustard, Mungbean) were collected from 15 upazilas during 2018-19. The germplasm was collected from farmer's field, home garden, farm store, market etc. the status of sample was mostly landraces. Samples were collected as seeds, seedlings, fruits from individual plant or population. Passport data like collector's number, local/cultivar name, date of collection, donor name, name of village, union, upazila, district and geographic location data were recorded. The samples were registered and conserving in active collection.

Stakeholder analysis on conservation and utilization of plant genetic resources in Mashok, Kapasia, Gazipur

The selected location was Mashok, Durgapur, Chandpur, Gazipur. The farmers were informed 5 days ago of the schedule. Objects of the interventions were made clear to the farmers and community was convinced for fulltime participation in the participatory meeting. Farmers listed some timber species and fruits, vegetables and several medicinal species. A total of 66 plant species observed in the study area of which 9 timber, 20 fruit, 7 medicinal, 9 fodder and 21 crops (Table). Snake gourd, zinger, coriander, radish, tomato, teasle gourd, sponge gourd, ridge gourd (Toroi and Jhinga), cucumbers, aroids, yams, sweet gourd , okra mustard, chilli, are very common. Among the plantation species Akashmoni, Mehogani, Eucalyptus, Lambo, Karanja, Guava, Papaya, Jujube, Mango etc were very common. Some of the species was lost and they use a limited number of species. The profit-oriented, changes the cropping patterns in local circumstances.

Characterization of GI and landraces mustard germplasm

The experiment was conducted with 119 germplasm of mustard (*Brassica rapa* and *Brassica juncea*) and rapeseed (Brassica napus) with three chack variety at PGRC, BARI, Gazipur. The maximum variability was found Maximum germplasm showed 68.03% ovate (83 grm.) leaf

blade shape in outline and 31.15% spathulate (38 acc.). Leaf division (incision) such as 65.57% entire (80 grm.), lyrate 31.97% (39 acc.) and 2.46% sinuate (3 acc.). Loosely branched small terminal headed floral apex branching pattern was observed *vz.* 88.52% and 11.48% was terminal head with smaller heads on axillary shoots.The wide ranges of phenotypic variations were observed on maximum traits. No. of seed / siliqua range 47.22 to 345.24, No. of siliqua /plant range 33.85 to 366.87, Siliqua length 47.317 to 346.05 cm, and plant height range 63.47 to 369.84cm were obtained. The maximum CV obtaine for seed yield per plant 24.62% followed by days to germination 18.74%, no. of siliqua per pod 18.54%, no. of primary brenches per plant 14.225. The frequency distribution observed higher on No. of primary branch /plant, Plant height, No. of seed /siliqua, No. of seed /siliqua and No. of siliqua /plant.

Characterization of soybean germplasm

The experiment was conducted with 46 germplasm of soybean (*Glycine max* L.) in the experimental field at Plant Genetic Resources Centre (PGRC) of BARI, Joydebpur, Gazipur, during winter 2018-19 to find out the variability in the germplasm. All the qualitative characters showed distinct variation among the germplasm. The maximum variation observed in seedling vigour, leaflet shape, seed coat colour, hillum colour, seed coat surface luster. Quantitatively highest variation was observed was observed in days to fruit setting (CV- 67.02%). Time required to first fruit setting ranged from 3.20-30.10 days with an average of 13.59 days. The early fruiting germplasm are BD-7177, BD-2332, BD-2329, TRMR-35, BD-2333, BD-2331 and BD-9024 and the late fruiting germplasm are BD-9420, BD-7175, BD-2334 and BD-2330.

Characterization of proso millets germplasm

The study was carried out with 97 germplasm of proso millets (*Panicum milliaceum*) in the experimental field at Plant Genetic Resources Centre of BARI, Joydebpur, Gazipur, during the rabi season in 2018-19 to find out the different variability among the germplasm. All the germplasm were collected from different part of Bangladesh. Qualitative variation was found in plant height, sheath pubescence, legule pubescence, inflorescence shape, degree of lodging, and seed color. Qualitatively the maximum variation was observed in seed colour. Dark brown seed color was found in (48.45%), brown (29.90%), yellowish-brown (15.64%), light brown (2.06%) and others (4.12%) germplasm. The highest coefficient of variation was found in grain yield (41.67%) and lowest CV was found in 100seed weight (g) (5.56%) followed by days to 50% flowering (8.57%).

Characterization of local brinjal germplasm at Ishurdi

The study was conducted at Regional Plant Genetic Resources Center, Regional Agricultural Research Station, Ishurdi, Pabna during Rabi season of 2018-19 to identify the important traits of brinjal accessions. The experiment involved thirty five brinjal germplasm. Variations among brinjal accessions were observed in different qualitative characteristics. Plant growth habit was upright for 9 accessions (26%), intermediate for 22 accessions (63%) and prostate for 4 accessions (11%). Plant height was found short, intermediate and tall. Maximum plant breadth was observed intermediate (most of accessions) others found in narrow and broad. In case of leaf blade length, 3% accessions were short, 91% intermediate and 6% long were found. Leaf blade lobing was found weak, intermediate, strong and very strong. Very acute to obtuse in leaf blade tip angle were observed. Variations were found in leaf prickles and leaf hair. Among the accessions different corolla color was observed like greenish white, white, pale violet, light violet and bluish violet. Maximum accessions were found in long for fruit length. Single fruit size varies from 100 gm to 620 gm and in case of 1000 seed weight it ranges from 4.0 to 6.2 gm. Few accessions *viz.* ISH-24, ISH-49, ISH-12, ISH-5, ISH-36, ISH-28, ISH-30, ISH-51, ISH-23, ISH-49 might be considered as better accessions which can be used in future brinjal improvement program**.**

Characterization GI and landraces of cucumber germplasm

Twenty one accessions of cucumber (Cucumissativus L.) were characterized at Plant Genetic Resources Centre (PGRC), BARI, Gazipur during suumer, 2019. Variability showed in different fruit characters at edible stage i.e stem end fruit shape, blossom end fruit shape. Fruit shape was oblong, oval, ellipsoid and blossom end tapered among the accessions. Light green and yellowish green fruit skin colour were at edible

stage. Where as brown and yellow fruit skin colour at mature stage was found in all accessions. In quantitative characters. Days to edible fruit stage ranged from 73 to 85 respectively. Average fruit length and fruit width was 20.33 and 6.47 cm, number of fruit per plant was ranged from 3.5 to 7.5. Maximum number fruit per plant was obtained from RAI-209 and minimum number of fruits per plant was recorded from IAH- 331.The highest coefficient of variation was found in fruit length (19.85 %) followed by number of fruits per plant (18.71%) and lowest in hundred seed weight (4.71%).

Characterization of GI and landraces of bitter gourd germplasm

An experiment was conducted at the Plant Genetic Resources Centre of BARI, Gazipur during 2018-19 to know the variability of 62 germplasm along with 02 check varieties of bitter gourd (*Momordica charantia* L.). Among the germplasm "Uchche" (25.8%) and "Korolla" (74.2%) were identified. Qualitative character disparity was found in early plant vigor, plant growth habit, twining tendency, tendril branching, leaf size and flower color. Germplasm varied in fruit shape, spindle shaped (66.13%),long cylindrical (4.84%), top shaped (3.22%) and globular (25.81%) having sparse (29.03%), light (43.55%) and deep tubercle (53.23%) fruit surface. Furthermore, Matt (17.74%), intermediate (51.61%) and glossy (30.65%) fruit skin luster were observed. Color variation was exhibited in fruit skinfor instance white (3.22%), light green (45.16%), green (32.26%) and dark green (19.36%). Moreover,low (20.97%), medium (35.48%) and high (43.55%) seediness were found among the germplasm. Germplasm also varied in the level of bitterness. However, discrepancy observed in quantitative parameters, fruit length (3.4 to 23.3 cm), fruit width (2.4 to 6.62 cm) and in others. Coefficient of variation percentage was highest in fruit weight (62.74%) and lowest found in days to last fruit harvest (5.30%).

Characterization of brinjal germplasm

Brinjal (*Solanum melongena* L.) is animportant popular year-round fruit vegetable in Bangladesh. The experiment was conducted with 285 germplasm of brinjal (Solanum melongena L.) in the experimental field at Plant Genetic Resources Centre (PGRC) of BARI, Gazipur, during winter 2018-19 to find out the variability in the germplasm. Descriptive statistics and analysis of variance revealed a wide range of variability for morpho-physiological traits. Estimated broad-sense heritability (h2) for all the measured traits ranged from 10.6% to 93%, indicating that all the traits were highly inheritable. Genetic variances were low-high for most morpho-physiological traits, indicating complex genetic architecture. Yield per plant was significantly correlated with Fruit diameter, number of fruits per plant, percent fruits infestation by brinjal shoot and fruits borer and fruit weight traits, indicating that direct selection based on fruit number and fruit weight might be sufficient for improvement of other traits. The first two principal components (PCs) explained about 81.27% of the total variation among lines for the thirty eightbrinjal morpho-physiological traits. Genotype by trait (G×T) biplot revealed superior genotypes with combinations of favorable traits. The average genetic distance was 3.53, ranging from 0.25 to 20.01, indicating high levels of variability among the germplasm. Heatmap explaining the overall performance of the genotypes indicated that the genotypes NSR-10, AC-240, K-29, NSR-8 and AH-101 accumulated higher proline signifying their potentiality. Therefore, selection of these genotypes might play a significant role for future breeding program.

Characterization of chilli germplasm

The experiment was conducted with 56 germplasm of chilli (*Capsicum* spp.) in the experimental field at Plant Genetic Resources Centre (PGRC) of BARI, Joydebpur, Gazipur, during winter 2017-18 to find out the variability in the germplasm. Qualitative characters showed distinct variation among the germplasm except hypocotyle colour, nodal anthocyanin, calyx margin shape and calyx annular constriction. Four categories leaf colour were observed such as green (87.69%), dark green (9.23%), purple (1.54%) and varigated (1.54%). The immature fruit colour was also found in four categories such as green (26.15%), deep purple (3.08%), green with blackish blush (69.23%) and whitish green (1.54%). Quantitatively highest variation was observed in number of fruits per plant (CV-68.78%) followed by yield per plant (CV-50.56%) and days to 50% fruiting (CV-49.30). Considering all the character studied the germplasm ATR-15 (82.45 g), AC-444 (76.69 g),

AC441 (72.20 g) and AR-254 (70.00 g) were found as the best yielder.

Characterization of okra germplasm

The experiment was conducted with 38 germplasm of okra (*Abelmoschus esculentus* L.) in the experimental field at Plant Genetic Resources Centre (PGRC) of BARI, Joydebpur, Gazipur, during winter 2017-18 to find out the variability in the germplasm. Qualitative characters showed distinct variation among the germplasm except shape of epicalyx segments, fruit pubescence, position of fruit and seed shape. The maximum variation was found in leaf shape followed by leaf colour, fruit shape, mature fruit colour and early plant vigour. Quantitatively highest variation was observed in number of seeds per fruit (CV-22.91%) followed by number of fruits per plant (CV-17.10%) and fruit length (CV-14.22%). Considering maximum number of fruits per plant the promising germplasm were identified as RISA-27, TT-196, N-80, NT-12 and NC-01.

Field screening of native black gram lines resistant to yellow mosaic virus and powdery mildew in natural condition at Ishwardi

A field experiment was conducted at Regional Pulses Research Station (RPRS), Madaripur during Kharif-II season of 2018 to evaluate the germplasms of locally collected black gram for searching of yellow mosaic virus and high yielding resistant genotypes. Significant difference wasobserved in every important parameter like scoring of BYMV, no of pods/plant, 100 seed weight, and seed yield (kg/ha) etc. The line BD-6853 provided the lowest YMV score (2.00) and the highest (6.00) was in BD-6869. The line BD-6814 and BD-10047 gave the highest seed yield (1833 kg/ha) and the lowest (1267 kg/ha) in BD-10040.

Characterization of snake gourd germplasm

An experiment was conducted at the experimental field of Plant Genetic Resources Centre of BARI, Gazipur, during the Kharif season in 2019. In this experiment snake gourd germplasm were 90. Out of them 80germplasm were germinated. After transplanting 6 germplasm were damaged. So existing was 74 accessions. This germplasm was collected from different districts of Bangladesh. Germplasm was varied for different qualitative and quantitative characters. Highest variation was observed in leaf size, fruit shape, fruit skin color and fruit lusture. Medium leaf size was observed (51.33%), spindle fruit shape (52.70%), green fruit skin colour (41.89%). Highest coefficient of variation also observed in % of germplasm (58.26), which was followed by number of fruit per plant (36.01%) and number of seeds per fruit (35.26) and lowest coefficient of variation was found days to germination (2.87%).

Characterization of foxtail millet at Jamalpur

Ninety four (94) accessions of foxtail millet (*Setaria italica*) were characterized at Plant Genetic Resources Centre (PGRC), RARS, Jamalpur. Qualitative variations were observed in growth habit, anthocyanin coloration of leaf collar, flag leaf colour, leaf attitude, blade pubescence, sheath pubescence, plant pigmentation, panicle lobes, lobes compactness, panicle compactness, panicle bristle, panicle attitude, panicle shape, grain shape and grain colour. In the quantitative traits highest 1000- seed weight was found in accession BD-ZS-12 (3.75g) followed by the characters yield per plant in accession BD-1181 (8.61g). Early flowering and early maturity was observed in BD-1025 (75 days and 115 days). Maximum panicle length present in accession BD- 1117 (19.49 cm.) followed by the characters flag leaf length in BD-1062 (52.44 cm), flag leaf breadth in RISA-58 (3.15 cm), length of peduncle in BD-1120 (32.53 cm) and number of elongated internodes in accession BD-896 (7).The highest plant height present in accession BD-906 (130.47 cm) and the lowest in BD-989 (79.34 cm). The highest coefficient of variation (CV %) were observed yield per plant (25.90). Unique selection and trait information is available within the population studied which may offer crop improvement opportunity.

Characterization of gladiolus germplasm

An experiment was conducted at the Plant Genetic Resources Centre of BARI, Gazipur during 2018-19 to know the diversity of 30 germplasm of gladiolus (*Gladiolus grandiflorus*L.). Among these germplasm twenty eight color were identified. Variation was found in plant height, length and breadth of leaf, flower size, weight of single stick, length of spike, length of rachis, no. of floret per spike, days to reach spiking. The highest CV was found in no. of shoot (58.9%) and the lowest CV was found in days to spiking (7.3%).

Molecular characterization of rapeseed-mustard germplasm using SSR marker

Brassica mustard species represent one of the most important oilseed crops in Bangladesh. A better understanding on their genetic diversity essential for the proper utilization of genotypes in breeding programs. In this study 120 genotypes were taken to characterize with the help of SSR markers to reveal the genetic diversity among genotypes of oilseed *Brassica* species. All 10 microsatellite markers were found to be polymorphic conferring to previous study.Among the primers Ra2-A11, Ra2-D04, Ra2-E03, Ra2-F11 and Ra2-G09 has been responded to SSR marker selection study. This experiment is being continued in the molecular breeding laboratory, Plant Genetic Resources Centre of Bangladesh Agricultural Research Institute, Gazipur.

Conservation of germplasm in active and base collection

Since its inception in 1987, Plant Genetic Resources Centre (PGRC) acts as a germplasm store house of the BARI mandated crops viz. cereals, pulses, oilseeds, vegetables, fruits, spices and tuber crops etc. The accessions were conserved in medium-term storage at + 4 to + 6^0C and long-term storage at -18 to -22^0C. Viability, quantity and moisture were checked before conservation. Accessions less than 85% viability and/or less quantity of seeds were regenerated. Generally, the seeds were dried at 6-8% moisture content before storing. Till now, the Centre has conserved 11081 (eleven thousand and eighty-one) accessions of 89 different BARI mandated crops in its gene bank. Among them, 1768 accessions were cereals, 3530 pulses, 552 oilseeds, 433 spices 4457 vegetables, , 283 fruits and 58 other crops. In 2018-19, a total of 282 Gerplasm were assigned as new accession and were conserved in gene bank of PGRC.

Monitoring of germplasm in active and base collection

The monitoring of 1991 accessions from different year (batch references) among five important crops viz. bottle gourd (812), tomato (310), spinach (201), okra (652) and safflower (16) were tested in 2018-19 by germination test. Among the monitored germplasm 949 accession from active collection and 1042 accessions were from base collection. The viability test was conducted on germination paper, sands and pulverized gravels. Combining all data, it was found that less than 40% germination was higher but 41-80% germination and 81-100% germination was found lower in case of active collection. Moreover, less than 40% germination was lower but 41-80% germination and 81-100% germination was found higher in case of base collection. Collectively, base collection performance was good over the active collection. The accessions having less than 70% germination and or less quantity will be regenerated in the following year.

Distribution of germplasm

Germplasm distribution is one of the important activities of Plant Genetic Resources Centre (PGRC). The centre distributed 980 accessions of 26 crops among the researchers, MS and PhD students, plant breeder, horticulturist and teachers of different Universities and Institutes for conducting research on varietal improvement as well as screening and evaluation like diseases, insect screening, salinity stress, mutation breeding, abiotic stress, fibre production, draught tolerant and molecular diversity analysis during 2018-19. Among the germplasm, 174 accessions were cereals (barley, buck wheat, foxtail millet and prosomillet), 226 pulses (grasspea, pigeon pea and mung bean), 102 oil seeds (mustard, sunflower, sesame and linseed), 100 spices (chilli), 597 vegetables (hyacinth bean, french bean, ash gourd, pumpkin, okra, brinjal, bitter gourd, snake gourd, radish, bottle gourd, leaf amaranth, ridge gourd and tomato). Ten to hundred seeds or 5-10 g seeds per accession were supplied to the users.

Regeneration of buck wheat, black cumin, pigeon pea, oat, finger millet, fenugreek, french bean, tomato, sulfa and popy germplasm

The experiment was conducted at the experimental field of Plant Genetic Resources Centre, BARI, Gazipur during 2018-19 including some crops namely as Buck wheat-6, Black cumin-32, Celery-5, Oat-1, Finger millet-1, Fenugreek-9, French bean-9, Tomato-26, Fennel-11, Poppy/ Postodana-1 and Sulfa-1 which were successfully grown to assist the regeneration and conservation program. All the crop gremplasm planted were planted in November 2018 with recommended practices to get adequate quantity of seed for future use. The The crops were harvested at time to time for each germplasm. Some qualitative and quantitative characters were recorded to know the overall

performance of those germplasm aiming to enrich the gene bank with good reproductive units.

Regeneration of linseed germplasm

The experiment was conducted at Plant Genetic Resource Centre, BARI, Gazipur during rabi season 2018-19 for regeneration of thirty-three (33) accessions and twenty-one (21) newly collected total fifty-four (54) germplasm of linseed (*Linum usitatissimum*). A few qualitative (8) and quantitative (9) characters were recorded for using reference data. Diversity were found in qualitative features apart from flower color, shape and size of the collected germplasm. Moreover, prominent variations were observed in quantitative characters like days to germination, first flowering, number of capsules per plant, plant per plot and in in 1000 seed weight. Highest CV (%) was found for plant per plot and lowest for days to 50% flowering. Satisfactory amount of seed was harvested and conserved for future use.

Conservation of gerplasm in field gene bank

PGRC is maintaining 273 germplasm including 213 accessions of 73 crops both indigenous and exotic germplasm in the field genebank. The fruit germplasm are mango litchi, banana, guava, jackfruit, jujube, aonla, bael, bilimbi, bullocks heart etc. The vegetables germplsm are taro, yam, elephant foot, drumstick etc. The exotic germplasm are rambhutan, pear, tamarind, coffee, passion fruit, dragon fruit and gynura etc. The intercultural practices were done as and when necessary. The field gene bank has been maintained since 1985 and continued for the following years.

***In vitro* bulblet formation of garlic from root tip for short-term storage of germplasm**

An efficient and novel method of direct bulblet regeneration from root tips in garlic was developed. The influenceof growth regulators, basal media and age of root explant on shoot initiation and proliferation was examined. Thebest growth regulator combination was 1-naphthaleneacetic acid and 6-benzyladenine at 1.5 and 15 µM, respectively,inducing shoot initiation from 70% of the explants. The frequency of bulblet initiation on different treatments wasnot similar. Explant root tips from plantlets taken 30 to 35 days after sprouting showed the highest bulblet initiation. Thus, it appears that the protocol is cheap and time bound andparticularly useful for conducting experiment for encapsulated or synthetic seed for short term conservation or cryopreservation and genetic improvement of garlic. Furthermore, as the protocol is costeffective, it can be further tested for commercial feasibility.

Microrhizomes production for *in vitro* short-term storage of ginger germplasm

Ginger is a rhizomatous plant that belongs to the family Zingiberaceae. It is a herbaceous perennial but cultivated as annual, with crop duration of 7–10 months. Ginger is native to Bangladesh, India and Tropical South Asia. The tuberous rhizomes or underground stems of ginger are used as condiment, an aromatic stimulant, and food preservative as well as in traditional medicine. Ginger is propagated vegetatively with rhizome bits as seed material. Cultivation of ginger is plagued by rhizome rot diseases, most of which are mainly spread through infected seed rhizomes. Micropropagation will help in production of disease-free planting material. MS medium supplemented with 9 mg/L BAP and 60-90 g/L sucrose under 16-h photoperiod within 10 weeks of cultivation were the best conditions for ginger microrhizomes induction. In vitro technology can thus become the preferred choice as it can be utilized for multiplication, conservation of genetic resources, generating variability, gene transfer, molecular tagging, and their utility in crop improvement of these crops.

Somatic embryogenesis of turmeric for short-term storage of germplasm

Turmeric is a rhizomatous herbaceous perennial but cultivated as annual, belonging to the family Zingiberaceae. It is a native of India and South East Asia. The tuberous rhizomes or underground stems of turmeric are used from antiquity as condiments, a dye and as an aromatic stimulant in several medicines. Turmeric is an important crop in India and it is used as a spice, food preservative, coloring agent, cosmetic as well as for its medicinal properties. Propagation is done vegetatively with rhizome bits as seed materials. It is plagued by rhizome rot diseases most of which are mainly spread through infected seed rhizomes. Micropropagation will help in production of disease-free seed. MS medium supplemented with 5 mg 6-BAP + 3 mg 2,4-D + 3 mg Kinetin, pH 5.6under 16-h photoperiod within 12 weeks of cultivation were the best conditions forturmaricembryogenesis. In vitro technology can thus become the preferred choice and

it can be utilized for multiplication, conservation of genetic resources, generating variability, gene transfer, molecular tagging, and their utility in crop improvement.

Zygotic embryo rescue of coconut *(Cocos nucifera* L.*) for* short-term germplasm conservation

The experiment was conducted with two locally cultivated coconut germplasm at the *In vitro* Conservation Laboratory of Plant Genetic Resources Centre, BARI, Joydebpur Gazipur. The study investigated the effects of liquid and solid media in the propagation of coconut zygotic embryos at initiation stage. MS medium supplemented with 2 mg NAA + 2.5 g activated charcoal + 8 g, pH 5.7were used for this experiment in both liquid and solid states. Results showed that solid state medium was better compared to liquid state. Embryo culture micropropagation has several advantages over conventional propagation methods; for instance, the production of disease free, high quality planting materials and the rapid production of many uniform plantlets in a limited space area are achievable by this technology.

***In vitro* conservation of potato, mint and yam**

In vitro conservation of germplasm is one of the objectives of Plant Genetic Resources Centre. This is a medium-term study of *in vitro* conservation of 8 potato (*Solanum tuberosum* L.) varieties, 3 mint (*Mentha* spp.) genotypes and 5 yam (*Dioscorea alata*) accessions which had been initiated during 2014, 2014 and 2017 correspondingly. Germplasm are being cultured on MS media at 22^0C and 60-70% humidity for *in vitro* conservation. Time to time sub-culture is being performed. However, attempt to callus culture of the germplasm has been successful. Conservation of these germplasm is going on and will be continued.

Database development and data entry for germplasm documentation

PGRC/BARI has taken a mission of creating a new, scalable version of the Germplasm Resource Information System (GRIN) with a powerful, flexible, easy-to-use plant genetic resource (PGR) information management system. The study has been started since October 2017-18. A core set of web services, will update data stored locally and enable third party data sharing. Open-source programming tools MySQL has been adopted for data entry and editing forms. The impact of system use will be evaluated by users during and following database implementation. Data uploading/updating of 3000 germplasm is in progress.

Effect of different fertilizer doses on black cumin at charland condition

An experiment was conducted in the farmers' field of the MLT site, Bhuapur, Tangail during two consecutive *rabi* seasons of 2017-18, and 2018-19 to find out the suitable fertilizer dose for black cumin to increase productivity and economic return of farmers. The experiment comprised with four treatments T_1= STB as per FRG' 2012, T_2= T_1+15% extra NPK, T_3=T_1+ 30% extra NPK and T_4= Farmers practice and two black cumin variety (V_1= BARI Kalozira-1, V_2= Local). Among the treatment's combinations the highest seed yield (0.95 t ha^{-1}) and gross margin (Tk. 99450 ha^{-1}) was obtained from soil test-based fertilizer dose with BARI Kalozira-1. The lowest seed yield (0.42 t ha^{-1}) was recorded from local variety with farmers practice.

Effect of nutrient management on the quality seed yield of groundnut

A field experiment was conducted at MLT site, Ghatail (AEZ-28), Tangail during consecutive two Kharif –II season of 2017 and 2018 to find out the suitable fertilizer dose for quality seed and increases the availability of quality seed of groundnut for upcoming *rabi* season. Four treatment combinations *viz*,. T_1= STB, T_2= T_1 +15% extra NPK of STB, T_3= T_1 + 30% extra NPK of STB, T_4= Farmers' practice were tested. The experiment was laid out in randomized complete block design with three (3) compact replications. The groundnut variety was BARI Chinabadam-8. Higher number of effective pods, 100-seed weight and germination percentage and seed vigor index were recorded form the STB +15% NPK of STB fertilizer dose. The highest pod yield 1.92 t ha^{-1} and 1.99 t ha^{-1} were recorded from plants treated with T_2 treatment combination from the consecutive two years, respectively and on an average of two years, the maximum pod yield 1.96 t ha^{-1} was obtained by STB fertilizer dose with 15% extra NPK. The lowest mean pod yield (1.12 t ha^{-1}) was obtained from Farmers' practice. The highest gross return (Tk.156800 ha^{-1}) and gross margin (Tk. 87517 ha^{-1}) were obtained from T_2 whereas the lowest gross return (Tk.89600 ha^{-1}) and gross margin (Tk.26911 ha^{-1}) was obtained from farmers' practice. STB fertilizer with 15% NPK dose of STB seems to be promising for the maximum pod yield, quality seed production and higher economic of groundnut cultivation in kharif-II under AEZ-28.

Effect of fertilizer dose and variety on the yield of chili at charland

An experiment was conducted in the farmers' field at the MLT site, Bhuapur, Tangail during the *rabi* season of 2018-19 to find out the suitable fertilizer dose for chilli and to increase productivity and economic return of farmers. The experiment comprised with four treatments T_1= STB as per FRG, 2012, T_2 = T_1 +15% extra NPK, T_3 =T_1 + 30% extra NPK, T_4 =T_1 + 45% extra NPK, and T_5= Farmers practice and two chilli variety (V_1= BARI Morich-1 and V_2= Farmers' variety). Among the treatment combinations the highest green chilli yield (11.84 t ha^{-1}) and gross margin (Tk. 369882 ha^{-1}) was obtained from soil test-based fertilizer dose with BARI Morich-1. The lowest green chilli yield (9.20 t ha^{-1}) having the lowest gross margin (Tk. 227159 ha^{-1}) was recorded from farmers' variety of T_5 treatment combination.

Effect of fertilizer dose on onion in charland ecosystem

A field experiment was conducted at multi location testing (MLT) site of charland Chilmari, Kurigram during the rabi season of 2018-2019 to find out the optimum dose of onion and productivity as well as

farmer's income. Five treatments viz. T_1: Soil test base (STB dose), T_2: STB dose + Vermicompost, T_3: Recommended dose + Vermicompost, T_4: Recommended dose and T_5: Farmers practice. The experiment was laid out in a randomized complete block design with three dispersed replications. Among the fertilizer combinations, STB dose with vermicopost (2000 kg ha^{-1}) gave the maximum buld yield of onion (9.84 t ha^{-}) which was at par with recommended dose with vermicompost (9.37t ha^{-1}). The lowest bulb yield (7.95) was obtained from farmer's practice. The highest gross margin (Tk. 65314 ha^{-1}) was found in STB dose treatment.

Effect of fertilizer dose on pumpkin in charland ecosystem

A field experiment was conducted at multi location testing site of charland, Chilmari, Kurigram during the Rabi season of 2018-2019 to find out the optimum dose of pumpkin (BARI Hybrid Mistikumra-1) and increase productivity as well as farmer's income. Five treatments viz. T_1: Soil test base (STB dose), T_2: STB dose + Vermicompost, T_3: Recommended dose + Vermicompost, T_4: Recommended dose and T_5: Farmers practice. The experiment was laid out in a randomized complete block design with three dispersed replications. Among the fertilizer combinations, recommended dose with vermicopost (2000 kg ha^{-1}) gave the maximum fruit yield (33.26 kg ha^{-1}) which was at par with STB fertilizer with vermicompost (31.48 kg ha^{-1}). The lowest fruit yield (27.62) was obtained from farmer practice. The highest gross return (Tk. 134913 ha^{-1}) was found in recommended dose with vermicompost treatment and the lowest gross margin was obtained from farmer's practice. Thus, it was found that additional manure especially vermicompost may enhance fruit yield of BARI Hybrid Mistikumra-1in stable charland situation.

Effect of sulphur, zinc and boron on mustard in charland

The experiment was conducted at charland condition under MLT site Ulipur, Kurigram to study the effect of S, Zn, and B on mustard during rabi season of 2016-17, 2017-18 and 2018-19. Soil test-based fertilizer was verified with different combination of 25% extra S or 1 kg extra B or 1 kg extra Zn (single or combined). The experiment was laid out in randomized complete block design with 3 replications. Among the fertilizer combinations, STB fertilizer with additional S, Zn and B gave the maximum mean seed yield (1433.78 kg ha^{-1}). The lowest mean seed yield (1114.55 kg ha^{-1}) was obtained from only STB fertilizer treatment. From the three years average results, it was calculated that the highest mean gross margin (Tk. 33582 ha^{-1}) was obtained from STB fertilizer with additional S, Zn and B treatment and it was lowest in only STB fertilizer treatment (Tk. 21635 ha^{-1}).

Effect of ash as a source of potassium and silica on mustard

The experiment was conducted at multi location testing)MLT(site Gobindaganj, Gaibandha during the rabi season of 2016-17, 2017-18 and 2018-19 to ascertain the effect of rice husk ash on seed yield of mustard**.** Different treatments (recommended fertilizer RF, RF + 25% extra K, RF +1.0 t ash ha^{-1}, RF + 1.25 t ash ha^{-1}, RF + 1.50 t ash ha^{-1}andK control were tested on BARI Sarisha-14**.** Recommended fertilizer with 25% extra K produced significantly higher seed yield in all years. Incorporation of rice husk ash plus recommended fertilizer resulted impressing performance and sharply increase yield traits up to 1.25 t ha^{-1} and thereafter the increasing trend was sloth. However, three years mean maximum mustard seed yield was obtained from 25% extra K added plot (1558.22 t ha^{-1}) followed by extra 1.25 t ha^{-1} ash treatment (1509.22 t ha^{-1}) and lower was found in K control treatment (1249.44 t ha^{-1}). The three years' average GM was higher (Tk. 29393 ha^{-1}) in RF + 25% extra K treatment followed by RF +1.25 t ash ha^{-1} treatment (Tk. 27290 ha^{-1}). The treatment RF + 1.25 t ash ha^{-1} produced 1.86% higher mean seed yield and 3.51% higher mean gross margin compared to recommended fertilizer. Which indicating that in case of ash using, 1.25 t ha^{-1} ash with recommended other fertilizers would be optimistic.

Effect of different fertilizer doses on sesame in charland condition

An experiment was conducted at MLT site Pirgonj, OFRD, Rangpur during the kharif of 2017-18 to find out the proper nutrient management packages

of sesame in charland for BARI Til-3 under field condition. Three fertilizer packages viz. T_1: Soil test based (STB) in organic fertilizer for high yield goal (HYG), T_2: IPNS basis fertilizer management for HYG with cow dung (5 t ha^{-1}) and T_3: Farmers practice were employed for the experiment. The experiment was conducted under RCB design with three dispersed replications. Among the treatments, identically higher seed yield of sesame was obtained from T_2 (1188 kg ha^{-1}) and T_1 (1170 kg ha^{-1}), which were mostly contributed by respective higher number of pod per plant. The seed yield was poor in T_3 (1140 kg ha^{-1}) treatment. Higher gross return and gross margin were calculated in T_2 treatment (Tk. 65340 and 41415 ha^{-1}, respectively followed by T_1 (Tk. 64340 and 39570 ha^{-1}, respectively). Gross return and gross margin were lower in T_3 treatment.

Effect of different fertilizer management on the performance of BARI Bt brinjal

An experiment was conducted at FSRD site Azoddhapur, Rangpur to find out the optimum fertilizer level for Bt Brinjal-4 during the year of 2017-18 and 2018-19. Six treatments were used for the experiment viz, T_1= STB fertilizer splitting as per recommendation (FRG, 2012), T_2= T_1 +25% NPK (NK splitting 5 times), T_3= T_1 +50% NPK (NK splitting 5 times), T_4= T_1 +75% NK (NK splitting 5 times), T_5= T_1 + 25% NPKS and T_6= Farmers Practices. The experiment was laid out in RCB design with 6 replications. Among the treatments, STB fertilizer with 50% additional NPK (NK splitting 5 times) gave maximum fruit yield (40.20 t $ha^{-1}$and 31.44 tha^{-1}). The highest gross margin (Tk. 510593 ha^{-1} and Tk. 379193 ha^{-1}) was found in T_3 treatment and these were lowest in farmers practice.

Effect of fertilizer doses with elevated levels of Potassium on soil salinity and yield of transplanted maize

The experiment was conducted at MLT site Kuakata, Patuakhali during the *rabi* season of 2018-19 to find out the effect of different fertilizer doses with elevated levels of potassium for maize cultivation in saline coastal area of Patuakhali under farmers field condition. Twenty days old poly bag BARI HybridMaize-9 seedlings were tested to observe the performance. There were four different fertilizer doses T_1: Soil test-based fertilizer (STB) dose, T_2: STB+ 50% K, T_3: Fertilizer Recommendation Guide (FRG'12) + 50% K and T_4: Farmer's practice (FP) + 50% K were employed for the experiment. The highest grain yield was observed in T_3 i.e. 225-46-165-35 N-P-S fertilizer doses (8.73 t ha^{-1}) and the lowest grain yield was obtained from T_1 (198-42-90-12.7 kg, N-P-K-S ha^{-1}) fertilizer doses (7.16 t ha^{-1})

Integrated nutrient management for sunflower in coastal soil

The experiment was conducted at MLT site Amtali, Barguna during rabi season of 2018-2019 to determine appropriate doses of fertilizer and to observe the yield performance in response to balance fertilizer in coastal area for sunflower production. It was observed that T_4i.e. 114-34-23-6 kg ha^{-1} NPKS with 1.5 t ha^{-1} vermicompost performed the best over other treatments. This dose produced the highest seed yield (2.16 t ha^{-1}) with higher benefit cost ratio (1.82). The lowest yield was obtained from T_6 (1.42 t ha^{-1}).

Validation on bio-fertilizer of different legume mungbean

An experiment was conducted at FSRD site Jamla, Dumki, Patuakhali in the *rabi* season of 2018-19 to find out the effect of different fertilizer doses and biofertilizer for Mungbean cultivation under farmers field condition. Three different methods were used. T_1= without Rhizobium inoculant + PKSZn, T_2= with Rhizobium inoculant + PKSZn, T_3= NPKSZn. The highest seed yield (1.52 t ha^{-1}) was recorded from T_3 treatment at Jamla and lowest yield (1.22 t ha^{-1}) was recorded from T_1 treatment.

Effect of ash for yield improvement and minimizing pest infestation in garlic under zero tillage condition

The trial was conducted at multi location testing site, Atghoria, Pabna during the rabi season of three consecutive years (2016-17 to 2018-19) to assess the effect of ash as a source of potassium and silica on yield traits and yield of garlic under zero tillage. Different treatments viz. T_1= Recommended fertilizer based on FRG'2012 (RF), T_2= T_1 + 3 ton ash ha^{-1}, T_3= T_1 + 5 ton ash ha^{-1}, T_4=Farmer's management were tested on local

variety of garlic. The application of ash along with recommended fertilizer resulted significantly higher bulb yield of garlic over recommended fertilizer and farmers' fertilizer management package. The maximum economic benefit in terms of gross return and gross margin was also obtained from RF + 5 t ash ha^{-1} which followed by RF + 3 t ash ha^{-1}. Therefore, application of 3-5 ton ash ha^{-1} coupled with recommended fertilizer may be a better fertilizer approach for higher bulb yield of garlic.

Development of fertilizer management package for garlic under zero tillage condition

The trial was conducted at multi location testing site, Atghoria, Pabna during the *rabi* season of two consecutive years 2017-18 and 2018-19 to find out the optimum fertilizer package for garlic under zero tillage condition. Different treatments viz. T_1= STB as FRG' 2012, T_2= STB + extra 20% NPK, T_3= STB + extra 20% NK, T_4= STB + extra 40% NK and T_5=Farmer's practice, were tested on local variety of garlic. Soil test based fertilizer plus 20% extra NPK and 40% extra NK exhibited better performance in yield contributing characters and bulb yield of garlic. The maximum economic benefit in terms of gross return and gross margin was obtained from STB plus extra 20% NPK treatment which was closely similar to STB plus extra 40% NK.

Development of fertilizer management package for onion

The trial was conducted at multi location testing (MLT) site, Sujanagar, Pabna during the *rabi* season of 2018-19 to find out the optimum fertilizer package for onion cultivation. Different fertilizer management packages viz. T_1= Recommended fertilizer (FRG' 2018), T_2= RF + Extra 25% NPKS, T_3= RF + 1.5 ton rice husk ash ha^{-1}, T_4= RF + 2 ton poultry manure ha^{-1} and T_5= Farmers fertilizer package were tested on popular variety of onion (BARI Piaz-1). The application of RF + 1.5 ton Ash ha^{-1} and RF + 2 ton PM ha^{-1} demonstrated better performance on yield attributes and higher bulb yield of onion. Maximum gross return and gross margin was obtained from RF + 1.5ton Ash ha^{-1} followed by RF + 2 ton PM ha^{-1} and RF + extra 25% NPKS.

Integrated nutrient management for country bean in pyramid agriculture system

The experiment was conducted at MLT site, Atghoria, Pabna during the year of 2018-19 to assess the effect of different nutrient management T_1= recommended fertilizer (RF: 45-30-30-6 kg NPKS as FRG' 2012), T_2= RF + 5 ton cow dung ha^{-1}, T_3= RF + 2 ton rice husk ha^{-1} and T_4= Farmers practice) on country bean in pyramid agriculture system. The highest fruit yield was obtained from RF plus 2 ton ash followed by RF plus 5 ton cow dung ha^{-1}. Cost and return analysis indicated that maximum gross return and gross margin was obtained from RF plus 2 ton ash ha^{-1} followed by RF plus 5 ton cow dung ha^{-1}.

Effect of fertilizer and irrigation on the yield and economic performance of cauliflower at Gazipur

The experiment was conducted in the farmers' field at Dhirashram MLT site, Gazipur during the *rabi* season of 2018-19 to know the effect of fertilizer and irrigation on yield and economic profitability of cauliflower. Three fertilizer doses viz. Farmers' fertilizer dose, STB fertilizer dose and IPNS basis fertilizer dose; and two irrigation levels viz. three irrigations (15 days interval) and four times irrigation (10 days interval) were tested on cauliflower (Var. Snow white). Higher cauliflower yield (54.9 t ha^{-1}) was obtained from IPNS basis fertilizer with four times irrigations which was followed by IPNS basis dose with 3 times irrigation (53.6 t ha^{-1}). Farmers' fertilizer dose with three and four times irrigation gave lower yield (38.2 and 38.1t ha^{-1}, respectively). Maximum economic return in terms of gross margin (Tk. 224730 ha^{-1}) was attained from T_3 treatment.

Response of potato to fertilizer dose at charland

The experiment was conducted at Dicrir Char, Faridpur Sadar, Faridpur during the rabi season of 2018-19 to find out optimum fertilizer package for higher productivity of potato under farmers' field situation in Low Ganges River Flood Plain soil (AEZ-12). The tested variety was potato (BARI Alu-41. The five treatments were T_1 (STB)=162-30-44-25-0-0.46 kg,N-P-K- S-Zn-B ha^{-1}, T_2 (T_1 + 20% NPK of T_1)= 194-36-53-25-0-0.46 kg, N-P-K-S-Zn-B ha-^{1}, T_3 (T_1+ 30% of NPK of T_1)= N_{210} P_{40}

$K_{57}S_{25}Zn_{0}B_{0.46}$ kg $ha^{-1}$and T_4 (T_1+ 30% of NPKS of T_3)= 225-42-61-33-0-0.46 kg, N-P-KS-Zn-B ha^{-1} and T_5 (FP)= 180-40-90-15 kg, N-P-K-S ha^{-1}were employed in the experiment. The experiment was laid out in 26 m^2 each plot in a randomized complete block design replicating six times. The highest tuber mean yield (24.76 t ha^{-1}) was obtained from (T_3) and the lowest yield (20.30 t ha^{-1}) was accounted from T_1 due to the lowest (37.75g) mean single tuber weight. In terms of cost and return, T_3 showed the highest mean gross margin (Tk.108829 ha^{-1}) and BCR (1.57).

Nutrient management for yield improvement of Bt brinjal in AEZ-12

An experiment was conducted at the FSRD Site, Sholakundu, Faridpur during the rabi season of 2018-19 to find out optimum fertilizer packages for higher productivity of BARI Bt brinjal under farmers' field situation. The tested variety was BARI Bt Begun-3. The experiment was laid out in randomized complete block (RCB) design with six replications. Five treatments were considered as T_1 (STB)= 119-15 -100-19- 0.5-0 kg, N-P-K-S-Zn-B ha-^{1}+ cow dung 10 t ha^{-1}, T_2 (RD)= 138-50-100-18-1.7-0 kg, N-P-K-S-Zn-B ha^{-1} + cow dung 10 t ha^{-1}, T_3 (T_2+ 50% of T_2)= 207-75-150-27-2.7-0 kg, N-P-K-S-Zn-B ha^{-1} + cow dung 10 t ha^{-1} and T_4 (FP)= 225-75 -125-35-2.7-1.3 kg, N-P-K-S-Zn-B ha^{-1} + cow dung 5 t ha^{-1} for the trial. The treatment, T_3 (T_2+ 50% of T_2) =207-75-150-27- 2.7-0 kg, N-P-K-S-Zn-B ha^{-1} + CD 10 t ha^{-1} appeared as the best over STB fertilizer dose. T_3 gave the highest yield (30.45 t ha^{-1}) and BCR (2.31) followed by treatment T_4.

Effect of different fertilizer doses on chilli with onion intercropping system at charland ecosystem

A field experiment was carried out at farmers' field of Sadar, and Daulatkhan, Bhola under AEZ-18 during the rabi season of 2017-18 and 2018-19 to find out an optimum fertilizer dose for chilli and onion intercropping system and to increase crop yield and economic return. Five fertilizer treatments viz., T_1= Soil test based fertilizer dose for chilli T_2= T_1 + 25% of T_1, T_3= T_1 + Soil test based fertilizer dose for onion (plant population adjusted), T_4= T_1 + 50% of onion fertilizer (plant population adjusted), T_5= Farmers' practice (farmers' fertilizer dose for chilli) were tested. The experiment was laid out in a RCB design with six dispersed replications. BARI Morich-2 and BARI Piaj-1 were used. Treatment T_3 produced the highest dry chilli equivalent yield both the years (2.82 and 2.86 t ha^{-1} in 2017-18 and 2018-19, respectively) that was at par with the treatment T_2 and T_4. Both gross return and Gross margin was also found highest in T_3 in both the years. In the first year BCR was highest in T_3 (2.95) but in the second year T_3 and T_2 gave same BCR (2.94) and it was the highest.

Development of fertilizer recommendation for four crop based mustard-mungbean-T. Aus-T. Aman cropping pattern in high barind tract

A study was undertaken at FSRD site, Kadamshahor, Godagari, Rajshahi in three consequtive years during 2015-18 to find out an optimum and economic fertilizer dose for Mustard-Mungbean-T. Aus-T. Aman cropping pattern in High Barind Tract. The soil of the experimental field was chemically analyzed and levels of the fertilizers were calculated on the basis of target yields as per Fertilizer Recommendation Guide' 2012. The treatments were T1: Soil test based fertilizer dose (FRG' 2012), T2: IPNS with 5 t cow dung ha^{-1} as of T1, T3: T1+25% NPK, T4: IPNS with 5 t cow dung ha^{-1} as of T3, T5: Farmers' practice employed for the trial. Pooled analysis was done for three years data. The yield of all crops performed better in T4: 25% higher doses and IPNS approach, nevertheless it gave the highest values of pooled system productivity (16.23 t ha^{-1}), production efficiency (47.73 kg $ha^{-1}day^{-1}$) and gross return (Tk. 342720 ha^{-1}). But, gross margin (Tk. 283347 ha^{-1}) and MBCR (2.09) was the highest in T3. The IPNS including treatments showed more production cost. The STB+25% NPK treatments with or without IPNS basis treatments increased N, P and K uptake by the crops in the sequence. The apparent balance (difference between inputs and outputs) for N and K at system level was negative with the K balance being the most negative. The P balance was positive in all treatments except farmer practice.

Nutrient management for BARI Bt begun at high barind tract

The study was carried out at FSRD site, Godagari, Rajshahi under OFRD, BARI, Barind station,

Rajshahi during the Rabi season of 2017-18 and 2018-19 to find out an optimum and economic fertilizer dose for transgenic Bt brinjal varieties at the farmers' field of High Barind Tract.The soil of the experimental field was chemically analyzed and levels of the fertilizers were calculated on the basis of target yields as per Fertilizer Recommendation Guide' 2012.The treatments were T_1:STB fertilizer splitting as per recommendation (FRG, 2012),T_2: T_1 +25% NPK (NK splitting 5 times), T_3: T_1 +50% NPK (NK splitting 5 times),T_4: T_1 +75% NK (NK splitting 5 times),T_5: T_1 + 25% NPKS, T_6= Farmers Practices (Average of 20 Farmers) for the trial. The trial consists of BARI Bt Begun-4 against non Bt counterpart. The fruit yield was the maximum in T_4: (T_1+75% NK (NK splitting 5 times), nevertheless it gave the highest gross return, gross margin and BCR both two years. The lowest yield was found inT_1: STB fertilizer splitting as per recommendation (FRG, 2012) in the year 2017-18 and T_6 (Farmers Practices) in the 2018-19. The minimum gross return, gross margin and BCR were obtained fromT_6 (Farmers Practices).

Development of fertilizer packages for white grain maize in high barind tract

A field experiment was conducted in the farmer's field of FSRD site, Kadamshahar, Godagari, Rajshahi during the Rabiseason of 2016-17, 2017-18 and 2018-19 to develop an optimum fertilizer dose and their application method for white maize cultivation in High Barind Tract. The experiment was laid out in randomized complete block design with three replications. There were five treatments namely T_1= STB fertilizer dose applied by 3 splits (1/3rd urea at basal+1/3rd urea at 8-leaf stage+1/3rd urea at 16-leaf stage) T_2= STB fertilizer dose applied by 2 splits (2/3rd urea at basal + 1/3rd urea at 16-leaf stage) T_3= STB fertilizer dose applied by 2 splits (half urea at basal+half urea at 16-leaf stage) T_4= 75% STB fertilizer dose applied by 2 splits (2/3rd urea at basal+1/3rd urea at 16-leaf stage) T_5=75 % STB fertilizer dose applied by 2 splits (half urea at basal+half urea at 16-leaf stage. In the 1st year and 3rd year, maximum grain yield was found in T_1 (STB fertilizer dose applied by 3 splits (1/3rd urea at basal+1/3rd urea at 8-leaf stage+1/3rd urea at 16-leaf stage)), but in 2nd year, maximum grain yield was found in T_3 (STB fertilizer dose applied by 2 splits (half urea at basal+half urea at 16-leaf stage)). The minimum grain yield was always found in T_4 (75% STB fertilizer dose applied by 2 splits (2/3rd urea at basal+1/3rd urea at 16-leaf stage)).

Effect of ash as a source of potassium and silica on maize

The trial was conducted at multi-location testing (MLT) site Gobindaganj, Gaibandha during the rabi season of 2016-17, 2017-18 and 2018-19 to see the response of maize to different tillage practice (conventional tillage and zero tillage) and rice husk ash as a source of K and silica**.** Different treatments viz. T_1 = Recommended fertilizer (RF) dose in conventional tillage (CT); T_2 = RF dose in Zero Tillage (ZT), T_3= T_1 + 25% extra K; T_4 = T_2 + 25% extra K, T_5= T_1 +1.0 t ash ha^{-1}; T_6= T_2 +1.0 t ash ha^{-1}; T_7 = T_1+1.50 t ash ha^{-1}; T_8 = T_2+1.50 t ash ha^{-1}; T_9 = Control K in T_1 and T_{10}= Control K in T_2, were tested with commercial hybrid maize variety Miracle maintaining RCB design. Identically higher grain yield was produced in recommended fertilizer with extra 25% K (10.39 t ha^{-1}) or 1.5 t ha^{-1} ash (10.14 t ha^{-1}) under zero tillage condition in 2018-19. The yield trend was more or less same in three years' average yield. The lowest grain yield was obtained in Potassium control with conventional tillage treatment (7.30 t ha^{-1}) in 2018-19 and also in three years average yield (6.12 t ha^{-1}). Incorporation of rice husk ash plus recommended fertilizer resulted slightly better performance in yield and yield traits compare to only recommended fertilizer. Moreover, maize performed slightly better under zero tillage condition than conventional tillage. In general, gross margin (GM) was higher in zero tillage condition than conventional tillage. The higher average GM was obtained from recommended fertilizer with 25% extra K (Tk.97219 ha^{-1}) followed by recommended fertilizer with extra 1.5 t ha^{-1} ash (Tk. 92870 ha^{-1}) and the lowest GM was calculated in K control with conventional tillage treatment (Tk. 47318 ha^{-1}). Thus, it was found that additional K fertilizer or ash may enhance grain yield of maize in stable charland.

Effect of split application of N and K fertilizer on maize in the charland ecosystem

The field experiment was carried out at stable charland of Gobindaganj under OFRD, Rangpur

during the Rabi season of 2016-7, 2017-18 and 2018-19 to determine the proper application system and optimum doses of N and K fertilizer for boosting maize production. Different treatments i.e. soil test base fertilizer (STB), STB with additional 15% N and K in two split and also STB with additional 30% N and K in three split applications were tested on commercial hybrid maize variety (var. Miracle) maintaining randomized complete block design. During 2018-19, the STB fertilizer with 30% extra N and K produced the highest grain yield (9.17 t ha^{-1}) followed by STB with 15% extra N and K (8.79 t ha^{-1}). Grain number per cob and thousand grain weight was more in additional 30% N and K plot than others. The three years individual and average results showed the same trends in maize production. However, the three years average gross margin was higher in STB fertilizer with 30% extra N and K (Tk. 74642 ha^{-1}) and these were lower in STB treatment (Tk. 62468 ha^{-1}). Thus, it was found that additional N and K fertilizer in 3 split application may enhance grain yield of maize in stable charland condition.

Validation on biofertilizer of groundnut

A field trial was conducted at the Dikrirchar Faridpur during the early kharif-I season of 2019 to find out the effects of rhizobial biofertilizers on the performance of groundnut. The Binachinabadam4 and inoculum BARI RAh-803 were used as the trial materials. The trial was laid out in RCB design with six dispersed replications. Three treatments viz., T_1 (without Rhizobium inoculant+ P_{22} K_{42} S_{40} Zn_5 kg ha^{-1}), T_2 (with Rhizobium inoculant + P_{22} K_{42} S_{40} Zn_5 kg ha^{-1}) and T_3 ($N_{100}P_{22}$ K_{42} S_{40} Zn_5 kg ha^{-1}) were considered in this regard. It is observed that, the seed yield obtained (1.46 t ha^{-1}) was the highest in plots where Rhizobium inoculant along with P_{22} K_{42} S_{40} Zn_5 kg ha^{-1} were used (T_2). Benefit cost ratio was also higher in T_2 treatment (1.51) over those of other two treatments.

Effect of planting materials and fertilizer application methods on the tuber yield of potato

A field experiment was conducted at MLT site, Barura, Chandina, Debidwer and Saharasti under on-farm research division (OFRD), Bangladesh Agricultural Research Institute, Cumilla during 2018-19 to find out the performance of planting materials on tuber yield of potato and also to find out a suitable fertilizer application method and doses for low cost potato production. Two factorial treatments A. planting materials: i. Whole tuber and Cut tuber B. Fertilizer application dose and method: I. Furrow application (TCRC recommended fertilizer dose N-P-K-S-Zn-B=161.2-44-150-19.2-3.50-1.63 kg ha^{-1}) II. Broadcast method (Farmers practice N-P-K-S-Zn-B=94.4-98.8-247-14.4-1.36-2.87 kg ha^{-1}), were used in the study. The treatment combinations were T_1=Whole tuber + furrow application, T_2=Cut tuber + furrow application, T_3= Whole tuber + broadcasting and T_4=Cut tuber + broadcasting. BARI developed modern potato variety BARI Alu-46 was used in the trial. The highest tuber yield was recorded in T_1 treatment (43.1 t ha^{-1}) followed by T_2 and T_3 treatment. On the other hand, from the cost and return analysis it was revealed that due to differentiation of cultivation cost of different treatments results showed that gross return, gross margin and ultimately BCR were height in T_2 treatment where cut tubers were planted with furrow method of fertilizer application and the lowest in T_3 treatment where whole tubers were planted with broadcast method of fertilizer application.

Development of fertilizer management packages for mustard- boro mixed cropping system

A field experiment was conducted at Muradnagar, Cumilla and Haziganj, Chandpur during *rabi* season of 2018-19 to find out the suitable dose of fertilizer for mustard-boro mixed cropping system and to calculate the cost and return of mixed cropping system in Cumilla region. The experiment was laid out in RCB design with six dispersed replications. Four different fertilizer management packages i.e T_1= Boro recommended fertilizer dose (BRFD) as per STB (N-P-K-S-Zn-B @100-16-66-12-1.3-1 kg ha^{-1}) + 10% excess fertilizer of BRFD, T_2 = BRFD + 20% excess fertilizer of BRFD, T_3 = BRFD + 30% excess fertilizer of BRFD, T_4 = Boro recommended fertilizer dose (BRFD) as per STB were used in the experiment. From the evidence of research it was observed that the highest rice equivalent yield (9.6 t ha^{-1}) was found in the treatment combination T_1 where boro recommended

fertilizer dose (BRFD) as per STB (N-P-K-S-Zn-B @100-16-66-12-1.3-1 kg ha^{-1}) + 10% excess fertilizer of BRFD were applied. From cost and return analysis, it was documented that among the four fertilizer management packages T_1 treatment made the highest gross margin Tk. 62206.00 ha^{-1} followed by T_2 (Tk.50952.00 ha^{-1}). The lowest gross margin (Tk. 44460.00 ha^{-1}) was obtained from T_4 treatment where Boro recommended fertilizer dose (BRFD) was applied.

A. Cropping Patterns

Development of alternate cropping pattern through T. Aman- wheat-fallow against T. Aman -fallow-fallow

The experiment was conducted at the MLT site, Koyra under Khulna district during the year of 2016-17, 2017-18 and 2018-19 to improve the productivity and profitability of existing cropping pattern T. Aman -Fallow-Fallow by introducing heat tolerant and late potential wheat var. BARI Gom-25. The improved cropping pattern T. Aman - Wheat –Fallow gave average highest rice equivalent yield (REY) over three years (7.83 t $ha^{-1}yr^{-1}$) than farmers practice (4.91 t $ha^{-1}yr^{-1}$). Introduction of wheat into existing T. Aman-Fallow-Fallow pattern gave highest gross return (Tk.148382ha^{-1}) and gross margin (Tk. 66319ha^{-1}). The marginal benefit cost ratio (MBCR) was found 2.56 which showed that inclusion of wheat in the existing pattern might be profitable and acceptable to the farmers.

Development of alternate cropping pattern T. Aman- okra- fallow against T. Aman-fallow-fallow in coastal area of batiaghata, Khulna

The experiment was conducted at the MLT site, Batiaghata under Khulna during the year of 2017-18 and 2018-19 tostudy the comparative agro-economic performance of two crop-based pattern and farmers' existing cropping pattern for increasing cropping intensity and productivity. Two crop-based cropping patter (T. Aman-Okra-Fallow) and farmers' existing cropping pattern (T. Aman -Fallow- Fallow) were tested.The improved cropping pattern T. Aman-Okra-Fallow gave highest rice equivalent yield (41.64 $tha^{-1}yr^{-1}$) over farmers practice (4.44 t $ha^{-1}yr^{-1}$). Introduction of okra into existing T. Aman-Fallow -Fallow pattern gave highest gross return (Tk. 629,925) and gross margin (Tk. 509,503). Average marginal benefit cost ratio (7.06) indicates the superiority of improved pattern over existing pattern.

Development of alternate cropping pattern gardenpea-boro-T. Aman against fallow- boro-T. Aman cropping pattern

The experiment was conducted at Multilocation Testing site (MLT), Satkhiraof On-Farm Research Division, BARI, Khulna during the year of 2017-18 to improve the productivity and profitability of existing cropping pattern Fallow-Boro-T. Aman by introducing a new crop gardenpea (BARI Motorshuti-3) after T. Aman harvest. Improved cropping patter (Gardenpea-Boro-T. Aman) and farmers' existing cropping pattern (Fallow- Boro-T. Aman) were tested. The improved pattern gave highest rice equivalent yield (25.91$tha^{-1}yr^{-1}$), highest gross return (Tk. 538213 ha^{-1}) and gross margin (Tk. 318302 ha^{-1}) which was 130 and 330 % higher over farmers' pattern. Farmers' practice gave the lower gross return (TK. 233498 ha^{-1}), and gross margin (Tk 74037ha^{-1}). The marginal benefit cost ratio (MBCR) was found 5.04 which indicated the superiority of improved cropping pattern over farmers' existing pattern.

Development of alternate cropping pattern wheat-T. Aus-T. Aman against wheat- fallow-T. Aman rice cropping pattern

The experiment was conducted at Multilocation Testing site (MLT), Pirgonj,Thakurgaon of On-Farm Research Division, Bangladesh Agricultural Research Institute, Dinajpur during the year of 2016-17 and 2017-18 to improve the productivity and profitability of existing cropping pattern wheat-Fallow- T. Aman by introducing a new crop T. Aus (var. BRRI dhan48). The higher rice equivalent yield (14.90 $tha^{-1}yr^{-1}$) was obtained from improved cropping pattern, and gave higher gross return (Tk.268350 ha^{-1}) and gross margin (Tk. 125094 ha^{-1}) which was 42 and 25% higher over farmers' pattern. Farmers' practice gave the lower gross return (Tk. 18853 ha^{-1}) and gross margin (Tk 100470 ha^{-1}) with an MBCR of 1.45.

Development of alternate cropping pattern maize –T. Aus-T. Aman against maize-fallow-T. Aman rice in dinajpur

The experiment was conducted at Multilocation Testing site (MLT), Pirgonj, Thakurgaon of On-Farm Research Division, Bangladesh Agricultural Research Institute, Dinajpurduring the year of 2016-17 and 2017-18 to study the comparative agronomic performanceof existing cropping pattern Maize-Fallow- T. Aman and improved cropping pattern Maize- T. Aus-T. Amanby introducing a new crop T. Aus (var. BRRI dhan48) after maize harvest.The higher rice equivalent yield (17.84tha^{-1}yr^{-1}) was obtained from improved cropping pattern (Maize-T. Aus-T. Aman) and gave higher gross return (Tk.356764 ha^{-1}) and gross margin (Tk. 158955 ha^{-1}) which was 37.44 and 33.57% higher over farmers' pattern. Farmers' practice gave the lower gross return (Tk. 259640 ha^{-1}) and gross margin (Tk 148090 ha^{-1}). The marginal benefit cost ratio (MBCR) was found 2.05 which indicated its superiority over farmers' pattern.

Development of alternate cropping pattern MUSTARD-Boro-T. Aman Rice against Fallow-Boro-T. Aman

The experiment was conducted at Multilocation Testing site (MLT), Shibpur of On-Farm Research Division, BARI, Narsingdi during three consecutive years of 2015-16, 2016-17 and 2017-18 to study the comparative agronomic performance of existing cropping pattern Fallow-Boro-T. Aman rice and improved cropping pattern Mustard- Boro-T. Aman riceby introducing a new crop mustard (BARI Sarisha-14) after T. Aman rice harvest. The higher rice equivalent yield (12.89 tha^{-1}yr^{-1}) was obtained from improved cropping pattern which was 37.57 % higher over farmers' existing pattern. At the same time improved cropping pattern Mustard- Boro-T. Amanrice gave higher gross return (Tk. 279600 ha^{-1}) and gross margin (Tk. 71876 ha^{-1}) which was 30.94 and 77.52 % higher over farmers' pattern. Farmers' practice gave the lower gross return (Tk. 213540 ha^{-1}) and gross margin (Tk 40488 ha^{-1}) with an MBCR of1.91.

Development of alternate cropping pattern Boro-sesbania -T. aman againstboro-sesbania – fallow in Narshindi

The experiment was conducted at Multilocation Testing site (MLT), Shibpur of On-Farm Research Division, Bangladesh Agricultural Research Institute, Narsingdi during the year of three consecutive years 2015-16, 2016-17 and 2017-18 to study the comparative agronomic performanceof existing cropping patternBoro-Sesbania-Fallow and improved cropping pattern Boro-Sesbania-T. Amanrice by introducing a new crop T. Aman rice (BRRI dhan57) after Sesbania as green manuring crop. Improved cropping patter (Boro-Sesbania-T. Aman rice) and farmers' existing cropping pattern (Boro-Sesbania- Fallow) as control were tested. Three crops can be grown successfully one after another in sequence of the tested pattern. The higher rice equivalent yield (11.67tha^{-1}yr^{-1}) was obtained from improved cropping pattern which was 56.02% higher over farmers' existing pattern. At the same time improved cropping pattern Boro-Sesbania-T. Aman rice gave higher gross return (Tk.208500 ha^{-1}) and gross margin (Tk. 74190 ha^{-1}) which was 31.10 and 67.47% higher over farmers' pattern. Farmers' practice gave the lower gross return (TK. 159040 ha^{-1}) and gross margin (Tk 44300ha^{-1}) with an MBCR of 1.67.

Development of alternate cropping pattern potato-maize-groundnut against potato-maize-T. Aman cropping pattern

The experiment was conducted at Multilocation Testing site (MLT), Domar, Nilphamari of On-Farm Research Division, Bangladesh Agricultural Research Institute, Rangpur during the year of 2017-18 to study the comparative agro-economic performance of existing cropping pattern Potato-Maize-T. Aman and improved cropping pattern Potato-Maize-Groundnut.The higher rice equivalent yield (28.78 tha^{-1}yr^{-1}) was obtained from improved cropping pattern which was 23.20 % higher over farmers' existing pattern and same cropping pattern also gave higher gross return (Tk. 505465 ha^{-1}) and gross margin (Tk. 242133ha^{-1}) which was 16.96 and 40.48% higher over farmers' pattern. Farmers' practice gave the lower gross return (Tk. 432166 ha^{-1}) and gross margin (Tk 172356ha^{-1}).

Development of alternate cropping pattern onion-groundnt-juteagainst onion-jute-fallow cropping pattern in char land of Rangpur region

The experiment was conducted at the farmers' field to observe the comparative performance and economic return of alternate cropping pattern (Onion+Groundnut/Jute) against existing cropping pattern (Onion-Jute-Fallow) at char land in Ulipur, Kurigramduring the year of 2017-2018. Bulb, grain or fiber yield of onion, groundnut and jute were recorded as 8.04, 1.49 and 1.77 t ha^{-1}, respectively in the improved cropping pattern whereas 6.10 and 1.89 t ha^{-1} yield of onion and jutewere recorded in the existing cropping pattern. The gross return was higher in improved pattern (Tk.335050 ha^{-1}) than existing pattern (Tk.187195 ha^{-1}) which was 78.98 % higher over existing pattern with an MBCR of 1.81.

Development of alternate cropping pattern maize-T. Aus-T. Aman againstmaize-fallow-T. Aman cropping pattern

The experiment was conducted at the farmers' field of MLT site, Sherpur, Bogura during the year of 2017-18 to improve the existing cropping pattern by inclusion of T. Aus and to increase crop yield and farmers income. The experiment was laid out in RCB design with six dispersed replications. The proposed cropping pattern Maize-T. Aus-T. Amanrice was tested against the existing farmers' cropping pattern Maize-Fallow-T. Aman rice. There were two treatments viz. Existing Cropping pattern: Maize (Dekulb-981)-Fallow- T. Amanrice (BRRI dhan49) and alternate Cropping pattern: Maize (Dekulb-981)-T. Aus (BRRI dhan48)-T. Amanrice (BRRI dhan62). Higher Rice Equivalent yield (16.48 $tha^{-1}yr^{-1}$) and gross margin (199860 Tk ha^{-1}) with an MBCR of 1.61.

Development of alternate cropping pattern onion-panikachu- T. Aman against panikachu-T. aman cropping pattern

The field trial was conducted at MLT site Joypurhat, Boguraduring the year of 2017-18 to develop Onion-Panikachu-T. Amanrice cropping pattern against Panikachu-T. Aman cropping pattern. There were two treatments viz. existing Cropping pattern: Panikachu (Local)-T. Aman rice (Gutiswarna) andaltrnate Cropping pattern: Onion (BARIPiaz-4)-Panikachu (BARI Panikachu-2) and T. Aman rice (Swarna-5). Higher Rice Equivalent yield (28.59 t ha^{-1} yr^{-1}) and gross margin (Tk. 406745 ha^{-1} were obtained from alternate cropping pattern over existing cropping pattern due to introduction of new crops with an MBCR of 1.62.

Development of potato-boro-T. Aman rice cropping pattern against fallow- Boro-T. Aman rice cropping pattern at mymensingh

The experiment was conducted at Multiplication Testing Site (MLT) Trishal and Tarakanda of On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh during the year of 2017-18 to study the comparative agro-economic performance of three crops patternfor increasing cropping intensity and productivityas compared withexisting farmers' pattern. Potato-Boro-T. Aman rice cropping pattern produced higher rice equivalent yield (30.16t ha^{-1}), gross return (Tk.476140 ha^{-1}), gross margin (Tk 230797 ha^{-1}) and MBCR (2.44) compared to Fallow-Boro-T. Aman rice cropping pattern. This pattern also increased system productivity of 159% over exiting one.

Development of wheat-jute-T. Aman cropping pattern against fallow-jute-T. Aman cropping pattern

An attempt was taken to transform Fallow-Jute-T. Aman cropping pattern into Wheat-Jute-T. Amanriceto determine the agro-economic performance through modern variety and improved technology. With the inclusion of wheat in jute-rice based pattern was compared in farmers' field at Netrakona region during the year of *rabi* 2016-17 and 2017-18. On an average of two consecutive years, the inclusion of wheat in between jute-rice pattern increased the rice equivalent yield (REY) 43% with farmers' existing pattern. The gross return was increased by 37% in Wheat-Jute-T. Aman rice sequences compared to existing jute-rice cropping pattern. The marginal benefit cost ratio, land utilization index and production efficiency indicated the superiority of the improved pattern over the farmers' practices. The experimental evidence reveals that there is an ample of substantial improvement of the productivity of the jute-rice cropping sequence with the inclusion of high yielding wheat varieties.

Development of alternate cropping pattern potato-Boro-yard long bean-T. Aman against existing potato-Boro-T. Aman pattern

An attempt was taken to transform Potato-Boro-T. Aman cropping pattern into Potato-Boro-Yard long bean-T. Aman to determine the agro-economic performance through modern variety and improved technology. With the inclusion of yard long bean in potato-rice based pattern was compared in farmers' field at Gouripur region of Mymensingh district during the year of *rabi* 2017-18. After one-year study period, the inclusion of yard long bean in between potato-rice pattern increased the rice equivalent yield (REY) 35% with farmers' existing pattern. The gross return was increased by 35% in Potato-Boro-Yard long bean-T. Aman rice sequences compared to existing Potato-rice cropping pattern. The marginal benefit cost ratio, land utilization index and production efficiency indicated the superiority of the improved pattern over the farmers' practices.

Improvement of lentil-sesame-T. Aman rice cropping pattern

The experiment was conducted in the farmers' field at MLT site, Kumarkhali, Khustiaduring the year of 2017-18 to test the agro-economic performance and increase productivity of cropping pattern Lentil-Sesame-T. Aman rice with latest varieties. The varieties Lentil (BARI Masur-6)-Sesame (Local)-T. Aman rice (BRRI dhan49) were replaced by Lentil (BARI Masur-8)-Sesame (BARI Til-4)-T. Aman rice (BRRI dhan75) rice. The average seed yield of lentil and sesame and grain yield of T. Aman rice were 2.03, 1.54 and 5.10 t ha^{-11}, respectively from improved cropping pattern which was 12.78, 25.20 and 43.26 % higher over existing pattern. Improvedcropping pattern produced higher rice equivalent yield (14.15 t $ha^{-1}yr^{-1}$) than farmers' existing cropping pattern (11.27 t $ha^{-1}yr^{-1}$) and it was 25.55% higher over existing pattern. Gross return and gross margin of improved cropping pattern were Tk. 306910 ha^{-1} and Tk. 186290 ha^{-1} with an MBCR of 1.51.

Development of foxtail millet-jute-T. Aman rice cropping pattern against Millet-Fallow T. Aman in the old Brahmaputra Flood Plain chars of Gaibandha

The experiment was conducted in the charland of the Jamuna river under Saghata upazila of Gaibandha during the year of 2017-18 and 2018-19 to increase cropping system intensification and productivity through three crop-based patterns instead of the existing practice and to disseminate the improved part on among the farmers. The results revealed that the improved cropping pattern produced the higher rice equivalent yield, REY (11.04 t ha^{-1}) than the existing cropping pattern (4.02 t ha^{-1}), that is almost three-times higher than the existing pattern. The profitability was also three times higher in the improved cropping pattern (Tk. 15,100 ha^{-1} yr^{-1}) than the farmers' existing cropping pattern (Tk. 49,750 ha^{-1} yr^{-1}). Inclusion of new crops (Jute) in the existing cropping pattern and replacement of local millet variety with BARI released high yielding millet variety (BARI Kaon-2) could play a significant role to increase the system productivity as well as profitability in the improved cropping pattern in the charland areas of Saghataupazila in Gaibandha district.

Development of alternate cropping pattern Potato/Maize-T. Aman against Maize-Fallow-T. Aman in the charland area

The experiment was conducted in the charland of the Jamuna river under Sundargonjupazila of Gaibandha during the year of 2017-18 and 2018-19 to increase cropping system intensification and productivity through three crop-based patterns instead of the existing and to disseminate among the farmers. The results revealed that the improved cropping pattern produced the higher rice equivalent yield (21.22 t ha^{-1}) than the existing cropping pattern (11.23 t ha^{-1}), that is almost double than the existing pattern. The profitability was also three times higher in the improved cropping pattern (Tk. 2,62,430 ha^{-1} yr^{-1}) than the farmers' existing cropping pattern (Tk. 89,950 ha^{-1} yr^{-1}). Inclusion of new crops (Potato) with relay Maize in the existing cropping pattern could play a significant role to increase the system

productivity as well as profitability of the farmers in the char areas of Sundargonj upazila in Gaibandha district.

Development of potato-chilli-groundnut cropping pattern against potato-chilli-T. Aman rice

An experiment was executed at the MLT site Hossainpur, during the year of 20117-18 to 2018-19 under AEZ # 9 to introduce groundnut against T. Aman rice in Potato-Chilli-T. Aman rice cropping patterns as well as to increase crop production and economic return of the farmers. It was laid out in RCB design with four dispersed replications. The improved cropping pattern gave the highest yield 39.97 t ha^{-1} and existing pattern gave 34.79 t ha^{-1} yield. The improve cropping pattern gave the higher gross margin (Tk. 496637 ha^{-1}) compared to existing pattern (Tk. 470300 ha^{-1}).

Development of wheat-mungbean-T. Aman rice cropping pattern against wheat-fallow-T. Aman rice in Barind area

The experiment was made at farmers' field of MLT site, Sapahar, Naogoanduring the year of 2017-18 to study productivity, production efficiency, land use efficiency and economic return of some cropping patterns in High Barind Tract. There were three cropping patterns in the study i.e., two improved cropping patters over existing Wheat-Fallow-T. Aman rice. The improved cropping patterns were Wheat-Mungbean-T. Aman rice and Wheat-Blackgram-T. Aman rice. The experiment was conducted with randomized complete block design with six dispersed replications. First year crop cycle was completed and second crop cycle is going on. In the first, higher rice equivalent yield was obtained from Wheat-Mungbean-T. Aman rice pattern. However, Wheat-Mungbean-T. Aman rice cropping pattern resulted in higher variable cost; nevertheless it gave the highest values gross return, gross margin, marginal benefit-cost ratio and production efficiency. This cropping pattern gave on an average 32% higher system rice equivalent yield (REY) compared to the existing Wheat-Fallow-T. Aman rice pattern.

Development of lentil-sesame- T. Aman rice cropping pattern against wheat-fallow-T. Aman rice in Barind area

The experiment was made at farmers' field of MLT site, Amnura, Chapainawabgonjduring the year of 2017-18 to study productivity, production efficiency, land use efficiency and economic return of some cropping patterns in High Barind Tract. There were two cropping patterns in the study i.e., Lentil-Sesame-T. Aman rice and Wheat-Fallow-T. Aman rice (cheak). The experiment was conducted with randomized complete block design with six dispersed replications. First year crop cycle was completed and second crop cycle is going on. In the first, higher rice equivalent yield was obtained from Lentil-Fallow-T. Aman rice pattern. However Lentil-Sesame-T. Aman rice cropping pattern resulted in higher variable cost; nevertheless it gave the highest values gross return, gross margin, benefit-cost ratio and production efficiency. This cropping pattern gave on an average 26% higher system rice equivalent yield (REY) compared to the existing Wheat-Fallow-T. Aman rice pattern.

Development of alternate cropping pattern mustard-T. Aus-T. Aman rice against fallow-T. Aus-T. Aman rice cropping pattern in AEZ 20

An experiment was executed at multilocation testing (MLT) sites, Moulvibazar during the year of three consecutive years of 2016-17, 2017-18 and 2018-19 to see the performance of improved cropping pattern and to increase the productivity and income of the farmers. The experimental design was RCB with six (6) dispersed replications. The existing and improved cropping patterns were Fallow-T. Aus-T. Aman (CP_1: Existing cropping pattern) and Mustard-T. Aus- T. Aman rice (CP_2: Improvement cropping pattern), respectively. BRRI dhan65 of T. Aus rice and BRRI dhan57 of T. Aman rice were used in this trial. The improved pattern CP_2 provided 9.44 t ha^{-1} of T. Aman rice equivalent yield which was almost 46.81% higher than that of existing pattern CP_1.

Development of alternate cropping pattern mustard-mungbean-T. Aman rice against mustard-fallow-T. Aman rice cropping pattern under AEZ 20 and 22

An experiment was executed at multilocation testing (MLT) site, Madhobpur, initiated in the

years of 2016-19 to see the performance of improved cropping pattern and to increase the productivity and income of farmers. The experimental design was RCB with six (6) dispersed replications. The existing and improved cropping patterns were Mustard-Fallow-T. Aman rice (CP_1: Existing cropping pattern) and Mustard-Mungbean-T. Aman rice (CP_2: Improved cropping pattern), respectively. BARI Sarisha-14 of mustard and BARI Mung-6 of mung bean were used and BRRI dhan57 of T. Aman rice will be used in this trial. The highest rice equivalent yield 8.23 t ha^{-1} was recorded from CP_2 compared to CP_1 (5.04 t ha^{-1}; which was almost 63.29% higher than that of existing pattern CP_1

Development of cucumber-jute-T. Aman rice cropping pattern against existing fallow-jute- T. Aman rice

The experiment was conducted at Nakla, Sherpur during the year of 2017-2018 to determine the agro-economic performance of Cucumber-Jute-T. Aman against existing Fallow-Jute-T. Aman rice cropping pattern through incorporation of modern high yielding varieties and improved management practices for crop production. The result revealed that the improved cropping pattern produced the higher rice equivalent yield (42.77 t $ha^{-1}yr^{-1}$) over the existing pattern (9.05 t $ha^{-1}yr^{-1}$). Gross return of the improved pattern was Tk.802600 ha^{-1} which was 319% higher than existing pattern of Tk. 191550 ha^{-1}. The gross margin was substantially higher in the improved pattern (Tk. 326124 ha^{-1}) than existing pattern (Tk. 46319 ha^{-1}). The marginal benefit cost ratio (MBCR) was found 1.84 which indicated the superiority of the improved cropping pattern over the existing pattern.

Development of alternate wheat-mungbean-T. Aman rice cropping pattern against existing wheat-fallow- T. Aman rice

The experiment was conducted at Kazirchar, Sherpur Sadar, Sherpur during the year of 2017-2018 to determine the agro-economic performance of Wheat-Mungbean-T. Aman rice against existing Wheat-Mungbean-T. Aman rice cropping pattern through incorporation of modern high yielding varieties and improved management practices for crop production. The result revealed that the improved cropping pattern produced the higher rice equivalent yield (13.65 t $ha^{-1}yr^{-1}$) over the existing pattern (7.51 t $ha^{-1}yr^{-1}$). Gross return of the improved pattern was Tk. 260230 ha^{-1} which was 82% higher than existing pattern of Tk. 142470 ha^{-1}. The gross margin was substantially higher in the improved pattern (Tk. 154817 ha^{-1}) than existing pattern (Tk. 55120 ha^{-1}). The marginal benefit cost ratio (MBCR) was found 6.51 which indicated the superiority of the improved cropping pattern over the existing pattern.

Development of alternate cropping pattern sunflower-T.aus- T. Aman rice against farmers existing relay cowpea/grasspea-fallow–T. Aman pattern in coastal region

The experiment was conducted at MLT Site Bauphal and Kuakata during the year of 2018-19 to determine the profitability of the alternate cropping pattern Sunflower (BARI Surjomukhi-2)- T. Aus (BRRIdhan48)-T. Aman rice (BRRI dhan39) against the farmers' existing pattern relay Grasspea/ Cowpea-Fallow-T. Aman rice (local: Moulata). The result revealed that the alternate cropping pattern is agronomically and economically more profitable than the existing pattern. The highest Rice Equivalent Yield (51.26 t ha^{-1}) was obtained from the alternate cropping pattern then the existing pattern (7.73 t ha^{-1}). The highest gross return (Tk 935050 ha^{-1}), gross margin (Tk 380550 ha^{-1}) and MBCR and 1.62 respectively) were obtain also higher from alternate cropping pattern over existing pattern.

B. Intercropping

Intercropping of groundnut and onion in charland of Mymensingh

An experiment was carried out in the farmers' field at Mymensingh Sadarupazila, Mymensingh to find out the suitable intercropping system to increase crop productivity and profitability during the year of 2016-17 and 2017-18.The treatment consisted of T_1= one row of onion in between two rows of groundnut, T_2=Two rows of onion in between two rows of groundnut, T_3= sole onion, and T_4=sole groundnut. Between the intercropped treatments, two rows of onion in between two rows of groundnut showed higher groundnut equivalent yield (5.60 and 6.17 t ha^{-1}, respectively in 2016-17

and 2017-18) and land equivalent ratio 1.50 and 1.61 as compared to other treatments.

Intercropping of chilli with bitter gourd

The experiment was carried out in farmers' field at Mymensingh Sadar, under On-Farm Research Division, BARI, Mymensingh to find out the suitable intercropping system in increasing crop productivity and profitability during two consecutive year of 2016-17 and 2017-18. Randomized complete block design were followed in the experiment following the treatments T_1=100% bitter gourd + 50% chilli, T_2=100% bitter gourd +75% chilli, T_3= 100% bitter gourd+ 100% chill, T_4= Sole bitter gourd (100%) and T_5 =Sole chilli (100%). Among the intercropped treatments, 100% bitter gourd in combination with 75% chilli showed higher bitter gourd equivalent yield (18.63 and 19.66 tha^{-1} in both the year) and land equivalent ratio (1.77 and 1.90) as compared to other treatments. From the economic point of view, the same treatment suggested the highest gross return and gross margin.

Intercropping of onion and chilli at charland of Mymensingh

An experiment was carried out at the farmers' field of Gouripurupazila, under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh to find out a suitable intercropping system of onion and chilli in increasing crop productivity and profitability during the year of 2017-18. For this instance, the treatments were consisted of T_1=Sole chilli, T_2=Sole onion T_3= one row of onion in between two rows of chilli, T_4=Two rows of onion in between two rows of chilli, T_5= three rows of onion in between two rows of chilli. Between the intercropped treatments, two rows of onion in between two rows chilli showed higher chilli equivalent yield (19.84 t ha^{-1}) and land equivalent ratio 1.55 as compared to other treatments.

Intercropping of mungbean with banana

An experiment was carried out at Jhikorgacha MLT site, Jashore during the year of 2016-17 and 2017-18 to evaluate the performance of mungbean intercropping with banana. Four treatments viz., T_1= Sole banana (2m x 2m), T_2= 4 rows of mungbean in between 2 rows of banana, T_3= 6 rows of mungbean in between 2 rows of banana and T_4= Broadcast of mungbean in between 2 rows of banana were used in the experiment. The experiment was laid out in RCB with 6 replications.Yield and yield contributing characters of of mungbean were influenced significantly due to intercropping. The highest mungbean yield (1.45 t/ha) was produced from T_3 (6 rows of mungbean in between 2 rows of banana) followed by T_2 (4 rows of mungbean in between 2 rows of banana) and this was lowest (1.25 t ha^{-1}) from T_4 (Broadcast of mungbean in between 2 rows of banana). The highest gross margin (581990 $Tk.ha^{-1}$) and benefit cost ratio (3.72) was found from T_3 (6 rows of mungbean in between 2 rows of banana). The lowest gross margin (Tk. 503030 $Tk.ha^{-1}$) and benefit cost ratio (3.45) was found from T_1 (Sole banana).

Intercropping of mungbean with papaya

An experiment was carried out at Jhikorgacha MLT site, Jashore during the year of 2016-17 and 2017-18 to evaluate the performance of mungbean intercropping with banana. Four treatments viz. T_1= Sole papaya (2m x 2m), T_2= 4 rows of mungbean in between 2 rows of papaya, T_3= 6 rows of mungbean in between 2 rows of papaya and T_4= Broadcast of mungbean in between 2 rows of papaya were used in the experiment. The experiment was laid out in RCB with 6 replications.Yield and yield contributing characters of of mungbean were influenced significantly due to intercropping. The highest mungbean yield (1.38 t/ha) was produced from T_3 (6 rows of mungbean in between 2 rows of papaya) followed by T_4 (broadcast of mungbean in between 2 rows of papaya) and this was lowest from T_2 (4 rows of mungbean in between 2 rows of papaya). The highest gross margin (579740 $Tk.ha^{-1}$) and benefit cost ratio (3.25) was found from T_3 (6 rows of mungbean in between 2 rows of papaya). The lowest gross margin (Tk.504360 ha^{-1}) and benefit cost ratio (3.01) was found from T_1 (Sole papaya).

Intercropping of sweet gourd with cabbage

The experiment was conducted at Multi-location Testing Site Jhikargacha, Jashore during the *rabi* season of 2017-18 and 2018-19 to evaluate the performance of sweet gourd as intercrop with cabbage and to increase the income of farmers.

Four treatments viz. T_1= Sole sweet gourd, T_2=Sweet gourd (2m × 2m) + Cabbage (60 cm × 45 cm), T_3=Sweet gourd (2m × 2m) + Cabbage (70 cm × 45 cm) and T_4=Sweet gourd (2m × 2m) + Cabbage (80 cm × 50 cm). The results of the experiment showed significant variation due to different treatments. It was observed that T_2 = Sweet gourd (2m × 2m) + Cabbage (60 cm × 45 cm) gave the highest head yield of cabbage (82.09 t ha^{-1}) and it was lowest (71.22 t ha^{-1}) from T4 = Sweet gourd (2m × 2m) + Cabbage (80 cm × 50 cm). Due to highest population the yield of cabbage was highest in T_2 treatment. Yield of sweet gourd was highest (18.21 t ha^{-1}) from T_1 when it was cultivated as sole followed by T_4 and T_3 and this was lowest from T_2. Sole sweet gourd showed highest yield for no inter competition of cabbage. The equivalent yield of cabbage was highest (113.99 t ha^{-1}) from T_2 followed by T_3 and this was lowest from T_1. The highest gross return (1139900 t ha^{-1}), gross margin (912600 t ha^{-1}) and BCR (4.31) were obtained from T_2 followed by T_3 and T_4 and it was lowest for T_1.

Intercropping of potato with maize in the farmers field at Manikganj

The experiment was conducted at Mukimpur village under Sadarthana of Manikganj district during the rabi season of 2018-19 to see the feasibility of intercropping potato with hybrid maize and its economic performance. Six intercrop combinations, T_1 = Maize (60cm x 25cm) + 1 row of potato (60cm x 15cm), T_2 = Maize (75cm x 20cm) + 2 row of potato (25cm x 15cm), T3= Maize (90cm x 20cm) + 3 row of potato (20cm x 15cm), T_4= Maize (105cm x 20cm) + 4 row of potato (20cm x 15cm) and T_5= Sole maize (60cm x 25cm) were evaluated. The variety of maize was Elite hybrid and the variety of potato was BARI Alu-40. The highest maize equivalent yield (23.93 t ha^{-1}), gross return (Tk. 366548.00 ha^{-1}) and gross margin (Tk. 186888.00 ha^{-1}) were obtained from treatment T4= Maize (105cm x 20cm) + 4 row of potato (20cm x 15cm) combination. The lowest maize equivalent yield (9.67 t ha^{-1}), gross return (Tk. 159200.00 ha^{-1}) and gross margin (Tk. 75140.00 ha^{-1}) were obtained from sole maize cropping.

Intercropping of onion and garlic with chilli in Tangail

A field experiment was conducted at the MLT sites Modhupur and Bhuapur, Tangail during the two consecutive rabiseason of 2016-17 and 2018-19 under AEZ-9 and 8 to find out suitable combination of onion and garlic with chilli at appropriate planting ratio for higher productivity and economic return. Four treatment combinations viz., T_1= Sole Chilli (100%), T_2= Chilli (100%) + Onion (one row), T_3= Chilli (100%) + Onion (Two rows), T_4 = Chilli (100%) + Garlic (one row) and T_5= Chilli (100%) + Garlic (Two rows) were considered. The treatments were arranged in randomized complete block design with three replications. Chilli variety (BARI Morich-2), Onion (BARI Peaz-1) and Garlic (BARI Rashun-1) were used in the study. From the two years study, the results of the field experiment indicated that the highest chilli equivalent yield 16.16 t ha^{-1} at Modhupur and 17.01 t ha^{-1} at Bhuapur were recorded from the two rows of onion in between two rows of chilli and the lowest chilli equivalent yield (14.41 t ha^{-1} at Modhupur and 14.09 t ha^{-1} in Bhuapur) was obtained from the sole Chilli in both the locations. The highest gross return (Tk. 565600 ha^{-1}at Modhupur and Tk. 595175 ha^{-1} Bhuapur) and gross margin (Tk. 470100 ha^{-1} at Modhupur and Tk 503085 ha^{-1} Bhuapur) were obtained from the two rows of onion in between two rows of chilli intercropped combination The sole crop of Chilli gave the lowest gross return (Tk. 504175 ha^{-1} at Modhupur and Tk. 493150 ha^{-1} at Bhuapur) and gross margin (Tk. 413814 ha^{-1} at Modhupur and Tk. 404460 ha^{-1} at Bhuapur). The results revealed that growing of two rows of onion is a agronomically feasible and economically viable intercrop with chilli.

Intercropping of short duration vegetables with sweet potato in Sylhet region

A field experiment was laid out during the year of 2018-19 in winter season at Kamalbazar, South surma, Sylhet.Five different intercropping combinations, T_1 = Sweet Potato + Red Amaranth T_2; = Sweet Potato + Leaf Amaranth; T_3 = Sweet Potato + Mustard Green; T_4 = Sweet Potato + Mustard and T_5 = Sweet Potato sole were considered. Highest sweet potato equivalent yield

(41.75 t ha^{-1}) was obtained from the treatment T_3 = (Sweet Potato + Mustard green) whereas the lowest yield (30.60 t ha^{-1}) was found from the treatment T_5 = (Sweet Potato sole). The highest gross return (Tk. 6,25,950 ha^{-1}) and gross margin (Tk. 4,95,500 ha^{-1}) was obtained from the treatment T_3 (Sweet Potato + Mustard green). Whereas the lowest gross return (Tk. 459000 ha^{-1}) and gross margin (Tk. 3,30,3000 ha^{-1}) was obtained from the treatment T_5 (Sweet Potato sole).

Intercropping of brinjal with amaranth, mustard green and coriander in Sylhet region

An experiment was conducted at multi location testing (MLT) site, Moulvibazar during the two consecutive years of 2017-18 and 2018-19 to find out the suitable crop combination for increasing total productivity, return and maximize land utilization through intercropping system. Five treatments viz. Brinjal 100% + Red amaranth 100%, Brinjal 100% + Leaf amaranth 100%, Brinjal 100% + Coriander 100%, Brinjal 100% + Mustard green 100% and sole of base crops (brinjal) were used in the study. Results showed that different intercropping combination did not influenced yield and yield contributing characters of brinjal All the intercropping combinations were performed better in terms of brinjal equivalent yield, gross return and benefit cost ratio (BCR) over sole crops. Among the intercropping combinations, Brinjal 100% (100 cm × 70 cm) + Mustard green 100% was the most feasible and profitable intercropping system in respect of brinjal equivalent yield (32.94 t ha^{-1}), gross return (Tk.498100 ha^{-1}), gross margin (Tk.341800 ha^{-1}) and benefit cost ratio (3.24).

Intercropping of maize with short duration vegetables and spices

A field experiment was conducted at multilocation testing (MLT) site in Moulvibazar during the year of 2017-18 and 2018-19. Six intercropping combinations, T_1 = Maize + Potato, T_2 = Maize + Red amaranth, T_3 = Maize + Spinach, T_4 = Maize + Data Shak, T_5 = Maize + Coriander and T_6 = Sole Maize (100% Maize) were considered. The highest maize equivalent yield 15.48 tha^{-1} was recorded from the treatment T_1 (100% maize + potato) whereas the lowest yield (9.71t ha^{-1}) was obtained from the treatment T_6 (sole maize). The highest gross return (Tk. 309600ha^{-1}) and gross margin (Tk. 147300 ha^{-1}) was obtained from the treatment T_1 (100% maize + potato). Whereas the lowest gross return (Tk. 19120000 ha^{-1}) was obtained from T_2 (Maize + Red amaranth) and gross margin (Tk. 108400 ha^{-1}) was obtained from the treatment T_3 (maize +spinach).

Intercropping squash with maize under varying planting system

The experiment was conducted at farmers field of MLT site Raniganj, Sadar, Dinajpur during the rabi season of 2018-19 to know the suitability of squash intercrop with maize with which row arrangement which could be useful to farmers and the economic performance of the maize-squash intercropping systems. Five different intercropping combinations along with sole cropping of maize and squash were employed in the study following randomized complete block design. The results revealed that the highest yield of maize and squash was obtained in sole cropping of component crops. The highest maize equivalent yield, land equivalent ratio and percent land save were obtained from the treatment T_2, where maize-squash planting ratio was 100:116 followed by T_5, where maize-squash ratio was 100:100. The highest gross return and gross margin were also obtained in 100:116 (T_2) and 100:100 (T_4). The overall results indicated that among the intercrop combinations maize-squash sowing ratio 100:116 (T_2) and 100:100 (T_5) was found suitable for total productivity and economic return of the system.

Intercropping of mukhikachu and onion at Bogura

A field experiment on intercropping of onion with mukhikacu was conducted at multi location Testing site at shibganj Bogura during the year of 2017-18 to find out the suitable intercropping system for increasing crop productivity and profitability For this instance, the treatments were consisted of T_1= sole mukhikachu (100%), T_2= sole onion (100%), T_3= mukhikachu (100%) + onion(one rows), and T_4= mukhikachu (100%) + onion(two rows). Intercropping reduced mukhikacu yield but productivity increased by 15.51-32.58% due to additional yield of onion. The highest mukhikacu equivalent yield (39.31 tha^{-1}), was obtained from the treatment T_4mukhikacu (100%) + onion (two

rows). Therefore, mukhikacu (100%) + onion (two rows) might be suitable combination for higher productivity and economic return.

Intercropping of vegetable with chilli in southern region of Bangladesh

A field experiment on intercropping of vegetables with chilli was executed at saline area of Kuakata in Patuakhali district during the *rabi* season of 2018-19 to find out an appropriate crop to cultivation with chilli for higher productivity and maximum economic return. The trial was consisted of five crop combinations viz., T_1: Sole chilli, T_2: chilli + Kangkong, T_3: chilli + Indian Spinash, T_4: chilli + Coriander and T_5: chilli+ Bushbean. Significantly the highest yield (dry chilli) was obtained from sole chilli (2.13 t ha-^{1}). Among the intercropping treatments, the highest chilli dry yield (1.91 tha^{-1}) was obtained from chilli + Kangkong. The lowest (1.85 tha^{-1}) was found in chilli + Indian spinach combination. Intercropping reduced 3 to 10 % chilli yield but total productivity as expressed by chilli equivalent yield increased by 25-45% over sole chilli due to the contribution of companion crops in coastal region.

C. Mixed Cropping

Mixed intercropping of lentil with groundnut at varying plant population in charland ecosystem

The experiment was conducted in the farmers' field at the MLT site, Bhuapur, Tangail under AEZ- 8 during the two consecutive rabiseason of 2017-18 and 2018-19 to verify the performance of groundnut as mixed crop with lentil in charland areas and to increase production and farmers' income. The treatment combinations used for the experiment were T_1: Sole Groundnut (100%), T_2: Sole lentil (100%), T_3: Groundnut (100%) + lentil (20%), T_4: Groundnut (100%) + lentil (40 %) and T_5: Groundnut (100%) + lentil (60%). Results showed that the yield of groundnut decreased with the increasing of lentil population. All the mixed cropping combinations showed superior in terms of gross return, gross margin and groundnut equivalent yield (GEY) than sole cropping. The highest mean groundnut equivalent yield (2.46 t ha^{-1}) was obtained in the treatment combination of Groundnut (100%) + lentil (60%) and it gave the highest gross return (Tk. 147600 ha^{-1}) and gross margin (Tk. 95755 ha^{-1}). The sole groundnut (100%) and sole lentil (100%) gave the lower gross return (Tk. 117000 and 66600 ha^{-1}) and gross margin (Tk. 72955 and 42600 ha^{-1}), respectively.

Mixed cropping of mungbean and sesame in drought prone high barind tract

The experiment was undertaken to verify the agro-economic performance of mixed cropping of mungbean with sesame and ensure the maximum utilization of the land for higher yield and economic return in HBT. A trial was conducted in a randomized complete block design with three replications at Basantapur, Godagari, Rajshahi during the kharif season of 2018 cropping season. In this experiment, mungbean (BARI Mung-6) and sesame (BARI Til-4) were grown mixed using additive percentages. In this study, the main plots were pure stand of two crops as well as four mixed cropping ratios viz: T_1= Sole mungbean (100%), T_2= Sole sesame (100%), T_3= 100% mungbean + 10% sesame, T_4= 100% mungbean + 15% sesame, T_5= 100% mungbean + 20% sesame and T_6= 70% mungbean + 30% sesame. The maximum mungbean equivalent yield ((1.45 t ha^{-1}), gross return (Tk. 725000 ha^{-1}) and gross margin (Tk.47800 ha^{-1}) was found from T_3 (100% mungbean + 10% sesame). The minimum mungbean equivalent yield ((1.12 t ha^{-1}), gross return (Tk.56000 ha^{-1}) and gross margin (Tk.31100 ha^{-1}) was found from T_6 (70% mungbean + 30% sesame). The maximum BCR was also recorded in T_3 where 100% mungbean mixed cropped with 10% sesame. The minimum BCR was also recorded in T_6. It was found that 100% mungbean mixed cropping with 10% sesame produced higher yield and economic return.

D. Relay Cropping

Performance of grass pea varieties as relay with T. Aman rice in low lying areas

An experiment was carried out at Tularampur MLT site, Narailduring the year of 2018-19. Three treatments viz. T_1=BARI Khesari-1, T_2= BARI Khesari-3 and T_3= Local were used in the experiment. The experiment was laid out in RCB with 4 replications. Yield and yield contributing

characters of of khesari were influenced significantly due to relay cropping with T. Aman. The highest yield (1.17 t ha^{-1}) was obtained from Local variety followed by BARI Khesari-3 (1.13 t ha^{-1}) and this was lowest from BARI Khesari-1 (0.98 t ha^{-1}). The highest gross margin (22200 $Tk.ha^{-1}$) and benefit cost ratio (2.18) was found from Local Khesari followed by BARI Khesari-3. The lowest gross margin (15550 $Tk.ha^{-1}$) and benefit cost ratio (1.82) was found from BARI Khesari-1.

Performance of field pea as relay cropping with T. Aman rice

An experiment was carried out at Jhikargacha MLT site, Jashoreduring the year of 2018-19. Three treatments viz. T_1= BARI Motor-1, T_2= BARI Motor-3 and T_3= Local were used in the experiment. The experiment was laid out in RCB with 3 replications. Yield and yield contributing characters of of field pea were influenced significantly due to relay cropping with T. Aman. The highest yield (2.77 t ha^{-1}) was obtained from BARI Motor-3 followed by BARI Motor-1 (2.53 t ha^{-1}) and this was the lowest from Local (2.48 t ha^{-1}) The highest gross margin (77450 $Tk.ha^{-1}$) and benefit cost ratio (4.97) was found from BARI Motor-3 The lowest gross margin (Tk. 67300 $Tk.ha^{-1}$) and benefit cost ratio (4.45) was found from Local.

Adaptation of different pulses as relay crop in the farmers' field of high barind tract

The experiment was undertaken to study the suitability of different pulses as relay cropping with T. Aman in the farmer’s field of High Barind Tract to increase production and develop farmers' livelihood. The field trial was conducted at the farmer's field of FSRD site Bashantopur, Godagari, Rajshahi during the year ofRabi 2016-17, 2017-18 and 2018-19. The study was designed by randomized complete block design with three replications. There were three varieties of different pulses i.e. BARI Masur-6, BARI Motor-1, BARI Khessari-3. The yield and most of the yield contributing characters like Plants m^{-2}, Plant ht (cm), No. of seeds $pod^{-1}$and TGW(g) showed significant variation in those three years.Grass pea (BARI Khessari-3) performed best in three seasons in respect of yield (1.40 t ha^{-1} ,1.12 t ha^{-1} and 1.13 t ha^{-1} respectively) and incase of lentil equivalent yield (LEY), gross return, gross margin and benefit cost ratio (BCR) showed higher in lentil (BARI Masur-6) than grass pea because of higher market price of lentil during the year of 2017-18 and 2018-19 but opposite scenario was showed in the previous year . In the 1st year, lentil (BARI Masur-6) showed the poorest performance in gross return, gross margin and benefit cost ratio (BCR) whereas pea (BARI Motor-1) showed the lowest performance during the year of 2nd year and grass pea (BARI Khessari-3) showed the lowest performance during the year of 3rd year.

Performance of lentil varieties as relay crop with B. Aman rice in Cumilla region

The experiment was conducted at the farmer`s field of Pirkashempur, Muradnagar, Cumilla under On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Cumilla during the year of the Rabi seasons of 2018-2019 to study the performance of lentil varieties as relay crop with B. Aman rice.The experimental treatments included 4 varieties viz. V_1= BARI Mashur-6, V_2 = BARI Mashur-7, V_3 = BARI Mashur-8, V_4 = Local Mashur. The experiment was laid out in a randomized complete block design with six dispersed replications. Among the varieties, BARI Mashur-8 showed the of pods and number of seeds $plant^{-1}$ resulting in the highest seed yield of 1.32 t ha^{-1}. Among the lentil varieties in relay planting system, BARI Mashur-8 offered the highest gross return of Tk. 105600.00 ha^{-1} coupled with gross margin Tk.79692.00 ha^{-1}. Though total cost was the same, BARI Mashur-8 showed the higher benefit over BARI Mashur-6, BARI Mashur-7 and local Mashur due to yield differences.

Relay cropping of panikachu with potato

The experiment was conducted in the farmers’ field at FSRD site, Elengha, Tangail under AEZ- 8 during the year of 2017-18 to verify the performance of panikachu as relay crop with potato to increase production and farmers' income. The treatment combinations used for the experiment were T_1: Potato + BARI Panikachu-3 T_2: Potato + BARI Panikachu-4, T_3: Potato + BARI Panikachu-

5 and T_4: Potato + local (Narikale). Results showed that all the relay cropping combinations showed superior in terms of gross return, gross margin and potato equivalent yield (PEY) than Farmers' Practice (T_4 treatment). The highest potato equivalent yield (93.51 t ha^{-1}) was obtained in the treatment combination of T_2: Potato + BARI Panikachu-4 and it gave the highest gross return (Tk. 935100 ha^{-1}) and gross margin (Tk. 828480 ha^{-1}). The lower gross return (Tk. 872100 ha^{-1}) and gross margin (Tk. 765480 ha^{-1}) was obtained from T_4 treatment, respectively.

Relaying sweet gourd with radish at char land of Jamalpur

The experiment was conducted at the Multi-Location Testing (MLT) site, Melandah, Jamalpur during the year of 2018-19 to find out the suitable relay crop combination of sweet gourd var. BARI Mistikumra-2 and local (Hybrid) with Radish (var. Hybrid) for higher yield and maximum economic return. The treatments were: T_1= Radish(100%)/sweet gourd (local) 2m×2m, T_2=Radish (100%)/sweet gourd (BARI Mistikumra-2) 2m×2m, T_3= Radish(100%)/sweet gourd (local) 2m×2.5m,T_4=Radish(100%)/sweet gourd(BARI Mistikumra-2)2m×2.5m, T_5=Radish (100%)/sweet gourd(local)2m×3m, T_6= Radish (100%)/sweet gourd (BARI Mistikumra-2) 2m×3m. The highest yield of radish(174.3 t/ha) was found from radish (100%)/sweet gourd (BARI Mistikumra-2) 2m×3m and lowest yield (128.3 t/ha) was found when it was grown with radish 100%/sweet gourd (Local) 2m × 2m. The highest radish equivalent yield was obtained from radish (100%)/sweet gourd (Local) 2m×2m relay cropping systems (414.10 t/ha). The gross return (6,21,150 Tk/ha) and gross margin (4,76,270 Tk/ha) was found highest from radish (100%)/sweet gourd (Local) 2m×2m relay cropping system.

E. Component Technologies

Effect of variety and fertilizer on onion bulb production under zero tillage condition

An experiment was carried out at the farmers field of Jajira, Shariatpur during the rabi season of 2018-19 to find out suitable variety and fertilizer dose for increasing bulb yield of onion under zero tillage condition. Four treatments i.e. T_1: BARI Piaz-1 + Recommended Fertilizer Dose (RFD), T_2: BARI Piaz-1 + Farmer's fertilizer dose (FFD), T_3: Local variety + RFD and T_4: Local variety + FFD were used. The significantly highest bulb yield (22.36 t ha^{-1}) was obtained from T_2 followed by T_4 where local variety and farmers fertilizer dose was used. The highest gross return (Tk.313040 ha^{-1}) and gross margin (Tk.79485 ha^{-1}) were accounted from T_2 due to the highest yield of onion found. The lowest gross margin (Tk. 47705 ha^{-1}) was obtained from that treatment where BARI Piaz-1 and recommended fertilizer dose was used.

Effect of sowing time of border crop safflower on onion seed production

An experiment was carried out at the FSRD site, Sholakundu, Faridpur during the rabi season of 2018-19 to find out an appropriate sowing time of safflower for better pollination and increasing seed yield of onion. Four treatments viz T_1: Safflower sowing 7 days before onion bulb planting, T_2 = Safflower and onion bulb sowing at same date (farmers practice), T_3=Safflower sowing 7 days after onion bulb planting T_4: Onion bulb planting without border crop were evaluated. It was laid out in RCB design with six dispersed replications. The highest seed yield (306.64 kg ha^{-1}) was obtained from sole onion plot (T_4) followed by T_1 (292.89 kg ha^{-1}). The lowest seed yield of onion was found in T_3 where safflower sowing 7 days after of onion bulb planting. Onion equivalent yield (336.58 kg ha^{-1}) was maximum in the treatment where safflower sowing 7 days before onion bulb planting followed by T_2 (331.23 kg ha^{-1}). The highest gross margin was obtained from treatment T_1= Safflower sowing 7 days before onion bulb planting (Tk. 38276 ha^{-1}).

Effect of mulching on the performance of lentil at farmers field in Faridpur

An experiment was conducted in the farmers' field at the FSRD Site, Faridpur during the *rabi* season of 2017-18 and 2018-19 to establish optimum plant population using different mulches in lentil field against foot and root rot and to increase maximum yield of lentil. BARI Masur-6 was used as the planting material. The trial was laid out in RCB design with four dispersed replications. Five treatments were employed in the study such as, T_1=

Ash 5 tha^{-1}, T_2= Ash 5 tha^{-1} + fungicide spray (Provax) at 36 DAS, T_3= Rice straw 3 tha^{-1}, T_4= Rice straw 3 tha^{-1}+ fungicide spray (Provax) at 36 DAS, and T_5= Farmers' practices (One weeding, no seed treatment, no fungicide spraying for foot and root rot but one irrigation at 25-30 DAS and different fertilizer dose). The average highest plant population m^{-2} (127.5) at 107 DAS was recorded from T_4 where rice straw mulch with Provax 200 spray at 36 DAS was used followed by T_3 (126.75) and T_2 (126) while the lowest population was recorded from no mulch treatment (T_5). The av. highest seed yield (2103 kg ha^{-1}) were obtained from T_4 treatment which was at par with T_2 (2023 kg ha^{-1}) and T_3 (2046 kg ha^{-1}). The av. highest gross return (Tk 112811 ha^{-1}) was obtained from T_4 but the highest BCR (1.54) was recorded in T_3. Considering overall performance, straw mulch treatments (T_3 and T_4) showed better performance than ash mulch treatments (T_1 and T_2). The lowest gross return (Tk 54288ha^{-1}) and MBCR (1.29) was obtained from no mulch treatment T_5 (Farmers' practice).

Effect of seed rate on the performance of lentil at farmers field under agroeeological zone-12

A field experiment was conducted at the FSRD Site, Faridpur during the *rabi* season of 2017-18 and 2018-19 to establish optimum plant population using different seed rates and to increase maximum seed yield of lentil. The BARI Masur-7 was used as the planting material. The trial was laid out in RCB design with four replications. Five treatments viz: S_1: 35 kg seed ha^{-1} (Standard seed rate), S_2: 40 kg seed ha^{-1}, S_3: 45 kg seed ha^{-1}, S_4:50 kg seed $ha^{-1}$and S_5: Farmer practice (48 kg seed ha^{-1} with local variety were considered. The highest plant population m^{-2}(155.08) was obtained from S_3 during harvest where 45 kg seed ha^{-1}. The highest average seed yield (1698.58 kg ha^{-1}) were recorded in S_3 treatment followed by S_2. The highest average gross return (Tk. 92231ha^{-1}), gross margin (Tk. 46359ha^{-1}) and MBCR (2.01) was accounted from S_3 treatment.

Effect of planting date on leaf growth, harvested leaves and seed yield of mustard green (lai shak) in Sylhet region

A field experiment was conducted at Guptorgao under south surma of Sylhet during the *rabi* season of 2017-2018 and 2018-19. The soil was clay loam in texture and acidic in nature, pH ranges 5.5-6.57. The experimental treatments consist of five different dates of seedling transplant viz. T_1: 15 October, T_2: 30 October, T_3: 15 November, T_4: 30 November and T_5: 15 December. The experiment was laid out in randomize complete block design with four replications. The mustard green (Lai shak) seedlings were raised by following farmer's agronomic cultural practices. From the result, 15 November transplanting recorded significantly higher crop yield attributing characters viz. harvested leaves $plant^{-1}$, weight of single leaf and ultimately seed yield (1.38 t ha^{-1}). The highest monitory benefit such as gross return (Tk..1283684 ha^{-1}) and gross margin (Tk. 1048140 ha^{-1}) was calculated from T_3 (15 November planting) followed by T_2 (30 October planting).

Performance of maize in zero tillage at before and after harvest of transplanted Aman rice

The experiment was conducted at farmer's field under the multi-location testing (MLT) site, Moulvibazar, during 2017-2018 and 2018-19 to find out suitable sowing time of maize in zero tillage at before and after harvest of T. Aman rice. The experiment was designed in randomize complete block with three replications. The treatments consist of four different times of seed sowing viz. T_1: 10 November as relay with T. Aman rice, T_2: 20 November as relay with T. Aman rice, T_3: 30 November in T. Aman harvested fallow land and T_4: 10 December in T. Aman harvested fallow land were used in this trial. The highest grain yield (10.01 t ha^{-1}) was obtained from T_2, but there were no significant difference with yield (9.54 t ha^{-1}) of T_1. The T_4 (10 December in T. Aman harvested fallow land) yielded significantly less (8.83 t ha^{-1}) than the others. In respect of cost benefit analysis maximum gross return (Tk. 200200 ha^{-1}) and gross margin (Tk. 105450 ha^{-1}) was observed in T_2 (20 November as relay with T. Aman rice). The lowest gross return and margin in Tk. 176600 ha^{-1}) and Tk. 81850 ha^{-1} were recorded in T_4 (10 December in T. Aman harvested fallow land).

Performance of different low water requirement crops in char land of Cumilla

An experiment was conducted at Chorbakar under Debidwer MLT site of Cumilla during the Rabi

season of 2018-19 to evaluate and selection of BARI developed low water requirement crops varieties in the drought prone area of char land. Wheat (BARI Gom-29, BARI Gom-30, BARI Gom-31), lentil (BARI Mashur-7), fenugreek (BARI Methi-1, BARI Methi-2), mustard (BARI Sarisha-14 and BARI Sarisha-17), coriander (BARI Dhonia-2) and black cumin (BARI Kaligira-1) were evaluated in the trial. From the research output, it was found that BARI Sarisha-17 is superior than BARI Sarisha-14 and produces the highest yield 1.2 t ha^{-1}. Among the wheat variety, the maximum yield was recorded from BARI Gom-31 (4.32 t ha^{-1}) compared to others. In case of Pulse crop, MARI Mashur-7 produces excellent performances in char areas and gives the seed yield 1.2 t ha^{-1}. Spices crops such as BARI Methi-2, BARI Methi-1, BARI Dhonia-2 and BARI Kaligira-1 shows better yield attributing characteristics and all of the varieties are produces excellent seed yield. From cost and return analysis, among the ten trial varieties of different crops, the highest gross return (Tk. 176000.00 ha^{-1}) and gross margin (Tk.134247.00 ha^{-1}) in char land were recorded from BARI Kaligira-1 followed by BARI Methi-2, BARI Methi-1 and BARI Mashur-7.

Effect of planting dates on the yield of Bt brinjal

The trial was conducted in 3 farmer's field at Tungipara and Muksudpur in Gopalganj during the year of 2018-19. The highest fruit yield was recorded from treatment T1 (38.30 ton/ha.) where the lowest fruit yield was recorded from T5 (6.43 ton/ha.). The highest gross return and gross mergin was also obtained from T1 and lowest from T5.

Effect of different planting methods on the yield of maize in haor areas of Kishoreganj

A field study was conducted during the year of the *rabi* seasons of 2018-19 to know the performance of transplanting methods of maize to secure maize from natural disaster mainly from early flash floods in the haor areas of Kishoreganj. The experiment was laid out in a randomized complete block design with three replications. It included five treatments i.e. i. poly bags seedling at 10 days ii. poly bags seedling at 20 days iii. seed bed seedlings at 10 days iv. seed bed seedlings at 20 days and v. farmer's practice. The variety was BARI Hybrid Maize-9. Among the treatments the highest yield was found from farmer's practice (11.46 t ha^{-1}) which was more or less similar (10.87 t ha^{-1}) to the poly bags seedling at 10 days. The highest gross margin (Tk.114710 ha^{-1}) and BCR (2.67) was calculated from farmer's practice as TVC was low in farmer's practice but maturity is earlier in poly bag and transplanting seedling.

Weed management in wheat-mungbean-rice cropping pattern under conservation agriculture in high barind tract

A field experiment was conducted at Farming System Research and Development (FSRD) site, Kadamshahar, Godagari, Rajshahi in three consecutive years during the year of 2015-2018 to develop sustainable and effective weed management strategies for wheat-mungbean-T. Aman rice under CA system in High Barind Tract. Four weed management strategies such as-WM_1: Pre-plant herbicide (Glyphosate) for wheat+ Pre-plant herbicide (Glyphosate) for mungbean+ Pre-emergence: Pretilachlor (Rifit) and Trisulfuron (Logrun) for rice; WM_2: Post emergence: Carfentrazone-ethyle (Affinity) for wheat+ Post emergence: Fenoxaprop-p-ethyl (Whipsuper) for mungbean+ Post-emergence: Pyrazosulfuron Ethyle (Laser); WM_3: One hand weeding for all crops and WM_4: No weed control were compared for two tillage options ST (strip tillage) and CT (conventional tillage). A split-plot design with three replications was used, with tillage options in the main plots and weed management strategies in the sub-plots. The ST gave higher grain yield of wheat compared to CT. In case of mungbean and T. Aman rice ST and CT showed similar grain yields. The weed population and biomass were slightly higher in ST system. Weed management treatment WM_1 recorded the highest yield of all component crops in Wheat-Mungbean-T. Aman rice sequence. This treatment also showed minimum weed population and dry weed biomass. Treatment ST with WM_1 showed higher rice equivalent yield, gross margin and BCR.

Effect of tillage options and residue retention on lentil-T. Aman cropping pattern in high barind tract

The field trial was conducted at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during

the year of 2018-19 with an objective to observe the performance of the crops under different tillage and residue management for Lentil- T. Aman rice cropping pattern in the High Barind Tract. The experiment was conducted in split plot design with three replications. Two tillage options viz. (i) ST= strip tillage and (ii) CT= conventional tillage; and three crop residue managements, viz. (i) R_0=no residue (ii) R_{20}=20% residue (iii) R_{30}=30% residue retention were studied. There was no yield difference between ST and in CT. But numerically higher yield was obtained from ST method. Among the residue management, 30% residue retention showed the highest yields of lentil (1.49 t ha^{-1}).

Weed management in lentil under tillage options in high barind tract

The field trial was conducted at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during the year of 2018-19 with an objective to observe the effects on weed control and performance of the crops under different tillage and weed management for lentil in the High Barind Tract. The experiment was conducted in split plot design with three replications. Two tillage methods viz. (i) ST= strip tillage and (ii) CT= conventional tillage; and five weed management options viz. (i) W_1= Pre-sowing (Glyphosate) (ii) W_2= Pre-emergence (Pendimethalin) (iii) W_3= Post-emergence (Fenoxaprop-p-ethyl), W_4= Hand weeding, and W_5 = Control (No weeding) were studied. The ST system gave numerically higher yield of lentil (1.61 t ha^{-1}). Among the residue management, W_2 showed the highest yields of lentil (1.81 t ha^{-1}) followed by W_1 (1.67 t ha^{-1}). The weed population and biomass were slightly higher in ST system than that of CT.

Effect of row distance and irrigation on the yield of lentil under strip tillage system

The field trial was conducted at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during the year of 2018-19 with an objective to find out the suitable spacing and irrigation regime for increasing lentil production in High Barind Tract. The experiment was conducted in split plot design with three replications. Two row spacing viz. (i) R_{20}= 20 cm apart from row and (ii) R_{30}=30 cm apart from row; and four irrigation regimes (light irrigation), viz. (i) I_1=One irrigation at vegetative stage (ii) I_2=One irrigation at pod setting stage (iii) I_3=Two irrigation at vegetative and pod setting stages and (iv) I_4=Control (No irrigation).The R_{30} gave numerically higher seed yield of lentil. Among the irrigation level, I_3 showed the highest yields of lentil (1.66 t ha^{-1}). The results indicate that, 30 cm row distance coupled with two irrigation might be a good option for higher yield of in High Barind Tract of Bangladesh.

Effect of planting time on quality seed production of onion in high barind tract

A field experiment was conducted in the farmer's field of FSRD site, Bashantopur, Godagari, Rajshahi during the Rabi season of 2018-19, 2017-18 and 2016-17 to find out suitable planting time for onion seed production in High Barind Tract. The experiment was laid out in a randomized complete block design with three replications. The treatments were five planting dates viz. 20 October, 30 October, 10 November, 20 November and 30 November. Among the planting dates the highest seed yield was obtained when planting was done on the 20 November during the three seasons (0.74 t ha^{-1} ,1.01 t ha^{-1} and 0.71 t ha^{-1} during 2018-19, 2017-18 and 2016-17, respectively) and 2nd highest seed yield was recorded when planting was done on the 30 November during 2018-19 and 2017-18 seasons (0.66 t ha^{-1} and 0.88 t ha^{-1}) but in 2016-17 it was recorded from 10 November planting (0.68 t ha^{-1}). Contrarily, it was the lowest on 20 October planting. The moisture content of the seeds of all the treatments were similar and there were no significant differences in 2018-19 2017-18 and in 2016-17. But there were significant differences in seed germination in three seasons. Maximum germination (88%, 86% and 85% in 2018-19, 2017-18 and 2016-17, respectively) was recorded on 20 November followed by 30 November. From three years results, it can be concluded that among the different planting dates, 20 November was the best for quality and seed yield. So, 20-30 November is the proper planting time for the yield and quality of true onion seeds production in High Barind condition.

Performance of short duration mustard varieties in between Boro and B. Aman rice at Manikganj

The experiment was conducted at Boinna village under Ghior thana and Ramnagar village under

Shibalaya thana of Manikganj district during the Rabi season of 2018-19 to verify the performance of short duration mustard varieties in between B. Aman and Boro rice. Two short duration mustard varieties were tested in this experiment namely, BARI Sarisha-14 and BARI Sarisha-17. The experimental design was Randomized Complete Block (RCB) with six dispersed replications. The field duration of BARI Sarisha-14 and BARI Sarisha-17 were 88 and 95 days, respectively. The seed yield of BARI Sarisha-14 (1800 kg^{-1}) was about 13% higher than BARI Sarisha-17(1600 kg ha^{-1}).

Performance of wheat under tillage technology by power tiller operated seeder and conventional method

An experiment was conducted on performance of wheat by tillage options in coastal saline area at Koyra, Khulna during the year of 2018-19. Two tillage options viz. Power Tiller Operated Seeder (PTOS) and conventional method (farmers' practice) were taken as treatments in the study. BARI Gom-25 was considered as wheat variety. Between two tillage technologies, PTOS performed better in the light of yield. Higher seed yield 2.95 t/ha was recorded from the plot where PTOS was used. The highest gross return (Tk.73,750/ha) and gross margin (Tk.43,750/ha) was also recorded from PTOS tillage technology. The BCR was calculated higher from PTOS and it was 2.46.

Performance of early planted tomato under partial shade condition

The experiment carried out at Agricultural Research Station, Alamnagar, Rangpur during late Kharif-II to early Rabi season of 2016-17, 2017-18 and 2018-19. From the three years average data, it was observed that tomato cultivated in Dhaincha planting in between all tomato rows (no cut) produced more fruit yield (16.87 t ha^{-1}) compared to open field condition where other dhainch planted environment including mango orchard produced identical fruit yield at early fruiting stage but during the later stage the identical higher fruit yield 26.46 t ha^{-1} and 25.93 t $ha^{-1}$was obtained from Mango orchard and Dhaincha planting in alternate tomato rows (cut down after tomato flowering) plot, respectively, where open field condition also produced the lowest fruit yield (19.58 t ha^{-1}). The treatment with dhaincha planted but undetopped, produced relatively higher fruits than the treatments where dhaincha was detopped after tomato flowering during early fruiting stage but the reverse trend was observed in case of later fruiting stage. Total mean fruit yield was higher in dhaincha planted in all rows (cut after flowering) plot (41.92 t ha^{-1}) and the total mean fruit yield was lowest in open field condition (32.07 t ha^{-1}). Higher economical profit was obtained from dhaincha planted in alternate rows with detopping (gross margin 902523 Tk. ha^{-1}) followed by dhaincha planted in alternate rows but undetopped plot (gross margin 876956 Tk. ha^{-1}) than open field or other conditions. Thus, partial shady environment at early growth stage of early planted tomato was found suitable as well as profitable.

Late planting potential of BARI tomato varieties in northern region of Bangladesh

An experiment was conducted at Multi Location Testing site, Domar, Nilphamri under OFRD, BARI, Rangpur during early Kharif season of 2018 to evaluate the suitability and performance of BARI developed summer hybrid tomato varieties with indian cultivar. Among the tested varieties, the highest total fruit yield (50.33 t ha^{-1}) was obtained from BARI Hybrid Tomato-8 with 1st transplanting and the lowest yield (14.09 t ha^{-1}) was obtained from Indian cultivar at 2nd transplanting. Higher tomato fruit yield with higher market price contributed more to get higher value (gross margin 364960 Tk. ha^{-1}) from BARI Hybrid Tomato-8.

Effect of border trees on potato in northern region of Bangladesh

The experiment was conducted at multi-location testing)MLT(site Gobindaganj, Gaibandha during the *rabi* season of 2018-19 to evaluate the effect of border trees on crop production in northern region of Bangladesh**.** The experiment consisted of two treatments viz. T1=Normal potato field, T2=Tree surrounded potato field. A popular potato variety BARI Alu-36 was used in this study. The experiment was laid out in randomized complete block design with three replications. Open field potato cultivation produced significantly higher tuber yield compare to tree surrounded potato filed. Higher tuber yield was recorded in T_1 (31.10 t ha^{-1})

than T_2 (18.45 t ha^{-1}). Higher gross margin (Tk.114219 ha^{-1}) was found from T_1 against T_2 treatment.

Effect of planting dates and variety on the yield of sweet gourd

An experiment was conducted at On Station of OFRD, BARI, Rangpur during Rabi season of 2018-19 to evaluate the performance of sweet gourd varieties with planting date. Three sweet gourd varieties viz, ACI Seed Company variety (Sweet baby), AMIN Seed Company variety (Kalozam) and BARI Hybrid Mistikumra-1 with four planting dates, 15 days interval started from 30 October were tested. Among the tested varieties, the highest total fruit yield (20.50 t ha^{-1}) was obtained from BARI Hybrid Mistikumra-1 with 1st planting date and the lowest yield (1.66 t ha^{-1}) was obtained from ACI Co. variety with 4th planting date. Higher fruit yield contributed more to get higher value (gross margin 157200 Tk. ha^{-1}) from BARI Hybrid Mistikumra-1.

Effect of different hormone on pod setting of summer country bean

The experiment was conducted at the FSRD site, Lahirirhat, OFRD, Rangpur during the Rabi season of 2016-17 and 2017-18 to evaluate the different hormone on pod setting and pod yield of BARI developed summer country bean BARI Sheem-7. There were five hormones as treatment, viz; T_1=Litocil, T_2=Crop care, T_3= Flora, T_4=Jada and T_5=Control. The experiment was laid out in a randomized complete block design with six dispersed replications. The highest pod yield was recorded from T_3 which containing flora and the lowest one in T_5 where no hormone was applied in both years. Similar to pod yield the higher gross margin was calculated in same treatment T_3 and the lower was in T_5 in both year. Therefore, using of flora hormone can be profitable for summer country bean production.

Effect of planting time on pod setting and yield of year-round country bean

The experiment was carried out at on-station of On-Farm Research Division, BARI, Rangpur during the year of 2016-17 and 2017-18 to find out the suitable planting time of country bean. There were twelve sowing time used as treatmenns that was at every 15 date of each month was sowing time. The 1st sowing was started on 15 September, 2016. The experiment was laid out in a randomized complete block design with three replications. The variety was BARI Sim-7. The highest pod yield was recorded from planted on 15 September in both years which was on 15 September, sowing time. The highest gross margin was calculated from T_1 (in both year). Therefore, 15 September may be suitable for country bean.

Effect of detopping of maize on grain and fodder yield of zero tillage maize in haor areas of Kishoreganj

A field study was conducted at Goroy, Nikli upazilla under OFRD, BARI, Kishoreganj during the rabi seasons of 2018-19, to observe the detopping effects of maize on grain and fodder yield. The experiment was laid out in a randomized complete block design with three replications. It included three treatments i. e; 1. Detopping at 25 days after pollination, 2. Detopping at 35 days after pollination, 3. Without detopping (control). The variety was BARI hybrid maize 9. Among the treatments the highest yield was found from farmer's practice (11.12 t ha^{-1}) followed by Detopping at 35 days after pollination (10.81 t ha^{-1}) and the lowest yield from detopping at 25 days after pollination(9.47 t/ha). Higher gross margin (Tk. 108655 ha^{-1}) and BCR (2.41) was calculated from detopping at 35 days after pollination followed by farmer's practice.

Performance of strip-planted wheat with post-emergence weed control by herbicides

The experiment was conducted at the experimental field of On-Farm Research Division, Gazipur during rabi season of 2017-18 and 2018-19 to evaluate the effect of post-emergence weed management on strip-planted wheat var. BARI Gom-30 by applications of herbicides and also to find out the most effective post-emergence herbicide and its suitable rate for controlling weeds under strip tillage system. Three post-emergence herbicides (ethoxysulfuron, carfentrazone-ethyl plus isoproturon and carfentrazone-ethyl) were tested at their label rate and double of the label rate comparing with the control (two times manual weeding). The study revealed that application of ethoxysulfuron at label rate and double of the label

rate was effective for grass weeds, but not for broadleaf weeds. Application of carfentrazone-ethyl plus isoproturon both at label rate and double of the label rate was effective to control all types of weeds. Moreover, the highest grain and straw yields were recorded from the plots treated with carfentrazone-ethyl plus isoproturon at label rate and similar results were also obtained from double rate application. Considering environmental aspect, the study suggests label rate application of carfentrazone-ethyl plus isoproturon for effective control of weeds in BARI Gom-30 under strip tillage system.

Weed controlling efficacy of herbicides in wheat-mungbean- T. aman rice cropping pattern under conservation agricultural systems

The study was initiated with wheat during *rabi* season of 2017-18 at the on-station field of On-Farm Research Division, BARI, Gazipur. Two herbicides (pendimethalin and carfentrazone-ethyl plus isoproturon) were tested to control weeds of wheat as five treatments along with one weedy control and one weed-free control (two times manual weeding). After harvest of wheat, mungbean was sown during kharif I season but the crop was completely damaged by stagnation of water for continuous rainfall of few weeks. The next crop was T. Aman rice which grown during kharif II season of 2018 and three herbicides (pretilachlor, pyrazosulfuron-ethyl and bispyribac-sodium) were tested as eight weed control treatments including one weedy control and one weed-free control (three times manual weeding). The study identified that the wheat field was infested with three grass weeds (Cynodondactylon, Digitariasanguinalis and Echinochloacolona) and five broadleaf weeds (Polygonumhydropiper, Physalisheterophylla, Chenopodium album, Ecliptaprostrate and Portulacaoleracea). Application of pendimethalin followed by carfentrazone-ethyl plus isoproturon effectively controlled on all types of weeds. This treatment produced the highest grain and straw yields of wheat. Moreover, the study also found that application of pyrazosulfuron-ethyl followed by bispyribac-sodium was the most effectual treatment for T. Aman rice as this treatment produced the highest grain and straw yield along with the most effective control of weeds.

Off-season watermelon production in sorjan bed

The experiment was conducted at MLT site Amtali, Borguna during Kharif II season of 2018 to determine appropriate methods & its response in coastal area for watermelon production. Crop grown on Trellis produced the highest fruit yield 14.40 t/ha in Amtoli and higher benefit cost ratio. Lower yield 7.7 t/ha was obtained from open sorjan bed (T_3).

F. Plant Protection Measures

Effect of different management packages for controlling bacterial wilt of Bt brinjal

An experiment was conducted at MLT site Barura, Debiwder and Chandina under Cumilla district and Saharasti under Chandpur during the Rabi season of 2018-19 to find out the effective packages for management of bacterial wilt incited by Ralstonia solanacearum. The experiment was laid out with five different bacterial wilt management packages i.e T_1 : Krosin-AG 10 SP (Streptomycin Sulphate 9% + Tetracycline Hydrochloride 1%) (Spray three different growth stage), T_2 :Stable Bleaching Powder (SBP) (Seed bed + Experimental field), T_3 :SBP + Cow dung, T_4 :Dolochone + Furadan (Carbofuran) + SBP + Cowdung and T_5 : Control in RCB design with five dispersed replications having unit plot size one decimal. From the research findings, it was clearly reveal that among the treatments, T_1 :Krosin-AG 10 SP (Streptomycin Sulphate 9% + Tetracycline Hydrochloride 1%) showed less per cent wilt incidence up to the harvesting (10.2%) and maximum wilt incidence was recorded in control plot (40.6%). Among the five wilt management packages T_1 : Krosin-AG 10 SP was found to be more effective compare to other treatments with respect to less incidence of disease. No BSFB infestation was found in BARI Bt Begun-2 but at border area BSFB infestation (39.56%) was found in non Bt Brinjal. From the cost and return analysis, it was observed that higher gross return (Tk. 604000.00 ha^{-1}) and gross margin (Tk. 508115.00 ha^{-1}) were obtained in T_1 treatment where Krosin-AG 10 SP was sprayed in three different growth stages and comparatively lower gross return (Tk. 204000.00 ha^{-1}) and gross margin (Tk. 113113.00 ha^{-1}) was found in T_5: Control treatment.

Evaluation of management packages against pod borer, helicoverpa armigera infesting chickpea in high barind tract

The study was conducted at FSRD site, Godagari, Rajshahi, during the Rabi season of 2017-18 and 2018-19 to find out an environment friendly management approach of chickpea pod borer at Barind area. There are six treatments viz. T_1:Pheromone mass trap (BARI developed) + Spraying of HNPV(0.1g/L of water), T_2:Pheromone mass trap (BARI developed) + Spraying of spinosad 2.5 SC (1.2 ml/L of water),T_3:Pheromone mass trap (Modified) + Spraying of HNPV(0.1/L of water), T_4= Pheromone mass trap (Modified) + Spraying of spinosad 2.5 SC (1.2 ml/L of water) T_5= Farmers' practice, Spraying of Nitro 505EC (cypermethrin+chlorpyriphos) @ 2ml/L of water and T_6= Untreated control (Water spray only). The experiment was laid out in a Randomized Complete Block Design with three replications.Two years results indicating that IPM package (T_1) comprising of Pheromone mass trap (BARI developed) + Spraying of HNPV (0.1/L of water) showed the best performance, reducing 84% and 83% pod damage over control and provided significantly the highest yield (1.55 t ha^{-1} and 1.49 t ha^{-1} respectively) during the Rabi seasons of 2018-19 and 2017-18, respectively. Consequently, the highest Marginal benefit cost ratio (MBCR) were 3.3 and 2.59 also recorded from this package from the both years 2018-19 and 2017-18. Hence, installation of Pheromone mass trap (BARI developed) + Spraying of HNPV (0.1/L of water),can be a good option for reducing pod damages, higher yield and higher economic benefit in High Barind Tract of Bangladesh

G. Agroforestry System

Performance of turmeric under fruit tree based agroforestry system

An experiment was conducted at the farmers' fields of Barura and Daudkandi of Cumilla, Kachua of Chandpur and Akhaura of Brahmanbaria during May 2018 to February 2019 to evaluate the performance of three BARI developed turmeric varieties with one local as check variety under mango-based agroforestry system, to increase the production and income of the farmers in this region. The highest fresh rhizome yield (14.9 t ha^{-1}) was found from BARI HAlud-3 under mango-based agroforestry system and lowest fresh rhizome yield (9.7 t ha^{-1}) was found from local in agroforestry system.

Performance of summer vegetables under fruit tree based agroforestry system

An experiment was conducted at the farmers' fields of Barura, Burichang and Debidwer of Cumilla; and Kachua of Chandpur during the summer season of 2018 to evaluate the performance of Indian spinach, okra, sponge gourd and mukhikachu under mango based agroforestry system, to increase the production of vegetables by using the fallow land under mango garden and income of the farmers in this region. Highest Indian spinach equivalent yield (48.75 t ha^{-1}), gross return (Tk. 856130 ha^{-1}), net return (Tk. 730090 ha^{-1}) and BCR (6.78),were found from mukhikachu cultivation in open field condition followed by Indian spinach in open field system and the lowest from Okra in agroforestry system (9.07 t ha^{-1}, Tk. 146950 ha^{-1}, Tk. 17520 ha^{-1} and 1.13 respectively).

Performance of inter cropping red amaranth with tomato and sweet gourd varieties under mango based agroforestry system

An experiment was conducted at the farmers' fields of Barura and Sadar Dakkhin of Comilla; Kachua of Chandpur and Akhaura of Brahmanbaria during the *rabi* season of 2018-19 to evaluate the performance of intercropping red amaranth with tomato and sweet gourd varieties under mango based agroforestry system, to increase the production of vegetables by using the fallow land under mango garden and income of the farmers in this region. Highest BARI tomato-17 equivalent yield (22.24 t ha^{-1}), gross return (Tk. 444790 ha^{-1}), net return (Tk. 328980 ha^{-1}) and BCR (3.79),were found from Ratan (tomato) cultivation and the lowest from Wonderball (sweet gourd) in agroforestry system (2.98 t ha^{-1}, Tk. 59670 ha^{-1}, Tk. -62690 ha^{-1} and 0.48 respectively).

Performance of pulses in mango based agroforestry system in high barind tract

The experiment was undertaken to study the suitability of pulses in mango-based agroforestry

system in High Barind Tract. The field trial was conducted at the farmer's field of FSRD site Bashantopur, Godagari, Rajshahi during the *rabi* season of 2018-19. The study was designed by randomized complete block design with three replications. There were four varieties of different pulses i.e. BARI Masur-6, BARI Motor-1, BARI Chola-5 and BARI Khesari-3 in the trial. As the crop were different, lentil equivalent yield (LEY) was considered for comparison. The LEY was the highest in chickpea (1.53 t ha^{-1}) followed by lentil (1.36 t ha^{-1}). The Grasspea gave the lowest LEY (0.82 t ha^{-1}). The highest gross return (Tk. 91800 ha^{-1}), gross margin (Tk. 62270 ha^{-1}) and BCR (3.10) were recorded from chickpea.

Performance of different vegetables and spices crops under lichi-based agroforestry system

The experiment was carried out at FSRD site Ojoddapur, Rangpur Sadar, Rangpur during the *rabi* season of 2018-19 To evaluate the performance of different crops in agroforestry system and to increase productivity and farmers income. Different crops such as radish, napashak, Indian spinach and garlic were selected for litchi-based agroforestry system in this study. Maximum fruit equivalent yield was obtained from litchi + garlic (13.50 t ha^{-1}) followed by litchi + indian spinach and litchi + napashak. Regarding economic benefit, all vegetables grown in litchi-based agroforestry system exhibited remarkably higher gross return and gross margin compared to sole litchi cultivation.

Performance of sweet potato varieties under litchi based agroforestry system

The experiment was undertaken to study the suitability of sweet potato in litchi-based agroforestry system in Rangpur region. The field trial was conducted at the farmer's field of FSRD site Ojoddapur, Rangpur Sadar, Rangpur during the *rabi* season of 2018-19. The study was designed by randomized complete block design with three replications. There were two varieties of sweet potato i.e. BARI Misti Alu-4, BARI Misti Alu-14, Between the sweet varieties, the LEY was the highest in litchi+ BARI Misti Alu-4 (19.50t ha^{-1}) followed by litchi+ BARI Misti Alu-14 (19.26 t ha^{-1}). The highest gross return (Tk. 1443000 ha^{-1}) was recorded from litchi+ BARI Misti Alu -4.

Feasibility of shade tolerant crops under agroforestry system

The agroforestry-based experiment was conducted at Farming System Research and Development (FSRD) site, Gongarampur, Pabna during the year of 2018-19. Two management condition viz. a) agroforestry and b) open field along with five crops viz. T_1= pea, T_2= cabbage, T_3= tomato, T_4= cauliflower and T_5= radish was considered as treatments in this trial. All the crops cultivated in open field condition exhibited siginficantly higher yield compare to agroforestry sytem except radish as its yield difference was insignificant. In terms of economic benefit, higher gross return and gross margin was attained from tomato (Tk. 723013 ha^{-1}) in open field condition.

Improvement of fruit based agroforestry system with high value crops

The experiment was carried out at extrapolation areas of FSRD site Ganggarampur, Pabna Sadar, Pabna during the *rabi* season of 2018-19 To evaluate the performance of high value crops in agroforestry system and to increase productivity and farmers income. Different high vAlue crops such as tomato, cauliflower and cabbage were selected for guava-based agroforestry system in this study. Maximum fruit equivalent yield was obtained from guava+ tomato (26.20 t ha^{-1}) followed by guava+ cabbage and guava+ cauliflower. Regarding economic benefit, all vegetables grown in guava-based agroforestry system exhibited remarkably higher gross return and gross margin compared to sole guava cultivation.

Development of sorjan based agroforestry system with quick growing fruits and vegetables in coastal area

The experiment was carried out at coastal areas of FSRD site Jamla, Dumki, Patuakhali during the *rabi* season of 2018-19 To evaluate the performance of high value crops in sorjan based agroforestry system and to increase productivity and farmers income. Different high value vegetables such as Brinjal, Bottle gourd, bitter gourd and quick growing fruits like papya, banna and guava were selected for sorjan based agroforestry system in this study. Considering

economic return from sorjan based agroforestry system higher gross return (Tk.48350) was obtained comparing same land under Fallow-Fallow-T. Aman cropping pattern that was only 7275 Tk. So sorjan agroforestry based is more profitable than Fallow-Fallow-T. Aman cropping pattern as well as ensuring vegetables and fruits for consumption round the year.

Seaweed

Effect of spacing on the yield of hypnea musciformis

The experiment was conducted at Nuniarchara sea beach to test the effect of spacing on the yield of Hypnea musciformis during winter season of 2018-19. In this study, four treatments viz. 10 cm, 20 cm, 30 cm and 40 cm spacing were considered as row spacing using "one-step semi floating" cultivation technique. The seeds of Hypnea musciformis were attached into plastic rope on 01 December 2018 and harvested on 30 December 2018. Among the treatments, 20 cm spacing produced the highest sea weed yield (2.26 t ha^{-1}) while 10 cm spacing gave the lowest yield (1.48 t ha^{-1}).

Performance of seaweed species in open sea

The experiment was conducted during winter season at Nuniarchara sea beach to find out the suitable seaweed species. After 30 days of transplanting, only Hypnea and Ulva survived. Other seaweeds did not survive due to high turbidity, high wave pressure and exposure of seaweeds under direct sunlight. Hypnea musciformis, Hypnea boergesenii and Ulva lactuca have high adaptive caliber against adverse conditions.

Development of alternate based cropping pattern consist of four crops in different location of Bangladesh to increase cropping intensity

Experiments on alternate cropping pattern (ACP) were conducted at different FSRD and MLT sites under On-Farm Research Division during 2017-18 & 2018-19 to increase the cropping intensity and productivity by developing four crop-based patterns against the farmers' existing two or three crop-based cropping pattern (FCP) and disseminate those ACPs among the farmers of respective locations. In most cases, the result exposed that the ACP with four crops could be established successfully with short duration crop varieties. In these studies, ACPs weremore profitable and viable than those of FCPsin terms of agronomic and economic point of view. Irrespective of locations, rice equivalent yield (REY), crop productivity and profitability were higher in ACPs than FCPs.

Cereal Crops

Adaptive trial of BARI released wheat varieties

An experiment was conducted at the farmer's field of Faridpur, Khulna, Kushtia, and Bogura to evaluate the performance of different BARI released latest wheat varieties in different AEZ's and to popularize them among the farmers in promoting their adoptions during the *rabi* 2018-19. It was laid out in RCB design with three to six replications. A total of seven varieties viz., BARI Gom-25, BARI Gom-28, BARI Gom-29, BARI Gom-30, BARI Gom31, BARI Gom-32 and BARI Gom-33 were tested in Faridpur, Khulna, Kushtia, and Bogura. In saline area of Khulna, BARI Gom-33 performed better (2.08 t ha^{-1}). The yields of wheat varieties in that location was lower in comparison to their potential yield might be due to adverse effect of salinity during reproductive stage. BARI Gom-32 (4.63 t ha-^{1}) and BARI Gom-33 (4.64 t ha-^{1}) performed better in terms of grain yield in Faridpur, and Bogura (3.68 t ha^{-1}) for BARI Gom-30 and BARI Gom-32. In Kushtia, the highest grain yield was obtained from BARI Gom-32 (5.21 t ha^{-1}) and BARI Gom-33(5.01 tha^{-1}).The highest gross return was found from the variety where the highest grain yield was obtained. In an average over the varieties, BARI Gom-32 (4.50 tha^{-1}) gave the highest yield followed by BARI Gom-28 (4.14 tha^{-1}) and the lowest was BARI Gom-25 (2.13 tha^{-1}).

Adaptive trial of drought and heat tolerant BARI hybrid maize varieties

An adaptive trial was conducted at Faridpur, Pabna, Sherpur and Bogura during *rabi*, 2018-19 to evaluate the performance of BARI Hybrid Maize (BHM) varieties with imported varieties/lines and to popularize among the farmers under on-farm situation in different AEZ's. A total of six BARI

released hybrid maize varieties viz., BHM -7, BHM -9, BHM -12, BHM -13, BHM -14 and BHM -15 addition of other six varieties/lines (imported) like Pacific 981, Elite, ZH-15445, NK-40, HTMA-19 and HTMA-21 were used in three locations.Among the BHM varieties, BHM-7 (10.43tha^{-1}), BHM-12 (10.81tha^{-1}) and BHM-13 (10.87tha^{-1}) showed satisfactory result. The grain yield range of BHM was 9.60 to 10.87 t ha^{-1}. Among the imported varieties, Elite and Pacific showed the highest result. Between the Heat Tolerant Maize in Asia (HTMA) varieties, higher yield was obtained from HTMA-19 (10.25 t ha^{-1}). Among the locations, the highest yield was obtained from Sherpur, followed by Pabna and Faridpur. However, BHM-12 BHM-13 and 981 showed the highest grain yield on basis of variety and locations. On the basis of benefit the highest benefit cost and ratio was obtained from Pacific 981(1.95) followed by Elite (1.86) and BHM-12 or BHM-13 (1.72). The performance of HTMA was not satisfactory.

Adaptive yield trial of maize hybrids at Manikganj

A field experiment conducted at Pouli village under Sadarthana of Manikganj district during *rabi* season of 2018-19 to observe the yield performance of BARI developed advanced lines of hybrid maize. Sixteen advanced lines of hybrid maize namely P1, P2, P3, P4, P5, P6, P7, P8 P9, P10, P11 ($F_{30}xM_{15}$), P12 ($F_{40}XM_{10}$), P13 ($F_{30}xM_1$), P14 ($F_{14}XM_{10}$, P15 (BHM-16), P16 (Elitehybrid) were evaluated in the study. The trial was laid out in RCB design with three dispersed replications. The highest grain yield of P15 (BARI Hybrid-16) was 13.21 t ha^{-1} followed by P9 (12.73 t ha^{-1}) and P12 (12.47 t ha^{-1}). The grain yield from Elite hybrid was recoded 10.22 t ha^{-1}. The seed yield of some other hybrid lines were found to be promising viz. P8 (11.94 t ha^{-1}), P10 (11.68 t ha^{-1}), P6 (11.35 t ha^{-1}) and P13 (11.35 t ha^{-1}), P4 (10.96 t ha^{-1}) and P7 (10.98 t ha^{-1}). The highest gross return (Tk. 213950.00 ha^{-1}) and gross margin (Tk.134040.00 ha^{-1}) was also obtained from P15 (BARI Hybrid maize-16).

On-farm trial of BARI developed maize hybrids

An adaptive trial was conducted at Cumilla, Tangail, Manikganj and Kushtia during the year of 2018-19 to evaluate the performance of BARI Hybrid Maize (BHM) varieties with imported varieties and to popularize among the farmers under on-farm situation in different AEZ's. A total of four BARI released hybrid maize varieties viz., T_1= BARI Hybrid Maize-7, T_2 = BARI Hybrid Maize-9, T_3= BARI Hybrid Maize-12 and T_4= BARI Hybrid Maize-13 addition of other five imported varieties like Pacific 981, NK-40, Elite, Miracle and Kaberi 7720 were used in four locations.Among the BARI Hybrid Maize varieties, BHM-7 (9.49 tha^{-1}), BHM-9 (11.10 tha^{-1}) and BHM-13 (9.21 tha^{-1}) showed satisfactory result. The range of grain yield was 9.21 to 11.10 t ha^{-1}. Among the imported varieties, Miracle (14.0 t ha^{-1}) and Kaberi 7720 (11.92 t ha^{-1}) gave higher grain yield. Among the locations, the highest yield was obtained from Manikganj followed by Cumilla, Kushtia and Tangail.

On-farm of BARI hybrid maize for Cumilla areas

Demonstration program was conducted at the farmers' field of Haripur in Dauadkandiupazilla and Amrataliin Barura Upazilla under Cumilla district during the *rabi* season of 2018-19 to evaluate the performance and to disseminate & popularize the newly developed BARI released Hybrid Maize variety among the farmers and private agencies. BARI Hybrid Maize- 9 and NK-40 were included in the demonstration program as check. BARI Hybrid Maize-9 showed the highest grain yield and yield contributing characters over NK-40. The hybrid maize variety NK- 40 produced the lowest yield.

Adaptive trials with barley genotypes in southern belt and barind areas

The trial was conducted at the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi, MLT site, Koyra, Khulna andSubarnacharupazilla under Noakhali district during Rabi 2018-19 with a view to select high yielding barley advance lines for drought/saline areas. The trial in Rajshahi and Khulna consists of two barley varieties namely BARI Barley-6 & BARI Barley-7 and three advance lines viz. BHL-25, BHL-27 and BHL-29 whereas in Noakhali, three varieties of barley viz, BARI Barley-6, BARI Barley-7 and BARI Barley-8 and three advanced lines (BHL-25, BHL-26, and

BHL-27) were used as testing materials. Out of five barley varieties/lines BHL-27 gave the highest grain yield (2.19 t ha^{-1}) followed by BHL-25 (1.99 t ha^{-1}) and the lowest grain yield was produced by BARI Barley-7(1.84 t ha^{-1}) in Rajshahi. BARI Barley-7 produced the highest grain yield (1.37 to 2.13 t ha^{1}) followed by BHL-25 (1.27 to 2.06 t ha^{-1}) at the Noakhali and MLT site, Koyra, Khulna, respectively.

Adaptive trials with BARI barley varieties in char areas

An adaptive trial was conducted under the charlad situation at the MLT sites, Bhuapur (AEZ-8), Tangail, Saghata, Gaibandha and Sariakandi, Bogura to observe the performance and popularize BARI Barley varieties in Char areas. The trial was conducted two years in Tangail whereas in other locations, it was executed during 2018-19. Two BARI varieties of barley viz., BARI Barley-6 and BARI Barley-7 were tested in the Char areas. In Tangail and Gaibandha, local cultivar was used. Among the tested varieties, the highest mean grain yield was observed in BARI Barley-6 (1.65 t ha^{-1}) followed by BARI Barley-7 (1.58 t ha^{-1}) and local (1.37 t ha^{-1}) from Tangail. In Gaibandha, the higher grain yield was recorded from BARI Barley-6 (2.5 t ha^{-1}) whereas the lowest in BARI Barley-7 (2.35 t ha^{-1}). In Bogura, the higher (2.45 t ha^{-1}) grain yield was recorded in BARI Barley-6. The higher grain yield was obtained from BARI Barley-6 over the locations. In Tangail, grain yield was lower than that of other locations.

Adaptive trials with BARI foxtail millet varieties in southern belt

An experiment was conducted during the Rabi season of 2018-19 by using three (03) BARI developed foxtail millet varieties (BARI Kaon-1, BARI Kaon-2 and BARI Kaon-3) at four (04) farmer's field of Subarnacharupazilla where initial soil salinity level (15 dS m^{-1}) were below 1 dS m^{-1}. The objectives of the adaptive trials were to disseminate and popularize BARI foxtail millet varieties in saline area. Among the tested varieties the highest grain yield was observed in BARI Kaon-2 (1.66 t ha^{-1}) which was statistically different from two varieties. However, the lowest yield was observed in BARI Kaon-3 (1.22 t ha^{-1}). In case of gross return, BARI Kaon-2 gave the higher gross return (TK 66,400 ha^{-1}) as well as gross margin (TK 49,998 ha^{-1}) compared to other two varieties.

Up-scaling of BARI foxtail millet varieties in char, barind and hilly areas

A trial was conducted at the farmer's field of MLT site, Melandah, Jamalpur and Bhuapur, Tangail under charland, FSRD site, Basantapur, Rajshahi under barind area and Dolu para and Tukhung para hill valleys in Bandarban to disseminate, popularize and select the best performance variety of BARI Kaon under farmer's field condition in different areas of Bangladesh. Three kaon varieties viz., BARI Kaon-1, BARI Kaon-2 and BARI Kaon-3 were evaluated. In Bandarban, local cultivar was included. The trial was executed during *rabi* 2018-19 for Jamalpur and Rajshahi and Kharif-I season 2017 & 2018 for Tangail and Kharif-I season 2018 for Bandarban. The highest grain yield was obtained from BARI Kaon-3 (3.10 t ha^{-1}) in Jamalpur and for Rajshahi and Tangail, it was observed from BARI Kaon-2. In Jamalpur, the lowest yield was from BARI Kaon-2 whereas in Rajshahi, it was from BARI Kaon-1 and BARI Kaon-3 from Tangail. Among the Four varieties, BARI Kaon-2 gave the highest yield (194.33 kg ha^{-1}) followed by BARI Kaon-1 (180.33 kg ha^{-1}) the lowest yield (160 kg ha^{-1}) was recorded from the local cultivar. In Bandarban, seeds were mixed with other crops seeds like rice, maize, sesame, cotton, sweet gourd, ash gourd, marpha, okra, chilli, brinjal etc. @ 01 $kgha^{-1}$.

Adaptive trial of BARI cheena-1 variety in barind areas

The trial was conducted during rabi season of 2018-19 at FSRD site Basantapur, Godagari, Rajshahi a High Barind area with BARI Cheena-1 variety with a view to disseminate and popularize BARI proso millet variety in HBT areas. The trial was set on three farmers' field on 300 m^2 for each. Seeds were sown on 03 November, 2018, by maintaining 25 cm row to row distance. N-P-K were applied @ 45-30-20 $kgha^{-1}$, respectively. Total TSP and MoP and half of urea were applied as basal. Rest half Urea was applied after seedling

establishment followed by irrigation. Standard plant protection measures were taken. The crop was harvested on 8 April, 2019. The mean plant height was 75.33 cm with a mean population of 229. The plants averagely produced 4.5 stems with a spike length of 20.4 cm. Number of grain/spike and 1000 grain weight was 139.26 and 4.76 g respectively. Mean grain yield was 1.21 t ha^{-1}.

Horticultural Crops

On-farm trial of BARI developed country bean variety

A field experiment was carried out at FSRD site Kamalbazar under South SurmaUpazilla of Sylhet and Muktagachaupazila under Mymensingh district during Rabi season of 2018-19 to evaluate the performance of BARI Sheem-6 in Sylhet region and BARI Sheem-9 and BARI Sheem-10 in Mymensingh region. The trial was laid out in RCB design with three dispersed replications. Two varieties of country bean viz. BARI Sheem-6 and farmer's variety (Goalgadda) as check and BARI Sheem-9 and BARI Sheem-10 were tested against a check variety. At Sylhet, local cultivar Goalgadda produced 29% higher pod yield (14.11 t ha^{-1}) than BARI Sheem-6 (10.97 t ha^{-1}) with maximum gross margin Tk. 159840.00 ha^{-1} and Tk. 75100.00 ha^{-1}, respectively. At Mymensingh, BARI Sheem-10 gave higher pod yield (12.66 t ha^{-1}) over local variety (12.12 t ha^{-1}) and BARI Sheem-9 (11.54 t ha^{-1}). BARI Sheem-10 offered the highest gross margin (Tk. 165124 ha^{-1}) whilst the lowest gross margin (Tk. 142724 ha^{-1}) was found in BARI Sheem-9.

Performance of country bean varieties at Pabna

The experiment was carried out at FSRD site, Ganggarampur, Pabna under during 2018-19 to evaluate the performance of country bean vrieties at farmers field. Three country bean varieties viz. V_1= BARI Sheem-9, V_2= BARI Sheem-10 and V_3=Local were were considered as treatments in this trial. The highest pod yield was found in BARI Sheem-10 (11.65 t ha^{-1}) and the lowest yield was recorded in local country bean variety (8.36 t ha^{-1}). The highest gross (Tk. 174750 ha^{-1}) return and gross margin (Tk. 58452 ha^{-1}) was obtained from BARI Sheem-10 followed by BARI sheem-10.

On-farm trial of BARI developed bitter gourd variety

The experiment was conducted at farmer's field of Cumilla, Jashore, and Rajshahi during Kharif season of 2018 and Kharif-I season of 2019 at Manikganj to evaluate the yield performance of BARI bitter gourd varieties viz. BARI Korola-1, BARI Korola-2, and BARI Korola-3 against farmers' variety. The experiment was laid out in RCBD with six dispersed replications. At Manikganj, BARI Korola-1 produced higher yield 20.65 t ha^{-1}. The yield of BARI Korola-2 ranged from 9.65 to 16.26 t ha^{-1} with an average of 13.15 t ha^{-1} irrespective of locations. At Rajshahi, BARI Korola-3 gave yield 13.54 t ha^{-1}. At Jashore, 25% higher yield was obtained from farmer's variety than BARI Korola-2 (10.45 t ha^{-1}) whereas Teya hybrid (11.76 t ha^{-1}) produced 25% higher yield than BARI Korola-2 (9.65 t ha^{-1}) in the farmers' field of Cumilla. In other locations, local varieties produced lower yields (8.39 to 8.78 t ha^{-1}) than BARI developed varieties.

On-farm trial of BARI developed eggplant hybrid varieties

The trial was conducted at Mymensingh, Cumilla and Bagherhat during Rabi season of 2018-19 to evaluate the performance of BARI developed hybrid eggplant varieties in farmers' field. BARI Hybrid Begun-2 and BARI Hybrid Begun-3 and BARI Hybrid Begun-4 were tested against check hybrid varieties in the tested locations. Irrespective of locations, BARI Hybrid Begun-3 (21.10 to 43.63 t ha^{-1}) and BARI Hybrid Begun-4 (27.60 to 39.98 t ha^{-1}) gave about 20% higher fruit yield than local hybrid variety (27.63 to 30.58 t ha^{-1}). Higher gross margin was also obtained from BARI Hybrid Begun-3 and 4.

On-farm trial of BARI released capsicum varieties

The trial was conducted at FSRD site Atia, Tangail during Rabi season of 2018-19 and to evaluate the performance of BARI released capsicum varieties and popularize the varieties among the farmers. BARI released two capsicum varieties viz., BARI Misti Morich-1, BARI Misti Morich-2 and locally available capsicum variety were evaluated in the study. The experiment was conducted in RCB

design with three replications. The highest fruit yield (9.65t ha^{-1}) was recorded from BARI Misti Morich-2 and it was statistically identical with BARI Misti Morich-1. The lowest fruit yield was obtained from Local variety (7.50 t ha^{-1}). The highest gross margin Tk. 1297074 ha^{-1} was obtained from BARI Misti Morich-2 and the lowest (Tk.977574 ha^{-1}) from local capsicum variety.

On-farm trial of BARI developed summer brinjal varieties

An on-farm trial was conducted at the FSRD site Pabna, during Kharif season of 2018 to evaluate the performance of BARI developed summer brinjal varieties over locally available variety at farmer's field. BARI Begun-10 (20.63 t ha^{-1}) and BARI Begun-8 (27.36 t ha^{-1}) gave significantly higher fruit yield over locally available hybrid variety (12.77 t ha^{-1}). The highest gross margin (Tk. 261695 ha^{-1}) was obtained from BARI Begun-10.

On-farm trial of BARI eggplant varieties at Manikganj

The adaptive trial was conducted at BoinnaPrashad village under Ghiorupazila of Manikganj district during *rabi* season of 2018-19 to evaluate the performance of BARI released eggplant varieties with local variety. Four BARI varieties viz. BARI Begun-4, BARI Begun-6, BARI Begun-8, BARI Begun-10 were evaluated with farmers variety (Uttara) as check in the study. The experiment was conducted in RCB design with 6 dispersed replications. Out of the tested varieties, BARI Begun-4 (28.17 t ha^{-1}) and BARI Begun-6 (22.67 t ha^{-1}) gave higher yield than other BARI varieties viz. BARI Begun-8 (15.17 t ha^{-1}) and BARI Begun-10 (14.17 t ha^{-1}). BFSB was the main constraint to achieve higher yield and appropriate measures were taken to control the pest. The higher gross margin (Tk. 155020.00 ha^{-1}) was also obtained from BARI Begun-4.

On-farm adaptive trial of BARI developed okra variety

The on-farm trial was conducted at Cumilla, Mymensingh, Pabna and Patuakhali district during Kharif season of 2018 to evaluate the performance of BARI Dherosh-2 against farmers' variety Alow at Cumilla, AurkaAunamikaat Mymensingh, Chamok at Patuakhali and a local cultivar at Pabna as check. The experiment was laid out in Randomized Complete Block design with six dispersed replications. BARI Dhesosh-2 produced higher marketable yield 9.8, 15.2 and 14.8 t ha^{-1}at Cumilla, Mymensingh and Pabna, respectively whereas local variety gave 8.3, 15.2 and 13.0 t ha^{-1}. BARI Dherosh-2 was resistant to YVMV in the farmers' field at Mymensingh but 9.2% infestation was recorded at Cumilla compared to the local variety (10.7%). At Patuakhali BARI Dherosh-2 exhibited 22 % higher yield than local varieties

On-farm trial of BARI developed hybrid pumpkin variety

A trial on pumpkin variety was conducted at Mymensingh, Kurigram, Cumilla, Satkhira, Patuakhali and Manikganj during Rabi season of 2018-19 to evaluate the performance of BARI developed pumpkin varieties in the farmers' field. BARI Hybrid Mistikumra-1 was tested against farmers' variety as check. The experiment was laid out in Randomized Complete Block design with six dispersed replications. The yield performance of BARI Hybrid Mistikumra-1 appeared to be promising in the tested locations. The yield of BARI Hybrid Mistikumra-1 ranged from 23.91 to 60.70 t ha^{-1} whereas farmers variety ranged from 12.3 to 30.8 t ha^{-1}. At Satkhira, BARI Hybrid Mistikumra-1 produced about 20% higher fruit yield (60.7 t ha^{-1}) than BARI Mistikumra-1 (50.7 t ha^{-1}). At Patuakhali fruit bearing, individual fruit wt. thickness of fruit and yield (20.87 t ha^{-1}) was higher in locally popular hybrid variety `Bengal sweet' than BARI hybrid Mistikumra-1.

On-farm trial of BARI developed pointed gourd varieties

An experiment was carried out in MLT site, Chuadanga during Kharif-I season of 2018 to evaluate the yield performance of BARI released pointed gourd varieties. Four-pointed gourd varieties viz. BARI Potol-1, BARI Potol-2, BARI Hybrid Potol-1 with a farmer's variety as check were evaluated. The experiment was conducted in randomized complete block design with six dispersed replications. BARI hybrid potol-1 (40.00 t ha^{-1}) produced 5% higher yield than farmer's variety (38.28 t ha^{-1}) and 15-18% higher than BARI Potal-1 and BARI Potal-2, The higher gross margin

(Tk. 35000.00 ha^{-1}) was also obtained from BARI hybrid potol-1.

On-farm trial of BARI developed ridge gourd variety

An experiment was conducted at Chandina and Debidwer under Cumilla district and Khosba under BrahmonBARIa district during Kharif season of 2018. The objective of the experiment was to evaluate the yield performance of BARI developed ridge gourd variety and to disseminate the variety among the farmers' in this region. The experiment was laid out in Randomized Complete Block design with four dispersed replications. BARI Jhinga-2 performed superior over the farmers' variety in all aspects. Yield and yield contributing parameters like fruit length and diameter, single fruit weight, number of fruits $plant^{-1}$, fruit weight $plant^{-1}$ were higher in BARI Jhinga-2 that leads to achieve higher fruit yield (22.8 t ha^{-1}). Local variety of produced lower yield (16.7 t ha^{-1}). Maximum gross margin (Tk. 260450 ha^{-1}) was also obtained from BARI Jhinga-2 and the lowest from farmers' variety (Tk.167900 ha^{-1}). Virus infestation was higher in local variety (25.11%) compared to BARI Jhinga-2 (12.33%).

On-farm trial of BARI stem amaranth variety at Manikganj

The adaptive trial was conducted in the farmers' field under OFRD, BARI, Manikganj during Kharif-I season of 2019 to evaluate the performance of BARI released stem amaranth variety. BARI variety viz. BARI Danta-1 was tested against a local variety as check in the study. The experiment was conducted in RCB design with four dispersed replications. BARI Danta-1(36.50 t ha^{-1}) gave 13% higher yield than the local variety (32.25 t ha^{-1}).

On-farm trial of BARI summer hybrid tomato varieties

An experiment was conducted at on station research field of BARI and MLT site, Barura, Chandina and Debidwer of Cumilla, Koshba of BrahmanBARIa, Saharasti of Chandpur under OFRD, BARI, Cumilla during June to September in 2018 to select high yielding summer tomato varieties at farmer's field. Two BARI developed hybrid variety such as BARI Hybrid Tomato-8 and BARI Hybrid Tomato-10 were included in the trial. BARI Hybrid Tomato-10 (19.40 t ha^{-1}) produced 66% higher fruit yield than BARI Hybrid Tomato-8 (14.35 t ha^{-1}). Plant mortality due to bacterial wilt was higher in BARI Hybrid Tomato-8 (37.60 %) than BARI Hybrid Tomato-10 (22.70%). The highest gross margin (Tk. 404200.00 ha^{-1}) was also obtained from BARI Hybrid Tomato-10 and the lowest (Tk. 151700.00 ha^{-1}) from BARI Hybrid Tomato-8.

On-farm trial of summer BARI bottle gourd variety

An on-farm trial was conducted at MLT site Jhikargacha, Jashore during kharif season of 2018 to evaluate the performance of BARI Lau-4 in farmers' field. The experiment was laid out in RCB design with six dispersed replications. Fruit length, fruit diameter, number of fruit $plant^{-1}$ and single fruit weight were higher in BARI Lau-4 than local variety. BARI Lau-4 (53.4 t ha^{-1}) gave about 13% higher yield than local variety (47.4 t ha^{-1}). Higher gross margin (378780Tk.ha^{-1}) and BCR (2.44) were also obtained from BARI Lau-4.

On-farm trial of BARI developed winter tomato varieties

The trial was conducted at Khulna, Cumilla, Bandarban and Patuakhali during Rabi season of 2018-19 to evaluate the performance of BARI developed winter tomato varieties. Four BARI Tomato varieties viz. BARI Tomato-14, BARI Tomato-17 and BARI Tomato-18 and BARI Tomato-19 with a locally available variety as check were evaluated in the study. The experiment was laid out in RCB design with six dispersed replications. BARI Tomato-14 (41.49 t ha^{-1}) and BARI Tomato-17 (40.31 t ha^{-1}) performed better at Khulna while BARI Tomato-18 (62.19 t ha^{-1}) and BARI Tomato-19 (68.71 t ha^{-1}) both produced higher yield at Cumilla. At Bandarban, BARI Tomato-18 (59.79 t ha^{-1}) and BARI Tomato-19 (55.12 t ha^{-1}) gave 51 and 39% higher yield than local variety (39.66 t ha^{-1}). At Patuakhali, BARI Tomato-18 the highest yield (72.12 t $ha^{-}1$) over BARI Tomato-19 (64.78) and check varity (69.00 t $ha^{-}1$).

On-farm trial of BARI winter bottle gourd variety

The trial was conducted at Jashore, Rangpur, Khulna and Patuakhali during Rabi season of 2018-19 to evaluate the performance of BARI developed high yielding winter bottle gourd variety in the farmer's field. BARI Lau-5 and a farmer's variety as check were used in this study. The experiment was laid out in Randomized Complete Block design with six dispersed replications. BARI Lau-5 gave higher yield (40.7 t ha^{-1}) compared to local variety (36.61 t ha^{-1}). The maximum gross margin was also obtained from BARI Lau-5 in all the tested locations.

On-farm trial of BARI developed winter hybrid tomato varieties

The experiment was conducted at Manikganj, Tangail and Khulna during Rabi season of 2018-19 to evaluate the performance of BARI winter hybrid tomato varieties at farmer's field. Three BARI hybrid tomato varieties viz. BARI Hybrid Tomato-5, BARI Hybrid Tomato-7 and BARI Hybrid Tomato-9 along with local hybrid were evaluated in the farmers' field. BARI Hybrid Tomato-5 produced higher yield at Delduar (97.46 t ha^{-1}) and Ghatail (88.23 t ha^{-1}) of Tangail than that of Khulna (74.34t ha^{-1}) and Manikganj (65.12 t ha^{-1}). BARI Hybrid Tomato-7 gave higher yield at both locations of Tangail (87.80 and 87.48 t ha^{-1}). BARI Hybrid Tomato-9 also performed better at Delduar (91.66 t ha^{-1}) and Ghatail (88.73 t ha^{-1}) whereas lower yield was recorded at Khulna (69.44 t ha^{-1}). Local hybrid produced lower yield (50.57 t ha^{-1} to 67.20 t ha^{-1}) at all the tested locations. Higher gross margin was obtained from BARI Hybrid Tomato varieties in all locations.

On-farm trial of BARI developed winter tomato varieties

The trial was conducted at Manikganj, Tangail and Munshiganj during Rabi season of 2018-19 to evaluate the performance of BARI developed winter tomato varieties. Four BARI Tomato varieties viz. BARI Tomato-14, BARI Tomato-15, BARI Tomato-16 and BARI Tomato-17 with locally available variety as check were evaluated in the study. All BARI developed tomato varieties performed better in the farmer's field of Tangail and Munshiganj than Manikgangj. BARI Tomato-14 performed better at Delduar (94.13 t ha^{-1}) and Ghatail (84.5 t ha^{-1}) while BARI Tomato-15 gave 84.40 and 87.7 t ha^{-1} at both locations of Tangail, respectively. BARI Tomato-16 and BARI Tomato-17 both produced higher average yield (86.04 and 91.1 t ha^{-1}) at Tangail, respectively. At Manikganj, higher yield from BARI Tomato-17 (46.6 t ha^{-1}) and BARI Tomato-14 (42.24t ha^{-1}) was obtained than local variety Ruma (35.36 t ha^{-1}) but check variety (Minto hybrid) gave higher yield (84.00 t ha^{-1}) at Munshiganj than BARI Tomato-16 (65.00 t ha^{-1}).

On-farm trial of BARI gladiolus varieties

The experiment was conducted in the farmers' field at the FSRD site, Atia, Delduar, Tangail and MLT site, Moulvibazar, Sylhet during Rabi season of 2018-19 to evaluate the performance of BARI released gladiolus varieties and to popularize the varieties among the farmers of Tangail region. BARI developed gladiolus varieties viz. BARI Gladiolus-3, BARI Gladiolus-4 and BARI Gladiolus-5 were tested at Tangail but BARI Gladiolus-3, BARI Gladiolus-4 and BARI Gladiolus-6 were evaluated at Moulvibazar, Sylhet. The experiment was conducted in RCB design with six dispersed replications. BARI Gladiolus-4 performed better in terms of spike production and economic return in both the tested locations. The highest number of spike ha^{-1} (19000 nos.) was produced in BARI Gladious-4 at Tangail and the highest spike yield in terms of weight (19.32 t ha^{-1}) was found from the same variety at Sylhet. Higher gross margin (Tk.541056 and 3514882 ha^{-1}) was also obtained from BARI Gladious-4 both at locations of Tangail and Sylhet.

Pulse Crops

Participatory varietal selection of chickpea in high barind tract

A field trial was conducted in the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during Rabi 2018-19 to develop variety through farmer's selection under Barind environments. Four advanced lines of chickpea viz.BCX-01008-4, ICCV-07102, ICCV-12110, BCX-09010-9 and two varieties BARI Chola-5 and BARI Chola-10 as check were tested in the farmer's field. Among

the tested entries BARI Chola-10 (1.80 t ha^{-1}) gave the maximum grain yield and 2nd highest yield produced by line ICCV-12110 (1.68 t ha^{-1}) and BCX-090109(1.63t ha^{-1}) which are statistically similar. BARI Chola- 5 gave minimum yield (1.29 t ha^{-1}). Though varieties BARI Chola-10 was highest yielder but considering the yield and yield contributing characters like plants m^{-2}, no. of pods $plant^{-1}$, 100 grains wt and seed yield ICCV-12110 is also a promising one among the tested lines for chickpea production in High Barind Tract.

Preliminary yield trial of chickpea in high barind tract

The field trial was carried out at the farmer's field of FSRD site, Basantopur, Godagari, Rajshahi during rabi season 2018-19 to select suitable chickpea variety through Preliminary yield trial (PYT) under drought prone area. Five genotypes of chickpea viz. BCX-13002-3, BCX-13004-4, BCX-13008-3, BCX-13002-2, BCX-13005-8 and two varieties BARI Chola-5 and BARI Chola-10 as a check were tested in the farmer's field. Among the tested genotypes BARI Chola-10 gave the maximum seed yield (1.77 t ha^{-1}) followed by BCX-13005-8 (1.70 t ha^{-1}) and minimum seed yield obtained from BARI Chola-5 (1.27 t ha^{-1}) and BCX-13002-3 (1.35t ha^{-1}) which are statistically similar.

Regional yield trail of blackgram genotypes in high barind tract

The field trial was carried out at the farmer's field of FSRD site, Basantopur, Godagari, Rajshahi during kharif-2 season to evaluate the high yielding black gram genotypes in drought prone area. Four genotypes/varieties of black gram viz. BG-7, BG-4, BG-2 and BARI Mash-3 were tested in the farmer's field. Among the tested genotypes/varieties BG-4 gave the maximum seed yield (1.28 t ha^{-1}) followed by BG-2(1.20 t ha^{-1}). Genotype BG-7showed minimum seed yield (1.01 t ha^{-1}).

Participatory varietal selection of blackgram

A field trial was conducted at Kandorkandi village under SadarUpazila of Manikganj district during Kharif 2 season of 2018 to evaluate the performance of four advance lines of black gram under farmers' field condition. Four advance lines of blackgram namely, P-01, P-02, P-03 and P-04 were evaluated. Among the advance lines, P-04(1.96 a ha^{-1}), P-01(1.92 t ha^{-1}) and P-02 (1.87 t ha^{-1}) performed better and lowest yield was recorded in P-03 (1.70 t ha^{-1}).

Participatory varietal selection of blackgram in high barind tract

A field trial was conducted in the farmer's field of FSRD site, Basantapur, Godagari, Rajshahi during kharif-2 season 2018 to develop variety through farmer's selection under Barind environments. Three advanced lines of Blackgram viz.BBLX-08010-4-1 BBLX-08008-2-1, BBLX-08010-2-1 and one variety BARI Mash-3 were tested in the farmer's field. The genotypes were evaluated for yield and yield components like days to flowering, days to maturity, plant height, no. of plants m^{-2}, no. of pods $plant^{-1}$,100 grain wt, grain and straw yield etc. with the close supervision of OFRD, Barind Station, Rajshahi. Among the tested entries BBLX-08008-2-1 (1.29 t/h) gave the highest yield on the other hand line BBLX-08010-4-1 gave the minimum yield (0.92 t ha^{-1}). Considering the yield and yield contributing characters BBLX-08008-2-1 is suitable one among the tested lines for Blackgram production in High Barind Tract.

Adaptive trial of BARI released blackgram varieties

The experiment was conducted at MLT site, Bheramara, Kushtia, two locations namely Saluca char Sariakandi and Boisaki, Dhunut, Bogura as well as char land of Mymensingh sadarupazila during Kharif-2, 2018-19 to select suitable variety of blackgram. Three varieties viz. BARI Mash-1, BARI Mash-2, BARI Mash-3 were tested against Local in Kustia and BARI Mash-3 against Local variety(s) in Bogura and Mymensingh. The seed yield in Kustia did not showed significant difference among the varieties but higher yield was produced in BARI Mash-3 (1.33 t ha^{-1}) whereas in Bogura and Mymensingh, BARI Mash-3 gave the satisfactory yield over over the local cultivar with an attractive gross margin (56085Tk/ha) and (58780Tk/ha) in Bogura and (65975Tk/ha) in Mymensingh.

Adaptive trial of BARI released lentil varieties in farmers' field

The experiment was conducted in MLT site, Bheramara, Kushtia, MLT stie, Gangni, Meherpur and MLT site, Chuadanga during *rabi* season 2018-2019 in farmer's field to observe performance of lentil variety in those area. A total of 4 varieties (BARI Masur-6, BARI Masur-7, BARI Masur-8 and Local) were tested. Among these varieties, BARI Masur-8gave the highest seed yield and profit.

Validation of biofertilizer of lentil

The experiment was conducted at Multi-location Testing Site Tularampur, Narail and Farming Systems Research and Development site (FSRD), Faridpur during Rabi season 2017-18 and 2018-19 to find out the performance of bio-fertilizer for growing lentil in the farmers field. Three treatments viz. T_1= Without Rhizobium inoculant + PKSZn, T_2= With Rhizobium inoculants + PKSZn, T_3=NPKSZnwereused in the experiment. The experiment was laid out in RCB with four replications using the variety of BARI Masur-6 and peat based rhizobium strains (BARI RLc-104). Yield and yield contributing characters showed significant variation due to fertilizer doses. Treatment T_2 that means PKSZn chemical fertilizers with inoculums' gave the highest yield (1.72 t ha^{-1} in Narail and 1.56 t ha^{-1} in Faridpur) in both the locations followed by farmers' dose (1.46 t ha^{-1} inNarail and 1.50 t ha^{-1} in Faridpur) and the lowest (1.38 t ha^{-1} in Narail and 1.38 t ha^{-1} in Faridpur 1.38 t ha^{-1}) from T_1: PKSZn without innoculum. Most of the yield contributing characters of lentil were also higher in the treatment T_2. Highest gross return (94600 Tk.ha^{-1} in Narail and 58750 Tk.ha^{-1}in Faridpur) were obtained from T_2 (PKSZn chemical fertilizers with inoculums). Similar trend was observed for gross margin.

Tuber Crops

Adaptive trial with BARI released potato varieties at different locations (1)

The trial was conducted at farmers' field of FSRD site Lahirirhat; MLT site Ulipur, OFRD, Rangpur and MLT site of OFRD, Gaibandha during the *rabi* season of 2018-19 to evaluate the performance of tuber yield of selected red skin potato varieties and to know farmers' opinion about the varieties. Potato varieties viz. BARI Alu-8, BARI Alu-28, BARI Alu-36 and BARI Alu-41 were tested used in these trials. Among the tested potato varieties BARI Alu-41 and BARI Alu-36 performed better at all locations and gave 28.52% and 24.59% higher tuber yield than national average yield. These two-variety showed less than 10% foliage infection due to Late Blight disease. Regarding Common Scab susceptibility, its severity was very low (<2%). The highest gross margin was recorded from BARI Alu-41 followed by BARI Alu-36. Farmers' choice of potato variety varied with locations mostly for yield performance and skin colour. According to farmers' choice the popular variety Cardinal could be replaced with BARI Alu-36 and BARI Alu-41 because of yield and disease infestation.

Adaptive trial with BARI released potato varieties at different locations (2)

The trial was conducted at farmers' field of thirteen different locations (Gopalgonj, Satkhira, Manikgonj, Mymensingh, Jhenaidah, Faridpur, Tangail, Kishoregonj, Sherpur, Cumilla, Narsingdi, Rajshahi and Bhola) under the supervision of On-Farm Research Division during Rabi season of 2018-19 to evaluate the performance of some selected (white skin) potato varieties and also to know farmers' judgement about the varieties. BARI released four potato varieties viz. BARI Alu-13, BARI BARI Alu-35, BARI Alu-37 and BARI Alu-40 were used in these trials. Among the tested potato varieties BARI Alu-40 produced the highest tuber yield at all locations with some exception in Jhenidah and Bhola, with an average yield of 36.63 t ha^{-1}, that was about 32.97% higher than the check variety BARI Alu-13. BARI Alu-37 produced the second highest tuber yield (average 33.78 t ha^{-1}) which 18.74% higher than the check variety. Except Sherpur and Bhola, rest all locations, BARI Alu-13 was the lowest yielder. Regarding, cut worm infestation, all the potato varieties showed very low infestation with a range of 0.48 to 2.25% in all locations, whereas, the Common Scab susceptibility was varied from 0.42-12.20% and in Mymensing showed the maximum (12.20%). The highest gross margin was recorded from BARI

Alu-40 (212,085 Tk ha^{-1}) followed by BARI Alu-37 (176,417tk ha^{-1}). According to farmers' judgement BARI Alu-37 and BARI Alu-40 could be the best potato varieties in terms of higher tuber yield as well as less insect and disease infestations and higher gross margin.

Adaptive trial with BARI released potato varieties in chattogram region

The experiment was conducted to evaluate the performance of BARI released potato varieties at MLT sits of Regional Agricultural Research station, Chattogram during the *rabi* season of 2018-19. The longest plant was observed on BARI Alu-72 (60.38 cm) and the shortest was found in BARI Alu-73. Maximum number of stems per hill was recorded from BARI Alu-72 (7.77) and minimum was BARI Alu-73. Maximum number of tubers per hill was found on BARI Alu-41(11.90) and minimum was BARI Alu-73 (4.75). BARI Alu-41 gave the highest tuber weight per hill (446.27 g) followed by BARI Alu-62 (372 g) and BARI Alu-73 gave the lowest tuber weight per hill (306.83 g). The highest tuber yield was recorded from BARI Alu-41 (29.88 t ha^{-1}) followed by BARI alu-62 (26.62 t ha^{-1}). The highest cutworm infestation (3.87%) was found from BARI Alu-41 which was statistically similar with BARI Alu-63; and the lowest infestation was recorded from BARI Alu-73 (0.60%). Maximum soft rot disease infection was obtained from BARI Alu-63 (2.47 %) which is similar to BARI Alu-41 (2.27 %) and minimum was in BARI Alu-62 (0.63%).

On-farm trials with BARI release potato varieties in different locations

An adaptive trial was conducted in farmers' field of MLT site Gaibandha, MLT site Manikganj; MLT site of OFRD Kishoreganj; MLT site of OFRD Sylhet; MLT site of Sadar, Bhola and MLT site Bauphal of Patuakhali during the rabi season of 2018-19 to evaluate the performance of tuber yield of selected potato varieties and to know farmers' opinion about the varieties. Potato varieties viz. BARI Alu-13; BARI Alu-36, BARI Alu-41, BARI BARI Alu-46 and BARI Alu-53 were used in the trial. Among the varieties BARI-Alu-41 was the highest yielder in Gaibandha; BARI-Alu-46 was the highest yielder in Sylhet; BARI Alu-40 was in Manikganj; BARI Alu-35 was in Kishoreganj and BARI Alu-37 was in Bhola and Patuakhali. Among the locations, the average highest tuber yield was recorded in Manikganj and the lowest tuber yield was found in Patuakhali. Among the potato varieties, BARI Alu-46 and BARI Alu-53 showed greater resistance to Late Blight of potato and common scab infection. The highest gross margin was recorded from BARI Alu-41in Gaibandha, BARI Alu-37 in Bhola and Patuakhali, BARI Alu-40 in Manikganj, BARI Alu-35 in Kishoreganj, BARI Alu-46 in Sylhet. Farmers' choice of potato variety varied with locations mostly for yield performance and skin colour.

Promotion and dissemination of BARI released late blight resistant potato varieties in northern districts

The trial was conducted at farmers' field of MLT site of OFRD, Gaibandha, MLT site of Mararhat, Lalmonirhat; MLT site Ulipur, Kurigram and MLT site of Pirganj, Rangpur during the rabi season of 2018-19 to evaluate the performance of recently released Late Blight resistant potato varieties BARI Alu-46 and BARI Alu-53 and to know farmers' judgement about the varieties. Among the tested potato varieties BARI Alu-46 and BARI Alu-53 performed better at all locations and gave 62.51% and 47.79% higher tuber yield than check variety (BARI Alu-25). These two-variety showed less than 0-5% foliage infection. Regarding Common Scab susceptibility, its severity was very low (<1%). The average highest gross margin was recorded from BARI Alu-53 followed by BARI Alu-46. Farmers' judgement about potato varieties varied with locations mostly for yield performance and skin colour. According to farmers' judgement the popular BARI Alu-46 and BARI Alu-53 was highly resistant to Late Blight of potato disease, which cut the fungicide cost greatly and reduce the cost of production without hampering tuber yield.

Promotion and dissemination of BARI released climate smart potato varietiy

BARI released saline and heat tolerant BARI Alu-72 and heat tolerant BARI Alu-73 were evaluated at the farmers field in Khulna region (Khulna sadar, Batiaghata, Dumuria, and Koyra), Patuakhali, Coxsbazar, Bhola and Borguna to observe their performance in the coastal areas of Bangladesh. Average of soil salinity level ranged from 2.5 to

11.3 dSm^{-1}in Khulna, 2.57 to 7.5 dSm^{-1} in Coxsbazar. 1.02 to 7.04 in Patuakhali. Bhola was non-saline. Among the varieties the average highest yield was found in BARI Alu-72 (26.89 t ha^{-1}). In all locations, BARI Alu-72 performed better due to its higher adaptability to heat and saline condition. Higher average gross return, gross margin and BCR were accounted from BARI Alu-72 for its higher yield.

On-farm trial of BARI released promising sweet potato varieties at different locations

BARI released sweetpotato varieties were evaluated in the farmers field of Multilocation Testing (MLT) site, Sadar Gopalganj (BARI Mistialu-5, BARI Mistialu-8, and BARI Mistialu-12); Bhuapur, Tangail (BARI Mistialu-4, BARI Mistialu-8, BARI Mistialu-10, BARI Mistialu-12, and local); Malandah, Jamalpur (BARI Mistialu-4, BARI Misti alu-7, BARI Mistialu-8, BARI Mistialu-13 and Jamalpur local), Sadar Faridpur (BARI Mistialu-8, BARI Mistialu-10, BARI Mistialu-12 and local), Bauphal, Patuakhali and Amtoli, Borguna (BARI Mistialu-5, BARI Misti alu-8, BARI Mistialu-10, BARI Mistialu-12) during the rabi season of 2018-19. The highest tuberous root yield was obtained from BARI Mistialu-8 (39.87 tha^{-1}) in Sadar, Gopalganj and the lowest yield was obtained from local variety (13.40tha^{-1}) at Sada, Faridpur. Out of the tested sweet potato varieties the highest gross return (Tk. 5,28,400ha^{-1}) was obtained from BARI Mistialu-8 at Charland of Sadar, Faridpur which was also showed the highest gross margin (Tk.3,57,400 ha^{-1}) due to highest production

Adaptive trial of BARI released promising sweet potato varieties in different locations

Field trials with four varieties viz. BARI Sweet Potato-8, BARI Sweet Potato-12, BARI Sweet Potato-14 and BARI Sweet Potato-15 were carried out at MLT site Pirganj, Rangpur; MLT site Saghata, Gaibandha; MLT site Kaliganj, Jhenidah; MLT site Sadar, Manikganj; MLT site Sadar Kishoreganj MLT site, Kamalbazar, Sylhet; MLT site Shibpur, Narsingdi and MLT site Daulatkhan, Bhola during Rabi 2018-19 to evaluate the comparative performance of BARI released high yielding sweet potato varieties. The tuberous roots yield was ranged from 17.30 to 44.91 t ha^{-1}, where BARI Mistialu-12 produced the highest tuberous root yield (44.91t ha^{-1}) at Daulatkhan, Bholaand BARI Mistialu-15 produced the lowest tuberous root (17.30 t ha^{-1}). Among the varieties, the average highest tuberous root yield was found in BARI Mistialu-12 (31.38 t ha^{-1}) followed by BARI Mistialu-8 (26.31 t ha^{-1}) and BARI Mistialu-14 (25.45 t ha^{-1}) while BARI Mistialu-15 produced the average lowest tuberous root yield (23.77 t ha^{-1}). The highest gross return (Tk. 505,500 ha^{-1}) and gross margin (Tk. 376,800 ha^{-1}) was estimated from BARI Mistialu-12 at South Surma, Sylhet. The lowest yield was obtained from BARI Mistialu-15 (gross return Tk. 173,000 $ha^{-1}$and gross margin Tk. 63,020 ha^{-1}) at Sadar, Manikganj.

Adaptive trials with BARI released varieties of panikachu at different locations

The experiment was conducted at MLT site Shimakhali, Magura, Sherpur, Cumilla and Tangail during the kharif season of 2017-18 to evaluate the performance of Panikachu varieties under farmers' field and to popularize among the farmers. Six varieties viz. BARI panikachu-1,2,3,4,5,6 and local were compared in this trial. The highest average number of stolon $plant^{-1}$ was observed in BARI panikachu-1 (19.17), followed by BARI panikachu-2 (16.47) and lowest in BARI panikachu-6 (8.10). Similar trend was also observed in stolon weight $plant^{-1}$. Stolon yield was highest (22.10 t ha^{-1}) in BARI Paniikachu-1 next to BARI panikachu-2 (17.21 t ha^{-1}), with some lower stolon production in BARI panikachu-4,5,6 than the local varieties.Rhizome yield (average of all locations) was the highest (43.28 t ha^{-1}) in BARI Panikachu-6, followed by BARI panikachu-5 (37.94 t ha^{-1}) similar to BARI panikachu-4 (37.20 t ha^{-1}) and the lowest was for BARI Paniikachu-1(21.50 t ha^{-1}). The highest gross return (614463 Tk. ha^{-1}), gross margin (392747 Tk. ha-1) were obtained from BARI Panikachu-1 with the highest BCR in BARI Panikachu-3 (3.75).

Adaptive trials with BARI released varieties of mukhikachu

The experiment was conducted at MLT site of Shimakhali, Magura, MLT site of Chadanga; MLT site Cumilla and MLT site of Rajshahi during the kharif season of 2017-18 to evaluate the

performance of Mukhikachu varieties under farmers' field condition and to know the farmers choice for commercial cultivation of these varieties. The highest number of corm plant^{-1} and weight of corm per plant was also highest fromBARI Mukhikachu-2 followed by BARI Mukhikachu-1. The highest corm yield (30.00 t ha^{-1}) was found in BARI Mukhikachu-2 while the local variety was the lowest (6.25 t ha^{-1}). The highest gross return (Tk. 354888 ha^{-1}), gross margin (Tk. 234532 ha^{-1}) and BCR (3.04) were obtained from BARI Mukhikachu-2 and these were lowest from Local.

Oilseed Crops

Adaptive trial of advanced lines of rapeseed

The experiment was conducted at FSRD site, Ganggarampur, Pabna Sadar, Pabna; Purbadhalaupazila under Netrakona district; KalaiGobindopur, Batakandi, Titash, Cumilla and at Chandradigholia, Gopalganj Sadarand Tungiparaupazila during rabi season of 2018-2019 with BC-100614(3)-1, BC-120114, Tori-7and BARI Sarisha-14 as a check to observe their performance in farmer's field and to select short duration high yielding variety of rapeseed to fit in between T.Aman – Boro rice. In Pabna, the highest seed yield was obtained from the advanced lines and the lowest seed yield was attained from Tori-7. Maximum economic benefit in terms of gross return and gross margin was also obtained from BC-100614 followed by BC-120114. In Netrakona, significantly the highest seed yield was obtained from BC-120614 (2100 kg ha^{-1}) followed by BC-120114 (1488 kg ha^{-1}) and BARI Sarisha-14 (1338 kg ha^{-1}).The performance of check variety Tori-7 showed the lowest yield (1215 kg ha^{-1}) potential compared to those tested lines and BARI Sarisha-14.The economic performance of those two lines also showed better than that of Tori-7.The highest gross return and gross margin (Tk.84000 ha^{-1}, Tk.54636 ha^{-1}) was obtained from BC-120614.BC-120114 and BARI Sarisha-14 also gave an attractive gross return (Tk. 59520 ha^{-1} and Tk.53520 ha^{-1}, respectively) and gross margin (Tk.30156 ha^{-1} and Tk.24156 ha^{-1}, respectively). In Comilla, all lines produced lower disease severity and higher seed yield compared to Tori -7 and BARI developed variety BARISarisha-14. In case of maturity, the advanced lines matured 2 to 4 days later than BARI Sharisha-14. The advanced line, BC-100614(3)-1 produced the highest seed yield compared to other line and check variety. In Gopalganj, the highest seed yield was offered by BARI Sarisha-14 (1.62 t ha^{-1}) followed by BC-120114 (1.61 t ha^{-1}), BC-100614(1.57t ha^{-1}); and the lowest yield was produced by Tori-7 (0.81t ha^{-1}).

Performance of BARI released short duration mustard varieties in high barind tract

A field trial was conducted in the farmer's field at FSRD site Basantapur, Godagari, Rajshahi during 2018-2019 cropping season to know the performance of short duration mustard varieties in High Barind Tract. Four varieties of mustard viz. BARI Sharisha-14, BARI Sharisha-15, BARI Sharisha-17 and Tori-7 were tested in the farmer's field. Among the tested varieties BARI Sharisha-17 gave the maximum seed yield (1.68 t ha^{-1}) and local variety gave minimum seed yield (0.71 t ha^{-1}).

Performance of BARI mustard varieties after harvesting of T. Aman in Chattogram region

The experiment was conducted to evaluate the performance of BARI released mustard varieties at MLT sits of Regional Agricultural Research station, Chattogram during Rabi season, 2018-19. The earliest days to maturity (82 days) was BARI Sharisa-15 and the latest days to maturity (85days) was BARI Sharisa-17. The tallest plant (104.80 cm) was observed on BARI Sarisa-17 and the shortest (86.50 cm) was BARI Sarisa-15. The maximum number of seeds per siliqua (28.1) was found in BARI Sarisa-17 and the minimum (22.3) in BARI Sarisha-14. The highest seed yield was obtained from BARI Sarisa-17 (1.55 tha-^{1}) and lowest was BARI Sarisa-15 (1.16 tha^{-1}). The highest gross margin was obtained from BARI Sarisha-17(38292 Tk/ha) followed by BARI Sarisha-14 (27942Tk/ha) and lowest in BARI Sarisha-15(20742 Tk/ha).

Performance of different mustard varieties under zero tillage cultivation in char land of pabna

The trial was conducted at at the extrapolation area of FSRD site Ganggarampur, Pabna during the *rabi*

season of 2018-19 to evaluate the performance different mustard varieties under zero tillage system at farmers' field in charland of Pabna. Four mustard varieties viz. V_1= BARI Sarisha-9, V_2= BARI Sarisha-14, V_3=BARI Sarisha-15 and V_4= BARI Sarisha-17 were tested. Different mustard varieties showed significant variations in respect of yield and yield contibuting characteristics. BARI Sarisha-17 gave the highest seed yield (1.75 t ha^{-1}) while BARI Sarisha-9 exhibited minimum seed yield (1.26 t ha^{-1}). The highest gross return of Tk.85490 ha^{-1} and gross margin of Tk. 32115 ha^{-1} attained from BARI Sarisha-17 under zero tillage system.

Adaptive trial of advanced lines of sesame

A trial was conducted at the FSRD site, Faridpur, MLT site Bauphal, Patuakhali and at Kumarkhaliupazilla of Kushtia during the Kharif I season of 2019 to evaluate the performance of advanced lines of sesame at farmers' field and to develop high yielding variety of sesame. In Faridpur and Patuakhali, four advanced lines viz. Ses-9751, Ses-0570, Ses-05163, Ses- 2010-01R along with two check variety BARI Til-4 and Binatil-1 were evaluated and BARI Til-3 and BARI Til-4 were tested against a Local variety in Kushtia. In Faridpur, BARI Til-4 performed better over advance lines (1.52 t ha^{-1}) followed by Ses-05163 (1.43 t ha^{-1}) and Ses-0570 (1.42 t ha^{-1}). The highest gross margin (Tk 64832 ha^{-1}) and BCR (2.69) was also calculated from BARI Til-4 followed by Ses-05163 and the lowest figure was found from Binatil1. In Patuakhali, the highest yield (1.81t ha^{-1}) was obtained from Ses-9751 followed by Ses-2010-01R (1.77 t ha^{-1}). Among the lines Ses-9751 and Ses-2010-01R produced more yield and Ses-0570 and Ses-05163 produced lower yield than the released varieties BARI Til-1 and BINA Til-4. On the other side, in Kushtia, BARI Til-4 offered the highest seed yield as well as maximum gross return.

On-farm trial of groundnut varieties at charland of Bhuapur

The experiment was conducted under charland situation at the MLT site Bhuapur, Tangail AEZ-8 during Rabi season of 2017-2018 and 2018-19 to find out the suitable groundnut variety for the charland of Bhuapur and to popularize the variety (ies) among the farmers. Five improved varieties of groundnut viz., BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10, Binachinabadam-6, Binachinabadam-7 and a local variety (Dhaka-1) were used in the experiment. The average highest pod yield (2.24 t ha^{-1}) and maximum shelling percentage (72.33%) was recorded in BARI Chinabadam-8. The lowest pod yield (1.41 t ha^{-1}) was obtained from local variety (Dhaka-1) and lowest shelling parentage (56.57%) found in Binachanabadam-8.

Performance of BARI linseed variety in charland ecosystem

The experiment was conducted at FSRD site, Atia and MLT site, Bhuapur during Rabi season of 2018-19. Four cultivars viz., Patuakhali, Noakhali, and Jokiganjalong with BARI released variety Nila, were tested to observe their performance in farmers' field. The highest seed yield was obtained from Potuakhali (0.98 and1.15 t ha^{-1}) in Atia and MLT Site, Bhuapur, Tangail, respectively followed by Niela. The lowest seed yield was obtained from Jokiganj (0.62 and 0.85 t ha^{-1}) in both locations, respectively.

Performance of soybean varieties under rainfed condition

An experiment was conducted at farmers' field of Mymensingh, Trishal during the *rabi* season of 2017-2018 to evaluate the performance of BARI developed soybean variety. BARI Soybean-5 and local variety (Shohag) were included as check in the experiment. BARI Soybean-5 produced the higher yield compared to the local variety. As production cost is same for both tested varieties BARI Soybean-5 also gave higher gross margin (Tk. 37000 ha^{-1}).

On-farm trial of sunflower varieties at charland ecosystem

The trial was conducted at FSRD site, Atia and MLT site, Bhuapur during the *rabi* season of 2018-19 at farmers' field to select suitable variety of sunflower and to increase production and income. A total of two varieties were tested (BARI Surjamukhi-2 and Hysun 33) at farmers' field. The experiment was conducted in RCB design with six dispersed replications in the both locations. The result showed that the highest seed yield 2.00 t ha^{-1}

and 1.75 t ha^{-1} were recorded in FSRD site, Atia and MLT site, Bhuapur from the variety BARI Surjomukhi-2.

Adaptive trial with mustard genotype in southern belt of Bangladesh

The experiment was conducted at the farmer's field at MLT site, Koyra, Khulna during *rabi* season 2018-19 to study the performances of five mustard genotype namely BJDH-12, BD JUN-536, BD-6959, BD-7104, and BD-10115. Significant variation was observed regarding to yield and yield contributing characters. Among the tested genotype BJDH-12 produced the highest yield (1.38 t ha^{-1}).

Spices Crops

On-farm verification trial of garlic varieties at Kuakata

The experiment was conducted at MLT site Bauphal, and MLT site Kuakata during *rabi* season of 2018-19 with different types of BARI released Garlic varieties, e.g: BARI Rosun-1, BARI Rosun 2, BARI Rosun 3 and Local Rosun, to observe their performance in farmers' field. Among the varieties at both locations Kuakata and Bauphal BARI Rosun-3 gave highest yield (5.3 tha^{-1}) and (4.7 tha^{-1}) respectively. Local Rosun gave the lowest seed yield (4.4 tha^{-1} and 3.84 tha^{-1}) at both locations.

Performance of different onion varieties Bauphal

A field trial on onion was carried out at charland of Bauphal under Patuakhali district during the winter season of 2018-19 under farmer's field condition to evaluate the comparative performance of two BARI developed varieties in coastal environment. The varieties were BARI Peaz-1, BARI Peaz-4. The yield performance of BARI Peaz varieties appeared to be promising in the coastal environment. Among the two varieties BARI Peaz-4 gave the highest yield of 12.1 tha^{-1} that was statistically similar to the yield of BARI Peaz-2(10.3 tha^{-1}). The highest gross return and gross margin of Tk. 302500ha^{-1} and Tk. 216200ha^{-1}, respectively was also found from BARI Peaz-4.

Agronomical management

Validation of sweet corn as influenced by spacing and fertlizer management

The experiment was conducted at Jhikargacha MLT site, Jashoreduring 2018-19. Four treatments viz.T_1= 180-53-105-40-5-1.5 N-P-K-S-Zn-B kg ha^{-1} Recommended Fertilizer Dose (RFD)+ 50% N- P-K of RF) with a plant spacing of 45 cm × 20 cm (11111 plants ha^{-1}), T_2= 180-53-105-40-5-1.5 N-P-K-S-Zn-B kg ha^{-1} (RFD+ 50% N- P- K of RF) with a plant spacing of 60 cm × 20 cm (83,333 plants ha^{-1}), T_3= 170-50-75-40-5-1.5 N-P-K-S-Zn-B kg ha^{-1} (RFD + 40% N- P- K of RF) with plant spacing 45 cm × 20 cm (111111 plants ha^{-1}) and T_4=170-50-75-40-5-1.5 N-P-K-S-Zn-B kg ha^{-1} (RFD+ 40% N-P- K of RF) with plant spacing 60 cm × 20 cm (83333 plants ha^{-1}). The highest yield (8.93 t ha^{-1}) was obtained from T_1= 180-53-105-40-5-1.5 N-P-K-S-Zn-B kg ha^{-1} (RFD+ 50% N- P- K of RF) with plant spacing 45 cm × 20 cm (111111 plants ha^{-1}) followed by T_3= 170-50-75-40-5-1.5 N-P-K-S-Zn-B kg ha^{-1} (RFD+ 40% N- P- K of RF) with plant spacing 45 cm × 20 cm (111111 plants ha^{-1}) and it was the lowest (8.55 t ha^{-1}) from T_4=170-50-75-40-5-1.5 N-P-K-S-Zn-B kg ha^{-1} (RFD+ 40% N- P- K of RF) with plant spacing 60 cm × 20 cm (83333 plants ha^{-1}). The highest gross margin (59810 Tk.ha^{-1}) and BCR (1.65) was found from T_1. The lowest gross margin (53350Tk.ha^{-1}) and BCR (1.57) was found from T_4.

Validation of popcorn as influenced by spacing and fertlizer management

The research programme was carried out at Jhikargacha MLT site, Jashoreduring 2018-19. Four treatments such as T_1=204-66-87-27-3-1.54N-P-K-S-Zn-B kg ha^{-1} (RFD + 50% NPK) with plant spacing 45 cm×20 cm (11111 plants ha^{-1}), T_2= 204-66-87-27- 3-1.54N-P-K-S-Zn-B kg ha^{-1} (RFD + 50% N-P-K)with plant spacing 60cm×20cm (83333plants ha^{-1}),T_3=190-65-80-40-5-1.5N-P-K-S-Zn-B kg ha^{-1} (RFD+ 40% N- P- K of RF) with plant spacing 45 cm × 20 cm (111111 plants ha^{-1}) and T_4= 190-65-80-40-5-1.5 N-P-K-S-Zn-B kg ha^{-1} (RFD + 40% N- P- K of RF) with plant spacing 60 cm × 20 cm (83333 plants ha^{-1}). The highest grain yield (3.23 t ha^{-1}) was recorded from T_1=204- 66- 87- 27- 3- 1.54N-P-K-S-Zn-B

kg ha^{-1} (RFD + 50% NPK) with plant spacing 45 cm x 20 cm (111111 plants ha^{-1}) followed by T_3= 190-65-80-40-5-1.5 N-P-K-S-Zn-B kg ha-1 (RFD + 40% N- P- K of RF) with plant spacing 45 cm x 20 cm (111111 plants ha^{-1}) and it was the lowest (2.93 t ha^{-1}) from T_4= 190-65-80-40-5-1.5 N-P-K-S-Zn-B kg ha-1 (RFD + 40% N- P- K of RF) with plant spacing 60 cm x 20 cm (83333 plants ha^{-1}). The highest gross margin (14400Tk.ha^{-1}) and BCR (1.17) was found from T_1. The lowest gross margin (5400 Tk.ha^{-1}) and BCR (1.06 was found from T_4.

Validation of effect of twig removal on yield of pea

The research work was carried out at Jhikargacha MLT site, Jashoreduring 2018-19 to validate the effect of twig removing on pod and vegetable yield of pea. Five treatments such as T_1=Twig removal of 5.0 cm from the tip at 25 DAE (Days after emergence) with BARI Motorshuti-1, T_2=Twig removal of 7.5 cm from the tip at 25 DAE from the tip with BARI Motorshuti-1, T_3=Twig removal of 5.0 cm from the tip at 25 DAE from the tip with BARI Motor-1, T_4=Twig removal of 7.5 cm from the tip at 25 DAE from the tip with BARI Motor-1 and T_5= No remove (BARI Motorshuti-1). The highest green yield (10.12 t ha^{-1}) was obtained from T_5= No remove (BARI Motorshuti-1) followed by T_1=Twig removal of 5.0 cm from the tip at 25 DAE with BARI Motorshuti-1, T_2=Twig removal of 7.5 cm from the tip at 25 DAE from the tip with BARI Motorshuti-1 and the lowest (5.87 t ha^{-1}) from T_4=Twig removal of 7.5 cm from the tip at 25 DAE from the tip with BARI Motor-1. The highest gross margin (Tk. 271330 ha^{-1}) and BCR (4.27) was found from T_5. The lowest gross margin (Tk. 122580 ha^{-1}) and BCR (2.47) was recorded from T_4.

Adaptive trial of intercropping Indian spinach with hybrid maize under different planting systems

The trial was conducted at MLT site Kaliganj, Jhenidah during the Rabi season of 2017-18 to validate the suitable combination of hybrid maize and Indian spinach intercropping for higher productivity. Plant height (217cm), cob length (15.2 cm), cob diameter (4.32 cm), grain per cob (425), 100 grain weight (26.2 g) and grain yield (6.78 t ha^{-1}) were the highest in treatment T_3 (sole maize) whereas it was the lowest from T_2 where Hybrid maize paired rows (37.5 cm) (150 cm × 20 cm) + 3 rows Indian spinach. The yield of Indian spinach was the higher (20.75 t ha^{-1}) in T_2 than T_1 (15.32 t ha^{-1}). The equivalent yield of maize was the highest (19.67t ha^{-1}) in T_2 followed by T_1 and the lowest in T_3. The highest gross return (344225Tk.ha^{-1}) and gross margin (253220 Tk.ha^{-1}) were obtained from T_2 followed by T_1 and the lowest in T_3.

Floating Agriculture

Adaptive trial of different fodder crops on floating bed in haor areas of Kishoreganj

A field study was conducted at Gaital, sadar and Goroy, Nikli upazilla under OFRD, BARI, Kishoreganj during the Rabi seasons of 2018-19 to observed the performance of different fodder crops on the floating bed in the hoar areas of Kishoreganj to meet up the fodder demand at crises period. The experiment was laid out in a RCBD with five replications. Four varieties such as BLRI para-1, Packchong (Thailand), BLRI Napier-4 and German grass were used. Among the varieties, the highest yield (620.8 kg year^{-1}) was recorded from German grass and the lowest yield (468.77 kg year^{-1}) obtained from BLRI Napier-4. The highest gross margin (Tk.1816 Bed^{-1}) and BCR (1.58) was calculated from German grass and the lowest gross margin (TK. 600 Bed^{-1}) and BCR (1.19) were obtained from BLRI Napier-4 grass.

Integrated farming research and development for livelihood improvement in the plain land ecosystem

The research and development activities under integrated farming were carried outin 5 sites ofPlainland ecosystem (FSRD site Ajoddhapur, Rangpur; Gangarampur, Pabna; Atia, Tangail, Sholakundu, Faridpur and Tarakandi, Sherpur) during the year of 2018-19. The research areas were i**)** Homestead production system ii**)** Crops and cropping system iii**)** Poultry and livestock production system, iv**)** Fisheries production system and v**)** Off-farm activities**.** All components of integrated farming such as vegetables, fruits,

cereal crops, livestock, fish and off-farm activities were brought under improved technological intervention and accordingly income was increased from these components. After intervention of the program, it was observed that vegetables consumption per farm family per year (407 kg) wasincreased remarkably*(*avg. 215*%)* as compared to before intervention *(*129 kg). In vegetables production system, it was found that farmers consumed most (Avg. 56%), sold about 37% and distributed about 7% among their neighbours, relatives and well wishers. Average consumption of fruits per year was also increased *(*Avg. 47*%)* after intervention of the technologyas compared to before intervention *(*155 kg per farm family per year). Results of field crops production program revealed that farmers obtained higher yield and economic return from their alternative or improved cropping pattern with improve variety(s) and better management approaches. Six improved cropping pattern (T. Aman-Mustard-Boro, T. Aus-T.Aman-Potato/Sweet gourd, Lentil-Jute-T. Aman, Mustard-Jute-T. Aman, T. Aus-T.Aman-Potato-Mungbean, T. Aus-T.Aman-Mustard-Boro) trials were conducted in different location of which T. Aus-T.Aman-Potato/Sweet gourd gave the highest productivity and economic return *(*Gross margin Tk. 386350 ha^{-1}). Newly released high yielding crop varieties were also introduced through on farm validation program where farmers obtained encouraging crop yieldsand gross margin *(*Tk. 6500-343160 Tk ha^{-1}).After deworming and vaccination against major diseases i.e. Anthrax, Foot and Mouth Disease, PPR and Black Quarter reduced disease frequency and mortality rate of cattle which contributed higher production. Poultry, Turkey bird and duck rearing in the homesteadarea created a good impact among the farm families as a good source of income and child nutrition. Mortality of poultry reduced (60-100%) after vaccination. Moreover, farm yard manure (FYM) production and utilization, and green fodder production were created a good impact among the farm families. Among the seasonal fish culture carp polyculture gave a satisfactory gross margin (Avg. Tk. 9831 $pond^{-1}$) at farmers' level. Mono-culture of fish (Pabda, Shing, Tangra, Tilapia) also created good impact at farmers level, where the gross margin attained 4700-9550 Tk. $pond^{-1}$. From off-farm activities, farmers also earned some extra money (Avg.Gross margin Tk. 9543 $household^{-1}$). The activities of Local service provider (LSP) was found promising for homegardening and other activities at FSRD site, Ajoddhapur, Rangpur. Partial integration among the farm components especially compost pit based integration could be established and needs to give more emphasis on documentation.Finally, it can be concluded that interventions made in different components exerted a visible positive effect in improving farmers' socio-economic condition and livelihood as well.The daily nutritional requirements of the family members were supplemented considerably due to increased consumption of vegetables and fruits from the homestead gardening and also from fish, chicken and livestock production. Active participation of the farmers' and women participation in agriculture and integration of their available resources in planned way may create a positive impact on improving livelihood of resource poor farm household after the project duration.

Climate resilient farming systems research and development for the coastal ecosystem

In Asia, some 52.7% of farms are <1.0 ha, with the smallest farm sizes (<0.4 ha) in Bangladesh (Devendra and Thomas, 2002) and number of marginal farm has been increasing from 4.48% in 1996 to 11.20% in 2005 with average size of 0.6 ha (BBS, 2009). In Noakhali (saline char land), with some 80% operational farm holdings are less than one hectare (DAE, Noakhali) which also limits for taken up additional and diversified farming activities. Despite farm sizes, emphasis given to rain-fed T. Aman production with few Rabi crops like soybean, mungbean, cowpea, grass pea, groundnut-in some cases risk of crop losses due to heavy rainfall cause early or late season flooding, larger breaks within the monsoon season may cause drought and finally the soil salinity. Recently extreme rainfall that occurred during last couple of year ago (2016) hampered T. Aman seedbed and seedlings. Furthermore, the income from cropping alone is hardly sufficient to sustain the farmer's family in case of small and marginal farmers; those constitute 80.3 per cent of agricultural population with only 36 percent of area operated. On the other hand, an Integrated Farming System (IFS) can

ensure the highest standard of food production with the minimum environmental impact with even highly vulnerable climatic conditions with the available resources accessible to farmer. Humans developed agricultural systems that combined crop production with animal husbandry 8 to 10 millennia ago (Allen et al., 2007; Russelleet al., 2007; Smith, 1995). Research on integrated crop and livestock systems has found to be highly productive and environmentally sustainable (Allen et al., 2005, 2007; Russelleet al., 2007). This productivity often reflects the improved soil structure and fertility, weed suppression and disruption of pest cycles created by diverse crop sequences and the livestock presence (Entzet al., 2002; Mckenzieet al., 1999; Tracy and Davis, 2009). In this aspect, there is scope to linkage mainstream agricultural research intervention for saline area by different research organization (BARI, BRRI, BLRI, BINA, BFRI etc.) with the desirable features of farming system which will help to develop relevant, client-oriented and location-specific Integrated Farming System. Modification and fine tuning of farmers existing framework and identify suitable enterprise combinations and assess returns and employment opportunities for small and marginal and medium farmers in the saline char area of Noakhali and Patuakhali which will minimize risks in the changing climatic conditions.

Farm productivity improvement through intervention of improved agricultural technologies in charland ecosystem

The integrated farming activities are carried out in Charland ecosystems of Mymensingh and Bogura during 2018-19. The research areas were i**)** Homestead production system ii**)** Crops and cropping systems iii**)** Poultry and livestock production systems, iv**)** Fisheries production systems and v**)** Off-farm activities**.** All components of integrated farming such as vegetables, fruits, cereal crops, livestock, fish and off-farm activities were brought under improved technological intervention and accordingly income were increased from these components. In Charland ecosystems of Mymensingh and Bogura overall results of homestead production program revealed that intake of vegetables were markedly increased (avg.236 %) by all families included in this system. Average intake of fruits per year was also increased (avg.250%) after intervention of the technology**.** Existing fruit tree management and new plantation has created a good impact on farm households**.** The farmers of this ecosystems obtained higher yield and economic return from their alternative or improved cropping pattern by using modern crops and crop cultivars along with better management approaches**.** Two improved cropping pattern Mustard-Boro-T**.**aman and Potato-Boro-T**.**aman trials were conducted in FSRD site, Char Kharicha, Mymensingh and one improved cropping pattern Mustard-Boro-T.aus-T.aman trials were conducted in FSRD Site, Sonatola, Bogura. Newly released high yielding crop varieties were also introduced through on farm validation program where farmers obtained higher crop yields and gross margin (Tk 35486-214710 Tk/ha**).** Due to deworming and vaccination program body weight and amount of milk was increased in cattle over pre intervention period. Mortality of poultry reduced (80-86%) after vaccination. Among the seasonal fish culture, carp polyculture gave higher gross margin (avg. Tk. 20072/pond) at farmers' level. Active participation of the farmers women participation in agriculture and integration of their available resources in planned way has created a positive impact on improving livelihood of resource poor farm household**.** Finally, it can be concluded that interventions made in different components exerted a visible positive impact in improving farmers' socio-economic condition and livelihood of the charland ecosystem as well.

Baseline Study of Char Farmers Livelihood in the Northern Bangladesh

A baseline survey was undertaken at three char areas namely Rajpur under Lalmonirhat Sadar Upazila of Lalmonirhat Begumganj under Ulipur Upazila of Kurigram and Chandanpat under Saghata Upazila of Gaibandha district, to know the socio economic status and to explore the existing agricultural practices for further expansion. Data were collected during July 2018 to February 2019. Random sampling technique has been used for collecting the data. The results of base line survey revealed that majority of the sample farmers cultivated local variety of crops with applying fertilizer indiscriminate dose of recommendations. Most of the farmers engaged

only in subsistence farming with low agricultural productivity. In the three char areas, T.aman rice, groundnut, chilli, grass pea, black gram, sweet potato, potato, sugarcane and Jute are the main cultivated crops. In the Kharif II season, most of the land occupy with T.aman rice or sometimes land is completely fallow due to flood. So, T.aman is a chance crop in the char land area. Sometimes T.Aman harvesting is late due to late planting. Rabi season is the main cultivating season of char farmers and after harvesting *rabi* crops, most of the farmers produce jute. Lack of knowledge about new crop variety/technology was the main problem of the farmer and it was due to less intervention of modern agricultural technologies/varieties from government and NGOs. The farmers are also getting less product price due to non-diversified and low-value crops, improper marketing channel, and inefficient transportation system.

On-farm trial of BARI released Bt brinjal varieties

The field trial was conducted at 22 districts of Bangladesh such as Bagerhat, Bandarban, Bhola, Bogura, Borguna, Brahmanbaria, Cumilla, Chandpur, Dinajpur, Faridpur,Gaibandha, Khulna, Kishoreganj, Madaripur,Mymensingh, Manikganj, Narsingdi, Patuakhali, Rajbari, Rangpur, Sylhetand Tangailduring 2018-`19 to observe the performance of transgenic BARI Bt brinjal varieties at the farmers' field. Tested fourBARI Bt brinjal varieties performed better against non Bt counter parts, reduced brinjal shoot and fruit borer (BSFB) infestation produced maximum healthy fruit and offered higher gross margin in all locations.These varieties showed maximum 0-2.4% shoot, 0-2.7% fruit infestation by number and 0-2.2% fruit infestation by weight against 12.3-91.50% shoot, 14.21-86.60% fruit by number and 16.90-82.503% fruit infestation by weight in non-Bt counter parts. Among the 22 districts, field trial under 17 districts totally free from BSFB infestation.

Production of mustard varieties at farmers field

The production programs were carried out at 11 locations of Bangladesh during the Rabi season of 2018-19. BARI Sarisha-14 and BARI Sarisha-17 were used as varieties in different locations. The seeds were broadcasted @ 8.0 kg ha^{-1}. Half of N and all other fertilizers were applied during final land preparation. The rest of N was top dressed at 33 days after sowing (DAS) followed by irrigation. For controlling Alternaria leaf spot, Rovral was spraying twice at the rate of 0.2 percent at 10 days interval from 45 DAS. For controlling aphid Malathion and Rison were sprayed @ 0.3 percent. At maturity yield data were collected accordingly.

Production of wheat varieties at farmers field

Production programs of wheat using BARI Gom-28, BARI Gom-29, BARI Gom-30, BARI Gom-32 were executed during the Rabi season of 2018-19 at different farmers' field of different locations. The seeds were treated with Provex @ 3g kg^{-1} seed. Seeds were sown @ 120 kg ha^{-1} maintaining line at 20 cm. The lands were fertilized as per BARI recommended dose i.e.110-22-60-15-4-1, N-P-K-S-Zn-B kg ha^{-1}. Two-third of N and all of other nutrients were applied as basal during final land preparation and one- third of N was top dressed after first irrigation i.e., 20-day after sowing (DAS). Irrigations were done twice at 20 DAS and 45 DAS. Affinity, a weedicide was sprayed after 5 days of 1st irrigation to control the broad leaf weed.

Lentil production as relay crop with T. Aman rice

BARI developed improved variety BARI Masur-8 and BARI Masur-7 were demonstrated through block approach as relay crop with T. Aman rice at MLT site, Atghoria and FSRD site Gangarampur, Pabna during the Rabi season of 2018-19. The total area of the demonstration plot was about 1 ha where six farmers were involved for each variety. The cooperative farmers were selected after a group discussion organized by OFRD, ARS, Pabna. The seeds of lentil were sown on 4 to7 November, 2018, 12 to 15 days prior to T. Aman harvest. Seeds were soaked overnight in fresh water for seed priming. The seed rate of lentil was 55 kg ha^{-1}. The fertilizers were applied @ 37-08-20-13 kg N-P-K-S ha^{-1}. No weeding but three times fungicides (Rovral 50 WP) spraying were done starting at the beginning of flowering and continued at 7-10 days interval. The crop was harvested on 20 February to 5 March, 2019. Data on yield, cost and return analysis was presented.

Pea production as relay crop with T. Aman rice

Field pea (var. BARI Motor-3) was demonstrated through block approach in Baoikhola village under MLT site, Atghoria, Pabna during the Rabi season of 2018-19. The size of the demonstration block was about 1 ha and six farmers were involved with the demonstration. The seeds of relay crops were sown on 05 November, 2018, which was 12-15 days prior to T. Aman rice harvest. Seeds were soaked overnight for seed priming. The fertilizers were applied @ 46-8-21-11 kg N-P-K-S ha^{-1}. The seed rate was 90 kg ha^{-1}. No weeding but three times fungicides (Score) were sprayed starting at the beginning of flowering and continued at 7-10 days interval. The crop was harvested on March 15, 2019. Data on yield, cost and return analysis were presented accordingly.

Mustard production as relay crop with T. Aman rice

The production program was conducted at MLT site, Atghoria, Pabna during the Rabi season of 2018-19 to assess the performance in relay condition as well as to disseminate the BARI Sarisha-17 at the farmers' level. Seeds of BARI Sarisha-17 were broadcasted on 5 to 15 November, 2018 10-12 days before T. Aman rice harvest. The crop was fertilized with 120-34-45-29-2-2 kg N-P-K-S-Zn-B respectively. Total amount of all the fertilizers except urea were applied during seed sowing. Urea was applied in two installments. Two-third urea was applied as basal and the remaining 1/3 was applied as top dress on 20-25 days after sowing (DAS). The fields were infested with aphid and Alternaria blight disease. Insecticide Malathion and Karate were applied once on 5-10 January, 2019 and fungicide Rovral 50 WP was applied two times on 5-10 January 2019 and 20-25 January 2019 depending on pest incidence. The crops were harvested on 10 to 15 February, 2019. All the relevant data were recorded carefully and documented accordingly.

Grass pea production as relay crop with T. Aman rice

Grass pea variety BARI Khesari-3 was demonstrated through block approach in Joardah village under Sadarupazila, Pabna during the Rabi season of 2018-19. The size of the demonstration block was about 0.5 ha and two farmers were involved with the demonstration. The seeds of relay crops were sown on 7 November, 2018, which was 12-15 days prior to T. Aman rice harvest. Seeds were soaked overnight for seed priming. The fertilizers were applied @ 46-8-21-11 kg N-P-K-S ha^{-1}. The seed rate was 70 kg ha^{-1}. No weeding but two times fungicides (Score) were sprayed starting at the beginning of flowering and thereafter 7-10 days interval. Data on yield and yield contributing characters were collected, compiled.

Production program of sesame in jhum cultivation

The pilot production programwas conducted at the farmers jhum field of Kyamlongpara, Dolupara and Tukhungparahill slopes in Bandarban Sadarupazila during the kharif (jhum) season, 2018. BARI Til-4 variety was used as a sowing material of the Pilot Production Program. Three farmers were selected for BARI Til-4 production. The land area for demonstrations were 100 decimals for each block respectively. Seeds were mixed with other crops seeds like rice, maize, kaon, cotton, sweet gourd, ash gourd, marpha, okra, chilli, brinjal etc. @ 01 kg/ha and sown in farmer's field on 17 May, 2018 at Kyamlongpara; 20 May, 2018 at Dolupara and 18 June, 2018 at Tukhung para respectively. The crop was harvested at full maturity when the capsules got straw color within 85-95 days after sowing. Yield and yield attributes were recorded. The average yield of BARI Til-4 in farmer's field was 107.33 kg ha^{-1}, which was highly appreciated and accepted by the farmers.

Production program of grasspea

The Production programme of grasspea was conducted at Tangail, Manikganj and Bhola during the Rabi season of 2018-19 in the farmers' field. The land was fertilized with 20-16-20-10-1.5 kg ha^{-1} of NPKS and B, respectively. Two-third of urea and all other fertilizers were applied during final land preparation. Remaining urea was applied as top dress at 30 days after sowing (DAS). Seeds were sown during 30 October to 11 November, 2018. Seeds were sown in broadcast with seed rate 50 kg ha^{-1}. The crop was harvested during 8-24 March, 2019. Yield was recorded by crop cut of 20 m^2 in different spots randomly from each plot.

Indofil M-45 @ 2 ml L^{-1} water was sprayed to control downy mildew disease.

Production program of kangkong at Manikganj

The production program of Kangkong was conducted at Mukimpur village under SadarUpazila of Manikganj district during Kharif-I season of 2019 in the farmer's field. BARI Gimakolmi-1 was cultivated in one farmer's field in 0.15 ha^{-1} of land. The seed of BARI Gimakolmi-1 was collected from Horticultural Research Centre of BARI, Gazipur. The experimental plots were fertilized with total fertilizers during final land preparation @ 130-24-60-18-5000 kg ha^{-1} of N-P-K-S-Cowdung were applied as urea, triple super phosphate and muriate of potash, respectively. Seeds were sown as broadcast @ 10 kg ha^{-1} on 04April, 2019. No irrigation was required as the land contained enough soil moisture and sufficient rainfall occurred during the growing season. Other plant protection measures were taken as and when required. Green leaves were harvested 6 times starting from 29 April to 14 August, 2019. Data on yield were recorded and converted into ton ha^{-1}.

Production program of field pea

The block demonstration of field pea was conducted at Mukimpur village under Sadarthana of Manikganj district during the Rabi season of 2018-19 in the farmers field. BARI Motor-3 was demonstrated in one farmer's field in 0.12 ha of land. The seed of BARI Motor-3 was collected from Pulse Research Sub-station of BARI, Gazipur. The experimental plots were fertilized with total fertilizers during final land preparation @ 20-18-20-10-1-1.5 kg ha^{-1} of N-P-K-S-Zn-B applied as urea, triple super phosphate and muriate of potash, respectively. Seeds were sown as broadcast @ 35 kg ha^{-1} on 5 November, 2018. No irrigation was required as the land contained enough soil moisture. Other plant protection measures were taken as and when required. Green pods were harvested from on 11 February, 2019. Data on yield and yield contributing characters were recorded and converted into ton ha^{-1}.

Production program of groundnut

The production program of BARI groundnut variety was conducted in the charland of Tangail and Manikganj during the Rabi season and the Kharif season of 2018-19, respectively. BARI Badam-8 and BARI Badam-10 were grown in the farmer's field under rainfed condition. The crop was fertilized with 12-32-43-54-2 kg ha-1 N-P-K-S-B, respectively. Half of nitrogen and full amount of P, K, S and B were applied at the time of final land preparation in the form of urea, triple super phosphate, muriate of potash, gypsum and boric acid, respectively. Remaining N were top dressed at 45 days after sowing (DAS) before flowering stage and covered with soil followed by irrigation. The plant spacing was 30 cm x 15 cm. Intercultural operation, pests and other crop management practices were done as and when necessary. Nirto @ 2 ml L-1 was sprayed to control insects. The seeds were sown during 10-15 November, 2018 and the crop was harvested during 5-8 April, 2018 during the Rabi season of 2018-19 at Tangail. On the other hand, the seed was sown on 20 to 21 February, 2019 and the crop was harvested on 23 June, 2019 during the Kharif season of 2018-2019 at Manikganj. Yield was recorded by crop cut of 20 m^2 randomly from each plot.

Production program of blackgram

Two block demonstration were conducted in the farmer's field at Manikganj and Tangail district during the Kharif 2 season of 2018. BARI Mash-3 was used in this demonstration. The seed of BARI Mash-3 was collected from Pulse Research Sub-station of BARI, Gazipur. Seeds were sown on 18-25 September, 2018. Seeds were sown as broadcast in the field. Soil was fertilized with NPK at the rate of 20.74, 20 and 20 kg ha^{-1}, respectively. One irrigation was given in the field to conserve soil moisture. Weeding, control of pests and other intercultural operations were done as and when required. The crop was harvested on 20-25 December 2018. At harvest, the yield data was recorded and converted into yield per hectare.

Production program of black cumin

The program was conducted with BARI Kalozira-1 at the charland area of the MLT site Bhuapur, Tangail (AEZ: 8) during the Rabi season of 2018-19 in the farmers field to popularize and disseminate the BARI developed Blackcumin variety among the farmers and also increase yields and economic return. BARI Kalozira-1 was cultivated among the 10 farmers covering 1.0

hectare of land. The crop was fertilized with 125-100-75 kg ha^{-1} urea, TSP and MoP, respectively. Half of Urea and full amount of TSP and MoP were applied at the time of final land preparation. Remaining urea was top dressed at 45 days after sowing (DAS) before flowering stage. The seeds were sown during 9-12 November, 2018 in broadcast with seed rate of 7 kg ha^{-1}. Intercultural operation, pests and other crop management practices were done as and when necessary. The crop was harvested during 21 March, 2019. Yield was recorded by crop cut of 20 m^2 randomly in different spot from each plot.

Production program of lentil

The production program of lentil was conducted at Manikganj, Faridpur and Bogura district during the Rabi season of 2018-19 in the farmers field with irrigation facilities. The seed of BARI Masur-8 was collected from Pulse Research Sub-station of BARI, Gazipur. The experimental plots were fertilized with total fertilizers during final land preparation @ 21-18-20-10-2-5000 N-P-K-S-B-cowdung kg ha^{-1} applied as urea, triple super phosphate and muriate of potash, respectively. Seeds were sown as broadcast @ 30 kg ha^{-1} on 20 October to 1November, 2018. Indofil M-45 was sprayed to control root rot disease. One irrigation was given at 35 DAS. Other plant protection measures were taken as and when required. Harvesting was done on 25 February 07 March, 2019. Data on yield and yield contributing characters were recorded plot wise and converted in to t ha^{-1}.

Production program of sesame

A block production program was conducted at farmer's field of FSRD site, under OFRD Faridpur during the Kharif I 2019 to observe the performance of BARI Til-4. The program was conducted in about 2 ha of land. A total of 14 farmers were selected. The crop was fertilized with 55-28-23-19-1.8-1.7 kg of N-P-K-S-Zn & B ha^{-1} in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. Two third of N and full amount of P, K, S, Zn and B was applied as basal during final land preparation. The remaining N was applied as top dress at 28-31 days after sowing (DAS) irrespective of farmers followed by irrigation. Data on yield and economic returns were recorded including BARI Til-4 and local two cultivar.

Production program of BARI hybrid maize in kharif season

A block production program was conducted under farmer's field situation at the FSRD site, Faridpur and MLT site, Rajbari during the Kharif I season of 2018-2019 to observe the performance of BARI Hybrid Maize-9 and to show it to local neighboring farmers, DAE personnel and NGO workers. The program was conducted in about 1ha of land. A total of 8 farmers were selected. The crop was fertilized with 250-55-110-40-5-1.5 kg of N-P-K-S-Zn & B ha^{-1} in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. One third of N and full amount of P, K, S, Zn and B was applied as basal during final land preparation. The remaining N was applied equally as top dress at 23-32 days after sowing (DAS) and 48-71 DAS irrespective of farmers followed by irrigation. Spacing was 60 cm x 25 cm. Data on yield, cost and return analysis were recorded. The crop was sown at 10 March to 1 April and harvested at 30 Jun to 11 July, 2019.

Demonstration of BARI developed linseed variety

The production program was carried out in the farmer's field of Homnaupazilla of Cumilla District and Sylhet during the Rabi season of 2018-19. The soil of the experimental plot was clay loam. Seeds were sown according to the farmer's practice i.e. broadcast method. Two farmers were included in this program. Seeds of BARI Tishi-1 were broadcasted @ 7.0 kg ha^{-1} on 15 November to 28 December, 2018. Fertilizers were applied at the rate of 37, 25, 25 and 20 kg ha^{-1} of N, P, K and S in the form of Urea, Triple Super Phosphate, Murate of Potash and Gypsum respectively in the field. Half of urea and full amount of all other fertilizers were applied during final land preparation. The rest of urea was top dressed twice in equal split at 23 and 46 Days after Sowing (DAS). No irrigation was applied. A spray of Dithane M 45 @ 0.2% for controlling leaf blight disease was done. The crop was harvested from 17 March to 1 April, 2019. Data were collected as per required.

Production program of sunflower

The experiment was conducted at Cumilla and Sylhet during the Rabi season of 2018-19. BARI developed Sunflower variety i.e. BARI Surjamukhi-2 was used in this program. The experimental land was ploughed by the tiller with four passes then laddered to prepares plot. Chemicals fertilizer were applied @ 100-30-60-20-1.5 kg ha-1 NPKS and B in the form of Urea, TSP, MoP, gypsum, boric acid in the field. Half urea and full doses of all other fertilizers sowing (DAS) and 45 DAS. The unit plot size was 100 decimals. seeds were sown on 30 November to 08 December, 2018. To control caterpillar Admairand Cortan Plus was sprayed twice at flowering and grain filling stage. The crops were harvested 7 to 22 March, 2019. Yield and Yield attributes were recorded properly.

Production program of BARI hybrid maize

Production program of BARI Hybrid Maize variety was conducted at the farmers' field of in Cumilla and Sylhet district during the Rabi season of 2018-19. Hybrid Maize-9 was used in this demonstration program. The demonstration program was laid out in RCB design with six dispersed replications. The total area under this program was 0.66 ha from each location with spacing of 60 cm × 20 cm. The seeds were sown on 18 November to 5 December, 2018 in the farmers' field. Manure and fertilizers such as Cow Dung, N, P, K, S, Zn and B were applied in the form of Urea, TSP, Muriate of potash, gypsum, Zinc sulphate and Boric acid at the rate of 5 t ha^{-1}, 250, 55, 110, 40, 5 and 1.5 kg ha^{-1} respectively. The one third of urea and all other fertilizers and manure were applied during final land preparation. Rest amount of urea was applied in two equal splits at knee high stage (40-45 DAS - 1st top dress) and before flowering (2nd top dress). Irrigation was done two times during crop period. Weeding was done 2 times to maintain proper hygienic condition of the crop. The crop was harvested from 18-29 April, 2019.

Production program of sweet corn

Production programme of one variety of sweet corn (BARI Sweet Corn-1) was conducted in the farmer's field during *rabi* season of 2018-19 for the dissemination and increasing area and production of sweet corn. The sowing date of sweet corn was done on 7 November 2018 and harvesting date of corn was ranged from 20 March to 18 April 2019.Results indicated that BARI Sweet Corn-1 produced grain yield of 8.4 t ha^{-1} with gross margin of Tk. 80574 ha^{-1}.

Production program of BARI developed soybean varieties

The production program was carried out in 5.65 ha^{-1}areas on thirty-three farmer's field of Cumilla and Bhola district during the Rabi season of 2018-19. The soil of the experimental plot was sandy loam. Seeds were sown continuously in lines at 30 cm spacing. Seeds of BARI Soybean-5, Bina Soybean-1, Bina Soybean-3, Bina Soybean-4 and Bina Soybean-5 were sown @ 50.0 kg ha^{-1} on 7-19 January, 2019. Fertilizers were applied at the rate of 27, 35, 60, 21 and 1.7 kg ha^{-1} of N, P, K, S and B in the form of Urea, Triple Super Phosphate, Murate of Potash, Gypsum and Boric acid, respectively. All the fertilizers were applied during final land preparation. No irrigation was required. Weeding was done twice at 25 and 50 DAS for maintaining hygienic condition. The crop was harvested 107-115 days after sowing dated on 24 April to 03 May, 2019, respectively. Moisture % of seeds was adjusted to 8-9 % and yield data was minimized accordingly. For controlling pest and diseases, Autostin and Virtako were sprayed early growing stage for controlling leaf roller and root & root rot diseases.

Production program of BARI pulses varieties in Bhola

The production program was carried out at the farmers' field at MLT site, Sadar, Borhanuddin, Charfashion and Daulatkhan, Bhola during the Rabi season of 2018-19 to validate and popularize the BARI developed pulse varieties in Bhola region.BARI Felon-1 and BARI Mung-6 were used in the program. The sowing date BARI Felon-1 was 15-20 December 2018, BARI Mung-6 was 15-25 Jan 2019, BARI Soybean-5 was 10-15 January 2019, BARI Sarisha-14 and BARI Sarisha-17 were 05-10 December 2018. All crops were sown in tillage method except grass pea. It was sown relay with T.Aman rice. Fertilizer and other management practices were done following as per recommendation. Weeding and intercultural operation was done as and when necessary. For

controlling thrips and pod borer of cowpea and mungbean and pod borer of soybean Volume Flexi @0.25 ml lit^{-1} water was sprayed twice at an interval of 10-15 days of first spray.

Production of sweet potato varieties

A field demonstration was carried out at Char land in Debidwer MLT site under Cumilla district and Hanarchar in Chandpur sadar under Chandpur district during the Rabi season of 2018-19 to evaluate the comparative performance of BARI released high yielding sweet potato varieties for this location and also disseminate the variety at farmer's level. The experimental site was medium high under AEZ 19 and the texture of soil was sandy loam. Six promising sweet potato varieties BARI Mistialu-4, BARI Mistialu-8, BARI BARIMistialu -12, BARI BARIMistialu -13, BARI BARIMistialu -14 and BARI BARIMistialu -15 and local variety (Lal Mistialu) were used in this trial in the two farmer's field. The plant spacing viz. 60 cm x 30 cm were used. The unit plot size was 10 m x 2.0 m. The trial was laid out in a Randomized Complete Block (RCB) Design with two dispersed replications. Sweet potato vines were sown on 8 November 2018 in Debidwer MLT and 29 November, 2018 in Hanarchar in Chandpur sadar under Chandpur district. Manures and fertilizers were applied at the rate of 10 t ha^{-1} cowdung and 105-45-105-15-2-1 Kg of N P K S Zn B ha^{-1}, respectively in the form of urea, TSP, MoP, gypsum, zinc sulphate and boric acid. Fifty percent of N, K and full dose of other fertilizers were applied during final land preparation. The rest amount of N and K fertilizer were applied at 35 DAP. Intercultural operations and plant protection measures were taken as and when necessary during the crop growing period. The crop was harvested on 23 March from Hanarchar in Chandpur sadar under Chandpur district and 07 May, 2019 Debidwer MLT, respectively. Analysis of different varieties was computed on the basis of prevailing market price.

Production of BARI released potato varieties

The varietal demonstration of potato varieties was evaluated at the MLT sites of Chandina in Cumilla, Kachua in Chandpur and Sherpur district respectively during the Rabi season of 2018-19. Four improved potato varieties such as BARI Alu-35, BARI Alu-37, BARI Alu-40 and BARI Alu-46 were evaluated in different locations under this demonstration. The trial was laid out in Randomized Completed Block (RCB) design with two dispersed replications. The tuber was planted on 20-26 November, 2018 with a spacing of 60 cm × 25 cm. The field was fertilized with 82-48-129-22-1 kg of N, P, K, S and B in the form of Urea, TSP, MoP, Gypsum, and Boric acid respectively according to the TCRC recommended furrow method. Half of the Urea and all other fertilizers were applied at the time of final land preparation and the rest amount of Urea was side dressed at 30 days after planting (DAP). Intercultural operations were done as per requirement. Dithene M-45 @ 4.5 g $L^{-1}$was sprayed at 30 DAP and Secure 70 WP @ 4.0 g $L^{-1}$was also sprayed at 71, and 78 DAP for the prevention of late blight disease. The insecticide Admire @ 1 ml L^{-1} with water was sprayed twice at 59 and 66 DAP for controlling insect vectors. The crop was haulm pulled 4-5 days before from harvesting and harvesting was done on 11-24 February, 2019.

Lentil production as relay crop with B. Aman rice

A production program was conducted at the farmer`s field of Pirkashempur, Muradnagar, Cumilla from the Rabi season of 2018-19 to disseminate and popularize the BARI developed lentil varieties as relay crop with B. Aman rice. The experimental field belongsto AEZ-19. The program included BARI Mashur-7 as a modern lentil variety. The trial was executed in 0.41 land areas with four farmers. Fertilizers were applied at the rate of 41, 17.5 and 1.7 kg ha^{-1} of N, K, and B in the form of Urea, Murate of Potash, and Boric acid, respectively. The quantity of seed required for each plot was weighed on the basis of recommended seed rate of 50 kg ha^{-1} and was kept in polythene bags. Priming of lentil seeds about 8-10 hours were done for good germination in the field. The seeds were relayed on 11-13 November, 2018 before 9-10 days of harvesting of B. Aman (Local Puichon). Weeding was done in 2 times in whole the cropping period. Urea @ 45 kg ha^{-1} was top dressed in the lentil field at 20 days after germination. The experimental plots were frequently observed to notice any change in plant

character and attack of pests and disease on the crop. To control of the infestation of stemfhylium blight of Mashur, Rovral was applied @ 5ml in10L of water in 2 times at 7 days interval.

Up-scaling of grass pea, mung bean, cowpea, lentil and field pea through pilot production program in southern Bangladesh

Rice-rice is the existing dominant cropping pattern in southern region of Bangladesh. But low price of paddy and hike price of labour and inputs the existing pattern is seemed to be not profitable. After T. Aman harvest a considerable areas in southern region remain fallow during dry season (December to April). Inclusion of pulse crop like Grasspea, Mungbean and Cowpea can help to change these situations. Potential of growing mungbean/cowpea after harvest of T. aman rice in south region is high due to late onset of rainy season and long dry period (210 to 230 days). Consideration of soil health issues a two-wheel drive power tiller operated seeder (PTOS) was decided to be used for crop plantation as improve cultivation practice. This practice will help to minimize cost of cultivation, minimum soil disturbance, timely planting and line sowing of the crop. Considering the above facts, a group based up-scaling program on grasspea (relay), mungbean, cowpea (Both relay and tillage), Lentil and motor (relay) was undertaken to understand and evaluate production technologies for dry season in saline free land to increase productivity and profitability in the Barisal Division in Southern Bangladesh

Pilot production of BARI hybrid maize under strip tillage system in Rajshahi

The experiment was conducted at Baduria, Charghat, Rajshahi during 2018-19 in High Ganges River Flood Plain Soil (AEZ-11). The production program was done in a compact 1 hectare block. Seeding was done with the help of power tiller operated Strip tillage machine. The seeds of BARI Hybrid Maize 9 @ 25 kg ha^{-1} were sown by keeping 60 cm X 20 cm on 8-10 December 2018. The lands were fertilized with 253-52-110-47-5-1, N-P-K-S-Zn-B kg ha^{-1} + 5 ton CD in the form of urea triple super phosphate, muriate of potash, gypsum, zinc oxaide and boric acid, as well as cowdung respectively.All fertilizers were applied as basal except urea after final land preparation. One third urea was applied as basal; rest two third was applied during first and second irrigation. Irrigations were done by four times at 25 DAS, 40 DAS, 65 DAS and 75 DAS. In strip seeding, One third urea and all recommended fertilizer dose was applied just before only one pass of Strip tillage operation and rest two third was applied during first and second irrigation. Strip tillage was used as planting, seeding and laddering. But in farmers' practices, the land was prepared well will 3-4 ploughing followed by laddering. Earthing up was done incase of farmer's practice only. Furadan @ 15kg ha^{-1} Crop was harvested on 1-2May 2019. All necessary data were collected and statistically analyzed with t-test.

Up scaling of BARI developed varieties of lentil through block demonstration at greater Rajshahi region of Bangladesh

The the scale up was conducted at Paba MLT site, Rajshahi during 2018-19 in High Ganges River Flood Plain Soil (AEZ-11). The production program was done in a 5 hectare block of which 1 hactare bed planting, 2 hactare strip seeding and 2 hactare conventional system. Seeding was done with the help of power tiller operated bed planter, strip tillage machine and conventional system from 19-25 November 2018. The land was fertilized with 23-18-20-1 N-P-K-B kg ha^{-1} (FRG, 2012) in the form of urea, triple super phosphate and muriate of potash, respectively before only one pass of bed planting and strip seeding operation and broadcasted during final land preparation at conventional system. But in farmers' practices, the land was prepared well will 3-4 ploughing followed by laddering. All fertilizers were applied as basal after final land preparation. Three times spray with Rovral @ 2 g L^{-1} was done at the time of flowering to pod development by maintaining 10 days interval. Different management practices like weeding and irrigation were done for normal growth of the crop.The varieties were BARI Moshur 6, BARI, Moshur 7, BARI mosur 8 and seed rate was 6 Kg ha^{-1} in bed and strip tillage and 8 Kg ha^{-1} in conventional system. Crop was harvested on 9-13 March 2019. All necessary data were collected and statistically analyzed with t-test.

Promotion and dissemination of BARI released late blight resistant potato variety

The disease-free seed potato production program was conducted at MLT site, Shibpur, Puthia, Paba, and Mohonpur, Rajshahi during the rabi season of 2018-19. Ten co-operative farmers were involved with the program and each of them was supplied 25 kg seeds of both BARI Alu 46 and BARI Alu 53 varieties. Seeds were collected from Tuber Crops Research Centre (TCRC) of BARI. Land area of each farmer was 10 decimals. The OFRD scientist and scientific staff provided technical support to the farmers for producing quality seed. Fertilization was done as per recommendation of TCRC, BARI (160-50-140-40-4-1 Kg, N-P-K-S-Zn-B ha^{-1} with 10 t cowdung ha^{-1}. Furadan and staple bleaching powder @15 kg and 20 kg ha^{-1} were also applied to control pests. All amount of cowdung was applied at the time of land preparation. Half of urea and all other fertilizers were applied as basal dose. Bleaching powder was applied during final land preparation and Furadan was applied in furrow before tuber planting. Tubers were covered by soil after planting. The rest half of urea was top dressed at 30 DAP. Farmers were suggested not to spray against late blight disease. However, other operations viz. earthing up, weeding, irrigation etc. were done as and when necessary. Seed potato was sown on 25 November - 28 November 2018. Ten days before harvesting of seed potato, haulm pulling was done to harden skin. Finally, potato tuber was harvested on 25 Feb.-05 Mar. 2019. After grading and processing of potato, the storable seeds were separated to store.

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Efficacy of different new fungicides in controlling sigatoka disease of banana

The experiment was conducted at RARS, Burirhat of Rangpur district during 2018-2019 to evaluate the efficacy of thirteen new foliar fungicides *viz*. Techvo 75WG, Forever 75WG, Dragon 75WP, Safa 30 SC, Paladin 40SC, Tricofol 75WP, Blasto 75WG, Trigger 75WP, Farm zeb 80 WP, SR Top 32.5 SC, Perky 50WP, Icivo 75WP, KG T2 Care 75 WDG and control against Sigatoka disease caused by *Cercospora musae* of banana. The experiment was carried out following Randomized Complete Block Design with three replications. The unit plot size was 4.0 m × 4.0 m and plant spacing was 2.0 m x 2.0 m. All the fungicides performed better over the control (unspray) to manage the disease. PDI ranged from 7.33 – 83.00%. The lowest PDI (7.33) was recorded in Techvo 75WG treated plot followed by SR Top 32.5 SC (8.00) and the highest (83.00) in control. The highest yield (40.4 t/ha) was recorded in Techvo 75WG and the lowest (22.25 t/ha) was in control. Among the fungicides Techvo 75WG, SR Top 32.5 SC, Dragon 75WP, Tricofol 75WP and Trigger 75WP showed the better performance in reduction of disease severity (more than 80%) over control.

Survey and identification of phytopathological causes of fruit dropping of lotkon

Lotkon (*Baccaurea sapida*) is a minor fruit crop has become increasingly important in Bangladesh recently. A survey was carried out in two upazilla, namely Shibpur and Belabo of Narsingdi district during 2018-19 cropping season. In each upazilla 10 different lotkon fruit orchards were surveyed and mass group of farmer's interaction was done to know the detail scenario about the diseases of lotkon. From this survey, no disease was identified from the collected fruit sample but one disease was identified from lotkon plant leaf that is Gray leaf blight caused by *Pestalotiopsis* sp. Older orchard were found more prone to disease development than to newer one. From the study, 7% & 15% orchard were found infected with *Pestalotiopsis* sp. in new and old orchards respectively. So far we know, this finding is new record for lotkon in context of Bangladesh. Further studies are needed regarding the diseases.

Efficacy of new fungicides in controlling purple blotch disease of onion

Two experiments were laid out in the research field of Plant Pathology, BARI, Joydebpur, Gazipur during 2018-2019 cropping season to evaluate the efficacy of some new fungicides as well as some fungicides for second year trail in controlling purple blotch disease of onion. Nine (9) new chemical fungicides as well as six (6) fungicides for second year trail were tested for the two experiments. Considering the disease severity all the fungicides were found effective against purple blotch as compared to unsprayed control. Among the fungicides in experiment no. 01, T_1=Trinazole 75 WDG (12.10%), T_2=Expert 75 WDG (14.60%) and T_9=Mc Col 70 WP (15.10%) were found effective in controlling purple blotch and showed highest yield (22.25 t/ha) in Trinazole treated plot followed by Mc Col (21.95 t/ha) and Expert (21.87 t/ha) and the lowest from the control. In experiment no. 02, T_2=Dole 55 WDG (10.15%) and T_3=Coppermet 55 WP (10.75%) performed highest disease reduction and highest yield (23.29 t/ha) and (23.12 t/ha) respectively. From the experimental findings, it was observed that Dole 55 WDG (0.07%) and Coppermet 55 WP (0.5%) were highly effective to control the purple blotch disease and increased higher yield of onion. The experiment no. 01 should be continued for second times trail.

Survey, isolation and identification of dragon fruit diseases

A survey program was carried out in dragon fruit orchards of Breeder Seed Production Centre (BSPC), Debigonj, Panchagarh and 10 other

orchards of Rangpur Division during 2018-19 cropping season. Disease plant samples were collected and cultured for identification of the pathogen in Plant Pathology laboratory, BARI, Gazipur following standard method. From the survey, two types of disease were identified from dragon fruit plant sample *viz*., i) Anthracnose caused by *Colletotrichum gloesporoides* and C. *truncatum* and ii) stem rot or soft rot caused by *Fusarium sp.* It was also found that 50% dragon plant was infected by anthracnose disease whereas 20% of total plants were attacked by stem rot or soft rot disease. Through pathogenicity test it was confirmed that *Colletotrichum gloesporoides* and C. *truncatum* are causal agents of anthracnose disease of dragon fruit and *Fusarium sp*. is causal agent of stem rot or soft disease of dragon fruit, respectively. It is necessary to continue this research for further investigation.

Efficacy of fungicudes in controlling white mold disease of French bean

The experiment was conducted at Plant Pathology Division, BARI, Gazipur during *robi* cropping season 2018-19 to evaluate the effectiveness of different groups of fungicides against white mold disease of French bean. Eleven different fungicides, namely $T_{1=}$Carbendazim (Autostin), $T_{2=}$Propiconazole (Tilt 250EC), $T_{3=}$Tebuconazole (Folicur 250EC), $T_{4=}$Difenoconazole (Score 250EC),$T_{5=}$Mancozeb (Indophil M45), $T_{6=}$ Hexaconazole(Contaf 5 EC),$T_{7=}$ Asoxytrobin+Difenoconazole(Amister top 325 SC) ,$T_{8=}$ Mancozeb+Carbendazim (Companion), $T_{9=}$Copper oxychloride(Sunvit50WP), T_{10}=Ipodione (Rovral 50WP), $T_{11=}$Fenamidone+ Mancozeb600WG (Secure) along with $T_{12=}$ Control treatment were applied with three replications from the first appearance of the disease at 10 days interval in field experiment. In the experiment, all the chemical fungicides reduced the disease over the control. The lowest disease incidence (1.33%) was recorded from T_3 (Folicur 250EC) treated plots followed by T_1 (Autostin) and T_2 (Tilt 250EC) treatment. and highest (11.67%)was from control treatment. The range of disease reduction over control was from 54.32% to 88.60%. The highest disease reduction (88.60%) was found in T_3 (Folicur 250EC) treatment. The maximum yield (10.30 t/ha) was obtained from T_3 (Folicur 250EC) treatment and minimum was 9.13 t/ha which was from control treatment (T_{12}).

Survey, isolation and identification of major diseases of gerbera flower

A survey was carried out in different Gerbera gardens in Godhkhali and Panisara union of Zhikorgasa, Jessore and HRC, BARI, Gazipur during October 2018 to February 2019 cropping season. Plant samples (*viz*. leaf, stem, flower and root) were collected and brought in the plant pathology laboratory for identification of the disease and pathogen following standard method. The isolated pathogen were identified based on morphological characteristics observed under a compound microscope comparing standard keys. Three species of fungi, namely *Pestalotia* sp, *Alternaria alternata, Fusarium oxysporum.* and *Meloidogyne incognata* were isolated from the infected plant parts of Gerbera which were responsible for the Leaf spot, Alternaria leaf spot, Fusarium wilt and Root knot diseases of Gerbera, respectively.

Evaluation of new chemical fungicides against early blight of tomato

The efficacy of some fungicides like Propicarb 70 wp (Propineb 70 wp), Moen 80 wp (Mancozeb 80 wp), Cibalux 75WP (Mancozeb+Carbendazim 75%WP), Joybun 80 WDG (Mancozeb), Azob 80 WDG (Mancozeb80%), Amazan 32.5 WP (Azoxystrobin + Fenoxanil), SC Double Action 76WP (Propineb 70%+Cymoxanil 6%) and one Bio fungicide (Phytosporin) along with commonly used fungicides *viz*., Rovral (Ipridione) and Amister top (Asoxytrobin+Difenoconazole) were tested against early blight of tomato at Plant Pathology Division of BARI during 2018- 2019 cropping season. The seedlings of BARI tomato - 15 were used. Spraying was started immediately after the onset of disease and a total of four sprays were applied at an interval of 12 days. All fungicide treatments reduced the disease intensity as compared to untreted control. The lowest percentage disease index (14.27) was recored in `Rovral treatment and the highest (18.73) was observed in Control treatment. Percent disease reduction ranges from 0.69% to 23.81%, while the lowest disease reduction was recorded from SC double action 76 WP treatment and the highest disease reduction was found from Rovral treatment over Control. The highest number of fruits (346.67) was found in Rovral treatment which was followed by T_4 (Joybun 80 WDG) and T_{10} (Amister top) treatment and the lowest (304.67) was observed in

Control treatment. The highest yield (31 ton/ha) was obtained from Rovral treated plot which was followed by Amister top and Phytosporin treatment where lowest was recorded from control treatment.

Survey, isolation and identification of diseases in tuberose and gladiolus

A survey was carried out in different gardens in Godhkhali and Panisara union of Zhikorgasa, Jessore and HRC, Gazipur during October 2018 to February 2019 cropping season. Plant samples (*viz.* leaf, stem, flower, corm and bulb) were collected and observed in the plant pathology laboratory for identification of the disease and pathogen following standard method. The isolated fungi were identified based on morphological characteristics observed under a compound microscope comparing standard keys. Three species of fungi, namely *Alternaria alternata*, *Fusarium graminearum* and *Colletotrichum* sp. were isolated from the infected plant parts of Tuberose which caused the diseases of Alternaria Leaf spot, leaf spot/ leaf blight, Anthracnose. On the other hand, Curvularia leaf spot, Fusarium wilt and Alternaria leaf spot diseases were found in Gladiolus which caused by fungi i.e, *Curvularia* sp., *Fusarium oxysporum* and *Alternaria alternata*, respectively.

Integrated management of sclerotinia rot diseases of marigold

The experiment was conducted at the laboratory and research field of Plant Pathology Division at BARI, Gazipur during winter season of 2018-19. The hybrid variety Inca was sown in 3× 3 m^2 plots size. A field experiments was laid out in Split Plot Design, the main plot treatment was T_1= Neem oil cake (600 kg/ha), T_2= Tobacco dust (600kg/ha) and the sub plot treatment was T_1= Secure 600 WG (1g/L), T_2= Score 250 EC (2g/L) T_3= Faja 70 WP (1g/L), T_4= Control with replicated thrice. Among the treatments, T_1 (Secure 600 WG) 1g/L with Neem oil cake(NOC) and T_2 (Score 250EC) 2ml/L fungicidal treatments with Tobacco dust (TD) showed more than seventy percentages white mold diseases reduction in field condition.

Efficacy of fungicides in controlling powdery mildew of pumpkin

A field experiment with ten treatments and one control was laid out in Randomized Block Design at Plant Pathology Division during the *rabi* season of 2018 and each treatment was replicated thrice. BARI Mistikumra -2 variety was sown in 3×3 m^2 plots maintaining pits size 50×50×45 cm. Efficacy of ten new fungicides , *viz*., T_1= Select one 72% (Mancozeb 64%+ Cymoxanil 8%WP), T_2= Agister35 SC (Azoxystribin 20%+Difenoconazol 15%), T_3 = Antivo75WDG (Tebuconazol 50%+ Trifloxystrobin 25%), T_4= Pesticide 32SC (Azoxystrobin 20% + Difenoconazol 12.5%, T_5= Hundred 35SC (Azoxystrobin 20% + Tebuconazole 15%, T_6 =Tahoe27 SC (Thifluzamide 9% Tebuconazole 18 %, T_7 = Armada 35SC (Epoxiconazole 30% + Azoxystrobin 5% T_8 =Campride-3WP (Carbendazim 10% + Metalaxyl 10%+ Imidaclopride 10% WP, T_9 =Amocozole plus-25 SC(Hexaconazole 3%+ Tricyclazole 22%), T_{10} =Conza plus10SC (Hexaconazole 3%) were tested to control of Powdery mildew of Pumpkin. Agister35 SC (86.81 %) and Antivo75WDG (83.85 %) reduce the Powdery mildew and increase the yield of pumpkin than other fungicides. So, Agister35 SC and Antivo75WDG are the better fungicides to reduce the Powdery mildew than the other fungicides.

Evaluation of different new fungicides in controlling anthracnose of chilli

The experiment was conducted in the laboratory and field in Plant pathology division, BARI, Gazipur, Bangladesh during *rabi* season of 2018-2019 with Randomized Complete Block Design (RCBD) with three replications. The size of the individual unit plot was 3.0 m × 2.0 m. Plant spacing was 50 cm × 40 cm. Local variety was used in the present experiment. Efficacy of sixteen new fungicides , *viz*., T_1= Azonil 56 SC, (Azoxystrobin 6%+Chlorothalonil 50%) (1ml/L), T_2=Sunsinil 72% WP (Mancozeb 64% + Cymoxanil 8% WP) (2gm/L), T_3=Camping 50%WP (Carbendazim 50%WP) (2gm/L), T_4=Safe guard 72%WP (Mancozeb 64%+Cymoxanil 8%WP) (2gm/L), T_5=Peer 50wp (Carbendazim 50%WP) (2gm/L), T_6=Seata 1.8 EC (Abamectin 1.8% EC) (2gm/L), T_7=Hemobin 75WDG (Tebuconazole 50%+Trifloxystroin 25%) (1gm/L), T_8=Abeco 20 EW (Copper abietate 20%) (1.2 kg/ha), T_9=Power Cardion 52.5 WP (Carbendazim 17.5% + Iprodion 35 %) (2 gm/L) T_{10}=Lilia 52.5SE (Propiconazole 12.5% + Tricyclazole 40% SE) (250ml/ha), T_{11}=Sarder 32.5 SC (Difenoconazole 20% + Azoxytrobin 12.5%) (200ml/acre), T_{12}=Perky 50 wp (Carbendazim 50% WP) (2

gm/Ltr), T_{13}=Dipo Gold 30EC (Defenconazole 15% Propiconazole 15%EC) (0.5ml/L), T_{14}=Hexol 10 EC (Hexaconazole 10%) (1ml/L), T_{15}=Bcozim 50 WP (Carbendazim 50%) (2g/L), T_{16}=Sadno 50 WP (Carbendazim) (2gm/L) were tested to reduce the anthracnose and increase the yield of chilli. Azonil 56 SC, Peer 50wp, Hemobin 75WDG, Dipo Gold 30EC, Bcozim 50 WP, Sadno 50 WP controlled effectively the growth of C. *capsici* in the laboratory conditions. So, they are the better fungicides to reduce the anthracnose diseases than the other fungicides.

Effect of sowing time on disease management to increase quality, quantity and shelf life of tomato

This study was conducted at the research field of Plant Pathology Division and Agricultural Research Station, Dinajpur, BARI, Bangladesh during 2018-19 in three different sowing dates with three varieties. Three tomato varieties were used in three dates of sowing - BARI Tomato-2, BARI Tomato-15, and Dinajpur local variety. The experiment was laid out in RCBD (factorial) with three replications. Significantly the highest fruit yield (25.29 kg) was found in December 07 sowing from BARI Tomato-2 followed by Dinajpur local (24.85kg) and BARI Tomato-15 (24.47kg). Incidence of late blight and TYLCV differed among three tomato varieties. Significantly higher incidence of Late blight disease was on BARI Tomato-15 followed by Dinajpur local and BARI Tomato-2 in three sowing dates. The highest shelf life of tomato was recorded in Dinajpur local variety (19days) and lowest in BARI Tomato-2 (7 days). BARI Tomato-15 showed moderate shelf life (9-10). The three varieties would be good for Gazipur farmers to harvest tomato up to May. The Dinajpur local variety has good quality for long shelf life. Therefore, shelf life and quality are equally important like yield for tomato and an important crieteria for variety development.

Survey on occurrences of bacterial wilt disease of Bt brinjal in Bangladesh

The experiment was an effort to find out the occurrence of the bacterial wilt disease in transgenic brinjal plants. Bacterial wilt is one of the key hindrances for brinjal production. The survey for bacterial wilt disease incidence was conducted in major Bt Brinjal growing areas of Manikgonj, Narsingdi, Kishoregonj and Gazipur districts during 2018-19 cropping season. From all the surveyed fields, data were collected on % Wilt Incidence. During survey, it was observed that Bt Brinjal-2, 3 and 4 were cultivated in Gazipur, Manikgonj, Narsingdi, and Kishoregonj; except one field in kishoregonj sador, where BARI Bt Brinjal-1 was cultivated. In Manikgonj district, wilt incidence was observed in all the surveyed areas and the % wilt incidence ranged from 5.56% to 26.79%; 4.63% to 30.3% and 8.33% to 22.32% for Bt Brinjal-2, Bt Brinjal-3 and Bt Brinjal-4, respectively. In Narsingdi, only Bt Brinjal-3 were cultivated in the surveyed areas and wilt incidence ranged from 2.78% to 8.55%. Bt Brinjal-3 were cultivated in the surveyed fields in Kishoregonj district with bacterial wilt incidence ranged from 3.21% to 18.4%. The bacterial wilt disease was observed in all the surveyed areas from Gazipur district and wilt incidence ranged from 3.85% to 99.59% in Bt Brinjal-2.

Collection, isolation and identification of *xanthomonascampestris*pv. *campestris* from cabbageand cauliflower

The major constraint for the cultivation of cabbage and cauliflower which is one of the most popular winter vegetables grown in Bangladesh is the black rot disease caused by *Xanthomonas campestris* pv. *campestris*. Twenty-two leaf samples were collected from different cabbage and cauliflower growing areas of Gazipur district during 2018-2019 cropping season. The pathogens were then isolated, purified and preserved following the proper procedures. The bacterium was identified through morphological characteristics on different solid media. With regard to morphological variations, the isolates varied in their morphology on different solid media used for screening. From the study it was observed that there were considerable variations in colony characters on different solid media, which gave clue to the presence of variations within *Xanthomonascampestris*pv. *campestris* populations in Bangladesh. This is valuable information to further study likeother morphological, physiological, biochemical, and molecular characteristicswhich will be helpful to find out the cause for the variations within the isolates and for devising various control measures.

Studies on symptomatic variability of prsv-p

Papaya ring spot virus (PRSV) transmitted by different types of aphid species is a severe threats

to papaya cultivation in Bangladesh. In field condition PRSV produced several variable symptoms in papaya namely mild mosaic, mosaic, severe mosaic, leaf distortion, fern leaf, shoestring, vein clearing and chlorotic leaf spot. The characteristics ring spot symptom on fruit is the identifying feature of PRSV in papaya but ring spot is not always associated with the above mentioned leaf symptoms of papaya. However, mechanical inoculation on to papaya seedling by any of the symptomatic filed sample produce characteristic yellowing, mild mosaic and mottling symptom but not the inoculated same field symptom. The objective of the present study is to find out the factor/s associated with such symptomatic variability of PRSV-P in Bangladesh. The virus identified by direct antigen coating immunosorbent assay (DAC-ELISA) and RT-PCR. Infection of others papaya infecting viruses or mixed infection with PRSV may produce different types of symptoms in papaya but our serological and molecular results suggested that only PRSV is producing such symptoms in field condition which may regarded as the biotypic variant of PRSV-P in Bangladesh. We did not find others papaya infecting viruses i.e Papaya leaf distortion mosaic virus (PLDMV) or Papaya mosaic virus (PMoV) singly or mixed infection with PRSV by molecular detection. On the other hand, we found mixed infection of PRSV with geminivirus which produce severe leaf curl symptom but the incidence is very low. The symptomatic variability in papaya due to PRSV; the host virus interactions, genetic variability are now in progress in PPD, BARI.

Confirmation of presence of citrus tristeza virus (CTV) in citrus by using molecular tools

Citrus is an important fruit crop in Bangladesh. Now a day's citrus cultivation in Bangladesh is severely hampered by different diseases. Viral disease of citrus is severe threats to citrus cultivation globally but none of the viral disease yet to be identified in Bangladesh. An attempt was made to identify a devastating citrus tristeza virus (CTV) in citrus by RT-PCR followed by sequencing. Seven citrus leaf samples (JaraLebu: *Citrus medica*) has been collected from RARS, Jamalpur characteristics symptoms with vein clearing, yellowing and mild mosaic. Three leaf samples out of seven were proceed to RNA extraction followed by RT-PCR and sequencing. The molecular diagnosis revealed that citrus tristeza virus (CTV) prevailing in *citrus medica*in Bangladesh. This is the first report of CTV in citrus in Bangladesh.

Survey and immuno-nucleobased based diagnosis of cucurbit infecting viruses in northern part of Bangladesh

A survey was conducted in Rajshahi, Natore and Joydebpur to assess viral diseases of cucumber, pumpkin, bottle gourd and bitter gourd. In the surveyed area different types of viral diseases are prevailing to infect cucurbits crops including mosaic, yellowing, mottling, leaf curling and bud necrosis with the percent incidence 30-80%. The DAC-ELISA coupled with RT-PCR followed by sequencing revealed that the identified virus were Papaya ring spot virus-P/W, and Cucumber mosaic virus (CMV). The leaf curl samples from cucumber amplified using universal primers of gemini virus. The identification of other viruses including species of gemini virus infecting cucurbit crops of these locations are now in progress.

Survey and identification of watermelon diseases in Bangladesh

A survey was conducted at Godagari and Gurudaspur upazilla of Rajshahi and Natore District, and the HRC experimental field for the identification of watermelon diseases in 2018-19 cropping season. Stunting and yellowing of leaf, bud necrosis and sudden decline is the predominate disease of watermelon in the surveyed area which are the characterize symptom of tospovirus. The virus was identified using direct antigen coating immunosorbent assay (DAC-ELISA) and reverse-transcription polymerase chain reaction (RT-PCR). The characteristic tospovirus disease like symptom in watermelon was high in HRC, experimental field (80-90%) and low in Gurudaspur (20-50%). The tospoviruses are the negative sense RNA virus found within the family Tospoviridae transmitted by different species of thrips. The DAC-ELISA and RT-PCR results suggested that watermelon bud necrosis virus (WBNV) is prevailing in godagari and gurudaspur upazilla where as Ground nut bud necrosis virus (GBNV) in HRC, experimental field which are the member of Tospovirus and are the major threats to watermelon production now a days.On the other hand, the mosaic disease having the low frequency compared to Tospovirus. Two fungal diseases namely leaf spot caused by Alternariasp and wilt caused by Fusarium sp has

been identified based on morphological characterization and pathogenicity test. The leaf spot disease caused by alternariasp appeared as an epidemic in gurudaspurupazilla in 2018-19 cropping season. Fusarium wilt is an another fungal disease of watermelon but the incidence is low (3-20%) in the current year. The sequencing and BLAST search of translation elongation factor alpha-1 (tef1) of rDNA of fusarium genome revealed that *Fusarium poliferatum*, *Fusarium solani* and *Fuariumequiseti* are prevailing to infect watermelon along with *Fusarium oxysporium*.

Evaluation of okra germplasm resistant to okra yellow vein mosaic virus (OKYVMV)

Okra (*Abelmoschusesculentus*) belongs to family Malvaceae. It is an important vegetable of the Indian sub-continent. It is widely grown in tropical, subtropical and warm temperature regions of the world. Okra Yellow Vein Mosaic Virus (OYVMV) is a devastating virus of Okra, significantly lowers the yield up to 94%. The virus can affect different parts of plant and causes heavy losses not only in respect to the fruit yield but also fruit quality. It is the major constrain of okra production in Bangladesh. An experiment was conducted at the plant pathology research field of BARI during 2018-19 to find out resistance source in okra genotypes against the virus. Fourteen varieties/genotypes were evaluated against OYVMV. Out of 14 varieties/genotypes, no varieties/genotypes showed resistant response against the virus. Only five (BARI-1, OK-122, Ruposhi, Kochi and Shamoli) varieties/lines showed tolerant reaction against OYVMV. BARI-2 and Ok-86 showed moderately susceptible reaction against the virus. Four varieties/cultivars (OK-06, OK-07, Hi-choice and Sabujsathi) represented as susceptible reaction. Three varieties/line Ok- 05, OK-285 and Patel (India) came out as highly susceptible.

Screening of cucumber germplasm against cucumber mosaic virus (CMV)

Cucumber (*Cucumissativus*) is an important commercial vegetables crop having export potential. Mosaic disease caused by *Cucumber mosaic virus* (CMV) is considered as the most serious virus disease of cucumber and causes severe yield loss, up to 100%. Fifteen varieties/cultivars were evaluated at plant pathology division net house of Bangladesh Agricultural Research Instituteagainst CMV during the year of 2018-19. Out of 15 varieties/cultivars, no variety/cultivar showed highly resistant or resistant response against the virus. Among the tested varieties/germplasm only one variety Piash (OP) showed mild mosaic symptom on few leaves (30 %) was graded as moderately resistant. The varieties/germplasm, ACI Green, Bonus, Hi-grad, Thailand, China, Japan-1 and 2 showed vein clearing and mild mottling were considered as moderately susceptible and Chottogram local, Lal teer, Sufola, ACI, Aduri F1, Modhumoti and Shahi-50 showed severe mosaic and mottling, were considered as susceptible.

Integrated management of *cucumber mosaic virus* of chilli (*Capsicum annum* L.)

Chilli (*Capsicum annuum* L.), belongs to the family Solanaceae is an important vegetable and spice crop having immense commercial importance. In Bangladesh CMV is one of the most important viruses which cause serious yield losses in chilli and can reduce fruit yield up to 80%. It is spread naturally by aphid in a non-persistent manner. Plant viruses are very difficult to control. Spraying of chemical insecticides is the only option available to the farmers for the management of CMV through vectors control. As the CMV is a non-persistence virus, only insecticidal spray may not control the disease effectively because of very short time is required to transmit the virus and vector is able to transmit virus before their death. An experiment was conducted to find out the effective management option against CMV of chilli. Six treatment packages with a control were evaluated at plant pathology research field, BARI during 2018-19. BARI Marich-1 was used in the field trial. Significant variation of disease incidence and severity was found in different treatment packages. Disease incidence and severity ranged from 10.95 to 38.50 % and 0.95 to 3.50, respectively in different treatment packages. The lowest disease incidence and severity was found in treatment package T2 (netting seedling, 1 spray of Bioneem 0.2% at 15 days after germination, use sticky yellow trap and 3 sprays of Bioneem at 15 days interval). The highest yield (12.24 t/ha) was recorded from T2 where the highest reduction of disease incidence (71.56 %) and maximum increase of yield (64.52 %) was found in the same treatment package.

Survey on diseases of fruit crops

Fruit cultivation is gaining popularity into commercial production from many years in Bangladesh. Fruit crops are prone to different diseases and cause severe yield loss every year. Among the diseases, gummosis of mango and jackfruit, greening of citrus, die back and anthracnose of guava, panama and sigatoka of banana, leaf spot of coconut etc. are the major diseases of fruit crops. A survey on major diseases of major fruit crops was conducted at Chapainowabgonj, Rangpur, Borishal, Gazipur and Khagrachori districts during 2018-2019 cropping season. From the survey it was found that gummosis disease of mango and jackfruit is prominent. Greening of citrus and die back of guava are in high incidence at Chapainowabgonj. Incidence of leaf spot of coconut is high at Borishal. Panama and sigatoka of banana are high prevalence at Rangpur. Incidence of other fruit diseases are low to medium at irrespective of surveyed locations.

Efficacy of new fungicides in controlling phomopsis blight and fruit rot disease of brinjal

Brinjal is an important vegetable in Bangladesh. There are a number of diseases that can cause yield reduction of brinjal. Among the diseases, phomopsis blight and fruit rot caused by *Phomopsis vexans* is found to be major disease of brinjal. Phomopsis blight and fruit rot disease reduced the yield and quality of brinjal. An experiment was conducted for controlling phomopsis blight of brinjal during the cropping season 2018-19 at the Plant Pathology Field, BARI, Gazipur. There were 7 treatments viz, T_1= Biomyl plus(0.2%), T_2= Top man (0.2%), T_3= Hayprogim (0.2%), T_4= Arba gold (0.2%), T_5= Defence (0.2%), T_6= Autostin (0.2%) and T_7= Control with three replications. The design of the experiment was RCBD. Variety of BARI Begun-4 (Kazla) was sown in the experiment. All the fungicides had significant effect on reduction of disease incidence compared to control. Fungicides of carbendazim group was found better for controlling phomopsis blight and fruit rot of brinjal compared to other tested groups.

Management of leaf spot and vine rot diseases of betel vine

Betel vine (*Piper betle*) is an important cash crop of Bangladesh. It is masticator having important socio-cultural use in Bangladesh.It is commercially cultivated in the vast area of northern and southern parts of Bangladesh. But this crop has been found to be infected by a number of serious fungal diseases viz.leaf spot, leaf rot, vine rot/foot rot/root rot and curvularia leaf spot. These diseases are found in all the seasons in Bangladesh but affect severely in rainy season. An experiment was conducted at RARS, Rahmatpur,Borishal during 2018-2019 cropping season having six treatments viz. T_1= Autostin (Carbendazim) @ 0.1%, T_2= Secure 600 WG (Fenamidone+ Mancozeb) @ 0.1%, T_3= Dithane M-45(Mancozeb) @ 0.1%, T_4= Tilt 250 EC (Propiconazole) @ 0.05 %, T_5= Nativo 75 WG (Tebuconazole+Trofloxystobin) @ 0.1%) and T_6= Control under natural condition in an established orchard to control the diseases of betel vine. Nativo, Tilt and Secure effectively control the leaf spot disease of betel vine. Nativo and Secure were also found highly effective in controlling the vine rot disease of betel vine. The highest yield 3.95 t/ha was found in Nativo treated plot followed by 3.2 t/ha in the Secure treated plot.

Yield loss assessment of ginger due to bacterial wilt based on physical seed sorting

Ginger cultivation is threatened by various diseases, such as rhizome rot, bacterial wilt, leaf spot, anthracnose, leaf blight, leaf blotch etc. Among the diseases of ginger, bacterial wilt is most damaging one. An experiment was conducted for yield loss assessment of ginger in Gazipur due to bacterial wilt. There were 6 treatments viz, T_1= 5% seed infection, T_2= 10% seed infection, T_3= 20% seed infection, T_4= 100% seed infection, T_5= Control (Farmer's practice/Farmers saved seeed) and T_6= healthy seed with three replications. All those categories of seeds had significant effect on seed germination, yield and disease incidence of the crop. Healthy seed showed the highest germination percentage and yield with lowest disease incidence. The highest disease incidence with lowest percentage of germination and yield were observed in 100% seed infection. The yield was decreased with the increased of percent seed infection.

Effect of nutrients to control purple blotch and tip-burn of onion in sustainable agriculture

An experiment was conducted in the field of Plant Pathology Division, BARI, Joydebpur during 2018-19 cropping year to evaluate the efficacy of plant

nutrient for the development of purple blotch disease and tip-burn of onion. Eight different plant nutrients (treatments) *viz.* potassium (MP fertilizer), phosphorus (TSP fertilizer), Boron (Bo fertilizer), Zinc (ZnSO4 fertilizer), calcium ($CaSO_4$), Copper ($CuSO_4$), silicon (silica gel) and manganese ($MnSO_4$) were tested against purple blotch disease and tip-burn of onion. The treatments were applied three time *viz.* 1st application at the time of seedling transplanting, 2nd application at the time of disease initiation (approx. 60 days after transplanting) and 3rd application 15 days after 2nd application. The dose of different treatment was @20 g/l of water. In case of control only water was applied. RCB design was followed with 3 replications. The variety BARI Piaz-1 was used. Results revealed that all the treatments decreased the purple blotch disease severity and tip-burn incidence, and increased plant growth as well as yield of onion as compare to control except $CuSO_4$ where the purple blotch disease severity and tip-burn incidence were higher. Application of MP fertilizer and Silica gel reduced 56.70% tip-burn incidence followed by $MnSO_4$, TSP, $ZnSO_4$, $CaSO_4$and Bo where the reduction of tip-burn incidence of onion was 54.02%, 51.35%, 43.75%, 43.31% and 43.31%, respectively compared to control. In case of purple blotch disease severity application of MP reduced 60.11% disease severity followed by the application of Silica gel, $MnSO_4$, TSP, $CaSO_4$, Bo and $ZnSO_4$ treatments where the reduction was 57.92%, 57.38%, 56.28%, 55.20%, 54.64% and 53.00%, respectively compared to control. The highest tip-burn incidence 74.67% and purple blotch disease severity 61.00% was observed in control treatment.

Application of TSP fertilizer gave the highest yield 18.19 tha^{-1} followed by the application of MP, $MnSO_4$, $CaSO_4$, Silica gel, Bo and $ZnSO_4$ where the yield was 17.64, 17.64, 16.80, 16.67, 16.25 and 15.42 tha^{-1}. The lower yield of onion 12.78 tha^{-1} was recorded in control plot which was followed by $CuSO_4$ treatment with the yield of 12.08 tha^{-1}. Application of TSP fertilizer gave the 29.74% higher yield compared to control which was followed by the application MP, $MnSO_4$, $CaSO_4$, Silica gel, Bo and $ZnSO_4$ where the yield was 27.55%, 27.55%, 23.93%, 23.34%, 21.35%, and 17.12%, respectively higher than control. From this study it may be concluded that plant nutrients especially potassium, phosphorus, zinc, silicon, calcium and boron have significant effect on the development of purple blotch disease and tip burn of onion. These nutrients also have significant role for growth and yield of onion.

Effect of nutrients to control purple blotch disease and tip-burn of garlic in sustainable agriculture

An experiment was conducted in the field of Plant Pathology Division, BARI, Joydebpur to evaluate the efficacy of plant nutrient for the development of purple blotch disease and tip-burn of onion. Eight different treatments viz. potassium (MP fertilizer), phosphorus (TSP fertilizer), Boron (Bo fertilizer), Zinc (ZnSO4 fertilizer), calcium ($CaSO_4$), Copper ($CuSO_4$), silicon (silica gel) and manganese ($MnSO_4$) were tested against purple blotch disease and tip-burn of onion. The treatments were applied three time viz. 1st application at the time of seedling transplanting, 2nd application at the time of disease initiation (approx. 60 days after transplanting) and 3rd application 15 days after 2nd application. The dose of different treatment was @20 g/l of water. In case of control only water was applied. RCB design was followed with 3 replications. Results showed that all the treatments decreased the purple blotch disease severity, tip-burn incidence and increased plant growth as well as yield of garlic as compare to control. The highest tip burn incidence and purple blotch disease severity was 74.33% and 56.00%, respectively observed in control. Application of $CuSO_4$ gave higher tip burn incidence and purple blotch disease severity by 53.33% and 36.00%, respectively. Application of MP gave the highest reduction 46.63% of tip-burn incidence compared to control followed by the application of TSP, $MnSO_4$, silicon and Bo where the reduction was 45.74%, 45.28%, 45.28% and 44.40%, respectively compared to control. Application of $ZnSO_4$ and $CaSO_4$ reduced 38.56% and 35.42%, respectively tip-burn incidence compared to control. In case of purple blotch disease of onion, application of MP gave the highest reduction 50.00% of purple blotch disease severity compared to control followed by TSP, $MnSO_4$, Bo, $ZnSO_4$, Silicon and $CaSO_4$ where the reduction of disease severity was 48.78%, 48.21%, 47.63%, 47.02%, 45.84% and 44.64%, respectively than control but significant differences among the treatments was not observed. All the treatments gave significantly higher yield compared to control. The lower yield of garlic was recorded from control and $CuSO_4$ treatments. Application of MP gave the

33.98% higher yield compared to control which was followed by the application of TSP, $CaSO_4$, Bo, $ZnSO_4$ and $MnSO_4$ where the yield was 30.48%, 29.45%, 29.34%, 28.59% and 27.50%, respectively higher than control. From this study it is observed that application of different plant nutrient have significant effect on plant growth, decreased purple blotch diseases severity and tip burn incidence as well as increase yield of onion. Among the nutrients MP, TSP, $MnSO_4$, $CaSO_4$, Silicon, Bo and $ZnSO_4$ were performed better than other treatments for reducing purple blotch disease severity, tip-burn and increasing plant growth as well as yield of garlic. Therefore it may be concluded that plant nutrients especially manganese, silicon, potassium, phosphorus and zinc have significant effect on the development of purple blotch disease, tip burn of garlic. Therefore plant nutrients calcium, manganese, silicon, potassium, phosphorus and zinc also have significant role for growth and yield of garlic.

Screening of organic composts for mass culturing of *trichoderma harzianum* to be used against soil-borne pathogen *sclerotium rolfsii* and *fusarium oxysporum* of chickpea

The experiment was conducted in the field of Plant Pathology Division, BARI, Gazipur to observe the suitability of organic compost and vermi-compost for mass culturing of bio-control agent, *Trichoderma harzianum* and its effectiveness against foot & root rot and wilt diseases of chickpea caused by *Sclerotium rolsfii* and *Fusarium oxysporum*. There were 6 treatments viz. (i) Seed treatment with Provax (ii) Soil amendment with organic compost (iii) Soil amendment with Tricho-organic compost (iv) Soil amendment with vermi-compost and (v) Soil amendment with Tricho-vermi-compost and (vi) Untreated control. The experiment was laid out RCB design with 3 replications. *T. harzianum* was multiplied in the mixture of Grasspea and wheat bran with mustard oilcake substrates. The formulated *Trichoderma* was used to mass multiplication in two different compost viz. organic compost and vermin-compost and its designated Tricho-organic-compost and Tricho-vermi-compost. Results of the present study revealed that soil amendment with Tricho-organic-compost and Tricho-vermi-compost gave the higher plant growth parameters *viz*. shoot height, shoot weight, root length and root weight, decreased seedling mortality as well as increased yield of chickpea followed by seed treatment with Provax 200 WP compared to control. The highest seedling mortality 27.67%% was found in control treatment. Soil amendment with Tricho-vermi-compost and Tricho-organic-compost and seed treatment with provax gave the lower seedling mortality with 10.07%, 10.33% and 9.67%, respectively followed by soil amendment with vermi-compost and organic-compost where seedling mortality was 16.00% and 17.33%, respectively. Seed treatment with Provax reduced 65.05% seedling mortality compared to control followed by soil amendment with Tricho-vermi-compost and Tricho-organic-compost where the reduction of seedling mortality was 63.61%, and 62.67% respectively than control. Soil amendment with Tricho-vermi-compost and Tricho-organic-compost gave higher yield of chickpea at 2083 and 2056 $kgha^{-1}$, respectively followed by seed treatment with Provax, soil amendment with vermi-compost and organic-compost with the yield was 1794, 1750 and 1694 $kgha^{-1}$, respectively. The lowest yield 1356 $kgha^{-1}$ was recorded in control. Yield was higher 34.90% compared to control due to application of Tricho-vermi-compost where as it was 34.05% by the application of Tricho-organic-compost. Seed treatments with Provax gave 24.42% higher yield of chickpea than control. From this study it may be concluded that soil amendment with Tricho-organic-compost and Tricho-vermi-compost are to be the best treatment for management foot & root rot and wilt diseases of chickpea and getting higher yield of chickpea than control. Seed treatment with chemical fungicide Provax also better treatment for management foot & root rot and wilt diseases of chickpea.

Screening of organic composts for mass culturing of *trichoderma harzianum* to be used against soil-borne pathogen *sclerotium rolfsii* of barley

The experiment was conducted to observe the suitability of organic compost and vermi-compost for mass culturing of bio-control agent, *Trichoderma harzianum* and its effectiveness against foot & root rot and wilt diseases of chickpea caused by *Sclerotium rolsfii* and *Fusarium oxysporum*. There were 6 treatments viz. (i) Seed treatment with Provax (ii) Soil amendment with organic compost (iii) Soil amendment with Tricho-organic compost (iv) Soil amendment with vermi-compost and (v) Soil amendment with

Tricho-vermi-compost and (vi) Untreated control. The experiment was laid out RCB design was followed with 3 replications. *T. harzianum* was multiplied in the mixture of Grasspea and wheat bran with mustard oilcake substrates. The formulated *Trichoderma* was used to mass multiplication in two different compost viz. organic compost and vermin-compost and its designated Tricho-organic-compost and Tricho-vermi-compost. Results showed that soil amendments with Tricho-vermi-compost and Tricho-organic-compost performed better in enhancing the plant growth parameters such as shoot height, shoot weight, root length and root weight of barley which was significantly differed from other treatments. The highest seedling mortality 36.33% was recorded in control treatment. Soil amendment with Tricho-vermi-compost gave the lowest seedling mortality 9.67% followed by soil amendment with Tricho-organic-compost and seed treatments with Provax where seedling mortality was 10.67% and 12.67%, respectively but significant differences among the treatments was not observed. Soil amendment with organic-compost and vermi-compost also observed significantly lower seedling mortality with 13.67% and 15.00% compared to control. The highest reduction of seedling mortality 73.38% was recorded in soil amended with Tricho-vermi-compost Seed treatments with Provax followed soil amendment Tricho-organic-compost and Seed treatments with Provax where the reduction seedling mortality was 70.63% and 65.13%, respectively compared to control. Soil amendment with only vermi-compost and organic-compost reduced 62.37% and 58.71% seedling mortality compared to control. Soil amendment with Tricho-vermi-compost and Tricho-organic-compost gave higher yield of barley at 2.83 and 2.72 tha^{-1}, respectively which was followed by seed treatment with Provax, soil amendment with organic-compost and vermi-compost by the yield of 2.42, 2.08 and 2.06 tha^{-1}, respectively. The lowest yield of barley 1.61 tha^{-1} was recorded from the control treatment. Barley yield was 43.11% and 40.80% higher compared to control due to application of Tricho-vermi-compost and Tricho-organic-compost and it was 33.47% due seed treatment with Provax. Soil amendment with only organic-compost and vermin-compost gave 22.60% and 21.84%, respectively higher yield compared to control. From this study it is observed that two compost viz. vermin-compost and organic compost are effective substrates for mass culturing of bio-control agent *T. harzianum* designated as Tricho-vermi-compost and Tricho-organic-compost. Soil amendments with Tricho-vermi-compost and Tricho-organic-compost are the best treatments for reducing seedling mortality and increasing plant growth and yield of barley. Seed treatment with Provax is also better treatment for the management of seedling blight disease of barley. Soil amendments with only vermi-compost and organic-compost have significant effect on the reduction of seedling blight disease as well as yield of barley compared to control. Therefore it may be concluded that soil amendment with Tricho-organic-compost and Tricho-vermi-compost are effective treatment for management seedling blight disease caused by *S. rolfsii* and increasing plant growth and yield of barley. Seed treatment with chemical fungicide Provax also gave promising results.

Screening of organic composts for mass culturing of *trichoderma harzianum* to be used against soil-borne pathogen *sclerotium rolfsii* of groundnut

The experiment was conducted to observe the suitability of organic compost and vermi-compost for mass culturing of biocontrol agent, *Trichoderma harzianum* and its effectiveness against foot and root rot disease of groundnut caused by *Sclerotium rolsfii*. There were 6 treatments viz. (i) Seed treatment with Provax (ii) Soil amendment with organic compost (iii) Soil amendment with Tricho-organic compost (iv) Soil amendment with vermi-compost and (v) Soil amendment with Tricho-vermi-compost and (vi) Untreated control. The experiment was laid out RCB design was followed with 3 replications. *T. harzianum* was multiplied in the mixture of Grasspea and wheat bran with mustard oilcake substrates. The formulated *Trichoderma* was used to mass multiplication in two different compost viz. organic compost and vermin-compost and its designated Tricho-organic-compost and Tricho-vermi-compost. Results showed that soil amendment with Tricho-organic-compost and Tricho-vermi-compost gave the higher shoot height, shoot weight, root length and root weight followed by soil amendment with vermi-compost and organic-compost and seed treatment Provax compared to control. All the treatment gave significantly higher seedling emergence than

control. Soil amendments with Tricho-organic-compost and Tricho-vermi-compost and seed treatment with chemical fungicide have significant effect against foot and root rot disease of ground nut. The highest seedling mortality 41.67% was recorded in control treatment. Seed treatments with Provax gave the lowest seedling mortality 10.67% followed by Soil amendment with Tricho-vermi-compost and soil amendment with Tricho-organic-compost where seedling mortality was 11.67% and 13.67%, respectively but significant differences among these treatments was not observed. Soil amendment with only vermi-compost and organic-compost also observed significantly lower seedling mortality with 20.67% and 21.0% compared to control which are significantly higher than other treatments. Seed treatment with Provax reduced 74.39% seedling mortality compared to control which was followed by soil amendment with Tricho-vermi-compost and Tricho-organic-compost where the reduction of seedling mortality was 71.99% and 67.19%, respectively than control. Soil amendment with vermi-compost and organic-compost reduced 50.40% and 49.60% seedling mortality compared to control. All the treatments gave significantly higher yield compared to control. The highest yield of groundnut 2.31 tha^{-1} was recorded from soil amendment with Tricho-vermi-compost treatment which was followed by soil amendment with Tricho-organic-compost, seed treatment with Provax, soil amendment with vermi-compost and organic-compost with the yield of 2.28, 2.10, 1.99 and 1.98 tha^{-1}, respectively. The lowest yield of groundnut 1.55 tha^{-1} was recorded from the control treatment. Soil amendment with Tricho-vermi-compost gave 32.90% higher yield compared to control followed by the application of Tricho-organic-compost and seed treatment with chemical fungicide where the yield was 32.02% and 26.19%, respectively higher compared to control. Soil amendment with only vermin-compost and organic-compost gave 22.11% and 21.72%, respectively higher yield compared to control. From this study it is observed that two *T. harzianum* compost designated as Tricho-vermi-compost and Tricho-organic-compost are the best treatments for reducing seedling mortality and increasing plant growth as well as yield of groundnut. Seed treatment with Provax also better treatment for management of foot and root rot disease of groundnut. Soil amendment with only vermi-compost and organic-compost have significant effect on the reduction of foot and root disease as well as yield of groundnut compared to control. From this it may be concluded that soil amendment with Tricho-organic-compost and Tricho-vermi-compost are to be the best treatment for management foot and root rot disease of groundnut and getting higher yield of groundnut than control. Seed treatment with chemical fungicide Provax also better treatment for management foot and root rot disease of groundnut.

Development of bio-rational based disease management package against root knot nematode and gummy stem blight diseases of bottle gourd

The experiments were conducted in the field of Plant Pathology Division, BARI during 2018-19 cropping season to develop eco-friendly integrated management technology against root knot nematode caused by *Meloidogyne incognita* and Gummy stem blight (GSB) caused by *Didymella bryoniae* diseases of bottle gourd. There were 8 treatments viz. (i) Tricho-compost-1 @ 2 kg/pit + Bordeaux paste/ Bordeaux mixture (ii) Tricho-compost-2 @ 2 kg/pit + Bordeaux paste/ Bordeaux mixture (iii) Tricho-compost-1 @ 2 kg/pit + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture (iv) Tricho-compost-2 @ 2 kg/pit + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture and (v) Poultry refuse @ 6-8 kg/pit + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture and (vi) Neem oil cake @ 500 g/pit + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture (vii) Saw dust burning + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture and (viii) Farmers practices. RCB design was followed with 4 replications. The bottle gourd variety BARI Lau-5 was used. During this study gummy stem blight disease of bottle gourd se was recorded in the experimental field. Results showed that all the treatments had significant effect on the reduction of root-knot disease severity and enhancing plant growth parameters and yield of tomato. All the treatment gave significantly higher shoot height, root length and root weight of bottle gourd compared to farmers' practices. In case of shoot weight integration of poultry refuse with Furadan 5G gave the highest shoot weight followed by integration of Tricho-compost-2 with Furadan 5G, neem oil cake with Furadan 5G, saw dust burning with Furadan 5G and Tricho-compost-1 with Furadan 5G. The

lowest shoot height, shoot weight, root length and root weight was recorded from farmers' practices. The maximum average gall index value 3.50 was recorded from the farmers' practices and the average gall index value drastically reduce to .73-1.50 was recorded due to application of different treatment. Integration of poultry refuse with Furadan 5G reduced 79.14% root knot disease severity compared to control followed by the integration of Tricho-compost-1 with Furadan 5G, Tricho-compost-2 with Furadan 5G, neem oil cake with Furadan 5G and saw dust burning with Furadan 5G where the reduction of disease severity was 75.43%, 71.43%, 67.14% and 66.00%, respectively compared to farmers' practices. Soil amendment with Tricho-compost-2 and Tricho-compost-1 also reduced 65.43% and 57.14% root knot disease severity compared to farmers' practices. Under control, average fruit number per plant was 28.00 and fruit yield 51.25 tha^{-1}. It was increased to 17.25-19.75 per plant and 59.38-75.50 tha^{-1}due to application of different treatments. Yield of bottle gourd was higher 32.12% compared to farmers' practice due to application of poultry refuse and Furadan 5G where as it was 25.45%, 23.38%, 22.64% and 19.61% due to integration neem oil cake with Furadan 5G,Tricho-compost-2 with Furadan 5G, Tricho-compost-1 with Furadan 5G and saw dust burning with Furadan 5G, respectively. Soil application with only Tricho-compost-2 and Tricho-compost-1 gave 20.39% and 13.69% higher yield over farmers' practices. The present study indicated that integration of different eco-friendly disease management approaches like integration poultry refuse, Tricho-composts and neem oil cake with and lower dose of nematicide Furadan 5G are effective in reducing root-knot nematode disease as well as increasing plant growth and yield of bottle gourd.

Development of biorational management package of root knot nematode and white mold diseases of country bean

A field experiment was conducted with a view to testing the efficacy of Poultry refuse (PR), Mustard oilcake (MOC) and chemical nematicide Furadan 5G (Carbofuran) for controlling root knot nematode of country bean through which growers will be benefited. There were 8 treatments viz. (i) Tricho-compost-1 @ 2 kg/pit + Bordeaux paste/ Bordeaux mixture (ii) Tricho-compost-2 @ 2 kg/pit + Bordeaux paste/ Bordeaux mixture (iii) Tricho-compost-1 @ 2 kg/pit + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture (iv) Tricho-compost-2 @ 2 kg/pit + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture and (v) Poultry refuse @ 6-8 kg/pit + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture and (vi) Neem oil cake @ 500 g/pit + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture (vii) Saw dust burning + Furadan 5 G @ 15-20 g/pit + Bordeaux paste/ Bordeaux mixture and (viii) Farmers practices. The unit pit size was 1 m x 2 m. RCB design was followed with 4 replications.The root-knot nematode infested soils were amended with PR (3 and 5 t/ha), MOC (0.3 and 0.6 t/ha) 3 weeks before seed sowing and Furadan 5G (40 kg/ha) on the day of seed sowing of country bean. On the other hand Tricho-composts were added @ 2 kg/pit 5 days before seed sowing.Results showed that all the treatments had significant effect on the reduction of root-knot disease severity and enhancing plant growth parameters and yield of tomato. All the treatment gave significantly higher shoot height, shoot weight, root length and root weight of country bean compared to farmers' practices (Table 1). The lowest shoot height, shoot weight, root length and root weight was recorded from farmers' practices. The maximum average gall index value 3.63 was recorded from the farmers' practices and the average gall index value drastically reduce to 0.50-0.93 was recorded due to application of different treatments (Table 2). Integration of Tricho-composts with Furadan 5G and poultry refuse with Furadan 5G gave the lower gall index value followed by soil amendment with Tricho-compost alone and integration of neem oil acke with Furadan 5G. But there are no significant differences among the treatments. All the treatments reduced more than 80% root knot disease severity compared to farmers' practices except integration of saw dust burning with Furadan 5G treatment where the reduction of root knot disease severity was 74.38% compared to farmers' practices. The yield of country bean was significantly higher in all the treatments compared to farmers' practices. The lowest yield was recorded from farmers' practices treatment. Yield of country bean was higher 35.68%-43.90% compared to farmers' practice due to application of different treatments. The present study indicated that integration of different eco-friendly disease management approaches like integration of poultry

refuse, Tricho-composts and neem oil cake with lower dose of nematicide Furadan 5G are effective in reducing root-knot nematode disease as well as increasing plant growth and yield of country bean. From the present study it may be concluded that integration of poultry refuse, Trichoderma based bio-fungicide called Tricho-compost and neem oil cake with minimum dose of nematicide Furadan 5G are the effective for reducing root-knot disease, as well as increasing plant growth and receiving higher yield of country bean.

Development of eco-friendly disease management technology of root knot and bacterial wilt of tomato

The experiments were conducted in the field of Plant Pathology Division, BARI during 2018-19 cropping season to develop eco-friendly integrated management technology against bacterial wilt caused by *Ralstonia solanacearum* and root knot nematode caused by *Meloidogyne incognita* diseases of tomato. There were 7 treatments namely i) Tricho-compost-1@ 3 tha^{-1}+Stable bleaching powder @ 20 $kgha^{-1}$, ii) Tricho-compost-2@ 3 tha^{-1}+Stable bleaching powder @ 20 $kgha^{-1}$, iii) Furadan 5G @ 40 $kgha^{-1}$+Stable bleaching powder @ 20 $kgha^{-1}$, iv) Neem oil cake @ 500 $kgha^{-1}$+ Furadan 5G @ 25 $kgha^{-1}$+Stable bleaching powder @ 20 $kgha^{-1}$, v) Tricho-compost-1@ 3 tha^{-1}+Stable bleaching powder @ 20 $kgha^{-1}$+ Furadan 5G @ 25 $kgha^{-1}$, vi) Tricho-compost-1@ 3 tha^{-1}+Stable bleaching powder @ 20 $kgha^{-1}$+ Furadan 5G @ 25 $kgha^{-1}$ and vii) Farmers practices. The experiment was laid out in a randomized complete block design with 3 replications. Root knot nematode infested field soils were treated Tricho-composts @ 3 tha^{-1} 5 days before seedling transplanting and Neem oilcake was applied 21 days before seedling transplanting where as stable bleaching powder were added during final land preparation and Furadan 5G was applied in soil before seedling transplanting. During this study there is no bacterial wilt disease was recorded in the experimental field. All the treatments had significant effect on the reduction of root-knot disease severity and increasing plant growth parameters and yield of tomato. Integration of Neem oil cake with Furadan 5G and stable bleaching powder or integration of Tricho-composts with stable bleaching powder and Furadan 5G gave the higher shoot height, shoot weight and root length followed by the integration of Tricho-composts with only stable bleaching powder and Tricho-composts with Furadan 5G and stable bleaching powder. The lowest shoot height was recorded from farmers' practices. The maximum average gall index value 5.08 was recorded from the control and the average gall index value drastically reduce to 1.08-1.92 was recorded due to application of different combination of neem oil cake with stable bleaching powder and Furadan 5G as well as integration of Tricho-composts with stable bleaching powder and Furadan 5G. Integration of neem oil cake with with Furadan 5G and stable bleaching powder reduced 78.74% root knot disease severity compared to control followed by the integration of Tricho-compost-1 with stable bleaching powder and Furadan 5G, Tricho-compost-2 with stable bleaching powder, Tricho-compost-2 with stable bleaching powder and Furadan 5G and Furadan 5G with stable bleaching powder where the reduction of disease severity was 74.61%, 73.82%, 72.04% and 72.04%, respectively compared to control. Under control, average fruit number per plant was 28.00 and it was increased to 35.33-41.33 per plant due to application of different treatments. Integration of neem oil cake with with Furadan 5G and stable bleaching powder gave and Tricho-compost-2 with stable bleaching powder and Furadan 5G gave higher fruit number per plant followed by integration of Tricho-compost-2 with stable bleaching powder, Tricho-compost-1 with stable bleaching powder and Furadan 5G and Tricho-compost-1 with stable bleaching powder. All the treatments gave significantly higher yield compared to control. Under farmers' practice, average fruit yield was 49.60 tha^{-1} and it was increased to 61.33-73.60 tha^{-1} due to application of different treatments. Yield was higher 32.61% compared to farmers' practice due to application of Tricho-compost-2 with stable bleaching powder and Furadan 5G where as it was 30.34%, 30.07%, 28.74% and 27.91% due to application of neem oil cake with Furadan 5G and stable bleaching powder, Tricho-compost-2 with stable bleaching powder, Tricho-compost-1 with stable bleaching powder and Furadan 5G and Tricho-compost-1 with stable bleaching powder, respectively compared to farmers' practices. The lowest number fruits yield was recorded from the farmers' practices treatment. From the present study it may be concluded that integration of Trichoderma based bio-fungicide called Tricho-compost and neem oil

cake with stable bleaching powder and lower dose of nematicide Furadan 5G are may the effective for reducing root-knot disease, as well as increasing plant growth and receiving higher yield of tomato.

Screening of neem products against root-knot nematode, *meloidogyne incognita* of tomato

The experiments were conducted in the field of Plant Pathology Division, BARI during 2018-19 cropping season to evaluate the neem based products such as neem leaf powder, neem leaf extract, neem seed extract, neem oil and neem oil cake for the management of root knot nematode of tomato caused by *Meloidogyne incognita*. There were 7 treatments namely i) Furadan (F) 5G @ 45 kgha^{-1}, ii) Soil application of neem leaf powder @ 2-3 gplant^{-1}, iii) Soil application of neem leaf extract (1:10 w/v), iv) Soil application of neem seed extract (1:10 w/v), v) Soil application of neem oil (1:10 v/v), vi) Soil application of neem oil cake @ 600 kgha^{-1} and vii) Untreated control. The experiment was laid out in a randomized complete block design with 3 replications. The field soil were inoculated with @ 1 gm galled chopped roots of Indian spinach per plant at the time of seedling transplanting. Neem leaf powder, neem leaf extract, neem seed extract and neem oil was applied twice, one is at the time of seedling transplanting and another is 40-45 days after seedling transplanting. Furadan were applied once at the time of seedling transplanting. Neem oilcake was applied 21 days before seedling transplanting for proper decomposition of neem oil cake in the soil. Results of this study showed that all the treatments had significant effect on the reduction of root-knot disease severity and increasing plant growth parameters and yield of tomato. Application of neem seed extract, neem leaf extract and neem oilcake gave the highest plant growth parameters viz. shoot height, shoot weight, root length and root weight followed by neem leaf powder, neem oil and Furadan 5G. The lowest shoot height was recorded from control. The maximum average gall index value 4.51 was recorded from the control and the average gall index value drastically reduce to 1.16-1.98 was recorded due to application of different neem product and Furadan 5G. Soil amendment with neem oil cake reduced 74.28% root knot disease severity compared to control which was followed by neem seed extract, neem leaf extract, neem leaf powder and Furadan 5G where the reduction of disease severity was 68.29%, 67.85%, 61.19% and 58.98%, respectively compared to control. All the treatments gave significantly higher yield compared to control. Under control, average fruit number per plant was 27.50 and fruit yield was 43.33 tha^{-1} and it was increased to 31.50-39.50 per plant and 55.83-69.58 tha^{-1} due to application of different treatments. Yield was higher 37.73% compared to control due to application of neem oil cake where as it was 34.60%, 34.18%, 29.26% and 25.19% due to application of neem seed extract, neem leaf extract, neem leaf powder and Furadan 5G, respectively compared to control. The lowest number fruits as well as yield was recorded from the control treatment. Application neem oil is less effective to increase plant growth as well as yield of tomato. The present study indicated that different neem products are effective in reducing root-knot nematode disease as well as increasing plant growth and yield of tomato. From the present study it may be concluded that neem based product are may the effective for reducing root-knot disease, as well as increasing plant growth and receiving higher yield of tomato.

Survey and management of wilt disease of guava

A survey was conducted to assess the guava wilt and the identification causal pathogen in the northern and southern part of Bangladesh, the major guava producing region. We have surveyed two upazilla namely Charghat and Godagari and Fruit Research Station BARI of Rajshahi district and Uzirpur and Swarupkati upazilla of Barishal district, the major Guava producing region in Bangladesh for determination of the wilt disease incidence and identification of the causal agent/s of the devastating disease. The wilt disease incidence was high in Rajshahi region (10-30%) compareed to Barisal region (2-7%). In the Charghat Upazilla of Rajshahi district the highest disease incidence was recorded in farmer field of Habibpur and Yousufpur village followed by Pannapara village. In the Godagari upazilla the highest disease incidence was recorded in farmer field of Bosontopur village followed by Kantobasa village. All the locations in Rajshahi regions farmers are cultivated locally available Guava variety known as Thai-2. Whereas, in the FRS, BARI the disease incidence was 5-10% and the variety was BARI-Peyara 2. In Barisal region the disease incidence was lower range from 2-7% both in Uzirpur and

Swarupkati upazila. We surveyed the guava orchard from the month of February to April 2019 and the average age of the orchards were 3-5 years. In Rajshahi region, some orchards we have observed even the disease incidence was more about 100%. We have collected the characteristic wilt disease infected samples i.e guava stem representing black discoloration of the vascular buddle and soil samples for isolation and identification of the causal pathogen. We have isolated the fungi from affected stem as well as soil in all the locations. The isolated fungi were *Fusarium* sp and we have performed the pathogencity test by three isolates namely CGW1; CGW2 and GGW1. After 40 days of inoculation characteristics symptoms of wilt has been appeared on to inoculated guava seedling but not in the non-inoculated control. The identification of the causal pathogen up to race using molecular tools and the pathogenicity test are in progress at Plant Pathology Division.

Survey of diseases of malta in southern region

A Survey was conducted in Pirojpur (Durgapur), Jalakhathi (Binoikathi and GavaRamchandrapur) and Barishal (Wazirpur, Babugonj and Banaripara) Districts. Respondents in different Upazilla recorded all the disease with the highest incidence being dieback (80%) followed by Sooty mold (70%), Greening (50%), Cankes (45%) and Gummosis (35%).

Management of damping-off disease in vegetable seedlings under floating agriculture

The experiment was conducted at RARS, Rahmatpur, Barihsal during 2018-2019 to find out a suitable management package against the damping-off disease of vegetables seedlings (sweet gourd and bottle gourd)under floating agriculture by seed treatment with provax (0.25%) + tema/ball soaking with provax (0.25%), seed treated with timsen (0.1%) + tema/ball soaking with timsen tm (n –alkyl dimethyl benzyl) @ 0.1% and seedling sprayed with timsen @ 0.1% and seed treatment with bioderma (3%)+ Tema/ball soaking with bioderma @ 0.3%,. From this experiment, it was found that seed and tema/ Ball treated with timsen tm (n –alkyl dimethyl benzyl) @ 0.1% and seedling sprayed with timsen @ 0.1% effectively control the damping-off disease in vegetable seedlings.

Screening of different brinjal lines/varieties against bacterial wilt under natural field condition

An experiment was conducted in the field of RARS, Jamalpur during 2018-2019 to screen out the resistant cultivars of brinjal against wilt disease. Twenty one germplasm and cultivars were used as treatments. Four germplasm were found highly susceptible and four germplasm showed susceptibility to bacterial wilt. Five germplasm were moderately susceptible to bacterial wilt. Among the tested germplasm seven germplasm and one variety namely BARI Begun-8 were found moderately resistant to bacterial wilt.

Survey of major diseases of brinjal and tomato in jamalpur and sherpur districts

A comprehensive survey was conducted in Jamalpur and Sherpur districts to measure the severity of major diseases of brinjal and tomato at this region during *rabi* season of 2018-19. Bacterial wilt of brinjal and viral disease of tomato were found to be higher in incidence. Wilting of tomato, viral disease of brinjal and phomopsis blight of brinjal were medium in incidence at different locations.

Surveillance of greening disease of citrus in jamalpur region

A comprehensive survey was conducted in Jamalpur and Mymensingh districts of the region to identify the incidence and severity of citrus greening during November 2018 to March, 2019. Different greening infected trees were found at several locations including RARS, Jamalpur. Collected leaf samples were sent to Plant Pathology Laboratory, BARI, Gazipur for molecular detection and confirmaton.

Screening of different citrus lines/varieties against greening disease under natural field condition

An experiment was conducted in the citrus block of RARS, Jamalpur during 2018-2019 to screen out the resistant citrus cultivars against greening disease. Thirteen germplasm and cultivars were used as treatments. Three germplasm were found infection free through visual investigation. Other germplasm showed characteristic motling symptom. Molecular analysis will be done for further confirmation.

Screening of new fungicides against tikka diseases of groundnut

An experiment was conducted at RARS, Jamalpur during 2018-2019 to screen different new fungicides against tikka disease of groundnut. Total nine (09) fungicides along with control (water spray) were tested in the field condition. Results showed that most of the tested fungicides reduced the disease significantly over control. Autostin 50 wp, Knowing 50 wp and Zidan 80 wp worked excellent and reduced disease intensity more than 70%.

Controlling white mold disease of mustard

Five (5) different treatment combinations and control were tested against white mold disease of mustard at RARS, Jamalpur during *rabi* season of 2018-19. No disease was observed in the field expeiment of mustard. There was no statistically significant variation among the yield of different treatments.

Integrated management of white mold disease caused by *sclerotinia sclerotiorum*

Nine (9) different treatment combinations and control were tested against white mold disease of mustard at RARS, Jamalpur during *rabi* season of 2018-19. No disease was observed in the field expeiment of mustard. There was no statistically significant variation among the yield of different treatments.

Evaluation of new chemical fungicides against late blight of potato

Twenty one of different new fungicides were tested against late blight disease of potato along with control (water spray) at RARS, Jamalpur during *rabi* season of 2018-19. No disease was observed in the experimental plot. There was no statistically significant variation among the yield of different treatments.

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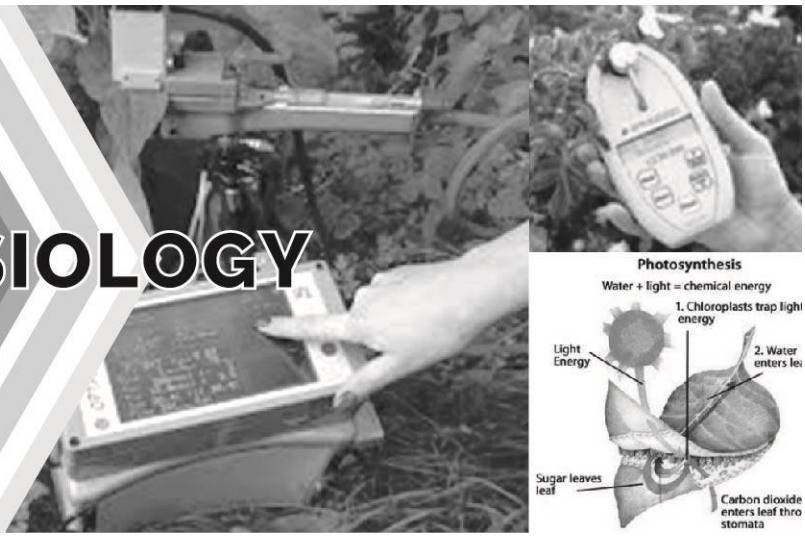


Physiological Response of Selected Rapeseed/ Mustard Genotypes to Salinity Stress

An experiment on rapeseed/mustard genotypes was conducted to find out salt tolerant genotypes during 2018-19 *rabi* season at the pot house of Plant Physiology Division, BARI, Gazipur. Five selected rapeseed/mustard genotypes (Jun-536, BJDH-12, BD-10115, BARI-14 and BD-6950) were tested under three salinity levels (0, 5 and 10 dS/m). Salinity was imposed at 20 days after sowing by adding NaCl solution. Salt solution was applied with an increment of 5dS/m in every alternate day until desired salinity levels were attained. In control treatment, pond water was used which salinity levels was 0.2 dS/m. Salinity levels were maintained by monitoring and adding salt solution when require up to maturity. The experiment was laid out in randomized complete block design with 5 replications. Plastic pots (top dia: 25 cm, bottom dia: 18 cm and height 25 cm; 12 kg soil) was filled up with soil and cowdung (4:1). Seeds were sown in each pot on 11 November 2018. Fertilizers were applied @100-30-80-20-3-1 kg/ha NPKSZnB. Half of N and all other fertilizers were applied as basal and remaining N was applied at 20 days after sowing (DAS). Irrespective of the genotypes, with the increase of salinity levels physiological parameters as well as seed yield were greatly affected. Leaf chlorophyll content did not show any remarkable variations due to salinity stress. However, leaf area, leaf photosynthetic rate; total dry matter (TDM) was reduced due to salinity stress which ultimately reduced seed yield irrespective of the genotypes. Sodium and potassium ion content and their ratios (K^+/Na^+) in leaf tissue were significantly affected by salinity with significant variability in genotypes. Among the genotypes, Jun-536 and BJDH-12 showed higher K^+/Na^+ ratio in leaf, which indicate higher tolerance to salinity compared to others under both the salinity levels. These genotypes also showed higher leaf photosynthetic rate, TDM production and seed yield under both the salinity levels compared to other genotypes. Results revealed that these two genotypes i.e. Jun-536 and BJDH-12 can be considered as tolerant genotypes against salinity stress.

Effect of high temperature stress at different growth stages of winter onion

A pot experiment was conducted at the Pot house of Plant Physiology Division, BARI Gazipur during *rabi* season of 2018-19 to evaluate the effect of high temperature stress on physiological and biochemical changes in winter onion. Four treatments namely T_1= open field (control), T_2= Inside polythene chamber from 20 days after transplanting (DAT) to 35 DAT, T_3= Inside polythene chamber from 35 DAT to maturity, T_4= Inside polythene chamber from 20 DAT to maturity were used in the study. High temperature was imposed by polythene covered chamber where temperature was 1.5 to 5.5 ºC higher (depending on time of the day) than outside of the chamber. The experiment was laid out in randomized complete block design with 10 replications. Plastic pot (top dia: 25 cm, bottom dia: 18 cm and height 25 cm; 12 kg soil) was filled up with soil and cowdung (4:1). Ten seedlings (40 days old) of BARI Piaj-1 were transplanted in plastic pots on 2nd January 2019. Fertilizers were applied 90-45-120-30-3-1.4 kg/ha of N P KSZnB. 1/2 N and half of K along with full amount of other fertilizers will be applied as basal. Remaining N and Kwas top dressed in 2 equal splits at 25&50 DAT.After 10 DAT, plants were thinned to five plants in each pot.Leaf chlorophyll content, leaf area, total dry matter production (TDM) and bulb yield was significantly reduced due to high temperature

stress; however, there exists variability among the treatments. Leaf area and TDM was significantly reduced in T_3 and T_2 treatments compared to control and T_4 treatments. Antioxidant activities (Catalase, Ascorbate peroxidase, Peroxidase) and Malondialdehyde were found more in T_3 and T_2 treatments indicating that plants in these two treatments faced more temperature stress than others. Consequently, higher bulb yield reduction (24.12%) was found in T_3 treatment followed by T_2 and the lowest in T_4 (8.17). Furthermore, it revealed that fluctuating temperature is very much harmful at bulb development stage of onion.

Physiological mechanisam of potato varities to high temperature stress

Potato (*Solanum tuberosum*) is a highly heat-sensitive crop; a slight rise from optimal temperature can lead to drastic decline in tuber yield. A field experiment was conducted with three selected potato varieties (BARI Alu-73, Diamont and Asterix) under four sowing dates (November 30, December 10, December 20 and December 30) for evaluating their response to sowing date imposed high temperature stress during rabi season of 2018-19. Sowing dates induced temperature variability showed remarkable influences on plant height; no. of stolon, leaf area, leaf chlorophyll content, photosynthetic parameters, dry matter production and tuber yield. Leaf area/plant was higher in November 30 planting crop followed by December planting with larger leaf area in BARI Alu-73. Planting date significantly decreased the leaf, stem and tuber dry matter production in potato varieties with the largest suppression under December 30 planting, and BARI Alu-73 being less suppressed than Diamont. Leaf chlorophyll content did not show any remarkable variation due to variation in planting dates except December 30. However, antioxidant activity like Catalyse (CAT), Guaiacol Peroxidase (POD) and Ascorbate peroxidase (APX) were found higher in December 20 and December 30planting crops than that of November 30 and among the variety their activity were found higher BARI Alu-73 followed by Asterix and those varieties also gave higher yield than Diamont. On the basis of growth parameters, photosynthetic, antioxidant activity and tuber yield the variety BARI Alu-73 can be selected as terminal high temperature tolerance genotypes.

Screening of wheat genotypes for drought tolerance at vegetative stage

Drought significantly reduces yield of many crop plants including wheat in the world. Screening of wheat genotypes that can thrive on limited water is vital to boost up the wheat production in rainfed areas. Twenty (20) wheat genotypes selected from our previous experiment, were evaluated again to drought at vegetative stage (stress was imposed from CRI stage to anthesis by withholding irrigation) with control (no drought). Our results from the pot experiment showed that SPAD (soil–plant analyses development, based on chlorophyll meter readings), plant height, leaf area and biomass of shoot were significantly reduced in plants exposed to drought stress compared with control plants. There were significant differences among the 20 wheat genotypes in terms of the reduction in these growth parameters. Genotypes BWSN 31 and KRL 19 showed the least reduction, indicating their high tolerance to drought stress, while genotypes BWSN 33 and BWSN 14 showed the greatest reduction, and drought stress symptoms appeared rapidly and severely in these genotypes. Significant genotypic differences in leaf total soluble sugar (TSS) content in response to drought stress were also observed in our experiment. The drought tolerant genotype BWSN 31 showed a higher TSS and the two drought-sensitive genotypes BWSN 33 and BWSN 14 showed a lower TSS than the control plants. On the basis of relative yield (RY), stress susceptibility index (SSI) and stress tolerance index (STI), the genotypes BWSN 31, KRL 19 and Borlaug were selected as drought tolerant at vegetative stage.

Screening of wheat genotypes for heat tolerance at reproductive stage

Heat stress negatively influences the grain filling processes in plants. This study was aimed to screen the wheat genotypes against heat stress, during reproductive stages. Twenty (20) wheat genotypes were sown in vinyl house of BARI, Gazipur, on 21 November, 2018. Two temperature regimes, namely, normal (~24°C in open field) and elevated (5±1°C) higher compared to open field mean air temperature in polythene chamber) temperature, were created immediately after anthesis to investigate the response of wheat genotypes to heat stress. Our results from the pot experiment showed

that SPAD (soil– plant analyses development, based on chlorophyll meter readings), plant height, leaf area and biomass of shoot were significantly reduced in plants exposed to heat stress compared with control plants. There were significant differences among the 20 wheat genotypes in terms of the reduction in these growth parameters. Genotypes BWSN 31, BWSN 48, BAW 1208 and BARI Gom-33 showed the least reduction, indicating their high tolerance to heat stress, while genotypes BWSN 33, PYT 13 and PYT 33 showed the greatest reduction, and heat stress symptoms appeared rapidly and severely in these genotypes. Significant genotypic differences in leaf cell membrane stability index (CMSI) in response to heat stress were also observed in our experiment. The heat tolerant genotype BWSN 31 showed a lower CMSI and the two drought-sensitive genotypes BWSN 33 and PYT 33 showed a higher CMSI than the control plants. On the basis of relative yield (RY), stress susceptibility index (SSI) and stress tolerance index (STI), the genotypes BWSN 31, BWSN 48, BAW 1208 and BARI Gom-33 were selected as heat tolerant at reproductive stage.

Morpho-physiological responses to salinity stress in potato varieties

A pot experiment was carried out at the research field of Plant Physiology Division, BARI, Gazipur, during rabi season of 2018-19 to investigate the morphological and physiological responses in potato (BARI Alu-72; salt tolerant, Granula; salt sensitive and Asterix) under control and two levels of salinity (6-8 dS m^{-1}; moderate and 10-12 dS m^{-1} severe). Pots were arranged in a randomized complete block design with three replications and each pot was considered as one replication. Plastic pot (top dia: 120 cm, bottom dia: 90 cm and height 42 cm; 25 kg soil) was filled up with field sandy loam soil and cowdung (4:1). Three tuber seed (about 50 g) was planted on 27 November to a depth of 6 cm soil in each pot. Treatment was imposed from 10 DAE to reproductive stage by adding NaCl solution. Pond water was used as control and that was 0.2 dS/m. The salt solution was applied with an increment of 5 dS/m in every alternate day until respective salinity levels was attained. Salinity levels were maintained by monitoring and adding salt solution when require up to maturity.Results show that salinity stress decreased total chlorophyll (Chl a+b), carotenoids (CAR), membrane stability index (MSI), biomass and yield $plant^{-1}$, and increased catalase (CAT), peroxidase (POD), ascorbate peroxidase (APX), glutathione peroxidase (GPX), glutathione S-transferase (GST) and glutathione reductase (GR) activity in all varieties and at all the salinity levels. Salinity induced decrease in total chlorophyll (Chla+b), CAR, MSI, biomass and yield $plant^{-1}$ were significantly higher in Granula, moderate in Asterix and lower in BARI Alu-72. However, BARI Alu-72 recorded higher activity of CAT, POD, APX, GPX, GR and GST as well as contents of K^+ and comparatively lower lipid peroxidation (MDA) and lipoxygenase (LOX) contents compared with others. Granula also showed higher Na and Na/K ratio. Results show that salinity tolerance of BARI Alu-72 as manifested by lower decrease in biomass and yield $plant^{-1}$ is associated with higher antioxidant activity and potassium contents, and lower MDA, LOX and sodium contents than salinity sensitive Granula. However, Asterix also showed relatively tolerant to salinity stress.

Morpho-physiological evaluation of selected sesame genotypes at flowering stage against waterlogging stress

Forty sesame genotypes (selected from our previous experiment) were evaluated at flowering stage by pot culture experiment to identify tolerant types for excess soil moisture by imposing flooding for 24 hours, 48 hours and 72 hours duration.The experiment was laid out in randomized complete block design with 3 replications and each pot was considered as one replication. Plastic pots (top dia: 20 cm, bottom dia: 15 cm and height 19 cm; 6 kg soil) were filled up with well mixed sandy loam soil and cowdung (4:1). Ten seeds were sown in each pot on 13th March 2018. Fertilizers were applied 100-30-55-25-3-1 kg/ha NPKSZnB. After emergence excess plants were thinned out and three plants pot^{-1} were maintained. Waterlog was imposed at 56-60 days after sowing by transferring the pots in a water tub where water was maintained about 5 cm above the soil surface of pots. After the treatment period, pots were removed from waterlogging and plants were allowed to grow at normal condition upto

maturity. Our results from the pot experiment showed that all the genotypes (100%) survived under control condition and varied (85.71-100%) in 24h waterlog condition. However, twelve and eight genotypesalone survived in 48 and 72 h of waterlogging, respectivelyand not a single plant of rest of the forty genotypes could overcome in these conditions.Interestingly, eight genotypes of 72 h of waterlogging also survived in 48 h of waterlogging. Observations of the twelve genotypes which survived 48 h of flooding were recorded and the results showed that the genotypes differed significantly for the characters under study.Waterlogging caused a drastic yield reduction in sesame, under 72 h waterlog condition, the lowest reduction (<40%) was recorded in G4 (28.54%) which was followed by G34, G1 and G5 and the moderate seed yield reduction (40-60%) was observed in G12 (42%) which was followed by G15, G14 and G21. However, under 72h waterlog condition, G5, G12, G4, G15, G34, G14, G21 and G1 showed better dry matter production compared to other genotypes. Consideration to all indices (TOL, STI, MOP, GMP, SSI, YSI and YI), the genotypes G5, G4, G12, G15 and G14 showed the best ranks mean and low standard deviation of ranks in both, 48 and 72 h waterlog conditions, hence they were identified as the tolerant genotypes, while genotypes G34, G21, G1, G19, G32, G16 and G31 as the relatively tolerant genotypes to waterlogging stress.

Screening of grasspea genotypes against salinity under laboratory condition

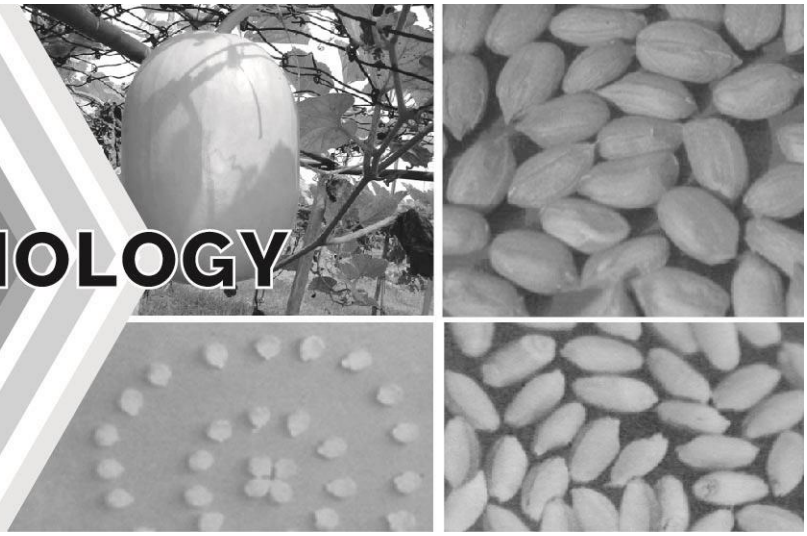
An experiment was conducted from November 20, 2018 to March 2, 2019 at Plant Physiology Laboratory, BARI, Gazipur, to screen salt tolerant grasspea genotypes at seedling stage. Forty grasspea genotypes were tested at seedling stage against two levels of salinity (0 mM and 120 mM) in Hoagland solution under laboratory condition during 2018-2019, to screen out the salt tolerant grasspeagenotypes. Distilled water (0 mM) was used as a control. The salt solution was prepared calculated amount of NaCl in distilled water. Subsequently, plants were transferred to hydroponic culture in a Hoagland solution (the Hoagland: tap water ratio was 1:1000 (w/w)) for an additional quantity (Furukawa, 2012). The PH of solution was maintained 6-7. Plastic pots were used in the experiment with a diameter of 10cm and arranged in a completely randomized design (CRD) with three replications. Each pot was supplied with 500 ml of the respective treatment solution. Seeds were sown on the plastic pots having bolting paper. The germination count was taken after 72 hours of sowing of seeds. A seed was considered to have germinated when both the plumule and the radicle emerged > 0.5cm. After 15 days, the shoot and the root length of ten randomly selected seedlings from each replicate were measured following a draftsman ruler (Azhar and McNeilly, 1987). Germination percentage (GP), root length (RL), and shoot length (SL) were significantly found to be affected by salinity. The genotypes BD-5585, BD-5580 and BD-5579 showed better performance at 0 mM, and 120 mM and survived up to 15 days after germination.

Morpho-physiological responses of the selected chilli genotypes in variable shading condition

To find out the shade tolerant Chilli genotypes, a study was conducted at pot house of Plant Physiology Division under BARI, during *rabi* 2018-2019. Selected six Chilli genotypes/varieties Co-640, Co-630, Co-639, Co-637, Co-446-1, BARI Morich-2were evaluated under three shading conditions *viz.*control (no shading), 25% and 50% shading. The experiment was carried out in RCB design with five replications. The 25% and 50% shading were ensured by covering the top and lateral portion of bamboo's structure using mosquito net followed by single and double layer respectively while in a control conditionno shading was imposed.The measureable light reduction in 25% and 50% shading was measured by a Sunfleck Ceptometer (LP-80, Decagon Device).Therefore, for the convenient of treatment carry out total 90 (26 cm top diameter, 20 cm base diameter and 25 cm in height) plastic pots were arranged equally in each shading and open field (control)condition. The pots had the enough perforation system at the bottom for drainage of water. The 30days old Chilli seedlings were transplanted on 27th November, 2018 in each pot according to the treatment.The shading nets were installed 10 days after transplanting and the effects were observed until final harvest.In order to test the shading effect photosynthetic active radiation (PAR) of each unit

was monitored by using quantum sensor of Licoor-6800 before the transplanting of seedling in pot. The PAR of non-shade (control) condition was 1200µmol m^{-2} s^{-1} while in 25% and 50% shading environment it were 900µmol m^{-2} s^{-1} and 600µmol m^{-2} s^{-1} respectively. All physiological and anatomical parameters measurements were conducted on clear days within the period of 11.00am to 1.30pm. The genotypes Co-640, Co-446-1 and Co-630, Co-639 werethe late (51 to 54 days) and early (37.0 days) respectively to perform the first flower under both shading and (non-shading) control condition. The genotype Co-446-1 was the late (77.0 days) and genotypes Co-630, Co-639 were early (46.0 days) for the first fruiting at open field and 50% shading condition respectively.The genotype Co-640 produced the longest fruit (7.50 cm), highest weight of 5 fruits (23.5 g) and genotype Co-630 produced highest number of fruit plant^{-1}(127.0) at 50% shading conditionthat directly contributed in producing highest fruit yield (352.9 g plant^{-1}) and (275.3 g plant^{-1}) respectively.The genotype Co-639 also showed the better response in producing fruit length (6.25 cm), fruit yield (260.4 g plant^{-1}) as well as physiological parameter under 50% shading condition.Shading effect caused reducing the rate of PAR absorption, photosynthesis and total CO_2 conductance irrespective of all genotype, excludingCo-639 and Co-637. Therefore, from this study it can be concluded that Chilli genotypes Co-640, Co-630, Co-639 and Co-637 were suitable for cultivation at 50% shadings (reduced solar radiation) condition as the yield contributing traits, yield and physiological parametersof these were higher than other genotypes.

17 SEED TECHNOLOGY



Effect of fruit maturity color and fruit weight on seed quality of bitter gourd

A laboratory study was conducted at the research laboratory of Seed Technology Division, BARI, Joydebpur, Gazipur during 2018-2019 to identify the appropriate fruit maturity color and fruit weight for better seed quality of bitter gourd. Three levels fruit color viz., i) Less than 20% yellow fruit (C1), ii) 20% to 50% yellow fruit (C2) and iii) Greater than 50% yellow fruit (C3), and three levels of fruit weight viz., i) less than 200 g (W1), ii) 200 g to 300 g (W2) and iii) greater than 300 g (W3). Bitter gourd variety was BARI Karola-1. Fruit maturity color was found significant on seed germination percentage, individual seedling length, individual seedling dry weight, vigor index-I, vigor index-II and germination index. Fruit weight was also showed significant variation in all seed quality parameters excluding individual seedling length and individual seedling dry weight. But interaction effect of fruit maturity color and fruit weight was observed insignificant in all seed quality parameters except germination index. Fruits of greater than 50% yellow, and fruit weight of greater than 300 g showed better performance in terms of seed germination percentage, individual seedling length, individual seedling dry weight, vigor index-I, vigor index-II and germination index.

Effect of drying method and after ripening period on seed quality of bitter gourd

A laboratory study was conducted at the research laboratory of Seed Technology Division, BARI, Joydebpur, Gazipur during 2018-2019 to identify the appropriate drying method and after ripening period for better seed quality of bitter gourd. Two levels of after ripening period viz., i) 0 day and ii) 1 day and five levels of drying methods viz., i) sun drying, ii) air drying (a constant air flow by a fan at ambient condition), iii) oven drying at 33°C, iv) oven drying at 37°C and v) drying by using drying beads were tested. Bitter gourd variety was BARI Karola-1. After ripening period and drying period individually was found significant on seed germination percentage, individual seedling length, individual seedling dry weight, vigor index-I, vigor index-II and germination index. But interaction effect of after ripening period and drying methods was observed insignificant in all seed quality parameters. Considering seed germination and seedling vigor index, one day after ripening period and oven drying at 37°C showed better performance in terms of seed quality parameters. Air drying may also be followed.

Effect of planting method and production management packages on seed yield and quality of onion

A field experiment was conducted at the research farm of Seed Technology Division, BARI, Joydebpur, Gazipur during 2018-2019 to identify a suitable management practice (planting method, spacing and fertilizer dose) for higher seed yield with better seed quality of onion. Two planting methods viz., flatbed method (P1) and raised bed method (P2) were assigned in main plots; two plant spacings viz., 30 cm X 20 cm (S1) and 25 cm X 20 cm (S2) were assigned in sub-plots, and two fertilizer doses viz., BARC fertilizer recommendation (RF; F1) and IPNS based fertilizer dose (F2) were assigned in sub-sub-plots. Onion variety was BARI Piaj-1. Considering seed yield, seed germination and vigor index of onion, raised bed planting along with plant spacing 25 cm X 20 cm and IPNS based fertilizer dose showed better performance compared to any other treatment combination.

Integrated nutrient management for quality seed production of bush bean

The experiment was carried out at the research field and laboratory of Seed Technology Division,

BARI, Gazipur during *rabi* season of 2018-19 to study the effect of different integrated nutrient management package on quality seed production of bush or French bean. A total of five treatments viz. T_1= 100% FRG (70-30-45-8-2-1.4 Kgha^{-1}NPKSZnB) + CD @ 5 ton ha^{-1}, T_2=80% FRG + Vermicompost @3 ton ha^{-1}, T_3=100% FRG + *Rhizobium* Biofertilizer @ 50g kg^{-1} seed, T_4=100% FRG +Biochar @ 3 ton ha^{-1} and T_5=80%FRG + Poultry manure @ 5 ton ha^{-1}. The growth and yield parameters of bush bean had the significant effect of treatments on plant height, SPAD value, NDVI value, number of branches plant^{-1}, shoot dry weight, number of pods per plant, pod weight per plant, length of pod, number of seeds per pod, hundred seeds weight and seed yield. Highest average seed yield of 1.72 tons ha^{-1} was recorded in T_4 treatment.The results indicated that the treatment T_4 also observed significantly higher on plant height (58.04 cm), SPAD value (53.20), NDVI value (0.83), number of branches plant^{-1} (6.71), shoot dry weight (15.93 g), number of pod per plant (21.89), pod weight per plant (19.88 g), length of pod (13.79 cm), number of seed per pod (4.41) and hundred seeds weight (27.45g). Seed quality parameter such as germination percentage (90.67%), moisture percentage (5.47%), seedling root length (9.02 cm), seedling shoot length (21.73cm), seedling dry weight (185.6 mg), seedling vigour index I (2788) and seedling vigour index II (16824) were recorded from T_4 treatment. It was concluded that treatment T_4 showed high quality seed production and synergistic effects on growth and yield of bush bean.

Effect of plant growth regulators on seed yield and quality of soybean at different time of application

The experiment was carried out at the research field and laboratory of Seed Technology Division, BARI, Gazipur during *rabi* season of 2018-19 to study the effect of plant growth regulator (GA_3) on seed yield and quality of Soybean at different stages of application. The factorial experiment was laid out in RCBD with 12 treatment combination of four different plant growth regulators viz., H_0 = Control (water), H_1= GA_3 (50 ppm), H_2= GA_3 (100 ppm), H_3= GA_3 (150 ppm) and three different time of application i.e. S_1= Vegetative stage, S_2= Flower initiation stage, S_3 = Pod formation stage. Soybean variety was BARI Soybean-6. The results indicated that the application of growth regulators GA_3 100 ppm (H_2) noticed significantly higher plant height (77.64 cm), number of seeds per pod (2.85) and seed yield (2.98 t/ha). Better seed quality parameter such as 100- seed weight (14.493 g), germination percentage (85.33 %) and vigour index (2780.9) were also noticed from GA_3 @ 100 ppm (H_2). Among the different time of application, pod formation stage (S3) recorded significantly higher number of pods per plant (112.28) and seed yield (3.00 t/ha) along with seed quality parameters viz., 100- seed weight (14.986g), germination (84.00 %), and seedling vigour index (2722.4). So the treatment combination of GA_3 @ 100 ppm at pod formation stage (H_2S_3**)** was found suitable for seed yield and quality of Soybean crop.

Effect of growth regulators on seed yield and quality of french bean

The experiment was carried out at the research field and laboratory of Seed Technology Division, BARI, Gazipur during rabi season of 2018-19 to investigate the effect of some growth regulators (GA_3 and IAA) on seed yield and quality of French bean. The seed yield and quality parameters like plant height, pod length, pod weight, number of green pod per plant, seed yield kg per hectare, germination percentage, seedling dry weight and vigor index were influenced significantly due to application of plant growth regulators. In French bean, the maximum height of plant (53.36 cm), pod length (16.22 cm), number of green pods per plant (35.73) and seed yield (1.91 t/ha) were observed in the treatment (T_7) GA_3 (125 ppm) while the minimum plant height (42.14 cm), pod length (15.06 cm), number of green pods per plant (28.80) and seed yield (1.20 t/ha), respectively observed in the treatment (T_3). Among the treatments, (T_7) GA_3 125 ppm showed significantly better seed quality parameters such as pod weight (4.79 g), germination percentage (94.66 %), seedling vigour index (18004) and seedling dry weight (190.47 mg).

Effect of seed priming on germination and seedling establishment of bitter gourd

An experiment was conducted under pot culture and laboratory of seed technology division, BARI, Gazipur during Kharif-1 season 2019 to find out the effect of seed priming on germination and seedling establishment of bitter gourd. Seeds of two cultivars of bitter gourd viz., V_1=Tia Karola (Hybrid) and V_2= BARI Karola-1 (OPV) were

treated with different priming materials viz., T_1- Seed soaking in water for 24 hours, T_2- Seed soaking in water for 36 hours, T_3- NAA (0.01%) for 24 hours, T_4-Seed soaking in water for 12 hours, T_5-KH2PO4 (1.5%) for 24 hours, T_6-NaH2PO4 (1.5%) for 24 hours and control T_7-unprimed. Seed quality parameters like germination percentage, seedling length, dry weight and vigor index-I and vigor index II were measured. Results revealed that T_5 performed better in the case of germination (%), seedling dry weight and vigor index-2 of the seedling. Germination speed, seedling length, fresh weight of seedling and vigor index-1 was found higher in treatment T_4. The variety Tia Karola (Hybrid) performed better than BARI Karola-1 (OPV) in all parameters studied.

Effect of growth regulators on seed yield and quality of pumpkin

The experiment was conducted at the research field and laboratory of Seed Technology Division, BARI, Gazipur from October 2018 to March 2019 to find out suitable growth regulator to achieve the best possible seed yield and seed quality of pumpkin. Pumpkin var. BARI Mistikumra-2 was used. The treatments comprised of three kinds of growth regulators viz. Ethrel 200 ppm, GA_3 325 ppm, NAA 100 ppm and control (water spray). Data were recorded on the number of fruit per plant, fruit weight, fruit girth, number of seed per fruit, seed weight per fruit, 100 seed weight, and germination percentage of seeds, germination speed and dry weight of seedling. Significant variation was found in the case of the number of fruit per plant, average fruit weight, number of seed per fruit, 100- seed weight. Results revealed that spraying of seedling with GA_3 @ 25ppm showed higher seed yield (255seed/fruit), germination (78.67%) and seedling vigor index than the other treatments.

Effect of zinc on seed yield and quality of pumpkin

The experiment was conducted at the research field and laboratory of Seed Technology Division, BARI, Gazipur from October 2018 to March 2019 to find out the optimum dose of Zinc to achieve the best possible seed yield and seed quality of pumpkin. The pumpkin var. BARI Mistikumra-2 was used as the test variety. The treatments comprised of four doses of Zn viz. T_1: 0 kg/ha (control), T_2: 2 kg/ha, T_3: 4 kg/ha and T_4: 6 kg/ha. Data were recorded on the number of fruit per plant, fruit weight, fruit girth, number of seed per fruit, seed weight per fruit, 100- seed weight, initial germination percentage of seed, germination speed, dry weight of seedling and seedling vigor index. Significant variation was found in the case of the number of fruit per plant, the number of seed per fruit, seed weight per fruit, and germination percentage and seedling vigor index. Results revealed that maximum number fruit along with a maximum of 206.67 seeds per fruit was obtained from T_2 and minimum in control. A maximum 71.67% initial germination of seed and maximum vigor index was also found in T_2.

Effect of pre-sowing invigoration seed treatment in groundnut

Different pre-sowing invigoration treatments have been developed to improve seed performance during germination and seedling early growth, to reduce the germination time, synchronize germination time and to improve the germination rate. 2% $CaCl_2$, 50ppm GA_3 and maceration were used as a priming agent, of them maceration and 50ppm GA_3 showed better performance in cumulative germination rate and germination percentage, and 2% $CaCl_2$ showed better performance in Seedling Vigor Index-II.

18 VERTEBRATE PEST

Study on the repellency of fungicide against field rats

Rat damage of agricultural crops is a worldwide problem. Different approaches for controlling rodent including chemical repellents are needed to mitigate crop losses. Two fungicide Taopath 60WP (40%Thiram + 20% Carbendazim) and Provax 200WP 2% and 3% were evaluated as rat repellents in laboratory trials. The results showed that rat was able to distinguish untreated and treated wheat during preference test. Consumption of Taopath and Provax 2% and 3% treated wheat seed was lower than the untreated wheat seed. In repellency test Taopath exhibited the better repellency than Provax and untreated control in the laboratory.

Survey on squirrel damage in different fruits and vegetables in selected areas of Bangladesh

A study was conducted among the farmers on squirrel problem in different crops in Pabna and Khulna districts of Bangladesh during 2018-19. Most of the farmers of Pabna district reported that one type and farmers of Khulna reported two types of squirrels which was brown and striped squirrels. According to the farmers' opinion, vegetables and fruit crops were frequently damaged by the squirrels. Most affected vegetable crops were bottle gourd (73.33%) followed by pumpkin (71.67%), bean (56.67%) and brinjal (51.67%). Among the fruit crops maximum damage was found in Guava (76.6%) followed by coconut (71.6%), litchi (68.3%), mango (36.6%) and ber (26.6%). Farmers reported that average Tk. 500-700 per family per year was lost due to vegetables damage caused by squirrels while it was more than Tk. 700 in case of fruits. Maximum damage was occurred at all growing stages of the crops (69.1%) followed by immature stage (27.27%) of the crop in all the season. Farmers were not sure about the breeding frequency (71.67%), breeding season (91.6%) and number of young per parturition (76.6%). Parturition usually took place in the tree hole (26%). Most popular control method used by the farmers was Trapping (21.6%) followed by repelling (15%) and shooting (11.6%).

Development of suitable bird repellent (sub-lethal dose) for repelling bird in sprouting wheat in laboratory

Bird depredation of agricultural crops is a worldwide problem. New strategies are needed by including chemical repellents to mitigate crop losses. One natural insecticide named neem seed oil (3% and 4%) and one barn lubricant (0.5% and 1%) were evaluated as bird repellent in caged feeding trials in bird aviary at Vertebrate Pest Division, BARI, Gazipur. For repellent tested, blue rock pigeon was able to distinguish untreated and treated wheat during preference test. Neem seed oil 3% and 4% treated wheat seed consumption was comparatively lower than the barn lubricant 0.5% and 1%. Test birds consumed more untreated wheat compared to other two treatments. In repellency test, neem seed oil exhibited the better repellency than barn lubricant and untreated control.

Effectiveness of seed treatment with anthraquinone and chlorpyrifos for reducing bird damage in wheat

The experiment was conducted at the bird aviary of Vertebrate Pest Division, BARI, Gazipur during rabi season to evaluate four concentrations (25%, 50%, 75%, and 100% of recommended rate) of two chemicals named Anthraquinone and Chlorpyrifos as repellent against blue rock pigeon. The experiment was divided into two phases such as pre-treatment phase and treatment phase. We randomly assigned five birds in each case for each treatment. During 5-day pre-treatment, we transferred all birds (40) to each case (45x30x40 cm^3). We provided 40g untreated wheat seeds in a plastic bowl and water (ad libitum) throughout the pre-treatment for acclimation. After acclimation, we provided 40g untreated seeds in one bowl and

40g treated seed in another bowl in each case and water (ad libitum) for five days. We kept two bowls randomized in north-south position in each case on the first day and altered the position of the bowls on subsequent days to overcome the side preference. We placed a plastic tray (same dimension as tray) under each tray for collecting spillage. We collected uneaten seeds remaining in the bowl and seed spillage remaining in trays under each case and subtracted them from the total amount of seed given at 8.00 am to 9.00 am daily. After removing old seeds, we offered new treated and untreated seeds to the birds again daily. A bowl containing 40g wheat seeds that was not exposed to the air was placed in a vacant case to measure the weight loss due to moisture.

We observed that consumption of treated seeds was significantly lower than the untreated seeds. Average consumption of Chlorpyrifos treated wheat seeds was 11.70 (± 0.76) g and untreated wheat seeds was 25.24 (± 0.84) g. The lower consumption {8.51 (±0.25) g and 8.47 (± 0.22) g} was obtained from the treated wheat seed with 75% and 100% recommended rate of Chlorpyrifos respectfully. Consequently, around 50% repellency was found from both of the treatments. On the other hand, average consumption of Anthraquinone treated wheat seeds was 4.25 (± 0.73) g and untreated wheat seeds was 31.10 (±0.99) g. The lower consumption was {1.52 (± 0.33) g and 1.47 (±0.43) g} obtained from the treated wheat seeds with 75% and 100% Anthraquinone. Accordingly, both treatments gave more than 80% repellency against the test birds.

Comparative efficacy of different traps (live, kill and gopher) for controlling rodents

Comparative efficacy of different traps was evaluated at ARS, Rajbari Farm, Dinajpur and farmers' fields during *rabi* season, 2018-19 to find out the most suitable trap for capturing rats. Three types of traps such as live trap, kill trap, and Gopher trap were used at different wheat fields for this study. The experiment was conducted in six wheat fields for seven trap nights. In each wheat field 5 live traps, 5 kill traps, and 5 Gopher traps were set. Each active burrow was treated with one trap. Therefore, total 630 trap nights were used for this study. So, each type of trap was used for 210 trap nights. Live traps and kill traps were set near the burrow opening while Gopher traps were set inside the burrow opening. All traps were set in every evening and the data were recorded in the following morning. From this experiment, it was revealed that success rate of live traps was higher than the kill traps and Gopher traps. Average success rate of live trap was 66% whereas success rate of Gopher trap was 56% and it was only 38.66% in in case of kill trap.

Efficacy of reflective ribbon as repellant against pest birds in tomato

The experiment was conducted at HRC field with the collaboration with HRC entomology section during *rabi* season in 2018-19 to find out the efficacy of different types of reflecting ribbons on tomato against pest birds. Five treatments *viz.* T_1 = multicolored reflecting ribbon, T_2 = silver colored reflecting ribbon, T_3 = multicolored reflecting ribbon with additional short & thin ribbon pieces, T_4 = silver colored reflecting ribbon with additional short & thin ribbon pieces, and T_5 = untreated control were used in this experiment. The experiment was laid out in RCB design with three replications. From this experiment, it was revealed that significantly maximum damage of tomato caused by the pest birds were in the control plots compared to reflecting ribbon treated plots. In control plots maximum 40.53% damage was happened by the birds whereas the lowest damage was happened in treatment T_3 (13.72%). T_4 (15.57% fruit damage), T_1 (17.01% fruit damage), and T_2 (18.18% fruit damage) treated plots also gave the better result. However, the highest BCR (3.67) was obtained from T_2 treated plots. Similar BCR (3.28 to 3.54) was also obtained other plots treated with different type of reflective ribbons.

Evaluation of some indigenous methods for controlling rodent in Bangladesh

The effectiveness of some indigenous techniques for repelling rodents was evaluated in the wheat and pulse field of Regional Agricultural Research Station and Pulse Research Centre of Ishurdi, Pabna during February 2019 to May 2019. Four indigenous techniques viz. kerosene mixed cow dung, engine oil mixed water, molasses mixed cotton and molasses mixed cement were evaluated for repelling rodents from wheat and pulse crop field. In wheat, kerosene mixed cow dung showed the highest success (72.58%) which was statistically similar with engine oil mixed water (66.77%). Only 27.67% success was recorded in case of molasses mixed cotton which was

statistically similar with molasses mixed cement (26.98%). Similarly, in pulse, kerosene mixed cow dung showed the highest success (68.98%) which was statistically similar with engine oil mixed water (59.35%). Only 16.39% success was recorded in case of molasses mixed cotton which was statistically similar with molasses mixed cement (15.87%). Considering the two field crops, the average rodent repelling success of kerosene mixed cow dung, engine oil mixed water, molasses mixed cotton and molasses mixed cement was 70.78%, 63.06%, 22.02% and 21.42%, respectively.

Effect of bait station design on bait uptake and control efficacy of rodent

The experiment was conducted in outdoor rat enclosure at vertebrate pest division in BARI, Joydebpur, Gazipur during 2018-19 to increase the consumption of poison bait by rat through providing bait with suitable bait station and to increase the control efficacy of Zn_3P_2 poison bait. Plain bait and poison bait were separately offered to rats with seven newly designed bait stations and their consumption was recorded. The different bait stations were wooden double opening bait station (WDO), the PVC pipe bait station (PVCP), cardboard double opening bait station (CDO), cardboard box double opening bait station (CBDO), metallic food cup bait station (MFC), earthen bowl bait station (EB), and paper bait station. Rat consumed significantly higher amount of plain bait from WDO (4.02 g/rat/day) bait station which was statistically similar with PVCP (3.59 g/rat/day) and EB (3.14 g/rat/day) bait station whereas CBDO (2.09 g/rat/day) bait station was the least preferred by rat which was statistically similar with paper (2.14 g/rat/day), CDO (2.24 g/rat/day) and MFC (2.41 g/rat/day) bait station. Similarly, in poison bait consumption, WDO (0.46 g/rat/day) bait station was highly preferred by rat that was followed by PVCP (0.30g/rat/day) bait station which was statistically similar with EB (0.23g/rat/day) and paper (0.21g/rat/day) bait station. On the other hand, The CBDO (0.06 g/rat/day) bait station was least preferred by rat that was statistically similar with CDO (0.07 g/rat/day) and MFC (0.10 g/rat/day) bait station.

Optimization of processing technique for roasted jackfruit seed maintaining nutritional quality

Mature and full ripe jackfruit was collected from local cultivar to investigate and optimize the roasting time and temperature combination. Full ripe bulbs were first separated from the fruit and the seeds were collected from the inside of the bulb. After washing with clean tap water seeds were dried in sun at ambient condition until surface water remove. The experiment was laid out with Complete Randomized Design (CRD). All the seeds were treated as roasted at 150^0 C for 10 minutes (T_1), roasted at 150^0 C for 20 minutes (T_2), roasted at 200^0 C for 10 minutes (T_3), roasted at 200^0 C for 20 minutes (T_4), roasted at 250^0 C for 10 minutes (T_5), and roasted at 250^0 C for 20 minutes (T_6). Roasted seeds were then evaluated by forming ten judgment groups using 9-hedonic scale to determine their optimum time and temperature combination for roasting. According to panel test result T_4 (200^0C for 20 minutes) scored highest overall acceptability (8.2) and regarded as best considering the quality parameters of roasted jackfruit seed.

Effect of ethylene on postharvest quality of mango

The experiment was conducted to evaluate the effect of ethylene application on postharvest quality of mango (*Mangifera indica*). It was laid out in Complete Randomized Design (CRD) with three treatments namely control (T_1, not treated with ethylene), 100 ppm ethylene in ripening chamber for 24 hours (T_2) and 150 ppm ethylene in ripening chamber for 24 hours (T_3) were used. The fruits were assessed for physiological changes such as weight loss over the storage period, firmness, biochemical aspects like TSS (^{0}B), titratable acidity (%), ascorbic acid content (mg/100g), total carotenoids (µg/100g). The data were recorded at 2, 4 and 6 days interval over the storage periods. In treated mangoes ripening process began after 36 hours calculated from the time of exposure to ethylene. But in case of control the time duration was 72 hours. The experiment showed little difference in respect to biochemical aspect as well as in physical aspect. It was found that mangoes harvested at mature green stage can easily be exposed to ethylene gas(100-150 ppm) for 24 hours in order to uniform ripening and early marketing maintaining better quality in all aspects though ripening chemical is used for ripening the fruits.

Effect of blanching techniques and preservatives on quality and shelf life of tender green jackfruit slices

Tender green jackfruit (65-70 days) was harvested for using as vegetable during early spring and summer until the seeds harden. The fruit matures towards the end of summer in June. The optimum stage of maturity (harvest) of jackfruit has been reported to be 90-110 days after the appearance of the spike. The experiment was laid out with Complete Randomized Design (CRD) with six treatments namely blanching at 95^0C for 3 min and treated with 500 ppm KMS (T_1), blanching at 95^0C for 3 min and treated with 1000 ppm KMS (T_2), blanching at 95^0C for 3 min and treated with 1500 ppm KMS (T_3), blanching at 95^0C for 6 min and treated with 500 ppm KMS (T_4), blanching at 95^0C for 6 min and treated with 1000 ppm KMS (T_5), blanching at 95^0C for 6 min and treated with 1500 ppm KMS (T_6). The results revealed that most of the enzymes were inactivated when treated with 1000 ppm KMS and blanched at 95^0C for 6 minutes (T_5). According to panel test result treatment T_5 also performed highest overall acceptability score (8.2).

Effect of harvesting time and storage periods on the starch content of potato

The experiment was jointly conducted at the laboratory of Postharvest Technology Division and

Tuber Crop Research Center (TCRC), Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, Bangladesh during December 2018 to July 2019 to study the effect of harvesting time and storage periods on the starch content of potato (Variety: BARI Alu 28). In field condition, the experiment was laid out in a 2 factors Randomized Completely Block Design (RCBD) with three replications and in the laboratory, it (experiment) was laid out in a 2 factors (Factor A: harvesting time with two levels, namely 1. 90 days after planting (DAP), 2. 100 DAP and Factor B: storage periods with two levels namely 1. ambient condition and 2. cool room temperature) Completely Randomized Design (CRD) with three replication. On the day of storage, potato harvest at 100 DAP yielded highest starch content (18.54%) than the potato harvest at 90 DAP (18.21%). But after 4 months of storage, the starch content was decreased gradually from 18.51 to 18.11% at cool room condition whereas it was decreased from 18.12 to 15.75% at ambient condition. Total sugar content was significantly increased from 3.03 to 3.67% at cool room condition while it was increased from 3.03 to 4.00% at ambient condition with the advancement of storage periods. So, the results obtained from the study confirmed that the starch content decreasing and total sugar content increasing tendency was observed with the advancement of storage periods.

Effect of extraction method on starch content of selected BARI potato varieties

The study was conducted to evaluate the starch content and dry matter content of the BARI developed selected 19 potato varieties *viz*. BARI Alu-7, BARI Alu-8, BARI Alu-13, BARI Alu-25, BARI Alu-28, BARI Alu-29, BARI Alu-34, BARI Alu-35, BARI Alu-36, BARI Alu-38, BARI Alu-40, BARI Alu-41, BARI Alu-43, BARI Alu-45, BARI Alu-54, BARI Alu-62, BARI Alu-68, BARI Alu-70 and BARI Alu-71 out of 81. The starch extraction and analytical work was carried out in the Postharvest Technology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701 and the selected varieties was grown in the research field of Breeder Seed Production Center, Debiganj, Panchagar, BARI, Bangladesh. Data were recorded for its starch content (%), dry matter content (%), total sugar content (%), moisture content (%) and ash content (%) of the selected 19 potato varieties while statistically all the data were significant. Consequently their (19 BARI Alu varieties) starch, dry matter, total sugar, moisture and ash content ranged from 8.54 to 18.54%, 11.33 to 22.53, 1.26 to 4.15%, 77.47 to 88.67% and 0.55 to 1.76% respectively. The highest starch, dry matter and moisture content were recorded for the BARI Alu-28 (Lady Rosetta) where the lowest was for the BARI Alu-54. The highest total sugar and ash content was observed for the BARI Alu-25 (4.15%) and BARI Alu-70 (1.76%) respectively. The major findings of the study distinctly indicates that lower moisture content (77.47%) contributed to produce higher content of dry matter (22.53%) and likely higher dry matter contributed to obtain higher content of starch (18.54%) than other BARI Alu varieties.

The nutritional analysis of selected minor fruits of Bangladesh

Minor fruits are the cheapest nutritional source and nutrition database is of great importance in addressing nutritional health benefits of rural and urban communities of Bangladesh. Considering documentation, conservation and promoting nutritional health of the local inhabitants and urban people therefore the present study was carried out. Under this study, 10 minor indigenous fruits were analyzed for their phytochemical, minerals and nutritional compositions. Nutrient data obtained from the study have been compared with published data reported in recognized journals and Books. The selected minor fruits namely Bilimbi (*Averrohoa bilimbi* L), Ber (*Zizyphus Mauritiana* Lam), Aonla (*Phyllunththus emblica* L), Elephant apple (*Dillenia India* L), Toikar **(***Garcinia pedunculata*), Daophal (*Garcinia xanthochymus*), Shatkora (*Citrus macroptera*), Hog plum (S*pondias pinnata*), Citron (*Citrus medica*) and *Jengkol* (*Archidendron pauciflorum***)** was collected according to the protocol of the sample. Results obtained from the study revealed that 10 primary metabolites (nutritional composition), 11 minerals and 19 secondary metabolites (phytochemical constituents) were detected in the selected fruits more or less. Most of the phytochemical constituents and minerals were rich sources of the selected minor fruits. All the selected fruits contained high quantity of total anthocyanin content, total flavonoid content, total ß-carotene content, ascorbic acid content, total antioxidant

capacity, NO free radical scavenging activity, reducing power activity, ferric reducing antioxidant property, DPPH radical scavenging activity, metallic chelating capacity, total phenolic, gallic acid, ferrulic acid and lutein content followed by other phytochemical constituents. In case of minerals, Ca, Mg, K, Na, P, S, B, Cu, Fe, Mn, Zn and B were present high or less quantity. But the Ca, Mg, K, Fe, Mn, Zn and B were predominant followed by other minerals. Among the nutritional compositions, protein, sugar and starch were higher followed by other primary metabolites. However, the study demonstrated that all the selected minor fruits were rich sources of phytochemical diversity and minerals. The phytochemical diversity and minerals are known to play an important roles in the pharmaceutical industry and health benefits. Flavonoids exhibit as anti-inflammatory, antiallergic, analgesic and antioxidant as well. Rather than that, flavonoids also exhibit a wide range of biological activities such as scavenges for hydroxyl radicals. The minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less. The data obtained from the study confirmed that the selected minor fruits contained ascorbic acid content from 22.29 to 664.92 mg/100 g. Therefore, the daily intake of 100 g minor fruits can prevent the scurvy in Bangladesh. Other phytochemicals obtained from the study like anthocyanin, carotenoid, ß-carotene and phenolic content can enrich and increase antioxidant activity. The strong antioxidant activities therefore could be able to reduce all kinds of cancer, anti-tumor, cell damage, carcinogenic, stroke, heart attack, coronary heart diseases, acute liver injury, diabetes and cardiovascular diseases.

Standardization of guava jelly through natural and bioactive approaches

Adulteration in Foods is a serious problems and tremendously increasing in Bangladesh day by day. This is now in national issue to ensure and preserved human rights for safe food consumption for all ages of peoples. By consumption adulterated foods, the future generation will be seriously affected both in physical and mental health. The processed food is mainly adulterated by using various harmful chemicals and toxic artificial colors during processing. Therefore, the present research was conducted to develop chemical and preservative free natural and bioactive guava jelly. Under this study, it was laid out with Complete Randomized Design (CRD). There were six treatments viz. T_1= Guava extracted juice 1 L + sugar 650 g +citric acid 7g + potassium metabisulfite (KMS) 0.20 g (control), T_2= Guava extracted juice 1 L+ sugar 650 g + lemon juice 100 mL + potassium metabisulfite (KMS) 0.20 g (control), T_3= Guava extracted juice 750 mL+ pineapple juice 250 mL + sugar 400 g + lemon juice 100 mL + honey 35 g, T_4= Guava extracted juice 1 L + sugar 650 g +citric acid 7g + Agar 10 g, T_5= Guava extracted juice 1 L + honey 150 g + lemon juice 100 mL, T_6= Guava extracted juice 1 L+ sugar 400 g + lemon juice 100 mL + honey 35 g and T_7= market sample. Among different treatments, treatment T3 and T6 achieved highest organoleptic score. The water activity of the treatment T3 and T6 was 0.56 and 0.59 within the range of a good microbial stability for the product. The color of the treatment T3 and T6 was excellent with their good appearance. The highest vitamin-C content (43.00 and 23.52 mg/100 g) and lower sugar content (45.07 and 45.04) was also noted for the T3 and T6. It is noteworthy that T3 and T6 were totally free from chemicals and preservatives. It is mentioned that honey and natural fresh lemon juice was used as preservative instead of potassium metabisulfite (KMS) and citric acid and other chemicals that is used by the food company. Thus, our natural product (T3 and T6) achieved excellent fresh lemon and honey flavor. This technology could be applied to home scale processing level as it is very simple and easy technique. Finally it can contribute to mitigate the adulteration of jelly. In addition, unemployment youth and women could directly be involved with processing of guava fruit to make a profitable job especially to improve their income.

Base line survey on existing hazardous agents in selected vegetables in supply chain as selected areas of Bangladesh

A survey was conducted in seven districts namely Cumilla, Narshingdi, Chattogram, Bogura, Jashore, Gazipur and Dhaka. A total of 30 samples having 210 samples from seven districts were randomly selected by the questionnaire. Data analysis from seven districts samples, the selected farmers were grouped into four categories based on the age distribution. Most of the farmers belonged to the

age group as following in Cumilla 41-60 (59.38%) years, in Narsingdi 41-60 (51.43%) years, in Chattogram 21-40 (50%) years, in Bogura 21-40 (44.83%) years, in Jashore 41-60 (45.71%) years and in Gazipur 41-60 (77.42%) years. According to educational level, illiterate, primary, secondary and higher secondary levels of education were recorded. Literacy rate was found higher in Chattogram (43.33%) compared to other selected districts. However, most of the farmers did not receive any training on vegetable pest management although some of them were engaged with various NATP program. Different types of insect-pest and diseases attacked vegetables crops at different growth stages, which caused severe loss of yield in the study areas. Hence, almost all of the vegetables growers used synthetic pesticides for protecting their crops from insects and pests. Among the farmers, nobody followed IPM approach in his pest management program. Generally, farmers of the study areas applied pesticides with higher dosages and frequencies (10-15 times) per season than the recommendation level. Most of the vegetables growers used pesticides like Sulcox, Tafgar, Vertimec, Sumicorn, Karahin, Boron, Emma etc. during development stage of vegetables. Almost all the case they are unknown of the physical, chemical, microbial and cross contamination.

Baseline survey on existing status of fried potato chips processing to marketing in selected locations of Bangladesh

The baseline survey was conducted with a view to generate information on existing fried potato chips from processing to marketing status in selected locations of Bangladesh. The baseline information was collected from seven selected districts namely Dhaka, Gazipur, Tangail, Mymensing, Bogura, Munshigonj and Jashore. Fifteen hawkers and five producers were randomly selected to collect the information by the pre-tested questionnaire from each location both from producer to consumer. Most of the hawkers of Bogura was above 40 years old (80%) followed by Dhaka who were 25-39 years old (60%). Eighty percent people were above 40 years old engaged in processing fried potato chips from Bogura. All aged people in Bogura preferred fried potato chips (100%) whereas maximum child in Dhaka (40%) liked fried potato chips. Bogura and Munshigonj people were unknown about healthiness knowledge of fried chips consumption. Bogura, Jashore and Munshigonj processors/producers were hawkers and they prepared the product and distributed the products to the market or direct involved in sale. Fried chips processing people in the survey area used deep frying technique (100%). Eighty percent of the small scale processors use soya bean oil for deep oil frying of potato chips. Most of the respondents changed their frying oil during frying when frying oil turned into cloudy.

Design and development of integrated waxing machine for fruits and vegetable

The aim of the present study was to design and development of an integrated semi-automated waxing machine for fruits and vegetables with a view to enhance the shelf life with improving quality at an ambient temperature. The fabricated machine comprised three basic units (such as washing, waxing and drying unit) which was made up of stainless steel. The dimension of washing and waxing unit were (1160 mm × 765 mm× 690 mm) while the drying unit was (1217 mm × 1310 mm × 420 mm). The washing unit consisted 5 brush pad rollers, the waxing unit had 5 foam pad rollers and the drying unit comprised belt conveyors (1210 mm × 400 mm), where speed can be adjusted by inverter. To evaluate the machine performance, lemon and tomato were used to wax coating with carnauba. Results revealed that 900 - 1000 fruits was waxed per hr. depending on the size and shape of the produce. The operating cost of the machine was reasonable with minimal time. The waxed sample was found to have shiny and glossy appearance with increased shelf life compared to the controlled sample (without waxed).

Determination of hazardous agents (Microbial load) in selected vegetables in supply chain at selected locations

This experiment was conducted to find out hazardous agents (microbial load) in selected vegetables at different locations of Bangladesh. Different vegetables such as data shak, cabbage, cauliflower, country bean, pointed gourd, tomato, indian spinach, okra, spinach, red amaranth, brinjal and bitter gourd were collected from farmer’s field and retailer market. All samples were analyzed to detect presence of different microbial agent such as Salmonella spp., Shigella, Escherichia coli (E. coli), Staphylococcus aureus, Listeria

monocytogenes. Hundred percent sample of country bean, indian spinach, bitter gourd, pointed gourd and brinjal contaminated by Samonella Spp. but 91.5% of tomato, 14.28% of okra, 66.7% of cabbage, 25% of red amaranth ,50% of data shak, 50% of cauliflower and 100% sample of spinach were not contaminated by Salmonella Spp. Presence of Shigella was detected in all tested sample. Hundred percent samples of pointed gourd and brinjal were not contaminated by Shigella. Escherichia coli (E. coli) were present in most of the collected sample. In cabbage and spinach Escherichia coli (E. coli) was found on border line of hygienic indicator.

Effect of different sanitizer on postharvest quality of tomato

This experiment was conducted to evaluate the efficacy test of selected sanitizers such as trisodium phosphate, acetic acid and succinic acid with three different concentrations (0.5%, 1% and 1.5%) on postharvest quality and shelf life of fresh tomato fruit. Green to tannish yellow colored tomato was collected and then dipped into the selected sanitizer solution with different concentration for the study. Salmonella spp. and *E. coli* was identified and quantified in treated sample up to 15 days storage at ambient condition (26±2ºC, 80±5% RH). The result showed that 1.0% trisodium phosphate and 0.5% acetic acid were more effective of treated tomato fruit during 15 days of storage at ambient condition. In terms of nutritional quality in treated tomato fruit, TSS (%) and total acid (%) content were increased while vitamin C (mg/100g) was declined with the advancement of thr storage period in most of the cases of the treated samples.

Determination of formaldehyde in selected fruits and vegetables

The experiment was conducted to detect naturally produced formaldehyde in fruits and vegetables based on spectrometric analysis in the laboratory of Postharvest Technology Division, BARI, Gazipur during 2018-2019. Some fruits (jackfruit, mango, grape, and apple) and vegetables (cauliflower, red amaranth, tomato, data shak, cabbage, brinjal, indian spinach and spinach) were collected from local market and analyzed to estimate the amount of formaldehyde which was produced naturally. Results revealed that naturally occurring formaldehyde was detected in jackfruit 9.633±0.187 ppm, mango 10.27±0.232 ppm, grape 2.426±0.662 ppm and apple 8.695±1.075 ppm. In vegetables formaldehyde was estimated in cauliflower 2.259±0.525 ppm, red amaranth 1.488±0.124 ppm, tomato 3.810±1.138 ppm, data shak 3.568±0.779 ppm, cabbage 2.341±0.489 ppm, brinjal 2.688±0.914 ppm, Indian spinach 1.766±0.707 ppm and spinach 2.623±0.516 ppm respectively.

Effect of de-greening treatment and edible coating on improving quality retention of mandarin fruit (var. Commercial)

This research experiment was conducted in 2018-2019 to determine the appropriate de-greening treatment with edible coating for improving mandarin fruit quality with shelf life at ambient condition (26±2 ºC, 70±5%RH). Fruit were degreened with three different concentration of ethylene such as 6 ppm, 9 ppm and 12 ppm as liquid form by the ethylene generator with a controlled ripening chamber. Fruit were exposed to 72 hrs in the chamber and another 48 hrs in ambient air. Carnauba wax coating was applied as surface coating and it was done by hand sprayer on waxing line. Among the treatments, 6 ppm ethylene + carnauba waxed fruit performed best in terms of overall quality and it significantly reduced weight loss (5-8%) after 3 weeks compared to other treatments. Degreening treatment with coated fruit significantly increased fruit peel appearance (L, a*, b*) resulted fruit surface color turned from greenish to yellowish and exhibited shiny surface during storage. Coated fruit also showed good firmer than non-coated fruit after 3 weeks storage. Nutritional composition of degreened fruit also performed significantly higher during storage. Consumer most preferred the overall quality of the treatment (6 ppm + carnauba) among the treatments.

Effect of de-greening treatment and edible coating on improving quality retention of sweet orange fruit (var. BARI Malta 1)

This research experiment was conducted in 2018 - 2019 to determine the potential de-greening concentration (liquid ethylene) and to evaluate the effect of edible coating on sweet orange for improving quality retention during ambient storage. Fruit dipped into hot water at 45°C for 30 mins performed best modify internal atmosphere that

was determined earlier to conduct another experiment (5% O_2 and ~15% CO_2) and carnauba wax coating was selected as a surface coatings. Three different ethylene concentrations such as 7 ppm, 9 ppm and 11 ppm ethylene were selected for the study. Fruit were exposed to ripening chamber for 72 hrs. and exposed in ambient air for another 48 hrs. Fruit immediately after hot water treated using hand applicator on a washing & waxing line to wax on the surface of the fruit. Among the treatments, 9 ppm C_2H_4+carnauba coated fruit performed best in terms of overall quality and it significantly reduced weight loss (8-10%) after 3 weeks. Wax coated fruit significantly increases fruit peel appearance (L, C*, H*) resulted fruit surface color turned from greenish to yellowish and exhibited shiny surface during storage. Consumer most preferred the overall quality of carnauba coated fruit (9 ppm C_2H_4+carnauba) treatment among the treatments.

Optimization of processing method for osmotically dehydrated mango slices/cubes

This experiment was carried out in 2018-19 to optimize the osmotically dehydrated mango products processing method with a view to make value added products from green mango. For the study, local variety of immature mango (var. Himsagar) was collected from commercial mango traders and then the fruit was washed with potable water. Fruit were sorted and randomly distributed for the experiment. Fruit were sliced and were treated with 4 different concentrations of KMS (potassium metabisulphite) considered as treatment (500 ppm, 1000 ppm, 1500 ppm and 2000 ppm). Fruit sliced were then blanched into hot water and then soaked into KMS mixed water for 30 mins. Fruit sliced were dried in a mechanical cabinet dryer for 12 hrs. Then dried slices were dipped into sugar solution at 45°B for 12 hrs. and dried in the dryer 16 -18 hrs. and preserved in HDPE packet. The fruit packet were stored at ambient condition. Among the treatments, mango sliced/cubes treated with 500 ppm KMS performed better appearance with nutritional quality during 6 months storage.

Optimization of processing method for dried mango (*mangifera indica* l.) products (aam chur)

This research experiment was conducted in 2018 - 2019 to optimize the dried mango products (Aam chur) processing method with a view to improve product quality and to make value added products from green mango. For the study, local variety of immature mango (var. Guti) were collected from commercial mango traders and then fruit washed with potatable water. Sorted and randomly distributed fruit were sliced and treated with 4 different concentrations of KMS (potassium metabisulphite) such as 500 ppm, 1000 ppm, 1500 ppm and 2000 ppm) and turmeric powder (2.5 g/kg & 5 g/kg). Untreated fruit slices were assumed as control treatment. Fruit sliced were blanched into hot water and then soaked into KMS mixed water for 50-60 mins. Mango sliced dried in a mechanical dryer for 48 hrs. and preserved them in HDPE packet. Among the treatments, mango sliced/cubes treated with 1000 ppm KMS and turmeric powder (2.5 g/kg) performed better color and quality during 8 months at ambient condition.

Optimization of processing method for plum pickle

The study was undertaken to optimize the processing of plum pickle to enhance the diversified use of the plum. There were six treatments using various salt and sugar percentages were used for the experiments. After twelve months of storage, the p^H was slightly increased during storage. The microbial growths of the plum pickle were seen in the formulation using plum with 3 percent salt and 10 to12 percent sugar after storage for twelve months but the absence of microbial growths was found in pickle using plum with 4 to 5 percent salt and 10 to12 percent sugar after twelve months of storage. Comparative sensory evaluation of different quality attributes of the plum pickle is judged and found the best formulation of plum pickle. The pickle is prepared using plum with 4 or 5 percent salt and 12 percent sugar scored highest overall acceptance.

Optimization of processing method for plum chutney

The study was undertaken to optimize the processing of plum chutney to extend the variegated use of the plum. There were five treatments using various sugar percentages were used for the experiments. The chutney will be stored for six month but after two months of storage, p^H and TSS was slightly increased where acidity was decreased. No microbial growths of the plum chutney were seen in all the treatments. The

intensity of light yellow color of the chutney were gradually increased and turn into light red color during storage. Sensory evaluation of different quality attributes of the plum chutney is judged and found the treatments T_3 (using 40% sugar in plum) scored highest overall acceptance (8.2 e.g. like very much to like extremely) followed by treatment and T_4 (using 50% sugar in plum).

Effect of pretreatments and storage temperatures on the physic-chemical properties and quality of plum

The study was undertaken to compare physico-chemical parameters and quality of the plum at different pretreatments and storage temperatures for long time use of fresh plum. There were nine treatments using various pretreatments and temperatures for the experiments. For analyzed stored plum firmness, pH, vitamin C and TSS data; it was noticed that in an ambient condition after 7 days stored plum was spoilage but in cold room when the storage temperature was 10 ± 1^0C, the stored plum was good in condition upto 35 days; whereas the stored plum was also good in condition upto 70 days if the storage temperature was 5 ± 1^0C and the plum was wash with clean water as well as it wash with 150 ppm NaOCL solution.

Preservation of plum using brine solution

The study was undertaken to find out the effect of brining on plum to investigate the shelf life of plum in an ambient condition. There were five treatments using various brine solution for the experiments. The brining plum will be stored for six month but the stored plum firmness, pH, acidity, TSS, vitamin C and β-carotene data were analyzed up to 2 month; it was noticed that in an ambient condition the plum firmness, acidity, vitamin C and β-carotene content were decreased as compared to an initial values but for TSS up to 4% brine solution it was decreased then increased whereas, an initial pH was low with stored plum.

Protocol Development and Micropropagation

Standardization of micropropagation protocol for BARI strawberry varieties and their large scale multiplication

Shoot tips of BARI Strawberry-2 and BARI Strawberry-3 were cultured on MS medium supplemented with different concentrations and combinations of BAP, Kn and GA_3. Four different treatments T_1, T_2, T_3, & T_4, were tested for shoot multiplication and elongation. In case of BARI Strawberry-2, for shoot formation 1.0 mg/l BAP + 0.5 mg/l Kn +1.5 mg/l GA_3 combination was found most suitable. Whereas in BARI Strawberry- 3, 0.5 mg/l BAP + 0.5 mg/l Kn +1.5 mg/l GA_3 treatment was found most suitable for shoot formation. In rooting, ½MS medium without hormone produced maximum root than full MS medium. In field performance, BARI Strawberry-2 performed better in fruit number per plant while in single fruit weight, BARI Strawberry-3 performed better.

In vitro regeneration of Chickpea (*Cicer arietinum* L.)

Embryonal axis of BARI Chola-6, BARI Chola-7, BARI Chola-8 and BARI Chola-9 were used for in vitro regeneration in MS medium which consist of TDZ in combination with 2ip and Kinetin. The maximum number of shoot (13.50), highest shoot length (5.63 cm) and maximum node number (4.58) were obtained from BARI Chola-7. In vitro grown shoots were induced for rooting in MS medium supplemented with IBA. The maximum root number (6.42) was obtained from BARI Chola-6. The highest root length (1.42 cm) and highest percentage of rooting (68%) were obtained from BARI Chola-8. Well rooted plantlets were transferred to potting media containing soil, saw and cocodust mixture for establishment. Only 20% plantlets were survived.

In vitro regeneration of Bitter gourd (*Momordica charantia* L.)

For the development of a suitable regeneration protocol of bitter gourd, leaf, internode and cotyledon of BARI Korala-1 was cultured on MS medium supplemented with different concentrations of plant growth regulators. The types of responses were different in various plant growth regulators. Maximum calli were obtained from leaf explant by culturing in MS medium supplemented with 1.5 mg/l 2, 4-D. 3.5mg/l BAP and 0.05mg/l NAA produced higher percentage of shoots and IAA 3.0 mg/l gave higher roots.

Rescue of Amritsagar banana from extinction through biotechnological approaches

Amritsagar banana was collected from different locations of the country such as Mymensingh, Gazipur, Norshingdi, Sylhet etc. and mother orchard has been established at research field of Biotechnology division, BARI, Joydebpur, Gazipur. Amritsagar banana collected from Goforgaon and Kapashia performed better than other varieties and were compared with each other by following the standard Descriptor for Banana (*Musa* spp.). This comparison demonstrate that Amritsagar banana (Kapashia) is superior than Amritsagar banana (Goforgaon) in respect of fruit length, diameter, weight and total fruit number, bunch weight. Shoot tips of Amritsagar banana (Goforgaon & Kapashia) were cultured on MS medium supplemented with different concentrations of BAP. Five treatments were tested for this study. Among the treatments, maximum no. of shoots was observed in T_3 treatment 6.5 and 5.4 in both lines. Well-developed shoots were transferred into ½ MS medium supplemented with different conc. of IBA for root induction. Five different treatments were (T_0, T_1, T_2, T_3 and T_4)

tested maximum numbers of longest roots were observed in both lines in treatment T3. The plantlets were transferred into the poly bag containing soil and cowdung.

Micropropagation of Dragon fruit (*Hylocereus undatus)*

Dragon fruit is being propagated by cutting mostly. But micropropagation may be a good means to produce more plantlet in a short time. For developing a micropropagation protocol of dragon fruit biotechnology division was taken an experiment. From this experiment we found that in micropropagation of dragan fruit explants form seedling given more response than explants from cutting. We observed that from a single explant we may produce 50 seedlings within 60 days through micropropagation and the rate of survival percentage is also good in the potting media for their further field establishment. So micropropagation of dragon fruit is a fruitful achievement for huge production of new seedlings within a short period.

***In vitro* regeneration of papaya (*Carica papaya* L.)**

The aim of this study was to develop an efficient regeneration protocol of papaya from immature seeds. Different concentrations of 2, 4-D were used for callus formation. The highest percentage of explant produced callus (56%) in 10 mg/l 2, 4-D concentration. In regeneration, the highest shoot number (32), highest shoot length (3.77 cm), maximum root number (4.33) and highest root length (2.47 cm) was observed in 0.06 mg/l both BAP & NAA and 3.5 mg/l GA_3.

Molecular genetics and genetic engineering

Marker-assisted transfer of salt tolerance (*Nax*) genes in Bangladeshi wheat varieties

An experiment was conducted with a view to developing salt tolerant wheat varieties using marker assisted selection. Progeny of a cross with two salt tolerant Australian wheat lines having Westonia background (Westonia 5907; Nax1 and Westonia 5924; Nax2) and two popular Bangladeshi wheat varieties BARI Gom-25 and BARI Gom-26 were evaluated in a non-replicated trial. A total of 72 BC3F5 lines were grown and 32 lines were selected on the basis of their performance for further evaluation. Seeds of all 72 BC3F6 lines were harvested and preserved for further research. Work for molecular genotyping of the selected lines for confirming the presence of Nax genes are in progress.

PCR-based detection and characterization of papaya viruses in Bangladesh

Papaya (*Carica papaya*, *Caricaceae*) is a major horticultural crop in Bangladesh. The tree is often infected by various pests and diseases. Papaya ringspot virus (PRSV) is the cause of one of the most important diseases of the plant which is transmitted by aphids.Virus infected papaya leaf samples were collected from 8 districts of Bangladesh. DNA and RNA was extracted from all the collected samples and preserved for further analyses. PCR and RT-PCR amplifications were performed using DNA and RNA from 5 of the isolated samples. Amplification products were obtained only from RT-PCR using primers specific for Papaya ringspot virus (PRSV). Phylogenetic analysis showed association of the selected samples with previously reported isolates from the region but high variability within the local isolates. The experiment will be continued for characterizing rest of the collected isolates.

Study on relative bacterial wilt tolerance of bt egg plant varieties and their non-bt parent lines

Thirty bacterial samples from *Ralstonia solanecearum* affected brinjal fields were collected from 6 different locations of Bangladesh during July 2017 to May 2018. In July 2018 to June 2019 PCR of samples collected from Gazipur were done to confirm the samples were *Ralstonia solanesearum* . 16S ribosomal DNA region was amplified using three sets of universal primers . The three sets of primer combination were 1. forward 8F, reverse 1492R ; 2. forward 8F, reverse 805R;1. forward 533F, reverse1492 R . PCR product was send for sequencing to generate more information about the samples.

Collection and identification of germplasm of cultivated crop and wild species for drought and salinity stress tolerance

Germplasms are the main building blocks for any crop improvement program. Availability of enough seed is pre requisite to conduct experiment. Total 120 proso millet and 16 sorghum germplasm were collected locally and grown during rabi 2018-2019 at Joydebpur, Gazipur to increase the amount of seed. Seeds of each line were harvested and preserved for screening in the next year. Sorghum seed purity was maintained through selfing.

Transformation of tomato for broad spectrum resistance against leaf curl viruses

Several experiments were conducted with a view to genetically transform tomato plants for broad-spectrum resistance against leaf curl viruses. Two binary vectors along with their four derivatives have been constructed for optimisation of transformation protocol. Based on the genome sequence of various ToLCV strains, DNA fragments from three diverse ToLCV species along with two tomato introns were amplified and cloned.Both the virus and intron sequences were assembled into sense/antisense configurations into Escherichia coli using standard protocols. In-house made vectors were tentatively named pBPA-BARI followed by a number.

FtFBP research activities

Maintenance/ purification of Bt brinjal variety/ lines

Field trial was conducted for maintenance of three Btbrinjal lines (BtDohazari, BtKhatkhatia, BtSingnath) and BARI Bt Begun-4 at the research field of Biotechnology Division, Gazipur and On Farm Research Division, Chelopara, Bogura, respectively during 2018-19. Unit plot size was 56 m^2 and replication was in three. Roughing and selection was done as per standard procedure and seed was harvested from desired plants and fruits. Crossing between Bt and its counterpart was done for Bt Dohazari, BtKhatkhatia, BtSingnath at the greenhouse of Biotechnology Division and selection and roguing was done for BARI Bt Begun-4.The amount of seed harvested from BtDohazari, BtKhatkhatia, BtSingnath and BARI Bt Begun-4 was 88 g, 180g, 200g and 250g, respectively.

Assessment of Bt trait and its expression in Bt brinjal varieties from different locations

Grow out test through qualitative ELISA was done in the seed samples of 551 kg of Btbrinjal seed which was produced in different locations during 2017-18. Only 2 sample out of 768 from RARS, Rangpur (i. e. genetic purity 99.76 %) showed negative result towards Cry1Ac protein. Seed sample from other stations showed hundred percent positive results indicated having genetic purity100%. Quantitative ELISA result revealed that Cry1Ac protein varied from 21.13 to 25.99 ppm DW irrespective of variety and locations which was much higher than the critical level. Hence, the produced Bt brinjal seed are able to resistance to brnjal fruit and shoot borer.

Breeder seed production of Bt brinjal varieties

Breeder seed production programme of four Bt-Brinjal varieties *viz*. BARI Bt Begun-1, BARI Bt Begun-2, BARI Bt Begun-3 and BARI Bt Begun-4 were conducted at 4 locations of BARI (Rangpur, Barisal, Gazipur and Bagura) in 0.47 ha (3.5 bighas) of land under the supervision of Biotechnology Division during the winter season of 2018-19. The amount of seed harvested as 15, 6, 7 and 50 kg from BARI Bt Begun-1, BARI Bt Begun-2, BARI Bt Begun-3, and BARI Bt Begun-4, respectively. The total amount of seed was 78 kg.

Tissue-specific expression and seasonal abundance of Cry1Ac protein in Bt brinjal varities

Young leaf, shoot, flower and fruits were collected from four Btbrinjal varieties BARI Bt Begun-1, BARI Bt Begun-2, BARI Bt Begun-3 and BARI Bt Begun-4 at 90, 120, 150 and 180 DAT in both winter and summer seasons. Lyophilized plant samples were assayed by Quantitative ELISA to determine the Cry1Ac protein. Data were analysized by Sigmaplot software. At the early fruiting stage, the Cry1Ac protein expression varied from 32.11 to 33.58 ppm in leaf, 26.24 to 28.51 ppm in shoot, 17.53 to 24.79 ppm in flower

and 19.278 to 24.53 ppm during winter season and 25.73 to 33.58 ppm in leaf, 19.28 to 29.62 ppm in shoot, 20. 07 to 27.63 ppm in flower and 22.41 to 30.28 ppm in fruit during summer season. Bt protein was decreased at the later fruiting stage in both seasons, although there was a fluctuation tendency during the winter season. All the Bt protein level was above the critical level to control brinjal fruit and shoot borer effectively.

Backcrossing of LBR potato clone D951 (137) with diamant

A crossing program was undertaken with a view to develop vector backbone free RB potato clone which will be used for producing late blight resistant potato variety in Bangladesh. In this cross, Diamant used as female parent and RB transgenic line D951-137 used as male parent. Tubers of both parents were planted in green house and provided artificial light for flowering. . After flowering, crossing was done. Berries were set within 7 days after pollination. More than 30 berries were set. Berries were harvested when matured. Berries were weighed and separated into large, medium and small size grades. Maximum berry diameter was recorded in 30 mm, minimum was 20 mm and average was 26.2. Maximum berry weight was found 8.90 g, minimum was 3.81 g and average was 5.90 g). Maximum seeds were recorded in 207/berry, minimum was 100 seeds/berry and average was 141.25. Maximum 100 seed weight was 0.065 g, minimum was 0.047 g and average was 0.056. Maximum (22), minimum (1) and average (11.14) tuber was found from single TPS seedling.

21 SOIL MANAGEMENT

Synchronization of different aged compost to crop demand, nutrient release and their contribution to the production of cauliflower

This study was conducted at the research field of Soil Science Division, BARI Gazipur during the *rabi* sason 2017-2018 & 2018-2019 to understand the release of nutrientsfor crops and their contribution to cauliflower growth and yield. Cauliflower cv. Whitehead was used for this experiment. Four different organic amendments of different ages were studied in comparison with only chemical fertilizer application. The amendment treatments were T_1: 30 days aged compost, T_2: 45 days aged compost, T_3: 60 days aged compost, T_4: 75 days aged compost. The experiment was laid out in a Randomized Complete Block Design (RCBD), where each treatment was replicated thrice. Data on growth and yield attributes of cauliflower were collected during the crop growing season and after harvesting. Necessary soil data were also collected periodically to determine available nitrogen (N) status as well as the microbial-respiration of soil during the experimental period. Yield and its component of cauliflower were significantly affected by different aged compost. The organic amended performed in the sequence: 30 DOC>45DOC>60 DOC>75 DOC. The increases of curd yield in 30 DOC, 45 DOC, 60 DOC and 75 DOC were 82.4, 60.5, 52.8 and 49.8 % higher than curd yield obtained with only chemical fertilizer. A significant increase in marketable yield, curd weight plant^{-1} of cauliflower and curd diameter was obtained with organic amended treatments relative to only chemical fertilizer application. The hetero-tropic respiration (CO_2 emission) was found higher in soils under 30 DOC which might be due the rapid decomposition of the semi-composted materials applied in the treatments. The available N recorded in 30 DOC treatmentwas more synchronised with the crop demand which resulted in increased yield of cauliflower in the same treatment. Overall, compost of 30 days old was found to be the best aged compost to apply for obtaining the best yield of crops like cauliflower. However, no discreet conclusion can be drawn unless the research continues for few more years.

Effect of mulch on soil temperature, soil moisture conservation and yield of chilli

The experiment was conducted at RARS, Jamalpur during the period of 2017-18 and 2018-19 to evaluate the effect of different mulch on soil temperature, soil moisture conservation and yield attributes of chilli. There were five treatments comprising T_1: no mulch, T_2: rice straw mulch @ 5 t ha^{-1}, T_3: water hyacinth mulch @ 5 t ha^{-1}, T_4: black polyethylene mulch and T_5: white polyethylene mulch. All the mulching materials were significantly different from the control. In 2018-19, black polyethylene mulch increased average soil temperature by about 5.3 ^{o}C at 5 cm depth and by 6.1 ^{o}C at 10 cm depth compared to no mulch treatment at 120 days. Mulch treatment also had a higher soil moisture content at 5 cm and 10 cm depth. The results revealed that, rice straw mulch apparently increased average soil moisture about 5.8 % at 5 cm depth and 6.0 % at 10 cm depth compared to control treatment. In 2017-18, rice straw mulch produced highest green chilli yield (9.13 t ha^{-1}) which was 26.62 % increased over no mulch treatment (7.21 t ha^{-1}) and in 2018-19, rice straw mulch also produced highest green chilli yield (8.49 t ha^{-1}) which was 27.28 % increased over no mulch treatment (6.67 t ha^{-1}). Considering economic analysis, in both the years, the highest benefit cost ratio (3.01) and (2.80) was obtained from same treatment T_2 i.e., rice straw mulch treatment.

Effect of conservation tillage and phosphorus on the productivity of pea-maize-t.aman rice cropping pattern and on soil health

A field experiments on Pea- Maize-T.aman rice cropping pattern were conducted in Grey Terrace soil of Joydebpur under AEZ-28 during *rabi* 2018-19 to observe the effect of tillage practices and phosphorus on soil properties and to increase the productivity of cropping system. There were 2 types of tillage such as Strip tillage (ST) and conventional tillage (CT). In addition, 3 type application of phosphorus such as granular dose(basal) (P_1), powder doses (P_2) and granular doses (split) (P_3) in a split plot RCB design with 6 treatments and 3 replications. Strip tillage gave more yield than conventional tillage for pea ($p \leq 0.05$) vice-versa for maize($p \geq 0.05$). Powder dose (basal) significantly performed the best than other phosphorus doses for both crops. The third crop T. aman is going on with successive growth.

Effect of conservation tillage and split application of potassium on the productivity of maize- black gram- t. aman cropping pattern and physico-chemical properties of soil

A field experiments on Maize-Black gram-T.aman rice cropping pattern were conducted in Grey Terrace soil of Joydebpur under AEZ-28 during rabi 2017-18 and 2018-19 to observe the effect of tillage practices and timing of potassium application on soil properties and to increase the productivity of the cropping sequence. There were 2 types of tillage such as Strip tillage (ST) and conventional tillage (CT). In addition, 3 split application of potassium such as basal dose (K_1), two split doses (K_2) and three split doses (K_3) in a split plot design with 6 treatments and 3 replications. Conventional tillage gave significantly more yield than strip tillage for T. aman but strip tillage gave more yield than conventional tillage for maize. For both crops two spilt doses performed better yield than other doses. Strip tillage with two spilt dose gave the most soil moisture and field capacity than other combinations but conventional tillage with two split doses gave the lowest penetration resistance than other combinations. Little positive and negative change was occurred for chemical properties. The third crop of second cycle T. aman is going on with vegetative stage.

Effect of minimum tillage and plant residue mulching on wheat cultivation in coastal saline areas of Bangladesh

In the coastal saline areas of Bangladesh, planting a crop in the residues of the previous crop along with minimal disturbance of soil can be a successful and sustainable cropping practice. Considering these aspects, a field experiment was conducted to evaluate the best tillage practice for wheat in saline areas and observe the effect of permanent soil cover on wheat at the Agricultural Research Station (ARS), BARI, Benarpota, Satkhira during the rabi season (winter) of 2018-2019. Wheat cultivation by Power Tiller Operated Seeder (PTOS), relay of wheat with and without residue, strip tillage of wheat with and without residue as well as farmers' practice were taken as the treatments in a randomized complete block design with three replications. Except the initial plant population, final plant population and days to heading and maturity; all other plant characters like Plant height, spikelets spike^{-1}, grains spike^{-1}, 1000 grain weight, grain and straw yield were significantly influenced by the sowing method and residue retention. Comparing the performances of different methods of sowing, strip tillage of wheat without residue (T_5) carried out the highest grain yield (4.12 t ha^{-1}) over relay production of wheat though strip tillage of wheat with residue (T_4) showed the statistically same yield . Relay of wheat with and without residue gave statistically identical grain yield which was the lowest among all other treatments while took the least days to maturity. Timely sowing through agro-machineries exerted significant influence on the grain set and yield of wheat. Considering yield and variable cost, the highest gross margin (Tk. 63750 /ha) and marginal benefit cost ratio (2.07) were calculated from T_5 where strip tillage of wheat without residue were practiced vigilantly.

Effect of minimum tillage and crop residue retention on soil physico-chemical properties and crop yields under a rice-based cropping system

An experiment was conducted at BARI Central Farm, Joydebpur and RARS, Jashore during 2016-17, 2017-18 and 2018-19 to observe the effects of tillage and residue retention on soil physico-chemical properties and crop yields along with to assess the system productivity in rice-based cropping system. Two tillage practices such as, T_1:

conventional tillage (CT) and T_2: strip tillage (ST) were assigned in main plot and two levels of residue retention such as R^+: 30 cm crop residue retention/incorporation of wheat and rice and full straw retention of mungbean, and R^-: removal of crop residue. In both the locations, increased residue retention conserved more available soil moisture content at 20 DAS (CRI), 50 DAS (spike initiation) and 80 DAS (grain filling) in soils in wheat field at dry condition whereas higher soil moisture was found in strip tillage at 50 DAS (spike initiation) and 80 DAS (grain filling) than conventional tillage. With these synergistic effects of strip tillage and residue retention, longer spike length and higher number of spikelets spike^{-1} of wheat were obtained than conventional tillage and residue removal (R^-). Consequently, statistically higher grain yield of wheat (4.30 and 3.91 t ha^{-1}) was found in strip tillage over CT practice (3.83 and 3.93 t ha^{-1}) whereas residue retention treatment gave higher wheat yield (4.35 and 3.66 t ha^{-1}) compared to residue removal treatment (3.78 and 3.64 t ha^{-1}) at Joydebpur and Jashore, respectively. On the other hand, tillage practices and residue retention had no significant effect on the previous crops mungbean and T. Aman. At RARS, Jashore, the ST gave higher rice equivalent yield (12.9 t ha^{-1} year^{-1}) over CT practice. After 7th crop harvested, increased residue retention showed increased nutrient concentrations and microbial population in soil over residue removal treatment.

Effect of tillage methods and biochar on the cropping system productivity and establishment of carbon and nitrogen footprints

A field experiments on Wheat-Mungbean-Monsoon rice cropping system was conducted in Grey Terrace soils of Joydebpur under AEZ-28 during 2017-2019 to observe the effect of conservation tillage practice (strip tillage) and organic C application including biochar on soil properties and crop yields, to find out the optimum combination of tillage practice and potential C source for soil C stabilization and, to assess C and N footprints under different tillage and C sources. The effects of conservation tillage were compared with conventional practices. In addition, four (4) carbon sourcessuch as crop residue retention, biochar of mungbeanstover, cowdung and farmer's practice were laid out in a split plot design with 8 treatments and 3 replications. The yield of crops was found higher in soils under biochar applied ST and CT practices. The increased yieldsin biochar amended soilsmight be associated with higher availability of N during important stages of the crop. The soil properties (i.e., available water content and soil strength) were congenial for crop production under strip tillage and biochar amended soils.Biochar amended soils under both strip and conventional planting was the best mitigation practice which diminishes the emission relative to conventional practice. However, the experiment should be continued to reach to a concrete conclusion.

Integrateed nutrient management for sustaining soil fertility and production of wheat-mungbean-t.aman cropping pattern

A long term field experiment on Wheat-Mungbean-T.aman cropping pattern was carried out in High Ganges River Flood plain Soils (AEZ-11) of RARS, Jashore during the year of 2000-2018. The objectives were to find out sustainable fertilizer recommendations, monitor soil health, estimate uptake of different nutrient for the cropping pattern and to make a balance sheet for each of the nutrient. There were six treatments viz. 125% recommended dose (RD), 100% RD, 75% RD, 50% RD, farmers practice and native nutrient. Results showed consistently highest yield from each of the crops of the pattern obtained with 125% RD treatment and which were statistically similar to 100% RD treatment. Highest total rice (system) yield of 12.92 t ha^{-1} year^{-1} was obtained from T_1 treatment (125% RD). Lowest total rice (system) yield of 6.89 t ha^{-1} year^{-1} was obtained from control i.e. native fertility treatment (T_6).Highest gross margin of 117557 Tk/ha/yr.was also obtained from T_1 treatment (125% RD).The highest benefit cost ratio of 1.83 was found in T_1 (125% RD).

Nutrient management for sustaining soil fertility and performance of mustard-mungbean-t.aman cropping

A long term field trial on Mustard-Mungbean-T.aman cropping pattern has been conducted in High Ganges River Flood plain Soils (AEZ-11) of RARS, Jashore during the year of 2000-2018. The objectives were to find out sustainable fertilizer doses for the pattern, monitor soil health, estimate uptake of different nutrients and make a balance sheet for each of the nutrient. There were three levels each of N (80, 120 and 160 kg ha^{-1}), P (18, 36 and 54 kg ha^{-1}) and K (35, 70 and 105 kg ha^{-1})

in the treatment combinations.The combined effect of 120-54-70-40-3-1 kg ha^{-1} of N-P-K-S-Zn-B (T_5) produced the highest seed yield (1.51 t ha^{-1}) of mustard.The residual effect of 120-54-70-40-3-1 kg ha^{-1} of N-P-K-S-Zn-B (T_5) gave the highest yield of both grain and straw yield of mungbean and T.aman rice. Highest total rice (system) yield of 14.73 t ha^{-1} $year^{-1}$ was obtained from T_5 treatment. Lowest total rice (system) yield of 8.65 t ha^{-1} $year^{-1}$ was obtained from control i.e. native fertility treatment (T_8). Highest gross margin of 133918Tk/ha/yr.and BCR of 1.83 was obtained from T_5 treatment. It was observed that a total amount of 1345.9, 285.3, 1242, 210.7 and 10.6 kg ha^{-1} of NPKS and Zn were removed from the soil by seventen cropping cycles while 1300, 540, 700, 250, and 15 kg ha^{-1} of NPKS and Zn were added in the soil as nutrients. N and K balances were found positive while P, S and Zn balances were found negetive.

Long-term integrated nutrient management for sustaining soil fertility and yield of maize-mungbean-t. aman cropping pattern

A long-term field experiment on Maize-Mungbean-T. aman cropping pattern was conducted in the Grey Terrace Soil (AEZ-28) of Gazipur during the year of 2007-2019 with the objectives of finding out suitable fertilizer combination for sustainable yield of the pattern, monitoring soil health as affected by chemical fertilizers and organic manures and to make a balanced sheet of each nutrient. There were six treatments viz. T_1: Native fertility, T_2: MYG (STB) from chemical fertilizers + 5 t ha^{-1} CD, T_3: HYG (STB) from chemical fertilizer, T_4: HYG (STB) from chemical fertilizer + 5 t ha^{-1} CD, T_5: HYG (STB) from chemical fertilizer + 3 t ha^{-1} PM and T_6: MYG (STB) from chemical fertilizers. Data revealed that the T_5 produced the highest yield of maize grain consistently in twelve cropping cycle. The legume component (mung bean) produced over 1 t ha^{-1} grain and added over 13 t ha^{-1} green biomass. The third crop (T. aman rice) also produced the highest yield in the T_5 treatment. The yields of maize and rice were statistically similar to all other fertilizer treatments.The native fertility treatment produced the lowest yield. N, K and S balances were found negetive whereas P balance was found positive except T_1 treatment (native fertility).

Effect of poultry litter biochar on maize in acidic soil

Effect of poultry litter biochar (PLB) on maize was conducted in acidic soil of Central farm Gazipur and Belabo, Norsindi during the year of 2018-19. Three rates of poultry litter (PL) and poultry litter biochar (3, 6 and 9 t ha^{-1}), compare to dolomaite @ 1 t ha^{-1} and no amending materials with recommended dose chemical fertilizer (RDCF) were investigated. Composite soil samples were collected to the depth of 0–15 cm and analyzed for bulk density, total porosity, pH, soil organic carbon, total nitrogen, available phosphorus, and potassium using standard procedures before and after biochar application. The results showed the application of biochar significantly reduced soil bulk density and exchangeable acidity when compared with a control ($p < 0.05$). Moreover, the total soil porosity, soil pH, total nitrogen, soil organic carbon, available phosphorus and potassium were significantly increased in the soil. Compare to poultry litter (PL), PLB exhibited a higher soil pH and organic carbon with the magnitude of the increase dependent on the amount of biochar incorporated to the soil. The yield of the BARI khoivutta using RDCF weighed 3.46 t ha^{-1} at Gazipur and 3.31 t ha^{-1} at Norsingdi. Obviously, PLB increased the grain yield from 4.34 t ha^{-1} to 5.29 t ha^{-1} at Gazipur4.17 t ha^{-1} to 5.34 t ha^{-1} Norsingdi, where highest yield found by addition of 9 t ha^{-1} PLB, respectively. Compared with the unamended control, yield increase up to 50% at 9 t ha^{-1} of biochar treated soil, whereas yield increases 20% at 1 t $ha^{-1}$of dolomite treated soil. The highest total organic carbon was obtained where higher dose of biochar applied, which leads to an increase in soil organic carbon.

Comparative study on crop straw and their biochars to increase carbon stock and soil health

The amelioration capacity of crop straws and their biochars in improving soil carbon stock and soil health for maize production were studied. Six crop straws, were used to prepare biochars by a device using pyrolysis method (temperature <700°C; oxygen-limited). Single application rates of 1% were used for both crop straws and their biochars in pot trail lasting 60 days each year and keep the pots in ambient condition. After three years, soil pH (1 : 2.5 soil to water), soil exchangeable acidity and soil exchangeable base cations were determined to evaluate the amelioration effects of these crop

straws and their biochars on an acidic soil. Biochar amendment increased soil pH, but crop straw and lime had no effect on soil pH as well as maize dry biomass.The biochars from legume straws induced more increase in soil pH than non-legume biochars. Thus more increase in soil pH induced by the high addition level of biochars led to the greater decrease in soil exchangeable acidity. Increment of carbon stock in soil ranges from 2.65 to 12.12% by using crop straw and biochar from same sources increasesaround 25% from initial soil organic carbon.Maize growth increased with application of biochar whereas crop straw showed least performance compared with control treatments. Comparatively, biochars produced double crop biomass than that of crop straw. The incorporation of biochar not only neutralize soil acidity, but can also improve soil fertility and carbon stock into the soil.

Effect of crop residue and their biochars for crop production

Comparative investigations on the effects of crop straw and its derived biochars on crop yield was investigated. Crop straws (i.e. groundnut straw, chickpea straw, and mustard straw) and their derived biochars were used where cowdung used as comparison. The changes of soil properties like pH, organic matter content and soil health effect on yield and yield components of maize. Results indicated biochar, especially those were high in pH, enhanced soil pH (>0.2 units, $p < 0.05$), whereas reduction and or unaffected of soil pH was observed among treatments with crop straws. The organic matter content increased with the application of crop straws and biochars as well as cowdung. The incorporation of biochars produced from crop straws increased the soil pH ranges from 0.28 ~ 0.39 unit, and their ameliorating effects varied due to raw materials of biochars. Increment of carbon stock in soil ranges from 0.07 to 0.08U by using crop straw and biochar from same sources increases around 30% from initial soil organic carbon (0.27 U). The incorporation of biochar not only neutralize soil acidity, but can also improve soil fertility and carbon stock into the soil. The results on the yield parameters of the BARI Khoi Bhuttas howed that crop straw increased the grain yield from 4.6 t ha^{-1} to 4.79 t ha^{-1} where crop straw biochar increased 5.26 t ha^{-1} to 5.88 t ha^{-1}, where 4.53 t ha^{-1}yield obtained from RDCF with cowdung 5 t ha^{-1}, that is 20% higher yield produced from RDCF treatment. Crop straw biochar enhanced the yield up to 55% from RDCF and 30% from crop straw.

Development of fertilizer recommendation for cauliflower with maize intercropping system

An experiment was conducted at BARI Central Research Station, Gazipur during the *rabi* season of 2018-2019. The experiment was conducted with nine treatments *viz.* T_1 (100% RDCF of Maize + 0% RDCF of Cauliflower), T_2 (100% RDCF of Maize + 10% RDCF of Cauliflower), T_3 (100% RDCF of Maize + 20% RDCF of Cauliflower), T_4 (100% RDCF of Maize + 30% RDCF of Cauliflower), T_5 (100% RDCF of Maize + 40% RDCF of Cauliflower), T_6 (100% RDCF of Maize + 50% RDCF of Cauliflower), T_7 (100% RDCF of Maize + 60% RDCF of Cauliflower), T_8 [Sole Maize (100% RDCF of Maize with recommended spacing)] and T_9 [Sole Cauliflower (100% RDCF of Cauliflower with recommended spacing)]. Both maize and cauliflower significantly influenced by different treatments**.** Average highest total system (maize) yield of 27.89 t ha^{-1} was obtained from T_7 treatment (100% RDCF of Maize + 60% RDCF of Cauliflower). Economic analysis revealed that highest BCR of 4.56 was obtained from T_6 treatment (100% RDCF of Maize + 50% RDCF of Cauliflower). BCR in sole maize and sole cauliflower were 2.62 and 4.49, respectively. Nitrogen, potassium and sulpher balance were found negetivewhere as phosphorus balance was found positive in all the treatments.

Efficacy of different form of urea on nitrogen availability and yield of maize

The experiment was conducted at BARI, Gazipur during rabi season of 2018-19 :i) find out use efficiency of different form of urea, ii) find out the yield and yield components of maize as influenced by different form of urea and iii) analyze cost and return of maize produced from different form of urea. There were four treatments viz. T_1: N-control, T_2: RD of nitrogen (225 kg/ha) in the form ofPrilled urea, T_3: Application of 200 kg nitrogen/ha in the form of urea super granule (USG), T_4: Application of 205 kg nitrogen/ha in the form of neem coated urea. P, K, S, Zn & B were applied @ 60, 110, 40, 4 & 1.4 kg ha^{-1}. The highest yield (9.37 t ha^{-1}) of maize was obtained from T_3 treatment (200 kg N as USG) which was very close to T_4 treatment (9.32 t ha^{-1}) . The lowest yield (5.78

t ha^{-1}) of maize was noted in N-control treatment (T_1). The actual nitrogen add (120 kg ha^{-1}), nitrogen uptake (178 kg ha^{-1}) and nitrogen balance (-58 kg ha^{-1}) by maize was highest in T_3 the treatment. If 1 kg extra nitrogen applied, 17.95 kg extra maize grain yield over N-control was observed in T_3 treatment. Cost and return analysis revealed that highest gross margin (75641 Tk. ha^{-1}) as well as BCR of 2.18 was obtained from T_4 treatment (Neem coated urea applied maize plot). BCR in prilled urea and USG applied maize were 2.13 and 2.12, respectively.

Effect of different sources of organic manure on the yield of cauliflower

A field experiment on effect of different sources of organic manure on cauliflower was conducted in the Grey Terrace Soil (AEZ-28) of Gazipur during the years of 2017-18 and 2018-19 to find out suitable organic manure for vegetable production and to find out the efficacy of different organic manures on producing vegetables. There were eight treatments *viz.* T_1: Native nutrient, T_2: Poultry manure @ 10 t ha^{-1}, T_3: Cowdung @ 20 t ha^{-1}, T_4: Farm Yard Manure @ 18 t ha^{-1}, T_5: Vermicompost @ 15 t ha^{-1}, T_6: Compost @ 15 t ha^{-1}, T_7: Tricho-Compost @ 10 t ha^{-1}, T_8: Bioslurry @ 15 t ha^{-1}. Data revealed that the T_5 treatment produced the highest yield of cauliflower 45.64 t ha^{-1} in 2018 and 41.52 t ha^{-1} in 2019. The native nutrient treatment produced the lowest yield (6.79 t ha^{-1} in 2018 and 16.81 t ha^{-1} in 2019). The uptake of nutrients by cauliflower curd was highest in the treatment T_5 (vermicompost). The highest gross margin (743150 Tk./ha) and MBCR (5.99) was noted from T_8 (Bioslurry) treatment.

Effect of bioslurry and chemical fertilizer on the yield and quality of onion

The experiment was conducted at central research farm, BARI, Gazipur during *rabi* seasons of 2017-18 and 2018-19 with the objectivesto find out the effect of bioslurry on the yield and yield components of onion and to find out nutrient uptake as influenced by different sources of bioslurry. There were eleven treatments *viz.* T_1: Native fertility, T_2: 75% Soil Test Based (STB) fertilizer, T_3: 75% STB + 3 t ha^{-1} Poultry Manure (PM), T_4: 75% STB + 3 t ha^{-1}PM slurry, T_5: 75% STB + 5 t ha^{-1}Cowdung (CD), T_6: 75% STB + 5 t ha^{-1} CD slurry, T_7: 100% STB, T_8: 100% STB + 3 t ha^{-1} PM, T_9: 100% STB + 3 t ha^{-1} PM slurry, T_{10}: 100% STB + 5 t ha^{-1} CD, T_{11}: 100% STB + 5 t ha^{-1} CD slurry. The highest yield of onion (13.52 t ha^{-1} in 2018 and 12.82 t ha^{-1} in 2019) were obtained from T_{11} treatment (100% STB chemical fertilizers + 5 t CD slurry ha^{-1}). The lowest yield of onion (7.53 t ha^{-1} in 2018 and 5.51 t ha^{-1} in 2019) was noted in native fertility treatment (T_1).Total Soluble Solid (TSS) content (17.15%) of onion bulb was recorded higher in T_{11} treatment where applying 100% STB chemical fertilizers + 5 t ha^{-1}cowdung slurry. The uptake of nutrients by onion bulb was highest in the treatment T_{11} (100% STB + 5 t ha^{-1}cowdung slurry) followed by T_9 treatment where applying 100% STB chemical fertilizers + 3 t Poultry manure slurry). The highest gross margin (105783 Tk/ha) and marginal value product (146200Tk/ha) was observed from T_{11} (100% STB + 5 t ha^{-1}cowdung slurry) treatment.

Effect of organic manures on vegetable crop production and carbon accumulation in soil

A field experiment on effect of organic manure onvegetable production and carbon accumulationsin soil was conducted in the Grey Terrace Soil of Gazipur (AEZ 28) during the year of 2016-2017 year to enhance carbon accumulation in soil, to improve the stock of organic carbon in the soil and to increase crop yield through integrated plant nutrition system (IPNS). First two years, the research was conducted on broccoli production. In this current year, the research was conducted on cabbage production. There were six treatments *viz.* T_1: Native nutrient, T_2: 75% STB, T_3: 100% STB, T_4: 5 t ha^{-1} CD + IPNS, T_5: 3 t ha^{-1} PM + IPNS, T_6: 3 t ha^{-1} VC + IPNS. Data revealed that the T_6 (VC + IPNS) treatment produced the highest yield of cabbage 85.54 t ha^{-1}. The native nutrient treatment produced the lowest yield. The highest nutrient uptake by cabbage was noted in T_6 treatment. IPNS through vermicompost improved nutrient status in post harvest soil. Organic manures also increased accumulation of organic carbon in soil.Highest net return was obtained in T_6(VC + IPNS) treatment but BCR was lower in this treatmentdue to high price of vermicompost. Among the all IPNS treatments, the highest BCR (6.09) was found in T_5 (PM + IPNS).

Development of fertilizer recommendation for four cropsbased cropping pattern: mustard-mungbean-jute-T. aman

A field experiment on Mustard-Mungbean-Jute-T.Aman cropping pattern were conducted atJashore

(AEZ-11) and Jamalpur (AEZ-8) during the year of 2017-18and 2018-19 of finding out suitable fertilizer combination for sustainable yield of the pattern, monitoring soil health as affected by chemical fertilizers and to make a balanced sheet of each nutrient. There were eight different treatments viz. T_1: 100% NPKSZnB (STB), T_2: T_1+ 25% N, T_3: T_1+ 25% NP, T_4: T_1+ 25% NK, T_5: T_1+ 25% PK, T_6: T_1+ 25% NPK, T_7: 75% of T_1, T_8: Native fertility. The experiment was laid out in RCB design with three replications. Data revealed that the grain yield of Mustard (BARI Sarisa-14), Mungbean (BARI Mug-6) and T. Aman (BRRI dhan57), and fibre yield of Jute (O-9897) were significantly influenced by the fertilizer treatments. The highest yield was obtained from the T_6 treatment where 25% additional NPK was added over the 100 % STB rate.

Nutrient management for a rooftop garden

The study was conducted at Gazipur (rooftop of Soil Science Division) during the year of 2017-18 and 2018-19. Two types of research work were conducted in this work. One was integrated nutrient management based research (Organic and inorganic combination) and another is towards soil organic ratio based research (Only used organic fertilizers) for safe food production in the rooftop garden. The experiment activities included fertilizer management of some vegetables, fruits and flowers; and influence of different ratio of soil and organic materials on the growth and yield of vegetables, fruits and flowers for rooftop garden. Prior to setting the experiments initial soil samples as well as organic fertilizers were analyzed and nutrient statuses were determined. Incase of experiments regarding nutrient management of some vegetables, fruits and flowers, T_7 treatment (80% of T_1 + 2 kg vermicompost /6kg soil) showed best performance followed by T_3 treatment (80% of T_1 + 2 kg Kitchen waste/6kg soil) for maximizing the yield of vegetables and flowers grown on the rooftop garden. Vegetables (capsicum & bottlegourd), fruits (strawberry) and flowers (periwinkle, gladiolus & gerbe ara) performed better in T_5 treatment (1 kg vermicompost for 1 kg soil) compared to others in the experiments related to influence of different ratio of soil and organic materials on the growth and yield of vegetables, fruits and flowers for rooftop garden. The lowest yield was recorded from the T_4 treatment (1 kg Cowdung for 2 kg soil). Resuts showed that, T_5 treatment gave 20-24% higher yield over other treatments.

Effect of biochar and chemical fertilizers in different bed condition on the growth and yield of brinjal

A field trial was conducted at Regional Agricultural Research Station (RARS), Jamalpur during the period of 2018-19. The objectives of the study were to observe the biochar and chemical fertilizers in different bed condition to improve the soil health and increase the yield. The experiment was laid out in Randomized Complete Block (RCB) design with two factors (biochar rate and different bed conditions) having three treatments in each factors replicated thrice. Three biochar rate were: C_1= 100% Recommended Dose of Chemical Fertilizer (RDCF) +biochar (0 t ha $^{-1}$), C_2 = C_1 + biochar (5t ha^{-1}) and C_3= C_1 + biochar (10 t ha^{-1}) and three bed conditions were:B_1 = flat bed (0 cm), B_2 = normal bed (8 cm) and B_3 =raised bed (15 cm). There were nine treatment combinations. The highest numbers of leaves, the total fresh and dry weights were given a positive effect with the biochar addition compared to the no addition of the biochar to the soil in different bed condition. The highest yield(40.47 t ha^{-1}) was obtained from the combination of biochar (10 t ha^{-1}) with normal (8 cm) bed condition which was statistically identical with the combination of biochar (10 tha $^{-1}$)with raised (15 cm) bed condition. The lowest yield (34.18 t ha^{-1}) was obtained from the combination of biochar (0 t ha^{-1}) with flat (0 cm) bed condition. Moreoverbiochars can be used as soil amendments and improving the soil fertility.

Development of fertilizer recommendation for garlic with coriander intercropping system

A field trial was conducted at Regional Agricultural Research Station (RARS), Jamalpur during 2018-19 to develop a fertilizer recommendation for garlic with coriander intercropping system. There were six treatments comprising T_1 = 100% RDCF of garlic+ 0% RDCF of coriander, T_2 = T_1 + 10% RDCF of coriander, T_3 = T_1 + 20% RDCF of coriander, T_4 = T_1 + 3 0% RDCF of coriander, T_5 = T_1 + 40% RDCF of coriander, T_6 = T_1 + 50% RDCF of coriander. Significantly the highest yield (6.36 t ha $^{-1}$) was obtained from T_6 (T_1 + 50% RDCF of coriander) treatment which was statistically identical with T_5

(T_1 + 40% RDCF of coriander) treatment. Significantly highest foliage yield (4.32 t ha $^{-1}$) of coriander was obtained from the T_6 (T_1 + 50% RDCF of coriander) treatment which was statistically identical with T_5 (T_1 + 40% RDCF of coriander) treatment (4.26 t ha $^{-1}$). The highest net return (425484 Tk ha $^{-1}$) was obtained from T_5 (T_1 + 40% RDCF of coriander) treatment which was followed by T_6 (T_1 + 50% RDCF of coriander) treatment (425310 Tk ha. $^{-1}$).The highest BCR (3.64) was obtained from T_5 (T_1 + 40% RDCF of coriander) treatment which was followed by T_6 (T_1 + 50% RDCF of coriander) treatment (3.58) and the lowest net return (201335 Tk ha^{-1}) from T_1 (100% RDCF of garlic+ 0% RDCF of coriander) treatment. Although the highest yield (6.36 t ha $^{-1}$) was obtained from T_6 (T_1 + 50% RDCF of coriander) treatment, BCR was lower than T_5 (T_1 + 40% RDCF of coriander) treatment due to higher cost of inorganic fertilizers.

Comparative study of different application methods of potassium on aroid

A field trial was conducted at Regional Agricultural Research Station (RARS), Jamalpur during 2017-18 to study the effect of basal and top dress application of potassium on quality of aroid and to increase the yield of aroids through potassium management. There were seven treatments comprising T_1= 100 % K of Recommended Dose of Chemical Fertilizer (RDCF) as basal, T_2 = 100 % K of RDCF as top dress (one split), T_3 = 50 % K of RDCF as basal + 50 % K of RDCF as top dress (two splits, T_4 = 50 % K of RDCF as basal + 50 % K of RDCF as top dress (three splits), T_5 = 50 % K of RDCF as basal + 50 % K of RDCF as top dress (four splits), T_6 = Farmer's practice, T_7= Native fertility. The yield attributes and yield of aroids were increased through potassium management. The highest stolon yield (27.81 t ha^{-1}) and highest rhizome yield (22.53 t ha^{-1}) was found in T_5 [50 % K of RDCF as basal + 50 % K of RDCF as top dress (four splits)] treatment, which was significantly higher than the other treatments.The treatment [T_6 i.e. Farmer's practice (CD @ 20 t ha^{-1}+ N_{270} P_{50} $K_{263}S_{20}$ kg ha^{-1})] showed the second highest yield (19.27 t ha^{-1}). The lowest stolon yield (8.34 t ha^{-1}) was in the control treatment.Top dressing of potassium application is effective on aroids production in Bangladesh.

Comparative study of effectiveness of TSP and DAP fertilizer on brinjal

The experiment was conducted at Regional Agricultural Research Station (RARS), Jamalpur during 2018-19 to find out suitable phosphorus fertilizer source and application method for higher brinjal production and to increase phosphorus use efficiency. There were six treatments comprising T_1 [P from TSP (100% basal dose)], T_2 [P from DAP (100% basal dose)], T_3 [P from DAP (50 % basal + 50% top dress)], T_4 [P from DAP (25 % basal + 75 % top dress)], T_5 [P from DAP (100 % top dress)] and T_6 (P-control). NKSZnB were used as a blanket dose in all treatment. Data revealed that, all the treatments were significantly different from control on all the growth and yield parameters. The highest brinjal fruit yield (35.77 t ha^{-1}) was found in T_3 treatmenti.e ;DAP application (50 % basal + 50% top dress) and the lowest (19.67 t ha^{-1}) came from control T_6 (phosphorus untreated treatment). Among the six treatments, T_3 treatment (DAP treatment) produced highest dry matter (12.52 t ha^{-1}), highest agronomic phosphorus use efficiency (536 kg yield kg P^{-1}) compared to TSP treatment.

Effect of biochar and vermicompost as an organic soil amendment in sweet orange

Field experiment on sweet orange (*Citrus sinensis* L.) plant was conducted in Regional Agricultural Research Station (RARS), Jamalpur with the objectives to investigate the effect of biochar and vermicompost on growth and fruit yield of sweet orange and to develop soil fertility through inclusion of biochar and vermicompost. The experiment started in 2017-2018 and was continued with second year (2018-19). There were five treatments comprising T_1: Biochar + IPNS based Chemical fertilizer ($N_{97}P_{20}K_{15}S_{18}Zn_3B_1$), T_2: Vermicompost + IPNS based chemical ferrtilizer ($N_{108}P_{45}K_{54}S_{18}Zn_3B_1$), T_3: Biochar + vermicompost + IPNS based Chemical fertilizer ($N_{103}P_{32}K_{34}S_{18}Zn_3B_1$), T_4: Chemical fertilizer ($N_{169}P_{79}K_{88}S_{18}Zn_3B_1$). All the treatments were significantly different from the control on all the growth and yield parameters. Data revealed that, T_3 treatment i.e; Biochar + vermicompost + IPNS based chemical fertilizer showed its best results with respect to vegetative and fruit characters of sweet orange plant. Among the four treatments, the highest fruit yield (8.23t ha^{-1}) was recorded in T_3

treatment (biochar-vermicompost combination treatment) and the lowest (5.85t ha^{-1}) was found in control T_4 (chemical fertilizer) treatment. Soil organic carbon (SOC), total N, available P, K and S contents in post-harvest soil were also highest in T_3 treatment. The overall results indicate that application of biochar @ 4 kg $tree^{-1}$ in combination with vermicompost @ 2 kg $tree^{-1}$ and IPNS based Chemical fertilizer was most effective in increasing sweet orange yield and carbon accumulation in soil than sole application of biochar or vermicompost in combination with recommended doses of chemical fertilizers.

Integrated nutrient management for sweet orange

The experiment was conducted at Regional Agricultural Research Station (RARS), Jamalpur to develop suitable and economic fertilizer dose for sweet orange cultivation through integrated nutrient management (INM) and to quantify the change of soil health due to addition of organic manure. The experiment started in 2016-2017 was running its third year cycle. There were seven treatments viz. T_1: 100% RDCF ($N_{169}P_{79}K_{88}S_{18}Zn_3B_1$), T_2: Cowdung 5 tha^{-1} + IPNS based inorganic fertilizer ($N_{144}P_{72}K_{76}S_{18}Zn_3B_1$), T_3: Cowdung 10 tha^{-1} + IPNS based inorganic fertilizer ($N_{119}P_{64}K_{65}S_{18}Zn_3B_1$), T_4: Poultry manure 3 tha^{-1} + IPNS based inorganic fertilizer, ($N_{151}P_{69}K_{74}S_{18}Zn_3B_1$), T_5: Poultry manure 5 tha^{-1} + IPNS based inorganic fertilizer, ($N_{139}P_{62}K_{64}S_{18}Zn_3B_1$), T_6: 125% RDCF ($N_{212}P_{99}K_{110}S_{18}Zn_3B_1$) and T_7: control. The tested variety was BARI Malta-1. The experiment was laid out in Randomized Complete Block design (RCBD) with 5 replications. Results revealed that, T_4 treatment (Poultry manure 3 tha^{-1} + IPNS based inorganic fertilizer produced highest sweet orange yield (7.37 t ha^{-1}) and the lowest yield (3.77 t ha^{-1}) was recorded in the T_7 comprises with control treatment. Soil organic carbon (SOC), total N, available P, K and S contents in post-harvest soil were also highest in T_4 treatment. The overall results indicate that T_4 treatment can help increase fruit yield of sweet orange and carbon accumulation in soil which in turns enriching soil organic matter.

Effect of different rates of mulch materials and fertilizers on soil salinity and mustard yield in coastal saline soils of Bangladesh

Straw mulching can improve soil nitrogen availability, increase plant growth and influence the physical and chemical properties of the soil. An experiment was conducted at Agricultural Research Station (ARS), BARI, Benarpota, Satkhira during *rabi* season of 2018-2019 to investigate the effect of mulching and different rates of fertilizers on mustard yield under saline soil. There were nine treatments viz. T_1 = Recommended Dose of Fertilizer (RDF), T_2 = Rice straw 5 t ha^{-1} + 100% RDF, T_3 = Rice straw 5 t ha^{-1} + 75% RDF, T_4 = Rice straw 2 t ha^{-1} + 100% RDF, T_5 = Rice straw 2 t ha^{-1} + 75% RDF, T_6 = Wheat straw 5 t ha^{-1} + 100% RDF, T_7 = Wheat straw 5 t ha^{-1} + 75% RDF, T_8 = Wheat straw 2 t ha^{-1} + 100% RDF and T_9 = Wheat straw 2 t ha^{-1} + 75% RDF. The highest seed yield (1.50 t ha^{-1}) was recorded in T_2 and lowest seed yield (1.12 t ha^{-1}) was observed in T_1 treatment. Furthermore, T_2 gave the highest level of MBCR (1.50). The lowest level of mean soil salinity during total field duration was recorded from T_2 (Rice straw 5 t ha^{-1} + 100% RDF) treatment and the highest level of mean soil salinity (7.7 dS m^{-1}) was observed in T_7 treatment i.e. wheat straw 5 t ha^{-1} + 75% RDF. Rice straw 5 t ha^{-1} along with 100% RDF may increase the mustard yield with maximum economic benefit.

Effect of phytohormone and different rates of nitrogen fertilizer on soil salinity and yield of sunflower

A field experiment was conducted at Agricultural Research Station (ARS), BARI, Benarpota, Satkhira during the *rabi* season of 2018-2019 to identify the best combination of nitrogen and phytohormones dose on ameliorating soil salinity and yield of sunflower. There were nine treatment combinations in two factorial RCBD approach where factor A was application of phytohormone (Abscisic Acid) at three rates (0, 100 and 200 ppm). On the other hand, factor B was six different levels of nitrogen fertilizer [0, Recommended dose of all fertilizers (RDF) + N_0; RDF + $N_{50\%}$; RDF + $N_{80\%}$; RDF + $N_{100\%}$ and Farmer's Practice) based on FRG, 2012 guide. From the result it is evident that among different treatment combinations, the highest total seed yield (1.48 t ha^{-1}) obtained under Abscisic Acid @ 200 ppm with RDF + $N_{100\%}$ may be ascribed to the applied optimum level of

nitrogen and abscisic acid which could improve synthesis of sufficient photosynthates. While the minimum (0.5 t ha^{-1}) seed yield was observed by the treatment where there was no application of nitrogen fertilizer and growth regulator. The lowest level of average soil salinity was recorded in P_3F_2 treatment combination (3.37 dS m^{-1}). The highest level of average soil salinity (5.72 dS m^{-1}) was recorded in P_1F_6 combination while maximum seed yield (1.48 t ha^{-1}) was obtained from P_3F_5 in where average soil salinity was 3.57 dS m^{-1} during total field duration.

Development of fertilizer recommendation for chilli with garlic intercropping system

An experiment was conducted at Central Research Farm, BARI, Gazipur and On Farm Research Division, BARI, Noakhali during the *Rabi* season of 2018-2019 to develop a fertilizer recommendation for chilli with garlic intercropping system. Six treatment combinations viz. T_1 = 100% RDCF of chilli + 0% RDCF of garlic, T_2 = 100% RDCF of chilli + 10% RDCF of garlic, T_3 = 100% RDCF of chilli + 20% RDCF of garlic, T_4 = 100% RDCF of chilli + 30% RDCF of garlic, T_5 = 100% RDCF of chilli + 40% RDCF of garlic and T_6 = 100% RDCF of chilli + 50% RDCF of garlic were tested. The experiment was laid out in randomized complete block design with 3 replications. Both chilli and garlic significantly influenced by different treatments. Significantly highest yield of green chilli (9.98 and 8.91 t ha^{-1} at Gazipur and Noakhali, respectively) and garlic (3.68 and 3.56 t ha^{-1} at Gazipur and Noakhali, respectively) were obtained from T_6 treatment (100% RDCF of chilli + 50% RDCF of garlic)which was statistically similar with T_5 treatment (100% RDCF of chilli +40% RDCF of garlic).Chilli equivalent yield progressively increases with the increase of inorganic fertilizers. The results showed that T_6 provided the highest CEY (17.32 and 16.03 t ha^{-1} at Gazipur and Noakhali, respectively)followed by T_5 (17.27 and 15.99 t ha^{-1} at Gazipur and Noakhali, respectively). The highest net return (334755 Tk. ha^{-1} and 306448 Tk. ha^{-1} at Gazipur and Noakhali, respectively) as well as BCR (4.45 and 4.28Gazipur and Noakhali, respectively) were obtained from T_5 treatment (100% RDCF of chilli +40% RDCF of garlic) while the lowest net return (264411 Tk. ha^{-1} and 2400143 Tk. ha^{-1} at Gazipur and Noakhali, respectively) as well as BCR (3.90 and 3.73 at Gazipur and Noakhali, respectively) were observed from T_1 treatment (100% RDCF of chilli + 0% RDCF of garlic).

Integrated nutrient management on sunflower in coastal char land

An experiment was conducted at coastal charland of OFRD, BARI, Noakhali, MLT site, Amtoli, Barguna and ARS, BARI, Benarpota, Satkhira during *rabi* season of 2018-19 to evaluate the effect of integrated nutrient management for better yield of sunflower. Six treatment combinations *viz*. T_1= Soil test based fertilizer dose for HYG, T_2 = IPNS with 5 t ha^{-1} cowdung, T_3 = IPNS with 5 t ha^{-1} compost, T_4 = IPNS with 1.5 t ha^{-1} vermicompost, T_5 = Farmers' practice and T_6 = Native control were tested. The experiment was laid out in randomized complete block design with 3 replications and BARI Sunflower-2 was used as test crop.The IPNS treatment combinations are significantly differ with rest of the treatments in terms of yield and economic return. Application of treatment IPNS with 1.5 tha^{-1}vermicompost significantly increased all of the parameters such as the plant height, head diameter, number of seed per head, 1000 seeds weight, seed yield and stover yield. The significantly highest seed yield (2.19, 2.23 and 2.06 t ha^{-1} at Noakhali, Barguna and Satkhira, respectively) was recorded in IPNS with 1.5 t ha^{-1} vermicompost treated plot (T_4) while the lowest seed yield (1.05, 1.10 and 1.02 t ha^{-1} at Noakhali, Barguna and Satkhira, respectively) was observed from absolute control treatment (T_6). Salinity level increased at slower rate in T_2, T_3 and T_4, treatments where IPNS based nutrient management packages were imposed. On the other hand, salinity level increased at higher rate in T_6 treatment followed by T_5 and T_1. During the crop growing period soil salinity ranged from 0.62 to 9.72 dS m^{-1}, 0.58 to 9.23 dS m^{-1}, 0.73 to 9.86 dS m^{-1} at Noakhali, Barguna and Satkhira, respectively from emergence to maturity stages of the crop. The highest net return (50790 Tk. ha^{-1}, 52765 Tk. ha^{-1} and 43940 Tk. ha^{-1} at Noakhali, Barguna and Satkhira, respectively) as well as BCR (1.75, 1.78 and 1.67 at Noakhali, Barguna and Satkhira, respectively) were obtained from T_4 treatment (IPNS with 1.5 t ha^{-1} vermicompost) whereas the lowest net return (14900 Tk. ha^{-1} ,15175 Tk. ha^{-1} and 11570 Tk. ha^{-1} at Noakhali, Barguna and Satkhira, respectively) and BCR (1.40, 1.33 and 1.26 at Noakhali, Barguna and Satkhira, respectively) were obtained from control (T_6) treatment.

Remediation of arsenic contaminated soils using organic and inorganic amendments

A pot experiment was carried out in the micronutrient experimental field of Soil Science Division of BARI, Joydebpur, Gazipur on 06 February 2019 to determine the effects of organic and inorganic materials to remediate contaminated soil with Arsenic (As). Arsenic was added to the pots at the rates of 4000 µg kg^{-1} and contaminated soils (10 kg pot^{-1}) amendments with red soil, bamboo charcoal/Ash, compost and lime each at 5 g kg^{-1} soil, except iron oxide which was 5 mg kg^{-1} soil. Addition of organic and inorganic materials to contaminated soil did not totally restrict the uptake of metal by maize plants. Red soil, bamboo charcoal/Ash, compost, iron oxide and lime addition led to decreased metal content in maize, and this decrease was better expressed with 17.5% for red soil, 9.51 % for bamboo charcoal/Ash, 34.8% for compost, 39.7% for iron oxide and 26.4% for lime. In maize plants for the highest. As concentration in bamboo charcoal/Ash treatment was found to be 71% in root and 29% in shoot; whereas in iron oxide and compost treatment, 72% was in the root and 28% in shoot. The present findings suggest that compost and Fe-oxide may be used as effective amendments to attenuate. As in soils by reducing its bioavailability. Arsenic was positively and significantly correlated with root and stem (r = 0.4526, P<0.05) and non significant relation between root and leaf (r = 0.3539; P-ns) in maize plant. The relation was much stronger in root and stem compared to root and leaf.

Remediation of heavy metals polluted soil from industrial effluents polluted areas through organic and inorganic amendments

This study was conducted to determine the effects of organic and inorganic materials to remediate contaminated soil with heavy metals. A pot study was performed by growing Maize (*Zea mays*) in metal contaminated soil (10 kg/pot) and soils amendments with red soil, bamboo charcoal/Ash, compost, and lime each at 5 g kg^{-1} soil, except iron oxide (5 mg kg^{-1} soil). The results showed that Pb, Cd, Ni, and Cr uptake by maize depended on the materials type. Application of organic and inorganic materials was shown to immobilize metals in soil and decreased the metal content of plants. Compost, lime and bamboo charcoal/Ash had significant impact on immobilization or phytoextraction of metal from soil. The percentage (%) of metal uptake decreased in maize with addition of organic materials compared with contaminated control were Pb – 27.9 to 70.3, Cd – 16.1 to 50.4, Ni – 20.6 to 74.6 and Cr – 3.20 to 45.1, where as it were 24.0 to 64.9, 21.3 to 60.7, 23.6 to 27.1 and 3.69 to 48.8, respectively for P, Cd, Ni and Cr under addition of inorganic materials. Addition of organic and inorganic materials to contaminated soil did not totally restrict the uptake of heavy metal by maize plants. Red soil, bamboo charcoal/Ash, compost, iron oxide and lime addition led to decreased metal content in maize, and this decrease was better expressed with 19.6 to 32.2% for red soil, 41.0 to 58.2 % for bamboo charcoal/Ash, 50.4 to 74.6% for compost, 3.20 to 32.4% for iron oxide and 40.6 to 67.8% for. The different effectiveness of amendment on heavy metal uptake by maize plant could be due to the nature and type of amendment. However, immobilization or phytoextractiontechniques might be used to remediate soil which contaminated with heavy metal.

Effectiveness of soil and foliar applications of zinc and boron on the yield of sweet pepper

A field experiment was carried out to study the effectiveness of soil and foliar application of micronutrients on the yield of sweet pepper (*Capsicum annuum* L.) at Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, located at 23º59′17″ N and 90º24′39″ E. The micronutrients zinc (Zn) in the form of zinc sulphate ($ZnSO_4$. $7H_2O$) as zinc source at the rate of 0.05 % and boron (B) in the form of boric acid (H_3BO_3) at the rate of 0.03% were applied as foliar spray at three different stages of plant growth i.e (i) before flower initiation; (ii) after fruit set when it becomes approximately marble sized; and (iii) after 20 days of second spray. The sweet pepper yield and its contributing yield traits were significantly affected by foliar fertilizer treatments as against soil application of B and Zn fertilizers. Among various treatments, foliar application of Zn (0.05 %) + B (0.03%) produced maximum fruit yield (24.8 t ha^{-1}) while the control no use of Zn (0.0) and B (0.0) produced minimum (16.2 t ha^{-1}) and it was statistically differed (21.9 t ha^{-1}) with soil application of B and Zn @ 2 and 6 kg ha^{-1} (T_5). The increment of yield was 28.9 to 53.5% and 2.89 to 14.3%, respectively, over control and soil application.The maximum marginal benefit-cost

ratio (MBCR) of 137 was obtained by application of Zn in combination with B followed by 128 MBCR from soil application of B and Zn. Higher sweet pepper production can be achieved by combined foliar application of Zn (0.05 %) + B (0.03%) (T_4) along with macro nutrients apply in the soil. Production cost will be minimized and yield of sweet pepper will be maximized through foliar application of Zn and B.

Effect of boron on flower, fruit set and yield of BARI Bt brinjal

A field experiment was carried out to study the effect of boron on flower, fruit set and yield of btbrinjal at Soil Science Division, BARI, Joydebpur, Gazipur. Design of the experiment was RCB with 3 (three) replications. The treatment combinations of foliar spray of boron were T_1:50 ppm B, T_2:100 ppm B, T_3:150 ppm B and T_4: control. The micronutrient boron (B) in the form of boric acid (H_3BO_3) having 18% boron were applied at full bloom and other two were given at an interval of 10 days. The tested variety was BARI Bt Begun-2. The yield and yield contributing character of btbrinjal were significantly affected by foliar application of boron. All parameters showed higher tendency in T_2 treatment. The highest yield (24.3 t ha^{-1}) was observed in 100 ppm foliar application of boron and it was significantly higher with untreated plants. Foliar application of boron is effective on flower, fruit set and yield of btbrinjal.

Growth, yield and bulb quality of onion (*Allium cepa* L.) in response to foliar application of zinc and boron.

A field experiment was carried out in the micronutrient experimental field, Soil Science Division of BARI, Joydebpur, Gazipur, 2018-19 study the Growth, Yield and Bulb quality of Onion (*Allium cepa* L.) in response to foliar application of zinc and boron. The experiment was laid out in a randomized block design (factorial) with three replications. There were 16 treatment combinations comprising 4 levels each of boron (0, 0.01, 0.02 and 0.05%) and zinc (0, 0.01, 0.02 and 0.05%).The integrated use of zinc and boron was found superior to their single applications. The interaction effect between zinc and boron was significant in case of bulb weight and yield of onion. The highest bulb yield (16.42t/ha) was found in T_{16} ($Zn_{0.05}B_{0.05}$%) treatment which was significantly higher over control. The yield benefit over control varied from 29 to 112% due to interaction effect.

Effect of boron application on recently released wheat varieties of Bangladesh

A pot experiment was conducted in the Net house of Soil Science Division of BARI, Joydebpur, Gazipur during *rabi* season, 2018-2019 inTista Meander Floodplain Soils (AEZ-3). The objectives were to evaluate the effect of boron on the yield of wheat, estimate boron use efficiency and to find out suitable variety for maximizing the yield. The experiment was designed in Completely Randomized Design (CRD) with three replications. Three varieties of wheat (BARI Gom-28, BARI Gom-29 and BARI Gom-30) with 5 levels of boron (0, 0.5, 1.0, 1.5 and 2 kg ha^{-1}) along with a blanket dose $N_{120}P_{30}K_{90}S_{15}Zn_3Mg_6$ kg ha^{-1} were used in the study. All the three varieties performed well with application of 1.5 kg B ha^{-1} as compared to the other B treatments. However, the highest yield (38.5 g pot^{-1}) was obtained with BARI Gom-30 variety receiving B at 1.5 kg ha^{-1}.

Determination of critical limit of zinc for lentil crop

A pot experiment was conducted at the net house of Soil Science Division of BARI on lentil during *rabi* season of 2018-2019 to determine the critical limit of zinc in soils and plant grown in twenty soils collected from the six AEZs such as Tista Meander Floodplain (AEZ-3), Karatoya –Bangali Floodplain (AEZ-4),Young Brahmaputra and Jamuna Floodplain (AEZ-8), High Ganges River Floodplain (AEZ-11), Low Ganges River Floodplain (AEZ-12) and Madhupur Tract (AEZ-28). The soils contained pH 5.36-8.62, organic matter 0.21-2.68 %. The available Zn content was estimated by one extraction method as 0.005 M DTPA (Diethylene TriaminePenta Acetic Acid). The DTPA extractable Zn in different soils ranged from 0.43-4.10 ppm. The soil available Zn was negatively correlated with soil pH, Ca, Mg and positively correlated with OM, K, dry matter yield. However, the point bellows which lentil shows zinc deficiency in soils was 0. 56 ppm as determined by Cate and Nelson's graphical procedure.

Response of zinc and boron on yield and nutrient content of coriander

A field experiment was conducted during *rabi* season of 2018-2019 at soil science division of BARI, Gazipur to study the response of zinc and boron on yield and nutrient content of coriander. The objectives were to identify a suitable combination of zinc and boron fertilizer for coriander production, to evaluate the requirement of zinc and boron fertilizer for coriander and to estimate zinc and boron content and uptake both leaves and seeds of coriander. Treatments combinations were compromises with three levels of zinc (0, 2, 4 kg ha^{-1}) and three levels of boron (0, 1, 2 kg ha^{-1}). Identical treatments and other fertilizers were used for foliage and seed production separately. The experiment was done with Randomized Complete Block Design (RCBD) with three replications. Among the various treatments, Zn_4B_1 produces highest foliage yield (4.63 t ha^{-1}) and Zn_2 B_2 produces highest seed yield (1.84 t ha^{-1}).

Effect of foliar application of zinc on the yield of maize in GTFP soils of coastal saline areas

Among many growth factors zinc was recognized as one of main limiting factors of maize crop growth and yielding. An experiment was conducted at Agricultural Research Station (ARS), BARI, Benarpota, Satkhira during *rabi* season of 2018-2019 to observe the effect of foliar zinc on maize yield and also find out the best dose of foliar zinc required for optimum maize yield in GTFP saline soil. There were five treatments *viz*. T_1 was Foliar application at vegetative stage (8 leaf stage) @ 0.05 % Zn solution, T_2 was Foliar application at vegetative stage (8 leaf stage) and reproductive stage (anthesis) @ 0.05 % Zn solution, T_3 was Foliar application at vegetative stage (8 leaf stage) @ 0.1% Zn solution, T_4 was Foliar application at vegetative stage (8 leaf stage) and reproductive stage (anthesis) @0.1 % Zn solution, T_5 was no application of Zn. Maize crop responded significantly to zinc foliar application in this year. The highest grain yield (7.39 t ha^{-1}) was recorded from foliar application at vegetative (8 leaf stage) and reproductive stage (anthesis) @ 0.05 % Zn solution (T_2) but it was statistically similar with T_3 and T_4. In this year of study, on the control plot T_5, i.e. fertilized only with NPK and no application of Zn produced the lowest (6.78 t grains ha^{-1}) but statistically same yield as T_1 was foliar application at vegetative stage (8 leaf stage) @ 0.05 % Znsolution. The highest average of soil salinity was at prior to harvesting with a value of 9.37 dS/m while the lowest average soil salinity with a value of 1.50 dS/m was recorded during sowing time.

Assessment of arbuscular mycorrhizal association in some fruits plant and field crops

Rhizosphere soils including fine roots of some fruit plants and field crops were collected from Godagari, Rajshahi and Regional Agricultural Research Station, Hathazari during 2018-2019 for counting AM spore population and determining colonization (%) in their roots. In fruit plants, the spore numbers of 100 g rhizosphere soil were recorded ranging from 79.67 (Jamrul) to a maximum of 248.0 (Malta). In case of field crops, the spore numbers of 100 g rhizosphere soil were recorded ranging from 62.67 (Brinjal) to a maximum of 190.0 (Mustard). A considerable variation was observed in average spore numbers recorded in different friuts and field crops. All the fruit plants showed similar percentages of root colonization by AM fungi. Among the fruit plants, the highest root colonization (30.0%) was found in Orange and lower colonization (20.0%) was found in all other plants. In the field crops, the highest root colonization (40.0%) was found in Chilli and lower colonization (10.0%) was found in maximum fieldcrops.

Study on Rhizobium, Azotobacter and phosphate solubilizing bacterial (PSB) population status in soils of different AEZs of Bangladesh

Soil microbes plays a major role to supply nutrient to plants as well as decomposition of organic materials and cycling of nutrients. Eight soil samples were collected from selected locations of different AEZs of Bangladesh to know the Rhizobium, Azotobacter and Phosphate solubilizing bacterial population at different AEZs of Bangladesh. Soil samples were collected from BARI Central Farm (AEZ-28); RARS, Jessore (AEZ-11); RARS Hathazari (AEZ 18), Codda, Joydebpur (AEZ-28); Kasiani, Gopalgonj (AEZ-19); ARS, Satkhira (AEZ-13); OFRD, Noakhali (AEZ-19); and OFRD, Patuakhali (AEZ-13). Rhizobium was grown in media and colonies were counted. The highest Rhizobium population (5.5×10^5 g^{-1} soil) was found in soils of Kasiani, Gopalgonj (AEZ-19) and the lowest population

(5.0×10^2 g^{-1} soil) was observed in soils of RARS, Hathazari (AEZ 18) and Satkhira (AEZ-13). Azotobacter was grown in media and Azotobacter colonies were counted. The highest Azotobacter population (5.5×10^5 g^{-1} soil) was found in soils of RARS, Jessore (AEZ-11) and the lowest population (2.0×10^3 g^{-1} soil) was observed in Noakhali (AEZ-19). Phosphate solubilizing bacteria was grown in Pikovskaya's media and PSB colonies were counted. The highest PSB population (3.5×10^5 g^{-1} soil) was found in soils of Agronomy field, Joydebpur (AEZ-28) and the lowest population (4.0×10^2 g^{-1} soil) was observed in Satkhira (AEZ-13).

Effect of Azotobacter on growth and yield of onion

The experiment was carried out during *robi* season of 2018 - 2019 in the research field of Soil Science Division, BARI, Joydebpur, Gazipur to find out the effect of Azotobacter inoculum along with different doses of N fertilizer on growth and yield of Onion. The experiment was designed in RCBD with 6 treatments and 4 replications. Onion (BARI Piaj-4) was used as a test crop. Liquid azotobacter inoculum was used in this experiment .The population density of used inoculum was more than 10^8cfu g^{-1} inoculant. There were six treatments viz. T_1: 100% N of Recommended Dose, T_2: 90% N + Azotobacter inoculum, T_3: 80% N + Azotobacter inoculum, T_4: 70% N + Azotobacter inoculum, T_5: Azotobacter inoculum and T_6: Control. Results of the experiment revealed that highest bulb yield of onion (23.48 t ha^{-1}) found in T_3 (80% N + Azotobacter inoculum) treatments which was statistically identical with T_1 : (21.91 t ha^{-1}) and T_2: 90% N + Azotobacter inoculum (22.08 t ha^{-1}) treatment. This result suggested that use of azotobacter inoculum in combination with reduced dose of N fertilizer was beneficial for onion and we could reduce 20% of nitrogenous fertilizer.

Response of lentil varieties to elite strains of Rhizobium

Field experiments were conducted at research field of soil science division, BARI, Joydebpur, Gazipur, during 2018-19 to study the response of Rhizobium inoculation with different BARI released lentil varieties. Four varieties of lentil *viz*. BARI Mosur-6, BARI Mosur-7, BARI Mosur-8 and BARI Mosur-9 and rhizobial inoculum (Rhizobium strain RLc-104) were used in these experiments. Unit plot size was 4 m x 3 m. The experiment was designed in randomized complete block having 3 replications in each treatment. Each variety was tested with/without Rhizobium inoculation. Inoculated plants gave significantly higher nodule number, nodule weight, shoot weight and seed yield compared to non-inoculated plants. Among fourvarieties, BARI Mosur-8 produced the highest nodule number and nodule weight. The highest seed yield (1.02 t ha^{-1}) was recorded in BARI Mosur-7. The interaction effect revealed that the highest seed yield of 1.12 ha^{-1} was recorded by inoculated BARI Mosur-7. It was revealed that rhizobium inoculation has positive effect on all the tested lentil variety.

Isolation of salt tolerant Rhizobium and their characterization, plant growth promoting and symbiotic performance on oilseed legume

A study was conducted at Soil Science Division, BARI, during 2018-2019 to isolate of salt-tolerant rhizobia species from coastal saline area of Bangladesh, characterize, plant growth promoting and symbiotic performance of those effective salt tolerant bacteria on oil seed legumes. For isolating of salt tolerant Rhizobium bacteria, 20 nodule samples were collected from soybean and groundnut root from different fields of saline stress soils (Noakhali, Lakhmipur, Cox's Bazar, Bhola, Patuakhali) of Bangladesh using global positioning system (GPS) record along with crop history. Nodules were collected aseptically, purified strains and preserved at 4^0C for short time preservation and kept in -20^0C, for long time preservation. The characters of 20 bacterial isolates (10 isolates from soybean and 10 isolates from groundnut) were studied following the standard microbiological and biochemical methods. The cells of Rhizobium isolates were examined under microscope and found that the cells were rod shape, motile and gram-negative bacteria. The biochemical characters such as Congo red, Gram staining, salt tolerance was investigated. The isolates were observed to lack the ability to absorb Congo red from YEMA medium. The salt tolerance study was carried out on YEM agar plate with each modified by NaCl at 0, 2, 4, 8, 16, 32 and 48 dSm^{-1}. All isolated bacteria were tested by growing on plate up to (>48 dS m^{-1}) level. Seedlings were grown in glass tube to check the infection ability of Rhizobium (strain SR1 to SR10 for soybean and strain GR1 to GR10 for groundnut) and found nodule formation in seedling roots within 30-50 days after inoculation.

DNA isolation, molecular characterization and gene sequences of salt tolerant Rhizobial strains and their symbiotic effect on groundnut at different salinity level under pot culture

A pot experiment was carried out at the net house of Soil Science Division, BARI, Joydebpur, Gazipur (24.00° N latitude, 90.25° E longitude and 8.4 m elevation) during rabi season of 2018 with the objective to symbiotic and molecular characterize of salt tolerant rhizobial strains and to evaluate the performance of salt tolerant bacterial trails on growth and yield of groundnut at different salinity level under pot culture. The pot soil belongs to the Chiata series of Grey Terrace Soil. The experiment was laid out in Complete Randomized Design (CRD) with three replications. There were 22 treatments viz. T_1: Rhizobium GR1, T_2: Rhizobium GR2, T_3: Rhizobium GR3, T_4: Rhizobium GR4, T_5: Rhizobium GR5, T_6: Rhizobium GR6, T_7: Rhizobium GR7, T_8: Rhizobium GR8, T_9: Rhizobium GR9, T_{10}: Rhizobium GR10, T_{11}: Rhizobium GR11, T_{12}: Rhizobium GR12, T_{13}: Rhizobium GR9, T_{14}: Rhizobium GR14, T_{15}: Rhizobium GR15, T_{16}: Rhizobium GR16, T_{17}: Rhizobium GR17, T_{18}: Rhizobium GR18, T_{19}: Rhizobium GR19, T_{20}: Rhizobium GR20, T_{21}: Rhizobium BARI RAh 801 and T_{22}: Control. The pot soils were modified with 0, 4, 8, 12, 16 dS m^{-1} salinity level by adding NaCl on to the pot. The tested crop was groundnut (cv. BARI China badam-8). Seeds were shown on 05 December 2018. Peat based rhizobial inoculum containing 108 cells g^{-1} inoculum was used at the rate of 1.5 kg ha^{-1}. Seeds were mixed thoroughly with inoculum (20:1 ratio) before sowing. Ten seeds were sown in each pot 1 cm soil depth. Seeds were used at the rate of 75 kg ha^{-1}. Application of salt tolerance Rhizobium biofertilizer on groundnut, the inoculated plants exhibited better performance in nodule numbers, nodule weights, aboveground biomass, root biomass, and plant height than non-inoculated plants, indicating that all Rhizobium sp. effectively enhanced nodulation and growth parameters on groundnut plant than non-inoculated plants in all salinity levels. In pot trials, plants inoculated with Rhizobium sp. showed higher pod yield, stover yield and seed yield than non-inoculated plants, revealing the positive impact of Rhizobium sp. on yield parameters of groundnut. Groundnut plants inoculated with Rhizobium sp.GR9 showed highest nut yield of groundnut than other strains inoculated and non-inoculated plants at different salinity levels.

Salt tolerant bacterial performance on groundnut in saline stress coastal region of Bangladesh

A field experiment was carried out at On Farm Research Division, BARI, Cox's Bazar and Noakhali during *rabi* season of 2018-19 with the objective to study on nodulation capacity of salt tolerant rhizobial strains and their performance on growth and yield of groundnut under field condition. Seeds were shown on 05 December 2018 and 18 December 2018 in Cox's Bazar and Noakhali, respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 12 treatments viz. T_1: Rhizobium GR1, T_2: Rhizobium GR2, T_3: Rhizobium GR3, T_4: Rhizobium GR4, T_5: Rhizobium GR5, T_6: Rhizobium GR6, T_7: Rhizobium GR7, T_8: Rhizobium GR8, T_9: Rhizobium GR9, T_{10}: Rhizobium GR10, T_{11}: Rhizobium BARI RAh 801 and T_{12}: Control. The tested crop was groundnut (cv. BARI China badam-8). Peat based rhizobial inoculum containing 10^8 cells g^{-1} and inoculum was used at the rate of 1.5 kg ha^{-1}. Seeds were mixed thoroughly with inoculum (20:1 ratio) before sowing. Seeds were used at the rate of 75 kg ha^{-1}. Application of salt tolerance Rhizobium biofertilizer on groundnut, the inoculated plants exhibited better performance in nodule numbers, nodule weights, aboveground biomass, root biomass, and plant height than non-inoculated plants, indicating that all Rhizobium sp. effectively enhanced nodulation and growth parameters on groundnut plant than non-inoculated plants. In field trials, plants inoculated with Rhizobium sp. showed higher pod yield, stover yield and seed yield than non-inoculated plants, revealing the positive impact of Rhizobium sp. on yield parameters of groundnut in saline area. Groundnut plants inoculated with Rhizobium sp.GR9 showed highest nut yield (2.77 t ha^{-1} at Cox's Bazar and 2.73 t ha^{-1} at Noakhali) of groundnut than other strains inoculated and non-inoculated plants.

Effect of Arbuscula rmycorrhizal fungi and phosphorus on cauliflower

A field experiment was conducted at Central Farm, Soil Science Division, BARI, during *rabi* season of

2018-2019 with the objectives to study the effect of combined use of arbuscularmycorrhizal fungi and phosphorus on growth and yield of cauliflower, and to reduce to use of P-fertilizer under field condition. The experiment was designed in factorial RCBD with six treatments and four replications. The cauliflower variety was snow white as test crop. Soil based arbuscularmycorrhizal (AM) inoculum and infected root pieces of the host plant were used at the rate of 1 kg soil m^{-2} in seedbed for producing cauliflower seedlings. The treatment combinations were: T_1P_1U: 0% P × without AM, T_2P_2U: 50% P × without AM, T_3P_3U: 100% P × without AM, T_4P_1AM: 0% P × with AM, T_5P_2AM: 50% P × with AM, T_6P_3AM: 100% P × with AM. Mycorrhizal inoculation significantly increased root weight (g), root colonization (%), spore population (100 g^{-1} soil) and curd yield (t ha^{-1}). Collar diameter (cm), plant height (cm), root length (cm), plant weight (kg), unfolded leaf ($plant^{-1}$) and curd circumstances (cm) were non-significant. The plant that received AM in nursery bed produced higher curd yield than without AM in all phosphorus levels of cauliflower. The highest curd yield (42.8 t ha^{-1}, 29.7% higher over control) was recorded in 50% P with AM (AM was used in nursery bed). The result indicates that inoculation of AM used in nursery bed can save 50% P in the field. The plant which did not receive AM in nursery bed produced lower yield in all phosphorus levels in the field.

Effect of biofertilizer, vermicompost and chemical fertilizers on cowpea

A field experiment was conducted at Central Farm, Regional Agricultural Research Station (RARS), BARI, Hathazari, Chattogram during *rabi* season of 2018-2019 with the objectives to evaluate the effect of Rhizobium biofertilizer, vermicompost and chemical fertilizers on cowpea. The crop variety was cowpea (BARI Fellon-1) and Rhizobium strain was BARI RVu-602. There were nine treatments viz. T_1: Control, T_2: Vermicompost (VC) @ 2.5 t ha^{-1}, T_3: VC @ 5 t ha^{-1}, T_4: VC @ 2.5 t ha^{-1} + Integrated Plant Nutrient System (IPNS) based NPKSZnB, T_5: VC @ 5 t ha^{-1} + IPNS based NPKSZnB, T_6: VC @ 2.5 t ha^{-1} + Rhizobium + IPNS based PKSZnB, T_7: VC @ 5 t ha^{-1} + Rhizobium + IPNS based PKSZnB, T_8: 100% NPKSZnB, T_9: Rhizobium + 100% PKSZnB which were replicated four times. Peat based rhizobial inoculum was used at the rate of 1.5 kg ha^{-1} as seed inoculant. Rhizobium inoculated cowpea with vermicompost @ 5 t ha^{-1} and IPNS based PKSZnB increased nodule number (16.3 $plant^{-1}$), nodule weight (0.23 g $plant^{-1}$), root weight (0.53 g $plant^{-1}$) and shoot weight (5.96 g $plant^{-1}$). It was observed that the same treatment produced the highest seed yield (1.42 t ha^{-1}, 82.1% higher over control) of cowpea which was differ with all other treatment except T_5 and T_6 treatments. This indicates that application of vermicompost @ 5.0 t ha^{-1} plus Rhizobium inoculant can reduce a considerable amount of chemical fertilizers. Vermicompost exhibited better performance in cowpea. To improve soil health and to maintain it as well as to improve crop production, we have to reduce chemical fertilizer. From the trial, it can be concluded that vermicompost @ 5 t ha^{-1} plus Rhizobium inoculant along with IPNS based chemical fertilizers except N may be recommended for cowpea cultivation.

Effect of *Trichoderma harzianum* and arbuscular mycorrhizal fungi on growth and disease management in groundnut (*Arachis hypogaea*)

The present study was carried out to evaluate the effect of indigenous Arbuscular Mycorrhizal Fungi (AMF) and *Trichoderm aharzianum* on germination, nodulation, colonization and yield of groundnut along with their biocontrol against groundnut foot and root rot caused by *Sclerotium rolfsii*. The bio-control potential of these bio-agents against foot and root rot pathogen was carried out under pot culture condition using arbuscularmycorrhizal fungi (AMF) alone or in combination with *Trichoderm aharzianum*in the nethouse of Soil Science Division, BARI, Joydebpur, Gazipur in 2019. The experiment was designed in CRD with eight treatments and four replications. The result showed that AMF + *Trichoderma* treatment produced the highest germination, nodulation, colonization and yield of groundnut compared to control or single inoculation. In contrary, *Sclerotium* + AMF + *Trichoderma* treatment produced significantly higher germination, nodulation, colonization and yield of groundnut compared to *Sclerotium* or single inoculation with *Sclerotium*.Dual inoculation (AMF + *Trichoderma*) increased 14.0% germination after 20 days after sowing, 5.25% nut yield and 24.4% stover yield compared to control. On the contrary, *Sclerotium rolfsii* + AMF + *Trichoderma* increased 30.3% germination after 20

days after sowing, 56.8% nut yield and 25.1% stover yield compared to only *Sclerotium rolfsii* trearment. These bio-control agents has proved not only both efficacious and safe under organic mode but also for ensuring biological control, better growth and improved productivity of this important oil crop of Bangladesh.

Effect of arbuscula rmycorrhizal fungi, biochar and vermicompost on soybean (*Glysine max*) in saline soil

The present study was carried out to evaluate the effect of indigenous Arbuscular Mycorrhizal Fungi (AMF), biochar and vermicompost on nodulation, colonization and yield character of soybean in 8 dS m^{-1} saline soil. The experiment was carried out under pot culture condition in the nethouse of Soil Science Division, BARI, Joydebpur, Gazipur in 2019. The experiment was designed in CRD with eight treatments and four replications. The ten treatments were T_1 : Control, T_2 : Arbuscular mycorrhiza (AM), T_3 : Biochar @ 10 t ha^{-1}, T_4 : Vermicompost@ 3 t ha^{-1}, T_5 : AM + Biochar @ 5 t ha^{-1}, T_6 : AM + Biochar @ 10 t ha^{-1}, T_7 : AM + Vermicompost @ 3 t ha^{-1}, T_8 : AM + Vermicompost @ 6 t ha^{-1}, T_9 : Biochar @ 5 t ha^{-1} + Vermicompost @ 3 t ha^{-1} and T_{10} : AM + Biochar @ 5 t ha^{-1} + Vermicompost @ 3 t ha^{-1}. The result showed that AM + Biochar @ 5 t ha^{-1} + Vermicompost @ 3 t ha^{-1} treatment produced the highest nodulation, colonization and yield character of soybean in 8 dS m^{-1} saline soil and control treatment produced lower nodulation, colonization and yield character of soybean in saline soil.AM + Biochar @ 5 t ha^{-1} + Vermicompost @ 3 t ha^{-1} treatment (T_{10}) produced 3.03%, 25.65%, 16.30% and 164% seed yield compared to T_9 (Biochar @ 5 t ha^{-1} + Vermicompost @ 3 t ha^{-1}), T_7 (AM + Vermicompost @ 3 t ha^{-1}), T_5 (AM + Biochar @ 5 t ha^{-1}) and T_1 (Control) treatment. On the other hand, T_{10} treatment produced 1.52%, 18.73%, 10.87% and 66.90% stover yield compared to T_9, T_7, T_5 and T_1 treatment. The above mentioned combination could sustain soil health, ensure better growth and productivity in a saline environment.

Performance of phosphate solubilizing bacteria and phosphatic fertilizer on microbial population status, growth and yield of barley

A field experiment was conducted at central farm of BARI, Joydebpur, Gazipur and central farm of Regional Agricultural Research Station (RARS), Ishurdi during *rabi* season 2018-2019 to evaluate the effects of phosphate solubilizing bacteria (PSB) and phosphatic fertilizer on microbial population status, growth and yield of barley and soil fertility improvement. The design of the experiment was factorial RCBD (two factors) with three replications. Factor one was inoculation with/without PSB and second one was P fertilizer doses. There were five fertilizer doses which were 0%, 25%, 50%, 75% and 100% of phosphorus fertilizer. The treatment combinations were ten. Plant height, spike length, no. of active tiller per plant, root length, no. of spike per hill, no. of grains per spike, 1000-seed weight, stover yield and seed yield performed better in PSB inoculation. In five different P fertilizer doses, we observed that 75% P fertilizer showed better results in respect of all the variables. The highest stover yield was 4.10, 4.15 t ha^{-1} and the highest seed yield was 2.32, 2.37 t ha^{-1} in both locations. Interactions of PSB and P fertilizer doses, all the parameters except plant height showed non-significant results in Gazipur but in Ishurdi, all the parameters except plant height and 1000-seed weight showed non-significant results, respectively. The maximum number of PSB population was recorded at PSB inoculation with 75% P fertilizer treated plot soil after harvesting of crop in both locations.

Effect of cropping pattern and seasonal variation on soil microbial biomass carbon and nitrogen in different AEZs soil of Bangladesh

A field experiment was conducted at central farm of BARI, Joydebpur, Gazipur.duringrabi season 2018-2019 to determine the soil microbial biomass carbon (MBC) and microbial biomass nitrogen (MBN) in long term cropping pattern and to monitor the soil fertility status. The design of the experiment was RCBD with three replications. There were six treatment combinations. The treatment combinations were T_1: Native fertility, T_2: MYG (STB) from fertilizer + CD (5 tha^{-1}), T_3: HYG (STB) from fertilizer, T_4: HYG (STB) from fertilizer + CD (5 tha^{-1}), T_5: HYG (STB) from fertilizer + PM (3 t ha^{-1}), and T_6: MYG (STB) from fertilizer. Biomass carbon and nitrogen were determined at 30 days interval in fourteen different dates in Maize-Mungbean-T.aman cropping pattern. The highest amount of biomass carbon and nitrogen was observed at HYG (STB) from fertilizer + PM (3 t ha^{-1}) treated plot and the lowest

amount was found at native soil treatment. The maximum quantity of MBC and MBN content was 1272.5 and 539.9µgg^{-1} for maize, 1003.3 and 417.7µgg^{-1} for mungbean and 973.4 and 407.8µgg^{-1} for T.aman, respectively recorded from 30 to 60 days interval from the HYG (STB) from fertilizer + PM (3 t ha^{-1}) applied plot. After 60 days, the quantity of biomass carbon was gradually decreased. The lowest amount of biomass carbon was recorded after each and every interval of soil sampling in native soil treatment.

Effect of biofertilizer and chemical fertilizers on soil microbial population status, nodulation pattern, nodule initiation date and yield of pulse crops

The field experiment were conducted at central farm of BARI and central farm of Regional Agricultural Research Station (RARS), Jamalpur during *rabi* season 2018-2019 to evaluate the effects of biofertilizer and chemical fertilizer on soil microbial population status, nodulation pattern, nodule initiation date and yield of pulse crops. The experiment was designed in randomized complete block (RCBD) with 2 factors (fertilizer doses and varieties) having 3 replications in each treatment. Three fertilizer doses were 100% PKSZnB, Rhizobium + 100% PKSZnB, 100% NPKSZnB and four varieties were BARI Masur-7, BARI chola-8, BARI mash-3 and BARI felon-1. Unit plot size was 3 m x 2 m. There were 12 treatment combinations. Basic doses of fertilizer were 50-22-42-20-5-1 kg N-P-K-S-Zn-B ha^{-1}. All the fertilizers except N were applied as basal at final land preparation. N was applied in three equal splits at 10, 20 and 30 days after sowing. Peat based rhizobial inoculum (BARI RLs-102, BARI RCa-259, BARI RVm-301 and BARI RVs-609) @ 1.5 kg ha^{-1} was used for seed inoculation. Peat based rhizobial inoculum was used containing about 10^8 cells g^{-1} inoculum.BARI chola-8 has the greater ability to produce maximum number of nodule than all other varieties. In this experiment we found that pulse crops required 18 to 21 days for their first nodulation. The nodulation pattern trend was BARI Chola-8> BARI Masur-7> BARI Fellon-1> BARI Mash-3 in both locations. In four varieties, nodule initiation was increased during the pre-flowering stages but decreases when it turns into reproductive stages. The better nodulation was observed after 63 days of nodule initiation except BARI Mash-3 because it requires 42 days for profuse bearing of nodule. Rhizobium + 100% PKSZnB performed better than any other fertilizer doses in both locations. In respect of variety, BARI Chola-8 gave better results than others also in both locations. Combined effects of fertilizer doses and varieties, Rhizobium + 100% PKSZnB with BARI Chola-8 and 100% NPKSZnB with BARI Chola-8 significantly gave the highest stover yield and seed yield in Gazipur and Jamalpur, respectively.

22 ENTOMOLOGY

Vegetables

Yard long bean

Development of a management approach against pod borer, *eucrysops cnejus* F. attacking yard long bean

The experiment was conducted in the research field of Entomology Division, BARI, Gazipur during kharif 1, 2019. Yard long bean seeds of Kagornatoki (Hybrid) variety were transplanted in a plot of 4m x 5.5m. The experiment was laid out in RCBD having 3 replications and 6 treatments including control. Standard agronomic practices were followed to raise the crop. The treatments were assigned as follows:

T_1= Package (1): Sanitation i.e. hand picking of infested flowers and pods with larvae + 4 sprays of bio-pesticide Antario (Bt-Kurstaki 1.4% + abamectin 0.1%) @ 1g/ litre of water at fortnightly interval; T_2= Package (2): Sanitation as above + 4 sprays of bio-pesticide *Bt* Kurstaki @ 0.5g/ litre of water at fortnightly interval; T_3= Package (3): Sanitation as above + 4 sprays of bio-pesticide Spinosad 45SC @ 0.4 ml/l litre of water at fortnightly interval; T_4= Package (4): Sanitation + Alternate spraying of Antario and Spinosad 45SC; altogether 4 sprays were done at fortnightly interval; T_5= Package (5): Farmers practice-spraying of Emamectin benzoate 5SG @ 1g/litre of water; altogether 8 sprays were done starting from the initiation of the pest attack at weekly interval; T_6= Untreated control.

Results indicated that, the package 4 showed significantly the lowest flower infestation (5.08%) which is statistically similar to package 1 (5.84%) and package 3 (5.67%). The control treatment showed significantly the highest flower infestation (19.57%) by pod borer. It is also observed that, the package 4 showed significantly the lowest pod infestation (6.02%) which is statistically similar to package 1 (6.47%) and package 3 (6.98%). Results also indicated that, the package 3 (Sanitation + Spinosad 45SC) treated plots produced significantly the highest yield (14.75 t/ha) followed by package 4 (Sanitation + alternate spraying of Antario and Spinosad 45SC) treated plots (14.58 t/ha) and package 1 (Sanitation + spraying of Antario) treated plots (14.42 t/ha). It is revealed that the highest (10.09) marginal benefit-cost ratio (MBCR) was calculated from package 1 treated plots followed by package 4 (6.97). So, considering MBCR, package 1 i.e. sanitation along with spraying Antario may be recommended for effective management of pod borer attacking yard long bean.

Evaluation of some bio-pesticides and chemical insecticides against sucking insect pests of yard long bean

The experiment was conducted in the research field of Entomology Division, BARI, Gazipur during 2019. Yard long bean seeds of Kagornatoki (Hybrid) variety were transplanted in a plot of 4m x 5.5m. The experiment was laid out in RCBD having 3 replications and 6 treatments including control. The treatments were assigned as follows:

T_1= Spraying Fizimite (Sodium lauryl ether) @1 ml/ litre of water; T_2= Spraying Fytomax 3EC (Azadiractin) @ 1 ml/ litre of water; T_3= Spraying Fytoclean (Potassium salt of fatty acid) @ 2 ml/ litre of water; T_4= Spraying Sefina 5DC (Aphidopyropropen) @ 2 ml/ litre of water; T_5= Spraying Admire 200SL (Imidacloprid) @ 0.5 ml/ litre of water and T_6= Control (Water spray only). Treatment applications were started as soon as the infestation of sucking insects were noticed and continued at weekly interval upto last harvest of the crop.

Results indicated that at 7 days after spray, Sefina 5DC recorded the lowest aphid population/ inflorescence (1.51) which was statistically similar to Fizimite treated plots (1.85). Accordingly, highest decrease (91.14%) of aphid population was

recorded from Sefina 5DC treated plots followed by Fizimite (89.02%). Similarly, at 7 Days after spray, Sefina 5DC recorded the lowest thrips population/ inflorescence (3.21) followed by Fizimite treated plots (4.52). Accordingly, highest decrease (66.35%) of aphid population was recorded from Sefina 5DC treated plots followed by Fizimite (54.39%). It is also revealed that at 7 days after spray, Sefina 5DC recorded the lowest jassid population (2.85/ 5 leaves) followed by Fizimite treated plots (4.25/ 5 leaves). Accordingly, highest decrease (79.61%) of jassid population was recorded from Sefina 5DC treated plots followed by Fizimite (70.52%). Significantly the highest marketable pod yield (13.89 t/ha) was obtained from Sefina 5DC treated plots which was followed by Fizimite treated plots (12.45 t/ha). Accordingly, the highest yield increase over control was calculated from Sefina 5DC (92.64%) followed by Fizimite (72.67%).

Results of the presented study clearly indicated that newly introduced chemical pesticide Sefina 5DC performed best offering lowest infestation of the target pests and the highest yield. The bio-pesticide Fizimite (Sodium Lauryl Ether) also holds promise in reducing attack of sucking pests and yield performance, and may be used in a well designed IPM program against sucking insect-pests of yard long bean.

Brinjal

Evaluation of new dimension management options against brinjal shoot and fruit borer, *leucinodes orbonalis* guenee.

The experiment was carried out at Entomology research field of BARI, Gazipur during 2018-19. The experiment was laid out in RCB design with three dispersed replications. Brinjal seedlings of BARI begun 8 variety were transplanted in a plot of 11.5m x 2.5m on 21 October 2018. Manures and fertilizer are applied as per recommended dose. Irrigation and mulching were done as and when required. There were five treatments including control. The treatments were: T_1= Antario (Bt-Kurstaki 1.4% + abamectin 0.1%) @ 0.75 kg/ha; T_2= Pheromone lure attract and kill (Mating disruption) @ 250 gm/ha + Soil-recharge (*Metarhizium* + *Trichoderma* + *Beauveria*) for pupa control @ 4.0 kg/ha; T_3= Pheromone lure attract and kill (Mating disruption); T_4 = Farmers' practice, chlorantraniliprole + thiamethoxam (Voliam flexi 300SC) @ 0.5 ml/L of water; T_5 = Untreated control.

The results revealed that significantly the lowest shoot & fruit infestation was found in the treatment pheromone lure attract and kill (Mating disruption) + soil recharge (9.91% & 10.17%, respectively).

The highest yield was recorded in the same treatment i.e. pheromone lure attract and kill + soil recharge (12.57 t/ha) followed by Antario (11.72 t/ha). Farmers' practice i.e. weekly spray of chlorantraniliprole + thiamethoxam (Voliam flexi 300SC @ 0.5 ml/L of water) treated plots offered 10.13 t/ha yield. Pheromone lure attract and kill + Soil recharge treatment provided highest yield increase over control (52.54%) followed by Antario (42.23%).

Pulses

Chickpea

Evaluation of some management packages against pod borer, *helicoverpa armigera* infesting chickpea

The experiment was conducted at Entomology division, BARI, Gazipur, during *rabi* 2018-19 to evaluate different IPM packages against pod borer infesting chickpea. The treatments were: T_1= Sex pheromone trapping (BARI water trap) + Spraying of spinosad (Success 2.5SC) @ 1.2 ml/L of water; T_2= Sex pheromone trapping (Moified-1) + Spraying of spinosad (Success 2.5SC) @ 1.2 ml/L of water; T_3= Sex pheromone trapping (Modified-2) + Spraying of spinosad (Success 2.5SC) @ 1.2 ml/L of water); T_4 = Farmers' practice, chlorpyrifos+ cypermethrin (Nitro 505EC) @ 1 ml/L of water, and T_5 = Untreated control. The experiment was laid out in a randomized block design with three replications (dispersed). The treatments were randomly allotted in each block. The unit plot size was 10m x 4m. The seeds of BARI chola 9 were sown on 25 November 2018 in rows with spacing of 50 cm and plant to plant distance was maintained 10 cm. Standard agronomic practices were done as recommended.

The infested pods ranged from 3.79 to 9.18% and there was significant differencees among the treatments. The lowest pod damage (3.79%) and the highest seed yield (1.46 t/ha) was obtained from T_2 i.e. Sex pheromone trapping (Modified-1) + Spraying of spinosad (Success 2.5SC @ 1.2

ml/L of water) and the second lowest pod damage (3.90%) and seed yield (1.44 t/ha) was observed from T_3 i.e. Sex Pheromone trapping (Modified-2) + Spraying of spinosad (Success 2.5SC @ 1.2 ml/L of water). However, the highest pod borer damage (9.18%) was found in untreated control plots with the lowest seed yield (1.01 t/ha). From the economic analysis, it is revealed that the treatment, T_4 i.e. spraying of chlorpyrifos+ cypermethrin (Nitro 505EC @ 1 ml/L of water) offered the highest marginal benefit cost ratio (1.13).

Pesticide residue analysis

Determination of pre harvest intervals for dimethoate, fenitrothion, lambda-cyhalothrin and chlorpyrifos+cypermethrin in major vegetables

The study was conducted to determine the per harvest interval (PHI) for dimethoate fenitrothion, lambda-cyhalothrin and chlorpyrifos+cypermethrin residue in broccoli, lambda-cyhalothrin and chlorpyrifos+cypermethrin in hyacinth bean on Maximum Residue Limit (MRL) Set by European Union. Six supervised field trials were conducted and sprayed with the recommended dose of dimethoate and fenitrothion (2ml/L of water) and lambda-cyhalothrin and chlorpyrifos+cypermethrin (1 mL/L of water). Samples were collected at 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15 days after spray (DAS). The quantities were above MRL in broccoli up to 13 DAS for dimethoate; 11 DAS for fenitrothion; 10 DAS for lambda-cyhalothrin and 11 DAS for chlorpyrifos+cypermethrin. No residue was detected in broccoli at 14DAS for dimethoate; 12DAS for fenitrothion, 14DAS for lambda-cyhalothrin and 12DAS for chlorpyrifos+ cypermethrin. The detected residues were above MRL in hyacinth bean up to 7 DAS for lambda-cyhalothrin and 9 DAS for chlorpyrifos+ cypermethrin. No residue was detected in hyacinth bean at 11 DAS for lambda-cyhalothrin and 10 DAS for chlorpyrifos+ cypermethrin. The PHI was determined in broccoli at 14 DAS for dimethoate; 12 DAS for fenitrothion; 11 DAS for lambda-cyhalothrin and 12 DAS for chlorpyrifos+ cypermethrin and in case of bean it was 10 DAS for chlorpyrifos + cypermethrin and 8 DAS for lambda-cyhalothrin.

Determination of pesticide residue in selected vegetables collected from different regions of Bangladesh

In order to detect and quantify the left over residue of six commonly used pesticides (chlorpyrifos, quinalphos, diazinon, acephate, cypermethrin and dimethoate) in different vegetables like yard long bean, hyacinth bean, cauliflower, brinjal, bitter gourd samples collected from local market of seven different locations viz. Cumilla, Bogura, Narsingdi, Jamalpur, Gazipur, Dhaka and Jashore comparison between the detected residue level with maximum residue limit (MRL) set by European Union (EU). Out of 60 analyzed samples of yard long bean, 11 samples (18% of the total number of samples) were contaminated with chlorpyrifos, quinalphos, dimethoate and diazinon residue, of which 15% samples were of above MRL. Sample of Narsingdi and Bogura had 21 (0.216 mg/kg) and 14 (0.142 mg/kg) times' higher chlorpyrifos residue then MRL. Among 60 analyzed samples of bean, of which 13% samples had dimethoate, chlorpyrifos and diazinon residues which were above MRL. Sample from Narsingdi had 0.206 mg/kg dimethoate residue which was about 20 times higher than MRL value and sample of Bogura had 0.124 mg/kg Chlorpyrifos residues which were 12 times higher than MRL value. Among 60 analyzed samples of cauliflower, 7 samples (11.67% of the total number of samples) were of above MRL with quinalphos, diazinon, cypermethrin and chlorpyrifos residues. Sample of Narsingdi contained 0.160 mg/kg quinalphos residue and Cumilla had 0.125 mg/kg diazinon residue which were 16 and 12.5 times higher than MRL value. Among 60 analyzed samples of brinjal, 8.33% samples were above MRL with acephate, quinalphos, acephate and chlorpyrifos residues. Samples of Cumilla contained 0.102 mg/kg acephate residue which were 10 times higher than MRL value. Among 60 analyzed samples of bitter gourd, 15% samples were contaminated with acephate, chlorpyrifos, quinalphos and diazinon residues which were above MRL. Sample of Narsingdi contained 0.154 mg/kg acephate residue and sample of Jashore had 0.104 mg/kg quinalphos residue which were 15 and 10 times higher than MRL value. The presence of pesticide residue exceed MRL in vegetables is unexpected very harmful to human food. A total of 126 samples of brinjal, cauliflower and hyacinth bean were collected from Karwan bazar, Mirpur 1

kanchabazar, Mohammadpur kanchabazar, Gulshan Agora and Dhanmondi Meena bazar and were analyzed for the quantification of pesticide residues. Among them, 21 samples (about 17%) were contaminated with the residues of chlorpyrifos, quinalphos, acephate, dimethoate and diazinon. Out of 21 contaminated samples, 19 samples (about 15%) of brinjal, cauliflower and hyacinth bean contained residue above MRL. Sample of cauliflower and brinjal collected from Mohammadpur kanchabazar showed 18 times and 16 times higher residue of acephate than the respective MRL. On the other hand, bean sample collected from Karwan bazar showed about 43 times higher residue of quinalphos and 15 times higher residue of diazinon, respectively than the respective MRL.

Monitoring of multiple pesticide residues in major fruits collected from different regions of Bangladesh

The study was conducted to analyze multiple pesticide residues in mango, litchi, guava and ber collected from different locations of Bangladesh. A simple and efficient multiple pesticide residue analytical method using Quick, Easy, Cheap, Effective, Rugged and Safe (QuEChERS) extraction technique and Gas Chromatography (GC) coupled with Flame Thermionic Detector (FTD) and Electron Capture Detector (ECD) were used for the determination of pesticide residues in 90 samples of mango, 70 samples of litchi, 62 samples of guava and 60 samples of ber. A total of 282 fruit samples were analyzed. Among the 90 analyzed samples of mango, 5 were contaminated with cypermethrin residues. The level of detected cypermethrin residues (0.05 mg/kg, 0.081 mg/kg, 0.087 mg/kg, 0.104 mg/kg and 0.287 mg/kg,) were below EU-MRLs; out of 70 analyzed samples of litchi, 4 had pesticide residues. Three were contaminated with cypermethrin residues (0.043 mg/kg, 0.06 mg/kg and 0.085 mg/kg), among them 2 had residues above EU-MRLs and 1 was contaminated with chlorpyrifos residue (0.093 mg/kg), which was above EU-MRLs; among the 62 analyzed samples of guava, 3 contained cypermethrin residues (0.04 mg/kg, 0.068 mg/kg and 0.113 mg/kg), of which 2 were above EU-MRL; out of 60 analyzed samples of ber, 4 were contaminated with pesticide residues. Two had chlorpyrifos residues (0.098 mg/kg and 0.209 mg/kg) and 2 had dimethoate residues (0.101 mg/kg and 0.0137 mg/kg). All the contaminated samples of ber contained residues above EU-MRLs. This study reflects the scenario of pesticide residue contamination in the selected fruits collected from different locations of Bangladesh, which will help the consumer to be aware of their health and safety.

Monitoring of multiple pesticide residues in betel leaf collected from different regions of Bangladesh

An easy and efficient multiple pesticide residue analytical method using Quick, Easy, Cheap, Effective, Rugged and Safe (QuEChERS) extraction technique and Gas Chromatography (GC) coupled with Flame Thermionic Detector (FTD) and Electron Capture Detector (ECD) were used for the determination of 7 organophosphorus insecticides, 3 synthetic pyrethroid insecticides and 2 fungicides residues in the samples of betel leaf collected from different locations of Bangladesh. A total of 70 samples were analyzed. Among the analyzed samples of betel leaf, 8 contained detectable residues of the sought pesticides. Out of 8 contaminated samples, 3 were contaminated with cypermethrin residues (0.205 mg/kg, 0.264 mg/kg and 0.354 mg/kg) and 2 were contaminated with lamda-cyhalothrin residues (0.01 mg/kg and 0.031 mg/kg) with a level above EU-MRls; 1 was contaminated with chlorpyrifos residue (0.028 mg/kg), which was below EU-MRLs; 1 was contaminated with dimethoate residue (0.102 mg/kg), which was above EU-MRLs and 1 was contaminated with difenoconazole residue (0.0648 mg/kg), which was below EU-MRLs. This study reflects the present scenario of pesticide residue contamination in betel leaf collected from different locals of Bangladesh.

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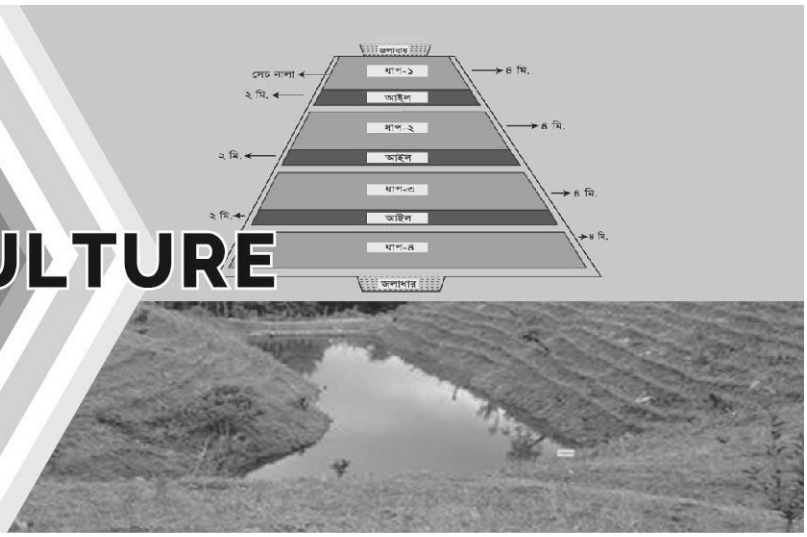


Evaluation of jackfruit germplasm in the hill region

Evaluation of existing eleven jackfruit germplasm was done at fruit farm of HARS, Khagrachari during the year 2018-19 with the objective to identify superior small sized jackfruit germplasm with high yield potentiality and edible qualities. Yield and yield components of the jackfruit germplasms revealed that number of fruits per plant ranges from 32-95. AH Kha 005 produced the maximum number of fruits (95) followed by AH Kha 010 (84) and the minimum was recorded in AH Kha 011 (32). Among the eleven germplasms, six produced more than 50 fruits per plant indicating high yielding potentiality. Single fruit weight ranges from 2.90-5.00 kg where AH Kha 010 produced the highest (5.00 kg) individual fruit weight and the lowest was found from AH Kha 009 (2.90 kg). TSS content of the fruit varies from 18-23.3 where AH Kha 005 produced the highest TSS (23.3 %). Yield (kg/plant) showed the highest (367.50 kg) in AH Kha 004 and the lowest in the line AH Kha 009 (142.10 kg). The edible qualities were varied from (36.65-52.67) % where AH Kha 005 showed the highest (52.67 %) followed by AH Kha 007 (52.33%) and the lowest was observed in AH Kha 008 (36.65 %).

Performance of mango (Kanchamitha) germplasm at hilly region

An experiment was conducted for the evaluation of one Kanchamitha mango germplasm (MI Kha 001) at the Hill Agricultural Research Station, Khagrachari during 2018-19. The full blooming period was mid of January. The tree habit was spreading to intermediate type. Harvesting period was 7 to 16 May, 2019. Total Soluble Solids (TSS) was noted 9.4 %. Edible portions were found (76.56 %). Overall growth conditions of the germplasm were found satisfactory. Considering the fruit characters and edible quality MI Kha 001 was considered as a promising mango for used as unripe condition.

Evaluation of sweet orange germplasm in the hilly region

The experiment was conducted to study the performance of sweet orange germplasm collected from different locations of CHT and planted at HARS, Khagrachari. Two germplasm viz. CS Kha 001, CS Kha 002 and a check variety BARI Malta-1 were evaluated to identify promising sweet orange germplasm in respect of fruit bearing, fruit quality and yield potentiality. Flowering time ranges from February to march in case of CS Kha 002 and BARI Malta-1 but in case of CS Kha 001 it was March. Harvesting time was late November in case of CS Kha 001. All the germplasm produced profuse fruit plants. No. of fruits per plants was the highest (212) in BARI Malta-1 while lowest (86) was CS Kha 002. Individual fruit weight was also varying from 139.33-197.67 g. The biggest (197.37 g) fruit were the recorded in CS 002 and the smallest (139.33 g) was observed in BARI Malta-1. Weight of fruits per plant was the highest (29.53 kg) in BARI Malta-1 while in case of CS Kha 001 it produced yield of 23.65 kg/plant and the lowest (17.00 kg) was in CS Kha 002. Number of seed ranges from 10-22. Seed width ranges from 5.2-5.7 mm and seed length was ranged from 13.5-13.8. 100 seeds weight observed the lowest (9.1 g) in CS Kha 001and highest (14.5 g) in BARI Malta-1 where in case of CS Kha 002 was found 9.4 g. TSS ranges from 7.5 to 8.5 % Brix and the mean was 7.93 % Brix.

In-situ evaluation of year round pummelo germplasm

The study was conducted at Protabpara near the Hill Agricultural Research Station, BARI, Khagrachari during the year 2018-19. One off-season pummelo germplasms (CGKha001) was

selected for the evaluation along with a normal season control. Mainly year round bearing occurred in the germplasm. Maximum numbers of mature (27) and immature (95) fruits were found in the month of March and November respectively. Average fruit weight was 1.39 kg. The maximum edible portion was obtained (38.22%) and the highest TSS (10.4%). The average number of fruits per month (12.67) was collected from CGKha001. **C**onsideration of fruit characteristics, edible quality, TSS, percent edible portion and yield potentialities, the germplasm CGKha001 was found promising.

Evaluation of late-season pummelo germplasm in the hilly region

The study was conducted at the Hill Agricultural Research Station, BARI, Khagrachari during the year 2016-17, 2017-18 and 2018-19. One off-season/late season pummelo germplasm (CGKha 001) was selected for the evaluation along with a check variety (BARI Batabilebu-5), Harvesting time December to January. Fruits of the proposed line are Pyriform shape, large size average individual fruit weight (1450 g) with excellent light yellow colour of rind where check variety produced less (875 g). Pulp is very sweet in taste, soft juicy, light pink in colour, having pleasant aroma and bitterness. Average edible portion is high (67.55%). Average TSS is comparatively high (9.30%) than check variety (9.05%). Fruit retention percentage is very high. Seeds are small in size (weight of 100 seeds is 40.44 g). The germplasm (CGKha 001) is less susceptible to insect- pests and diseases and plant can survive in drought condition.

Characterization and evaluation of turmeric lines

The experiment was conducted at Hill Agricultural Research Station, Khagrachari during May, 2018 to February, 2019. Four turmeric lines were considered for evaluation in RCB design with three replications. The highest leaf length (48.76 cm) was found in CL Kha 006 followed by CL Kha 002 (44.53 cm) which was statisticaly similar to CL Kha 003 (43.90 cm). The highest number of primary fingers / clump (14) and secondary fingers / clump (22.00) was obtained from CL Kha 002 which was statisticaly similar to CL Kha 006. Weight of primary fingers (223.00 g) and mother rhizomes per clump (96.16 g) were the highest in CL kha 002 and that were statisticaly similar to CL Kha 006. CL kha 002 possessed the highest finger breadth (2.83 cm) which was statisticaly similar to CL Kha 009 (2.33 cm) followed by CL kha 003 and CL kha 006. Weight of secondary finger/ clump (119.73 g) and rhizome yield /clump were the highest (438.83 g) in CL Kha 002 followed by CL Kha 006. CL Kha 002 produced the highest fresh yield (23.03 t/ha) which was statistically similar to CL Kha 006 (22.30 t/ha).

Design and development of low cost automatic irrigation systems

An experiment is going on at Hill Agricultural Research Station, Khagrachari to develop automatic irrigation systems affordable for medium and marginal farmers to apply exact amount of water at the right time with minimum involvement of human labour. A prototype has been developed to test in the laboratory to calibrate and observe the system. The system is based on a NodeMCU (ESP 8266) open-source microcontroller. Soil moisture sensor, DC motor and modem have been used along with relevant electronic components. The system automatically sends data to a database by a web server. Based on the observations from the prototype, proper modifications will be made and bigger equipment will be added to the system in the coming year to test in the field.

Evaluation of pegion pea germplasm

This experiment was conducted at the hill valley of Hill Agricultural Research Station, Khagrachari. Four pegion pea genotypes were planted under this study. Seeds were sown on the hill valley following line sowing method. Each plot consisted of 3 rows. In each replication, 5 plants were randomly selected for data collection. Quantitative characters showed variation in days to 50% flowering ranged from 109.33 to 121.33days. Plant height was found within a range of 80.47 to 86.27 cm. Accession E4 showed first flowering, maturity, maximum pods per plant, dwarf plant height and maximum yield. The reason behind the higher and lower yield might be less number of plants per plot.

Regional yield trial of mukhikachu lines

The experiment was carried out at Hill Agricultural Research Station (HARS), Khagrachari during

2018-19 to evaluate some promising mukhi kachu lines. Four Mukhi kachu lines viz., MK-122, MK-129, MK-131, MK-176 and two check variety i.e. BARI Mukhi khachu-1(Bilashi) and BARI Mukhi khachu-2 were used in these study. In case of no of corm and weight of corm all the lines showed statistically similar character. Number of cormel were the highest (156.22) in MK-129 and the lowest (117.67) in MK-122 where weight of cormel were maximum (3870.89 g) and minimum (2758.67 g) in MK-122. Plot yield were found maximum (22.54 kg) in MK-129 which was statistically similar to MK-176 (21.38 kg) and minimum (18.63 kg) were found in Mk-122. Dry weight percentage were ranges from (24.14-26.86) % where MK-176 and MK-129 were found maximum and MK-122 were found minimum.

Regional yield traial of bottle gourd lines during winter and summer

A field experiment was conducted at the Hill Agricultural Research Station, Khagrachari from November 2018 to April, 2019 to evaluate the performance of different bottle gourd germplasm. Among the germplasm the highest yield (49.19 t/ha) was obtained from the line BARI Lau-4 followed by LS151C (37.8 t/ha) and the lowest (33.85 t/ha) was received from BARI Lau-3. Bottle and oblong shape fruits were found with the different color combination.

Evaluation of Indian dillenia germplasm in hilly region

Three Indian dillenia germplasm were evaluated at the Hill Tracts Agricultural Research Station, Ramgarh during the year 2018. The line DI RAM 003 produced the maximum number of fruits (539/plant) while heavier fruit (744.3 g/fruit) was produced by the line DI RAM 005. The maximum fruit yield (396.3 kg /plant) was obtained from the line DI RAM 005 and the lowest yield (101.4 kg/plant) was recorded in DI RAM 002.

Evaluation of golden apple germplasm in the hilly region

Four Golden apple germplasm were evaluated at the Hill Tracts Agricultural Research Station, Ramgarh during the year 2018. The line SDRAM 001 produced the maximum number of fruits (4247/plant) and heavier fruit (100 g/fruit) was produced also by the line SD RAM 001. The maximum fruit yield (424.7 kg /plant) was obtained from the same line SD RAM 001 and the lowest yield (182.4 kg/plant) was recorded in SD RAM 004.

Evaluation of star gooseberry germplasm in hill region

Five germplasm of star gooseberry fruits were evaluated at Hill Tracts Agricultural Research Station, Ramgarh, Khagrachari during 2018-19. The highest number of fruits (562/plant) was found from PA RAM 002 and weight of fruits (2.82 kg/plant) was harvested from the same germplasm and TSS (%) was almost similar for all germplasm.

Evaluation of china mandarin germplasm in hill region

Forty germplasm of China Mandarin were evaluated at Hill Tracts Agricultural Research Station, Ramgarh during the year 2019. Plant height, base girth, number of main branch/plant, plant spread (N-S), plant spread (E-W) and number of fruit/plant range were 1.94-4.10 m, 13.0-18.0cm, 1.0-3.0, 1.10-1.80 m, 0.99-1.92 m and 15-105, respectively.

Evaluation of jaboticaba germplasm in hilly region

Five germplasm of Jaboticaba fruits were evaluated at Hill Tracts Agricultural Research Station, Ramgarh, Khagrachari during April, 2018. The maximum number of fruits (729/plant) was found from EC RAM 004 and weight of fruits (4.67 kg/plant) was harvested from the same germplasm and TSS (%) was also the highest (11.9%) in EC RAM 004.

Perfomance of grafted and seedling plants of velvet apple var. BARI bilati Gab-1

The experiment was conducted at the Hill Tracts Agricultural Research Station, Ramgarh, Khagrachari during 2018 to observe the performance of grafted and seedling plants of BARI Bilati gab-1. Average plant height varies from 2.50 m to 5.12 m, number of branches/plant (9.1), base girth (20.3 cm) were found from grafted plant. In case of seedling plant, number of branches/plant (7.5), base girth (27.0 cm) was recorded. The higher number of fruits (30.6/plant) was obtained from grafted plant compared to seedling plant (14.3/plant). Yield was also higher (5.67 kg/plant) in grafted plants compared to seedling plants (2.67 kg/plant)

Integrated nutrient management for mango var. BARI Aam-3 in hilly region

An experiment was conducted at Hill Agriculture Research Station of Ramgorh, Khagrachori during the year 2016-2017 and 2017-2018 to evaluate the effects of N, P, K and S on the yield and yield components of Mango. The experiment was arranged in a randomized complete block design comprising one absolute control treatment along with thirteen other treatment combinations having four levels each of nitrogen (0, 200, 400 & 600 g tree^{-1}), phosphorus (0, 50, 100 & 150 g tree^{-1}), potassium (0, 150, 300 & 450 g tree^{-1}) and sulphur (0, 25, 50 & 75 g tree^{-1}) along with a blanket dose of $Zn_{10}B_5$ g tree^{-1} and decomposed cowdung 5 kg tree^{-1}. There was positive impact of each nutrient on the yield and yield attributes of mango. Highest number of fruits plant^{-1} (71.73 in 2016-17 and 80.57 in 2017-18), single fruit weight (295 g in 2016-17 and 303 g in 2017-18), fruit length (7.18 cm in 2016-17 and 7.28 cm in 2017-18), fruit diameter (6.56 cm in 2016-17 and 9.85 cm in 2017-18) and edible portion (165 g in 2016-17 and 168.8 g 2017-18) were recorded in T_4 ($N_{400}P_{100}K_{300}S_{50}$) treatment. Average highest fruit yield of 23.31 gm tree^{-1} also recorded from same treatment. From the regression equation, the optimum dose of nitrogen, phosphorus, potassium and sulphur were found 381.1, 94.3, 324.9 and 49.6 g tree^{-1}.

Integrateed nutrient management for velvete apple var. BARI bilati Gab-1 in hilly region

An experiment was conducted at Hill Agricuture Research Station of Ramgorh during the year 2017-2018. The aim of the experiment was to find out fertlilizer requirement of velvete apple var. BARI Bilati gab 1. There were four threatment viz. T_1: control, T_2 : $N_{300}P_{80}K_{200}$ g/tree, T_3 : 80% of T_1, T_4 : 120%. It was laid out in a radomized complete block design, replicated three times. A blanket dose of 5 kg cowdung/tree, 40 g S/tree, 10 g Zn/tree and 5 g B/tree were apllied in each treatment. The highest fruit weight/plant significantly influenced by different fertilizer packages. Significantly the highest weight of fruits/plant (5.79 kg) were obtained from T_4 (i.e. 120% of T_1) treatment. Moderate weight of fruits/plant were obtained from T_2 (4.66 kg) and T_3 (3.76 kg) treatment. The lowest weight of fruits/plant was found in T_1 (2.85 kg) treatment. About 103.16, 63.51 and 31.93% yield increase over control (i.e. T_1 treatment) were recorded from T_4, T_2 and T_3 treatment, respectively. Highest TSS (14.1) was also obtained from T_4 (i.e. 120% of T_1) treatment. As there is a increasing trend in fruit yield of Bilati Gab with the increase of fertilizer, more fertilizers namely nitrogen, phosphorus and potassium required for Bilati Gab to sustain production and restore fertility. Treatment T_3 can be revised with 140% of T_1 treatment instead of 80% of T_1 treatment

Adaptive trials with BARI maize hybrids in different hilly districts

The work was carried out to determine the performance of four BARI released maize hybrids namely BHM-7, BHM-9, BHM-13, BHM-14,two selected lines HTMA-19, HTMA-21 and two commercial hybrid (Sunshine), 981 at Hill Tracts Agricultural Research Station, BARI, Ramgarh, khagrachari Hill District during *kharif*-1 season 2019. All the maize hybrids as well as commercial one showed significant differences for days to silking, days to tasseling, plant height, ear height, cob length, cob diameter, number of cob per plot, No. of grain per cob,1000 grain weight, grain yield per plot and grain yield (t/ha). Where only ear height, days to silking and grain yield showed significances differences at 5% level besides other parameters showed 1 % level of significance. BHM 9 was the tallest 215 cm and sunshine was the dwarf 188 cm. The highest cob length was recorded in sunshine and the lowest one BHM 13.Bold seeded entry was recorded as commercial hybrid BHM 9 followed by sunshine whereas HTMA 21 bears the smaller sized seeds. The number of cob per plot was the highest in 981 followed by HTMA 19 and BHM 13. The hybrid 981 showed better performance regarding to yield 9.45 t/ha mostly similar as sunshine (9.40 t/ha), BHM-9 (9.38 t/ha) followed by HTMA-19, HTMA-21, BHM-13, BHM-14 and BHM-7, respectively. Therefore high yield scorer is also suited for favorable environments to hilly areas of Bangladesh.

Adaptive trials with BARI kaon varieties in the hilly areas

An experiment was conducted at hill tracts Agricultural Research station, Ramgarch, khagrachari hill district during *kharif*- season 2019 to observe the performance of BARI kaon varieties in hilly area. There were three kaon varieties BARI kaon 1, BARI Kaon-2 and BARI Kaon-3 (dwarf variety).The highest grain yield (1.57 t/ha) was recorded in BARI Kaon-1 followed by BARI kaon-2 and the lowest grain yield was recorded from BARI Kaon-3 (1.10 t/ha.).

24 SERVICES OF ASICT

Agricultural Statistics and Information & Communication Technology (ASICT) Division has been conducting research works as well as service activities for BARI personnel and other stakeholders of agriculture system. Research activities have been conducting through BARI annual research program. Besides, ASICT Division has been working to implement "National ICT policy 2018" and "Digital Bangladesh 2021".This division has been conducting different support service activities as well as research activities with its scientific manpower.

Research Activities

Mapping and monitoring of mango orchards in Rajshahi region using satellite remote sensing techniques

The study was conducted to develop an effective technique to extract and monitor mango orchard area from freely available satellite imagery. The goal of this study was to produce accurate Sentinel-2 derived mango orchard extent product for Greater Rajshahi region. A pixel-based supervised classification approach with the CART (Classification And Regression Trees for classification) and SVM (support Vector Machine) classifier on the GoogleEarth Engine (GEE) cloud computing platform were used to develop mango orchard extent product for the study area using Sentinel-2 10-m, time-series data for the 2015–2018 time-period. At first, a machine learning classifier CART was adopted to identify 7 (seven) common classes (namely, trees, water-body, charland, built-up area, bare lands and crop land). The area under tree coverage was then extracted for further classification into mango orchard and others using SVM algorithm. An interactive prototype of web based geo-portal namely, GeoMango has been developed for semi-automatically map mango orchards in the greater Rajshahi region. Results showed that the system could successfully map the mango orchards in this region with high accuracy. Remote Sensing based results showed good agreement with the data reported by the Bangladesh Bureau of Statistics (BBS). Results of mango orchards area derived from GeoMango platform has been compared with the statistics reported by BBS. While, both results show an increasing trend of mango orchard coverage with time, RS based technique overestimated (3.8~12.3%) the area compared to BBS. Output yielded from GEE has been rendered in the GeoMango portal for public sharing and accumulation of feedback for further improvement.

Characterising dry season's agricultural landuse in northwest Bangladesh: spatial dynamics and water use

The northwest region of Bangladesh has experienced changes in cropping patterns, an increase in irrigated areas and associated water demand. Tracking historical changes in irrigated crops and their associated water use at the local-scale can only be practically achieved using remote sensing technologies. Bangladeshi Agricultural Institute (BARI) and CSIRO have been developing methods to map dry season crops and estimate their water use from freely accessible satellite data supported by ground sampling, expert knowledge, machine learning image processing algorithms, and high performance computing system. The overall aim of the research is making a diagnosis and analysis of data and methodologies for crop mapping and water use estimation via remote sensing. Crop phenology and monthly evapotranspiration for the whole of northwest region in Bangladesh processed and estimated at scales ranging from 30 m to 500 m horizontal resolution for the 1991–2016 period using a combination of remote sensing data, machine learning algorithms and field survey data. A supervised classification algorithm using multi-temporal VIs (EVI, GVMI and NDWI) data to map crop types and their water use were implemented. The idea is to capture the phenology and associate

it to known/inferred crop types. Some 14 cropping patterns including major crops such as rice, wheat, maize and potatoes of this region were estimated for this research. For water use estimation, two vegetation indices were processed from the spectral data and downloaded on a monthly time-step to estimate actual evapotranspiration (ET_a) at 250 m spatial resolution through the CSIRO CMRSET (Csiro Modis ReScaled EvapoTranspiration) algorithm. Monthly ET_a was estimated by scaling Priestley-Taylor potential evapotranspiration (ET_p) via a crop factor obtained from EVI and GVMI. The crop type mapping and water use estimation using remote sensing techniques showed the satisfactory results for the north-west 16 districts crop area.

Assessment of cropping patterns for sustainable intensification in drought prone ecosystem using remote sensing and geospatial modeling

Bangladesh Government has given high priority to sustain groundwater use for irrigation. Hence, it is important to conduct agricultural land use and cropping patterns analysis and their implication to foster sustainable intensification (SI) strategies in the drought-prone regions of Bangladesh. Remote sensing and geospatial modelling can play a vital role to assess cropping patterns and availability of natural resources on the ground and allocate them judiciary for SI in agriculture. Geospatial modeling can help allocate an appropriate cropping-pattern based on the best judicial use of available natural resources. Hence, in order to facilitate sustainable cropping intensification in the problem agro-environments of Bangladesh, current research project has been initiated to carry out in the drought-prone agro-ecosystems prevailing in the Barind Tract region of Bangladesh. Historical land use/cover change analysis at a time lapse of every ten years since 2001 will be conducted for dry season cropping practices mostly by using Landsat data archives. Daily 250m NDVI and EVI composite available from MODIS sensors' on-board Terra and Aqua satellites will be used to complement data requirements for crop monitoring. For recent crop types and cropping pattern mapping, data from Sentinel 1 and 2 satellites data will be exploited. Very high-resolution satellite data and imagery collected by Unmanned Areal Vehicle (UAV) will be used as reference for training of algorithms for classification of satellite imagery. Crowd sourcing geo-visual web-interface will be developed to collect ground reference data and validate map outputs with multi-stakeholder involvements. Post-classification land use/cover change analysis will be performed to depict winter seasons' land use/cover changes in the study area. Historical land use/cover maps developed for every ten (10) years intervals will be used to find relationship with irrigation water availability from surface water sources in the High Barind area. Surface water maps will be generated as a part of land use analysis. Implication of current dry-season agricultural practices on water and other natural resources will be quantified within the GIS. Available major alternative technologies (crop types, varieties, management options etc.) will be listed and their selection/suitability criteria to comprise a suitable cropping pattern and fit in any particular locality will be scored. Finally an integrated geospatial model will be developed for decision support to target expansion of specific cropping pattern suitable for SI at a particular location.

Determinants of household food security in rural Bangladesh: An imperial analysis of farm level data

The study endeavors to estimate the food security status and identify the determinants of food security among households in Hakimpur Upazila in Dinajpur district, Bangladesh. It was found that households of Hakimpur upazila in Dinajpur district were food insecure during the period of the survey. Number of dependents, income of household head, age of household head and level of education were found to significantly influence household head food security in the study area positively. It is recommended that social security measures must ensure that the benefits of public efforts to improve food security and nutrition are universal. Human rights based practices are preferable.

Effects of climatic factors on the yield of exotic potato germplasom

Some new potato varieties (viz. Alberta, AlRusset, Arizona, Dunstar, Fontane, HZD 1249, Innovator, Ottawa, Primavera, Sayada and Tiamo) were introduced one year back in the country by private sectors for evaluation and selection as well as to release for mass cultivation. This study was conducted at BARI head quarter and five other potato growing stations (Jamalpur, Jashore,

Munshigonj, Bogura and Panchagarh) of BARI during Rabi 2018-19 seasons to see the yield potentiality as a commercial variety in Bangladesh's climatic condition. Simple linear regression model was used to analyze the effect of the climate factors of maximum temperature, minimum temperature, humidity, rainfall and sunshine on yield of the varieties or lines. The average maximum temperature has positive effect on the yield of all the varieties or lines. Other climate factors like average minimum temperature, average humidity and average sunshine hour have positive effect on yield of most of the varieties or lines. Al.Russet and Primavera showed the significant positive effect for the average maximum temperature. But the other variables have no significant effect. Although intercept of most of the varieties or lines for Rainfall variable were significant.

Scientists' perceptions on the role of information and communication technologies (ICTs) in agriculture

The study was conducted to appraise the perception of agricultural scientists on the role of Information and Communication Technologies (ICTs) in agriculture. Data were solicited from 142 selected agricultural scientists from two research institutions, e.g. Bangladesh Agriculture Research Institute (BARI) and Bangladesh Rice Research Institute (BRRI) through proportionate random sampling technique. Along with data of personal characteristics of scientists and types of ICTs they used, collection of perception related data was performed using Likert–type scale on 5-point continuum. Factor analysis with polychoric correlation matrix was applied to obtain factor score and this score was used (as an index of all perception related variables) for further analysis. Multiple linear regression model applied for measuring effect of personal variables on perception level of scientists. Scientists expressed their positive perception in using ICTs tools for agricultural research activities and its dissemination. Higher education level, foreign degree/diploma/training of more than 6 months and trainings on ICTs had positive and significant influence on perception, while scientists' designation, age and working experience had negative influence. Hence, scientists may be highly encouraged for higher education especially in abroad and capacity building on ICTs.

Service Activities

Web Information

BARI developed technologies and related information are being publishing regularly through its own web site (www.bari.gov.bd & বিএআরআই.বাংলা) and mobile apps. In addition to technologies, some important issues like tender circular, job circular, journal publication, annual report etc. are also hosted as and when necessary.

List of information uploaded in the website and mobile apps during 2018-19

SN	Subject	Uploaded Number	Type of Information
1	Office Order	1757	PDF
2	Notice	335	PDF & Doc
3	Reports, Publications & News	22	PDF
4	Agro Technology, Description of variety	97	PDF
5	Leave Order, Transfer/Promotion	680	PDF
6	NOC	258	PDF
7	Higher Study, Training, Meeting-Abroad	280	PDF
8	Photo gallery, Video	78	Image & YouTube
9	Tender, Job Notice	117	PDF
10	Others	164	PDF and Doc
	Total	**3788**	**-**

Query-Answer

BARI has been started online e-agriculture services to the beneficiaries. Any stakeholder can ask question related to agriculture with the help of on-line facility of BARI web site and Mobile web apps. BARI has been giving services on-line feedback through website (www.bari.gov.bd) and Mobile web apps (baritechnology.org/m) to end

users. During 2018-19, BARI has provided answers of all 299 questions after soliciting from 14 Centres/Divisions.

Citizen Information Service Centre

BARI has started disseminating technological information to the citizen. Any citizen can come and obtain his/her required agricultural technological information/service directly from Citizen Information Service Centre and/or from respective crop centre/research division at BARI. During 2018-19, 70 citizens of different professionals from 19 districts has visited BARI citizen services information centre and got services on 19 different areas.

Ensuring access to information of citizens through the Right to Information Act

BARI has appointed personnel to ensure citizen's access to the information in an easiest way. During 2018-19, the following information has been provided to the citizens.

Citizen's access to information in 2018-19

SN	Name of the Authority	No. of application received as of the format of Right to Information Act, 2009	N0. of application which has solved through providing information	No. of decisions for not providing requested information and the reason for that decision	No. of appeals against the decision of the officer in charge	No. settlement appeals	No. of disciplinary action taken by the authorities against the officer in charge	Amount received as the value of information as per rule 8 of Right (Regulation of Information) to Information Act, 2009	Details of different activities taken by the authorities
1	2	3	4	5	6	7	8	9	10
1	Bangladesh Agricultural Research Institute, Gazipur	2**	2**	-	-	-	-	-	-

** BARI has provided answers of all 299 questions received through website and mobile apps.

Online based service to the citizen

BARI has been started online based services to the citizen. Each year at least one online based service would be developed. During 2018-19, two services e.g. Online APA reporting and Online Loan Management has been developed. Selected person can submitted his report through BARI developed APA reporting system from online service (baripmis.org/apa). On the other hand, BARI employee can apply for loan through baripmis.org/form-app

List of online based services in BARI

SN.	Link	Service	Year
1.	bari.taletalk.com.bd	Job application	2016-17
2.	baritechnology.org/crpt	District wise cropping pattern	2017-18
3.	baripmis.org/apa	Online APA reporting	2018-19
4.	baripmis.org/loan	Online Loan Management	2018-19

Service simplification (SPS) to the citizen

BARI has been started service simplification using ICT. Each year at least one service simplification would be developed. During 2018-19, one service simplification has been developed for Information collection and preservation of BARI scientists/officer/staff through online PMIS software.

List of service simplification in BARI

SN.	Type	Service	Year
1.	Information centre	Citizen information services	2016-17
2.	Collection of seed and seedling	Limited collection of BARI develop variety seeds and sapling.	2017-18

SN.	Type	Service	Year
3.	Collection and preservation of personal information	Information collection & preservation of BARI scientists/officer/staff	2018-19

ICT based innovation to the citizen

BARI has been started ICT based innovation to the citizen services. Each year at least one ICT based innovation must be developed. During 2018-19, "Mobile apps for Mango yield estimation" has been developed.

List of ICT based innovation to the citizen services in BARI.

Sl. No.	Type	Innovation	Year
1.	Apps	Krishi Projukti Vander	2016-17
2.	Online based	Faster analysis of soil samples	2017-18
3.	Apps	Mobile apps for mango yield estimation	2018-19

Annual Innovation Report

BARI has been implemented annual innovation working plan. In each year, BARI innovation plan has been developed according to prescribed format of Ministry of Agriculture. The brief report on Innovation working plan of 2018-19 has given in the following table

Report on Annual Innovation Working Plan 2018-19

SN	Subject	Proposed Topics (Task to do)	Implementation Progress
1.	Formulation of Innovation Work Plan	Formulation of Annual Innovation Work Plan	Innovation Work Plan 2018-19 has been prepared
2.	Meeting	Call for meeting of Innovation Team in every months	Ten meetings of Innovation Team has been held
3.	Report	Preparation and submission of annual report (July, 2018-June, 2019) of Innovation Team	Innovation Working Plan 2018-19 and its Half-yearly & Yearly self-evaluation report has been uploaded on the website and submitted to the ministry.
4.	Innovative Ideas	Call for Innovative Ideas, compiling & preserving them on a priority basis after validation	Compilation of the innovative ideas has been prepared
5.	Piloting of Innovative Ideas	Taking actions for piloting Innovative Ideas	One innovative idea is under piloting process (Mobile apps for estimating Mano Yield)
6.	Experience gained from Innovation Ideas	Implementation and supervision of the ideas of the subordinate department/agency and preparation of the report on the basis of experience (success/ failure).	One innovative idea has been implemented and one report has been prepared.
7.	Nationally Implementation	Implementation of Innovative piloting project country-wide	Countrywide replication of one innovative idea is under process
8.	Enrichment of Innovative Capabilities	Conducting Innovation Training/ Workshop/Study tour to enhance the Innovation Capacity	• 1 workshop and 3 trainings have been organized • 1 person was sent abroad on study tour
9.	E-services and E-filing Activities	Implementation of E-file management and E-services	E-filing system is running smoothly. 2 E-services has been developed (baripmis.org/apa and baripmis.org/loan)

Social Networking (Facebook)

BARI has been disseminating its regular activities among public through social networking. Any person can ask and interact with BARI authority regarding technologies and/or other information through its official Facebook page (www.facebook.com/BD.GOV.BARI). At present

BARI facebook page is followed by more than 7900 facebook users. During 2018-19, a total of 200 posts or public Q/A were moderated/addressed through BARI facebook page.

Web based mail services

BARI has its own domain of email connectivity under the name "bari.gov.bd". At this moment 674 web based email addresses has been assigned under BARI domain. It has been decided to assign email address to all scientists under BARI domain gradually.

Network and Antivirus maintenance

ASICT division was giving services on LAN & Antivirus maintenance especially for the head quarter scientists and officers. Rendering 24 hours internet services at BARI headquarters. At present more than 500 computers are connected with network and provided with a corporate version of antivirus.

Network and Antivirus maintenance during 2018-19

SN.	Subject	Number
1.	Trouble shooting for LAN & internet connectivity	772
2.	Trouble shooting for Antivirus	292
3.	New internet connectivity	47
4.	Network connection repair	30
Total		**1141**

Wi-Fi connectivity

BARI has been established Wi-Fi connectivity in different places. ASICT division was giving services on Wi-Fi & maintenance especially for the head quarter scientists and officers. At present 400 devices are connected in Wi-Fi network.

Statistical analysis service

ASICT division has been giving services on statistical analysis through computer package software such as R and SPSS. Some important analysis has been given to the scientists of different Centre/Division. During 2018-19, ASICT division has provided analytical assistance on 22 different research programs.

E-Governance

(a) e-Filing system

Access to Information (a2i) has been established e-filing system in BARI head quarter. ASICT division has been assisted on e-filing system especially for the head quarter personnel. At present 134 personnel are connected in e-filing system.

List of file and letter issued through e-filing system during 2018-19

SN.	Name of Wing/Centre/ Division/Section	No. of file	No. of letter issued	
			2017-18	2018-19
1.	DG Office	1	17	220
2.	Support and Service wing	3	0	3
3.	Research Wing	19	4	92
4.	Training & Communication Wing	39	3	8
5.	Planning and Evaluation Wing	11	18	32
6.	Horticulture Research Center	9	80	69
7.	Oilseed research center	17	512	297
8.	Tuber Crops Research Center	153	54	155
9.	Plant Genetic Research Center	16	46	50
10.	Agronomy Division	17	50	87
11.	Plant Breeding Division	24	203	190
12.	Soil Science Division	76	312	828
13.	Entomology Division	166	39	100
14.	On-Farm Research Division	27	79	66
15.	Agricultural Economics Division	13	22	21
16.	FMPE Division	6	100	91

SN.	Name of Wing/Centre/ Division/Section	No. of file	No. of letter issued	
			2017-18	2018-19
17.	IWM Division	2	71	126
18.	ASICT Division	12	36	33
19.	Posted in Harvest Technology Division	4	52	3
20.	Biotechnology Division	7	133	81
21.	Seed Technology Division	6	37	7
22.	Plant Physiology Division	2	63	55
23.	Vertebrate pest management Division	26	87	127
24.	Farm Division	15	0	2
25.	Plant Pathology Division	26	0	6
26.	Machinery Repair and Maintenance Division	1	84	74
27.	Regional Spice Research Center	24	15	5
28.	Pulse research sub station	47	50	30
29.	Administration Section	386	1078	757

*Finance and Accounts, Building & Ground, Common Service and Transport Section did not issue any letter through e-filing system during 2018-19.

e-Tendering system

Central Procurement Technical Unit (CPTU) has been established e-tendering system at BARI. ASICT division has been assisted on e-tendering system especially for the head quarter through two Procurement Entity (PE) offices like Building & Ground section and Procurement & Store section. During 2018-19, 100 e-tendering has been implemented through two PE offices.

Table 1. List of e-tendering during 2018-19

SN.	Name of office	e-tendering
1.	Procurement & Store section	59
2.	Building & Ground section	41
	Total	**100**

Labour Management Software

BARI labour management automation is going on full swing. At present, 53 centre/division /section and 1349 labour information are included in this automation. This automation software is divided into three parts viz, Labour Information, Labour Salary and Labour Report. Each part can be operated solely and has an options to be integrated together as per requirements.

(d) Salary System Software

BARI payroll management system has been developed for BARI personnel. This system is user friendly. Any person can be used own BARI ID number and prepare his/her salary statement. At present 400 scientist/officer/staff are using this system.

(e) Management Information System (MIS) Software

MIS software is divided into three separate modules viz. Personnel Management Information System (PMIS), Training Management Information System (TMIS), Publications Management Information System (Publication). Each module can be operated solely and has a options to be integrated together as per requirements.

Table 2. Present status of 3 modules

Modules	Achievement (data entry)
Personnel Management Information System (PMIS)	100 %
Training Management Information System (TMIS)	50 %
Publications Management Information System (Publication)	20%

Human resource development

ASICT division has engaged human resources development through various type of training program related to ICT.

Table 3. List of training course conducted during 2018-19

SN.	Title	Duration (day)	No. of participants	Institute
1	Scientists training on open source software R	5	200	NARS
2	Training on Innovation of citizen services.	2	40	BARI
3	Training on mentor and mentee	2	20	BARI
4	Training on Innovation of citizen services.	5	20	BARI
Total			280	

Participation in different ICT Fair and Field day

ASICT division has participated at ICT fair and organized field day on mobile apps in different places.

Table 4. List of ICT Fair and Field day organized during 2018-19

SN.	Title	Duration	Organized by	Place
1.	Seminar on ICT based Innovation	11 September 2018	BARI	BARI Seminar Room
2.	Digital Innovation Fair-2018	11-13 October 2018	Gazipur District Administration and a2i	Rajbari Gazipur
3	Field day on Mobile Apps	06 May 2019	ASICT Divison & OFRD Comilla	RHRC Comilla
4	Field day on Mobile Apps	12 May 2019	ASICT Divison & RARS Rahmatpur, Barishal	RARS Rahmatpur, Barishal
5	Participation in innovation showcasing	22 June 2019	MoA and a2i	BARC

Training & Communication

During 2018-19, Twenty eight (28) scientists were sent abroad for higher study (MS, Ph. D and Postdoc). One hundred and twenty seven (127) scientists/officers were sent abroad for training/workshop/study tour/visit meeting/ conference etc. Besides, thirty one (31) scientists were sent to different universities in the country for Ph. D degree. Total 387 scientists, officer and staff have been sent in 73 different training courses, 304 scientists attended 40 workshops and 24 scientists attended 5 seminars organized by various organizations in the country.

Seminar & Workshop

Communication Section of T&C arranges seminars and workshops in various fields of agricultural research. A total of 10 (ten) seminars and 10 (ten) workshops were organized at BARI during the year 2018-19 on different aspect of agricultural Knowledge share to achieve the goal of Annual Performance Agreement (APA). A total of 1705 participants of BARI and other national research organization were actively participated in these seminars and workshops.

MoU & LoA singed

During the period 2018-19, BARI had signed MoU with 10 (ten) organizations and LoA with 5 (five) organizations. All of the organizations signed MoU and LoA with BARI were voluntary organization. The purpose of the MoU and LoA were to promote collaboration between agricultural research and development and also for promotion of technology transfer to the end users.

Publication

BARI regularly publishes journal, newsletters (Bengali and English), annual report, books and booklets on the evolved technologies in order to disseminate information to the users including farmers. Brochure, manuals, and other literatures on BARI are also being published. During the year under report, 4 issues of ne wsletter, brochure of the institute, annual report, a few booklets and some other literatures have been compiled, edited and published. Further, more than hundred science articles revived from scientists of home and abroad has been processed for publication in the journal.

BARI Library 2018-19

A. **Mandate:** BARI Library is mandated to help fulfill the purpose of the institute, as an adjunct of the researcher's tool and it's tends to play a significant role for providing right information to the researchers at the right time. So the mandates are:

- Building up a balanced and comprehensive collection in the sphere of agriculture and its allied fields based on the scientists needs with a bit focus on the generalist's interests.
- Preparing and processing the procured materials to ensure users effectiveness.
- Making the research community aware of new information and technology collected in and organized technically.
- Participating inter-library loan and network system to serve the researchers effectively.
- Providing aid on the use of the library and help to find, locate and evaluate the information available in the library.
- Establishing Management Information System (MIS) i.e. digital library and library automation system using library management software in the library.
- Adopting the technique of economic method to preserve and repair the collection to ensure its continued use.
- Developing the mini-libraries at the regional and sub-regional station to feed the scientists with their needed information.

B. **Existing facilities:** Information resources materials collected so far have been properly catalogued, classified and organized. The Library now houses following information resource materials.

1. Existing Collection of BARI Library: 85,351

Items	Quantity
Books, Reports, Proceedings, etc.	46,199
Archival collection	2,670
Thesis	833
Periodicals (bound in book form)	4,247
Journal	24,335
Newsletter	613
Bulletin	120
Pamphlets	696
Booklets	243
Reprint	518
Leaflets	4,877

2. Information resources added during the year 2018-2019

a. Books, Reports, Proceedings etc. and Thesis: 217

Items	Purchased	Exchange	Gift / Complimentary		Total
Books	70	-	74		144
Research reports, project reports & proceedings	-	16	34		50
Thesis (MS & Ph.D)	-	-	MS- 06	Ph.D- 17	23

b. Serial Publications (printed form)
Journals, Newsletters, bulletins etc : 192

Items	Purchase	Exchange	Gift / Complimentary	Total
Journals	-	42	55	97
Newsletters	-	08	42	50
Bulletins	-	-	45	45

3. Document Processed for Services:

SI No.	Procured material processed	No.
01	**Document Accessioned**	314
02	Catalogued & Classified and pasted with call numbers, book pockets and due slips	217

4. Services Provided to Users:

Sl No.	Services provided to the Scientists	Number
1.	Article downloaded from Online journal (May 2019)	2,139
2.	Documents Charged/Discharges	287
3.	Users Referenced	818
4.	Number of photocopies made	9,572
5.	Publication Distributed (Journal, Newsletter & Report) in Exchange & Complimentary)	108
6.	Correspondence made	94

5. Online Browsing Facilities:

<u>Subscribed Journals (Publisher's list)</u>

01. American Institute of Physics
02. American Physical Society
03. American Society of Agricultural and Biological Engineers (ASABE)
04. American Society for Civil Engineers
05. Annual Reviews
06. British Institute of Radiography
07. Cambridge University Press (CPU)
08. Canadian Science Publishing (was NRC Press)
09. Cochrane Library
10. EBSCO Host including CMMC
11. Edinburgh University Pres
12. Geological Society
13. Mary Ann Liberty
14. Nature- Nature Research Journals (48 titles)
15. Nature- Palgrave Macmillan Journals
16. Nature- Academic Journals
17. Optical Society of America
18. Policy Press
19. Project MUSE Journals
20. Royal College of Physicians
21. Royal Society
22. Scientific American

23. SPIE Digital Library
24. Springer ALL (2000+ titles
25. Springer- Adis Collection
26. Wiley Online Library- ***continued access only to 2018 content confirmed***
27. Indian Online Journals

e-Book

28. Project MUSE books
    Complete collection (17,000+ titles)
29. De Gruyter LIS books collection
30. Wiley Online Library

Complementary journal

(http://login.research4life.org/tacgw/AppPortal/)

AGORA & HINARI

i. http://www.aginternetwork.org
   ID: ag-bgd026
   Password: GQ34ACDX
ii. http://www.who.int/hinari
   ID: BAN053
   Password: 70555

BARI Digital Library: BARI library has lunched "**BARI Digital Library**" which is associated with both digital and automated library system. Now this digital library is available for user access through internet from anywhere. The web address is www.barilibrary.org. Here SLiMS library software has used. In this page main icons are:

	Icons	Document uploaded
1.	BARI Publications	192
2.	Bengali Books	406
3.	Reference	2034
4.	Booklet	62
5.	Fiction	13
6.	Center's Publication	194
7.	Divisional Publications	136
8.	Newsletter	45
9.	Report	8
10.	Journal	11
11.	Thesis – MS	334
12.	Thesis –Ph.D	389
13.	Leaflet	296
14.	Personal Publications	70
	Total	4190

Photography Section

The photography section processing photograph & video clips to ensure effective uses of its parent institute and is designed to help researchers, outside of the Institute in print, soft images and electronic form at the right time.

Photography Section Covered the following activities during 2018-2019

- To expose, collect, preserve and display photograph of different crop varieties.
- To display photographs of visitors, research, agricultural fairs, BARI technology village activities, publications and other activities on the central display board.
- Provide new technology, design and ideas to make new generation research community.
- To co-ordinate ensure all kind of photographic equipment's information.
- Make video documentary for broadcasting based of the scientists demand.
- To co-ordinate and supply the photography news of several programme for published the newspapers, magazine, journal, TV etc.
- To co-ordinate and supply the photographs and news info of the editorial and publication section for newsletter.
- To co-ordinate and supply the photographs and news info of the ICT for BARI Facebook and website.
- Coverage the Director General and Directors visit in out station of BARI.

Table- 1. Summary of activities of photography Section during 2018-2019

Sl. No	Activities	Number
1	Photograph exposed in Digital Camera	27,000 above
2	Photo Editing	10,500 above
3	Video Recording programme	36 above

26 Planning & Evaluation Wing

Introduction

Planning is an organizational process as well as public policy body of an organization for creating and maintaining a plan; and the psychological process of thinking about the activities required to create a desired goal. This process is essential to the creation and refinement of a plan or integration of it with other plans. The term is also used to describe the formal procedures used in such an endeavor, such as the creation of documents to discuss the important issues to be addressed, the objectives to be met, and the strategy to be followed.

Planning is a process for accomplishing purpose. It is blue print of research and activities and a road map of development. It helps in deciding objectives both in quantitative and qualitative terms. It is setting of goals on the basis of objectives and keeping in view the resources available. A plan should be a realistic view of the expectations. Depending upon the activities, a plan can be long term, middle term or short term. It is the framework within which it must operate. For management seeking external support, the plan is the most important document and key to growth. Preparation of a comprehensive plan will not guarantee success, but lack of a sound plan will almost certainly ensure failure.

A plan serves three critical functions such as-

- Helps management to clarify, focus, and research their activities or project's development and prospects.
- Provides a considered and logical framework for research and activities which could develop and pursue research/activities for the fulfillment of the strategies.
- Offers a benchmark against which actual performance could be measured and reviewed.

Program evaluation is a systematic method for collecting, analyzing, and using information to answer questions about projects, policies and programs, particularly about their performance on effectiveness and efficiency.

As with most things in international development, there is no standard definition of a Monitoring and Evaluation (M&E) framework, or how it differs from an M&E plan. For many organizations, an M&E framework is a table that describes the indicators that are used to measure whether the program is a success.

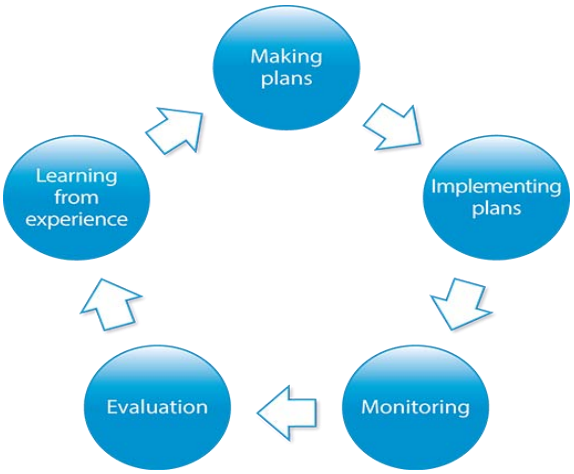


Figure: A Thematic Diagram of Planning & Evaluation Process

Evaluation is a tool or a process which implements during a program's might examine whether the program is successfully recruiting and retaining its intended participants, using training materials that meet standards for accuracy and clarity, maintaining its projected timelines, coordinating efficiently with other ongoing programs and activities, and meeting applicable legal standards. Evaluation during program implementation could

be used to inform mid-course corrections to program implementation (formative evaluation) or to shed light on implementation processes (process evaluation).

For community-engaged initiatives, formative and process evaluation can include evaluation of the process by which partnerships are created and maintained and ultimately succeed in functioning.

Program evaluations are successful if the following three conditions are met:

- Program objectives are well defined in terms of specific measures of program performance (Log Frame)
- Intended uses of evaluations are well-defined, and
- Monitoring and evaluation plans are developed.

Activities of Planning and Evaluation Wing

Planning and Evaluation Wing playing is a pivotal role for BARI. Planning is a process of deciding in advance what we want to get (our goal) and how we will get it. Evaluation enables us to assess how well we are doing and to learn from this. The activities of planning & evaluation wing of BARI are:

1. Preparation and processing of Project Proposal (DPP/RDPP/TAPP)
2. Preparation of new skim (Karmasuchi) under revenue budget.
3. Preparation of monthly report (IMED-05) and quarterly report (IMED 02 and 03)
4. Preparation of project director`s profile (IMED-01)
5. Preparation of procurement plan (Works, goods & services), work plan of projects and their subsequent approval by the authority.
6. Monitoring and evaluation of development projects including procurement status (tender related activities).
7. Preparation of Project Completion Report (PCR).
8. Preparation of financial and physical progress report of the project and send to the Ministry of Agriculture
9. Co-ordination of Project Implementation Committee (PIC) meeting.
10. Co-ordination of planning and development co-ordination committee (P&DC) meetings of BARI
11. Liaison with IMED, planning commission and different ministries as and when necessary.
12. Performing other activities as directed by the Director General, BARI.
13. Participate in the monthly ADP review meeting in Ministry of Agriculture.
14. Prepare quarterly / half yearly report according to "Annual Performance Agreement"
15. Preparation of budget and report for "Sustainable Development Goals target, 2030".
16. Preparation of ADP and RADP for on-going & proposed development projects.
17. Preparation of monthly progress report on work plan for prime minister's office and Ministry of Agriculture.
18. Preparation of monthly progress report of "Implementation of Guidelines issued by Honorable Prime Minister"
19. Preparation of answers to the questions of Jatiya Sangshod (National Parliament).
20. Participation in Mid-term budget framework meeting.
21. Preparation of Five Year Plan (FYP).
22. Preparation of research activities according to Sustainable Development Goals (SDGs) which was instructed by cabinet division as well as collaborated with United Nations (UN) and Food and Agricultural Organization (FAO).
23. Preparation of Projects for Delta Plan-2100.

Table 1. Post and Position of Planning & Evaluation Wing

Designation	Organogram	Existing
Officer		
Director	1	1
Chief Scientific Officer	1	1
Principal Scientific Officer	3	1
Senior Scientific Officer	2	2
Scientific Officer	3	2
Sub total	**10**	**7**
Staff		
Steno-Typist	1	0
UDA	1	0
Computer Operator	2	1
LDA cum Typist	4	4
MLSS	2	1
Sub total	**10**	**6**
Total:	**20**	**13**

Table 2. Existing Manpower of Planning & Evaluation Wing (Officer)

Sl. No.	Name	Designation
1.	M. Habibur Rahman Sheikh	Director
2.	Dr. Nirmal Chandra Shil	Chief Scientific Officer
3.	Dr. Md. Abu Hena Sorwar Jahan	Principal Scientific Officer
4.	Dr. A H M Fazlul Kabir	Senior Scientific Officer
5.	Dr. Deeder Sultana	Senior Scientific Officer
6.	Md. Amirul Islam	Scientific Officer
7.	Hasib-Bin-Saif	Scientific Officer

Table 3. Development Projects Implemented During 2018-19: 9

(In lakh Tk.)

Sl.no.	Name of the Projects (Implementation period)	Total Project Cost	Allocation of 2018-19	Expenditure up to June 2019 & % of allocation		Cumulative Progress upto June 2019
				Financial	Physical (%)	
1.	Improvement and Quality Seed Production of Wheat and Maize-2nd Phase (July 2015 to June 2020)	2332.75	315.00	315.00 (100%)	100%	1919.50 (82%)
2.	Strengthening of Oilseed and Pulses Research and Development in Bangladesh (April 2016 to June 2021)	2363.59	296.00	295.38 (100%)	100%	1638.12 (69%)
3.	Strengthening Research on Horticultural Crops and Dissemination of Horticultural & Field Crop Technology in Charland Areas (April 2016 to June 2021)	7055.52	1419.00	1419.00 (100%)	100%	4359.99 (62%)
4.	Research, Extension and Popularize of Vegetables and Spices Cultivation on Floating Bed (July 2017 to June 2022)	3651.65	1151.00	1119.00 (97%)	97%	1461.00 (40%)
5.	Development and expansion of bio-rational based integrated pest management of vegetables, fruits and betel leaf (January 2018 to December 2021)	2085.00	824.00	824.00 (100%)	100%	1026.00 (49%)
6.	Strengthening of Spices Crop Research in Bangladesh (October 2017 to June 2022)	9400.00	2080.00	2080.00 (100%)	100%	2155.00 (23%)
7.	Establishment of Agriculture Research Station, BARI, Gopalganj and eco-friendly agricultural development project in south-western part through strengthening of research (July 2018 to June 2023)	15700.00	130.00	130.00 (100%)	100%	130.00 (1%)
8.	Smallholder Agricultural Competitiveness Project (SACP) (BARI Part) (July 2018 to June 2024)	1457.97	43.00	43.00 (100%)	100%	42.64 (3%)
9.	Upgrading Regional Horticulture Research Station, Cumilla to Regional Agricultural Research Station (July 2018 to June 2023)	3727.52	42.00	42.00 (100%)	100%	42.00 (1%)
	Total:	**47774.00**	**6300.00**	**6267.38 (99.48%)**	**99.48%**	**12774.25** (27%)

Table 4. List of Projects to be Implemented During 2019-20: 9

(In Lakh)

Sl.no.	Name of the Projects (Implementation period)	Allocation 2019-20	Status
1.	Improvement and Quality Seed Production of Wheat and Maize-2nd Phase (July 2015 to June 2020)	412.00	5th year
2.	Strengthening of Oilseed and Pulses Research and Development in Bangladesh (April 2016 to June 2021)	373.00	4th year
3.	Strengthening Research on Horticultural Crops and Dissemination of Horticultural & Field Crop Technology in Charland Areas (April 2016 to June 2021)	1088.00	4th year
4.	Research, Extension and Popularize of Vegetables and Spices Cultivation on Floating Bed (July 2017 to June 2022)	614.00	3rd year
5.	Development and expansion of bio-rational based integrated pest management of vegetables, fruits and betel leaf (January 2018 to December 2021)	556.00	2nd year
6.	Strengthening of Spices Crop Research in Bangladesh (October 2017 to June 2022)	2372.00	3rd year
7.	Establishment of Agriculture Research Station, BARI, Gopalganj and eco-friendly agricultural development project in south-western part through strengthening of research (July 2018 to June 2023)	10372.00	2nd year
8.	Smallholder Agricultural Competitiveness Project (SACP) (BARI Part) (July 2018 to June 2024)	434.00	2nd year
9.	Upgrading Regional Horticulture Research Station, Cumilla to Regional Agricultural Research Station (July 2018 to June 2023)	1150.00	2nd year
	Total	**17371.00**	**-**

Table 5. List of new Projects Included in the ADP Book (Unapproved & Non-allocated) for 2019-20: 11

Sl.No.	Name of the Projects (Implementation period)	Total Project Cost (In Lakh Tk.)	Remarks
১.	কৃষি যন্ত্রপাতি ও লাগসই প্রযুক্তি উদ্ভাবনের মাধ্যমে ফসল উৎপাদন ব্যবস্থাকে অধিকতর লাভজনক করা (জুলাই, ২০১৯-জুন, ২০২৪) Farm machinery technology development for profitable crop production (July, 2019- June, 2024)	5213.00	শীঘ্রই পিইসি অনুষ্ঠিত হবে।
২.	যশোর জেলার ঝিকরগাছায় ফুল গবেষণা কেন্দ্র স্থাপন (জুলাই, ২০১৯-জুন, ২০২৪) Establishment of Floriculture Research Centre at Jhikargacha of Jessore District (July, 2019- June, 2024)	25000.00	পিইসি সভার সুপারিশের আলোকে সম্ভাব্যতা যাচাইসহ ডিপিপি পূনর্গঠন করা হচ্ছে
৩.	আঞ্চলিক ডাল গবেষণা কেন্দ্র মাদারীপুরে গবেষণা জোরদারকরণের মাধ্যমে বৃহত্তর ফরিদপুর এবং বরিশাল অঞ্চলে ডাল ফসলের উৎপাদন বৃদ্ধি (জুলাই, ২০১৯-জুন, ২০২৪)	17600.00	পরিকল্পনা কমিশনে প্রক্রিয়াধীন

Sl.No.	Name of the Projects (Implementation period)	Total Project Cost (In Lakh Tk.)	Remarks
	Enhancing production of pulse crop at Greater Faridpur and Barisal region through strengthening research of Regional Pulses Research Centre, Madaripur (July, 2019- June, 2024)		
৪.	জীব প্রযুক্তি গবেষণা জোরদারকরণ প্রকল্প (জুলাই, ২০১৯-জুন, ২০২৪) Strengthening of Bio-technological Research Project (July, 2019- June, 2024)	3400.00	ডিপিপি প্রণয়নের কাজ চলছে
৫.	বিএআরআই এর অবকাঠামো উন্নয়ন ও গবেষণা কার্যক্রম জোরদারকরণ প্রকল্প (জুলাই, ২০১৯-জুন, ২০২৪) Infrastructure development and strengthening of research programme of BARI (July, 2019- June, 2024)	77500.00	কৃষি মন্ত্রণালয়ের সুপারিশের আলোকে ডিপিপি পূনর্গঠন পূর্বক কৃষি মন্ত্রণালয়ে প্রেরণ করা হয়েছে
৬.	পাহাড়ি কৃষি গবেষণা জোরদারকরণ প্রকল্প (জুলাই, ২০১৯-জুন, ২০২৪) Hill Agricultural Research Strengthening Project (July, 2019- June, 2024)	61300.00	ডিপিপি প্রণয়ন করা হয়েছে।
৭.	আঞ্চলিক উদ্যানতত্ত্ব গবেষণা কেন্দ্র, নরসিংদীকে আঞ্চলিক কৃষি গবেষণা কেন্দ্রে উন্নীতকরণ (জুলাই, ২০১৯-জুন, ২০২৪) Upgrading Regional Horticulture Research Station, Narsingdi to Regional Agricultural Research Station (July, 2019- June, 2024)	11500.00	ডিপিপি প্রণয়নের কাজ চলছে
৮.	কিশোরগঞ্জে কৃষি গবেষণা কেন্দ্র স্থাপন ও সরেজমিন গবেষণা কার্যক্রম জোরদারকরণের মাধ্যমে এলাকার কৃষির উন্নয়ন (জুলাই, ২০১৯-জুন, ২০২৪) Establishment of Agricultural Research Station and Strengthening On-farm Research Programme for Agricultural Development in Kishoreganj District (July, 2019- June, 2024)	85395.00	ডিপিপি প্রণয়ন করা হয়েছে।
৯.	উপকূলীয় লবণাক্ত এলাকায় কৃষি গবেষণা জোরদারকরণ প্রকল্প (জুলাই, ২০২০-জুন, ২০২৫) Strengthening of Agricultural Research at Coastal Saline Regions Project (July, 2019- June, 2024)	11766.46	ডিপিপি প্রস্তুত করা হয়েছে।
১০.	পার্বত্য এলাকায় কাজু বাদাম এবং কফি চাষ গবেষণা উন্নয়ন ও সম্প্রসারণ প্রকল্প (জুলাই, ২০১৯-জুন, ২০২৪) (বারি অঙ্গ) Improvement of Research and extension of Cashew Nut and Coffee in Hill tracts area. (July, 2019- June, 2024) (BARI Component)	18800.00	ডিপিপি প্রস্তুত করা হয়েছে।
১১.	জলবায়ু সহিষ্ণু ফসল উৎপাদন প্রযুক্তি উদ্ভাবন এবং উন্নয়ন প্রকল্প (জুলাই, ২০১৯-জুন, ২০২৪) Climate Resilient Crop Production Technology Generation and Development Project (July, 2019- June, 2024)	36600.50	প্রকল্পটি বৈদেশিক সাহায্যের অর্থায়নে পরিচালিত হবে এবং ডিপিপিটি প্রণয়ন পূর্বক কৃষি মন্ত্রণালয়ে পাঠানো হয়েছে।

Table 6. New projects sent to the MoA for Further Processing and Development: 11

ক্র. নং	প্রকল্পের নাম	প্রাক্কলিত ব্যয়	অগ্রগতি
১.	লেবু জাতীয় ফলের গবেষণা ও উন্নয়ন জোরদারকরণ প্রকল্প (জুলাই, ২০১৯ - জুন, ২০২৪) Strengthening Citrus Research and Development Project (July 2019-June 2024)	১৩৪১৪.৪৫	কৃষি মন্ত্রণালয়ের মতামত অনুযায়ী ডিপিপি পূনর্গঠনের কাজ চলছে
২.	ফল গবেষণা জোরদারকরণ প্রকল্প (জুলাই, ২০১৮ - জুন, ২০২৩) Strengthening of fruit research project (July 2018- June 2023)	৫৩০২৫.০০	ডিপিপি প্রণয়নের কাজ চলছে
৩.	ফসল সংগ্রহোত্তর গবেষণা জোরদারকরণ প্রকল্প (জুলাই, ২০১৯ - জুন, ২০২৪) Postharvest Research Strengthening Project (July 2019-June 2024)	৯০৫৮.৭৯	ডিপিপি মূল্যায়ন পূর্বক মতামতসহ সংশিণ্টষ্ট বিভাগে প্রেরণ করা হয়েছে
৪.	আঞ্চলিক মসলা গবেষণা কেন্দ্র, বিএআরআই, মাগুরা শক্তিশালীকরণ (জুলাই, ২০১৯ - জুন, ২০২৪) Strengthening of Regional Spices Research Center, BARI, Magura (July 2019- June 2024)	১৬,০০০.০০	ডিপিপি প্রণয়নের কাজ চলছে
৫.	বসত বাড়ীর আঙ্গিনায় বাগান স্থাপনের মাধ্যমে দারিদ্রপীড়ত কৃষকদের পুষ্টি নিরাপত্তা অর্জন ও আয় বৃদ্ধি (জুলাই, ২০১৯ - জুন, ২০২৪) Achievement of Nutritional Security and Increasing Income of Poor Farmers through Establishing Homestead Garden (July 2019- June 2024)	২১,৬১৭.১২৮	সার-সংক্ষেপ মন্ত্রণালয়ে প্রেরণ করা হয়েছে।
৬.	কন্দাল ফসল গবেষণা জোরদারকরণ প্রকল্প (জুলাই, ২০১৯ - জুন, ২০২৪) Tuber Crops Research Strengthening Project)July, 2019- June, 2024(	১৮২৪৮.৪৪	কৃষি মন্ত্রণালয়ে ব্যয় পর্যালোচনা কমিটির সিদ্ধান্তের আলোকে ডিপিপি পুনর্গঠন করা হচ্ছে
৭.	বরিশার জেলার বানারীপাড়া উপজেলায় কৃষি গবেষণা কেন্দ্র স্থাপন (জুলাই, ২০১৯ - জুন, ২০২৪) Establishment of Agriculture Research Station at Banaripara Upazila of Barisal district)July, 2019- June, 2024(	৮,৭২১.০০	ডিপিপি মূল্যায়ন পূর্বক মতামতসহ সংশ্লিষ্ট বিভাগে প্রেরণ করা হয়েছে
৮.	রংপুর এলাকায় নীল চাষের আধুনিক উৎপাদন কলাকৌশল, প্রক্রিয়াজাতকরণ এবং ব্যবহার (জুলাই, ২০১৯ - জুন, ২০২৪)	১০,০০০.০০	Concept Note মন্ত্রণালয়ে প্রেরণ করা হয়েছে।
৯.	পিরোজপুর জেলায় কৃষি গবেষণা কেন্দ্র স্থাপন (জুলাই, ২০১৯ - জুন, ২০২৪)	২০,২৭৯.৬৫	Concept Note মন্ত্রণালয়ে প্রেরণ করা হয়েছে। ডিপিপি প্রণয়নের কাজ চলছে
১০.	নিরাপদ ও রপ্তানীমুখী সবজি ও ফল উৎপাদন প্রকল্প (ডিএই এর সাথে সমন্বিত) (জুলাই, ২০১৯ - জুন, ২০২৪)	১৪,৮৬৪.৭০	কৃষি মন্ত্রণালয়ের সুপারিশ অনুযায়ী ডিএই কর্তৃক ডিপিপি প্রণয়ন করে সমন্বয় করার জন্য ডিএই'তে প্রেরণ করা হয়েছে।
১১.	সর্জান পদ্ধতিতে সবজি চাষ	-	Concept Note তৈরীর কাজ চলছে

Table 7. Skims Implemented by BARI During 2018-19: 12

(লক্ষ টাকায়)

ক্র. নং	কর্মসূচির নাম ও মেয়াদকাল	মোট বরাদ্দ	২০১৮-১৯ অর্থ বছরের বরাদ্দ	জুন/২০১৯ পর্যন্ত অগ্রগতি	আর্থিক অগ্রগতি %	জুন/২০১৯ পর্যন্ত ক্রমপুঞ্জিত অগ্রগতি
১	২	৩	৪	৫	৬	৭
১.	উদ্ভাবিত আলু ও ভিটামিন সমৃদ্ধ মিষ্টি আলুর নতুন জাতসমূহের প্রজনন বীজ উৎপাদনে প্রদর্শনীর মাধ্যমে সমস্যা চিহ্নিতকরণ ও গবেষণা ভিত্তিক কর্মসূচী (জুলাই, ২০১৬ - জুন, ২০১৯)	৬৪০.০০	১৯৭.০০	১৯৭.০০	১০০.০০	৬১৬.৭৫
২.	খেসারী, মাসকালাই ও ফেলননের জাত উন্নয়ন, বীজ উৎপাদন এবং সংগ্রহোত্তর প্রযুক্তি উদ্ভাবন ও বিস্তার কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৩১৪.০০	১৫২.০০	১৫২.০০		২০৪.০০
৩.	কাঁচা কাঁঠালের ভেজিটাবল মিট প্রক্রিয়াজাতকরণ কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৫৪৯.৩৯	৩০৭.২৫	৩০৫.৩২	৯৯.৩৭%	৪১৯.২৪
৪.	আমের স্থানীয় জাতের উন্নয়ন, উৎপাদন প্রযুক্তি উদ্ভাবন এবং বারি উদ্ভাবিত প্রতিশ্রুতিশীল জাতসমূহের মাতৃকলম উৎপাদন ও বিতরণ কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৫১৫.০০	২৯০.০০	২৯০.০০	১০০%	৩০৫.০০
৫.	ফসল নিবিড়তা বৃদ্ধিকরণে চার ফসল ভিত্তিক ফসল বিন্যাস উদ্ভাবন ও বিস্তার কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৩২০.০০	১৪০.০০	১৪০.০০		১৭০.০০
৬.	অপ্রচলিত তেল ফসলের (সয়াবিন, সূর্যমুখী এবং তিসি) গবেষণা ও উন্নয়ন জোড়দারকরণ কর্মসূচি। (জুলাই, ২০১৭ - জুন, ২০২০)	৩১০.০০	১৪৫.০০	১৪১.২৫	৯৭.৪১%	১৬৬.২৫
৭.	পিঁয়াজের প্রজনন বীজ উৎপাদন কর্মসূচি। (জুলাই, ২০১৭ - জুন, ২০২০)	১৬২.০০	৯২.২০	৯২.২০	১০০%	১১৭.০০
৮.	কাঁচা আম প্রক্রিয়াজাতকরণ ও সংরক্ষণ কর্মসূচি। (জুলাই, ২০১৭ - জুন, ২০২০)	৬৯.৬১	৩০.৬৩	৩০.৬৩	১০০%	৪৫.৬৩
৯.	গোলমরিচ, কালিজিরা এবং জিরাসহ অন্যান্য অপ্রচলিত মসলা ফসলের গবেষণা, জাত ও প্রযুক্তি উন্নয়ন কর্মসূচি জুলাই/২০১৭- জুন/২০২০	৩৩২.৫০	২৪১.৭৫	২৪১.৭৫	১০০%	২৪১.৭৫
১০.	উপকূলীয় অঞ্চলের লবনাক্ত জমিতে সূর্যমুখী উৎপাদন ও বিস্তার এবং সংগ্রহোত্তর প্রযুক্তি উদ্ভাবন কর্মসূচি জুলাই/২০১৮-জুন/২০২১	১৩৪.৯৫	১৫.০০	১৫.০০	১০০%	১৫.০০
১১.	চীনাবাদামের উন্নত জাত ও আন্তঃফসল প্রযুক্তি উদ্ভাবনের মাধ্যমে চরাঞ্চলের কৃষকদের পুষ্টি ও	৯৬.৫০	১৫.০০	১৫.০০	১০০%	১৫.০০

ক্র. নং	কর্মসূচির নাম ও মেয়াদকাল	মোট বরাদ্দ	২০১৮-১৯ অর্থ বছরের বরাদ্দ	জুন/২০১৯ পর্যন্ত অগ্রগতি	আর্থিক অগ্রগতি %	জুন/২০১৯ পর্যন্ত ক্রমপুঞ্জিত অগ্রগতি
১	২	৩	৪	৫	৬	৭
	আর্থিক অবস্থার উন্নয়ন কর্মসূচি জুলাই/২০১৮-জুন/২০২১					
১২.	বাংলাদেশে অর্কিড, ক্যাকটাস-সাকুলেন্ট ও বাল্ব-করম জাতীয় ফুলের জাত উন্নয়ন, উৎপাদন, সংগ্রহোত্তর ও মূল্য-সংযোজন প্রযুক্তি উদ্ভাবন এবং বিস্তার কর্মসূচি জুলাই/২০১৮-জুন/২০২১	৩৪৬.০০	৪৫.০০	৪৫.০০	১০০%	৪৫.০০

Table 8. Skim to be Implemented 2019-2020: 13

(লক্ষ টাকা)

ক্রমিক নং	কর্মসূচির নাম ও মেয়াদ	প্রাক্কলিত ব্যয়	২০১৯-২০ অর্থবছরে বরাদ্দ
১.	খেসারী, মাসকালাই ও ফেলননের জাত উন্নয়ন, বীজ উৎপাদন এবং সংগ্রহোত্তর প্রযুক্তি উদ্ভাবন ও বিস্তার কর্মসূচি। (জুলাই, ২০১৭ - জুন, ২০২০)	৩১৪.০০	১১০.০০
২.	কাঁচা কাঁঠালের ভেজিটাবল মিট প্রক্রিয়াজাতকরণ কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৫৪৯.৩৯	১২৭.৯০
৩.	আমের স্থানীয় জাতের উন্নয়ন, উৎপাদন প্রযুক্তি উদ্ভাবন এবং বারি উদ্ভাবিত প্রতিশ্রুতিশীল জাতসমূহের মাতৃকলম উৎপাদন ও বিতরণ কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৫১৫.০০	২১০.০০
৪.	ফসল নিবিড়তা বৃদ্ধিকরণে চার ফসল ভিত্তিক ফসল বিন্যাস উদ্ভাবন ও বিস্তার কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৩২০.০০	১৫০.০০
৫.	অপ্রচলিত তেল ফসলের (সয়াবিন, সূর্যমুখী এবং তিসি) গবেষণা ও উন্নয়ন জোড়দারকরণ কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৩১০.০০	১৪০.০০
৬.	পিঁয়াজের প্রজনন বীজ উৎপাদন কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	১৬২.০০	৪৫.০০
৭.	কাঁচা আম প্রক্রিয়াজাতকরণ ও সংরক্ষণ কর্মসূচি (জুলাই, ২০১৭ - জুন, ২০২০)	৬৯.৬১	২৩.৯৮
৮.	গোলমরিচ, কালিজিরা এবং জিরাসহ অন্যান্য অপ্রচলিত মসলা ফসলের গবেষণা, জাত ও প্রযুক্তি উন্নয়ন কর্মসূচি জুলাই/২০১৭- জুন/২০২০	৩৩২.৫০	৯০.৭৫
৯.	উপকূলীয় অঞ্চলের লবনাক্ত জমিতে সূর্যমুখী উৎপাদন ও বিস্তার এবং সংগ্রহোত্তর প্রযুক্তি উদ্ভাবন কর্মসূচি জুলাই/২০১৮-জুন/২০২১	১৩৪.৯৫	৬৬.৯০
১০.	চীনাবাদামের উন্নত জাত ও আন্তঃফসল প্রযুক্তি উদ্ভাবনের মাধ্যমে চরাঞ্চলের কৃষকদের পুষ্টি ও আর্থিক অবস্থার উন্নয়ন কর্মসূচি জুলাই/২০১৮-জুন/২০২১	৯৬.৫০	৪১.৫০
১১.	বাংলাদেশে অর্কিড, ক্যাকটাস-সাকুলেন্ট ও বাল্ব-করম জাতীয় ফুলের জাত উন্নয়ন, উৎপাদন, সংগ্রহোত্তর ও মূল্য-সংযোজন প্রযুক্তি উদ্ভাবন এবং বিস্তার কর্মসূচি জুলাই/২০১৮-জুন/২০২১	৩৪৬.০০	১৫৬.০০
১২.	উপকারী নভেল বেসিলাস ব্যাক্টেরিয়া দ্বারা উৎপাদিত জৈব পণ্য ব্যবহার করে বেগুনের ঢলে পড়া রোগ নিয়ন্ত্রণের প্রযুক্তি উদ্ভাবন ও বিস্তার কর্মসূচি জুলাই/২০১৯-জুন/২০২১	২৮২.০০	১৯৭.০০
১৩.	বাংলাদেশ কৃষি গবেষণা ইনস্টিটিউটের উদ্ভিদ রোগতত্ত্ব গবেষণাগার এ্যাক্রিডিটেডকরণ কর্মসূচি জুলাই/২০১৯-জুন/২০২০	৯২৭.৪৫	৯২৭.৪৫

Table 9. New Skims 2019-2020 Under Process of Approval: 4

ক্র. নং	কর্মসূচির নাম	বাস্তবায়নকাল	সংশ্লিষ্ট কেন্দ্র ও বিভাগ	প্রাক্কলিত ব্যয়
১.	বাংলাদেশ কৃষি গবেষণা ইনস্টিটিউটের মৃত্তিকা বিজ্ঞান গবেষণাগার এ্যাক্রিডিটেশন কর্মসূচি	সেপ্টেম্বর ২০১৯ - আগস্ট ২০২১	মৃত্তিকা বিজ্ঞান বিভাগ, বিএআরআই, গাজীপুর	১০০০.০০
২.	জোয়ার ভাটা প্রবণ দক্ষিণাঞ্চলের পতিত জমিতে উদ্যানতাত্ত্বিক ফসলের উপযোগিতা যাচাই পূর্বক উৎপাদনশীলতা বৃদ্ধি	জুলাই ২০১৯ - জুন ২০২২	আঞ্চলিক উদ্যানতত্ত্ব গবেষণা কেন্দ্র, লেবুখালী, দুমকী, পটুয়াখালী	২৩৬.০৭
৩.	নিরাপদ ফল ও সবজির উৎপাদন এবং তাদের রপ্তানি বৃদ্ধিকরণ কর্মসূচী	জুলাই ২০১৯ - জুন ২০২২	আঞ্চলিক উদ্যানতত্ত্ব গবেষণা কেন্দ্র, শিবপুর, নরসিংদী	৯৬৭.০৫
৪.	বাংলাদেশের দক্ষিণাঞ্চলে চাষকৃত গুরুত্বপূর্ন ফল, পান, সুপারি ও ডাল ফসলের ক্ষতিকারক পোকামাকড় সনাক্তকরন ও সমন্বিত বালাই ব্যবস্থাপনার মাধ্যমে নিরাপদ ফসল উৎপাদন প্রযুক্তি উদ্ভাবন ও বিস্তার কর্মসূচি	জুলাই ২০১৯ - জুন ২০২২	আঞ্চলিক কৃষি গবেষণা কেন্দ্র, রহমতপুর, বরিশাল	৭২৩.৪২৫

Table 10. New Skims Under Process of Consideration upon Revision 2019-2020: 11

ক্র. নং	কর্মসূচির নাম	বাস্তবায়নকাল	সংশ্লিষ্ট কেন্দ্র ও বিভাগ	প্রাক্কলিত ব্যয়
১.	বার্লি, মিলেটস্ ও সরগমের ''ক্লাইমেট স্মার্ট'' জাত উদ্ভাবন, উন্নয়ন ও বিস্তার কর্মসূচী	জুলাই ২০১৯ - জুন ২০২২	উদ্ভিদ প্রজনন বিভাগ, বিএআরআই, গাজীপুর	৫১৯.৮০
২.	ফ্রেশকাট ফলমূল ও শাকসবজি প্রক্রিয়াজাতকরণ ও সংরক্ষণ কর্মসূচী	জানুয়ারি ২০২০ - জুন ২০২২	পোস্ট হারভেস্ট টেকনোলজি বিভাগ, বিএআরআই, গাজীপুর	৮৭৬.৩০
৩.	কচু জাতীয় ফসলের জার্মপ্লাজম সংগ্রহ, মূল্যায়ন, উন্নত জাত বিস্তার এবং সমন্বিত সার ব্যবস্থাপনার মাধ্যমে উৎপাদন বৃদ্ধি ও কৃষকের আর্থসামাজিক অবস্থার উন্নয়ন কর্মসূচী	জুলাই ২০১৯ - জুন ২০২২	কন্দাল ফসল গবেষণা কেন্দ্র বিএআরআই, গাজীপুর	৯১৮.৩৭
৪.	বারি উদ্ভাবিত সবজির জাত সমূহ বিশুদ্ধকরণ, বীজ বর্ধন, পুষ্টিমান নির্ধারন ও জাতসমূহের বিস্তার	জুলাই ২০১৯ - জুন ২০২২	উদ্যানতত্ত্ব গবেষণা কেন্দ্র, বিএআরআই, গাজীপুর	৯০২.৭৬
৫.	পানি সাশ্রয়ী সেচ প্রযুক্তি ব্যবহারের মাধ্যমে পাহাড়ী, উপকূলীয় ও চর অঞ্চলে ফসলের উৎপাদনশীলতা বৃদ্ধিকরণ	জুলাই ২০১৯ - জুন ২০২২	সেচ ও পানি ব্যবস্থাপনা বিভাগ, বিএআরআই, গাজীপুর	৯৯৯.৫৯
৬.	বিভিন্ন কৃষি পরিবেশে কৃষিতাত্ত্বিক প্রযুক্তি উদ্ভাবন ও উদ্ভাবিত প্রযুক্তির উপযোগীতা পরীক্ষণ কর্মসূচী	জুলাই ২০১৯ - জুন ২০২২	কৃষিতত্ত্ব বিভাগ, বিএআরআই, গাজীপুর	১৫০.০০
৭.	বাংলাদেশের দক্ষিণ ও দক্ষিণ-পশ্চিমাঞ্চলে অপ্রধান দানাজাতীয় ফসল প্রবর্তনের মাধ্যমে জলবায়ু অভিযোজনক্ষম লাগসই প্রযুক্তি উদ্ভাবন ও শস্য বহুমুখীকরণ	জুলাই ২০১৯ - জুন ২০২২	আঞ্চলিক কৃষি গবেষণা কেন্দ্র, রহমতপুর, বরিশাল	৬২৯.২৪
৮.	পরিবেশবান্ধব সমন্বিত রোগ-পোকা দমন ব্যবস্থাপনার মাধ্যমে বাস্তুভিটাস্থ ফল বাগানের উৎপাদন বৃদ্ধি ও কৃষকের আর্থিক অবস্থার উন্নয়ন কর্মসূচী	জুলাই ২০১৯ - জুন ২০২২	আঞ্চলিক কৃষি গবেষণা কেন্দ্র, জামালপুর	২৮৪.০০
৯.	উপকূলীয় জোয়ার প্লাবিত অঞ্চলে আধুনিক টেকসই প্রযুক্তি উদ্ভাবনের মাধ্যমে তরমুজ উৎপাদন, বিস্তার ও কৃষকের জীবন যাত্রার মান উন্নয়ন শীর্ষক কর্মসূচী	জুলাই ২০১৯ - জুন ২০২২	সরেজমিন গবেষণা বিভাগ, পটুয়াখালী	৮৯৫.০০

ক্র. নং	কর্মসূচির নাম	বাস্তবায়নকাল	সংশ্লিষ্ট কেন্দ্র ও বিভাগ	প্রাক্কলিত ব্যয়
১০.	ভিটামিন সমৃদ্ধ মিষ্টি আলুর জাত ও সংগ্রহোত্তর বহুমুখী ব্যবহারের গবেষণা এবং বিস্তার কর্মসূচি	জুলাই ২০১৯ - জুন ২০২২	কন্দাল ফসল গবেষণা কেন্দ্র বিএআরআই, গাজীপুর	৯৯৬.৯৪
১১.	ক্লাইমেট স্মার্ট জার্মপণ্ঢাজম চিহ্নিত করণ, সংগ্রহ, মূল্যায়ন ও সংরক্ষণ কর্মসূচি	জুলাই ২০১৯ - জুন ২০২২	উদ্ভিদ কৌলিসম্পদ কেন্দ্র, বিএআরআই, গাজীপুর	৯৭৮.০০

Table 11. Other Activities done by Planning & Evaluation Wing 2018-19

Sl. No.	Title	No. of Reports
১.	পরিকল্পনা ও মূল্যায়ন উইং এর বার্ষিক কর্মসম্পাদন চুক্তি (এপিএ) প্রণয়ন ও বাস্তবায়ন ২০১৮-১৯	১
২.	পরিকল্পনা ও মূল্যায়ন উইং এর বার্ষিক কর্মসম্পাদন চুক্তির অগ্রগতির প্রতিবেদন (ত্রৈমাসিক, অর্ধবার্ষিক, বার্ষিক)	৪
৩.	SDGs এর আলোকে প্রতিষ্ঠানের কর্ম পরিকল্পনা প্রণয়ন ও অগ্রগতির প্রতিবেদন প্রণয়ন	১
৪.	Monthly Progress Report (IMED 05/2008) of Development Projects	১২
৫.	এডিপিভূক্ত উন্নয়ন প্রকল্পসমূহের সময় নির্দিষ্ট কর্মপরিকল্পনা	১২
৬.	এডিপিতে অন্তর্ভূক্ত কৃষি মন্ত্রণালয়ের প্রকল্পসমূহের আর্থিক ও বাস্তব অগ্রগতি প্রতিবেদন	১২
৭.	একনেক সভায় উপস্থাপনের জন্য কৃষি মন্ত্রণালয়ের এডিপি/আরএডিপি'র অগ্রগতির তথ্য	১২
৮.	এডিপিভুক্ত প্রকল্পসমূহের উচ্চশিক্ষা, প্রশিক্ষণ সংক্রান্ত তথ্যাদির অগ্রগতি প্রতিবেদন	১২
৯.	উন্নয়ন প্রকল্পের কর্ম ও ক্রয় পরিকল্পনা প্রণয়ন	২
১০.	উন্নয়ন প্রকল্পসমূহের ক্রয় পরিকল্পনার বাস্তবায়ন অগ্রগতি প্রতিবেদন	১২
১১.	এডিপি বাস্তবায়ন অগ্রগতি সম্পর্কিত প্রকল্প ভিত্তিক প্রতিবেদন	১২
১২.	Quarterly Progress Report (IMED 02-03/2008) of Development Projects	৪
১৩.	বার্ষিক উন্নয়ন কর্মসূচি (এডিপি) প্রণয়ন	১
১৪.	সংশোধিত বার্ষিক উন্নয়ন কর্মসূচি (আরএডিপি) প্রণয়ন	১
১৫.	মধ্যমেয়াদী বাজেট কাঠামোর (MTBF) আওতায় ২০১৮-১৯ অর্থ বছরের ব্যয়ের প্রাক্কলন এবং ২০১৯-২০ থেকে ২০২০-২১ অর্থ বছর পর্যন্ত প্রক্ষেপণ	২
১৬.	বাজেট বাস্তবায়ন পরিকল্পনা (ফরম-গ.২) প্রণয়ন এবং বাস্তবায়ন অগ্রগতি পরিবীক্ষণ প্রতিবেদন	৪
১৭.	কার্যক্রমসমূহ, ফলাফল নির্দেশক এবং নির্দেশকের (Key Performance Indicators) লক্ষ্যমাত্রা ও মাসিক অগ্রগতির প্রতিবেদন	৪
১৮.	রাজস্ব বাজেটের আওতায় বাস্তবায়নাধীন কর্মসূচিসমূহের অগ্রগতি প্রতিবেদন	১২
১৯.	রাজস্ব বাজেটের আওতায় বাস্তবায়নাধীন কর্মসূচিসমূহের প্রশিক্ষণ সংক্রান্ত প্রতিবেদন	১২
২০.	রাজস্ব বাজেটের আওতায় বাস্তবায়নাধীন কর্মসূচিসমূহের ক্রয় সংক্রান্ত অগ্রগতি প্রতিবেদন	৪
২১.	৭ম পঞ্চবার্ষিক পরিকল্পনা ২০১৬-২০২০ (Seventh Five Year Plan) সংক্রান্ত প্রতিবেদন প্রণয়ন	১
২২.	বার্ষিক উন্নয়ন কর্মসূচি (এডিপি) প্রণয়নের লক্ষ্যে বৈদেশিক সাহায্যপুষ্ট প্রকল্পসমূহের প্রকল্প সাহায্য বরাদ্দ প্রাক্কলন	১
২৩.	মাননীয় প্রধানমন্ত্রী কর্তৃক প্রদত্ত নির্দেশনা বাস্তবায়ন অগ্রগতি প্রতিবেদন	১২
২৪.	জেলা প্রশাসক সম্মেলন ২০১৭-এর উদ্বোধন অনুষ্ঠানে মাননীয় প্রধানমন্ত্রী কর্তৃক প্রদত্ত নির্দেশনা বাস্তবায়ন।	১২

Future Plan

List of Future Projects in Related to SDGs (2021-2030) beyond 7th FYP

1. Expansion of homestead gardening, school gardening commercial fruit gardening as a source of nutritional security all year round.
2. Expansion of appropriate post harvest management technologies (Processing, preservation & packaging) to reduce production loss and develop market linkage among the producer and consumer.
3. Production & distribution of good quality seed
4. Increase agricultural productivity or production through modern technology transfer, minimizing yield gap, crop diversification & intensification with high value crop production.
5. Extension of appropriate post harvest management technologies through training and demonstration
6. Increase water use efficiency through improved on-farm water management technologies such as AWD, Dug well, Buried Pipe, Hose Pipe, Raised Bed rice irrigation, Drip & Sprinklers irrigation, Hand shower irrigation, Mulching etc.
7. Introduction of renewable energy to provide irrigation.
8. Research and Extension of Vegetables and Spices Cultivation on Floating Bed
9. Integrated Agricultural Research & Development Project in South West part of Bangladesh
10. Soil management through organic and inorganic amendments
11. Development of climate smart crop varieties and Seed
12. Development of stress tolerant (Salinity, drought, water submergence, cold, heat, etc and diseases, insect resistant) high yielding major crop varieties.
13. Seed production and supply of climate resilient crop varieties.
14. Collection, preservation and maintenance of plant genetic resources for food and agriculture for medium or long-term conservation.
15. Morphological and molecular characterization of the collected genetics resources.
16. Enhancement of pulse research and extension at greater Faridpur and southern region of Bangladesh
17. Strengthening of Spices Crop Research in Bangladesh
18. Tuber Crops Research Strengthening Project
19. Established value chain development for vegetables, fruits by encouraging public-private partnership (PPP)
20. Biotechnological and hybrid research capacity development.
21. Development of Nutrient enriched and Biotic stress tolerant crop varieties
22. Manpower development (PhD, MS, Short/long duration training, etc)
23. Strengthening of ICT for effective and rapid technology transfer.
24. Extension of Biotic stress tolerant crop varieties

Projects beyond 7th FYP Period (2021-2030) aligning with SDGs

1. Development and extension of cereals, vegetables, fruits, pulses, oilseed and tuber crops with nutrient enriched varieties.
2. Extension and expansion of bio-rational based IPM/IDM, INM GAP, Biopesticides approaches and organic agriculture
3. Development of high yielding, hybrid and transgenic crop varieties.
4. Promotion of organic and safe food production for human
5. Enhancement of crop production through Farm Mechanization
6. Enhance Integrated Agricultural Productivity Approach
7. Introduction of water saving technologies such as, drip irrigation, sprinkler irrigation, furrow irrigation, alternate furrow irrigation, deficit irrigation, etc. at farmers levels
8. Improvement and extension of the existing cropping pattern and crop zoning to increase productivity

9. Women empowerment in production, processing & other income generating activities.
10. Expansion of appropriate post harvest management technologies (Processing, preservation & packaging) to reduce production loss and develop market linkage among the producer and consumer.
11. Increase agricultural productivity or production through modern technology transfer, minimizing yield gap, crop diversification & intensification with high value crop production.
12. Production & distribution of good quality seed
13. Increase water use efficiency through improved on-farm water management technologies such as AWD, Dug well, Buried Pipe, Hose Pipe, Raised Bed rice irrigation, Drip & Sprinklers irrigation, Hand shower irrigation, Mulching etc.
14. Development of small farm tools and machinery
15. Introduction of renewable energy to provide irrigation.
16. Popularization/Extension of environment friendly green technologies (e.g. GAP, IPM, INM, AWD, Dry seed bed, bio pesticides, organic agril. etc.)
17. Extension of climate smart soil and fertilizer management and climate smart crop varieties.
18. Emphasis on extension work to mitigate stress condition like drought, salinity, submergences, flooding & other disasters
19. Soil management through organic and inorganic amendments
20. Increase use of rural & urban organic wastages, waste water and crop residues for renewable energy (biogas) and bio-pesticides instead of chemical pesticides.
21. Development of climate smart crop varieties and Seed
22. Development of stress tolerant (Salinity, drought, water submergence, cold, heat, etc and diseases, insect resistant) high yielding major crop varieties.
23. Emphasis on research and development work to mitigate stress, condition like drought, salinity, submergences, flooding & other disasters
24. Seed production and supply of climate resilient crop varieties.
25. Increase use of rural & urban organic wastages, waste water and crop residues for renewable energy (biogas) and bio-pesticides instead of chemical pesticides.
26. Collection, preservation and maintenance of plant genetic resources for food and agriculture for medium or long-term conservation.
27. Morphological and molecular characterization of the collected genetics resources.
28. Biotechnological and hybrid research capacity development.
29. Development of Nutrient enriched and Biotic stress tolerant crop varieties
30. Strengthening research facilities for HQ and outreach stations.
31. Establishment of new research station/centre under.
32. Manpower development (PhD, MS, Short/long duration training, etc)
33. Strengthening of ICT for effective and rapid technology transfer.
34. Strengthening Research-Extension-Education-Farmers linkage among SAARC countries & international organizations.
35. Encourage Public-Private Partnership (PPP) for agricultural development in value chain development/agro-processing/Food processing/farm mechanization.
36. Extension of Biotic stress tolerant crop varieties.

Fund for the Institute was received from development and revenue budget of the Government of Bangladesh. The development budget was made available through the annual development program (ADP) for the on-going development projects under the Institute (Table 2). Out of total ADP allocation of Tk. 7934.07 lakh. The GoB funding was Tk. 7934.07 lakh, which was offered by different aid-giving agencies as Project Aid (PA).

Besides, an amount Tk. 25824.61 lakh was made available from the revenue budget to meet the recurring expenditure of the already complied projects of the Institute (Table).

Table-1: Budget provision of BARI for 2018-2019 (in lakh Tk.)

Total	GOB Head			Project Aid (PA/RPA	Capital Head	Revenue Head		Total
	ADP	Revenue	Total			ADP	Revenue	
33758.68	**7934.07**	**25824.61**	**33758.68**	**0**	**2092.00**	**5290.22**	**25808.26**	**31098.48**

Table-2: Development Budget (Annual Development Programme) of BARI for 2018-2019 (in lakh Tk.)

No.	Name of Projects & Programs	Total	GOB	PA	Capital	Revenue		Total
						Pay & Allow.	Contingency	
	A. Development Projects							
1.	Improvement and Quality Seed Production of Wheat and Maize-2nd Phase	315.00	315.00	0	0	9.00	272.00	281.00
2.	Strengthening of Oilseed and Pulses Research and Development in Bangladesh	296.00	296.00	0	0	38.38	212.62	251.00
3.	Strengthening Research on Horticultural Crops and Dissemination of Horticultural & Field Crop Technology at Charland Areas	1419.00	1419.00	0	102.00	5.00	1251.36	1256.36
4.	Research, Extension and Popularize of Vegetables and Spices Cultivation on Floating Bed	1151.00	1151.00	0	76.00	19.22	924.55	943.77
5.	Development and expansion of bio-rational based integrated pest management of vegetables, fruits and betel leaf (January 2018 to December 2021)	824.00	824.00	0	429.00	6.50	271.77	278.27

No.	Name of Projects & Programs	Total	GOB	PA	Capital	Revenue		Total
						Pay & Allow.	Contingency	
6.	Strengthening of Spices Crop Research in Bangladesh	2080.00	2080.00	0	1465.00	53.00	444.20	497.20
7.	Establishment of Agriculture Research Station, BARI, Gopalganj and eco-friendly agricultural development project in south-western part through strengthening of research	130.00	130.00	0	0	3.00	87.00	90.00
8.	Upgrading Regional Horticulture Research Station, Cumilla to Regional Agricultural Research Station	42.00	42.00	0	18.00	1.00	19.74	20.74
9.	Smallholder Agricultural Competitiveness Project (SACP) (BARI Part)	10.00	10.00	0	2.00	0	6.72	6.72
	Sub-Total Development Projects:	**6267.00**	**6267.00**	**0**	**2092.00**	**135.10**	**3489.96**	**3625.06**

Table-3: Non Development Budget (Annual Programs) of BARI for 2018-2019 (in lakh Tk.)

No.	Name of Projects & Programs	Total	GOB	PA	Capital	Revenue		Total
						Pay & Allow.	Contingency	
	B. Programs							
1.	Problem Identification and Research base Programme on newly Release Potato and Sweet Potato Varieties through Demonstration and breeder seed Production.	197.00	197.00	0	0	0	197.00	197.00
2.	Khesari, Blackgram, Felon Variety development, seed production and post harvest technology innovation and dissemination program.	152.00	152.00	0	0	0	152.00	152.00
3.	Program on varietal improvement and technology development research of black pepper, black cumin and cumin with other nonconventional spice crops.	241.75	241.75	0	0	0	241.75	241.75
4.	Processing and Preparation of Vegetable Meat from Green jackfruit.	307.24	307.24	0	0	0	305.33	305.33
5.	Improvement of local mango variety, development of production and distribution of mother prop gules of BARI developed promising varieties	290.00	290.00	0	0	0	290.00	290.00

No.	Name of Projects & Programs	Total	GOB	PA	Capital	Revenue		Total
						Pay & Allow.	Contingency	
6.	Development and extension of four crop based cropping pattern to increase cropping intensity program.	140.00	140.00	0	0	0	140.00	140.00
7.	Strengthening of nonconventional of crops research (soyabean, sunflower and linseed).	141.25	141.25	0	0	0	141.25	141.25
8.	Programme for the Production of Onion Breeder Seed.	92.20	92.20	0	0	0	92.20	92.20
9.	Programme for the Processing and Preservation of Green Mango.	30.63	30.63	0	0	0	30.63	30.63
10.	Production, Dissemination and postharvest Technology Development of Sunflower for Saline lands of Coastal Region.	15.00	15.00	0	0	0	15.00	15.00
11.	Enhancement of nutritional status and economic condition of charland farmers through development of modern groundnut varieties and intercropping technologies.	15.00	15.00	0	0	0	15.00	15.00
12.	Program on Varietal Development, Production and Postharvest Technology of Orchid, Cactus-Succulent, Corn and Bulbous flower and their Dissemination in Bangladesh.	45.00	45.00	0	0	0	45.00	45.00
	Sub-Total Programs:	**1667.07**	**1667.07**	**0**	**0**	**0**	**1665.16**	**1665.16**
	Grand Total (A+B):	**7934.07**	**7934.07**	**0**	**2092.00**	**135.10**	**5155.12**	**5290.22**

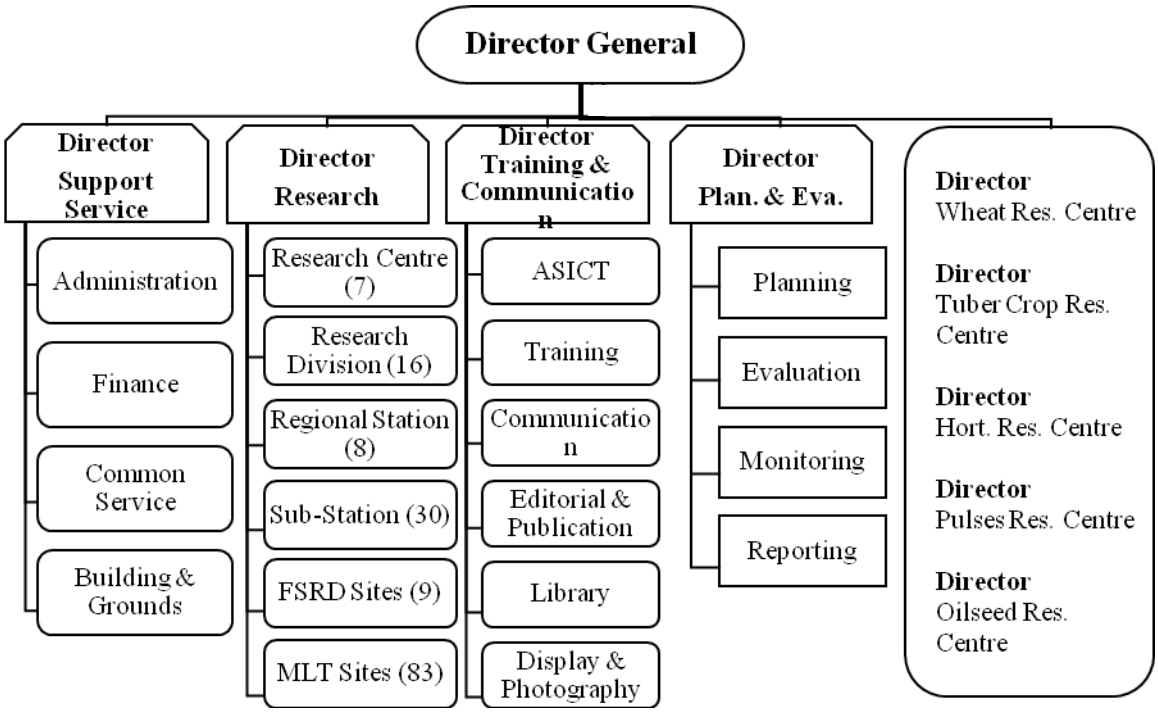
Institutional information:

BARI (Bangladesh Agricultural research Institute) is the largest multi-crop research institute conducting research on a wide variety of crops such as cereals, tubers, pulses, oilseeds, vegetables, fruits, spices, flowers, etc. Besides variety development, this institute carries out research on such areas as soil and crop management, disease and insect management, water management and irrigation, development of farm machinery, improvement of cropping and farming system management, post-harvest handling and processing, and socio-economic studies related to production, processing, marketing and consumption. The institute functions with the Director General as the chief executive along with three directors of its four major wings such as Research Wing, Support Service Wing, Training & Communication Wing and Planning & Evaluation Wing. The research Wing executes and monitors all the research programs and other research activities through 7 special crop research centers, 16 research divisions, 8 regional agricultural research stations and 30 sub-stations. Support Service Wing provides all the logistics support for research and personnel management. This wing is also responsible for infrastructural development and general procurement of the institute. The Training & Communication Wing is responsible for human resource development through conducting short term, mid tram as well as long term training and arranging scholarships for higher studies. Dissemination of information through print and electronic media, organizing seminars and symposia are also the important areas of activities of this wing. The Panning & Evaluation Wing is responsible for developing, executing, monitoring, evaluation of different projects.

BARI has a long historical background of its own. The emergence of the Institute in its present status has occurred through a number of changes starting from simply a sub-ordinate status under the Department of Land Records in the then Bengal. On the recommendation of the famine commission in 1880, the Bengal Department of Agriculture was established as a sub-ordinate part of the Department of Land Records in the then Bengal. In 1906, Lord Curzon, the then Vice Roy of India had granted separate status to the Bengal Department of Agriculture and in the same year, a Nuclear Agriculture Research Laboratory under this department was established at Tajgaon, Dhaka In 1908, an experimental station what has become known as Dhaka Farm was established on an area of 161.20 hectares of land. This Dhaka Farm was the predecessor of BARI and some other research institutes. Establishment of Dhaka Farm offered a good scope for conducting research in the field level in 1947, Bengal Department of Agriculture was renamed as East Pakistan Department of Agricultural. The two constituent divisions of the department were Research and Extension. In 1962, there was a severe blow to agriculture research when the land of Dhaka Farm was acquired for establishing Second Capital (today called Sher-e-Bangla Nagar). In 1968 two separate directorates were established – one was Directorate of Agriculture (Extension and Management) and the other was Directorate of Agriculture (Research and Education). The Directorate of Agriculture (Research and Education) was mostly concerned with research. This directorate was also responsible for the management of Bangladesh Agriculture Institute (BAI) at Sher-e-Bangla Nagar, Dhaka. Later in 1980s and 1990s, two other agriculture colleges, one in Patuakhali and the other in Dinajpur, were established. These two agriculture colleges were also administered by BARI until these became universities in 1971, the former provincial organization took on national responsibilities. Like many other sectors, agricultural sector inherited poor manpower and insufficient administrative set ups as well. Therefore, it was rightly thought to have established a coordinated and comprehensive research and some major decisions were taken up in 1973. Another important development in the year was the presidential Order No. XXXII that helps strengthen and reconstitute agricultural research organizations and system in the country. Upon subsequent developments of research institutions led to further restructuring in 1976,

through the presidential Order No. LXII, the Bangladesh Agricultural Research Institute (BARI) emerged as an autonomous and effective research organization following the dissolution of the Directorate of Agriculture (Research and Education) with sufficient operational flexibility, structural modification and improvement of regional and sub-stations.

Organizational Information:



Operational information:

Director General who is the Chief Executive of the institute has overall responsibility for administration, finance, development and execution of program related to research, manpower development, dissemination of information, transfer of technology and other extension activities. The Director General is assisted by four directors: Director (Research), Director (Support Service), Director (Training & Communication) and Director (Planning & Evaluation).

Director (Research) is responsible for program planning, monitoring and evaluation of the research activities as performed by the research centers, divisions and the regional and sub-stations.

Director (Support Service) is responsible for personal management, finance & accounts, procurement, infrastructure development, security, transportation and repair & maintenance.

Director (Training & Communication), on the other hand, is responsible for the transfer of technologies to the users through trainings, seminars, workshop, print & electronic media. Human resource development through training and arrangement scholarships for higher studies at home and aboard also fall within his responsibilities.

Director (Panning & Evaluation) is responsible for developing, executing, monitoring, evaluation of different projects under development budgets and Programmes (Karmosuchi) under revenue budget of GoB with the help of crop centers, sub-centers, divisions, Regional Agricultural Research Station (RARS) and Agricultural Research Station (ARS). Also involves in financial management, procurement activities, infrastructure development and arrange meetings like Project Implementation Committee (PIC), Project Evaluation Committee (PEC) of different projects and Planning & Development Committee (P&DC) meeting of the institute.

Each research division is headed by a Chief Scientific Officer (CSO) who is also designated as divisional head whereas a research center is headed

by a Director/Project Director. Each divisional head is assisted by the concerned scientist starting from Scientific Officer (SO) to Principal Scientific Officer (PSO). On the other head, each research center is comprised of scientists from various disciplines in the rank of Scientific Officer (SO) to Chief Scientific Officer (CSO).

Regional Stations are headed by senior scientist equivalent to the status of CSO, while the sub-stations are headed by the scientists in the rank of either PSO or SSO.

Information on Right to Information: RTI of BARI

Designated Officer	
Officer's name	**:** Dr. Md. Saiful Islam ড. মো. সাইফুল ইসলাম
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Designated Officer (Alternative)	
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Designated Officer (Appeal)	
Officer's name	: Md. Nasiruzzaman মো. নাসিরুজ্জামান
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Mobile	: 01730-592056
Email	: secretary@moa.gov.bd
Website	: www.moa.gov.bd
Office	: Ministry of Agriculture (MoA), Dhaka

List of Information delivery to the citizen during 2018

ক্রমিক নং	কর্তৃপক্ষের নাম	তথ্য অধিকার আইন, ২০০৯ এর ফরমেট অনুযায়ী তথ্য সরবরাহের জন্য প্রাপ্ত আবেদনের সংখ্যা	তথ্য সরবরাহের মাধ্যমে নিষ্পত্তিকৃত আবেদনের সংখ্যা	অনুরোধকৃত তথ্য না দেয়ার সিদ্ধান্তের সংখ্যা ও উক্ত সিদ্ধান্ত গ্রহণের কারণ	দায়িত্বপ্রাপ্ত কর্মকর্তার সিদ্ধান্তের বিরুদ্ধে আপীলের সংখ্যা	আপীল নিষ্পত্তির সংখ্যা	কর্তৃপক্ষ কর্তৃক দায়িত্বপ্রাপ্ত কর্মকর্তার বিরুদ্ধে গৃহীত শাস্তিমূলক ব্যবস্থার সংখ্যা	তথ্য অধিকার (তথ্য প্রাপ্তি সংক্রান্ত) বিধিমালা ২০০৯ এর বিধি ৮ অনুযায়ী তথ্যের মূল্য বাবদ আদায়কৃত অর্থের পরিমান	কর্তৃপক্ষ কর্তৃক গৃহীত বিভিন্ন কার্যক্রমের বিবরণ	এন্তব্য
১	২	৩	৪	৫	৬	৭	৮	৯	১০	১১
১	বাংলাদেশ কৃষি গবেষণা ইনস্টিটিউট, গাজীপুর	২**	২**	-	-	-	-	-	-	-

** বিএআরআই এর ওয়েবপোর্টাল ও মোবাইল অ্যাপস হতে ই-কৃষি সংক্রান্ত ২৯৯টি প্রশ্ন পাওয়া গিয়াছে ও ২৯৯ টি উত্তর দেওয়া হয়েছে।

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