Volume 47, Issue 1, 2022 ISSN 0253-5408

BANGLADESH JOURNAL OF AGRICULTURE

Bangladesh Agricultural Research Council

ISSN 0253-5408

BANGLADESH JOURNAL OF AGRICULTURE

VOLUME 47 ISSUE 1 JUNE 2022

Bangladesh Agricultural Research Council
www.barc.gov.bd

BANGLADESH JOURNAL OF AGRICULTURE
VOLUME 47, ISSUE 1, JUNE 2022

BANGLADESH JOURNAL OF AGRICULTURE

ISSN 0253-5408

This Journal is indexed in Agrindex, Biological Abstract, CAB International Abstracting Services, Index Medicas, The Essential Electronic Agricultural Library (TEEAL), Bangladesh Agricultural Bibliography, Bangladesh Science and Technology Index and other indexing services.

Subscription

Each volume is priced as below

Institutional

Local currency	US dollar
Tk. 200	$ 20

Individual

Tk. 100	$ 10

Cheques, Money Orders, Drafts, etc. should be issued in favour of the
Bangladesh Agricultural Research Council (BARC),
Farmgate, Dhaka-1215, Bangladesh

All correspondences regarding journal should be made to:

Executive Editor
Bangladesh Journal of Agriculture
Bangladesh Agricultural Research Council (BARC)
Farmgate, Dhaka-1215, Bangladesh
Email:bjabarcjournal@gmail.com

JUNE 2022

BANGLADESH JOURNAL OF AGRICULTURE
VOLUME 47, ISSUE 1, JUNE 2022

CONTENTS

Bangladesh J. Agri. 2022, 47(1): 1-15 *DOI: https://doi.org/10.3329/bjagri.v47i1.60589*

SOLAR BUBBLE DRYER: ALTERNATIVE TO SUN DRYING FOR REDUCING DRYING LOSSES

S. Aktar[1], M. A. Alam[2*], M. M. Alam[3], C. K. Saha[3] and J. C. Roy[3]

[1]Department of Farm Power and Machinery, Sylhet Agricultural University (SAU), Sylhet;
[2]Agricultural Engineering Unit, Bangladesh Agricultural Research Council (BARC), Dhaka;
[3]Department of Farm Power and Machinery, Bangladesh Agricultural University (BAU), Mymensingh. Bangladesh

Abstract

The Solar Bubble Dryer (SBD) is a latest low cost drying technology and flexible alternative to sun drying. Technical performance was investigated by observing moisture content and temperature distribution at different points of the dryer. The moisture distribution was uniform and its content was reduced initially from 19.5, 20.6 and 20.3% to 14, 15.6 and 14%, respectively in the 1st, 2nd and 3rd trial of the dryer. The temperature distribution was almost same but it was sometimes lower than the ambient temperature. The drying rate, drying capacity and drying efficiency were found to be 3.9 kg/hr, 1000 kg/batch, and 12.3%, respectively. Every trial took 3 - 5 days but it was difficult to achieve desired moisture of 12.0%. The average germination rate of SBD dried paddy (89.66%) was more than that of sun-dried paddy (84%). The milling recovery was found 71% for SBD dried paddy and 72.4% for sundried paddy. The percentage of broken rice in SBD dried paddy sample was more than that of sun-dried sample because of high moisture content (14.5%) and less hardness (22.5 N). The operating cost of paddy drying in SBD dryer was found Tk. 1410.9 per ton whereas that of traditional sun drying methods was found Tk.1047.3 per ton. Although, drying by SDB is not profitable over traditional drying, it has advantage to protect drying loss of fresh harvested paddy during unpredictable weather condition in rainy season.

Keywords: Drying efficiency, Drying loss, Drying rate, Solar Bubble Dryer

Introduction

Bangladesh is an agriculture based country and its economy depends on agriculture. Paddy is the main staple crop in our country and second crops in the world. Bangladesh is now producing about 34.6 million ton of rice (USDA, 2021) to feed about 168.22 million of people (BBS, 2020). Freshly harvested paddy has high moisture content up to 20-25% (IRRI, 2013). Paddy has a high respiration rate and is susceptible to attacks by micro-organisms, insects and other pests. Proper or incomplete drying or ineffective drying results in qualitative or quantitative loss. Harvested grains with high moisture should be dried at 14% -18% for storing for 2 to 3 weeks, otherwise, mold damage and discoloration occur and respiratory damage occurs. Grain should be dried at 12% -13%

*Corresponding author: ashraf1982s@gmail.com

moisture content to protect against insect infestation for 8 to 12 months of storage and 9% or less moisture content to protect seed viability (IRRI, 2013). Due to low temperature and high relative humidity, world is facing a problem to moist paddy deterioration after harvesting. In order to reduce post-harvest losses, farmers harvested raw paddy early and sell it in the market, which reduces the farmer's income. Country's food security heavily relies on its ability to safely store its food, feed-grain and seed stocks.

An efficient drying method is necessary to supply continuously for growing population and to ensure high quality marketable products. The amount of post-harvest loss in traditional process is cutting and handling 1-5%, sun drying 3-5%, open storage 5-10%, village milling (Angle bar huller) 20-30% whereas combine harvesting and machine threshing is 1-5%, mechanical drying 1-2%, sealed storage 1-2% and commercial milling 5-10% (Hodges *et al.,* 2011). Most traditional method in sun drying of grain is unhygienic due to grain quality deterioration by uncontrolled factor and damage by bird. Due to industrialization and export of manpower, it is difficult to dry the grain during peak season, especially during Boro and Aus seasons. To address these problems, SBD is a modern drying innovation that minimizes the effects of unpredictable weather to commodities during its drying stage. The SBD is the latest drying technology that aims to provide a simple and flexible alternative to sun drying. Therefore, the aim of the study was to evaluate the performance of Solar Bubble Dryer. It improves the traditional sun-drying process and eliminates all losses due to spillage, animals, the weather, and vehicles running over the grains.

Materials and Methods

Experimental site

The SBD is currently being tested on rice by IRRI's national partners in the Philippines, Cambodia, Myanmar, Vietnam, Indonesia, Thailand, and Nicaragua. In the contexts on Bangladesh the performance evaluation of SBD was conducted at the workshop of Department of Farm Power and Machinery, Bangladesh Agricultural University (BAU), Mymensingh.

Description of the dryer

SBD is made of two plastic sheets one is black and other is transparent. The black one is at the bottom where the grains are placed and a transparent one as roofing. Both sheets are connected by a zipper. The SBD uses solar energy from the sun in two ways. Firstly, the transparent plastic sheet serves as a solar collector to convert energy from the sun's rays (entering through the transparent top of the drying chamber) to heat, therefore increasing the temperature of the air for faster drying. Secondly, the SBD is equipped with a photovoltaic panels system that consists of solar panel for generating electricity a rechargeable deep cycle battery for use at night. The dryer has two ventilators placed at the air inlet at one end of the dryer to inflate and hold up the polyethylene plastic sheet, thus providing the dome shape (Fig. 1).

The ventilators also move the air inside the dryer, ensuring a homogenous distribution of heat and reducing the moisture content. The drying air leaves the dryer at

the other end through an adjustable outlet. On a typical sunny day, the surface of the grains heats up so much that users need to increase the frequency of stirring the grains. A simple roller with ropes attached to both of its ends is periodically dragged underneath to mix the grains without the need to open the tunnel. A rake is available to mix the grain on the drying chamber. The capacity of the dryer is 1000 kg. Detail specifications of the SBD are given in Table 1.

Fig. 1. Pictorial views of Solar Bubble Dryer (SBD)

Table 1. Specification of the dryer

Parameters	Product Specification
Drying area, m^2	50
Overall dimension (L×W), m	26 × 2
Packed dimension (L×W×H), m	1 × 1.1 × 0.3
Packed Weight, kg	95 (without battery)
Components: SBD body	
Capacity (Maximum), kg	1000
Top cover	UV-resistant LDPE
Drying floor	Reinforced PVC
Zipper	Heavy duty zipper (open ended)
Electronic Components	
Wiring Harness	MC4: #14 standard wire
Solar panel	
Frame	Aluminum bars
Charge controller	SRNE (SR-SL10A)
Solar battery	12V 70Ah deep cycle battery (sold separately)
Unit(s)	2 panels, 100W per panel
Ventilator	
Frame	Collapsible aluminum bars
Unit(s)	2 units, 12V, 0.254m diameter with casing
Mixing	
Rake mixer	0.025m diameter aluminum tube
Roller mixer	2.4m G.I. Pipe

Technical parameter of the dryer were measured by computing the moisture content of paddy (%), temperature (^{o}C), relative humidity (%), air flow rate (ms^{-1}), solar radiation (Wm^{-2}).

Experimental set-up and procedure of test

The dryer was set-up in a drying floor, solar panel with 12-volt battery. Black sheet of SBD was placed on the drying floor in a uniform way according to its length and grains are placed in equal thickness about 35 mm. A measuring scale and wooden leveler were used for uniform grain thickness on drying floor. Fourteen *k-type* thermocouples were set up at different location for recording temperature according experimental design (Fig. 2). To get continuous temperature reading at 10 second interval the thermocouples were connected to Fluke data logger which was attached with a computer during drying operation. Then zipper was closed and drying operation was started. The evaporated moist air was passing through the outlet with the help of two ventilators (12-V, 0.254m diameter with casing) which was associated with a collapsible aluminum bars frame. The ventilators were attached with black and transparent polythene sheets in inlet portion with the help of rope. Two solar panels (100 W per panel) were fixed by an aluminum bar in the south facing direction at 45° angle to get maximum solar radiation collection. A solar battery (12-V 70Ah deep cycle battery) was used as auxiliary operation during sunny day and vice-versa during night or cloudy weather. The battery was connected with solar panel and ventilators by a charge controller (SRNE-SR-SL10A) to control the voltage. Then, the ventilators were started to make the dome like shape of the polythene plastic roof and drying operation.

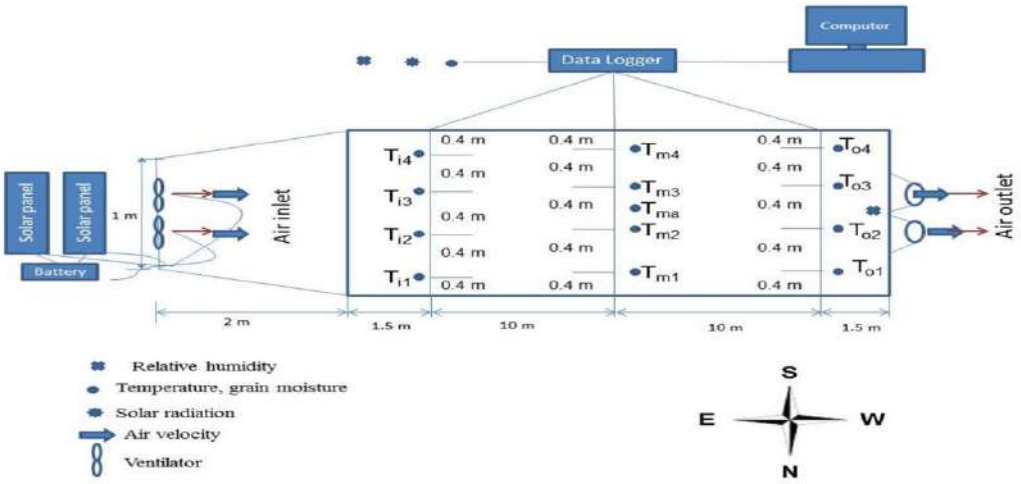

Fig. 2. Experimental layout of the dryer (T-temperature sensor, i-inlet, m-middle, o-outlet and measurement in meter)

The drying time of three trials were considered when the solar radiation was available enough for drying operation to investigate the technical performance of solar dryer (Bala *et al.*, 2005). The dried samples were spread out at night in the dryer and only one ventilator run by the battery as auxiliary operation, then drying was continued the next morning. The total length of the dryer was 25 meter whereas the heating area was 2 meter and 23 meter was used for spreading grain. The initial moisture content of paddy, weight of paddy, air flow rate, ambient temperature, relative humidity and solar radiation

readings were recorded before drying operation and every half an hour interval similar data were recorded during drying operation. The grain temperature reading was recorded in every 10 seconds interval by using FLUKE (Model-FLUKE 2635A Hydra series Data bucket) data logger. A computer was attached with data logger to receive the recorded data in real time. An electrical balance (Model- ES-HA precision balance scale, accuracy: ± 3d) was used to weight paddy. The moisture content of paddy was measured manually by using a Riceter L (Model-Riceter L, accuracy: ± 0.2% at 105^{o}C, measurement range 11-30% for paddy rice) moisture meter after collection of paddy sample. The paddy sample was collected from three different locations inside the dryer in every half an hour interval. The collected paddy samples were also used to measure moisture content using oven dry method. A desiccator was used to store paddy sample for oven drying. The ambient temperature and relative humidity was measured by using TRH-1000 (Model-TRH 1000, temperature accuracy: ± 0.6°C @ 25°C, ± 2°C from -40°C to 70°C and ± 4% RH between 20 to 80% RH) data logger. Testo (Model- Testo 416, accuracy: (± 0.2 m/s + 1.5% of mv) anemometer measured the air flow rate at the outlet point of the dryer. The air flow rate was measured to check how swiftly evaporated grain moisture passes through the outlet point. Solarimeter (Model-SL 100) was used to measure solar radiation during drying operation.

Seed germination

Seed germination rate was determined through germination tests after drying. The viability of grain is directly linked to the temperature attained by grains during drying. When the drying temperature is above 43^{o}C, the seed loses its vigor. The deterioration of the seed vigor in rice crop accounted for 20% of the yield losses (Shenoy *et al.*, 1988). At first, 100 (one hundred) gram dried paddy sample were taken from SBD. Then purity test was conducted to get pure seed, other seed and inert matter from each sample. The germination rate was calculated using the number of germinated or germinated seeds in 100 pure seeds taken from the dryer as a sample. The germination test was conducted in sand medium with a plastic pot. The sand medium was soaked with water within 12 hours. After that the plastic pot was filled with the moist sand medium. Then the 100 number of pure seed was placed carefully without overlapping. Finally the pot was kept in proper environment for sprouting. The number of germinated seeds was counted after 5 days for each entry. The germinated seedlings root and shoot length was measured after 14 days. Germinated seedlings were recorded for each entry and the germination percentage computed**.** The germination rate was calculated by the following equation.

$$\text{Germination rate, (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds planted on tray}} \times 100$$

Milling test

Timely harvesting, threshing, drying, and stored properly can result in the production of good quality milled rice. Delays in drying, and moisture migration in storage can result in broken and discolored milled rice. The initial moisture content of paddy and drying air temperature influence the drying rate and head rice yield obtain at

43°C to 45°C temperature was considerably higher than sun drying (Chouw and Athapol, 2001). At first, 100 gram dried paddy sample was cleaned for milling recovery test. Five replications were taken for the test. A laboratory rubber roller rice husker (Model-JLGJ2.5, Rate of husking (%): ≥99.9) was used to dehusked the cleaned paddy. Then an iron roll rice whitener (Model- LNMS 15) was running four minutes to clean the bran from the dehusked paddy. Definitions are provided to clarify terms commonly used in reference to milling yield measurement.

Head rice yield was defined as the ratio of the total head rice to the total rough rice.

$$\text{Head rice yield (\%)} = \frac{Mass\,of\ \text{head rice}}{\text{Mass of rough rice}} \times 100$$

Percentage of milling recovery was calculated as the ratio of the milled rice (head rice and broken) to the total rough rice.

$$\text{Milling recovery (\%)} = \frac{Mass\,of\ \text{milled rice}}{\text{Mass of rough rice}} \times 100$$

Data analysis and calculation

The measuring data were collected in a data sheet and analyzed with the help of MS Excel software. The energy was absorbed from solar radiation and the total energy output was determined in dryer during drying operation. Moisture content of paddy was determined by two methods, one is direct method and other is indirect method. In the experiment moisture content was calculated by direct method using an oven and other was indirect using a manual moisture meter. All the sample of paddy was dried in the oven for 24 hrs at 130^{0}C to determine the initial and final moisture content of paddy (Cnossen *et al.*, 2001). Dryer performance was measured using drying efficiency equation as well as the total energy supplied to the drying chamber and the total energy utilized by the drying chamber to remove desired moisture. The energy supplied by solar radiation and the total energy output was determined in SBD. The drying efficiency of dryer is defined as the ratio of energy used to evaporate the moisture from the paddy to the energy input to the dryer. It was calculated with the following equation:

$$\text{Drying efficiency } \eta = \frac{WL}{E_t}$$

Where, W = the weight of water evaporated (kg), L = the latent heat of evaporation of water (MJ/kg), and E_t = total energy consumption (MJ).

The total energy consumption of SBD dryer was measured from the solar radiation of the sunshine. Then the drying area of the SBD dryer was calculated. After that the drying time was calculated. The total energy consumption was calculated with the following equation:

$$E_t = \frac{R_s \times \mathrm{A} \times \mathrm{t}}{10\text{^}6}$$

Where, E_t = energy consumption (MJ); R_S= solar radiation, (Wm^{-2}); A = drying area of SBD (m^2) and t = drying time (s)

Fixed cost and variable cost are considered for economic analysis. Depreciation, taxes, interest on the capital investment, insurance and shelter were considered as fixed cost which is independent of use. Alternatively, the variable cost such as fuel, lubrication, daily service, power and labor used by the power source and the dryer were considered as operating cost of the dryer. Benefit-cost ratio and payback period were also measured.

Sun drying method

The performance of SBD was compared with traditional sun drying method. Paddy was dried in open sun shine and simultaneously in every SBD trial. Same initial weight and moisture content of paddy were used in sun drying with 30 mm grain thickness. In case of sun drying, two labors were engaged for stirring the paddy at half an hour interval when the sun light was available. The moisture content of paddy, the ambient temperature and relative humidity were measured for sun drying method.

Results and Discussion

Temperature and solar radiation during SBD drying operation

The technical performance evaluation of SBD dryer is in terms of temporal distribution of temperature and moisture content. The Fig.3 is shown that the ambient temperature (^{0}C) with the solar radiation (Wm^{-2}) during the drying operation. When the ambient temperature increases, then the solar radiation increase rapidly. The similar result are reported on experimental analysis on corn drying of a sustainable solar dryer (Gisele *et al.*, 2020). Drying operation was conducted at 12.30 pm when solar radiation reaches maximum. The solar radiations were entering by the UV-resistant, water proof and transparent cover film into the drying chamber. At the time of entering the solar radiation was short wave length and after entering into the drying chamber it became long wave length and finally it was trapped as like a green house. Paddy was heated up and moisture was vaporized and cooled moisture was passed out by outlet. First one hour the solar radiation was maximum and fluctuated because of foggy and cloudy weather. Solar radiation intensity was achieved maximum at 2.00 to 4.00 pm about 750 Wm^{-2} at the 3rd trial of 3rd day. After 19 hrs later the intensity of solar radiation was decreased to 400 Wm^{-2} at the 3rd trial of 4th day. The drying operation was stopped at 2nd day of 3rd trial due to foggy weather.

Temperature distribution inside and outside of SBD dryer

The temperature inside the drying chamber was more or less similar with the ambient temperature (Fig. 4). Solar radiation intensity maximum was 1 to 3 hrs and

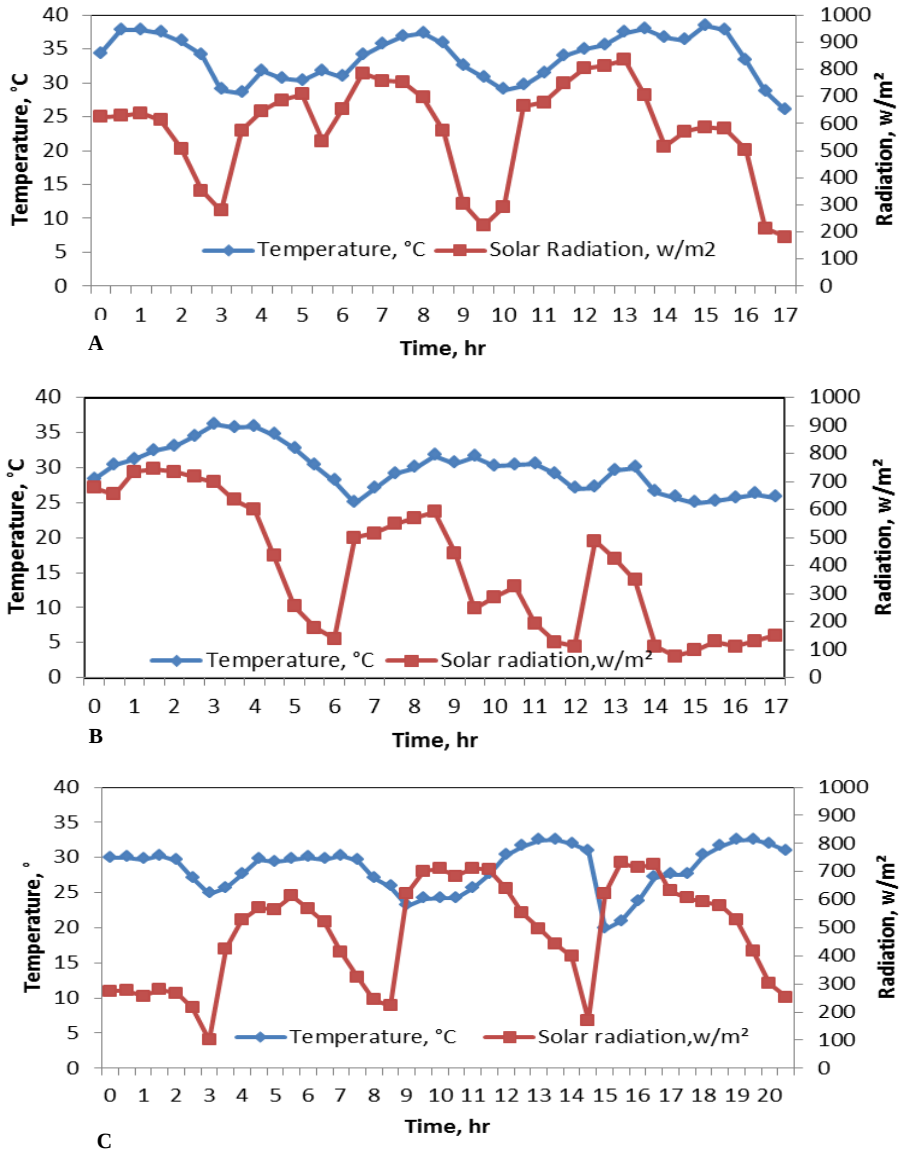

Fig. 3. Relation between ambient temperature and solar radiation during drying operation- (A) Trial 1, (B) Trial 2 and (C) Trial 3

temperature variation occurred at that time. Consequently the drying air temperature inside the drying chamber was maximum and drying rate of paddy was increased. Hossain *et al.*, (2012) reported the similar results for rough rice seed drying in the hybrid dryer. Due to unpredictable weather condition its normal working procedure hampered. There were three trials and 1st and 2nd trial was taken 3 days almost same. But 3rd trial was taken 5 days as a result it takes more time than those others because of 2nd day sun were invisible and there was foggy and cloudy weather. Drying operation of 2nd day of 3rd trial was totally closed.

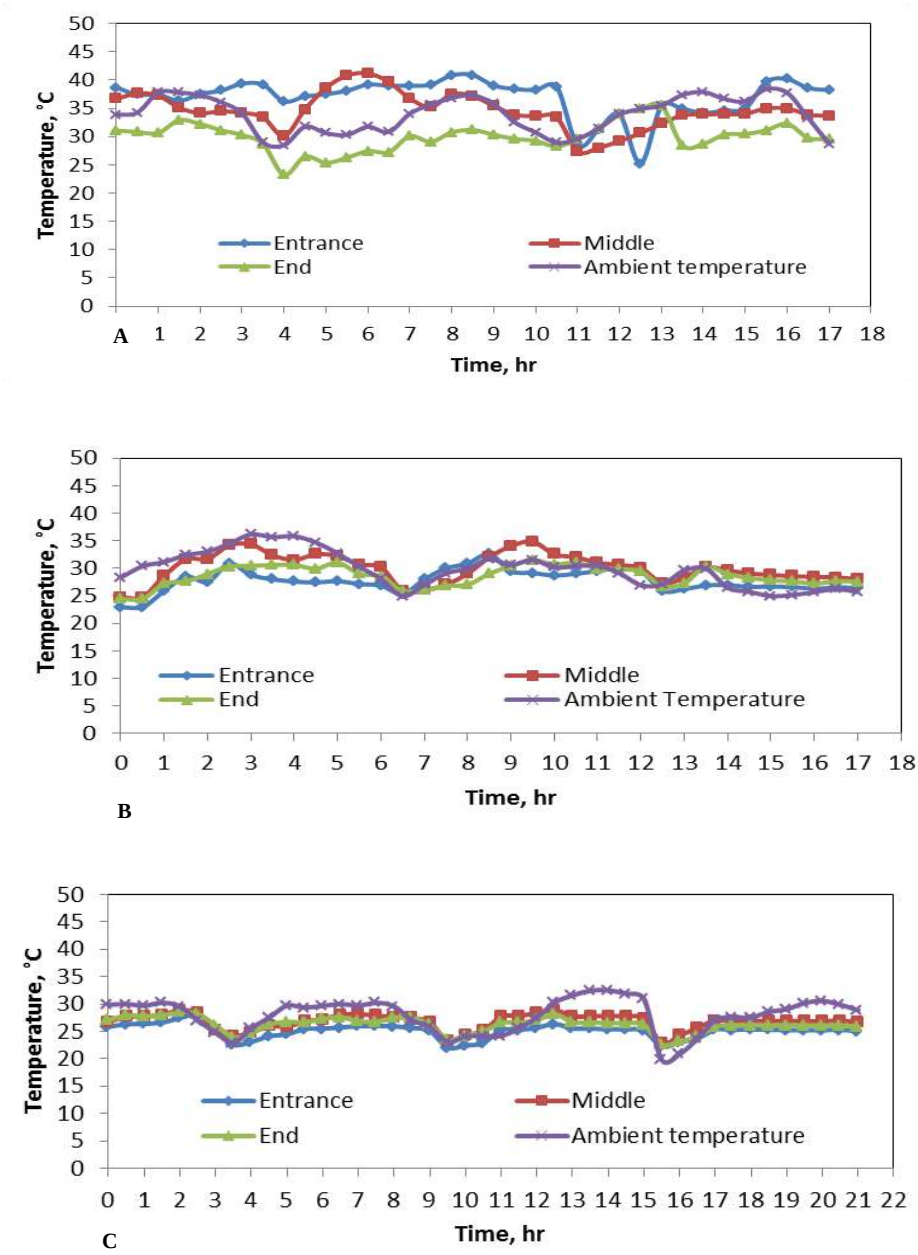

Fig. 4. Variation of temperature at different point of the SBD dryer in (A)Trial 1, (B) Trial 2 and (C) Trial 3

Moisture removal rate in different trials of SBD

Moisture removal profile with time is shown in Fig. 5. It shows that moisture content of paddy of inlet, middle and outlet portion on SBD dryer was decreased gradually with the time passed on all trials. The variation of moisture content among the

inlet, middle and outlet locations were very much low during drying. The paddy sample in all locations inside the SBD was dried uniformly with time and finally the moisture content of paddy was achieved about same moisture value. Alam *et al.*, (2016) reported that the similar result for grain drying in all part of the BAU-STR dryer within 3 to 5 hours.

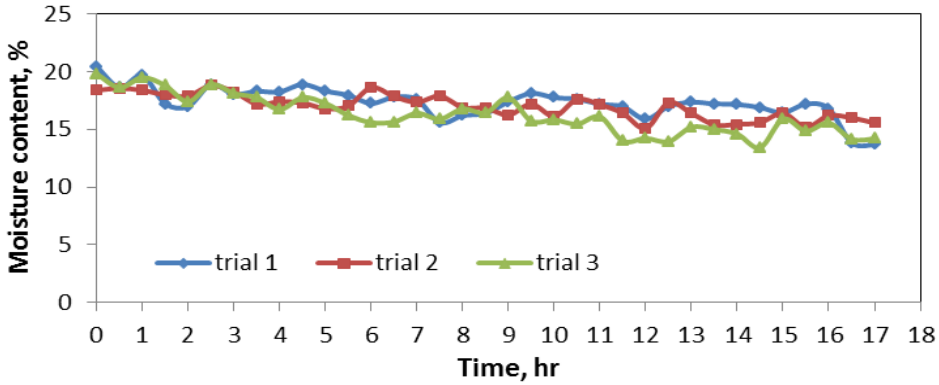

Fig. 5. Variation of moisture content at the middle point of SBD dryer in Trial 1, Trial 2 and Trial 3

The variation of moisture removal rate measured by moisture meter and oven dry method is shown in Fig. 6. Moisture content of paddy both in manual and oven dry method was determined from the collected paddy half an hour interval. Moisture profile shows the smooth curve which is gradually decreases with time both in manual and oven dry method.

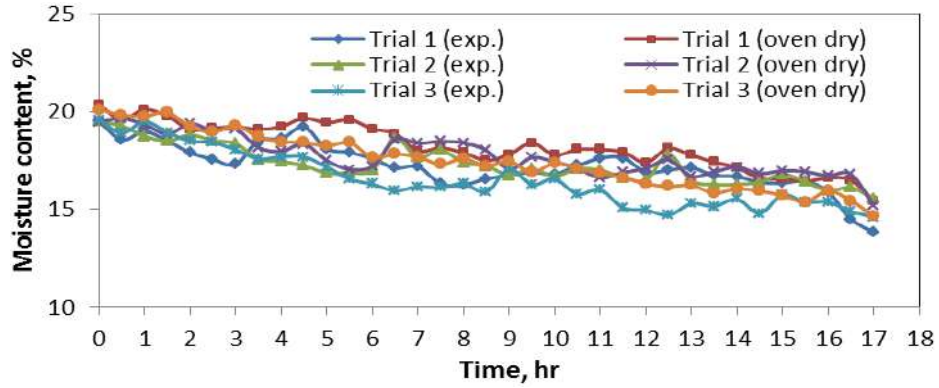

Fig. 6. Comparison of moisture content between experimental (manually moisture meter) and oven dried in Trial 1, Trial 2 and Trial 3

The moisture content of paddy builds up in every next day morning 1-2% compared with end time of last day because of entering moist air in SBD through the ventilators. The re-wetting phenomena of the grains occurred during the night time if the drying is not completed in one day (Ashfaq *et al.*, 2015). At the end of drying operation (3 to 5 days), the moisture content of paddy remains stable at about 14% due to

equilibrium moisture content mechanism. The desired moisture content of paddy was 12% but actually achieved about 14%. The experiment trial 1 and trial 2 taken 3 days and trial 3 taken 5 days because of the foggy and dense weather. At day time moisture content of paddy was reduced but at night time the paddy gained moisture from the inlet portion because backup battery run the fan of inlet portion and cold air entered into the drying chamber. The paddy regained moisture and increased the moisture content by about 1-2% during the nighttime.

Technical performance of SBD dryer

Drying capacity, drying efficiency, moisture removal rate was measured to determine the technical performance of the dryer. Paddy was dried from average initial moisture content 20.1% to final moisture content 14%. Drying performance and fundamental parameter of paddy of the dryer are shown in Table 2. The drying rate, drying capacity, drying efficiency were varied with the variation of solar radiation, ambient air temperature and relative humidity. Aghbashlo *et al.*, (2015) explained that the drying rate becomes better while the drying air temperature supplied through the sun collector becomes excessive is because of extensive warmness and mass transfer observed through an excessive rate of water evaporation. The average drying rate, drying capacity and drying efficiency were 3.9 kg hr^{-1}, 60.2 kg hr^{-1} and 12.3%.

Table 2. Technical performance measurement of the Dryer

Trial	Max. temp.	Min. temp.	Initial MC (%)	Final MC (%)	Initial weight of paddy (kg)	Final weight of paddy (kg)	Moisture removed (kg)	Drying time (hr)	Drying rate (kg hr^{-1})	Drying efficiency (%)
1	41.2	23.2	19.5	14.0	1000	931.2	64.5	16.0	4.0	10.3
2	34.8	23.0	20.6	15.6	1000	937.7	59.5	16.0	3.7	14.0
3	28.9	22.1	20.3	14.0	1000	920.5	73.7	18.0	4.1	12.6

Seed germination rate of SBD dried paddy

Seed germination test in terms of counting the number of seedlings germinated. Seed sample was taken from SBD dried paddy and sun dried paddy. The germinate rate in SBD dryer and sun dried paddy is shown in Table 3. The average germination rate in SBD dried paddy is 89.66% (average of 3 trials) is more than the sun dried paddy (84%).

Rice quality assessment of SBD dryer

Milling test was determined from SBD dried paddy and sun dried paddy. Milling recovery, broken rice, hardness for SBD dried paddy and sundried paddy are shown in Table 4. Head rice yield depends on grain moisture content and temperature. Milling recovery of SBD dried paddy in average 71% and sundried paddy is 72.4 %. The percent of broken rice in SBD dried paddy sample is more than that of sundried sample because of high moisture content (14.5%) and less hardness.

Table 3. Germination rate of SBD and sun dried sample

Treatments	Sprouted seed	Dead seed	Abnormal seedlings	Normal seedlings
Trial 1	0	1	8	91
Trial 2	3	1	6	90
Trial 3	1	2	9	88
Sundry	5	3	8	84

Table 4. Milling recovery of dried paddy in SBD Dryer and sundry method

Treatments	Milling recovery, %	Broken rice, %	Unbroken rice, %	Hardness, N
SBD-1	70.5±0.8	40.7	59.3	21.6
SBD-2	70.9±1.1	27.7	72.3	18.3
SBD-3	73.1±1.0	6.6	93.4	27.8
Sundry	72.4±1.7	11.6	88.4	23.2

Drying loss in SB dryer during Aman season

Drying loss of paddy in SBD during Aman season at laboratory is shown in Fig. 7. The drying loss was between 0.40 to 0.93% during Aman season. It was revealed that the drying loss of SB dryer less than 1.0% in Aman season whereas it was found in open sun drying (field) at different locations in the range of 2.41 to 3.95% (Alam *et al.*, 2019).

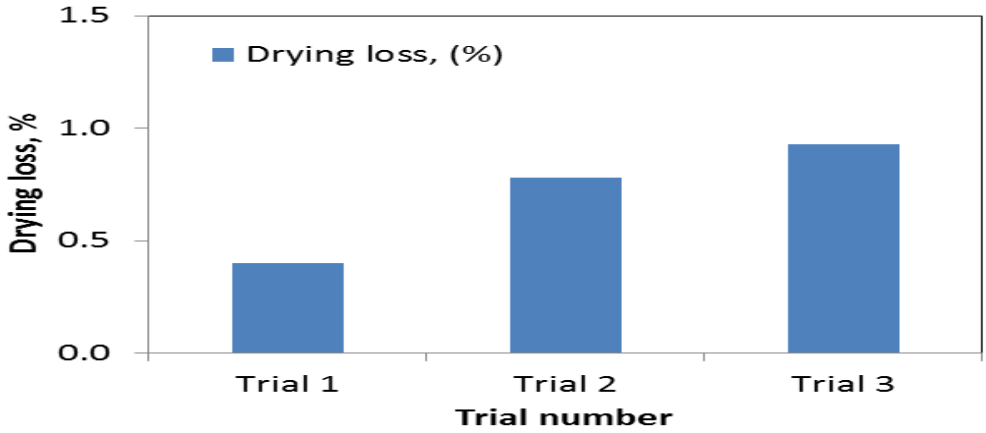

Fig. 7. Drying losses of paddy in SB dryer at laboratory

Economic analysis

Economic analysis for SBD dryer is given in Table 5. The purchase price of SBD dryer was Tk. 183000 with economic service life 10 years. The operating cost of paddy drying was found Tk. 1410.9 per ton in SBD dryer whereas in traditional sun drying methods the operating cost was Tk.1047.3 per ton. Ashfaq *et al.*, (2015) indicated that the

operating cost of solar assisted rough rice dryer was obtained Tk. 900 per ton while the operating cost of drying by using open sun drying method ranged from Tk. 1500 to 2000 per ton. Though the dryer is not profitable over traditional drying, it is suitable to save harvested paddy from unpredictable weather.

Table 5. Economic analysis of SBD dryers

Description	Traditional drying	SBD
Drying capacity, kg hr^{-1}	38.2	60.2
Operating hour, hr yr^{-1}	-	900
Operating cost, Tk. ton^{-1}	1047.3	1410.9
Benefit cost ratio	-	0.7
Save over traditional, Tk. ton^{-1}	-	-363.6

Break-even point analysis

The break–even theory is based on the fact that there is a minimum cost level at which a Venture neither makes profit nor loss. The Fig.8 shows that the initial stage the drying cost is high for 5 ton paddy are dried per year. The traditional drying will be more profitable than the SBD dryer. The desired point is 120 ton annual used of paddy where no profit or no loss.

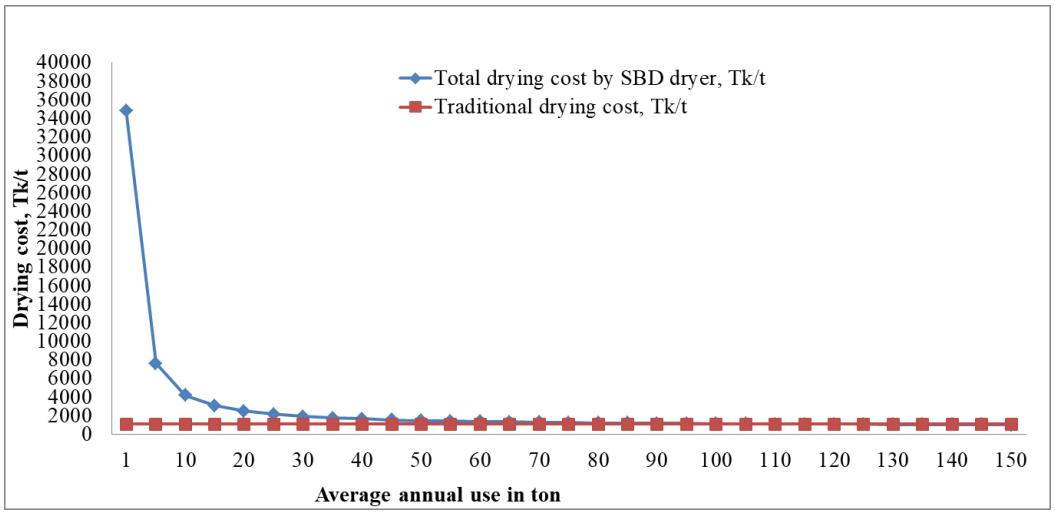

Fig. 8. Break-even point analysis of SBD dryer

Sun drying method

Paddy was dried in open sun shine using same variety BRRI dhan49. The initial moisture content was similar with SBD trial 1, 2 and 3. Paddy was dried from 19.5 to 13.9%, 20.6 to 14.3% and 20.3 to 12% with same duration of SBD drying in trial 1, 2 and 3, respectively. The moisture removal rate in open sun drying was more or less similar to

SBD drying. Drying cost of paddy in sundry method was lower than that of SBD drying operation due to high initial cost of SBD dryer (Table 5).

Conclusion

The temperature distribution and moisture removal rate was uniform in all locations of SBD dryer during drying operation. The required drying time was more or less similar with traditional sun drying method (3 to 5 days), however it was so difficult to achieved desired moisture content (below 12%) due to humid and foggy weather condition. It is difficult to protect moisture condensation in the black sheet of drying floor stirring with rake and tube mixer. Considering the technical performance and economic analysis, the SBD is applicable to protect qualitative and quantitative loss of fresh harvested paddy though it is not profitable for the weather condition in Bangladesh. Improved stirring mechanism and perforated screen might be incorporated for refining the performance of the dryer.

Acknowledgement

Program activities are funded by the United States Agency for International Development (USAID) under Cooperative Agreement No. (Grant Number: UReRA 2015-05296-01-00).

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Aghbashlo, M., J. Muller, H. Mobli, A. Madadlou and S. Rafiee. 2015. Modeling and simulation of deep-bed solar greenhouse drying of chamomile flowers. *Dry. Technol.* 33(6):1–12.

Alam, M.A., C.K. Saha, M.A. Momin, M.M. Alam and B.K. Bala. 2016. Spatial distribution of temperature and moisture in grain bin and grain bin size effect on STR dryer performance in Bangladesh. *J. Agricultural Machinery and Biores. Eng.* 7(1): 1-8.

Alam, M.A., C.K. Saha and M.M. Alam. 2019. Mechanical drying of paddy using BAU-STR dryer for reducing drying losses in Bangladesh. *Progres. Agricul.* 30(1):42-50.

Ashfaq, S., M. Ahmad, A. Munir and A. Wajid. 2015. Design, development and performance evaluation of a small-scale solar assisted paddy dryer for on farm processing. *J. Food Process Technol.* 6(9):480.

Bala, B.K., M.A. Ashraf, M.A. Uddin, and S. Janjai. 2005. Experimental and neural network prediction of the performance of a solar tunnel drier for drying jackfruit bulbs and leather. *J. Food Process Eng.* 28:552–566.

BBS. 2020. Key findings of sample vital registration system 2020, Report on Bangladesh sample vital statistics 2020, Monitoring the situation of vital statistics of Bangladesh project (3rd phase), Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Sher-E-Bangla Nagar, Bangladesh.

Cnossen, A.G., T.J. Siebenmorgen, W. Yang and R.C. Bautista. 2001. An application of glass transition temperature to explain rice kernel fissure occurrence during the drying process. *Dry. Technol.* 19(8):1661–1682.

Chouw, I. and N. Athapol. 2001. Effect of drying air temperature and grain temperature of different types of dryer and operation on rice quality. *Dry. Technol.* 19(2):389–404.

Gisele, M.S., A.G. Ferreira, R.M. Coutinho and C.B Maia1. 2020. Experimental analysis of corn drying in a sustainable solar dryer. *J. Advance. Res. Fluid Mechanics and Thermal Sci.* 67(2):1-12.

Hodges, R.J., J.C. Buzby and B. Bennett. 2011. Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *J. Agricul. Sci.* 149:37–45.

Hossain, M.A., M.S. Hassan, M.S. Islam, M.A. Hossain and M. Rahman. 2012. Development and performance evaluation of hybrid dryer for quality grain seeds. *Int. J. Energy Machinery*. 5(1):42-52.

IRRI. 2013. International Rice Research Institute, Paddy Drying, Postharvest Unit, CESD, IRRI, V2. Accessed from www.knowledgebank.irri.org/images/docs/training-manual-paddy-drying.pdf

Shenoy, S.N., T.R. Paris and B. Duff. 1988. Farm level harvest and post-harvest seed management practices of farm women in an irrigated rice system: a case study: Paper presented at "Women in Rice Farming System Network Orientation and Planning Workshop", held at the International Rice Research Institute, Los Banos, Laguna, Philippines.

USDA. 2021. Production, Supply, and Distribution. Foreign Agricultural Service. United States Department of Agriculture. Internet site Retrieved from: https://apps.fas.usda.gov/psd-online/app/index.html#/app/advQuery.

Bangladesh J. Agri. 2022, 47(1):16-26 *DOI: https://doi.org/10.3329/bjagri.v47i1.60590*

PHYTOCHEMICAL CHARACTERISTICS AND ANTIOXIDANT POTENTIAL OF LITCHI SEEDS

M. N. Aktar[1], M. M. Islam[1], M. S. Raza[1], B. S. Azhar[1], Z. R. Moni[2] M. M. Rahman[3], A. T. M. M. Rahman[1] and M. A. K. Tang[1*]

[1]Deptartment of Applied Nutrition and Food Technology, Islamic University (IU), Kushtia; [2]Nutrition Unit, Bangladesh Agricultural Research Council (BARC); [3]Nutrition Unit, PBRG sub-project, BARC, Dhaka. Bangladesh

Abstract

Phytochemicals act against free radicals and are formed in human body continuously and damage body cells, causing many diseases like cellular damage, cancer, etc. Plant and their different parts are the main sources of phytochemicals. Litchi (*Litchi chinensis* Sonn.*)* is one of the most popular fruits of which only flesh is consumed by humans and the rest of the parts especially seeds are discarded. This study has been carried out to detect antioxidant potential in various extracts (aqueous and ethanol) of Bombay litchi variety seeds and to discover the contextual connection of phytochemicals as antioxidant activities. The collected seeds were washed, dried in sunlight, and finally ground to fine powder to a uniform particle size for extraction and isolation of phytochemicals. The qualitative and quantitative phytochemical analysis and antioxidant activities were determined using standard methods. Phytochemical screening reveals that most of the phytochemicals were extracted from litchi seed in ethanol. TPC and TFCs of ethanol extract were 19.86 and 20.60 mg/g, respectively. The antioxidant activity was estimated by DPPH assay method from litchi seed extracts, and IC_{50} of the seed phytochemicals and ascorbic acid was observed to be 274 and 240 µg/ml, respectively. On the other hand, free radical scavenging activities of seed phytochemicals were determined with ABTS assay; IC_{50} of seed phytochemicals and ascorbic acid was noted as 31 and 29 µg/ml, respectively. Results suggested that the litchi seed is one of the richest sources of phytochemicals that can be used as a source of bioactive compounds. It is concluded that bioactive litchi seed phytochemicals can be used as herbal medicine defense against aging, oxidative stress, cell damage as well as cancer.

Keywords: Antioxidant, Free radicals, *Litchi chinensis* Sonn, Phytochemicals

Introduction

Phytochemicals are plant-based biologically active natural substances that have the antioxidant and medicinal activity to provide health benefits for humans (Hasler and Blumberg, 1999; Zhao *et al*., 2015). In general, phytochemicals protect plants from environmental stresses, diseases, and contribute to the plant's color and flavor (Koche *et*

* Corresponding author: makashemsa@gmail.com

al., 2016). Different parts of a plant such as a leaf, bark, fruits, seeds, etc. produce a large number of bioactive compounds that protect from free radical damage thus known as natural antioxidants and act against aging (Hasler and Blumberg, 1999; Zhao *et al*., 2015). Oxidative stress caused by free radicals is associated with the development of numerous diseases such as cardiovascular, neurodegenerative, autoimmune diseases, cancers, etc. (Valko *et al.*, 2006). Medicinal plants contain various phytochemicals that have high antioxidant activities. Consequently, current research on naturally occurring bioactive compounds especially from plant sources has a great concern for lessening oxidative stress that causes free radicals randomly formed in our body. Natural antioxidants have no side effects. Antioxidants reduce oxidative damage by delaying or inhibiting the production of reactive oxygen species or reactive nitrogen species and ultimately reduce or inhibit the complications such as cancer (Koche *et al.*, 2016). In the last few decades, phytochemicals have received much more attention because of their antioxidants and medicinal properties (Zhang *et al.*, 2015; Altemimi *et al.*, 2017; Forni *et al.*, 2019).

Litchi (*Litchi chinensis* Sonn.*)* is one of the most delicious and popular common fruits in Southeast Asia and fresh fruit are rich in Vitamin C. Only the flesh of the litchi fruitis consumable and the rest of the parts, especially seeds are discarded. However, litchi seeds are rich in protein, carbohydrates, vitamins, minerals, and seed extract have a role in the prevention of fatty liver and are widely used in relieve neuralgic pain (Wang *et al.*, 2011; Shukla *et al.*, 2013; Sonia *et al.*, 2017). The seed extract is also used to reduce or control inflammation, allergy, diabetic, hyperlipidemia, pyretic, obesity, cardiovascular problem, viral infection, and different type of cancer, etc. (Xiao *et al.*, 2004; Wang *et al.*, 2006; Ibrahim *et al.*, 2015). However, as far as we know, there is no research work done on phytochemicals and their role in litchi seeds cultivated in Bangladesh. So, litchi seed can open a new window in food safety and the field of functional food or nutraceuticals. This study aims to detect antioxidant potential in various extracts (aqueous and ethanol) of Bombay litchi variety seeds collected from Rajshahi, Bangladesh and to discover the contextual connections of phytochemicals as antioxidant activities.

Materials and Methods

Preparation of sample

Litchi fruits (Bombay variety) were collected from Shaheb Bazar, Rajshahi, Bangladesh in the last week of May, 2019. About one kg seeds were collected, washed, dried in sunlight, and finally ground to fine powdered to uniform particle size and stored in an airtight container for extraction and isolation of phytochemicals. All chemicals used in this study were of analytical grade.

Seed extract preparation

The seed powder (1 g/20 mL) was soaked in extracting media (water and 30% ethanol) at 4°C for 72 hours with occasional shaking. The samples were filtered with muslin cloth and finally with Whatman 42 filter paper and collected supernatant one. The precipitate one was (about 1 g/10 mL) soaked again in extracting media at 4ºC for one hour for extraction of rest of the part of phytochemicals; filtered and collected the supernatant. All the supernatant were collected and evaporated at 90-100ºC still dried (Zhang *et al.,* 2018; Chunli *et al*., 2015). The residues were collected and used for qualitative and quantitative investigation of phytochemicals.

Qualitative analysis of phytochemicals

The different phytochemicals were qualitatively studied by using the following methods (Eke *et al.,* 2014).

Alkaloids test

The alkaloids were identified by Meyer's reagent. The extract residues (0.1 g) were defatted with 5% ethyl ether for 15 min and followed for 20 min in 5 mL of 1 N HCl on steam. After centrifugation of the sample, one or two drops of Meyer's reagent were added and the result was recorded.

Tannins test

The presence of tannins was analyzed by adding a few drops of 5% $FeCl_3$ solution in a test sample (0.1 g of dried sample per 2 mL distilled water) and the result was noted.

Flavonoids test

The dried powder was dissolved in 10% ethanol (0.1 g/1 mL) and then 1 mL sample was mixed in 5 mL diluted ammonia and followed by a few drops of concentrated H_2SO_4 for qualitative analysis of flavonoids. The effect was recorded.

Saponins test

To analyze the saponins compound, add a drop of 1 N sodium bicarbonate solution in 2 mL (0.1 g of dried sample in 2 mL distilled water) solution then shaken vigorously, left for 3 minutes and finally the result was documented.

Terpenoids test

The terpenoids were qualitatively analyzed by the addition of 2 mg of dry powder in acetic anhydride solution in a test tube, cooled, and added 1 mL of conc. H_2SO_4. The outcome was noted.

Steroids test

For steroids analyses, 2 mL solution (0.1 g of dried powder in 2 mL distilled water) was added in chloroform (2 mL) and added 3-4 drop of conc. H_2SO_4, mixed well. The result was noted. The presence of resins was determined by dissolving 0.1 g of dried extract in acetone, the solution was poured in distilled water and the result was recorded.

Total phenolic content (TPC) estimation

The TPC was measured by FCR (Folin-Ciocalteu's Reagent) method using a spectrophotometer (Kaur and Kapoor, 2002). Dried powder (0.05 mg/mL in ethanol) was used in the determination of TPC. The reaction mixture was made by mixing 0.5 mL of sample with 2.5 mL diluted FCR (10 times diluted), and 2.5 mL of 7.5% $NaHCO_3$. Blank was concomitantly prepared, containing 0.5 mL ethanol, 2.5 mL of diluted FCR and 2.5 mL of 7.5% of $NaHCO_3$. After 25min, the absorbance was recorded at 760nm. All the experiment was done at least in triplicate and the mean value was documented. The calibration curve was prepared by the different concentrations of gallic acid (GA) (Fig. 1) as standard agent. The TPC was expressed in terms of GA equivalent.

Measurement of flavonoids

The flavonoids are expressed as flavones and flavonols. The total flavonoid contents (TFC) was calculated from the crude extract of litchi seeds by using a colorimetric described by Chang *et al.*, 2002. The dried powder was dissolved in ethanol and made up 0.05 mg/mL. One mL sample was mixed in 0.5 mL of 5% $NaNO_2$ and 0.5 mL of 10% $AlCl_3$ and incubated for 10 min. After incubation, 2 mL of 1 M NaOH was mixed. After 15 min, the absorbance was taken at 510 nm. The calibration curve was made by the different concentrations of Catechin as a standard substance (Fig. 2). TFC was calculated and expressed in µg/mL.

Determination of total antioxidant activity (TAA)

TAA was measured by the FRS method of DPPH (1,1-diphenyl-2-picrylhydrazyl); described by Prieto *et al.*, 1999 and Mensor *et al*., 2001 with a little modification by Re *et al.*, 1999 called $ABTS^+$ (2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) method. In this method, 0.1 mM of DPPH in ethanol and the 1.0 g of dried litchi powder was mixed, centrifuged and the clear solution was used in this experiment. 5 mL of sample at different concentrations was taken in different test tubes and added 3 mL of 0.1 mM DPPH in each tube. Control was made without sample. The absorbance was recorded at 517 nm after 30 min and converted into the percentage of antioxidant inhibition activity of DPPH using the following equation:

$$\text{Inhibition (\%)} = (A_0\text{-}A_1)/A_0 \times 100$$

(Where, A_0 was the abs. of the control, A_1 was the Abs. of the sample or ascorbic acid)

Ascorbic acid was used as standard and TAA of sample that was compared to antioxidant activity of ascorbic acid. The results were also expressed as µg sample/mL. The IC_{50} value means 50% of the free radical was inhibited of DPPH by ascorbic acid or the sample.

The antioxidant activity of litchi seed was measured by $ABTS^+$ method. 7 mM ABTS and 2.45 mM potassium persulfate (1:1) was mixed and stored at dark room to oxidative stable form for 12-16 h to form free radicals and used as a stock solution. Three mL of stock solution was mixed in 1 mL of ascorbic acid or sample at different concentrations; stand for 6 min and the absorbance was recorded at 735nm. Ethanol and ascorbic acid was used blank and standard, respectively. Antioxidant activity was expressed as-

$$\text{Inhibition (\%)} = (A_0\text{-}A_1)/A_0\times 100$$

(Where, A_0 is the abs. of ethanol and A_1 is the abs. of sample or ascorbic acid)

The results were also expressed as µg sample/mL and IC_{50} means that the amount of ascorbic acid or sample to inhibit 50% free radicals activity that calculated by the calibration curve. All the experiment was done at least triplicate and average result was used for data analysis.

Statistical analysis

The results were presented as standard deviation as mean ± standard error (SE) of triplicate measurements.

Results and Discussion

Qualitative analysis of phytochemical

The qualitative analysis or screenings of phytochemicals of litchi seeds of alcoholic and aqueous extract are summarized in Table 1. The phytochemicals screening pointed out that most of the phytochemicals were present in the litchi seed extract in 30% ethanol. Most of the phytochemicals like alkaloids, flavonoids, terpenoids, steroids, tannins, and resins were extracted in ethanol whereas; terpenoids, steroids, and tannins were extracted in aqueous media. Only saponin was not present in ethanolic extract (Table 1). Therefore, it can be suggested that ethanol is a suitable extracting media for the extraction of phytochemicals from the litchi seed. A similar result was published by Eke *et al.*, 2014.

Table 1. Phytochemical evaluation of alcoholic and aqueous extract

S/N	Phytochemicals	Observation	Ethanol extract	Aqueous extract
1.	Alkaloids	A turbid ppt was observed	+ve	-ve
2.	Flavonoids	A brown ring was formed	+ve	-ve
3.	Terpenoids	Pink color was formed	+ve	+ve
4.	Steroids	Red color was observed	+ve	+ve
5.	Tannins	Blue-black ppt was formed	+ve	+ve
6.	Saponins	No change	-ve	-ve
7.	Resins	Turbid was formed	+ve	-ve

Quantitative analysis of phytochemical

In this work, quantitative phytochemicals content was determined from the litchi seed extract in 30% ethanol and water. The ethanol extract contained 6.18% phytochemicals in seed powder extract whereas; the water extract contained 5.84% (Table 2). The raw seeds contained 3.09% and 2.92% phytochemicals in ethanol and

water extract, respectively because 50% weight was decreased when fresh litchi seeds were dried into a powder. Alcohol was the suitable extracting media of phytochemicals from the litchi seed. The similar result was reported by Shukla *et al.*, 2013; Eke *et al.*, 2014; Iqbal *et al.*,2019; Rosales *et al.*, 2019. So, the rest of the studies were done by using 30% ethanol extract residues.

Table 2. Phytochemicals content of litchi seeds by different extracting media

Extracting media	Weight of seed (g)	Weight of powder (g)	Yield/Dried wt. (g)	Yield in dried (%)
Ethanol	20	10	0.618±0.026	6.18
Water	20	10	0.584±0.031	5.84

Total phenolic content

The phytochemical substances of litchi seeds were measured in terms of TPC and TFC. As, it has been accepted that these compounds are present in natural plant and plant products; serves as a potent antioxidant and stabilize or neutralize the free radicals which are responsible for oxidative damage. TPC was measured by using a calibration curve made by different concentration of gallic acid as standard substance (Fig. 1) and phenolic substance was measured from the litchi seed extract. The TPC was calculated as 19.86 mg/g of dried litchi seed and 9.98 mg/g of fresh litchi seed (Table 3).

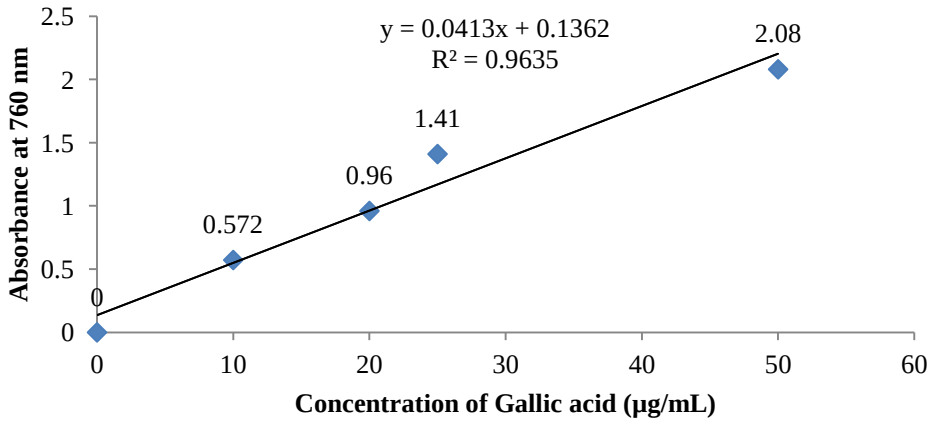

Fig. 1. Standard curve of Gallic acid

Total flavonoids content

The Flavonoids component was measured 20.6 mg/g of dried litchi seed powder and 10.3 mg/g of fresh litchi seed (Table 3). TFC content was measured using a calibration curve made by different concentration of Catechin as standard substance (Fig. 2).

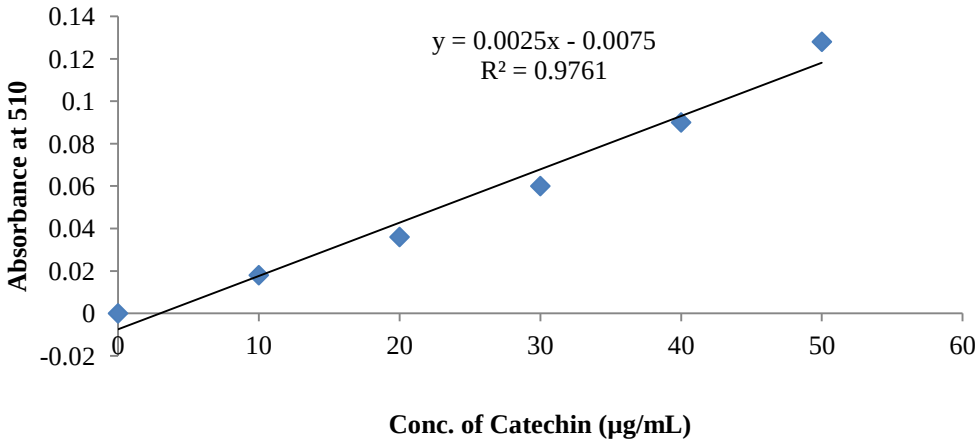

Fig. 2. Standard curve of Catechin

Table 3. Total phenolic and flavonoid content of litchi seed

Phytochemicals	Amount in dried powder (mg/g)	Amount in fresh litchi seed (mg/g)
TPC	19.86±1.90	9.98±0.98
TFC	20.60±2.17	10.32±1.04

Antioxidant activity

The antioxidant activities of different concentrations of seed extract and standard ascorbic acid was exhibited in a dose dependent manner of free radical scavenging assay. The litchi seed phytochemicals exhibited significant antioxidant activity and the activity of litchi seed phytochemicals were compared with standard ascorbic acid (Table 4). The result was shown in Table 5 that showed litchi seed phytochemicals exhibited almost same effectiveness to ascorbic acid. The IC_{50} value of litchi seed phytochemicals and ascorbic acid were also calculated and the value of litchi seed phytochemicals and ascorbic acid was 274.92 and 240.42 µg/mL, respectively (Table 6). The scavenging activity of litchi seed phytochemicals was increased with increasing concentration and the IC_{50} value of litchi seed phytochemicals and ascorbic acid were 31.44 and 29.33 µg/mL, respectively (Table 6).

Discussion

The phytochemicals investigation in this study revealed that alkaloids, flavonoids, terpenoids, steroids, tannins, and resins were existent in litchi seed (Table 1) which is supported by the previous studies cited by Eke *et al.*, 2014. The litchi seed is one of the richest sources of phytochemicals (6% in dried seed) and maximum phytochemicals

Table 4. Free radical of DPPH was inhibited by the antioxidant activity of litchi seed phytochemicals and ascorbic acid

Conc. of antioxidant (µg/mL)	Inhibition by phytochemicals (%)	Inhibition by ascorbic acid (%)
Blank	0	0
100	15	22
200	36	44
300	54	71
400	82	92
500	94	95

Table 5. Free radical of $ABTS^{+}$ was inhibited by antioxidant compound of litchi seed and ascorbic acid

Conc. of antioxidant (µg/mL)	Inhibition by phytochemicals (%)	Inhibition by ascorbic acid (%)
Blank	0	0
10	24	26
20	39	41
40	61	66
60	73	78
80	86	91

Table 6. The anti-oxidant capacity of litchi seed phytochemicals and ascorbic acid in terms of IC_{50}

Antioxidant assay method	IC_{50} of ascorbic acid (µg/mL)	IC_{50} of seed phytochemicals (µg/mL)
DPPH assay	240.42±2.70	274.92±2.40
ABTS assay	29.33±2.90	31.44±3.10

were extracted in ethanol (Table 2). The result is supported by Shukla *et al*., 2013 and Rosales *et al*., 2019. The TPC and TFC were determined at 1.98% and 2%, respectively from the dried litchi seed (Table 3). The results showed that litchi seeds are the richest sources of bioactive compounds such as TPC, TFC, etc. compare to the other sources of Iqbal *et al.,* 2019 and Rosales *et al.,* 2019 and related results were also described by Shukla *et al*., 2013. Phenolic compounds are broadly distributed in plant tissues, mainly contributing color and flavor of flowers, fruits or seeds.

The concentration of phenolic compounds may range from 0.5 to 5.0 g/100g dry weight of plant tissues (Swanson, 2003). The present results indicated that the litchi seeds

are the richest sources of phytochemicals. The phytochemicals contain many phenolic groups. The phenolic group/ring of phytochemicals is associated with antioxidant abilities. Not only do they exhibit antioxidant activity, but they are also in volved to reduce many diseases and play a fruitful role in human health (Minatel *et al.*, 2017). The free radical scavenging activity of phytochemicals is recognized as the capacity of neutralized free radicals, donating a proton, capturing electrons, or detoxification of heavy metal ions (Bendary *et al.*, 2013).

The antioxidant activity of litchi seed phytochemicals is summarized in Table 4-6. The IC_{50} value of litchi seed phytochemicals was 274 and 31µg/mL for DPPH and ABTS scavenging methods, respectively; however, for ascorbic acid that was 240 and 29 µg/mL, respectively. The results indicated that litchi seed phytochemicals showed strong antioxidant activity capacity in both antioxidant scavenging methods (Table 4-6). The results revealed that the phytochemicals of litchi seed act as a strong antioxidant identical to ascorbic acid (Table 6). Paliga *et al*., 2017 and Shukla *et al.*, 2013 reported the antioxidant activity of litchi seed phytochemicals higher than 78.36%. Ibrahim and Mohamed, (2015) reviewed the chemical constituents and pharmacological activities of litchi seed, listing the single constituents known over the past few decades. It is well evident that the litchi seed is one of the richest sources of phytochemicals, and these phytochemicals are used as strong antioxidants. Free radicals are unavoidably formed in life naturally and captured or remove hydrogen or proton, creating oxidative damage; as a result different types disorders degenerate. Three main steps initiation, propagation, and termination are mediated by free radicals in our body. The antioxidant substances fight against free radicals and protect our bodies from serious diseases. The main sources of these antioxidants are plants. Human beings consume antioxidants through diet and fight against free radicals. Several phytochemicals possessing polyphenolic structures have been advocated as nutraceuticals and used as food supplements for better healthcare in recent years (Halliwell, 1996). Flavonoids consist of many indispensable substances which have a great beneficial effect on health and are used as nutraceuticals. The components are also used for pharmaceutical, medicinal and cosmetic purposes (Halliwell, 1996). From our study, it is revealed that the litchi seed is one of the richest sources of phytochemicals that act as antioxidants and can play a great role against different diseases and disorders in the body.

Conclusion

L. chinensis is one of the most delicious and popular common fruits in various countries of world not only due to its juicy arils and nutritional benefits but also for pharmacological activities against various ailments. Only flesh of the litchi fruit is consumable and the rest of the parts, especially seeds are discarded. The phytochemical constituents present in seeds of *L. chinensis* illustrated that the seeds may be advocated as nutraceuticals as food supplements for better healthcare, or used both in a pharmaceutical

and dietary supplement for human being as well as animals. As a result, the wastage or discarded one can be used to economical one.

Conflicts of Interest

We have no conflicts of interest.

Acknowledgment

We are grateful to the Ministry of Science and Technology of Bangladesh and Islamic University, Kushtia, Bangladesh for funding in order to carry out this project. We are also grateful to Dr. Nur-Es-Saba Homyra, a plant taxonomist and lecturer of the Department of Botany, Kushtia Government College, Bangladesh for the identification and authentication of the litchi fruits.

References

Altemimi A, N Lakhssassi, A Baharlouei, DG Watson and DA Lightfoot. 2017. Phytochemicals: extraction, isolation and identification of bioactive compounds from plant extracts. *Plants.* 6(4):1-23.

Bendary E, RR Francis, HMG Ali, MI Sarwat and SEI Hady. 2013. Antioxidant and structure–activity relationships (SARs) of some phenolic and anilines compounds. *Annals of Agricul. Sci*. 58(2):173-181.

Chang C, M Yang, H Wen and J Chern. 2002. Estimation of total flavonoid content in propolis by two complementary colorimetric methods. *J. Food DrugAnal.*10:178–182.

Chunli S, Z Wu, Z Wang and H Zhang. 2015. Effect of ethanol/water solvents on phenolic profiles and antioxidant properties of Beijing propolis extracts. *Evidence-Based Complementary and Alt. Medicine*. 2015:1-9.

Eke ON, AU Augustine and HF Ibrahim. 2014. Qualitative analysis of phytochemicals and antibacterial screening of extracts of *Carica papaya* fruits and seeds. *Int. J. Modern Chem.* 6(1):48-56.

Forni C, F Facchiano, M Bartoli, S Pieretti and JF Wei. 2019. Beneficial role of phytochemicals on oxidative stress and age-related diseases. *Bio. Med. Res. Int*. (4):1-16.

Halliwell B. 1996. Oxidative stress, nutrition and health. Experimental strategies for optimization of nutritional antioxidant intake in humans. *Free Rad Res.* 25(1):57–74.

Hasler CM and JB Blumberg. 1999. Phytochemicals: biochemistry and Physiology. *J. Nutr.* 129: 756-757.

Ibrahim SRM and GA Mohamed. 2015. *Litchi chinensis*: medicinal uses, Phytochemistry and pharmacology, *J Ethnopharmacol.*174:492-513.

Iqbal Z, M Javed, G Rafique and T Saleem. 2019. A Comparative study of total phenolic contents and antioxidant potential of seeds of Peganumharmala. *Int. J. of Biosci.* 14(3):121-127.

Kaur C and HC Kapoor. 2002. Anti-oxidant activity and total phenolic content of some Asian vegetables. *Int. J. Food Sci. Technol.* 37:153–161.

Koche D, R Shirsat and M Kawale. 2016. An overview of major classes of phytochemicals: their types and role in disease prevention. *Hislopia J.* 9:1-11.

Mensor LL, FS Menezes, GG Leitao, AS Reis, TC Dos Santos, CS Coubel and SG Leitao. 2001. Screening of Brazilian plant extracts for antioxidant activity by the use of DPPH free radical method. *Phytother Res.* 15:127–130.

Minatel IO, CV Borges, MI Ferreira, HA Gomez, CYO Chen and GPP Lima. 2017. Phenolic compounds: functional properties, impact of processing and bioavailability (Phenolic compounds-biological activity) In. Tech. Publisher. pp.1-24. DOI: 10.5772/66368

Paliga MZ, RM Novello, J Dallago, JD Scapinello, MD Magro, MVL Tres and JV Oliveira. 2017. Extraction, chemical characterization and antioxidant activity of *Litchi chinensis* Sonn. and *Avena* sativa L. seeds extracts obtained from pressurized n-butane. *J. Food Sci. Technol.* 54(3):846–851.

Prieto P, M Pineda and M Aguilar. 1999. Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdinum complex: specific application to the determination of Vitamin E. *Anal. Biochem.* 269:337-341.

Re R, N Pellegrini, A Proteggente, M Yang and C Rice-Evans. 1999. Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Rad Biol Med.* **26**: 1231–1238.

Rosales MP, RE Jiménez, MOA Ramos, BMT Hernández, OF García, CMP Salgado and CMS López. 2019. Phenolic compounds in the pulp, pericarp and seed of Litchi (*Litchi chinensis* Sonn.) in different stages of maturation. *Nutri. Food Sci. Int. J*. 8(3):1-8.

Shukla RK, D Painuly, A Porval and A Shukla. 2013. Proximate analysis, nutritive value, total phenolic content and antioxidant activity of *Litchi chinensis* Sonn. *Natural Products.* 9(1): 7-15.

Sonia E, M Lauricella, G Calvaruso, AD Anneo and M Giuliano. 2017. *Litchi chinensis* as a functional food and a source of antitumor compounds: An overview and a description of biochemical pathways. *Nutrients.* **9(9)**: 992.

Swanson BG. 2003. Tannins and phytochemicals. Encyclopedia of food sciences and nutrition, 2nd ed. Academic Press. Pp. 5729- 5733.

Valko M, CJ Rhodes, J Moncol, M Izakovic and M Mazur. 2006. Free radicals, metals and antioxidants in oxidative stress-induced cancer. *Chem. Biol. Interact*. 160:1-40.

Wang L, G Lou, Z Ma and X Liu. 2011. Chemical constituents with antioxidant activities from litchi (*Litchi chinensis* Sonn.) seeds. *Food Chemis.* 126(3):1081-1087.

Wang X, Y Wei, S Yuan, G Liu, Y Lu, J Zhang and W Wang. 2006. Potential anticancer activity of litchi fruit pericarp extract against hepatocellular carcinoma in vitro and in vivo. *Cancer letters***.** 239(1):144-150.

Xiao LY, D Zhang, Z Feng, Y Chen, H Zhang and P Lin. 2004. Studies on the antitumo r effects of lychee seeds in mice. *J. Chin. Med. Mater*. 27:517–518.

Zhang YJ, RY Gan, S Li, Y Zhou and HB Li. 2015. Antioxidant phytochemicals for the prevention and treatment of chronic diseases. *Molecules.* 20(12):21138-21156.

Zhang OW, LG Lin and WC Ye. 2018. Techniques for extraction and isolation of natural products: a comprehensive review. *Chin. Med.* 13:20.

Zhao Y, Y Wu and M Wang. 2015. Bioactive substances of plant origin. Handbook of food chemistry. Springer, Berlin, Heidelberg pp 967- 1008.

Bangladesh J. Agri. 2022, 47(1):27-38 *DOI: https://doi.org/10.3329/bjagri.v47i1.60591*

EFFECTS OF TILLAGE, MULCH AND IRRIGATION ON MAIZE (*Zea mays* L.) YIELD IN DROUGHT PRONE AREA

M. S. Islam[1], M. K. Alam[2*], N. Salahin[1], M. J. Alam[1], M. A. M. Hussen[2] and A. T. M. A. I. Mondol[1]

[1]Bangladesh Agricultural Research Institute (BARI), Gazipur; [2]Bangladesh Agricultural Research Council (BARC), Dhaka. Bangladesh

Abstract

The experiment was conducted to study the effect of tillage, mulch and irrigation on soil moisture, yield and yield attributes of hybrid maize (var. BARI Hybrid Maize-6). Two tillage practices (minimum tillage and conventional tillage), two levels of mulches (no mulch and rice straw mulch @ 3 t ha^{-1}) and three irrigation frequencies (one irrigation at 32 days after sowing (DAS), two irrigations at 32 and 55 DAS and three irrigations at 32, 55 and 85 DAS were used as treatment variables. Twelve treatment combinations were assigned in a split-split plot design with three replications. Minimum tillage and mulch conserved more moisture than conventional tillage with no mulch in both years. Minimum tillage and mulch (rice straw) as well as irrigation at 32, 55 and 85 DAS gave higher grain yield than conventional tillage with no mulch and any level of irrigation. Results revealed that application of straw mulch along with three irrigations and any kind of tillage practice might be a suitable combination for obtaining higher yield of maize in drought prone area.

Keywords: Drought, Maize yield, Minimum tillage, Straw mulch

Introduction

Maize, the third most important cereal crop after rice and wheat in Bangladesh, is being grown mostly in the rabi season all over Bangladesh. The present momentum is revolutionary due by far but not limited to high yield potential and extent of diversified usage *viz.* ever-expanding poultry feed market, important ingredients of cattle feed and fish feed, mixing with wheat flour for making bread and many others. With the advancement of time, the production area reached at 202,000 ha in 2009-2010 (BBS, 2014) where it was 10,000 ha in 1995, 137,000 ha in 2005-2006 (Hasan *et al.*, 2007) and the production was approximately 2.5 million tons in 2009-2010 (BBS, 2014). Maize production in Bangladesh increased significantly from 1,954,000 in 2011 to 4,700,000 t in 2020 rising at an increasing annual rate (a maximum of 17.1% in 2019 which then decreased to 14.6% in 2020) (BBS, 2021). The yield is now stagnated at around 6.5 t ha^{-1} (BBS, 2016 and AIS, 2014) in the ecologically unfavourable areas but the average yield was targeted by the government at 8.5 t ha^{-1} by 2030. Nevertheless, in the year 2015-2016, the production of maize could meet only around 65% of the national maize demand for poultry and other feeds.

* Corresponding author: khairul.alam@barc.gov.bd

The traditional cropping system of the Chapainawabganj area has been T. Aman rice grown in the Kharif-II season (June/July-Oct/Nov) followed by fallow. Now rice-based intensive cropping systems are followed in this area. However, most of the area remains fallow during moisture deficiency periods due to deficiency of soil moisture for unavailability of groundwater and attenuated recharging of groundwater. Though coverage of irrigation and rain-fed rabi cropping have been increased, around 40-50 % of the HBT keeps on fallow after the harvest of T. Aman rice (BBS, 2016). Accordingly, maize crop in rice–maize systems in South Asia and Bangladesh is put forward to grow in the fallow period rather than rice-rice system because of increased yield, profit potential and efficient water use (Gathala *et al.,* 2013). The repeated current practice of growing transplanted rice through puddling and maize with conventional tillage degrades soil structure, delays maize sowing and reduces its yield potential, increases energy and labour requirements, ultimately leading to high production costs. Conservation agriculture (CA)-based tillage and crop establishment options may hold the potential to overcome such problems (Gathala *et al.,* 2013; Alam, 2018; Bell *et al.,* 2019). The development of conservation tillage practices for dry land (drought-prone) crop production has been and will be a dynamic process. Conservation agriculture can increase infiltration and reduce runoff and evaporation compared to conventional tillage and zero tillage with mulching and irrigation (Salahin, 2017; Islam, 2016). Mulching conserves soil water in a season with long periods without rain. Consequently, more soil water is conserved enabling crops to grow during short-term dry periods (Alam *et al*., 2014). Tillage and residue mulching management may significantly affect crop yields during years of poor rainfall distribution (Johnston and Hoyt, 1999).

The northwestern districts namely Rajshahi, Dinajpur, Rangpur, Bogura and Pabna are particularly drought-prone and receive only 127 mm of rainfall annually (Gathala *et al.,* 2013). About 5.73 m ha of the problem soils of Bangladesh is subjected to moderate and/or severe drought (Khan *et al.,* 2008). The impact of drought spreads disproportionately amongst different regions of Bangladesh. This is an expensive operation that cannot be deployed regularly in dry land farming. Mulch ameliorated the hydrothermal regime of the soil, improved the vegetative and flowering performance and significantly increased the fruit yield over bare ground (Agele *et al.,* 2000). No-till without or with little mulch is not a sustainable practice. Almost all environmental benefits of minimum tillage are due to the mulch cover at the soil surface. Minimum tillage should out-yield tilled crops in areas where drought stress is a problem due to the water conserved by the mulch cover (Agronomy Guide, 2007-2008). To cope with the challenge to feed the large population of Bangladesh, the extent of drought-prone areas and their according importance must add new momentum to the planning in getting food-self-sufficiency. Therefore, this study was undertaken to develop an appropriate tillage method, mulching and irrigation frequency for retention of soil moisture and productivity of maize in drought prone areas.

Materials and Methods

The experiment was conducted at Horticulture Centre, Chapainawabganj under Soil Science Division, BARI, during rabi season of 2011-2012 and 2012-2013. The

geographical position of the experimental site was 24º35" N latitude and 88º16" E longitude. The site belongs to Agroecological Zone -11 having Calcareous Dark Grey Floodplain soils with some Calcareous Brown Floodplain soils under sub-group Typic Haplaquepts and the order Inceptisols. The climate is generally marked by high temperature (6.2°C in January to 42.9°C in June), considerable humidity and moderate rainfall (137 ± 323 mm). The hot season commences early in March and continues till the late of July. The maximum and minimum temperature during the crop growing period was 6.2 °C in January and 40.5°C in May in 2011-2012 and 6.5°C in January and 41.2°C in May in 2012-2013. The crop received 261.5 mm and 255.3 mm of total rainfall during the crop season of 2011-2012 and 2012-2013, respectively. Most of the rainfall received during the growing seasons occurred in May (harvesting time) (Alam, 2018). The detailed information about the physico-chemical characteristics of soils studied is presented in Tables 1a and 1b.

Soil moisture, bulk density and particle density were determined by the gravimetric method, core sampler and pycnometer method (Karim *et al.*, 1988). Soil pH (1: 2.5, soil: water) was measured using a glass electrode pH meter (Ghosh, 1983); available P and organic C were measured by Olsen and wet oxidation method according to Jackson, (1973). Total N, available S, and Ca were determined by micro-Kjeldahl method, turbid metric method and complex metric method, respectively (Page *et al.*, 1989). Exchangeable K and Mg were measured using NH_4OAC extraction method and particle size distribution was determined according to Black, (1965). Available Zn, Cu, Fe and Mn were determined by using diethylene triamine pentaacetic acid (DTPA) extraction method (Lindsay and Norvell, 1978). Soil field capacity was measured using pressure plate apparatus.

Twelve treatment combinations comprised two tillage practices *viz.* minimum tillage (a furrow was made by furrow opener), conventional tillage (tillage was done by three passes of a power tiller); two levels of mulching viz. no mulch and rice straw mulch @ 5 t ha^{-1} and three irrigation frequencies viz. one irrigation at 32 days after sowing (DAS), two irrigations at 32 and 55 DAS and three irrigations at 32, 55 and 85 DAS. The experiment was assigned in a split-split plot design with three replications where tillage practices were allocated in the main plot, mulch levels were in the sub-plot and irrigation was in the sub-sub plot. The unit plot size was 9.0 m × 6.0 m. Seeds of maize (var. BARI Hybrid Maize-6) were sown on 24 and 26 December 2011 and 2012, respectively maintaining 75 cm × 25 cm spacing. A fertilizer dose of 255 kg N, 55 kg P, 100 kg K, 40 kg S and 1 kg B ha^{-1} were applied in form of urea, triple superphosphate, muriate of potash, gypsum and borate, respectively. In addition, cowdung was applied at the rate of 5 t ha^{-1}. One-third of nitrogen and other fertilizers were applied at the time of final land preparation and the remaining nitrogen was applied in two equal splits at 30 and 55 DAS. All intercultural operations such as weeding, earthing up, fertilizer application etc. were done as and when required. The crop was harvested on 5 & 8 May 2012 and 2013, respectively. The seeds were sun-dried and weighed. Data on yield and yield contributing characters were taken. Data that were collected were subjected to analysis of variance and Duncan's Multiple Range Test (DMRT) was used for mean separation (Gomez and Gomez, 1984).

Table 1. Physico-chemical characteristics of experimental soils at Chapainawabganj

1a) Physical properties of soil

Soil depth (cm)	Bulk density (g cm^{-3})	Particle density (g cm^{-3})	Porosity (%)	Field capacity (%)	Textural class
0-15	1.45	2.54	42.91	33.42	Clay loam

1b) Chemical properties of soil

Soil depth (cm)	pH	OM	Total N	Ca	Mg	K	P	S	B	Cu	Fe	Mn	Zn
		%		meq 100 g^{-1}				µg g^{-1}					
0-15	7.2	1.32	0.063	11	2.52	0.10	12	13	0.2	1.6	58	10	2.2
Critical level				2.0	0.8	0.2	14	14	0.2	1	10	5	2

Results and Discussion

Effects of tillage on soil moisture

Tillage practices resulted in varied soil moisture on different days of sowing (Fig. 1 and 2). Conventional and minimum tillage failed to show significant differences among them in soil moisture content in any of the growing seasons. The changing of soil moisture pattern was almost similar in both the years. The highest soil moisture was observed in 2012-2013. It was observed that minimum tillage contained slightly higher moisture than conventional tillage over the years.

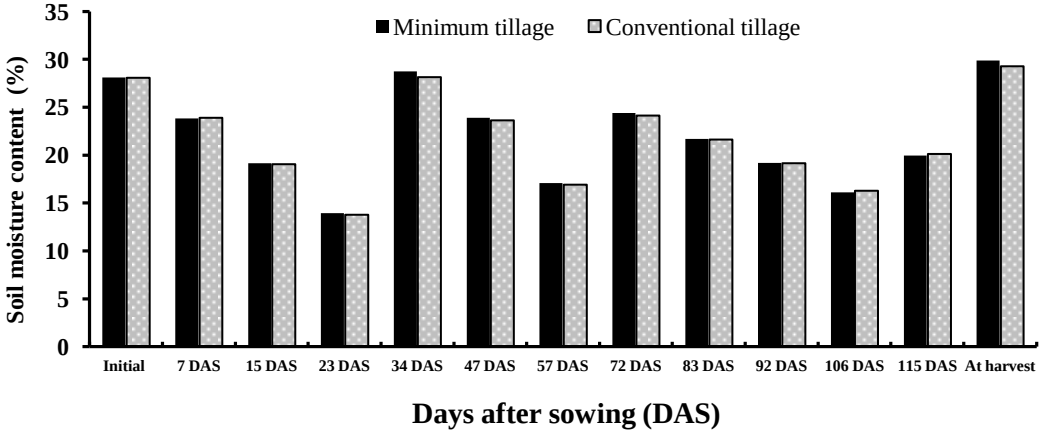

Fig. 1. Effects of tillage practices on soil moisture content at different days of sowing (2011-2012)

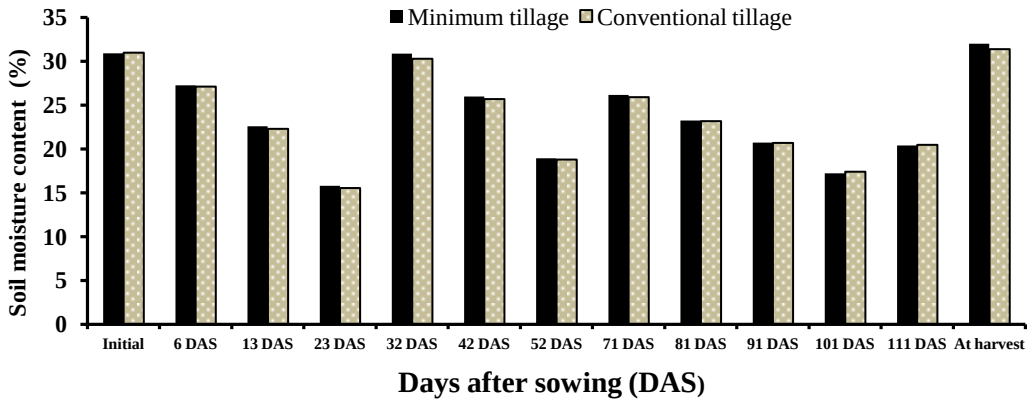

Fig. 2. Effects of tillage practices on soil moisture content at different days of sowing (2012-2013)

Effect of mulch on soil moisture

Mulching practices showed varied soil moisture retained in the soil on different days of sowing in both the years (Figs. 3 and 4). Significantly higher soil moisture retention occurred through mulching than no mulch. Fig. 3 and 4 revealed that comparatively higher soil moisture during 2012-2013 was observed than in 2011-2012. Yang *et al.* (2006) cited that the straw mulch is effective in conserving soil water and maintaining the microbial environment favorable for their activities. Mulch conserves soil moisture and prevents soil moisture from flowing back to the surface (Bu *et al.*, 2002).

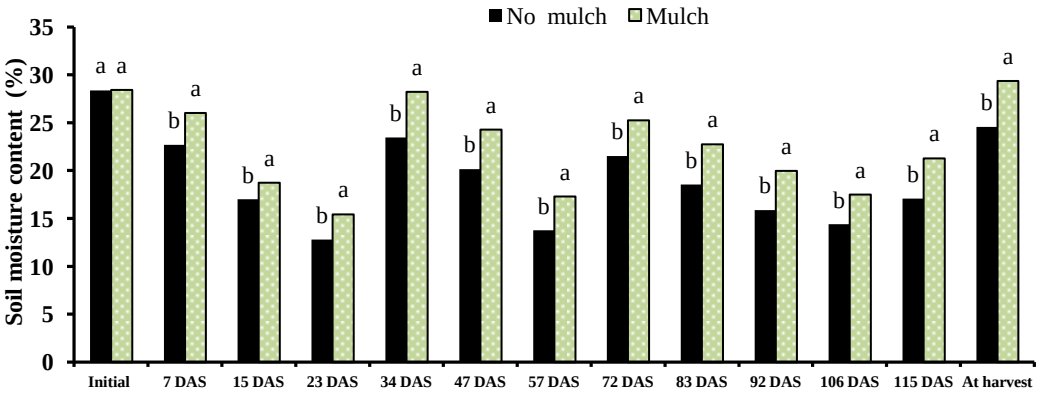

Fig. 3. Effects of mulching on soil moisture content at different days of sowing (2011-2012)

Effects of irrigation on soil moisture

Irrigation practices showed a variation in soil moisture retention over cropping seasons in both 2011-2012 and 2012-2013 (Figs. 5 and 6). From sowing up to 23 February, there was no variation in soil moisture retention due to irrigation water application but significant changing occurred among irrigation practices from 9 March to 23 April.

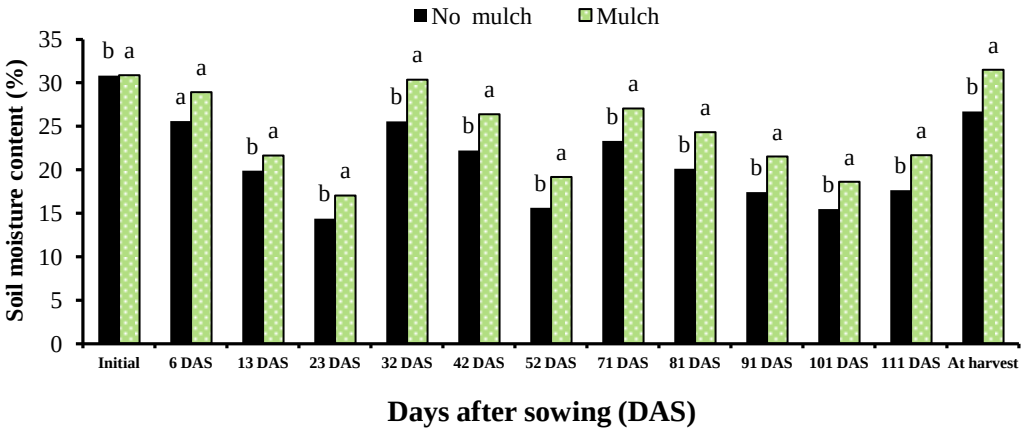

Fig. 4. Effects of mulching on soil moisture content at different days of sowing (2012-2013)

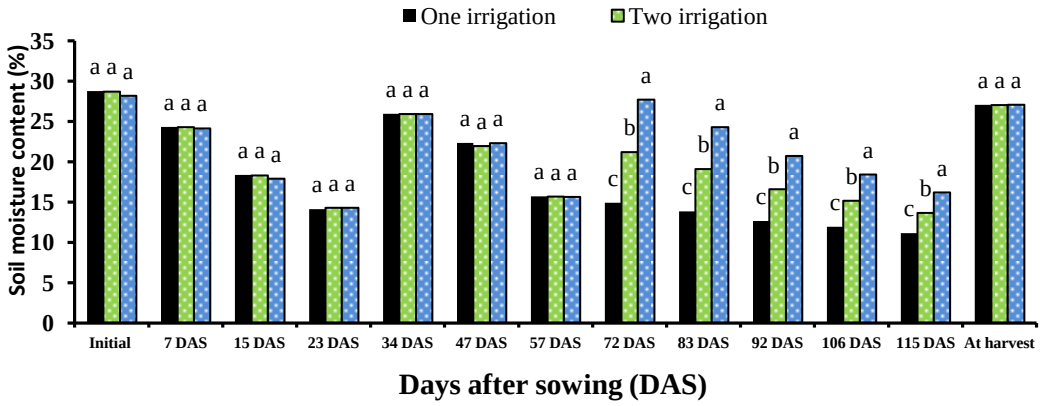

Fig. 5. Effects of irrigation on soil moisture at different days of sowing (2011-2012)

At the final date of sampling, soil moisture was similar to irrigation practices during the maize growing season in 2011-2012. As irrigation was applied on 23 February for all irrigation practices, the variation started getting visible from the date. The increase in moisture condition in three irrigation practices followed by two irrigation practices was for the increased number of irrigation applied at the different intervals while one irrigation treatment only received irrigation on 23 February (Figs. 5 and 6).

Effects of tillage practices on yield contributing characters and yield of maize

Tillage practices showed significant influence on cob length and grain yield of maize. Plant height, cob diameter and 100-seed weight were not found significant due to tillage practices (Table 2). Minimum tillage produced larger cob (15.1 cm) and higher grain yield (5.41 t ha^{-1}) than conventional tillage which produced smaller cob (14.7 cm) and lower grain yield (5.41 t ha^{-1}). The increased yield in minimum tillage can be attributed to the higher availability of nutrients with increased soil moisture status (Busari *et al.*, 2015).

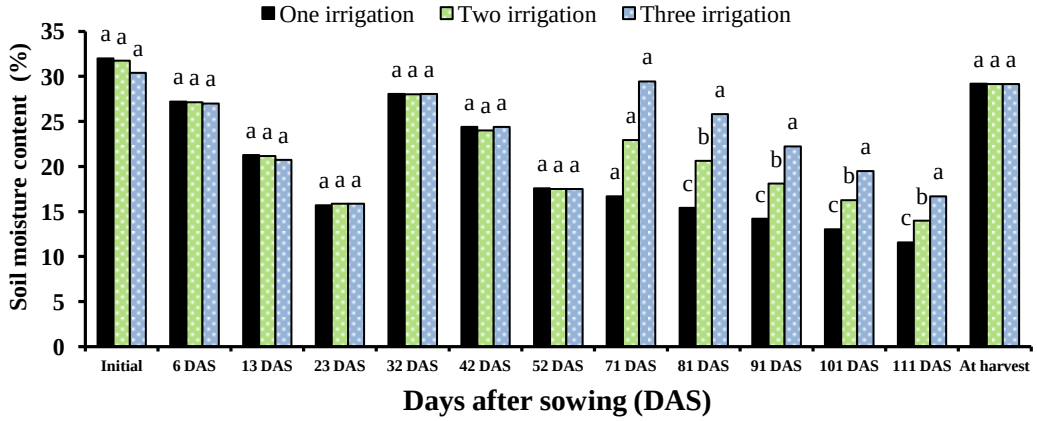

Fig. 6. Effects of irrigation on soil moisture at different days of sowing (2012-2013)

Effects of mulching on yield contributing characters and yield of maize

The application of mulch had a significant effect on the yield and yield attributes of maize (Table 2). Mulching practice gave higher plant height, longer cob with higher cob diameter, number of grains cob^{-1}, 100 seed weight and grain yield than that of under no mulch practice. Mulch practices conserved higher moisture over the growing season. The increased moisture in mulch practice would make nutrients available and continue the in-season turnover of the nutrients over the season of maize growth (Bu *et al.*, 2002).

Effects of irrigation on yield contributing characters and yield of maize

Irrigation frequency showed significant differences in yield and yield attributes of maize (Table 2). Three times irrigation at 32, 55 and 85 DAS performed better than double at 32 and 55 DAS and single irrigation at 32 DAS and the trends showed as three irrigations > two irrigations > single irrigation. The results are in agreement with Amin *et al.*, (2015) who stated that the irrigation frequency had a clear-cut effect on the total dry matter weight and grain yield of maize. Kara and Biber, (2008) also reported that the yield of maize increased significantly due to the application of irrigation.

Table 2. Effects of tillage, mulch and irrigation practices on the yield contributing characters and yield of maize (pooled data)

Treatment	Plant height (cm)	Cob length (cm)	Cob diameter (cm)	Grains cob^{-1} (nos.)	100-seed weight (g)	Grain yield (t ha^{-1})
Tillage practice						
Minimum tillage	159	15.1 a	3.6	312	29.0	5.41 a
Conventional tillage	144	14.7 b	3.4	268	28.3	4.97 b
LSD $_{0.05}$	NS	0.3	NS	NS	NS	0.21
Mulching						
Mulch	167 a	16.2 a	3.7 a	373 a	29.7 a	6.07 a
No Mulch	135 b	13.7 b	3.3 b	207 b	27.7 b	4.32 b
LSD $_{0.05}$	20.9	1.9	0.14	37	1.5	0.30
Irrigation frequency						
One irrigation	120 c	13.5 b	3.3 b	217 c	27.5 c	3.01 c
Two irrigation	148 b	14.2 b	3.4 b	274 b	28.4 b	5.50 b
Three irrigation	185 a	17.1 a	3.9 a	379 a	30.1 a	7.07 a
$LSD_{0.05}$	4.4	1.2	0.2	22	0.5	0.45
CV (%)	13.6	6.9	5.8	14.9	8.9	9.6

NS = Not significant, Means followed by same letter (s) in a column do not differ significantly at 5% level of significance

Combined effects of tillage and mulch on the grain yield of maize

The tillage method and mulching combination noted significant variation in the grain yield of maize (Fig. 7). Both the tillage practices with mulching gave the maximum yield relative to both tillage practices without mulching. The yield increased due to the application of mulch with MT and mulch with CT was 1.41 and 2.08 t ha^{-1} which was about 30 % and 53 %, respectively over no mulch irrespective of tillage methods. Tillage method and mulching combination kept the surface layer wetter that exchanged water uptake with increasing vegetative growth, grains cob^{-1} and 100-grain weight and ultimately increased yield. Similar results were obtained by Khurshid *et al.* (2006) who stated that the integrated use of tillage and mulch were beneficial in improving the growth and yield of maize.

Combined effects of tillage and irrigation on the yield contributing characters and yield of maize

The combined effects of tillage and irrigation frequency were found to be significant for plant height, cob length, the number of grains cob^{-1} and grain yield of maize with an exception to cob diameter and 100-grain weight (Table 3). Minimum tillage with 3 irrigations produced the tallest plant (194 cm) which was statistically identical to conventional tillage with 3 irrigations. The shortest plant (118 cm) was obtained from lower levels of irrigation irrespective of tillage methods. Both tillage practices with 3 irrigations gave the longest cob (17.7 cm) and conventional tillage with

single irrigation produced the shortest cob (13.0 cm). Minimum tillage with 3 irrigations gave the maximum number of grains cob^{-1} (419) and it was statistically different from all other treatment combinations. The highest grain yield (7.49 t ha^{-1}) of maize was obtained from minimum tillage with 3 irrigations which was similar to conventional tillage with 3 irrigations. Minimum tillage with 2 irrigations and conventional tillage with 2 irrigations gave statistically identical yields. The lowest yield (2.85 t ha^{-1}) was obtained from minimum and conventional tillage with single irrigation. Minimum tillage practices conserved more soil moisture, especially after several days of irrigation water application when crops undergo moisture stress. By retaining increased moisture, it might help increase root growth (Newell and Wilhelm, 1987) and acquire more nutrients from the rhizospheric zone (Alam *et al.*, 2014).

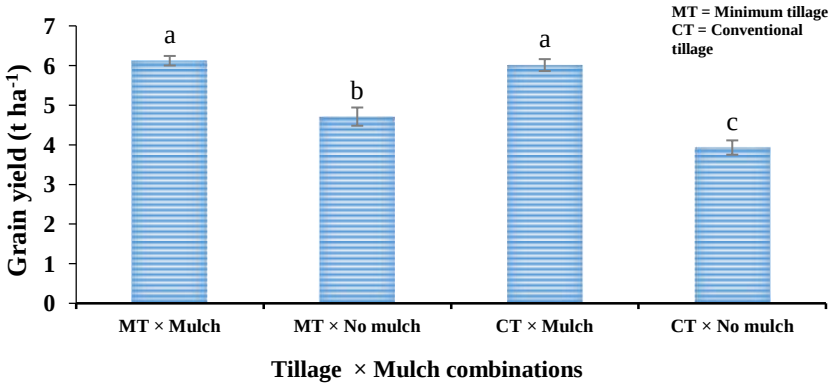

Fig. 7. Effects of tillage and mulching combination on the grain yield of maize (average of two years). Vertical bars represent standard errors of mean (±).

Table 3. Combined effects of tillage and irrigation on the yield contributing characters and yield of maize (pooled data)

Interaction of tillage × irrigation	Plant height (cm)	Cob length (cm)	Cob diameter (cm)	Grains cob^{-1} (nos.)	100-grain weight (g)	Grain yield (t ha^{-1})
MT × 1 irrigation	123 de	14.1 bc	3.5	221 d	28.0	3.18 c
MT × 2 irrigation	159 bc	13.7 bc	3.5	298 c	28.6	5.58 b
MT × 3 irrigation	194 a	17.7 a	3.9	419 a	30.6	7.49 a
CT × 1 irrigation	118 e	13.0 c	3.2	213 d	27.1	2.85 c
CT × 2 irrigation	137 cd	14.7 b	3.3	293 c	28.3	5.43 b
CT × 3 irrigation	177 ab	16.4 a	3.8	340 b	29.7	6.64 a
$LSD_{0.05}$	6.3	1.7	NS	32	NS	1.02
CV (%)	13.6	5.4	4.3	11.7	6.7	7.6

NS = Not significant, Means followed by same letter (s) in a column do not differ significantly at 5% level of significance

Combined effects of mulch and irrigation on the yield contributing characters and yield of maize

The combination of mulch and irrigation exerted a significant influence on plant height, cob length, a number of grains cob^{-1} and grain yield of maize. Cob diameter and 100 grain weight were not found significant due to mulching and irrigation (Table 4). All the yield parameters performed the best in the mulch with 3 irrigations combination compared to other combinations. Significantly the highest grain yield (8.28 t ha^{-1}) was obtained from mulch with 3 irrigations and the lowest (3.53 t ha^{-1}) from no mulch with single irrigation. The results showed that higher maize yield in this drought-prone region may be achieved by using a proper combination of mulch and irrigation. Similar results were obtained by Gill *et al.,* (1996) in a semi-arid sub-tropical monsoon region, Ludhiana, India.

Table 4. Combined effects of mulch and irrigation on the yield contributing characters and yield of maize (pooled data)

Interaction of tillage × irrigation	Plant height (cm)	Cob length (cm)	Cob diameter (cm)	Grains cob^{-1} (nos.)	100 grain weight (g)	Grain yield (t ha^{-1})
Mulch × 1 irrigation	125 cd	14.1 bc	3.5	291 c	28.6	3.73 e
Mulch × 2 irrigation	166 b	15.4 b	3.5	373 b	29.4	6.19 b
Mulch × 3 irrigation	211 a	19.2 a	4.2	456 a	31.0	8.28 a
No mulch × 1 irrigation	116 d	13.1 c	3.2	143 e	28.6	3.53 e
No mulch × 2 irrigation	130 c	13.0 c	3.3	176 d	27.5	4.81 d
No mulch × 3 irrigation	159 b	15.0 b	3.5	303 c	29.2	5.85 c
$LSD_{0.05}$	6.3	1.7	NS	32	NS	0.85
CV (%)	10.8	6.9	5.1	13.7	7.2	9.4

NS = Not significant, Means followed by same letter (s) in a column do not differ significantly at 5% level of significance

Conclusion

Results revealed that mulching under both tillage practices performed better in terms of moisture conservation than the tillage practices without mulches. Hence, the climate-related water stress may be successfully managed by minimum tillage along with three times irrigation at 32, 55 and 85 DAS and mulch @ 5 t ha^{-1} for obtaining a higher yield of maize.

Acknowledgement

The author would like to thank the Scientists of Lac Research Centre, Kalyanpur, Chapainawabganj for supervising the research from time to time. Thanks are also due for Laboratories of Soil Science Division, BARI, Gazipur.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Agele, S.O., G.O. Iremiren and S.O. Ojeniyi. 2000. Effects of tillage and mulching on the growth, development and yield of late-season tomato (*Lycopersicon esculentum* L.) in the humid south of Nigeria. *J. Agricul. Sci.* 134**:**55-59.

Agronomy Guide. 2007-2008. The Pennsylvania State University Part 1, Section 1: Soil Management.

AIS (Agricultural Information Services). 2014. Department of Agricultural Extension. Government of the People's Republic of Bangladesh, Dhaka.

Alam, M.K. 2018. Assessment of soil carbon sequestration and climate change mitigation potential under conservation agriculture practices in the eastern gangetic plains. PhD thesis, Murdoch University. pp. 335.

Alam, M.K., M.M. Islam, N. Salahin and M. Hasanuzzaman. 2014. Effect of tillage practices on soil properties and crop productivity in wheat-mungbean-rice cropping system under subtropical climatic conditions. *Sci. World J.* : Article ID 437283.

Amin, M., L. Anjum, A. Alazba and M. Rizwan. 2015. Effect of the irrigation frequency and quality on yield, growth and water productivity of maize crops. *Qual. Assur. Saf. Crops* 7:721–730.

BBS (Bangladesh Bureau of Statistics). 2014. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Finance and Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

BBS. 2016. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Finance and Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

BBS. 2021. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Finance and Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Bell, R.W., M.E. Haque, M. Jahiruddin, M.M. Rahman, M. Begum, M.A.M. Miah, M.A. Islam, M.A. Hossen, N. Salahin, T. Zahan, M.M. Hossain, M.K. Alam and M.N.H. Mahmud. 2019. Conservation Agriculture for Rice-Based Intensive Cropping by Smallholders in the Eastern Gangetic Plain. *Agriculture*. 9(1):1-17.

Black, C.A. 1965. Methods of Soil Analysis Part-I and II, American Society of Agronomy, Madison, Wis, USA.

Bu, Y.S., H.L. Shao and J.C. Wang 2002. Effect of different mulch materials on corn seedling growth, nutrient contents and distributions. *J. Soil and Water Conserv.* 16(3):40-42.

Busari, M.A., S.S. Kukal, A. Kaur, R. Bhatt and A.A. Dulazi. 2015. Conservation tillage impacts on soil, crop and the environment. *Int. Soil and Water Conserv. Res.* 3:119–129.

Gathala, M.K., V. Kumar, P.C. Sharma, Y.S. Saharawat, H.S. Jat, M. Singh, A. Kumar, A., M.L. Jat, E. Humphreys, D.K. Sharma, S. Sharma and J.K. Ladha. 2013. Optimizing intensive cereal–based cropping systems addressing current and future drivers of agricultural change in the northwestern Indo–Gangetic Plains of India. *Agric. Ecosyst. Environ* 177:85–97.

Ghosh, P. 1983. Institute of agriculture, Visva-Bharati Srinike tan-731-236. West Bengal, India. *Indian J. Agricul. Res.* 32:75–80.

Gill, K.S., P.R. Gajri, M.R. Chaudhary and B. Singh. 1996. Tillage, mulch and irrigation effects on corn (*Zea mays* L.) in relation to evaporative demand. *Soil and Tillage Res.* 39:213-227.

Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. 2nd Edn. International Rice Research Institute Book. A Wiley Inter. Publication. New York. 442-443.

Hasan M.M., S.R. Waddington and M.E. Haque, *et al.* 2007. Contribution of whole family training to increased production of maize in Bangladesh. *Progress. Agricul. (Bangladesh).* 18(1):267-281.

Islam, M.A. 2016. Conservation Agriculture: Its effects on crop and soil in rice-based cropping systems in Bangladesh, PhD thesis. School of Veterinary and Life Sciences, Murdoch University, Australia. pp. 317.

Jackson, M.L. 1973. Soil Chemical Analysis. Constable and Co. Ltd. Prentice Hall of India Pvt. Ltd., New Delhi, India.

Johnston, A.M. and G.D. Hoyt. 1999. Changes to the soil environment under conservation tillage. *Hort. Technol.* 9:380-393.

Kara, T. and C. Biber. 2008. Irrigation frequencies and corn (*Zea mays* L.) yield relation in northern Turkey. *Pak. J. Biol. Sci.* 11(1):123-126.

Karim, Z., S. M. Rahman, M. I. Ali and A. J. M. S. Karim. 1988. Soil Bulk Density. A Manual for Determination of Soil Physical Parameters,Soils and Irrigation Division, BARC.

Khan, M.S., M.M. Rahman, R.A. Begum, M.K. Alam, A.T.M.A.I. Mondol, M.S. Islam and N. Salahin. 2008. Research experiences with problem soils of Bangladesh. Soil science division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. 1-176.

Khurshid, K., M. Iqbal, M.S. Arif and A. Nawaz. 2006. Effect of tillage and mulch on soil physical properties and growth of maize. *Int. J. Agricul & Biol.* 8:1560–8530.

Lindsay, W.L. and W.A. Norvell. 1978. Development of a DTPA test for zinc, iron, manganese, and copper. *Soil Sci. Soc. America. J.* 42:421–428.

Newell, R.L. and W.W. Wilhelm. 1987. Conservation tillage and irrigation effects on corn root development. Publications from USDA-ARS / UNL Faculty. 113

Page, A.L., R.H. Miller and D.R. Kenny. 1989. Methods of Soil Analysis. Part 2, American Society of Agronomy, Soil Science Society of America, Madison, Wis, USA, 2nd Edition.

Salahin, N. 2017. Influence of Minimum Tillage and Crop Residue Retention on Soil organic matter, Nutrient content and Crop productivity in the rice-jute system, PhD Thesis. Department of Soil Science. Bangladesh Agricultural University, Bangladesh. pp. 246.

Yang, Y., X. Liu, W. Li and C. Li. 2006. Effect of different mulch materials on winter wheat production in the desalinization soil in Heilongjiang region of North China. *J. Zhejiang Univ. Sci. B.* 7(11):858-867.

Bangladesh J. Agri. 2022, 47(1): 39-65 *DOI: https://doi.org/10.3329/bjagri.v47i1.60592*

ASSESSMENT OF CLIMATE CHANGE RISKS AND ADAPTATION OF IMPROVED FARMING PRACTICES IN DEKHAR HAOR OF SUNAMGANJ DISTRICT

M. A. Haque[1*], S. M. Moniruzzaman[2], M. F. Hossain[3] and M. A. Alam[2]

[1]Practical Action Bangladesh, Dhanmondi, Dhaka; [2]Bangladesh Jute Research Institute (BJRI), Dhaka; [3]Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Bangladesh

Abstract

Flash flood is the most commonly occurring water related disaster in the haor area of Bangladesh. It's occurs during the pre-monsoon season (March-April-May). The haor area is very susceptible to climatic risk and prone to early flash flood in consecutive year. In response, the government of Bangladesh has initiated a number of institutional interventions through development plans to better support sustainable adaptation. A study was carried out to assess the climate change risks and adaptation of indigenous farming practices of dekhar haor in Sunamganj district. Data were collected through direct interview from randomly selected 96 farmers, 4 Focus Group Discussion and 10 Key Informant Interviews during September 2019 to January 2020. It was found that the most potential climatic hazards of the study area were flash flood, thunderstorm, hailstorm and drought. The data related to agricultural adaptation strategies to climate change indicated that the majority (54.2%) farmers had medium adaptation and 45.8% low adaptation and no farmers were found with high adaptation. Climatic risks at different agricultural sectors such as crop protection, community protection, fisheries, livestock and risk of drought were assessed through comparative analysis of climatic hazards, vulnerability to climate change and adaptation capacity.

Keywords: Adaptation, Climatic risks, Dekhar haor, Flash flood, Indigenous farming practices

Introduction

Bangladesh is vulnerable to rapid onset disasters including floods, river erosion, cyclones, droughts, tornadoes, cold waves, earthquakes, drainage congestion/water logging, arsenic contamination, salinity intrusion and global climate change etc as so much of its economy relies on agriculture (DM and RD, 2010). Floods are annual phenomena, with the most severe flood occurring during the months of July and August. Regular river floods affect 20% of the country, increasing up to 68% in extreme years. The north-eastern part of Bangladesh is known as Haor region. It spread over seven districts Sylhet, Sunamganj, Habiganj, Maulovi Bazar, Kishoreganj, Bhramanbaria and Netrokona. The Haor area altogether covers 1.99 million ha which is around 13.5% of the country's total surface area (Khan, 2010). Dekhar haor is one of the most important, famous and large haor in Bangladesh. It is moderately deep, semi remote and core haor area located in east of the Tanguar system. The Haor covers four upazilas namely

[*] Corresponding author: enam4656@gmail.com

Sunamganj Sadar, Dakshin Sunamganj, Dowarabazar and Chhatak under the Sunamganj district. Total area of the Haor is about 11514.6 hectares. Dekhar Haor is made up of 36 small, medium and large interconnecting beels, canals, rivers and crop lands. There is a great importance of this haor in fish production and a big pocket of boro rice production. It is the source of livelihood for more than 1, 00,000 people. The haor goes under flooding (5-10 m) from late May to October while it looks like a sea (which is called haor corrupt word from Sagar). The haor area remains waterlogged for about six to seven months in a year. About 86% of the total cropped area of haor is highly potential for boro rice production and vital supplier of inland freshwater fisheries with a fishing area of 114793 hectares (Master Plan of Haor Areas, 2012). Swamp forest is dominated by Hijal (*Barringtonia acutangula*), Koroch (*Pongamia pinnata*) and other flood tolerant tree species are visible in the haor. Haor is predominantly a single cropped (boro rice) area. The scenario of existing cropping patterns practiced in Sunamgonj is Boro-Fallow-Fallow (80%), Fallow-Fallow-T.Aman (3%), Boro-Fallow-T.Aman (8%) and Fallow-Aus-T.Aman (6%) respectively (DAE and Field survey, 2008). Boro rice is the principle crop of this region. But pre-monsoon flash flood from the very steep uplands adjacent to the region in Asam and Meghalaya Hills range in India is a common phenomenon, causing immense damage to the standing Boro crops before harvesting. To protect the Boro crop damage due to pre-monsoon flash flood BWDB constructed 46 Submersible Embankments in the haor region. The positive impact of the submersible embankment on Boro production has also negated the notion that loss of Boro production from the unprotected areas of the region might outweigh any incremental production from the submersible embankment (Bangladesh Disaster Management Reference Handbook, 2015; Saleh and Mondal, 2007). Rural poor households have to depend upon fisheries and off-farm labour to supplement the meager farm income. The common property nature of the water bodies or Jalmohals and the uncertain lease arrangements inhibits the full growth potential of the fisheries sector. The haors are known as an area of severe poverty and limited livelihood options with many people seasonally migrating to find work. Vegetable production in the field using different vegetable based cropping patterns revealed that more than one crop can be harvested from comparatively high land of the haor area with higher net income as well as employment generation with higher rice equivalent yield thus creating opportunity for alternative livelihood option for the poor. Already today, there are high costs and consequences due to flooding in haor areas with land being eroded away, fatalities, construction, infrastructure failures and disease (IPCC, 2013; McBean, 2004). Higher sea level and changes in precipitation patterns will not only increase the risk of flooding but also of erosion and landslides (e.g. Andersson *et al.*, 2013, 2014). Therefore, the farmers will be more vulnerable to climate change in haor areas of Bangladesh and its impacts of climate variability and change cause additional risks for agriculture. In view of the above facts, the study was undertaken to climate change risks based on climatic hazards, extent of impact and agricultural adaptation status with the following objectives: (i) To identify the major climatic hazards and existing vulnerability for agricultural production in the selected haor area, (ii) To identify the adaptation levels of agricultural farming practices in the changing situation in the selected *haor* area, (iii) To analyze the climatic risks for different sectors of agricultural farming in the selected haor area and (iv) To explore the relationship between personal attribute of the farmers and their agricultural adaptations to climate change.

Materials and Methods

Description of the haor and selection of study area

Dekar haor is a resourceful wetland basin located in the North-East part of Bangladesh, lies between latitude 24°34'N to 25°12'N and longitude 90°56'E to 91049'E under Sunamganj district. The Dekar haor covers four upazilas namely Sunamganj Sadar, Dakshin Sunamganj, Dowarabazar and Chhatak having an area of 11514.6 ha. In monsoon, it is full of water look like an inland sea, but in the dry season maximum portion of the haor becomes dry except some deeper portions. The average water depth varies from 1.07 meters in winter and 3.1 meters in monsoon. The haor covers a total 36 small and large interconnecting beels, channels, rivers and crop lands (CNRS, 2004). The haor is a critical habitat for fishes and other aquatic species. A large number freshwater fishes, thousands of indigenous and migratory birds and non-fishes aquatic organisms have been found. The haor is also the home grounds for many organisms and provide suitable areas for feeding, breeding, nursing and so on. Boro is the main crop in the area.

The research instrument and its preparation

The study was conducted through peoples' consultation focused on farmers' response. Three tools were used to assess the climatic risks and adaptation measures around dekhar haor area under Sunamgonj district, such as (i) Farmers' Interview (ii) Focus Group Discussion (FGD) and (iii) Key Informant Interview (KII). The questionnaires were prepared for collection of data from the respondents keeping the objectives of the study in mind. The question and statements contained in the schedule were simple, direct and easily understandable by the farmers.

Population coverage and sampling

As per physical observation of the researcher, 86 villages listed on the bank of Dekhar Haor with a population of 87427 for 15150 households and their livelihood is very crucially depend on dekhar haor ecosystem.

Sampling village selection

As Dekhar Haor is surrounded by 8 unions under 4 upazilas of Sunamgonj district, for farmers' interview 2 villages has selected as sample village from each of 8 union considering the most adjacent to haor area and farmers' livelihood & vulnerability is more depended on haor context. For conducting FGD, 4 villages has selected on the East, West, North & South side of dekhar haor to accumulate the climatic risk in all sides of the haor.

Farmer's interview

Six sample farmers were selected from each of 16 sample villages in consultation with respective UP Member and community leader to include large, middle, small and landless farmers with diversification in livelihood intervention on crops cultivation, fishing, vegetable cultivation and livestock rearing etc. According to agricultural census of Bangladesh, a farm household was classified into three categories

such as: small (up to 2.4 acres); medium (2.5 to 7.4 acres); and large (7.5 acres or more) (BBS, 2011). In a total 96 farmers' interview was conducted.

Focus group discussion (FGD)

4 FGDs were conducted at village level in 4 sides (East, West, North and South) of dekhar haor to accumulate different risk, vulnerability, experience and idea of all part of haor. 10-15 participants were took part in each FGD (Crop farmers, livestock farmers, fishermen's and community leaders) with representation of different categories farmer and community leader also. Age of the participants is not less than 30 years to capture the experience and idea in the changing climate during last 10 years.

Key informant interview (KII)

Ten categories of personnel had listed to conduct the KIIs for getting diversified experience and idea from different level and perspectives such as (i) Upazila level leader - Upazila Chairman, Sunamganj Sadar (ii) Union level leader-UP Chairman, Pandergaon UP, Dowarabazar (iii) Community level leader- UP Member, Mollapara UP, Sunamganj Sadar (iv) Women leader- Upazila Women Vice-Chairman, Dakshin Sunamganj (v) Planning level agricultural professional- Upazila Agriculture Officer, Sunamganj Sadar (vi) Implementation level agricultural professional- Sub Assistant Agriculture Officer, Dakshin Sunamganj (vii) Press media journalist- Editor, The Daily Sunamkantha (viii) Electronic media journalist- Staff Reporter, RTV (ix) Development worker- Upazila Manager, DASCOH and (x) Research worker- Research Associate, Sylhet Agricultural University (Dekhar haor project). The questionnaires for Farmers' Interview, FGD & KII has developed with same contents and in addition selected characteristics of the farmer included in Farmers' Interview. The following major issues, problem or statement had delivered in the questionnaires such as (a) Farmer characteristics: Age, Education level, Farm size, Annual income & Extension media contact of the farmer (b) Respondents' perception of climate change: believe in climate change, perception of climatic variability in changing situation and causes of climate change (c) Climatic risks analysis in agricultural farming: Climatic hazards ranking and Impact of climate change as experienced and observed by respondents and (d) Agricultural adaptation to climate change in Dekhar Haor as experienced and observed by respondents.

Questionnaires

The questionnaires for farmers' interview, FGD & KII has developed with same contents and in addition selected characteristics of the farmer included in farmers' interview. The following major issues, problem or statement had delivered in the questionnaires.

Farmer characteristics

Age, education level, farm size, annual income & extension media contact of the farmer.

Respondents' perception of climate change

Believe in climate change, perception of climatic variability in changing situation and causes of climate change.

Climatic risk analysis in agricultural farming

Climatic hazards ranking and Impact of climate change as experienced and observed by respondents. Agricultural adaptation to climate change in dekhar haor as experienced and observed by respondents.

Variables of the research and their measurement

The independent variables of the research were age, education level, farm size, annual income and extension media contact of the farmer, respondents' believe in climate change, perception of climatic variability in changing climate and causes of climate change. The dependent variables of the research were climatic hazards ranking as experienced by respondents, impact of climate change as observed by respondents and agricultural adaptation for climate change. Procedure for measuring independent and dependent variables has been presented below:

Measurement of independent variables

Age of the farmer was measured in terms of actual years from their birth to the time of interview. A score of one (1) was assigned for each year of one's age. Education of a farmer was measured on the basis of year of schooling in formal educational institution. Score 1 was given for each class have completed. Respondent who don't know how to read and write, education score was taken as zero (0). A score of 0.5 was given to that respondent who could sign his/her name only. The farm size of a farmer was measured in hectares. The data were first recorded in term of local unit i.e. 'care' and then converted to hectare.

Annual income of a farmer was measured in taka on the basis of his total yearly earning from different sources (e.g. agricultural and non-agricultural) in last year. A score of one (1) was assigned for each thousand taka. The extension media contact of the farmer was measured by the total scores of media contact on the basis of the frequency of visit and contact with 10 selected media contact. The extent of contact was determined against a four point scale and scores were arranged for all 10 categories of related media contact and frequency of communication such as Not at all, Rarely, Occasionally and Frequently 0,1,2,3 respectively. Thus the score of a farmer could range from 0 to 30, where 0 indicating no extension media contact and 30 highest extension media contact. Throughout the assessment: Farmers' Interview, FGD & KII, respondents were asked that they believe in climate change and find out response in terms of YES or NO. Number and percent of respondents in different interviews calculated. The perception of climatic variability (precipitation, temperature, wind speed & extreme events) during last 10 years and their comments were measured by Extent of perception were three categories Increased, Reduced and No change. Each category was divided into two parts (such as # is number and % is percentage). The respondents were asked about the causes of climate change and their comments were measured by counting number of citation.

Measurement of dependent variables

A-four point rating scale from "High" to "Not ever" was developed as High = 3, Medium = 2, Low = 1 and Not ever = 0 to measure the extent of damage for 10 listed climatic hazards in haor areas as experienced by the respondents. The range of climatic hazards score of the respondents could vary from 0 to 30, where, 0 indicate no climatic hazards and 30 indicated full climatic hazards. However, its having computed the "extent of climatic hazards" score for each of 110 respondents, the climatic hazards index (CHI) was calculated to compare the relative hazards with ranged from 0 to 330. A-four point rating scale from "High" to "Not ever" was developed as High = 3, Medium = 2, Low = 1 and Not ever=0 to measure the extent of impact for 15 listed problems as effect of climate change in hoar areas as experienced by the respondents. However, besides having computed the "extent of impact of climate change" score for each of 110 respondents, the climatic change impact index (CCII) was calculated to compare the relative impact. The CCII for each of the climate change problem/statement ranged from 0 to 330, where, 0 indicate no climate change impact and 330 indicated full or extreme impact of climate change. A-four point rating scale from "High" to "Not ever" was developed as High = 3, Medium = 2, Low = 1 and Not ever = 0 to measure the extent of adaptation for 15 listed adaptation aspects in haor areas as experienced by the respondents. The range of extent of adaptation score for climate change of the individual respondents could vary from 0 to 45, where, 0 indicate no adaptation for climate change and 45 indicated full adaptation for climate change. After having computed the "extent of adaptation" score for climate change for each of 110 respondents, the farmers was categories according to their overall agricultural adaptation to climate change. The climate change adaptation index (CCAI) for each of the adaptation aspects calculated to compare the relative adaptation. The CCAI ranged from 0 to 330, where, 0 indicate no adaptation and 330 indicated full adaptation for climate change.

Climatic risks assessment

Risk assessment is a process to determine the nature and extent of such risk, by analyzing hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. According to the ISDR publication: Living with Risk, the stages of a risk assessment are the following (shown in the order in which they are normally conducted).

- Hazard identification to identify the nature, location, intensity and likelihood (probability or frequency) of a threat
- Vulnerability analysis to determine the existence and degree of vulnerabilities and exposure to a threat(s)
- Capacity analysis to identify the capacities and resources available to reduce the level of risk, or the effects of a disaster
- Risk analysis to determine levels of risk
- Risk evaluation to make risk priorities which need countermeasures

Adaptation policy framework (ADF)

The United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) have initiated a process to develop a so-called adaptation policy framework (APF). The APF project aims to strengthen adaptive capacity of human systems, in multiple sectors, to all climate-related threats. This is done by providing guidance to developing countries for conducting adaptation policy assessments that help them to integrate adaptation to climate change into sustainable development plans, and to link longer-term climate change to current problems caused by climate variability (UNDP, 2003). The APF builds on a framework published in Burton *et al.,* (2002). Key innovations of the APF, used in vulnerability and adaptation studies, are (i) It treats policy as the overarching purpose (and vulnerability as subordinate to it), (ii) It starts by assessing current vulnerabilities, including the effectiveness of adaptation to recent climate experiences, (iii) It links adaptation to climate change with adaptation to current climate variability and extremes, (iv) It integrates climate adaptation into sustainable development plans, (v) It emphasizes the importance of using a stakeholder-led approach

Data collection

Data were collected through interviewing 96 sampled farmers, facilitating 4 village level focus group discussions and conducting 10 key informant interviews to accumulate the climatic risk in all sides of the haor. So, total respondents of 110. The researcher himself collected data for this assessment. During data collection the researcher had taken assistance from local leaders and development worker of the research area to familiar himself with the sampled farmers and to arrange FGD. After physical observation of research area and sample selection the data were collected during September 2019 to January 2020.

Data processing and analysis

A database were developed with properly coded and transferred from all questionnaires to an excel sheet. The statistical measures, such as number, percentage, range, mean, standard deviation and rank order were used in describing the variables as applicable. The data analysis was performed by using Statistical Package for Social Sciences (SPSS). Pearson's Product Moment Co-efficient of Correlation-r (2-tailed) was used to determine the nature of relationship between the dependent and independent variables.

Results and Discussion

Characteristics profile of the respondents

Characteristics profile of the farmers were determined and presented in Table 1. It is revealed that most (about 81%) of the respondents were young to middle aged having varying level of education with the highest proportion 36.5% of the farmers had primary level and 13.5%of the farmers had secondary level of education. Majority (42.71%) of the farmers had medium farm size of the land and 50% of farmers had low income which is below the poverty line of WB-DRG (2016) and 40.63% medium income compared to 9.37% high income. Most of the households cannot maintain a monthly

saving, since they are already facing income insecurity due to large household and changing climatic conditions and more than half of the respondents (59.37%) had low extension media contact, while 19.79% of them had medium extension media contact, 15.63% had no extension media contact and only 5.21% had high extension media contact. Thus, 75% of the farmers had zero to low extension media contact which is very below to up to the mark.

Table 1. Socio demographic characteristics profile (Diener and Don Rahtz, 2000)

Variables	Measurement	Categories	Respondents Number	Respondents %	Mean	Standard Deviation
Age	Years	Young (<35)	19	19.79		
		Middle (36-55)	59	61.46	46.63	10.19
		Old (>55)	18	18.75		
Education	Year of schooling	Illiterate (0)	31	32.3		
		Illiterate but can sign only(0.5)	17	17.7	3.26	3.49
		Primary (1-5)	35	36.5		
		Secondary (6-10)	13	13.5		
Farm Size	Hectare	Landless (0)	4	4.17		
		Small (0.01-1.00)	40	41.67	1.42	1.108
		Medium (1.01-3.00)	41	42.71		
		Large (>3.00)	11	11.45		
Annual income	Tk. in Thousand	Low income (<50)	48	50	58.104	32.14
		Medium income (50-100)	39	40.63		
		High income (>100)	9	9.37		
Extension media contact	Scoring Scale	No extension media contact (0)	15	15.63		
		Low extension media Contact (1-5)	57	59.37	4.06	3.63
		Medium extension media contact (6-10)	19	19.79		
		High extension media contact (>10)	5	5.21		

Respondents' perception of climate change

Respondents' believe in climate change: Throughout the assessment 100% of respondents of all interviews: Farmers' Interview, FGD and KII said that they believe in climate change. Number and percent of respondents in different interviews is shown in Table 2.

Respondents' perception on climatic variability in changing situation

To evaluate climate change parameters, respondents were asked to find out the features of major climatic variability: precipitation, temperature, wind speed and extreme events with some visual and measurable phenomenon in changing situation during last 10 years. The findings of respondents' perception are presented in Table 3.

Table 2. Number and percent of respondent based on believe in climate change

Respondent	Total Respondent	Yes		No	
		Number	%	Number	%
Farmers' interview	96	96	100	0	0
Focus Group Discussion (4#)	52	52	100	0	0
Key Informant Interview	10	10	100	0	0
Total	158	158	100	0	0

Table 3. Distribution of the respondents based on perception of climatic variability

S.N.	Climatic variability	Statement	Extent of perception (Total data=110) (# is number and % is percentage)					
			Increased		Reduced		No change	
			#	%	#	%	#	%
1	Precipitation	Annual	6	5.45%	94	85.45%	10	9.09%
		In rainy season	8	7.27%	59	53.64%	43	39.09%
		In dry season	7	6.36%	99	90.00%	4	3.64%
		Length of rainy season	6	5.45%	81	73.64%	23	20.91%
2	Temperature	Annual	108	98.18%	0	0.00%	2	1.82%
		In Winter season	93	84.55%	15	13.64%	2	1.82%
		In Summer season	108	98.18%	2	1.82%	0	0.00%
		Length of cold season	3	2.73%	104	94.55%	3	2.73%
		Length of hot season	106	96.36%	0	0.00%	4	3.64%
3	Wind speed	Intensity in Summer season	58	52.73%	38	34.55%	14	12.73%
		Intensity in Monsoon season	8	7.27%	61	55.45%	41	37.27%
		Intensity in Winter season	20	18.18%	50	45.45%	40	36.36%
		Intensity of hotness	110	100%	0	0.00%	0	0.00%
4	Extreme events	Intensity of coldness	88	80.00%	19	17.27%	3	2.73%
		Intensity of storm	10	9.09%	67	60.91%	33	30.00%
		Intensity & frequency of flash flood	109	99.09%	1	0.91%	0	0.00%

A promising approach to conveying the reality of climate change is to develop indicators– numbers and scales that track the state or level of some aspect of the climate. One widely used indicator in climate science is the change in the global average temperature of the lower atmosphere. This indicator is also one of the targets set out by the 2015 Paris Agreement on climate change, which calls for keeping a global

temperature rise this century to well below 2°C above pre-industrial levels while pursuing efforts to limit the temperature increase even further, to 1.5°C. Indicators have a number of advantages. They are quantified, objective, based on data provided by virtually all countries, and they demonstrate change over time. In addition to indicators that capture progress on mitigation, indicators can measure changes in the climate change impacts that should be targeted by adaptation efforts.

Socio-economic indicators of how climate impacts sectors such as health and agriculture are also, of course, critically important. Developing these indicators is a major challenge because of the diversity of climate impacts and a lack of systematically collected data on climate impacts in affected sectors from authoritative sources. Most people are aware that the temperature or more specifically, the global average temperature of the atmosphere just above the earth's surface – is rising, but this is not sufficient as an indicator of climate change. People focus on the surface-level atmosphere because that is where we live, and its temperature, which has been reliably measured for over 150 years, shapes our daily lives. But more than 90% of the excess heat trapped by humanity's greenhouse gas emissions is stored in the ocean, with much smaller amounts absorbed by the atmosphere, the cryosphere and land. Therefore, the atmosphere's temperature does not provide a complete picture of the earth's climate or of the full dimensions of climate change, and at worst can contribute to a false sense of security.

Causes of climate change

There were many causes of climate change found in the interview with respondents; manufacturing and industry produce emissions, mostly from burning fossil fuels to produce energy for making things like cement, iron, steel, electronics, plastics, clothes and other goods. This leads to global warming and climate change. Out of these one was God and others were environment related. A large number of respondents (75.45%) believed that climate is changing by God. The causes of climate change had supported by the respondents is presented in Table 4. The causes of climate change supported by the respondents were 87.27% for deforestation, 75.45% by God, 53.64% for over population, 40.91% for agricultural practices, 24.55% for environmental pollution, 14.55% for use of motor vehicle, 13.64% for urbanization, 10.91% for industrial activities and 0.91% for natural and normal respectively. The impacts of climate change are devastating in developing countries due to lack of capacity in accordance with the changing climate. Forests are one the main natural factors that regulate and determine climate, weather patterns and amount of CO_2 of an area. With rapid industrialization and rapid urbanization there is a significant increase in deforestation and as a consequence rise in global mean surface temperatures. Strategies designed for mitigating climate change are focused on reducing the emissions of greenhouse gases (GHGs), particularly carbon dioxide (CO_2). One of the main causes of CO_2 emissions is deforestation. Forests act as natural filters for carbon dioxide absorption in the atmosphere.

Table 4. Distribution of the respondents based on causes of climate change

S.N.	Causes/Issues	Respondents' perception (N=110)		Ranking
		No of citation/ Assigned a number	% of Respondents	
1	Deforestation	96	87.27	1
2	Industrial activities	12	10.91	8
3	Agricultural practices	45	40.91	4
4	Over population	59	53.64	3
5	Urbanization	15	13.64	7
6	Use of motor vehicle	16	14.55	6
7	Environmental pollution	27	24.55	5
8	Natural and normal	1	0.91	9
9	God	83	75.45	2
	Total	354		

Identification of major climatic hazards in dekhar haor

Calculated the Climatic Hazards Index (CHI) to compare the relative hazards through computed the scores of extent of damage by each of 10 listed climatic hazards for each of 110 respondents. Distribution of the respondents according to the extent of damage for each climatic hazard was been shown in Table 5 along with climatic hazards index (CHI) and its rank.

Table 5. Distribution of the respondents based on extent of damage by climatic hazards index (CHI) and hazard ranking

S.N.	Name of the hazards	Extent of damage (Total data=110)				CHI	Ranking
		High	Medium	Low	Not ever		
1	Flash flood	110 (100%)	0	0	0	330	1
2	Flood	46 (42%)	47 (43%)	17 (15%)	0	249	6
3	Drought	84 (76%)	25 (23%)	1 (1%)	0	303	4
4	Cold	0	52 (47%)	57 (52%)	1 (1%)	161	7
5	Hailstorm	85 (77%)	25 (23%)	0	0	305	3
6	Haor wave	36 (33%)	67 (61%)	7 (6%)	0	249	5
7	Rainstorm	0	32 (29%)	78 (71%)	0	142	9
8	Thunderstorm	108 (98%)	2 (2%)	0	0	328	2
9	Tornado	0	13 (12%)	97 (88%)	0	123	10
10	Dew	0	44 (40%)	64 (58%)	2 (2%)	152	8

Climatic hazards index (CHI) of 110 respondents for each hazard was ranged from 0 to 330. Data presented in Table 5, indicated that the most potential climatic

hazards in the research area faced by the respondents were flash flood (330), thunderstorm (328), hailstorm (305), drought (303) and haor wave (249) respectively, in accordance to probability of risks.

Identification of major impacts of climate change in dekhar haor

Computed the scores of extent of impact in each of 15 listed climate change impact statements for 110 respondents and calculated the climate change impact index (CCII) to compare the severity of impacts. Distribution of the respondents according to the extent of impact in 15 listed climate change impact statements have been shown in Table 6 along with climate change impact index (CCII) and ranking of impact statements.

Table 6. Distribution of the respondents based on extent of impact of climate change and impacts ranking

S.N.	Impact	Extent of impact (N=110)				CCII	Ranking
		High	Medium	Low	Not ever		
1	Temperature increased at Summer season	98 (89%)	11 (10%)	1 (1%)	0	317	4
2	Temperature decreased at Winter season	58 (53%)	25 (23%)	27 (24%)	0	251	9
3	Increased duration of flooding	4 (4%)	38 (34%)	45 (41%)	23 (21%)	133	13
4	Increased height of flooding	1 (1%)	13 (12%)	62 (56%)	34 (31%)	91	14
5	Changed seasonal diversity	4 (4%)	87 (79%)	19 (17%)	0	205	11
6	Changed cropping pattern	2 (2%)	36 (33%)	70(63%)	2 (2%)	148	12
7	Increased drought	95 (86%)	14 (13%)	1 (1%)	0	314	5
8	Decreased soil fertility	101 (92%)	9 (8%)	0	0	321	3
9	Decreased crop yield	1 (1%)	9 (8%)	6 (6%)	94 (85%)	27	15
10	Increased pest and diseases	86 (78%)	22 (20%)	2 (2%)	0	304	6
11	Decreased cultivable land	30 (27%)	46 (42%)	33 (30%)	1 (1%)	215	10
12	Decreased livestock production	49 (44%)	55 (50%)	6 (6%)	0	263	8
13	Decreased availability of fodder from natural source	84 (76%)	24 (22%)	2 (2%)	0	302	7
14	Decreased fish production	104 (94%)	6 (6%)	0	0	324	2
15	Increased frequency and intensity of extreme events	106 (96%)	3 (3%)	1 (1%)	0	325	1

The climate change impact index (CCII) of 110 respondents for each of 15 listed climate change impact statements could be ranged from 0 to 330 where 0 indicated no impact and 330 represented maximum impact of a single statement. Data presented in the table 6 indicated that most severe impacts of climate change (as top in ranking) faced by the respondents of the study area were increased frequency and intensity of extreme events (325), decreased fish production (324), decreased soil fertility (321), temperature increased at Summer season (317) and increased drought (314) respectively. The Table 6 also showed that the last three least severe impacts were decreased crop yield (27), increased height of flooding (91) and increased duration of flooding (133) respectively as observed by respondents of the study area.

Agricultural adaptations to climate change in Dekhar haor

Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. The intergovernmental panel on climate change defines adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. It also refers to actions that people, countries, and societies take to adjust to climate change that has occurred. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities. Based on their adaptation score, the farmers were classified into three categories: Low adaptation (0-20), Medium adaptation (21- 35) and High adaptation (>35). The distribution of the farmers according to their overall agricultural adaptation strategies to climate change is shown in Table 7. The majority 54.17% of the farmers had medium adaptation and 45.83% low adaptation and no farmer found with high adaptation (Table 7).

Table 7. Categories of farmer based on agricultural adaptation (calculated CCAI)

Observed range	Categories	Frequency	Percentage	Mean	SD
8-29 (possible range: 0-45)	Low adaptation (0-20)	44	45.83	21.97	3.93
	Medium adaptation (21-35)	52	54.17		
	High adaptation (>35)	0	0		
	Total	96	100.00		

Computed scores of extent of agricultural adaptation to climate change in each of 15 listed climate change adaptation options for 110 respondents, and calculated the climate change adaptation index (CCAI) to compare the extent of adaptations. Distribution of the respondents according to the extent of adaptation in each of 15 listed adaptation options was been shown in table 8 along with CCAI and ranking. The climate change adaptation index (CCAI) of the 110 respondents for each of 15 listed adaptation options could be ranged from 0 to 330 where 0 indicated no adaptation and 330 represented highest adaptation of a single measure. Data presented in the Table 8 indicated that most potential options (as top in ranking) adopted by the farmer of the

study area were increased cultivation of short duration crops (289), developed seedbed in separate high land or homestead (272), construction and raising of crop protection

Table 8. Distribution of the respondents based on extent of agricultural adaptation to climate change and ranking of adaptation options

S.N.	Aspect of adaptation	Extent of adaptation (Total data=110)				CCAI	Ranking
		High	Medium	Low	Not ever		
1	Changing cropping pattern	3 (3%)	2 (2%)	101 (91%)	4(4%)	114	10
2	Crop diversification	0	17 (15%)	90 (82%)	3(3%)	124	8
3	Followed modern cultivation system	59 (53%)	44 (40%)	6 (6%)	1 (1%)	271	4
4	Introducing integrated farming system	1(1%)	6 (5%)	97 (88%)	6 (6%)	112	11
5	Followed the weather forecast	0	19 (17%)	82 (75%)	9 (8%)	120	9
6	Increased cultivation of short duration crops	75 (68%)	29 (26%)	6 (6%)	0	289	1
7	Changed sowing and planting time of crops	6 (5%)	45 (41%)	56 (51%)	3 (3%)	164	7
8	Increased livestock rearing (cow, goat, poultry, duck, etc.)	0	4 (4%)	104 (94%)	2 (2%)	112	12
9	Introduced and increased fodder cultivation for livestock	0	0	4 (4%)	106 (96%)	4	15
10	Increased vegetable cultivation	37 (34%)	55 (50%)	17 (15%)	1 (1%)	238	5
11	Increased tendency of conserving water in the ditch for irrigation	1 (1%)	17 (15%)	64 (58%)	28 (26%)	101	13
12	Developed seedbed in separate high land or homestead	55 (50%)	53 (48%)	1 (1%)	1 (1%)	272	2
13	Produced seedling in different slot in different time	14 (13%)	51 (46%)	43 (39%)	2 (2%)	187	6
14	Plantation of Hijol & Koros tree	0	7 (6%)	58 (53%)	45(41%)	72	14
15	Construction and raising of crop protection embankment	52 (47%)	57 (52%)	1 (1%)	0	271	3

embankment (271), followed modern cultivation system (271) and increased vegetable cultivation (238) respectively. The Table 8 also showed that the last three least adopted options were introduced and increased fodder cultivation for livestock (4), plantation of Hijol & Koros tree (72) and increased tendency of conserving water in the ditch for irrigation (101) respectively as observed by respondents of the study area.

Relationship between selected characteristics of the farmers and their agricultural adaptation to climate change

The findings of the relationships between the selected independent and dependent variables of the study explores in this section. The independent variables were age, education, farm size, annual income and extension media contact. The dependent variable was agricultural adaptation to climate change. Summary results of correlation co-efficient (r) between the selected characteristics of the farmers and their agricultural adaptation to climate change has been presented in Table 9. Pearson's Product Moment Co-efficient

Table 9. Correlation between dependent variable (agricultural adaptation to climate change) and independent variables (age, education level, farm size, annual income and extension media contact)

Variable	Age		Education level		Farm size (hector)		Annual income (BDT)		Extension media contact		Agricultural adaptation for climate change	
	R	Sig.	R	Sig.	R	Sig.	R	Sig.	R	Sig.	R	Sig.
Age	1											
Education level	0.039	0.708	1									
Farm size	0.044	0.670	0.495**	0.000	1							
Annual income (BDT)	0.138	0.179	0.273**	0.007	0.730**	0.000	1					
Extension media contact	- 0.096	0.353	0.322**	0.001	0.599**	0.000	0.642**	0.000	1			
Agricultural adaptation to climate change	0.116	0.259	0.383**	0.000	0.422**	0.000	0.309**	0.002	0.300**	0.003	1	

** Correlation is significant at the 0.01 level.

of Correlation (r) was used to test the null hypothesis concerning the relationships between two variables. One percent (0.01) and five percent (0.05) level of probability was used as the basis for rejecting null hypothesis. The result of correlation of co-

efficient test between the selected characteristic of the farmers and their agricultural adaptation to climate change has shown in Table 9. The findings of Table 9 indicated that the age of the farmers had no significant and negative relationship with their agricultural adaptation to climate change. While the other selected characteristics of the farmer: education level, farm size, annual income and extension media contact had significant and positive relationship with their agricultural adaptation to climate change. Thus, it could be said that education level, farm size, annual income and extension media contact of the farmer played an important role on their agricultural adaptation to climate change. Therefore, it could be concluded as the higher the education level, farm size, annual income and extension media contact of the farmers, found the more capability in agricultural adaptation to climate change in the study area. The study conducted by Islam, (2013) also found similar findings in case of relationship between selected characteristics of the farmers and their agricultural adaptation to climate change in drought prone area of Rajshahi Division. The findings indicated that the age of the farmers had no significant and negative relationship with their agricultural adaptation to climate change while the education, firm size, annual income, credit received and cosmopoliteness of the farmers had significant and positive relationship with their agricultural adaptation to climate change. The study area occupies with semi braind soil and considered as semi drought prone area that the correlation analysis indicated that age, education, environmental hazards and impact of climatic change had no significant relationships with their agricultural adaptation to climate change. Credit received and agricultural adaptation to climate change had positively significant relationships. Farm size, annual income, knowledge about climate change and cosmopoliteness of the farmers had highly positive significant relationships with their agricultural adaptation to climate change.

Climatic risks assessment for different sectors of agricultural farming practices in dekhar haor

A number of sectoral policies and plans were developed by the Government of Bangladesh (GoB) since 1990s. Considering the fact that Bangladesh is highly susceptible to climate change, only one sectoral policy on the Haor areas, has considered climate change. The agricultural support services and institutions at the national and local levels need risk information for planning their activities and providing timely services to the ultimate beneficiaries. Better informed decision-support systems can be very efficient and capable of providing need-based information services to the farmers, livestock herders and fisheries. Users of climate information at institutional level need historical climate information, climate monitoring products and forecasting in different time scales for institutional decisions. The agriculture support institutions (extension and research) should offer and also make use of information about agriculturally relevant precipitation indices progress of the precipitation indices from the past to current, near real-time information about the crop state and early-warning systems for humanitarian response. Crop monitoring and yield forecasting allow timely interventions by the government to avoid crisis. The strategies include contingency plans, alternate livelihood options and response plans for food aid (Fig. 1). Large-scale monitoring of agriculture and crop-yield forecasting generally rely on: (i) regionalized analyses of cultivated areas, crop type distribution and crop condition based on near-real-time satellite imagery merged with

available in-situ observations; (ii) meteorological monitoring and mid-term forecasts based on observation networks and model outputs; and (iii) regionalized knowledge of agricultural systems and their sensitivity to meteorological conditions.

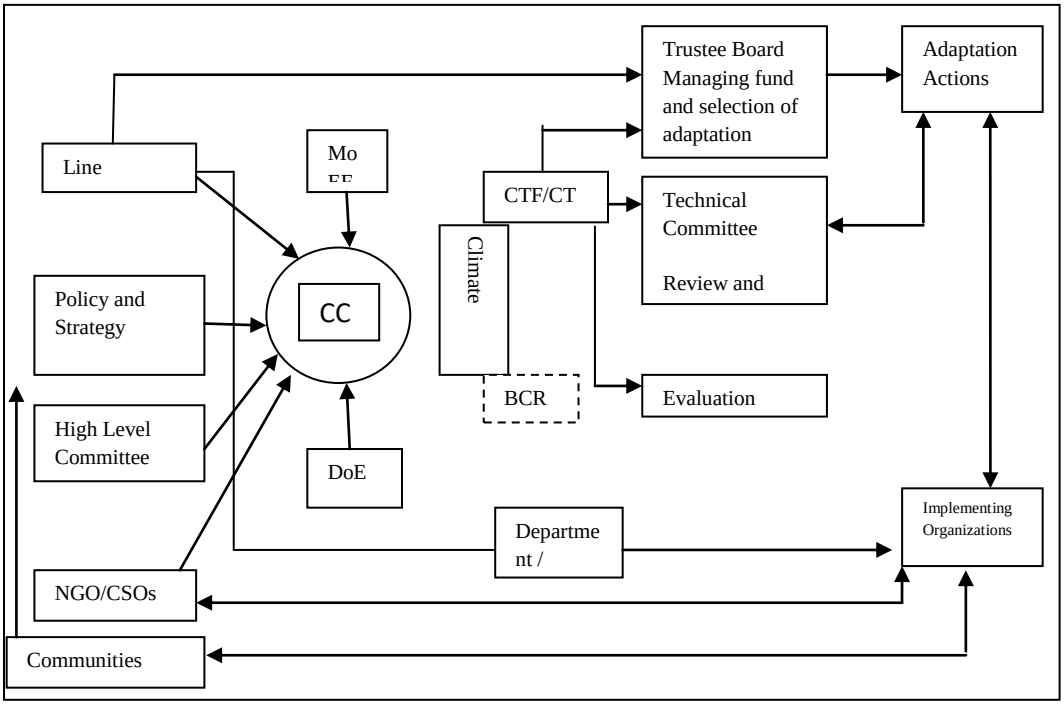

Fig. 1. Conceptual framework on climate change related policy and institutions in Bangladesh

The crop monitoring and yield forecasting capabilities in developing countries are weak and need strengthening at the national level with more emphasis on collection of data such as meteorological, agro-meteorological, soil, remote sensing and agricultural statistics. Climate information at all time scales is crucial to advance risk management and improve sustainable production. The climate information and likely decisions are: (i) climate change scenario to understand the trend and alter system-level decisions (cropping or grazing); (ii) seasonal climate information to make strategic decisions (crop type, marketing, forward selling, livestock herding rate, etc.); (iii) intra-seasonal forecasts to schedule tactical operations (e.g. fertilizer, water and other adjustable inputs); and (iv) weather forecasts for the day-to-day operations. .

Categorization of hazards, impacts and adaptations and interactive analysis

The listed climatic hazards, impacts of climate change (vulnerability) and agricultural adaptations to climate change (capacity) has categorized by different sectors of agricultural farming practices. The interactive analysis of hazards, impacts and adaptations by ranking and index score has expressed the risk situation of respective sector. The risk feature of different sectors has shown in Table 10.

Table 10. Categorization of hazards, impacts and adaptations and interactive analysis by ranking and index score

	Sectors	Hazards (rank)	Impacts (rank)	Adaptations (rank)	Index (score)
1.	Crop Protection	Flash flood (1)			330
		Flood (6)			249
			Increased frequency and intensity of extreme events (1)		325
				Increased cultivation of short duration crops (1)	289
				Construction and raising of crop protection embankment (3)	271
				Increased vegetable cultivation (5)	238
2.	Community Protection	Thunderstorm (2)			328
		Haor wave (5)			249
				Plantation of Hijol & Koros tree (14)	72
3. Fisheries			Decreased fish production (2)		324
				No adaptation measure found	0
4.	Livestock		Decreased availability of fodder from natural source (7)		302
			Decreased livestock production (8)		263
				Increased livestock rearing (cow, goat, poultry, duck, etc.) (12)	112
				Introduced and increased fodder cultivation for livestock (15)	4

Table 10. Contd.

	Sectors	Hazards (rank)	Impacts (rank)	Adaptations (rank)	Index (score)
5.	Environmental Risk of drought	Drought (4)			303
			Increased drought (5)		314
				Changing cropping pattern (10)	114
				Increased tendency of conserving water in the ditch for irrigation (13)	101
6.	Crop Production	Hailstorm (3)			305
		Dew (8)			152
		Tornado (10)			123
			Decreased soil fertility (3)		321
			Increased pest and diseases (6)		304
			Decreased cultivable land (10)		215
			Decreased crop yield (15)		27
				Followed modern cultivation system (4)	271
				Followed the weather forecast (9)	120
				Introducing integrated farming system (11)	112
7.	Haor flooding	Rainstorm (9)			142
			Increased duration of flooding (13)		133
			Increased height of flooding (14)		91
				Produced seedling in different slot in different time (6)	187

Table 10. Contd.

	Sectors	Hazards (rank)	Impacts (rank)	Adaptations (rank)	Index (score)
8.	Changing seasonal feature	Cold (7)			161
			Temperature increased at Summer season (4)		317
			Temperature decreased at Winter season (9)		251
			Changed seasonal diversity (11)		205
			Changed cropping pattern (12)		148
				Changed sowing and planting time of crops (7)	164
				Crop diversification (8)	124
Total		10	15	15	

Identification of the sectors at risk

The following sectors were illustrated as at risk through interactive analysis of climatic hazards, impact of climate change and agricultural adaptation to climate change in Table 10. The graphical comparisons of climatic hazard index (CHI), climate change impact index (CCII) and climate change adaptation index (CCAI) are presented below to understand the risk feature of respective sector:

Crop protection

The interactive analysis in Fig. 2 indicated that the farmer has been adopting some measures to protect the crops from flash flood, flood and other extreme events. Hence the study considered only farmer and community level adaptation practices. But considering the time and scale of flash flood in changing situation, it would be beyond of farmers' copping capacity and it needs government and central level efforts to reduce the risk. So, still now crop protection is the top most burning issue for haor dwellers. Sunamganj District in the Haor region is a highly disaster prone area due to its geological location and geographic formation in particular to flashflood. Role of climate change on flash flood is yet to be established. A recent study by BUET (Islam, 2017), reveals that pre-monsoon rainfall and its intensity may increase in the future. The probability of the occurrence of flash flood will likely be higher in the future due to climate change. From 2000 flash flood hit haor region dated on 30 April 2000, 19 April 2002, 15 April 2004, 03 April 2010 and 17 April 2016. Changes of weather phenomenon and increase of extreme

weather events has already been observed in all over the world. In 2016, new record of warming was set comparing to the modern temperate record dated since 1880 according to the NASA. The mean annual temperature of the planet was warmer above 0.99 ^{O}C than the mid-20th century. The average temperature of the planet has risen about 1.1 degrees Celsius since the late 19th century.

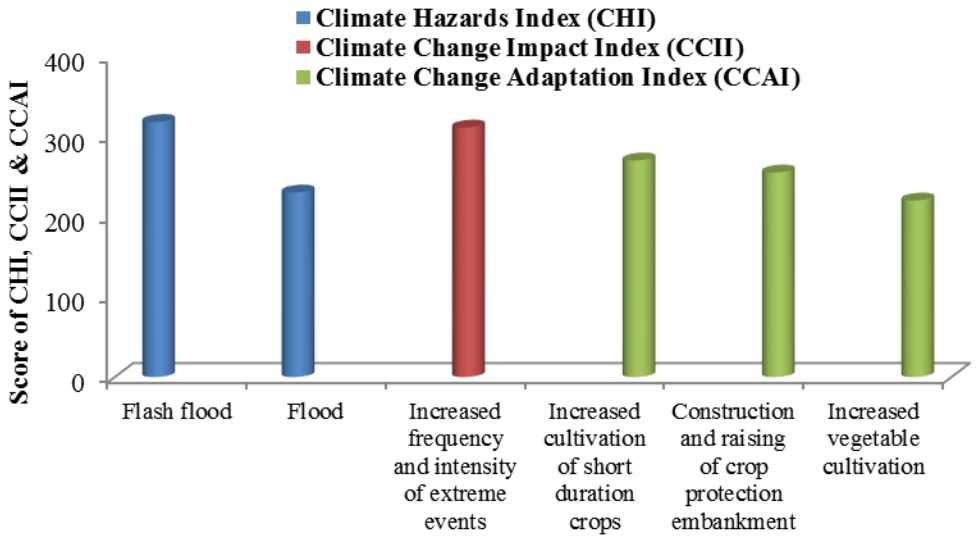

Fig. 2. Interactive analysis of hazard, impact and adaptation for crop protection

Community protection

Haor community is facing two climatic hazards, thunderstorm and haor wave which are potential threat to human life and homestead respectively. The interactive analysis in Fig. 3 indicated that plantation of Hijol & Koros tree was the least adopted option to protect homestead in dekhar haor and no adaptation measure found against thunderstorm. In Bangladesh, the number of thunderstorm and days when thunderstorm occurred has been increasing simultaneously for changing climate during recent years. People died by thunderstorm, about 67% when working in agricultural land, haor, pond, river, etc. The destruction feature of thunderstorm in Table 11 expresses the degree of risk. Through the satellite view analysis of last 10 years, NASA & Maryland University of USA reported that the highest number of thunderstorm occurred in Sunamganj around the world for the month of March-May. More than 25 nos. thunderstorm hit per sq.km in Sunamgonj during March-May. Naturally more thunderstorms occurred in North-East part of country due to its geographical location and topography. During March-May clouds cooled at Kashia Hill and Meghalaya area. Thunderstorm occurred by the friction between layers of clouds, so thunderstorm is more at the foot of this area in Sunamganj.

Fisheries

Fish and paddy are the two major resource of haor. The study found a vital climatic impact that fish production in dekhar haor has decreased crucially, but the interactive analysis in Fig. 4 indicated that no adaptation measure has taken in this contest. The issue was raised vitally in KIIs & FGDs that livelihood of a large number of

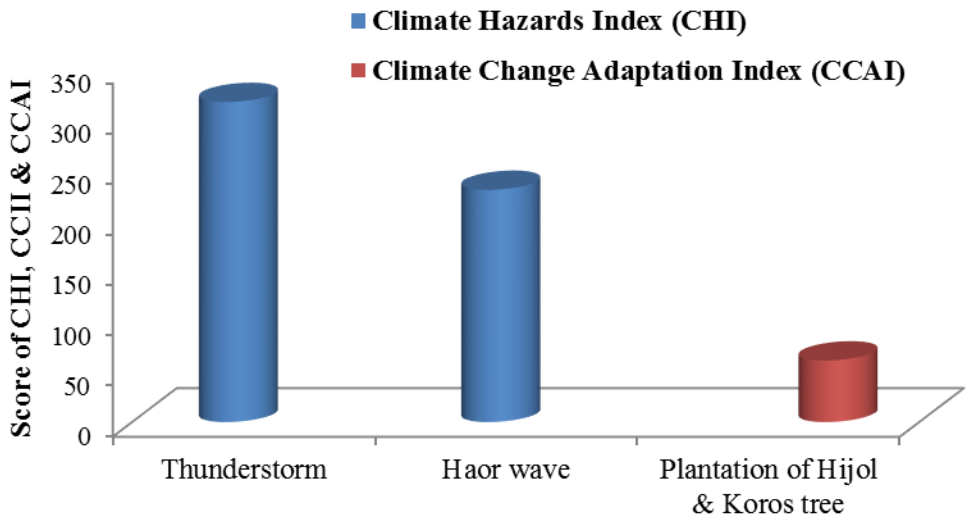

Fig. 3. Interactive analysis of hazard and adaptation for community protection

Table 11. Feature of thunderstorm in Bangladesh & Sunamganj context

Year	Average # of thunderstorm per year	# of person died by thunderstorm	# of person died by thunderstorm on the month of May	Destruction of thunderstorm in Sunamgonj
2011	978	179		
				13 people died in a mosque of Dharmapasha Upazilla on 10th August 2012
2012	1210	301		
2013	1415	285	128	
2014	951	210	79	
2015	1218	274	91	37 people died during last 3 years
2016	1500+	350	132	

(Data source: BMD & BDF, Data own analyses)

fishermen is going to insecure day by day due to mishandle of fish act and regulation. So, fisheries' is most vulnerable sector in research area and need to address to safe livelihood

of haor dwellers. Mazumder *et al.*, (2015) observed in dekhar haor that total fish biodiversity was reducing drastically where about 19 available fish species became unavailable in the study area within 10-15 years. It was reported by the respondent fishers that the availability of fish has been declining due to various manmade and natural reasons. Main reasons for declining fish diversity were siltation, fishing by complete dewatering, indiscriminate fishing, use of illegal fishing gears, use of katha fishing method, use of chemical fertilizers, use of insecticides and pesticides in agriculture, drought in summer, making obstacle in natural movement of fishes through infrastructures etc. However, a total of 65 fish species have remained left in Dekhar Haor that need to be conserved.

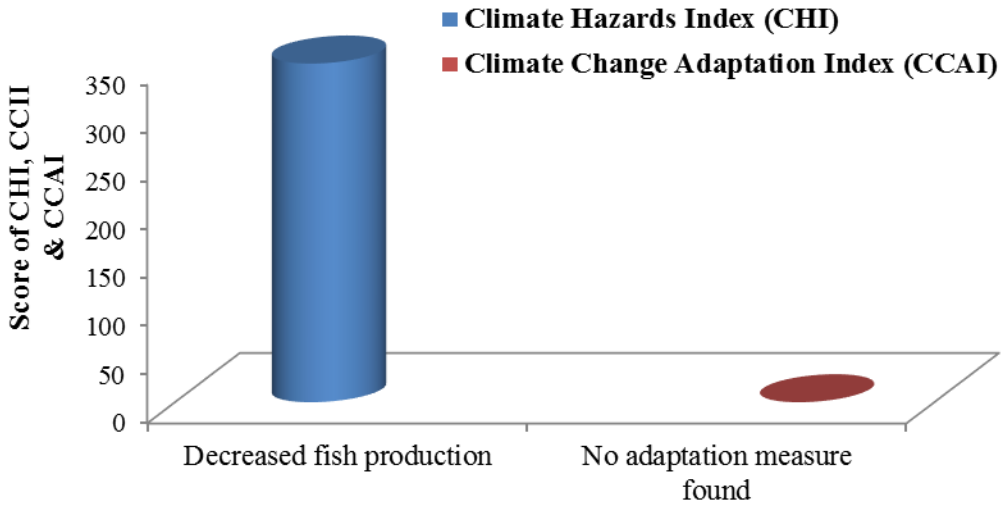

Fig. 4. Interactive analysis of climatic impact and adaptation for fisheries sector

Livestock

Livestock (cow, goat, sheep, check, duck, peacock, etc. rearing) sector could be an alternative livelihood intervention for haor dwellers to reduce climatic risk by minimizing dependency on only boro paddy. Livestock scenario in dekhar haor has discussed in KIIs & FGDs vitally that livestock rearing increased in small scale as commercial firm (chick & duck rearing) but decreased in widespread at household level, resulting livestock production has been decreasing day by day. To assess the livestock perspective in Dekhar Haor, the interactive analysis in Fig. 5 indicated that a very minimal scale of adaptation found in fodder cultivation and livestock rearing in contest to two climatic impacts in availability of fodder and livestock production with high scale. So, the study disclosed the livestock sector as at risk and need to be emphasized for the improvement of poor haor dwellers.

Risk of drought

Drought is one of the main problems which hamper the estimated agricultural production in Bangladesh over the last few decades. Causes of drought are related to non-availability of surface water resources and a shortage of rainfall. Now, haor agriculture is also

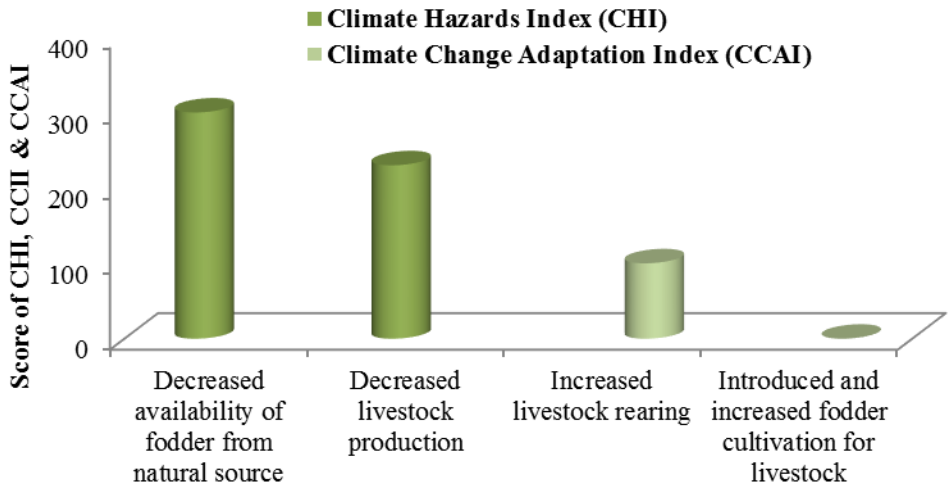

Fig. 5. Interactive analysis of climatic impact and adaptation for livestock sector

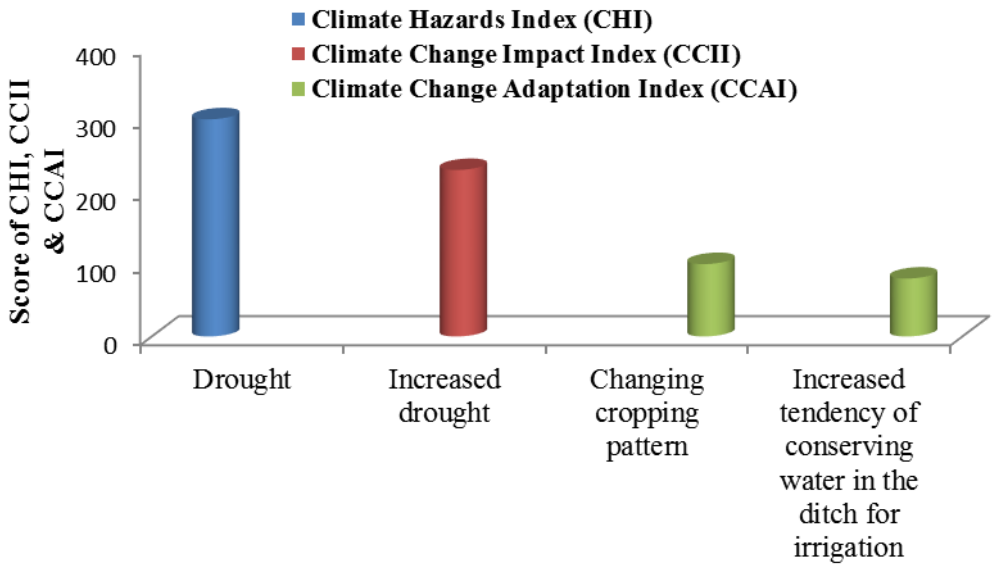

Fig. 6. Interactive analysis of hazard, impact and adaptation for risk of draught

susceptible to draught. The interactive analysis in Fig. 6 indicated that draught was one of the top most potential climatic hazards in the study area and it is increasing due to climatic impact in high scale, but very small scale of adaptation found in cropping pattern and conserving water which are not in satisfactory level. So, the risk of draught in dekhar haor needs to be addressed.

Conclusion and Recommendations

The study disclosed the agricultural sectors such as crop protection, community protection, fisheries, livestock and risk of draught are at climatic risk which needs to address by intensive research and risk reduction measures. During FGDs and KIIs, the respondents raised their opinions to take necessary initiative by government and nongovernment organization to mitigate the climatic risks in dekhar haor. Transible mitigation measures recommended in addressing the areas at risks: Introduction of short duration variety of boro rice to reduce risk of early flash flood and intensification of homestead vegetable cultivation and floating vegetable cultivation, crop diversification and increasing livestock rearing at household level to reduce dependency on mono crop (boro rice). Construction of the temporary earthen embankment duly and compartmental embankments cum submergible concrete road with adequate number of culvert and establishment of sluice gate or rubber dam on Mohasing River to protect dekhar haor from early flash flood. Enhance people's awareness to stay in house during thunderstorm (particularly on the month of March-May), establishment of earthling system for high-rise building and massive plantation program (preferably date palm) could be undertaken in dekhar haor to safe human lives from thunderstorm. Digging the beels around dekhar haor, more restocking and caged-fish culture and establishment of sanctuary and community based fisheries management system to increase fish production in dekhar haor. Digging the beels around dekhar haor, more restocking and caged-fish culture and establishment of sanctuary and community based fisheries management system to increase fish production in Dekhar Haor. Establishment of weather station and flash flood forecasting and early warning systems for haor areas and enhance people's knowledge on climate change perspectives: reasons, future scenario, impacts and adaptations, etc. in addressing the climatic risks Different climate change adaptation activists i.e. GoB, INGO, NGO, UN organization, local government, community and farmer etc. should have to be worked together with an integrated long term plan to protect livelihood of more than one lac dekhar haor dwellers. Some adaptations practices have been observed in dekhar haor are (i) Intensive homestead vegetable cultivation, a good practice at Nayagaon village in Dekhar Haor of Joykalas Union under Dakshin Sunamganj (ii) Floating vegetable cultivation,a demonstration of adaptation in dekhar haor at Lakshmansree UP under Sunamganj Sadar (iii) Livestock rearing and grazing in dekhar haor kanda, an opportunity for strengthening alternative livelihood for haor dwellers through introducing fodder cultivation (iv) Mustard cultivation as crop diversification, a crop diversification practice in dekhar haor at Nayagaon village of Joykalas union under Dakshin Sunamganj could be replicated and can help in finding out the strategy in future climate change adaptation.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Andersson, S., Y.R. Bergman, M. Johansson, E. Persson and L. Nyberg. 2013. Efficiency of landslide prevention tools – evaluation of Scandinavian practices. *Int. J. Disaster Risk Reduction.* 3:44–61.

Andersson, S., Y. Falemo and S. Tremblay. 2014. Development of methodology for quantitative landslide risk assessment – example Göta river valley. *Nat. Sci*. 6 (3):130–143.

Bangladesh Disaster Management Reference Handbook, 2015. https://reliefweb.int/sites/reliefweb.int/files/resources/disaster-mgmt-ref-hdbk-bangladesh.pdf

BBS. 2011. Statistical Yearbook of Bangladesh, Bangladesh Bureau of Statistics. Dhaka, Bangladesh.

Burton, I., S. Huq, B. Lim, O. Pilifosova and E.L. Schipper. 2002. From impact assessment to adaptation priorities: the shaping of adaptation policy. *Climate Policy*. 2:145–149.

Climate Change – Scientists View – Do all scientists agree that climate change is occurring and is caused by human activity**.** https://warmheartworldwide.org/climate-change.

CNRS (Center for Natural Resource Studies). 2004. Management of aquatic ecosystems through community husbandry. Feasibility report on MACH (Management of Aquatic Ecosystems through Community Husbandry) outreach program. 10pp.

Department of Agricultural Extension (DAE), 2008. Field Crops wing, Khamar Bari, Farmgate, Dhaka-1215.

DM and RD. 2010. National Plan for Disaster Management 2010-2015, Disaster Management Bureau, Ministry of Food and Disaster Management, Bangladesh.

Intergovernmental Panel on Climate Change (IPCC). 2013. The physical Science Basis. Cambridge University Press, Cambridge.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Climate change impacts, adaptation and vulnerability - Summary for policymakers. Contribution of Working Group II to the Fourth Assessment Report of the IPCC.

Islam, A. 2017. Climate change and crops in haor areas. The Independent. Dhaka.

Khan, S.I. 2010. Wind analysis for wave prediction in haor areas. M. Engg. Thesis, Department of Water Resources Engineering, Bangladesh University of Engineering and Technology, Dhaka.

Master Plan of Haor Areas. 2012. Draft Final Report, Vol. II, Ministry of Water Resources, Bangladesh Haor and Wetland Development Board, Government of the People's Republic of Bangladesh, pp. 1-18

Mazumder, S., K.D. Pandit, M. Kunda, A.H.A. Rashid and M.A. Sufian. 2015. Present Status of Fish Biodiversity in Dekhar Haor, Bangladesh: a Case Study, Department of Aquatic Resource Management, Sylhet Agricultural University, Sylhet-3100, Bangladesh, *World J. of Fish and Marine Sci.* 7(4):278-287.

McBean, G. 2004. Climate change and extreme weather. A basis for action. *Nat. Hazards.* 31 (1):177–190.

Saleh, A., F.M. and M.S. Mondal. 2007. Impact of a Submersible Embankment Projects on Boro Production in Haor Areas, Final Report, IWFM, BUET, Dhaka. Socio demographic characteristics profile. 2000. Advances in quality of life theory and research 2000. Social indicators research series, Volume-4, Edited by Ed Diener and Don R. Rahtz @ Springer Science + Business Media Dordrecht.

UNDP. 2003. User's Guidebook for the Adaptation Policy Framework. Final Draft. United Nations Environmental Programme, New York City, NY.

WB-DRG (World Bank, Development Research Group) 2016. Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population). http://data.worldbank.org/indicator/SI.PO-V.DDAY.

Bangladesh J. Agri. 2022, 47(1): 66-74 *DOI: https://doi.org/10.3329/bjagri.v47i1.60593*

STUDY ON IN VITRO MICROPROPAGATION OF *ROSA SP.*

S. Afrin[1], M. A. Rahman[2*], M. Khalekuzzaman[1], M. M. Hasan[2] A. H. F. Fahim[2] and M. A. Alam[2]

[1]Department of Genetic Engineering and Biotechnology Rajshahi University (RU), Rajshahi;
[2]Spices Research Center, Bangladesh Agricultural Research Institute (BARI), Bogura. Bangladesh

Abstract

Tissue culture has long been recognized as an ideal experimental paradigm for studying the mechanisms governing plant cell growth, division, and physiological and biochemical processes. The present investigation was undertaken to establish a standard method for callus induction, shoot and root regeneration of rose at Genetic Engineering and Biotechnology Laboratory, University of Rajshahi, Bangladesh in 2010. Shoot tip and nodal segments were used as experimental materials excised from field grown plants for callus induction. The direct shoot was observed from both shoot tip and nodal segments for shoot regeneration. *In vitro* regenerated shoot cuttings were used for root regeneration. Proper manipulation of auxin (2, 4 -D and NAA) was used to induce callus from different explants. Different growth regulators (BAP, KIN and GA_3) were casted-off in combination for shoot regeneration and proliferation. Again, different concentrations of auxins (IBA, NAA, and IAA) were applied for root initiation. Among the hormonal supplements used, 2, 4 -D was found best in all respect of callusing response for all types of explants. The highest percentage (90%) of callus induction was observed in media having MS (Murashige and Skoog) + 4.0 mg/L 2, 4 -D. In case of shoot regeneration, 100% of cultured explants regenerated shoot in media with MS + 2.0 mg/L BAP + 0.5 mg/L KIN. While, 2.0 mg/L BAP + 0.5 mg/L KIN + 0.1 mg/L GA_3 induced 100% shoot proliferation. Moreover, for root induction, ½ MS + 1.0 mg/L IBA + 1.0 mg/L NAA proved to be the best (80%) from *in vitro* regenerated shoot cuttings, and the highest mean number of roots was 5.0. Rooted shoots were acclimatized and successfully established in a natural condition where 60% of the transplanted plants survived.

Keywords: Callus induction, Hormones, Micro propagation, Regeneration, Rose root induction, Shoot proliferation

Introduction

Rosa is a genus of approximately 100 species that can be found throughout the Northern Hemisphere's temperate and subtropical climates (Rehder, 1960). The number of chromosomes ranges from 2n = 2x = 14 to 2n = 8x = 56. (Darlington and Wylie, 1955). The rose genome has some of the lowest DNA content of any Angiospermae with *R. wichuraiana* (2n = 14) having a 4C value of only 0.45-0.48 pg (Lloyd, 1986). Hybrid

* Corresponding author: atiksobari26@yahoo.com

Tea (big flowered), Floribunda (cluster flowered), and tiny roses are cultivars that are currently most widely grown in gardens as aesthetic plants (Short and Roberts, 1991). Hybrid Tea and miniature roses are also produced under glass to sell cut flowers and pot plants. Each of these rose classes can bloom at any time during the growing season. The rose, on the other hand, is connected with beauty and special occasions all across the world, and it is the most popular decorative plant in many nations (Loo, 1982). Every year, more than 200 million rose bushes are planted in gardens around the world, representing US$720 million retail market (Short and Roberts, 1991). Sales of almost four billion blossoms with an estimated annual retail value of US$11 billion demonstrate the rose's prominence as a cut flower. Approximately 30 million field-grown plants and 0.5 million cut flowers are marketed in the United Kingdom each year. Cut flowers are in higher demand in continental Europe with 900 million sold annually in just one market at Aalsmere (Holland). On the other hand, rose oil is in high demand in the perfume industry (Krussmann, 1981; Kukreja *et al.*, 1989; Chomchalow and Sahavacharin, 1982). A recessive gene is responsible for this "perpetual blossoming" trait (Hurst, 1941). Wylie (1954) highlighted the modern garden rose's limited genetic foundation claiming that only eight species contributed considerably to their gene pool. Introgressive hybridization attempts to introduce novel genes into current garden roses are hampered by F_1 sterility, which might result from variations in the parents' ploidy levels or chromosomal incompatibility (Short and Roberts, 1991). *R. rugosa* cultivars are commonly used in amenity horticulture, especially for roadside verges and urban environments. They have a longer flowering season than other "species" of roses, despite not having the trait for eternal flowering. The majority of cultivars are very heterozygous and do not produce true to type offspring. As a result, they are vegetatively propagated (Short and Roberts, 1991). Other classes, such as *R. canina* 'Inermis,' *R. multiflora* 'Simplex,' and *R. dumentorum* 'Laxa,' are propagated by budding or grafting onto root stocks of species like *R. canina* 'Inermis,' *R. multiflora* 'Simplex,' and *R. dumentorum* 'Laxa' (Short and Roberts, 1991). The benefits and drawbacks of "own-rooted" plants are significant factors to consider while evaluating the market for micro-propagated roses. Micropropagation is a technique for multiplying significant cultivars using aseptic tissue culture procedures (Short and Roberts, 1991).

Micro-propagation has numerous advantages and applications in commercial nursery operations (Chu, 1986; McCown, 1986; Pierik, 1987; Stimart, 1986). New plantlet within a short period after utilizing a small amount of initial plant tissue, viruses and diseases free plantlet, season independent supply of seedlings throughout the year after utilizing ten times lower space than the conventional technique supplying new subspecies and variety and looking to cultivate challenging plants, such as specific breeds of roses to find more success with the tissue culture process than traditional soil can be ensured by exploiting micropropagation/tissue culture technique (Plant Cell Technology, 2022) in this era of climate change, especially in Bangladesh. In recent years, worldwide research activity on the *in vitro* method of micropropagation has expanded substantially (Murashige, 1977). Bangladesh is no exception when it comes to efforts in poor countries. As a result, this research was carried out to develop a standard method of *in vitro* micropropagation of *Rosa sp.* to encourage commercial production of the plant in Bangladesh.

Materials and Methods

In the present investigation, *Rosa sp.* (L.) was used as experimental material. For *in vitro* culture, shoot tips, nodal segments, leaves, and internodes were used as explants. Explants were collected from the Botanical garden of Rajshahi University. MS (Murashige and Skoog, 1962) media were used for primary culture and their subsequent subculture, callus induction, shoot differentiation and root induction. In all cases, sucrose was added at the rate of 30 g/ml. Growth regulators were added separately to different media according to requirements. Agar was added at the rate of 7 g/ml. Different constituents of MS including growth regulators of the culture media were separated into stock solutions for ready use during the preparation of culture media. Shoots of *Rosa sp.* (L.) were cut into pieces, namely shoot tips, nodal segments, leaves, and internode segments carefully with the help of a forceps and dissecting blade. These explants were taken into a conical flask and thoroughly washed under running tap water for 30 minutes to remove loose contaminates attached to explants. Then these explants were washed with distilled water containing 1% sterilant, namely savlon (v/v) and 2 drops of Tween-80 for 20 minutes to remove gummy substance. This was followed by three successive washing with distilled water to make the material free from savlon. Subsequently, the materials were transferred to running laminar air flow hood. The shoot apices were taken into three sterile conical flasks and suspended in different concentrations of sodium hypochlorite for different periods of 1-10 minutes to ensure a contamination free culture. To remove every trace of the strident, the materials were then washed at least six times with sterile distilled water. The pH was adjusted to 5.8 by using KOH or HCl. The inoculated culture vessels were incubated in a growth chamber containing a special culture environment. The vessels were placed on the shelves of a cupboard in the growth chamber. Unless mentioned specially, cultures were grown in the growth chamber illuminated by 40 watts white fluorescent tubes fitted at a distance of 30-40 cm from the culture shelves. The cultures were maintained at 26 ± 1°C under the warm fluorescent light intensity varied from 2000 to 3000 lux. Generally, the photo-period was maintained as 16 hours light and 8 hours dark. The vessels were checked daily to observe the response.

Results and Discussion

Callus induction is the prerequisite on the way to generate somaclonal variation in plants. MS medium was employed with various concentrations of auxin alone or in combination of auxin and cytokinin to see the callus induction efficiency of different explants. Among them, the highest percentage (90%) of very good callus (+++) induction was observed in MS + 4.0 mg/L 2,4-D, it took 15-20 days to form a complete callus, and the minimum percentage was 40% in MS + 2.0 mg/L 2,4-D after 28-30 days (Fig. 1A). It was white in color, but no regeneration was found when they were sub cultured in a new medium. When the explants were treated with NAA alone, the highest percentage of callus induction was 80% with MS + 4.0 mg/L NAA after 18-20 days and the lowest was 60% with MS + 2.5 mg/L NAA after 28-30 days (Table 1).

In this experiment, 10 different concentrations of BAP + KIN were used to observe their effects on multiple shoot induction from nodal segments. Among those concentrations, 2.0 mg/L BAP+ 0.5 mg/L KIN showed the highest (100%) shoot induction, the maximum number of shoots per plant was 6 and mean length was 4.0 cm approximately after 7-8 days (Table 2). Minimum shoot induction was observed (55%) in 1.0 mg/L BAP + 0.1 mg/L KIN and the number of shoots per plant were 3 and mean length was 1.8 cm approximately after 26-28 days (Table 2).

Table 1. Effects of different concentrations of Auxin in MS medium for callus induction from nodal segments.

Hormonal supplements mg/L	No. of explants inoculated	% of explants produced callus	Mean days to Callusing	Degree of formation of Callus
2,4-D				
2.0	20	40	29.00	+
2.5	20	50	26.00	+
3.0	20	75	19.00	++
4.0	20	90	17.50	+++
4.5	20	70	20.00	++
Mean	20	65	22.30	-
SE	0.00	8.94	2.21	-
NAA				
2.5	20	60	29.00	+
3.0	20	75	21.00	++
4.0	20	80	19.00	+++
5.0	20	70	23.00	++
5.5	20	70	26.00	++
Mean	20	71	23.60	-
SE	0.00	3.32	1.78	-

2, 4 D = Auxin; NAA = Naphthalene Acetic Acid; SE = Standard Error; + = Good; ++ = Better and +++ = Best.

For shoot proliferation growth regulators, especially Cytokinins are one of the most important factors affecting the response (Lane, 1979; Bhojwani, 1980). GA_3 helps in increasing shoot length, MS medium supplemented with different combinations and concentrations of BAP, KIN, and GA_3 were used to observe the growth of *in vitro* cultured shootlets. Results are shown in Table 3. Among all the combinations, 2.0 mg/l BAP + 0.5 mg/L KIN + 0.1 mg/L GA_3 showed very significant (100%) proliferation of shoot (Fig. 1B). Number of shoots per explant was 4 and mean length of shoot was 2.50 cm after 28 days.

Media with different hormonal combinations and concentrations, such as (IBA + NAA, IBA + IAA, IBA + IAA + NAA) were used. Root induction was observed significantly in some media. Medium supplemented with different concentrations (0.2 + 0.2, 0.2 + 0.5, 0.5 + 0.5, 1.0 + 1.0, and 1.0 + 1.5 mg/L) of IBA + NAA were tested to observe the effect of this auxin on root induction with different concentrations. The highest percentage of root induction was found supplemented with 1.0 mg/L IBA + 1.0

Table 2. Effects of different concentrations and combinations of BAP and KIN in MS medium for shoot induction from nodal segments of mature plants.

Hormonal supplements mg/L	No. of explants inoculated	% of explants in which shoot regenerated	Highest no. of shoot produced	Mean length (cm) of longest shoot	Days to shoot regeneration	Degree of shoot growth
BAP+ KIN						
1.0+0.1	20	55	3	1.8	27.00	+
1.5+0.1	20	60	4	2	22.00	+
2.0+0.1	20	65	4	2.5	22.00	++
2.0+0.2	20	88	5	3.5	11.00	+++
1.0+0.2	20	70	4	2.0	19.00	++
2.0+0.4	20	75	4	3.0	18.00	++
2.0+0.5	20	100	6	4.0	7.50	+++
2.5+0.5	20	75	4	3.20	13.50	++
2.5+1.0	20	65	3	3.10	22.50	+
2.5+1.5	20	60	4	2.50	24.00	+
Mean	20	71.30	4.10	2.76	18.65	-
SE	0.00	4.39	0.28	0.23	1.96	-

BAP = Benzyl Amino Purine; KIN = Kinetine; SE = Standard Error; + = Good; ++ = Better and +++ = Best.

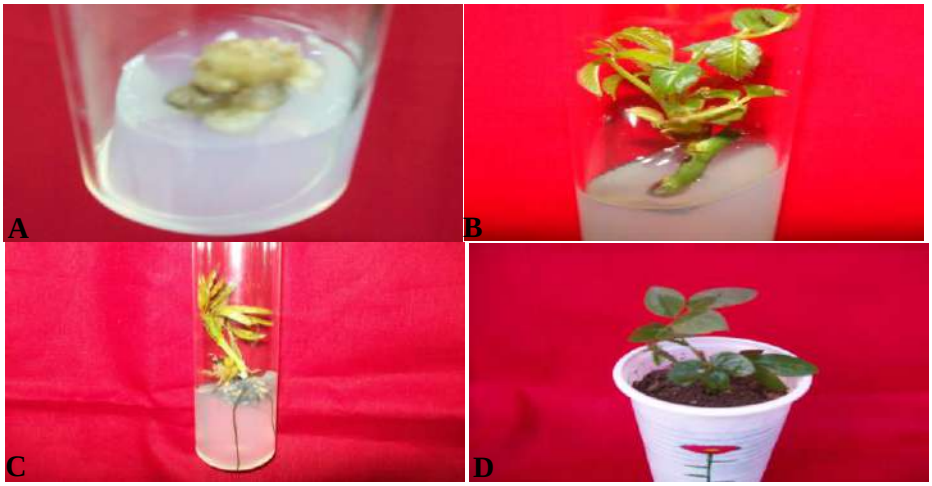

Fig. 1. A-D Plant regeneration in *Rosa sp.* (L.). A. Callus induction with 4.0 mg/L 2, 4-D. B. Multiple shoot regeneration and elongation with MS+2.0 mg/L BAP+0.5 mg/L KIN C. Root induction with ½ MS+1.0 mg/L IBA+1.0 mg/L NAA. D. Potting of rose plant

mg/L NAA. In this case, 80% of the explants produced root within 15-20 days (Fig. 1C). Mean number of roots per explant was 4 and mean length of the longest root was 6.3 cm.

Different concentrations (0.5 + 0.5, 0.5 + 1.0, 0.5 + 1.5, 1.0 + 0.2 and 1.0 + 0.5 mg/L) of IBA + IAA were applied to observe the effect of this auxin on root induction with different concentrations. The highest percentage of root induction was found supplemented with 1.0 mg/L IBA + 0.5 mg/L IAA. In this case, 70% of the explants produced root within 15-18 days.

Table 3. Effects of different concentrations and combinations of BAP, KIN and GA_3 in MS medium for shoot proliferation from explants of *in vitro* cultured plants (Results after 28 days).

Hormonal supplements mg/L	No. of explants inoculated	% of explants proliferated shoot	Mean no. of shoot per explant	Mean length of shoot
BAP+KIN+GA_3				
1.0+0.1+0.01	15	75	1.70	1.34
1.5+0.1+0.05	16	80	2.15	1.50
1.5+0.2+0.07	16	80	2.28	1.26
1.5+0.5+0.10	18	90	3.61	2.44
1.0+0.2+0.10	17	85	2.50	2.00
2.0+0.2+0.10	17	85	2.42	1.98
2.0+0.5+0.10	20	100	4.00	2.50
2.5+0.5+0.10	18	90	3.55	2.00
2.5+1.0+0.15	17	85	2.71	1.90
2.0+1.0+0.15	16	80	1.80	1.16
Mean	17	85	2.67	1.81
SE	0.45	2.24	0.25	0.15

BAP = Benzyl Amino Purine; KIN = Kinetine; GA3 = Gibberellic Acid; SE = Standard Error.

Mean number of roots per explant was 5, and mean length of the longest root was 6.3 cm IBA + IAA + NAA with different concentrations (ranges from (0.5 + 0.2 + 0.2 to 1.0 + 1.0 + 1.0)) were used and 60% explants produced root with the combinations of 0.5 mg/l IBA + 0.5 mg/L IAA + 0.5 mg/L NAA within 18-22 days, mean number of roots were 3.2, and mean length was 3.1 cm (Table 4). About 50% of plant survived following a hardening stage. Micro-propagated *Rosa sp.* (L.) once established in soil, showed vigorous and uniform growth (Fig. 1D). No morphological abnormalities have been observed.

The present study provides a method that ensures micropropagation of *Rosa sp.* (L.). Auxin is carefully required for the induction of callus from variety of tissue explants except cambial tissue that proliferate without an exogenous supply of Auxin. Many researchers observed, 2, 4-D as the best Auxin for callus induction as common as even in dicot (Nadel *et al.,* 1989). Similar effects were seen during using 2, 4 -D for callus induction. Duran villa *et al.,* (1989) reported that nodal segments of citrus species (seedling) showed good shoot in MS medium supplemented with 3.0 mg/L BAP.

Hasegawa (1980) reported that nodal explants of rose responded better in BAP-KIN combination with BAP. The findings of the present investigation showed full similarities with the reports of Hasegawa (1980). The best rooting (up to 100%) was obtained by culture on half strength MS medium with 0.15 mg/L NAA (Ognjanov *et al.*, 1989). In some cases, more than one auxin acted synergistically for the induction of roots e.g., IBA + NAA (0.2 mg/L each) for guava (Duran villa *et al.*, 1989) were used for successful root induction. In the present investigation also show the similarities with the previous experiments. This technique described here seemed to be adaptable for large micropropagation on *Rosa sp.* (L.) and can be applied for economic purposes.

Table 4. Effects of different concentration and combination of auxin in ½ strength MS medium for root induction from *in vitro* regenerated shoot cuttings.

Hormonal supplements for rooting	No. of shoots sub cultured	Shoots derived from the explants of mature plants.			
		% of explant produced root	Days to root regeneration	Mean no. of roots	Mean length of roots (cm)
IBA + NAA					
0.2 + 0.2	18	10	27.50	2.7	3.0
0.2 + 0.5	18	40	21.00	2.9	4.0
0.5 + 0.5	20	60	19.00	3.2	4.2
1.0 + 1.0	20	80	17.50	5.0	6.3
1.0 + 1.5	20	50	20.00	3.9	5.0
Mean	19.20	48	21.00	3.54	4.50
SE	0.49	11.58	1.72	0.42	0.54
IBA + IAA					
0.5 + 0.5	15	40	22.50	2.5	2.0
0.5 + 1.0	15	50	22.50	3.6	2.5
0.5 + 1.5	18	50	22.50	2.3	3.0
1.0 + 0.2	18	60	19.00	3.9	4.5
1.0 + 0.5	18	70	16.50	4.0	6.0
Mean	16.80	54	20.60	3.26	3.60
SE	0.73	5.10	1.23	0.36	0.73
IBA + IAA + NAA					
0.5 + 0.2 + 0.2	15	30	27.50	2.8	2.5
0.5 + 0.5 + 0.2	15	40	27.50	2.7	3.0
0.5 + 0.5 + 0.5	15	60	20.00	3.2	3.1
1.0 + 0.5 + 0.5	15	50	21.00	2.1	2.5
1.0 + 1.0 + 1.0	15	50	21.00	2.4	3.5
Mean	15	46	23.40	2.64	2.92
SE	0.00	5.10	1.68	0.19	0.19

IBA = Indole Butyric Acid; NAA = Naphthalene Acetic Acid; IAA = Indole Acetic Acid; SE = Standard Error.

Conclusion

For year-round supply of rose and rose products need to have a reliable and disease-free propagule by adopting a sound method where micropropagation would be a panacea. Application of different hormones in different combinations or alone in diverse concentrations for callus formation, shoot regeneration, and root initiation is an effective technique of vegetative propagation of rose. In this study, MS + 4.0 mg/L 2,4-D combination for callusing, MS + 2.0 mg/L BAP + 0.5 mg/L KIN treatment for shoot regeneration, 2.0 mg/L BAP + 0.5 mg/l KIN + 0.1 mg/L GA_3 for shoot proliferation and ½ MS + 1.0 mg/L IBA + 1.0 mg/L NAA for root initiation were observed better for micropropagation of *Rosa sp.* (L.). Rooted shoots after applying the aforesaid method could easily be acclimatized and transplanted in the natural condition for ensuring quality supply of seedlings of commercial cultivars of roses within a short time. This study has provided a technique of micropropagation of *Rosa sp.* (L.) which could effectively be used by progressive gardeners as well as in rose industry.

Acknowledgement

This study was approved and funded by the Genetic Engineering and Biotechnology Department of the University of Rajshahi, Bangladesh.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Chomchalow, N. and O. Sahavacharin. 1982. Role of tissue culture in the development of medicinal plants and spices. In Tissue culture of economically important plants: proceedings of the International Symposium held at the Botany Department, National University of Singapore, Singapore, 28-30 April 1981/edited by AN Rao. COSTED and ANBS (Asian Network for Biological Sciences).

Chu, I.Y. 1986. The application of tissue culture to plant improvement and propagation in the ornamental horticulture industry. In Tissue culture as a plant production system for horticultural crops. Springer, Dordrecht, (pp. 15-33).

Darlington, C.D., J. Ammal, E. J. Ammal and A. P. Wylie. 1955. Chromosome Atlas of Cultivated Plants. Chromosome Atlas of Flowering Plants. By CD Darlington and AP Wylie. George Allen & Unwin.

Hasegawa, P.M. 1980. Factors affecting shoot and root initiation from cultured rose shoot tips. *J. Americ. Soc. for Hort. Sci.* 105(2):216-220.

Hurst, C.C. 1941. Notes on the origin and evolution of our garden roses. *J. Royal Hort. Soc*. 66: 282-289.

Krussmann, G. 1981. The complete book of roses. Timber Press, Portland, OR.

Kukreja, A.K. 1989. Tissue culture and biotechnology of medicinal and aromatic plants.

Lloyd, D. 1986. The induction, *in vitro*, of chromosomal variation in Rosa (Doctoral dissertation, North East London Polytechnic).

Loo, S.W. 1982. Perspective on the application of plant cell & tissue culture. In Plant tissue culture 1982: proceedings, 5th International Congress of *Plant, Tissue and Cell Culture* held at Tokyo and Lake Yamanake, Japan, July 11-16, 1982/edited by Akio Fujiwara. Tokyo: Japanese Association for Plant Tissue Culture.

McCown, B.H. 1986. Woody ornamentals, shade trees, and conifers. In Tissue culture as a plant production system for horticultural crops. Springer, Dordrecht, pp. 333-342.

Murashige, T. 1977. Clonal crops through tissue culture. In Plant tissue culture and its bio-technological application. Springer, Berlin, Heidelberg, (pp. 392-403).

Murashige, T. and F. Skoog, 1962. A revised medium for rapid growth and bio assays with tobacco tissue cultures. *Physiol. plantarum*. 15(3):473-497.

Nadel, B.L., A. Altman and M. Ziv. 1989. Regulation of somatic embryogenesis in celery cell suspensions. *Plant Cell, Tissue and Organ Cul.* 18(2):181-189.

Ognjanov, V. 1989. Kultura antera i delova sejanaca breskve *in vitro. Jug. Voc*. 23(87/88):471-477.

Pierik, R.L.M. 1987. *In vitro* culture of higher plants as a tool in the propagation of horticultural crops. In international symposium on propagation of ornamental plants, 226:25-40.

Plant Cell Technology. 2022. Accessed on 06 February 2022 from https://www.plantcell technology.com

Rehder, A. 1960. Manual of cultivated trees and shrubs hardy in North America, 2nd edn. Springer, Berlin, Heidelberg, New York.

Short, K.C. and A.V. Roberts. 1991. *Rosa spp.*(roses): *In vitro* culture, micropropagation, and the production of secondary products. In Medicinal and Aromatic Springer, Berlin, Heidelberg, Plants III (pp. 376-397).

Stimart, D.P. 1986. Commercial micropropagation of florist flower crops. In Tissue culture as a plant production system for horticultural crops, Springer, Dordrecht. pp. 301-315.

Bangladesh J. Agri. 2022, 47(1):75-87 *DOI: https://doi.org/10.3329/bjagri.v47i1.60594*

STUDIES ON THE ETHNO-MEDICINAL PLANTS AND THEIR TRADITIONAL USES AMONG THE MARMA COMMUNITY OF ROWANGCHHARI UPAZILA OF BANDARBAN DISTRICT, BANGLADESH

M. S. Alam[1*], M. M. Rahman[2], R. Haider[1], T. K. Ray[1] and M. M. Rahman[3]

[1]Minor Forest Products Division, Bangladesh Forest Research Institute (BFRI), Chattogram; [2]Department of Botany, Jahangirnagar University (JU), Dhaka; [3]Institute of Disaster Management and Vulnerability Studies, Dhaka University (DU), Dhaka. Bangladesh

Abstract

Indigenous communities of the Rowangchhari upazila mostly depend on ethnomedicine for their primary health care. The purpose of the present study was to document significantly distinguishable ethno-medicinal plants and their ethno-pharmacological applications among the Marma community of Rowangchhari upazila of Bandarban Hill District. In this study, interviews and group discussion were conducted from July 2019 to December 2021 to obtain ethno medicinal data from the local herbalist and elderly villagers. Simultaneously, medicinal plants were also collected and recorded from natural wild habitats as well as from local markets during the study period. Local/village doctors (Baiddays) were also consulted regarding the names and uses of traditional medicinal treatments. In this study, a total of 81 medicinal plant species under 76 genera and 42 families have been recorded and documented, which have been used for the treatment of different ailments. Plant species used by herbal practitioners are mostly herbs (38%) and the representative from Euphorbiaceae family contained the maximum species (8). The most frequent usage category of ailments reported was skin problems. The majority of the remedies were prepared from juice (38%) and leaves were the most frequently used plant part (42%). The most widely used medicinal plants included, *Achyranthes aspera* L., *Terminalia chebula* Retz., *Abelmoschus moschatus* Medik., *Ageratum conyzoides* L., *Blumea balsamifera* DC. and *Centella asiatica* (L.) etc.

Keywords: Marma, Medicinal plants, Rowangchhari, Traditional uses

Introduction

Human beings are indispensably dependent on plants for their survival. Use of plants to treat several ailments has been a prehistoric value in human civilization. Still now plants are key source of therapeutic drugs. According to the World Health Organization (WHO), more than 80% of people in under developed countries rely on traditional medicine (Behera, 2006) the majority of which is derived from plants (Senthilkumar *et al*., 2013). For the majority of rural populations, medicinal plants play a key role in primary healthcare systems (Hamayun *et al.,* 2003). The indigenous people of different countries of the world, living amid nature, have first-hand knowledge on

* Corresponding author: sahalam25@yahoo.com

benefits provides by the plants including medicinal value. Plants were utilized not just for the treatment of various ailments, but also as preventative measures against various ailments (Rahmatullah *et al.,* 2010). A number of significant modern pharmaceuticals have been derivative from plants used by indigenous people (Balick and Cox, 1996) including antibiotics, anti-malarial drugs, cardiotonics, sympatho and para-sympathomimetics etc. Yusuf *et al*., (2007) provide information on 69 medicinal plants used by the Chittagong Hill Tracts tribal people. Mohiuddin *et al*. (2012) reported ethno medicinal knowledge on 70 plant species belonging to 36 families that were used by the Marma, Bwam, Murang and Tanchangya tribes in the Bandarban hill areas. According to Rahman, (2010), the majorities of the country's tribal groups live in hilly areas and rely on herbal medicine for primary healthcare.

Ethno medicinal information about the uses of medicinal plants can be a valuable resource for scientists searching for new medications, as well as having a significant bio economic influence in the future (Ghiselin and Landa, 2005). Furthermore, plant-based medicine is becoming more well-known and used around the world (Tugume *et al*., 2016). Indigenous peoples in extreme rural places who live in harmony with nature and preserve a close bond between man and environment are also familiar with the usage of therapeutic plants (Senthilkumar *et al*., 2013). Native knowledge developed by people living in a specific community is unique, and it can help indigenous people develop a sustainable development strategy (Biswas *et al*., 2011). The Marma communities of Chittagong Hill Tracts retain such kind of knowledge particularly from their healthcare perspective, which is transferred from generation to generation by oral directives. The indigenous knowledge may vary within the same community living aloof in almost inaccessible pockets of hilly regions. Marma, commonly known as Maghs, is the second largest tribe in Bandarban hill district, with the majority of members living in inaccessible hills. They use a number of plants for the treatment of different complaints (Alam, 1992). A number of ethno medicinal investigations among herbal practitioners in Bangladesh's Chittagong Hill Tracts have been reported (Motaleb *et al.,* 2013; Yusuf *et al.,* 2006; Rahman *et al.,* 2007; Rahmatullah *et al.,* 2011; Khisha *et al.,* 2012; Sarker *et al.,* 2012; Esha *et al.,* 2012; Hanif *et al.,* 2009; Uddin *et al.,* 2004).

Most of the Marma tribes have a basic knowledge of medicinal plants that are used for first aid cures for coughs, colds and fever. This type of knowledge passed down through generations mostly by oral tradition. But unfortunately traditional medicinal healers have gradually migrated to other jobs in recent years in search of a better lifestyle. As a result, traditional medical knowledge is rapidly dwindling. Indigenous knowledge must be documented in order to conserve and use biological resources. However, there is very little information available on the ethno-medicinal plants used by Marma communities. The current study was carried out to document some valuable traditional knowledge on herbal treatment by Marma communities of Rowangchhari upazila in the Bandarban Hill District.

Materials and Methods

The present investigation was carried out for about two and a half years from July 2019 to December 2021 in Rowangchhari upazila in the Bandarban Hills District of Bangladesh. Total area of Rowangchhari upazila is 442.89 sq km, located in between 22°03' and 22°20' north latitudes and in between 92°14' and 92°30' east longitudes. The

upazila consists of 4 Unions/Wards, 15 Mauzas/Mahallas. The total population of Roangchhari upazila is 27,264. Of these, 14,243 are males and 13,021 are females. A total of 8.51% of the population is Muslim, Hindu, 0.97%, 68.90%, Buddhists, Christians, 16.64% and 4.98% others (BBS, 2011). The upazila is inhabited by Marma, Chakma, Tripura, Thanchangya, Murang, Bawm, Kheyang, Khumi and other ethnic groups. The Marmas are the largest tribe inhabiting the forested hilly region in the Rowangchhari upazila of Bandarban Hill District. Three different paras namely Mandui para, Rowangchhari bazar para and Bijoy para were randomly selected to execute the present investigation. Documentation was made by conducting as many random interviews as possible with traditional health practitioners, elderly men and women. The interview procedure was chosen by employing open-ended and semi-structured questioning techniques, which were then noted. Information collected on the mentioned local names, uses, and methods of use, diseases for which the formulations were used and dosages. For better information about ethno medicinal plants three prominent seasons (winter, summer and monsoon) of the year were selected. An interpreter was involved during data collection and sharing who had translated the local language into Bengali. To validate the collected information, it was cross-checked in the field. The common plant samples were identified in the field by the authors and the unidentified species were preserved in the herbarium sheet and finally identified with the help of plant taxonomists of Forest Botany Division of Bangladesh Forest Research Institute, Chattogram and Bangladesh National Herbarium, Dhaka. Voucher specimens were deposited in the herbarium of Bangladesh Forest Research Institute (BFRI).

Results and Discussion

The present study documented 81 plant species under 42 families in 76 genera that are traditionally used for the treatment of 99 different health conditions (Table 1). The plants are listed with their scientific name, vernacular name, Marma name, habit, plant parts used, mode of use and ailments treated. Among the families, Euphorbiaceae represented the highest number of (8) of medicinal plant species, followed by Asteraceae (7), Lamiaceae (5), Apocynaceae and Zingiberaceae (4), Acanthaceae, Caesalpiniaceae and Solanaceae (3), Araceae, Fabaceae, Malvaceae, Mimosaceae, Piperaceae, Rubiaceae, Rutaceae, Sapindaceae, Scrophulariaceae, Verbenaceae and Vitaceae shared 2 species individually. The rest of the families comprised one species each (Fig. 1). In life form, herbs (38%) were found to be the most used plant, followed by shrubs (27%), trees (21%) and climbers (14%) respectively (Fig. 2). According to Baydoun *et al*., (2015) herbs were dominantly used in herbal preparations due to their medicinal properties and to serve various primary human ailments and therapeutic indications.

The most used plant part was leaves (42%) followed by root (20%), whole plant (12%), bark (9%), rhizome (5%), flower and fruit (4%), seed (2%), stem and latex (1%) (Fig. 3). The simple collection of leaves compared to other parts of the plant makes it a favorite for herbal preparation (Giday *et al*., 2003). Besides, leaves are the most active part of the plant in terms of the production of metabolites and photosynthesis (Ghorbani, 2005). Moreover, easy collection and availability make the leaves and flowering parts common for herbal practitioners (Baydoun *et al*., 2015).

Table 1. List of plants used by the Marma people for treating different ailments

Sl. No	Scientific name	Vernacular Name	Marma Name	Family	Habit	Plant parts used	Ailments
1.	*Abelmoschus moschatus* Medik.	Musakdana	Falu mao wabang	Malvaceae	Herb	Leaf, root and seed	Snake bite, cough, fever, anemia and tonsillitis
2.	*Achyranthes aspera* L.	Apang	Chai-chi	Amaranthaceae	Herb	Whole plant	Carbuncle, constipation, body pain, dropsy and gynecological complexity
3.	*Actinostemma tenerum* Griff.	Golapata	Kangbui	Cucurbitaceae	Herb	Leaf and flower	Hydrocele and abdominal pain
4.	*Adenosma indianum* (Lour.)	Barakesuti	Puro peteng	Scrophulariaceae	Herb	Leaf	Asthma
5.	*Ageratum conyzoides* L.	Fulkuri	Wichee	Asteraceae	Herb	Leaf	Cutting wounds, edema, sneezing, hiccup and headache
6.	*Allophyllus cobbe* (L.) Raeusch.	Aitachita	Si sa calaai	Sapindaceae	Shrub	Leaf and root	Wound healing, skin diseases, hydrocele and rheumatic pain
7.	*Alocasia acuminata* Schoot	Pata bokakachu	Mohra pring	Araceae	Herb	Rhizome and stem sap	Skin diseases and earache
8.	*Alpinia conchigera* Griff.	Konchi elachi	Padagrah	Zingiberaceae	Herb	Rhizome	Gastric pain, dyspepsia, stomach pain and diarrhea
9.	*Alstonia scholaris* (L.) R. Br.	Chhatim	Choilibang	Apocynaceae	Tree	Stem bark and latex	Rheumatic pain, gout and skin diseases
10.	*Baliospermum solanifolium* (Burm. f.)	Danti	Tung kra mon	Euphorbiaceae	Shrub	Leaf, bark and root	Rheumatic pain, enlarged spleen and burning sensation of the body
11.	*Bauhinia acuminata* L.	Shet kanchan	Thangba pang	Caesalpiniaceae	Tree	Leaf, root and bark	Epilepsy, jaundice and leprosy
12.	*Begonia roxburghii* (Miq.) DC.	Gonirakto	Kayokha khine	Begoniaceae	Herb	Whole plant	Stone in urinary tract, intestinal worms, spleen problem and jaundice
13.	*Blumea balsamifera* DC.	Nagor chandal	Seratagun gach	Asteraceae	Shrub	Leaf	Gout, edema, leg pain, cough and chronic eye diseases
14.	*Bridelia retusa* (L.) A. Juss.	Katakoi	Faima	Euphorbiaceae	Tree	Root	Cough, fever and leucorrhoea
15.	*Cardiospermum halicacabum* L.	Lataphatki	Nalamaichi	Sapindaceae	Climber	Whole plant	Whooping cough, chicken pox, healing wounds and asthma
16.	*Centella asiatica* (L.) Urban	Thankuni	Mrang khua	Apiaceae	Herb	Leaf	Blood dysentery, indigestion, conjunctivitis, insomnia and wound heal
17.	*Chromolaena odorata* (L.) R.M.king	Bara shialmuti	Aga bya	Asteraceae	Herb	Whole plant	Cough, gastric and wound heal

Table 1. Contd.

Sl. No	Scientific name	Vernacular Name	Marma Name	Family	Habit	Plant parts used	Ailments
18.	*Cissus quadrangularis* L.	Harjora	Harsanga	Vitaceae	Climber	Whole plant	Fracture bone, indigestion, cancer and peptic ulcer
19.	*Cissus repens* Lam.	Marmaria lata	Oarong khaen	Vitaceae	Climber	Leaf	Jaundice and boils
20.	*Clausena heptaphylla* (Roxb.)	Panmouri	Rowak cu ba	Rutaceae	Shrub	Leaf and root	Cancer, fever, hysteria and mental disorder
21.	*Clerodendrum wallichii* Merr.	Tara tabah bhat	Tara tabo gach	Verbenacaeae	Shrub	Leaf and root	Fever, skin allergy, abdominal pain and boils
22.	*Commelina benghalensis* L.	Dholpata	Marakh aunge	Commelinaceae	Herb	Leaf	Malnutrition, leprosy and sores
23.	*Costus speciosus* (J. Koenig) Sm.	Keu	Premdaba	Costaceae	Herb	Whole plant	Evil spirit, indigestion, paralysis and earache
24.	*Crateva magna* (Lour.) DC.	Barun	Kainthak	Capparaceae	Tree	Stem bark and root	Rheumatic pain and contraceptive
25.	*Curcuma longa* L.	Halud	Nanhuo	Zingiberaceae	Herb	Rhizome	Wound healing, dysentery, fracture bone and stomachache
26.	*Cyclea barbata* Miers	Thangbandri	Tuwang-noyee	Menispermaceae	Climber	Leaf and root	Easy delivery, body pain and epilepsy
27.	*Cymbopogon citratus* (DC.)	Lebugandhi ghas	Chabalan apan	Poaceae	Herb	Leaf	Nasal congestion, cough and tuberculosis
28.	*Datura metal* L.	Dhutura	Dutra gach	Solanaceae	Shrub	Leaf and fruit	Headache, skin diseases and tumor
29.	*Dillenia pentagyna* Roxb.	Hargaza	Harjola	Dilleniaceae	Tree	Bark	Blood dysentery, diarrhea, tuberculosis and pneumonia
30.	*Eclipta prostrata* (L.) L.	kalokeshi	Bahushi	Asteraceae	Herb	Whole plant	Resists hair fall, constipation and boils
31.	*Elatostema papillosum* Wedd.	Silajhara	Pokri	Urticaceae	Herb	Leaf and root	Abscess, pneumonia and paralysis
32.	*Entada rheedii* Spreng.	Gilagach	Gilanoi	Mimosaceae	Climber	Whole plant	Skin diseases, bowel complaints and wound healing
33.	*Ficus hispida* L.f.	Kakdumur	Fah-shai-ba	Moraceae	Tree	Fruit and root	Stop vomiting, epilepsy and menstrual hemorrhage
34.	*Flueggea virosa* (Roxb. *ex* Willd.)	Khaukra	Repapok	Euphorbiaceae	Shrub	Root	Burning eye, small pox and gonorrhea
35.	*Holarrhena antidysenterica* (L.)	Kurchi	Lakthu	Apocynaceae	Tree	Bark	Threadworm, abdominal pain, dysentery and mouth sore
36.	*Ichnocarpus frutiscens* (L.) R. Br.	Syamalota	Langibkhe nuyee	Apocynaceae	Climber	Leaf	Stop bleeding, fever and ham
37.	*Ixora coccinea* L.	Rangon	Kaya machaoi	Rubiaceae	Shrub	Root and flower	Hiccup, fever, leucorrhoea and dysmenorrhea

Table 1. Contd.

Sl. No.	Scientific name	Vernacular Name	Marma Name	Family	Habit	Plant parts used	Ailments
38.	*Jasminum sambac* (L.) Aiton	Beli	Kyaklung pai	Oleaceae	Shrub	Leaf and root	Fever, insect bite, abdominal pain and urinary tract infection
39.	*Jatropha gossypifolia* L.	Laljeol	Karachuni	Euphorbiaceae	Shrub	Leaf and root	Fistula, hydrocele and excessive menstruation
40.	*Justicia adhatoda* L.	Basok pata	Lespu pang	Acanthaceae	Shrub	Leaf	Cough, cold, fever and asthma
41.	*Kaempferia galanga* L.	Sugandi bach	Mirisiga	Zingiberaceae	Herb	Leaf and rhizome	Sore eyes, headache and flatulence
42.	*Leucas zeylanica* (L.) R. Br.	Shetodrone	Pai thung sa	Lamiaceae	Herb	Whole plant	Fever, gout and blistery
43.	*Leucus aspera* (Willd.) Link.	Dondakolos	Pi tung cha	Lamiaceae	Herb	Whole plant	Tonsillitis, cough and headache
44.	*Litsea glutinosa* (Lour.) Robinson	Menda	Cheng pichalla	Lauraceae	Tree	Bark, leaf and root	Joint pain, blood dysentery and tumor
45.	*Melastoma malabathricum* L.	Ban tezpata	Bum bium bam	Melastomaceae	Shrub	Root and leaf	Toothache, boils, dysentery, scabies and gynecological problem
46.	*Merremia vitifolia* (Burm.f.)	Kormolata	Khyai pacha	Convolvulaceae	Climber	Leaf and root	Injury, inflammation and stomachache
47.	*Micromelum minutum* (J. G.Forster)	Dulia	Pukhong cheyinga	Rutaceae	Tree	Leaf and bark	Tooth decay, evil spirit and headache
48.	*Mikania cordata* (Burn. f.) Robinson	Refuzi lata	Woalaban	Asteraceae	Herb	Whole plant	Stop bleeding and wound healing
49.	*Mimosa pudica* L.	Lajjaboti	Khrapaing	Mimosaceae	Shrub	Whole plant	Abscess, filaria, measles, pyorrhea and hydrocele
50.	*Molineria recurvata* (Dryand.)	Satipata	Oli fahok	Liliaceae	Herb	Leaf and root	Stop bleeding and fracture bone
51.	*Ocimum americanum* L.	Bon tulsi	Nung aprou	Lamiaceae	Herb	Leaf	Bronchitis, abdominal pain and nose bleeding
52.	*Ocimum tenuiflorum* L.	Kalo tulsi	Nung gri	Lamiaceae	Shrub	Leaf	Cold, cough, influenza and gastric
53.	*Oroxylum indicum* (L.) Kurz	Khona	Khron sha mi	Bignoniaceae	Tree	Bark and leaf	Headache, body pain, hydrocele, jaundice and tonsillitis
54.	*Paederia foetida* L.	Gandha-bhaduli	Khebang way	Rubiaceae	Climber	Leaf	Stomach disorder, constipation, urticaria, anklitis and gout
55.	*Peperomia pellucida* (L.) H. B. & K.	Luchipata	Fopang pang	Piperaceae	Herb	Whole plant	Allergy, boils, eye inflammation and insect stings
56.	*Persicaria hydropiper* (L.) Spach	Biskatali	Oak tong	Polygonaceae	Herb	Leaf	Joint pain, carbuncles and stomach pain
57.	*Phyllanthus emblica* L.	Amloki	Chacabang	Euphorbiaceae	Tree	Fruit	Anorexia, dyspepsia, flatulence and hair fall

Table 1. Contd.

Sl. No.	Scientific name	Vernacular Name	Marma Name	Family	Habit	Plant parts used	Ailments
58.	*Phyllanthus reticulatus* Poir.	Chitki	Ghung-nel	Euphorbiaceae	Shrub	Leaf and root	Boils, diabetes and malaria,
59.	*Physalis minima* L	Fotka	Pholaopa	Solanaceae	Herb	Whole plant	Easy delivery and insomnia
60.	*Piper longum* L.	Pepul	Shin mang thui	Piperaceae	Climber	Leaf and fruit	Breast pain, body pain, delivery pain and chronic bronchitis
61.	*Plumbago zeylanica* L.	Shet chita	Kain kawk	Plumbaginaceae	Shrub	Leaf and root	Piles, blood dysentery, contraception and irregular menstruation
62.	*Pueraria tuberosa* (Roxb. *ex* Willd.) DC.	Botrajineem	Yang thrih	Fabaceae	Climber	Leaf and flower	Stop bleeding and leprosy
63.	*Rauvolfia serpentina* (L.) Benth. *ex* Kurz.	Sarpagandha	Bhomaraja	Apocynaceae	Shrub	Leaf and root	Hypertension, constipation, swollen of body and schizophrenia
64.	*Ricinus communis* L.	Bherenda	Crakchu	Euphorbiaceae	Shrub	Leaf and seed oil	Constipation, anal fistula, chest pain and mental disorder
65.	*Saraca asoca* (Roxb.) Willd	Ashok	Prajok	Fabaceae	Tree	Bark, leaf and flower	Dysmenorrhea, irregular menstruation, stomachache and dysentery
66.	*Scoparia dulcis* L.	Bandhane	Young boi pru	Scrophulariaceae	Herb	Whole plant	Breast pain, gallstone, earache and jaundice
67.	*Senna alata* (L.) Roxb.	Dadmardhan	Pouchibang	Caesalpiniaceae	Shrub	Leaf	Ringworm, eczema, hookworm and constipation
68.	*Senna tora* (L.) Roxb.	Chakunda	Dang geya	Caesalpiniaceae	Shrub	Leaf	Insanity, cough, eczema and ringworm
69.	*Sida rhombifolia* L.	Lal berela	Preduang lulang	Malvaceae	Shrub	Leaf and root	Pain, quick delivery, burning urination and carbuncle
70.	*Solanum torvum* Swartz.	Tit begun	Kharaing	Solanaceae	Shrub	Root and leaf	Hemorrhage, ear pain, leucorrhoea and tonsillitis
71.	*Spilanthes calva* DC.	Marhatinga	Hangfui	Asteraceae	Herb	Leaf	Knee pain, epilepsy, allergy and snake bite
72.	*Staurogyne argentea* Wall.	Chemdima	Rmbung	Acanthaceae	Herb	Leaf	Jaundice, cancer, gout and body pain
73.	*Sterculia villosa* Roxb. *ex* smith	Udal	Deudal	Sterculiaceae	Tree	Leaf	Burning urination, obesity and impotency
74.	*Suregada multiflora* (A. Juss.) Baill	Maricha	Fa choin da	Euphorbiaceae	Tree	Leaf and root	Rheumatism, pneumonia, cough and fever
75.	*Synedrella nodiflora* (L.) Gaertn.	Relanodi	Hanphui	Asteraceae	Herb	Leaf	Eczema, urticaria and stomachache
76.	*Terminalia chebula* Retz.	Horitaki	Ajubang	Combretaceae	Tree	Fruit	Leucoderma, constipation, ulcer, flatulence, enlarged spleen and diarrhea

Table 1. Contd.

Sl. No.	Scientific name	Vernacular Name	Marma Name	Family	Habit	Plant parts used	Ailments
77.	*Thunbergia grandiflora* (Roxb. *ex* Rottler)	Neel lata	Gain dhaya	Acanthaceae	Climber	Leaf	Leucorrhoea, treat swollen of the body, eye diseases and hysteria
78.	*Vitex negundo* L.	Nishinda	Thoaibai gach	Verbenaceae	Tree	Leaf	Abdominal pain, black fever, headache, cough and asthma
79.	*Woodfordia fruticosa* (L.) Kurz.	Dhaiphul	Se be gra	Lythraceae	Tree	Flower	Skin diseases, diarrhea, dysentery and stop bleeding
80.	*Xanthosoma violaceum* Schott	Dudhkachu	Prinme	Araceae	Herb	Rhizome and leaf	Stop bleeding, rheumatic pain and itchy skin
81.	*Zingiber montanum* (Koen.) Dietrich.	Bon ada	Playu	Zingiberaceae	Herb	Rhizome	Gastric, stomachache, constipation and amenorrhea

To treat different diseases, the most common formulations were prescribed as juice (38%), followed by paste (29%), decoction (16%), pills (9%), powder (5%), curry (2%) and infusion (1%) (Fig. 4). Conforming to Nadembega *et al*. (2011) in traditional herbal drugs, decoction can be considered one of the common forms of herbal formulations because it is very easy to prepare ethnomedicine simply by mixing plant parts with boiling water. Nonetheless, herbal healers of Rowangchhari upazila mostly practiced juice extraction formulations. It is conceivably due to their local adaptation to the harsh situation of Rowangchhari upazila and the tradition they inherited from their predecessor.

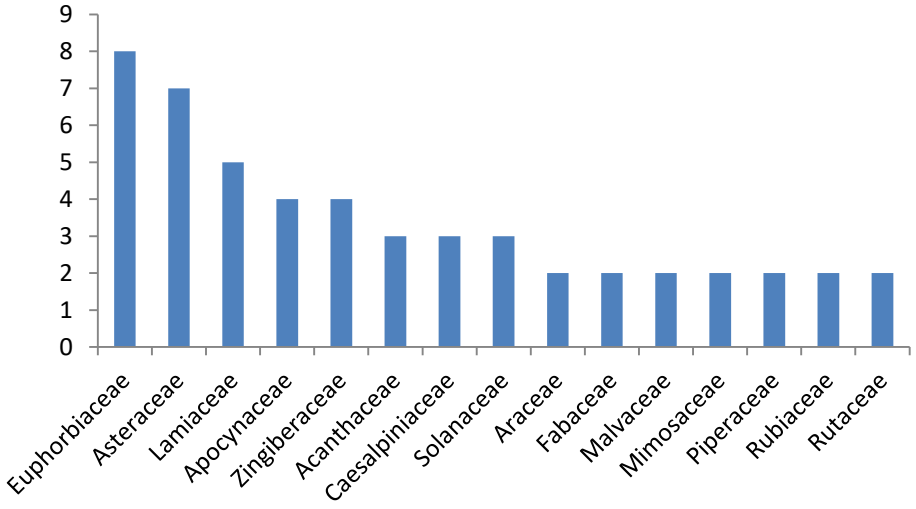

Fig. 1. Ethno medicinal plant species distribution among the dominant 15 family

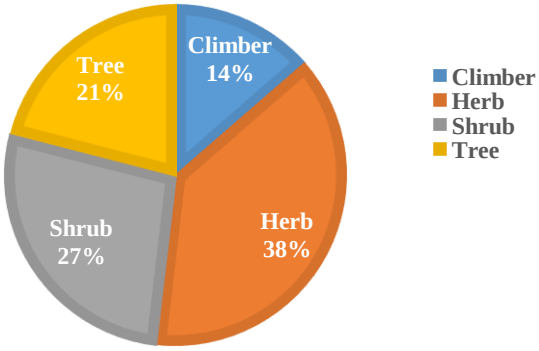

Fig. 2. Habit-wise classification of ethno medicinal plants used by the Marma Community

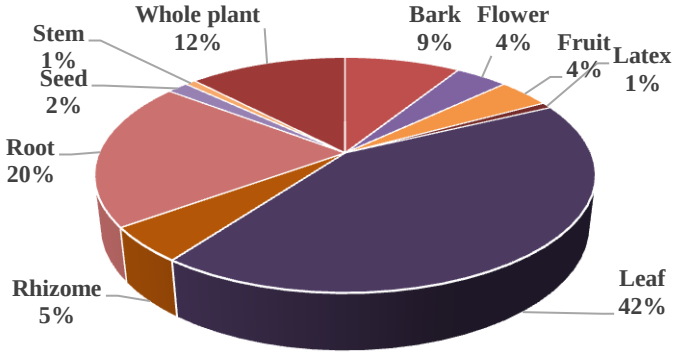

Fig. 3. Percentage of use of plant parts used by the Marma community

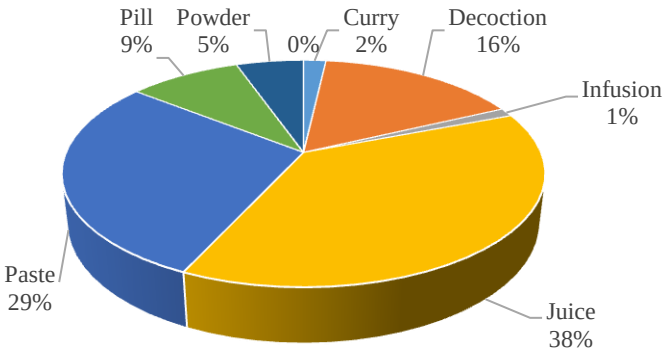

Fig. 4. Modes of providing herbal treatment by the Marma community

A total of 99 diseases or symptoms that were treated by the herbal practitioner were recorded from this study and it was found that skin diseases were treated by most of

the plants (13) followed by cough and fever (11), gastritis (10), constipation, dysentery, Jaundice and stomachache (8 each), body pain, gynecological complexity, headache and rheumatism (7 each), abdominal pain, bleeding and boils (6 each), asthma, gout, hydrocele, mental disorder and tonsillitis (5 each) (Fig. 5). It was reported that *Myrtus communis* was used for dysentery, rheumatism, hemorrhages, diarrhea, gastric ulcer and vomiting (Sumbul *et al.*, 2011). The fruit of *Foeniculum vulgare* was used for diabetes, renal diseases, stomach problems, and hypertension (Jouad *et al.*, 2001). Abe and Ohtani (2013) reported in their study that *Solanum nigrum* is used for the management of hypertension. The ethno medicinal importance of *Agave bracteosa* for breathing problems in children and treating mouth ulcers was discussed by Uniyal *et al.*, (2006). The aerial parts of *Artemisia vulgaris*, a member of family Asteraceae is used for the treatment of diabetes (Qureshi *et al*., 2007). Dulla and Jahan (2017) reported that the entire plant of *Cynodon dactylon* is used to treat tuberculosis and diabetes.

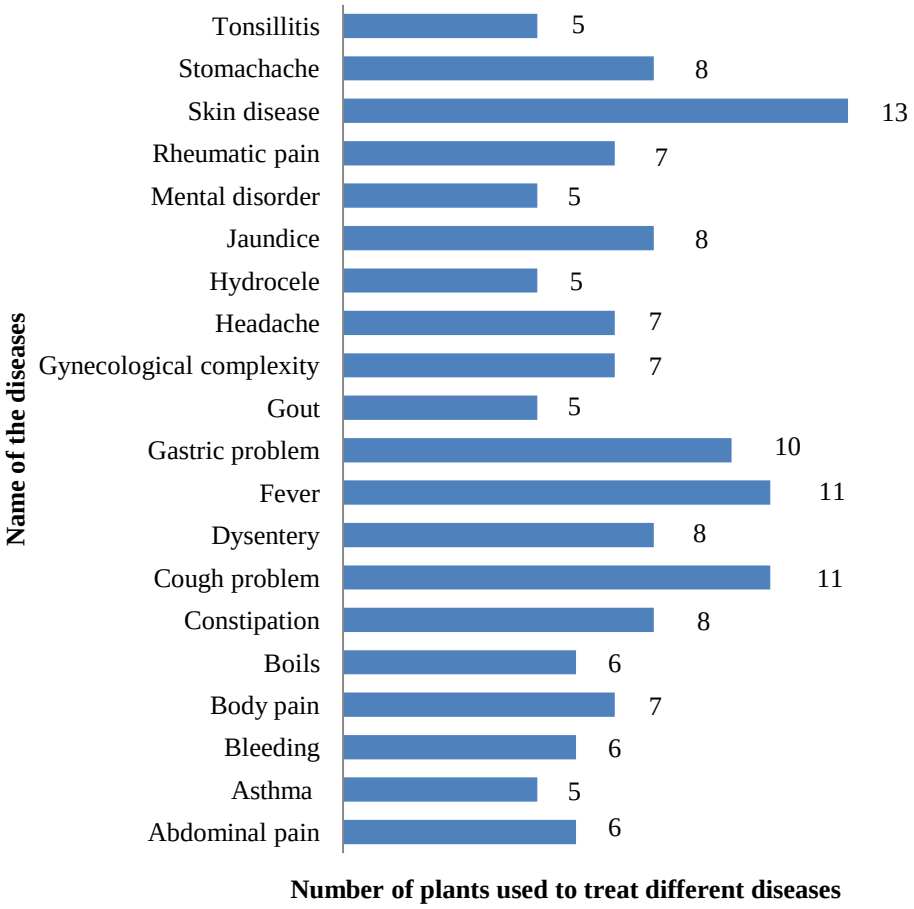

Fig. 5. Number of plants with different ethno medicinal actions (Diseases that used five and above number of plants)

Conclusion

The study revealed that the study area has a great biodiversity with a variety of medicinal plants and still needs more exploration. The local people of the Rowangchhari upazila widely used medicinal plants to treat various human ailments. The usage of these medicinal plants as remedies should be based more on modern scientific study. It is important to take the necessary steps to train the local Baiddays. The study should be expanded to other tribal communities in the Bandarban Hill District in order to identify any previously unknown medicinal plants that have been used for centuries to treat a variety of difficult conditions.

Acknowledgement

We would like to convey our heartfelt gratitude to the National Agricultural Technology Program (NATP Phase-2) of the Bangladesh Agricultural Research Council (BARC), Dhaka for providing financial support to carry out the research work. The authors express gratitude to the traditional healers of Marma's of Rowangchhari who have given the permission for sharing their indigenous knowledge.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Abe, R. and K. Ohtani. 2013. An ethno botanical study of medicinal plants and traditional therapies on Batan Island, the Philippines. *J. Ethnopharmacol*. 145(2):554–565.

Alam, M.K. 1992. Medicinal ethno botany of the Marma tribe of Bangladesh. *Economic Bot*. 46(3):330-335.

Balick, J.M. and P.A. Cox. 1996. Plants, People and Culture: The Science of Ethno botany. Scientific American Library, New York. p.228.

Baydoun, S., L. Chalak, D. Helena and A.N. Apostolides. 2015. Ethno pharmacological Survey of Medicinal Plants Used in Traditional Medicine by the Communities of Mount Hermon, Lebanon. *J. ethnopharmacol*. 173:139-156.

BBS (Bangladesh Bureau of Statistics). 2011. Statistical Year Book of Bangladesh, Ministry of Planning, Government of the Peoples' Republic of Bangladesh.

Behera, K.K. 2006. Ethnomedicinal Plants used by the tribals of similipal bioreserve Orissa, India: A Pilot Study. *Ethnobot. leafl.*10:149-173.

Biswas, K.R., T. Khan, M.N. Monalisa, A. Swarna, T. Ishika, M. Rahman and M. Rahmatullah. 2011. Medicinal plant used by folk medicinal practitioner of four adjoining village of Narail and Jessore district, Bangladesh. *Am.-Eurasian J. Sustain. Agric*. 5(1): 23-33.

Dulla, O and F.I. Jahan. 2017. Ethnopharmacological survey on traditional medicinal plants at Kalaroa Upazila, Satkhira District, Khulna Division, Bangladesh. *J. Intercult Ethnopharmacol*. 6(3):316–325.

Esha, R.T., M.R. Chowdhury, S. Adhikary, K.M.A. Haque, M. Acharjee, M. Nurunnnabi and Z. Khatun. 2012. Medicinal plants used by tribal medicinal practitioners of three clans of the chakma tribe residing in Rangamati district, Bangladesh. *Am. - Eurasian J. Sustain. Agric*. 6(2):74-84.

Ghiselin, M. and J. Landa. 2005. The economics and bio economics of folk and scientific classification. *J. Bioecon*. 7(3):221-238.

Ghorbani, A. 2005. Studies on pharmaceutical ethnobotany in the region of Turkmen Sahara, North of Iran: (part 1): general results. *J. Ethnopharmacol*. 102(1):58-68.

Giday, M., Z. Asfaw, T. Elmqvist and Z. Woldu. 2003. An ethnobotanical study of medicinal plants used by the Zay people in Ethopia. *J. Ethnopharmacol*. 85(1):43-52.

Hamayun, M., M.A. Khan and S. Begum. 2003. Marketing of medicinal plants of Utror-Gabral Valleys, Swat. Pakistan. *J. Ethnobot.* Leaflets. SIUC USA.

Hanif, A., M. S. Hossan, M.M.K. Mia, M.J. Islam, R. Jahan and M. Rahmatullah. 2009. Ethnobotanical survey of the Rakhain tribe inhabiting the Chittagong Hill Tracts region of Bangladesh. *Am. - Eurasian J. Sustain. Agric*. 3 (2):172-180.

Jouad, H., M. Haloui, H. Rhiouani, J. Hilaly and M. Eddouks. 2001. Ethnobotanical survey of medicinal plants used for the treatment of diabetes, cardiac and renal dis-eases in the North centre region of Morocco (Fez–Boulemane). *J. Ethnopharmacol*. 77(2-3):175–182.

Khisha, T., R. Karim, S.R. Chowdhury and R. Banoo. 2012. Ethnomedical Studies of Chakma Communities of Chittagong Hill Tracts, Bangladesh. *Bangladesh J. Pharmacol*. 15(1):59-67.

Mohiuddin, M., M.K. Alam, S.R. Basak and M.K. Hossain. 2012. Ethno-medico Botanical Study among the Four Indigenous Communities of Bandarban, Bangladesh, *Bangladesh J. Plant Taxon*. 19(1): 45-53.

Motaleb, M.A., M.K. Hossain, M.K. Alam, M.M.A.A. Mamun and M. Sultana. 2013. Commonly used Medicinal Herbs and Shrubs by Traditional Herbal Practitioners: Glimpses from Thanchi upazila of Bandarban. IUCN (International Union for Conservation of Nature), Dhaka, Bangladesh. i-xii 294.

Nadembega, P., J.I. Boussin, J.B. Nikiema, F. Poli and F. Antognoni. 2011. Medicinal plants in Baskoure, Kourittenga Province, Burkina Faso: an ethnobotanical study. *J. Ethnopharmacol*. 133 (2):378-395.

Qureshi, R.A., M.A. Ghufran, S.A. Gilani, K. Sultana and M. Ashraf. 2007. Ethnobotanical studies of selected medicinal plants of Sudhan Gali and Ganga Chotti hills, District Bagh, Azad Kashmir. *Pak. J. Bot*. 39 (7):2275–2283.

Rahman, M.A. 2010. Indigenous Knowledge of Herbal Medicines in Bangladesh: Treatment of Skin Diseases by Tribal Communities of the Hill Tracts Districts. *Bangladesh J. Botany.* 39 (2): 169-177.

Rahman, M.A., S.B. Uddin and C.C. Wilcock. 2007. Medicinal Plants used by Chakma Tribe in Hill Tracts Districts of Bangladesh. *Indian J. Tradit. Knowl*. 6(3):508-517.

Rahmatullah, M., A.H. Mollik, M. Ali, B. Abbas, R. Jahan, A. Khatun, S. Seraj and S. Ahsan. 2010. An Ethnomedicinal survey of Vitbilia Village in Sujanagar Sub-District, Bangladesh. *Am. - Eurasian J. Sustain. Agric*. 4(3):302-308.

Rahmatullah, M., P. Chakma, A.K. Paul, D. Nasrin, R. Ahmed, F. Jamal, D. Ferdausi, M. Akber, N. Nahar, S. Ahsan and R. Jahan. 2011. A survey of preventive medicinal plants used by the Chakma residents of Hatimara (south) village of Rangamati district, Bangladesh. *Am.- Eurasian J. Sustain. Agric*. 5(1):92-96.

Sarker, B., F. Akther, U. Ayman, R. Sifa, I. Jahan, M. Sarker, S.K. Chakma, P.K. Podder, Z. Khatun and M. Rahmatullah. 2012. Ethnomedicinal investigations among the Sigibe clan

of the Khumi tribe of Thanchi sub-district in Bandarban district of Bangladesh. *Am.-Eurasian J. Sustain. Agric*. 6(4):378- 386.

Senthilkumar, K., V. Aravindhan and A. Rajendran. 2013. Ethnobotanical Survey of Medicinal Plants Used by Malayali Tribes in Yercaud Hills of Eastern Ghats, *Indian J. Nat. Remedies.* 13(2):118-132.

Sumbul, S., M.A. Ahmed, M. Asif and M. Akhtar. 2011. *Myrtus communis* Linn - A review. *Indian J. Nat. Products and Resources*. 2(4):395–402.

Tugume, P., E.K. Kakudidi, M. Buyinza, J. Namaalwa, M. Kamatenesi, P. Mucunguzi *et al*. 2016. Ethnobotanical survey of medicinal plant species used by communities around Mabira Central Forest Reserve, Uganda. *J. Ethnobiol. Ethnomedicine*. 12(5):1-28.

Uddin, S.N., M. Z. Uddin, M.A. Hassan and M.M. Rahman. 2004. Preliminary ethnomedical plant survey in Khagrachari district, Bangladesh. *Bangladesh J. Plant Taxon*. 11(2): 39-48.

Uniyal, S.K., K.N. Singh, P. Jamwal and B. Lal. 2006. Traditional use of medicinal plants among the tribal communities of Chhota Bhangal, Western Himalaya. *J. Ethnobiol. Ethnomedicine*. 2(1):14.

Yusuf, M., M.A. Wahab, J.U. Chowdhury and J. Begum. 2006. Ethno-medico-botanical Knowledge from Kaukhali Proper and Betbunia of Rangamati District. *Bangladesh J. Plant Taxon*. 13(1):55-61.

Yusuf, M., M.A. Wahab, J.U. Chowdhury and J. Begum. 2007. Some Tribal Medicinal Plants of Chittagong Hill Tracts, Bangladesh, *Bangladesh J. Plant Taxon*. 14(2):117-128.

Bangladesh J. Agri. 2022, 47(1): 88-94 *DOI: https://doi.org/10.3329/bjagri.v47i1.60595*

IDENTIFICATION OF ECTOPARASITES FROM DOMESTIC PIGS OF RANGAMATI DISTRICT

A. Islam[1*], A. K. M. A. Rabbi[1], S. S. Labony[1], M. S. A. Sardar[2] T. Farjana[1] and Anisuzzaman[1]

[1]Department of Parasitology, Bangladesh Agricultural University (BAU), Mymensingh; [2]Central Disease Investigation Laboratory (CDIL), Department of Livestock Services (DLS), Dhaka. Bangladesh

Abstract

Ectoparasite infestations have direct and indirect negative impacts on its host. Ectoparasite fauna of pigs of Bangladesh is not well documented. Our objective was to detect the ectoparasite fauna among the pigs in Rangamati district of Bangladesh. We examined, 480 pigs from 104 households by close inspection and detected one species of louse *(e.g., Haematopinus suis)*, three species of ticks (*Amblyoma testudinarium*, *Haemaphysalis bispinosa*, and *Rhipicephalus sanguineus)*, and one species of flea (*Ctenocephalides canis*). Pathology and economic losses due to the detected ectoparasites in Rangamati district need further investigation for the betterment of the local pig industry.

Keywords: Ectoparasites, Flea, Lice, Pig, Tick

Introduction

Pig raising in Bangladesh is restricted to non-Muslim minority communities only and the total household pig population in Bangladesh was estimated as 3.26 million (BBS 2010). Almost all the pigs raised in Bangladesh are the Eurasian wild boar (*Sus scrofa*) except a few cross-bred pigs between native pigs and European pigs. Pigs play important roles as reservoirs of many zoonotic pathogens (Meng *et al*., 2009). In Bangladesh, pigs are mostly reared in the semi-intensive system (Islam *et al*., 2021), which probably favors the transmission of different diseases, including ectoparasites like lice, tick and mites. Ectoparasite infestation can cause discomfort due to itching and irritation in host animals which may result in irregular feeding and weight losses (Hiepe and Ribbeck, 1975) along with moderate to serious blood loss. Some ectoparasites of pigs like lice and ticks can transmit different protozoan, rickettsial and viral pathogens to the host (Scott, 1988; Liu and Bonnet, 2014). The geo-climatic condition of Bangladesh favors the survival, multiplication and transmission of different ectoparasites. Few previous studies have documented the parasites of pigs from different areas of Bangladesh (Islam *et al.*, 2006a; Islam *et al.*, 2006b). Unfortunately, pig farmers have very limited knowledge about ectoparasites affecting pigs and their harmful effects on their health and production performances. Furthermore, they are not familiar with the use of insecticides or acaricides, even, they have very limited access to veterinary services, which further

*Corresponding author: rajibdvmpara@gmail.com

worsen the situation (Islam *et al*., 2021). Having knowledge about the parasitic fauna of the animal population of a geographic location is important to develop an effective control strategy. This study was conducted to detect the ectoparasite fauna among the pigs in Rangamati district of Bangladesh

Materials and Methods

We examined 480 domestic pigs from 104 households in the Rangamati district during 2015 and 2016 (Fig. 1), located in the Southeastern hilly areas in Bangladesh. After restraining, we thoroughly examined pigs by parting the hair and close inspections and collected ticks, lice and fleas manually from different parts of the body. To collect mites, we made skin scrapings from the external ear and occasionally from other body parts where skin lesions were observed. We preserved ticks, lice, fleas and skin scrapings in 70% ethyl alcohol in labelled glass vials. Parasites were identified following the descriptions of Hoogostraal, (1956) and Soulsby, (1982) by preparing permanent slides following the procedures of Cable, (1957). Descriptive statistics was used to present the data which are in Table 1.

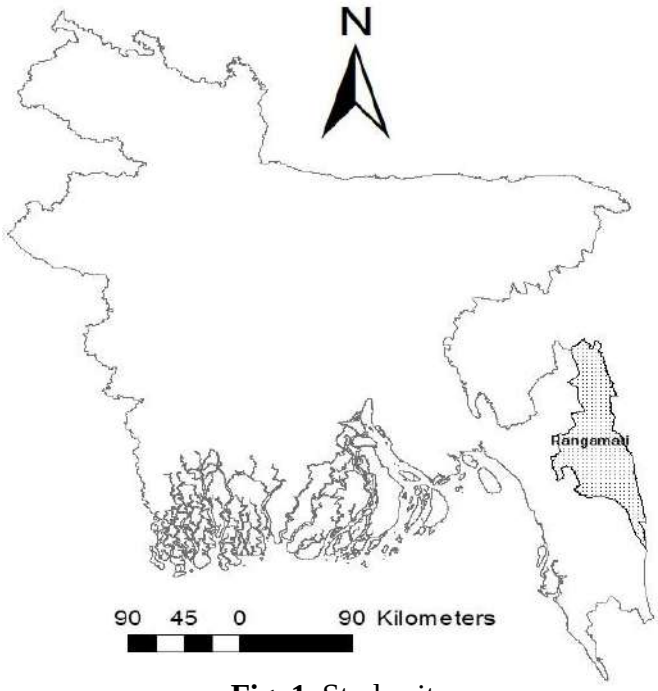

Fig. 1. Study site

Results and Discussion

To determine the occurrence of ectoparasites in pigs in the hilly areas in Bangladesh, we examined 480 pigs from 104 households. Among 104 households surveyed, 89 had local pigs and 15 have cross-bred pigs. Eighty-one farms had 1-5 pigs and 23 households had at least six or more pigs. Ten households were raising pigs

following the scavenging system, 91 following semi-intensive system and only three following intensive system. Scavenging and semi-intensive systems are used to reduce the inputs and maximize the outputs. While examining, we detected one species of louse: *Haematopinus suis* (Fig. 2) three species of ticks: *Amblyoma testudinarium* (Fig. 3), *Haemaphysalis bispinosa* (Fig. 4), and *Rhipicephalus sanguineus* (Fig. 5), and one species of a flea: *Ctenocephalides canis* (Fig. 6). of the parasite detected, the louse *H. suis* was the highest in both local (90%) and cross-bred pigs (93%). However, ticks such as *A. testudinarium* (11%), *H. bispinosa* (5%), and *R. sanguineus* (3%), were present only in local pigs. On the other hand, the flea, *C. canis* was detected both in local (2%) and cross-bred pigs (7%). *H. suis* and *A. testudinarium* were present in both type of households having 1-5 pigs and at least 6 or more pigs. *H. suis* was present among all types of households, however, the highest infestation rate was detected in the intensive system (100%) (Table 1).

Table 1. Ectoparasite in different categories of the households

Parameters	Louse, Number (%)	Tick, Number (%)			Flea, Number (%)
	Haematopinus suis	*Amblyoma testudinarium*	*Haemaphysalis bispinosa*	*Rhipicephalus sanguineus*	*Ctenocephalids canis*
Breed (Number)					
Local (89)	80 (90)	10 (11)	4 (5)	3 (3)	2 (2)
Cross-bred (15)	14 (93)	0	0	0	1 (7)
Number of pigs (Number)					
1-5 (81)	73 (90)	7 (9)	4 (5)	3 (4)	3 (4)
6> (23)	21 (91)	3 (13)	0	0	0
Rearing system (Number)					
Scavenging (10)	7 (70)	4 (40)	1 (10)	0	0
Semi-intensive (91)	84 (92)	6 (7)	3 (3)	3 (3)	3 (3)
Intensive (3)	3 (100)	0	0	0	0

H. suis or hog louse, a common ectoparasite of pigs with global distribution (Damriyasa *et al*., 2004; Nsoso *et al.*, 2006; Mannathoko and Modise, 2006), has been reported to infest pigs of any age group and any health status (Damriyasa *et al*., 2004). Higher infestation in pigs with *H. suis* is usually seen in the farms with higher stock density and in pigs having poor body condition, which also indicates, frequent access to forage outside (Damriyasa *et al*., 2004). A previous study has reported the prevalence of *H. suis* among domestic pigs of Bangladesh (Islam *et al*., 2006a). *H. suis* can mechanically transmit swine pox and African swine fever to pigs (Doster, 1995; Sanchez and Badiola, 1966).

Fig. 2. *H. suis* at 40X magnification

Fig. 3. *A. testudinarium* at 40X magnification

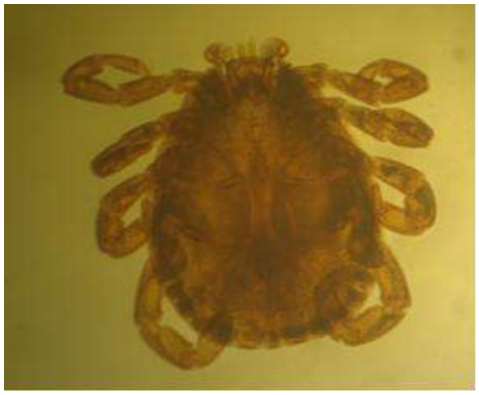

Fig. 4. *H. bispinosa* at 40X magnification

Fig. 5. *R. sanguineus* at 40X magnification

Fig. 6. *C. canis* at 40X magnification

H. suis can carry and spread *Mycoplasma suis*, which causes porcine infectious anemia among pigs (Prullage *et al*., 1993). On the other hand, *A. testudinarium* has been reported to infest and feed on livestock and even humans from different countries (Nakamura-Uchiyama *et al*., 2015; Yamauchi *et al*., 2012). A previous study from Bangladesh has also documented the prevalence of *A. testudinarium* among both cattle and pigs (Islam *et al*., 2006b). Forest areas in the highlands probably provide ideal habitat for *A. testudinarium*, as this tick is distributed more in the arboreal areas of different Asian countries (Hoogstraal *et al*., 1972). *A. testudinarium* can transmit *Ehrlichia chaffeensis* and *Rickettsia tamurae* to humans (Cao *et al*., 2000; Imaoka *et al*., 2011).

H. bispinosa commonly infests ruminants of Bangladesh and is more prevalent in the central part of the country. A previous study from Bangladesh has reported *H. bispinosa* from goats, cattle and buffaloes (Islam *et al*., 2006b). It is a three-host tick and vector of theileriosis, a protozoan disease of the ruminants. Probably this is the first report from Bangladesh of this parasite in pigs. *R. sanguineus* mainly infests dogs and is commonly known as brown dog tick, however, it has also been reported to infest cattle and goats (Islam *et al*., 2006b) in Bangladesh. It is a three-host tick and acts as a vector of babesiosis, ehrlichiosis, and Q-fever. *C. canis* popularly known as dog flea, infest both wild and domestic canids around the globe (Durden *et al*., 2005) and has been reported from dogs, cats, rabbits, rats, gray foxes, red foxes, woodchucks, and humans as well (Fox, 1940). This ectoparasite can act as the intermediate host for the tapeworm *Dipylidium caninum*, and the nematode, *Acanthocheilonema reconditum* (Durden and Hinkle. 2009). In Bangladesh, street dogs and free-roaming cats are very common and probably pigs acquired the flea from either from dog or cat.

Conclusion

Taken together, pigs of Rangamati district were found to be infected with different species of ectoparasites. Pathogenicity, disease transmission and economic losses of the detected ectoparasites in its pig hosts in Rangamati district need further investigation to develop a control strategy for reducing the burden of these parasites.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Bangladesh Bureau of Statistics (BBS). 2010. Report of the household-based livestock and poultry survey 2009. In: Divisions: Ministry of Planning, Government of the People's Republic of Bangladesh.

Cable, R.M. 1957. An Illustrated Laboratory Manual of Parasitology. 4th edn. Burgess publishing Co., Minneapolis, Minnesota, U.S.A.

Cao, W.C., Y.M. Gao, P.H. Zhang, X.T. Zhang, Q.H. Dai, J.S. Dumler, L.Q.F. Fang and H. Yang. 2000. Identification of *Ehrlichia chaffeensis* by nested PCR in ticks from Southern China. *J. Clin. Microbiol*. 38:2778–2780.

Damriyasa, M., K. Failing, R. Volmer, H. Zahner and C. Bauer. 2004. Prevalence, risk factors and economic importance of infestations with Sarcoptes scabiei *and Haematopinus suis* in sows of pig breeding farms in Hesse, Germany. *Med. Vet. Entomol*. 18(4):361–367.

Doster, A.R. 1995. Skin diseases of swine. *J. Swine Health and Prod*. 3:256–261.

Durden, L.A. and N.C. Hinkle. 2009. Fleas (Siphonaptera). In Mullen G, Durden L. (editors). Medical and Veterinary Entomology, 2nd Ed. San Diego, CA. Academic Press.

Durden, L.A., T.N. Judy, J.E. Martin and L.S. Spedding. 2005. Fleas parasitizing domestic dogs in Georgia, USA: Species composition and seasonal abundance. *Vet. Parasitol*. 130:157-162.

Fox, I. 1940. Fleas of Eastern United States. Ames, IA. Collegiate Press.

Hiepe, T. and R. Ribbeck. 1975. The pig louse (*Haematopinus suis*). *Angew. parasitol*. 16:202-208.

Hoogostraal, H. 1956. American Ixodoidea. Vol I. Ticks of the Sudan. 1st edn. Bureau of Medicine and Surgery, Department of Navy.

Hoogstraal, H., B.L. Lim, M. Nadchatram and G. Anastos. 1972. The Gunong Benom Expedition 1967. Ticks (Ixodidae) of Gunong Benom and their altitude distribution, hosts and medical relationships. *Bulletin of the British Museum (Natural History) Zoology, London*. 23:167–186

Imaoka, K., S. Kaneko, K. Tabara, K. Kusatake and E. Morita. 2011. The first human case of *Rickettsia tamurae* infection in Japan. *Case Rep. Dermatol*. 1:68–73.

Islam, A., S. Majumder, Anisuzzaman, A.K.M.A. Rabbi, M.S. Rahman and M.H. Rahman. 2006a. Prevalence and pathology of ticks and lice of pigs in relation to age and management systems in Bangladesh. *Int. J. BioRes*. 1(3):22-27.

Islam, A., A.A. Trisha, M.S.A. Sardar, M. Akbor, A.A. Bhuyan, M.S. Hossain, M.A.Z. Faruk, S. M.K. Sharif, Z. Narar and Anisuzzaman. 2021. Pig raising practices by unprivileged, ethnic people in Bangladesh. *Insights Vet. Sci*. 5:1-5.

Islam, M.K., M.A. Alim, N. Tsuji and M.M.H. Mondal. 2006b. An investigation into the distribution, host-preference and population density of Ixodid ticks affecting domestic animals in Bangladesh. *Trop. Anim. Health. Prod*. 38:485–490.

Liu, X. Y. and S.I. Bonnet. 2014. Hard Tick Factors Implicated in Pathogen Transmission. *PLOS Negl. Trop. Dis*. 8(1):e2566. https://doi.org/10.1371/journal.pntd.0002566.

Meng, X.J., D.S. Lindsay and N. Sriranganathan, 2009. Wild boars as sources for infectious diseases in livestock and humans. *Philos. Trans. R. Soc. Lond. B. Biol. Sci*. 364:2697-2707.

Nakamura-Uchiyama, F., Y. Komuro, A. Yoshii and Y. Nawa. 2015. *Amblyomma testudinarium* Tick Bite: One Case of Engorged Adult and a Case of Extraordinary Number of Larval Tick Infestation. *J. Dermatol*. 27:774-777.

Nsoso, S.J., G.G. Mannathoko and K. Modise. 2006. Monitoring production, health and marketing of indigenous Tswana pigs in Ramotswa village of Botswana. Livest. *Res. Rural Dev*. 18. http://www.lrrd.org/lrrd18/9/nsos18125.htm.

Prullage. J.B., R.E. Williams and S.M. Gaafar. 1993. On the transmissibility of Eperythrozoon suis by *Stomoxys calcitrans* and *Aedes aegypti*. *Vet. Parasitol*. 50:125–135.

Sanchez, C. and C. Badiola 1966. African swine fever virus in *Haematopinus suis*. *Bull. Off. Int. Epizoot*. 66:699–705.

Scott, D.W. 1988. Large Animal Dermatology. 1st edn. W. B. Saunders Company. Harcourt Brace, Javanovich, Inc. Germany.

Soulsby, E.J.L. 1982. Helminths, Arthropods and Protoza of domesticated Animals. 7th edn. Bailliere Tindall, L. London.

Yamauchi, T., A. Takano, M. Munetoshi and H. Kawabata. 2012. Human Infestation by *Amblyomma testudinarium* (Acari: Ixodidae) in Malay Peninsula, Malaysia. *J. Acarol. Soc. Jap*. 21:143-148.

Bangladesh J. Agri. 2022, 47(1): 95-101 *DOI: https://doi.org/10.3329/bjagri.v47i1.60596*

REPRODUCTIVE DISEASES AND DISORDERS OF DAIRY COWS IN THE GAZIPUR DISTRICT

M. R. Islam[1*], A. A. Maruf [2], M. S. I. Sajib[3] and M. M. Hossain[4]

[1]Department of Surgery and Theriogenology, Sher-e-Bangla Agricultural University (SAU), Dhaka; [2]Department of Livestock Services (DLS), Gazipur; [3]Livestock and Dairy Development Project, DLS, Brahmanbaria; [4]Department of Anatomy, Histology and Physiology, SAU, Dhaka. Bangladesh

Abstract

Reproductive diseases and disorders of dairy cows significantly reduce their productivity which is of great concern to dairy producers because most reproductive disorders adversely affect future fertility. The objective of this study was to determine the incidence of reproductive diseases and disorders in dairy cows at Gazipur Sadar Upazila of Bangladesh. A total of 2430 dairy cows from total 150 small (<10 dairy cows) and large scale (>10 dairy cows) dairy farms were studied using predesigned questionnaires during January 2016 to December 2018. Twenty reproductive diseases and disorders were diagnosed. Among them, the major reproductive diseases and disorders were anestrous, mastitis, repeat breeding, metritis, retained placenta, and the minor problems were heat detection diseases and disorders. Total incidence of reproductive diseases and disorders was 21.51%, among the major reproductive diseases and disorders, incidence of anoestrus 6.79%, mastitis 3.66%, repeat breeding 3.20%, metritis 2.34%, retained placenta 1.31% and heat detection 1.06%. The highest occurrence of reproductive disease was anoestrus in dairy cows with low body condition score (BCS $\leq$ 2) than that with fair (2.5) and good ($\geq$3-3.5) body condition scores. Anoestrus, mastitis, and repeat breeder should get top priority considering reproductive diseases and disorders research to gain more knowledge to control them in the study area context.

Keywords: Body condition score, Incidence, Rectal palpation, Reproductive diseases Reproductive disorders, Ultrasonography

Introduction

Reproduction is a vital factor in determining the efficiency of animal production. In cattle production, good reproductive performance is essential to efficient management and production as a whole. However, the successful economy of a dairy farm either large or small scale lies in proper and optimal reproductive rhythm of each individual cow within the normal physiological range. Any deviation in the breeding rhythm or abnormality in the reproductive system results in a progressive economic loss (Islam *et al.,* 2013). In Bangladesh, mostly small-scale dairy producers are depended on crop residues with a limited supply of concentrates. Recently, large-scale dairy producers

Corresponding author: rashed.suth@sau.edu.bd

increased in a number and play an important role to fulfill the milk and meat production and national demand. Reproductive diseases and disorders are the major causes of reduced productivity in cattle that result in failure to produce or delay in producing the annual life calf and reduced lifetime production of cows (Maruf *et al.*, 2012). In case of small ruminant (sheep and goat), the most pressing constraint on goat and sheep reproduction in Bangladesh is dystocia, abortion, and mastitis (Sultan *et al.*, 2015). Reproductive diseases and disorders leading to prolonged intervals between calvings and low conception rate were reported earlier in Bangladesh (Shamsuddin *et al.*, 2001). It is accepted that bovine genital infections, either specific or non-specific in nature, account for the large number of pregnancy failures in cows (Sirohi *et al.*, 1989). Some researchers studied reproductive diseases in large government dairy farms and identified retained placenta, metritis, pyometra, endometritis, cervicitis, persistent corpora lutea, cystic ovaries, and non-functional ovaries (Shamsuddin e*t al.* 1988). The percentage of retained placenta was as high as 42.3% (Ahmed, 2005). Large scale dairy farms increase along with small scale dairy farms. Therefore, a cross-sectional study of the amplitude of reproductive diseases and disorders in small and large scale dairy farms in the Gazipur Sadar Upazila of the Gazipur district

Materials and Methods

Study areas, periods and animals

Gazipur Sadar Upazila in the Gazipur district of Bangladesh was selected as study area. A total of 2430 dairy cows from 150 small (<10 dairy cows) and large scale (≥10 dairy cows) dairy farms were selected. The reproductive diseases and disorders data were collected using predesigned questionnaires from January 2016 to December 2018. Information was collected on the total number of cows in the farms, history of reproductive diseases and disorders, and diagnosed reproductive problems by rectal palpation and ultrasonography. The recorded diseases from computerized and written data serve as an essential tool for the rapid and accurate presumptive diagnosis of incidence of reproductive diseases and disorders in a dairy farm. The incidence rate of reproductive diseases and disorders were calculated from the collected on-farm and recorded data.

Incidence rate of reproductive diseases and disorders = Affected cows/Total cows × 100

The assessment of BCS was done by visual and tactile appraisal of specific body regions to subjectively assess heifer's body energy reserves as fat. A scoring system from 1 to 5 scales with 0.5 fractions is used for scoring body condition (Heuer *et al.*, 1999).

Rectal palpation and ultrasonography

The suspected reproductive diseases and disorders were monitored by rectal palpation and B-mode ultrasonography using a transrectal probe. Briefly, the ultrasound machine (PharVision MicroV10, Classic Medical Supply, Inc., USA) was set near the animal where electrical connection was available. The cows were restrained in a squeeze chute to reduce stress and risk of injury to the animal. Fecal material was evacuated from the rectum and the perineum was washed with clean water. The linear probe was

lubricated with an ultrasound transmission gel (Aquasonic ®, Parker Laboratories, Inc., USA) and was inserted into the rectum, was moved forward over the vagina through the rectum to place it lateral to the cervix. Specific changes on the cervix were identified. Then the body and horn of the uterus were examined and changes were recorded. The ovary was held by the hand in the rectum, was brought in front of the transducer face and the entire ovary was scanned. The development and regression of the corpus luteum and other ovarian changes, such as follicle development, were carefully noted and recorded. The changes in the uterus and cervix were also recorded on the same day.

Statistical analysis

The data obtained from the questionnaire was entered in Microsoft Excel 2016. The data were tabulated, analyzed, and compared in percentages by using the statistical software MINITAB.

Results and Discussion

In total 150 (<10 dairy cows) and large scale (>10 dairy cows) dairy farms were studied for major reproductive diseases and disorders. Anestrous, mastitis, repeat breeding, metritis, retained placenta, poor heat detection, ovarian cysts, abortion, and dystocia were the major reproductive problems. Moreover, the body condition score of cows had a significant effect on the occurrence of reproductive diseases and disorders.

Incidence of reproductive diseases and disorders in dairy cows

Twenty reproductive diseases and disorders were diagnosed in 525 dairy cows among 2430 dairy cows (Table 1). Incidence of reproductive diseases and disorders were 21.51% in total population, among of the diseases and disorders anoestrus 6.79%, mastitis 3.66%, repeat breeder 3.20%, metritis 2.34%, retained placenta 1.31%, early embryonic death 0.53%, poor heat detection 1.06%, ovarian cyst 0.08%, uterine prolapsed 0.08%, vaginal prolapsed 0.28%, still birth 0.16%, abortion 0.57%, fetal mummification 0.20%, dystocia 0.65%, pyometra 0.16%, ovarian tumor 0.12%, cervicitis 0.04%, sulphingitis 0.08%, ovobursal adhesion 0.04% and ovarian atrophy 0.04%. Anestrous was the most important cause of infertility of cows in the study area, mastitis, repeat breeder, metritis, retained placenta, and poor heat detection were the next consequence. The highest proportion of cows suffered from anestrous (31.42%; n=165), and the lowest proportion of cows (0.19%; n=1) had cervicitis, ovarian adhesion, and ovarian atrophy. The mastitis (16.95%; n=89), repeat breeder (14.85%; n=78), metritis (10.85%; n=57), retained placenta (6.09%; n=32), poor heat detection (4.95%; n=26) were diagnosed as major reproductive diseases and disorders. The prevalence of reproductive disorders was 23% in dairy cows in Patiya upazila of the Chittagong district of Bangladesh (Maruf *et al.,* 2012). Our study found the incidence of reproductive diseases and disorders was 21.51% in small and large scale dairy farms in Gazipur Sadar

Table 1. Incidence of reproductive diseases and disorders in dairy cows of Gazipur Sadar Upazilla of the Gazipur District.

Dairy cows	Reproductive diseases and disorders	Affected cows	Incidence of reproductive diseases and disorders (%)	Proportion of reproductive diseases and disorders among affected cows (%)
2430	Anoestrus	165	6.79	31.42
	Mastitis	89	3.66	16.95
	Repeat breeding	78	3.20	14.85
	Metritis	57	2.34	10.85
	Retained placenta	32	1.31	6.09
	Early embryonic death	13	0.53	2.47
	Poor heat detection	26	1.06	4.95
	Ovarian cyst	02	0.08	0.38
	Uterine prolapsed	05	0.20	0.95
	Vaginal prolapsed	07	0.28	1.33
	Still birth	04	0.16	0.76
	Abortion	14	0.57	2.66
	Fetal mummification	05	0.20	0.95
	Dystocia	16	0.65	3.04
	Pyometra	04	0.16	0.76
	Ovarian tumor	03	0.12	0.57
	Cervicitis	01	0.04	0.19
	Sulphingitis	02	0.08	0.38
	Ovobarsal adhesion	01	0.04	0.19
	Ovarian atrophy	01	0.04	0.19
		Total = 525	21.51	

upazila of the Gazipur district. On the other hand, the major reproductive disorders recorded in goats were dystocia (41.21%), abortion (21.83%), mastitis (21.89%), retained placenta (11.82%), and pyometra (3.44%) (Sultan *et al.,* 2015). Similarly, major reproductive disorders in sheep were dystocia (53.71%), abortion (25.0%), pyometra (7.12%), mastitis (7.16%), and retained placenta (7.17%) (Sultan *et al.,* 2015). The occurrence of anoestrus was 6.79%, which was lower than that (26.52%) observed in South West Ethiopia (Bitew and Prasad, 2010). The prevalence of retained fetal membrane was 1.31%. Previously, reported 27.73% cases of retained placenta in Karan Fries cows (Satya Pal, 2003). In comparison, other researchers reported lower incidence of retained fetal membrane (0.31%, 1.47%, 8.28%, and 7.84% respectively) (Shamsuddin *et al.,* 2010). The occurrence of metritis was recorded 25.57% in South West Ethiopia (Molalegne and Shiv, 2011). Our study found the occurrence of metritis was 2.34%.

Retained placenta is an important post-parturient problem in cattle farming. Its incidence can be as high as 12% even in normal delivery, about 63% of the retained placenta out of 750 calving in the Savar Dairy farm; the highest incidence was recorded in March and the lowest in September (Shamsuddin *et al.*, 1988). The incidence of repeat breeding in the present studies was 3.20% which was lower than the findings in Ethiopia (Getachew and Nibret, 2014). In addition to these, communal use of bulls for natural services is also considered as contributing factor reported 5% repeat breeding cases (Shamsuddin *et al.*, 2010). The prevalence rate of pyometra 0.16% was lower than the prevalence rate of Savar dairy farm 8.2% (Shamsuddin *et al.*, 1988).

Body condition score (BCS) and reproductive diseases and disorders

Body condition scores had great effects on reproductive diseases and disorders. In Table 2, BCS 2 or equivalent it was shown that prevalence of anoestrus 18.09%,

Table 2. Incidence of reproductive diseases and disorders on BCS in dairy cows (N=2430); N= Number of observations; n= Number of animals affected.

Reproductive diseases and disorders	Body condition score					
	BCS ≤2, n=525		BCS 2.5, n=890		BCS ≥3-3.5, n=1015	
	No.	%	No.	%	No.	%
Anoestrus	95	18.09	45	5.05	25	2.46
Mastitis	17	3.23	25	2.80	47	4.63
Repeat breeding	19	3.61	27	3.03	34	3.34
Metritis	10	1.90	18	2.02	29	2.85
Retained placenta	05	0.95	09	1.01	18	1.77
Early embryonic death	07	1.33	05	0.95	01	0.09
Poor heat detection	13	2.04	07	0.78	06	0.59
Ovarian cyst	00	00	01	0.11	01	0.09
Uterine prolapsed	00	00	00	00	05	0.49
Vaginal prolapsed	00	00	01	0.11	06	0.59
Still birth	02	0.38	02	0.22	00	00
Abortion	02	0.38	05	0.56	07	0.68
Fetal mummification	01	0.19	04	0.44	00	00
Dystocia	09	1.71	05	0.56	01	0.09
Pyometra	00	00	00	00	04	0.39
Ovarian tumor	00	00	01	0.11	02	0.19
Cervicitis	00	00	00	00	01	0.09
Salphingitis	00	00	02	0.22	00	00
Ovobarsal adhesion	01	0.19	00	00	00	00
Ovarian atrophy	00	00	01	0.11	00	00

mastitis 3.23%, repeat breeder 3.61%, metritis 1.90%, retained placenta 0.95%, early embryonic death 1.33%, poor heat detection 2.04% and dystocia; on BCS 2.5 the prevalence of anoestrus 5.05%, mastitis 2.08%, repeat breeder 3.03%, metritis 2.02%, retained placenta 1.01%, early embryonic death 0.95%, poor heat detection 0.78% and dystocia 0.56%; and on the BCS ≥ 3-3.5 prevalence of anoestrus 2.46%, mastitis 4.63%, repeat breeder 3.34%, metritis 2.85%, retained placenta 1.77%, early embryonic death 0.09%, poor heat detection 0.59% and dystocia 0.09%. The body condition score is an arbitrary scale for estimating the amount of body fat in cows (Wildman *et al.,* 1982). Cows with good BCS (2.5) conceived at a higher rate than did thin (≤2.0) and over-conditioned (>3.5) ones (Maruf *et al.,* 2012). BCS at estrus positively correlates with the conception rate (Roche *et al.,* 2007). This variation might be due to the management system, feeding, and breed of animals.

Conclusion

According to our study anoestrus, mastitis, and repeat breeders are the three most important reproductive diseases and disorders. Knowledge in terms of risk factors and their mitigation already available about these diseases should be extended to farmers to control them.

Acknowledgement

The authors acknowledge the Upazila Livestock Office, Gazipur Sadar, Gazipur for their cordial support to do this research.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Ahmed, W.A. 2005. Overview on some factors negatively affecting ovarian activity in large farm animals. *Global Veterinaria*. 1:53- 66.

Bitew, M. and S. Prasad. 2010. Study on major reproductive health problems in indigenous and cross breed cows in and around bedelle, South West Ethiopia. *J. Animal and Veterinary Advances.* 10:723-727.

Getachew, E. and M. Nibret. 2014. Major reproductive health disorders in cross breed dairy cows in Ada'a district, East Shoa, Ethiopia. *Ethiopia Global Veterinaria*, 13:444-449.

Heuer, C., Y.H. Schukken and P. Dobbelaar. 1999. Postpartum body condition score and results from the first test day milk as predictors of disease, fertility, yield, and culling in commercial dairy herds. *J. Dairy Sci.* 82:295-304.

Islam, M.R., N.S. Juyena, M.M.U., Bhuiyan, M. M. Rahman and R.N. Ferdousy. 2013. Treatment outcomes in postpartum anoestrus cows guided by transrectal ultrasonography. *Progressive Agricul.* 24:93-100.

Maruf, A.A., M.R. Islam, M.M. Rahman, M.M.U. Bhuiyan, and M. Shamsuddin. 2012. Prevalence of reproductive disorders of dairy cows in the Chittagong district of Bangladesh. *Bangladesh Vet J,* 46:11-18.

Molalegne, B. and P. Shiv. 2011. Study on major reproductive health problems in indigenous and cross-Breed cows in and around bedelle, South West Ethiopia. *J Anim Vet Adv*, 10(6): 723-727.

Roche, J.R., K.A. Macdonald, C.R., Burke, J.M. Lee and D. P. Berry. 2007. Associations among body condition score, body weight, and reproductive performance in seasonal-calving dairy cattle. *J. Dairy Sci.* 90(1):376-391.

Satya, P. 2003. Investigation on health disorder in dairy cattle and buffaloes during pre and post-partum period. Phd Thesis submitted to NDRI, Karnal.

Shamsuddin, M., M.G.S., Alam and J.U. Ahmed. 1988. Reproductive disorder of cross-bred cows. *Bang. Veterinary J.* 22:21-28.

Shamsuddin, M., Bhuiyan, M. M., Sikder, T. K., Sugulle, A. H., Chanda, P. K., Alam, M. G. and Galloway, D. 2001. Constraints limiting the efficiency of artificial insemination of cattle in Bangladesh. *IAEA Conference*, 20174522:9-7.

Shamsuddin, M., Bhattacharjee, J., Goodger, W. J., Momont, H., Frank, G., Talukder, A. K. and Akteruzzaman, M. 2010. Community-based productivity veterinary service for smallholder dairy farmers in Bangladesh. In: Suntainable improvement of animal production and health. Food and Agriculture Organization of the United Nations, Rome, 247-253.

Sultan, A., Islam, M. R., Yadav, R. K., Akhter, R. and Ahmed, J. U. 2015. Prevalence of different reproductive disorders of small ruminants in five upazillas of Mymensingh district. *Asian J. Med .and Bio. Res.* 1:74–79.

Sirohi, N. S., Monga, D. P. and Knar, S. K. 1989. Microbiological studies on some reproductive disorders of cattle. *Indian J. Ani. Sci.* 59:537-541.

Wildman, E. E., Jones, G. M., Wagner, P. E., Boman, R. L., Troutt Jr, H. F. and Lesch, T. N. 1982. A dairy cow body condition scoring system and its relationship to selected production characteristics. *J. dairy sci*. 65(3):495-501.

Bangladesh J. Agri. 2022, 47(1): 102-112 *DOI: https://doi.org/10.3329/bjagri.v47i1.60597*

ASSESSING TRAINING CONTENTS, CURRICULUM AND PROCESS OF AGRI-ENTREPRENEURSHIP DEVELOPMENT FOR FARMERS

R. Roy[1*] and M. A. Rahman[2]

[1]Department of Agricultural Extension & Information System, Sher-e-Bangla Agricultural University (SAU), Dhaka; [2]HELVETAS Swiss Intercooperation, Dhaka, Bangladesh

Abstract

There is a lot of saying about farmers becoming 'entrepreneurs.' But what is an agri-entrepreneur and what is agri-entrepreneurship? How can agri-entrepreneurial skills be developed? How do agri-entrepreneurial farmers respond to change their farming enterprise? How can extension workers help farmers to develop agri-entrepreneurial capacity? These questions are still unexplored in Bangladesh. The objectives of this study were to assess the existing agri-entrepreneurship development training manuals for the purpose of identifying better yet unexploited contents and curriculum in facilitating sustainable entrepreneurial skills and attitude of farmers, which will contribute to growth in agribusiness and income for farmers of the country. The methodology included document collection, key informant interview (KII), and literature review and analysis. The managerial skills and entrepreneurial spirit of farmers are essential for agri-entrepreneurship; rural farmers have a high potentiality of agri-entrepreneurship; however, they are facing challenges to gained formal entrepreneurial training and supports, and extension workers must provide demand-driven training and advisory services to enhance agri-entrepreneurship. Investing in agri-entrepreneurship can open a new horizon of agricultural development.

Keywords: Agri-entrepreneur, Entrepreneurship Extension worker, Farmer

Introduction

The economy of Bangladesh is highly dependent on agriculture. Since about 87 percent of rural households rely on agriculture for at least part of their income (World Bank, 2006) that clearly indicates the poverty reduction potential of the agriculture sector. Despite the fact that Bangladesh has shown good achievement in agriculture development, the country still depends on subsistence production systems largely dominated by small and marginal farmers. (World Bank, 2017). The world is moving from local markets to national and global markets, meaning our farmers may be competing with neighboring entrepreneurial farmers from another country, which is increasing pressure on farmers to commercialize their operations (Ferris *et al.,* 2012). The Bangladesh government has taken initiative to commercialize the agriculture sector, but though few farmers have entrepreneurial spirit, many of them do not have educational entrepreneurial skills in the country (Ferris *et al.,* 2012). These farmers are not

* Corresponding author: ranjan@sau.edu.bd

innovative, do not take risks and lack the drive with an entrepreneurial spirit. Actually, the farmers are facing challenges to gain entrepreneurial capacity for limited access to entrepreneurship training and support (Kahaan, 2012). The extensionists also face limitations to identify better curriculum for the potential farmers who want to be an entrepreneur. Therefore, it is the time for developing the entrepreneurial capacity of farmers. The purpose of this study is to assess and screen out the better contents, curriculum, and process for redevelopment of the agri-entrepreneurship training module for farmers of our country, so that any extension worker can be prepared for the agri-entrepreneurship development module for providing entrepreneurial training. Different NGO workers and Sub-Assistant Agriculture Officers (SAAOs), Department of Agricultural Extension (DAE) can also use these contents for further development of agri-entrepreneurship development modules.

Materials and Methods

The methodology was used in three steps: secondary study with document collection, primary study with Key Informant Interview (KII), and data review & analysis and reporting. The first two steps were done simultaneously. Meeting and collecting the available entrepreneurship development training manuals from different Government and NGO Offices, then collecting existing similar manuals from other entrepreneurship development organizations from websites and directly from public departments as the secondary sources. Conduct KII with some experts on agricultural management or entrepreneurship such as Food and Agriculture Organization (FAO), International Labour Organization (ILO), etc. who have knowledge on the intended documents as primary sources. The collected materials and data were reviewed and analyzed in similar manuals, reports and hand books. The existing information on entrepreneurship development training contents, curriculum and process has been summarized and compiled, later on to be elaborated for the assigned training module by extensionists or NGO workers.

In order to review the existing information on agri entrepreneurship, related modules were collected from different sources. The collecting materials from different projects are: 1 Business skills and entrepreneurship development training and planning manual (Edward, 2018). 2 Module: Agricultural Entrepreneurship (Ferris *et al.*, 2012). 3 Entrepreneurship in Farming (Kahaan, 2012). 4 Agri-Entrepreneurship Training Manual, Nova Scotia Agricultural College Truro, Nova Scotia, Canada, funded by Canadian International Development Agenciy (CIDA), 5 Entrepreneurship Development Training Manual (Neubert, 2016) and 6 Start and Improve Your Business (SIYB), International Labour Organization (ILO). The collected documents from web links are: 7 The Module: Entrepreneurship Competence (Tutlys, 2016). 8 Training Module on Entrepreneurship (Mullanji and Topalli, 2017). The collected documents from the public departments are: 9 Doing Business in Bangladesh, A Guide of Investment Rules, Bangladesh Investment Development Authority (BIDA), 10 Bangladesh Investment Handbook. A guidebook of Investors, Bangladesh Investment Development Authority (BIDA), 11 Entrepreneurship Development Training ToT Manual for Upazila Officers, Small and Cottage Industries Training Institute (SCITI). (Hereinafter manual name referred to the module 1 to 11). During the collection and review it was focused particularly on businesses of individual

farmers with proper investment and concentrated only on formal farmer training manuals which included DAE principles such as increasing production and productivity, cost effectiveness, bottom-up planning, development of agri-business, adoption to climate change etc. (NAEP, 2012). Therefore, the above 11 modules are reviewed by the team. Authors jointly performed the screening process of the contents from existing modules and the analysis to draw major findings and reporting.

Results and Discussion

The study findings are described in different sub sections. The subsections are overview of the entrepreneurship development training (contents with observations) of reviewed documents, training duration of the reviewed modules, different training methods used in the different manuals, content analysis, proposed contents/sub contents (curriculum), and proposed training delivery process by this curriculum. These subsections are illustrated below sequentially:

Overview of the entrepreneurship development training of reviewed documents

During review, major training contents found in module 1 are overview of the business skills and entrepreneurship development training, introduction to business, and entrepreneurship development, business planning data collection, aggregation of projection, sustainable business model- organization, leadership and operation and enterprise management skills: marketing, production, enterprise or organizational and financial management skills. The observations are that this manual is for farmer's organization, focused on entrepreneurship development through agriculture value chain development. Contents of module 2 are agricultural entrepreneurship, introduction to agripreneurship, the role of the extensionist in agripreneur development, criteria for a successful business, evaluating entrepreneurs, defining the business idea, identifying markets, managing key activities and partners, business planning, the basics of sales, assessing risk, record keeping, building a business relationship, putting plans into action and monitoring. The major observation is that it includes working with individual farmers to develop farm plans, as well as working with farm organizations in areas of market analysis, financing, sales and building business opportunities for farming clientele.

Major contents found in module 3 are understanding entrepreneurship in farming, entrepreneurial responses, entrepreneurial qualities, building entrepreneurship skills, and extension support for developing entrepreneurial capacity. The module is a guidebook of new extension workers that includes a better understanding of the concept and practice of entrepreneurship by which extension workers will be better able to help farmers develop the skills and spirit of an entrepreneur. Contents found in module 4 are group formation and strengthening, postharvest handling system, marketing, record-keeping, financial management, participatory learning, and case studies (on post-harvest management). The module emphasized on group formation and leadership, postharvest methods of agri-products and their marketing and has been designed for use in northern Ghana. It has included a trainer's guide for participatory learning and action which is comprehensive for trainers to provide training farmers with participatory methods. Contents found in

module 5 are effective facilitation, understanding basic concepts of entrepreneurship, generating a business idea, developing a business plan, marketing, costing and pricing, operational management, record keeping etc. Major observations are that this module focused for youth, women, trainers and mid-level professionals on entrepreneurship used mainly in Eastern Africa (Ethiopia, Kenya, Tanzania and Uganda) (Neubert, 2016). It includes the detailed business planning process which is essential for the success of an entrepreneur.

Contents found in module 6 are generating business ideas, business plan, marketing, costing, buying and stock control, people and productivity, record keeping, planning for business etc. The observations are that Generate Your Business Idea (GYBI) is a training programme for people who want to start a business but are not sure of the business idea to pursue. It assists potential entrepreneurs to identify different business ideas, to analyze them and select the most promising one. In the module 7 the contents found are meaning and definition of entrepreneurship, contents of competency and skill, development of the business idea, business plan for a farm, business visits, assessment of business competencies, and references of sources of business services. The major observations are that this document is focused on agricultural farm business for all levels of trainees, includes generating business ideas which are more feasible and emphasizes on good and bad examples on starting a new business. Contents found in module 8 are the lifestyle of an entrepreneur, working challenges, exploring youth entrepreneurship, being your own boss, communication, introduction to entrepreneurship, entrepreneurship education, successful enterprise, my entrepreneurial competencies, social enterprise etc. The main observations are that the module is mainly for youth entrepreneurs aged 15-35 years old. This is basically a workshop and exercise-based module, on entrepreneurship for Training for Trainers (ToT), which was held in Durres, Albania (Mullanji and Topalli, 2017). Contents found in module 9 are investment opportunities in Bangladesh, investment climate, cost components of various inputs to production, registration of companies and firms, registration of industrial projects and other services, exploring from Bangladesh rules, procedures etc. This manual is mainly for investors, focused on investment rules in Bangladesh. This is also a guidebook for export and import.

The major contents found in module 10 are business climate and opportunities, starting a business, cost of doing business, paying taxes, applying for visa, sectors overview etc. It was observed that this manual is a guide for all kinds of investors and delivers up-to-date information on business climate, processes required to start and operate a business, tax/policy regimes, incentives and comparative advantages including visa rules. Finally, the major contents in module 11 are entrepreneurship attributes, concept of business, trade selection process, small and micro enterprise development, marketing, production, organizational & financial management, business plan preparation, loan processing and the major observations for this module are that the module is developed for ToT of Upazila Govt. Officers on entrepreneurship, focused on rural and urban educated but unemployed youth, men and women.

Training duration of the reviewed modules

Most of the training manuals are developed for 3 to 5 days duration. However, "Start and Improve Your Business (SIYB)" has many contents where the duration of training was not mentioned clearly.

Different training methods used in the different manuals

The following methodologies have been used as the training methods in different manuals or modules and handbooks, which are reviewed by the team. The majors are lecture, open discussion, demonstration, PowerPoint presentations, poster paper or flipchart presentation, practical sessions, group work and group presentation, brainstorming for solving the problems, case study sharing, tool or format sharing, role-playing, small group discussions, simulations game, and ice breakers.

Content analysis

The most interesting contents of different modules are sustainable business models, which includes value = benefits-costs, where risk factors are considered with costs for new entrepreneurs either agricultural farmers or other off farm entrepreneurs. Some modules can be used to train diverse groups particularly for the farmers, some might be useful for those who particularly want to generate new business ideas, acquiring good and bad experiences on starting a new business. The government document is very essential to know investment opportunities and government subsidies or financial aid or incentives for farmers due to their lack of access. As the small farmers are majority new entrepreneurs the risks and challenges of entrepreneurship should be kept in the proposed training module. However, the different contents in different modules on agri-entrepreneurship are analyzed in Table 1 below and considering this analysis and above discussion, the author team proposed the contents mentioning which manuals are also given in the right column in the same Table.

Proposed contents/sub contents (curriculum)

Reviewing the relevant documents and analyzing as well as findings from the documents, we would like to propose the following contents/sub-contents as curriculum. However, the proposed contents for the intended training for farmers including objectives are given Table 2.

The major contents in the proposed curriculum are kept related to entrepreneurship development contents with sub contents. According to the above table the overall curriculum of the proposed module is divided into ten sessions. Session 1 is the start of the training followed by an opening session and a pre-evaluation test to understand the primary knowledge of the participants on agri-entrepreneurship. The session 2 to 8 will deal with different entrepreneurial-related topics focused on the practical skills that entrepreneurs need to have to set up a successful agri-enterprise.

The sessions mostly focus on basic concept of entrepreneurship and agri-entrepreneurship, ways of identification and selection new agri-business ideas, proper start and successfully manage an agri-enterprise/business, developing detailed Business

Table 1. Content Analysis

Content	Reviewed documents*											Proposed contents
	1	2	3	4	5	6	7	8	9	10	11	
Introduction to business and Entrepreneurship development	√			√	√	√	√			√	√	√
Introduction to agripreneurship		√										√
Agricultural entrepreneurship		√										√
understanding entrepreneurship in farming			√	√								√
Identifying markets, mapping resources and partners in a business,		√										√
Generate business idea					√				√	√		√
Types of business institutes					√			√				√
What is successful business / characteristics of successful business / Success story of agri-business		√	√	√	√	√		√	√			√
Evaluating entrepreneurs (clients)		√										
Business plan	√	√	√	√	√		√	√	√	√		√
Marketing management	√	√	√	√			√		√			√
Production management	√	√	√				√					√
Financial management	√	√	√				√					√
Organizational management	√	√	√				√					√
Operational management	√				√							
Costing				√	√				√			√
Pricing and profit					√							√
Buying and stocking				√	√							
Record keeping				√	√				√			√
Institutes in assisting business establishment, training institutes and necessary business weblink								√				√
Working challenges (for business)		√				√					√	√
The role of the extensionist in agripreneur development		√										√

* The module 1 to 11 were illustrated in the section “Materials and methods’’

Table 2. Proposed Content/Sub-content with objectives:

Session number: Contents	Sub-contents	Objectives
Session 1: Inauguration of the training	▪ Opening and introducing ▪ Clarify participants expectations and concerns ▪ Understanding on overall objectives of the training ▪ Establish norms for conducive environment and active participation ▪ Pretest evaluation.	Farmers will introduce each other, able to understand the overall objectives and provide their expectations from the training
Session 2: Basic concept of business/entrepreneurship	▪ What is entrepreneurship? ▪ What is agri-entrepreneurship? ▪ Who is an entrepreneur? ▪ Characteristics of good agri-entrepreneur ▪ Types of entrepreneurs based on size and institution ▪ Benefits of entrepreneur/agri-business ▪ What are the legal requirements for doing the agri-business (trade license is enough for a small agri farm)? ▪ Anyone can be an agri-entrepreneur (youth, men, women, physical disorders etc.) ▪ Challenges to start a business and possible solutions considering farmer idea ▪ Case study (success and failure story on operating agri-farm)	Farmers will be able to understand the basic concept of entrepreneurship, agri entrepreneurship, entrepreneur, legal requirement of any agri-enterprise.
Session 3: Generating business idea and selection of specific agribusiness	▪ What is an agribusiness idea? ▪ What makes a good business idea? ▪ Example of different agri- farms and agri-businesses ▪ How to find a good agri-business idea? ▪ Generate your own agri-business ideas? ▪ Analyze agri-business ideas and select best one	Farmers will be able to generate knowledge on agribusiness idea and can be select best one based on their capacities and local markets
Session 4: Developing agribusiness plan	▪ What is a business plan? ▪ Why is an agribusiness plan necessary? ▪ Agribusiness plan (production plan, marketing plan, organizational plan and financial plan) ▪ Practicing Agribusiness plan (on-farm business plan) ▪ Reference organization for improving agribusiness	Farmers will be able to know about business plans and achieve the skills on "how to develop an Agribusiness plan". The Extensionist will be introduced with reference organizations for improving agribusiness.

Session number: Contents	**Sub-contents**	**Objectives**
Session 5: **Costing of goods**	▪ What are the costs? ▪ Importance of costing in agribusiness ▪ Types of costs ▪ Method of calculation of per unit cost	Farmers will be able to understand costing, importance of costing and capable of calculating per unit cost.
Session 6: Pricing and profit	▪ What is pricing? ▪ Factor influence pricing ▪ Price setting and profit calculation	Farmers will be able to know about pricing, factors influence pricing and can set price for profit
Session 7: Marketing for small farm business	▪ What is marketing? ▪ Who are customers? ▪ What are their needs? ▪ 4 Ps (Products, Price, Place, Promotion) ▪ Marketing process	Small farmers will be able to understand marketing and meet customer demands through the marketing process.
Session 8: Record keeping and accounting	▪ What is a record? ▪ What is record keeping? ▪ Importance of record keeping ▪ Types of record ▪ How can records improve your business?	Farmers will be able to know about record and record keeping, its importance and how records can improve the business.
Session 9: Planning and Closing	▪ Farm plan for next season ▪ Post evaluation test ▪ Recap of the 3rd day and entire training ▪ Closing of the training.	Farmers will acquire practical knowledge on planning and be able to make their individual initial plan for next season which will greatly contribute to the success of the training.
Session 10: Participatory learning and effective communication	▪ What is participatory learning ▪ What is facilitation ▪ Importance of participatory learning ▪ Participatory learning process, tools and method ▪ What is communication and types of communication ▪ Effective communication skills. ▪ How to communicate effectively.	The extensionist or NGO worker will be able to realize basic concepts on participatory learning, facilitation and effective communication, so that they will be capable of further development of the module and acquire skill on conducting the training directly towards the farmers.

Plan (BP), analysis of costing with per unit cost of agri-product, ways of attractive price setting and profit calculation, process of keeping record and account for a business, linkages between the entrepreneur and all the resources and services actors needed to

successfully continue an enterprise. Session 9 is a planning and concluding session, where participants are given an individual planning format to develop a future plan of what an individual entrepreneur will do by next season. After this a post evaluation test will be conducted for all participants to compare with the pre-evaluation test and then accordingly conclude the session with a closing speech as well. Another, the session 10, is only for extension workers for their ToT for better understanding the approach, tools and participatory learning process, facilitation and effective communication. It will serve as a practical guide for facilitators to elaborate modules with contents as well as conducting process of training, so that the extension workers can facilitate entrepreneurship training based on the participatory learning approach.

Proposed training delivery process by this curriculum

The major discussions in review show how an agri-entrepreneur is different from traditional farmers, the finding showed that an entrepreneur is any person who creates and develops a new business idea and takes the risk of setting up an enterprise to produce a product or service which satisfies customer needs and wants (Kahaan, 2012). Entrepreneur refers to the person and entrepreneurship defines the process. All entrepreneurs are businesspersons, but not all businesspersons are entrepreneurs. An agri-entrepreneur is therefore an agri-business-minded farmer who always finds the ways to improve the business. In the entrepreneurship point of view the first is the managerial skills needed to start and run a profitable farm business by farmers and the second is 'entrepreneurial spirit' of farmers (Kahaan, 2012). Both are important and need to be matched for agri-entrepreneurship. Thus, training delivery methods should be changed from traditional methods. Therefore, the proposed method is to increase business management skills and technical skills of individual agri entrepreneurs.

Traditionally, most extension agents, especially those supported by Governments and NGOs have focused on helping farmers to work in a group approach, to grow more produce, but there some lacking to develop agri-enterprise options with an individual approach (Babu *et al*., 2021). The farmer group support model should not be considered as outdated, this approach has good results around the world, in producing diverse products derived from customer needs (Ferris *et al.*, 2012). However, this model is not the 'only' approach, we offer a complementary approach, which seeks to support the more individualistic agri-entrepreneur. Therefore, the proposed contents are used for module development by extensionists for training of individual agri-entrepreneurs. First as a trainer the extensionist or NGO worker will be received ToT from projects operated by either Government or NGOs. After receiving ToT, they will prepare a module by using proposed contents as well as curriculum. After developing the module, a three days long training schedule will be developed mentioning time, methods, required materials and facilitators. The facilitators will provide support to organize training of farmers with this agri entrepreneurship module. After training, farmers should be able to achieve success in running their farms, as profitable businesses. For this drive to greater commercialization, farmers may need further support and advice from extension agents. So, the extension workers might conduct the training for farmers regularly with market analysis, developing farm plans etc. including disseminate demand-driven advisory

services to the new set of clients and thus the client will be shifting over as an agri-entrepreneur.

Conclusion

Through this study, it may be possible to further prepare the agri-entrepreneurship development training module in order to bring more responsive and sustainable results to the farmers in Bangladesh. There is a high potential of some farmers who have entrepreneurial spirit in rural areas, however, they are facing challenges to gain formal entrepreneurial training and support. Extensionists as well as NGO professional have also been facing limitations to identify better curriculum for that agri-entrepreneurial training, but the screening out of contents and curriculum on agri-entrepreneurship development training might inspire the extensionists to develop further modules with their field-based knowledge and skills which will be more practical for rural farmers. This module will increase the skills on agri-entrepreneurship and thus they will be able to know the ways of identifying and selecting new agri-business ideas, start properly as well as can manage successfully with profitability, which can accelerate the reducing poverty. Investing in agri-entrepreneurship can open a new horizon of agricultural development. The Government of Bangladesh should invest in generating state of the art knowledge on agri-entrepreneurship, considering current and imminent challenges such as climate change, which is currently unavailable. The Ministry of Agriculture and the DAE should seize the opportunities of enhancing agri-entrepreneurship through developing innovative finance and creating conducive environments.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Babu, S., Y. Zhou, R. Khan and N. Srivastava. 2021. Youth Entrepreneurship in Agribusiness Bangladesh Country Report, Syngenta Foundation for Sustainable Agriculture. Dhaka. Bangladesh. p.7

Edward, M. M. 2018. Business skills and entrepreneurship development training and planning manual, Feed the Future Kenya, Accelerated Value Chain Development (AVCD) Program, International Potato Center. ISBN: 978-92-9060-508-9. Lima, Peru. pp. 3-58.

Ferris, S., L. Geyer, C. O'Mahoney and M. Erasmus. 2012. Module: Agricultural Entrepreneurship, Global Forum for Rural Advisory Services (GFRAS), Agridea, Lindau, Switzerland. pp. 3-233.

Kahaan, D. 2012. Entrepreneurship in Farming, Farm Management Extension Guide, Vol. 5. Food and Agriculture Organization of the United Nations (FAO), Rome. Italy. pp. 3-93.

Mullanji, A. and I. Topalli. 2017. Training Module on Entrepreneurship, RAISE Project (Raising the Advantages of Youth through Innovation and Social Enterprise), Beyond Barriers, Erasmus+ Programme (EU), Durres, Albania from https://www.salto-youth.net/downloads/toolbox_tool_download-file-1646.

Neubert, U. 2016. Entrepreneurship Development Training Manual, DSW (Deutsche Stiftung Weltbevoelkerung), European Union (EU). Berlin, Germany. pp. 4-102.

New Agricultural Extension Policy (NAEP). 2012. Ministry of Agriculture, Government of the People's Republic of Bangladesh. Dhaka. p.v.

Tutlys, V. 2016. The Module: Entrepreneurship Competence, Vitautas Magnus University (LT), NORDPLUS, Science-Economy-cohesion- creating the future of Lithuania, European Union from https://www.academia.edu/41861879/.

World Bank. 2006. Bangladesh: Growing the economy through advances in Agriculture. Ministry of Agriculture, Government of the People's Republic of Bangladesh. Dhaka. p.1.

World Bank. 2017. Climate-Smart Agriculture in Bangladesh. CSA Country Profiles for Asia Series. International Center for Tropical Agriculture (CIAT), Washington, D.C. p.28.

Bangladesh J. Agri. 2022, 47(1): 113-120 DOI: https://doi.org/10.3329/bjagri.v47i1.60598

DUCKLING PRODUCTIONS BY RICE HUSK INCUBATORS IN BANIACHANG UPAZILA OF HABIGANJ DISTRICT

M. M. Rana[1*], M. S. K. Sarker[1], A. A. Bhuiyan[2], A. A. Bhuyan[3] and M. R. Islam[4]

[1]Poultry Production Research Division, Bangladesh Livestock Research Institute (BLRI), Savar; [2]Livestock Division, Bangladesh Agricultural Research Council (BARC), Dhaka; [3]Biotechnology Division, National Institute of Biotechnology (NIB), Ashulia, Dhaka;
[4]Department of Livestock Services (DLS), Dhaka. Bangladesh.

Abstract

The study aims to know the scenario of duckling production using rice husk incubator and socio-economic status of the farmers of Vatiapara village under Baniachang upazila of Habiganj District. A total of 140 number of households were interviewed among them 64.7% family had homestead land followed by 35.3% family had both homestead and cultivated land. All living houses were of tin made with 70% nuclear and 30% joint family. There about 9.1% illiterate and 39.4% people could sign only. The primary, secondary and higher secondary or upper educational levels were 25.7%, 18.2% and 7.6%, respectively. More than 76.5% family are engaged directly in duckling production whereas 23.5% family are involved in catching and cultivating fish. About 23.5% families were fully occupied in fisheries and 41.25% family in integrated agriculture as secondary occupation. On an average, their income was 10,676 Tk. Among the selected families 59% got training on duck rearing with hatchery management. Based on 70% hatchability, per family produced monthly more than 7000 number of ducklings from 10000 number of hatching eggs. The yearly turnover is calculated as to nine months hatching operation since the enterprise remained almost stop from the late November to mid-February. Hatching egg price was different due to seasonal variation and, on an average, it was 10.50 Tk. Overall 7088 number of ducklings were produced per household monthly, which valued about 177200 Tk. (25 Tk./duckling) and net profit was 66535 Tk./month. Thus, the community-based duckling production can be encouraged more among the families through providing an adequate technical knowledge, training and an improvement of marketing channel to increase socio-economic status of the farmers.

Keywords: Duckling production, Proper marketing, Rice husk incubator, Socio-economic profile

Introduction

In Bangladesh, more than half of the people those who are leading their livelihood based on agricultural and livestock farming. The poultry sector is an integral part of farming systems in Bangladesh and has created both direct and indirect employment opportunity, improved food security and enhanced supply of quality protein

* Corresponding author: mdmasudrana2002@gmail.com

to people's meals, contributing country's economic growth and poverty alleviation in rural and urban areas of Bangladesh (Hamid *et al.,* 2016). Duck is one of the important livestock sub-sectors that generally being reared under scavenging system predominantly in the regions which are prone to seasonal inundation. The vast areas of haors, canals, bills, ponds and low-lying water reservoirs considered to be the breeding grounds for a number of biotic structures to support the duck rearing in Bangladesh (Rahman *et al*., 2009). It plays a significant role to provide subsidiary income and creates employment opportunity for landless, marginal and small farmers in the coastal and low-lying water reservoirs areas (Afrin *et al*., 2016; Begum *et al*., 2020). Additionally, it can contribute efficiently in increasing meat and egg production that are cheap source of good quality animal protein to the nation for the fulfillment of their nutritional requirement ducks are the only second to chicken. In the earlier study, it has been estimated that the consumption of duck meat and egg in Bangladesh is about 30% of total poultry consumption (Islam *et al*., 2003). According to the Department of Livestock Services (DLS, 2020) of Bangladesh, duck accounts for around 16% of the country's total poultry production while chicken hold the remaining 84%. Similarly, in other study, it has been reported that chicken population is dominant over other poultry species which almost 90%, followed by 8% duck and a small number of quails, pigeons and geese (Das *et al*., 2008). However, following the information of last five years duck population data of Bangladesh, it has been shown that the total duck population is steadily increasing from 52.240 million in 2016 to 59.72 million in 2020 (DLS, 2020). At the same time, duckling production through traditional rice husk incubator system is also one of the important promising sectors in the coastal and low-laying water reservoir areas throughout the country. It can contribute significant role to lead livelihood improvement, food security, create employment opportunity, woman empowerment as well as keeping a minor contribution to the national revenue. In spite of these potentialities, duckling production by traditional rice husk incubator system has remained a neglected business partly in low-laying water reservoirs areas even though no basic statistics are available. Lack of scientific knowledge, training and proper marketing channel are some of the major impediments for development of duckling production by the system of traditional rice-husk incubator. Therefore, a survey study was conducted to know the overall scenario of duckling production using traditional rice husk incubator and socio-economic status of the farmers at Vatiapara village of Baniachang Upazila of Habiganj District.

Materials and Methods

This survey study was carried out for three days during the month of September since 2017 at Vatiapara village of Baniachang upazila under Habiganj District of Bangladesh, with a view to know the scenario of duckling production using traditional rice husk incubator with socio-economic status of the farmers. In the survey method of this study, a total of 140 of the 200 families were considered by simple random sampling technique, those who either directly or partially practiced in rice husk incubator for duckling production. Keeping in view the objective of the study, an interview schedule was developed with necessary correction and modification. Data were collected from the selected families by conducting direct interviews through personal visit. Before commencement of the interview, a brief introduction about the purpose of the study was

discussed to the respondents. Thereafter, the questions were asked in easy and understandable language with friendly manner. Also, some interviews were conducted at the market, road side mini tea stall, when the respondents spent their leisure time and as to the given time of some respondents. The primary information of the families was collected i.e. such socio-economic condition, availability of duck eggs, price of eggs, existing knowledge on hatchery management and marketing of ducklings as well as training on duck hatchery with management etc. Descriptive statistics such as percentage, frequency distribution and overall mean were performed to represent the data using Microsoft excel 2010.

Results and Discussion

Scio-economic characteristics of the survey households

The overall socio-economic status of the survey area families was presented in Table 1. It has been shown that about 64.7% of the total families have a small area of homestead land, which averaged 4.47 decimal/family; and remaining 35.3% family has cultivated land which average in per family was 192.17 decimal. Houses were made corrugated iron sheet with types of family were 70% nuclear and 30% joint. Size of the family members up to 4, 5 to 6 and more than 6 were 11.8%, 47.1% and 41.0%, respectively. Average member in each family in the survey area was 6.23 number which was comparatively a little higher as to the national average family size of 4.06 number (Bangladesh HIES, 2016). According to the educational qualification data of the survey area, there was found only about 9.1% illiterate and could sign only 39.4% among the considering of total number of population. In addition, we came to know from the information of interviewing data about 25.7%, 18.2% and 7.6% were received primary, secondary and higher secondary or upper education of the total population, respectively. However, the literacy rate in the survey area was very poor than the national context where the statistics of literacy rate is claimed to be 72.76% (https://Country-economy, 2016; BBS, 2016). Regarding to the professional information, it was found more than three-quarters (76.5%) of total family was mainly involved in collection of hatching eggs for rice husk incubator business of duckling production. Rest of the family which was 23.52%, those are leading their livelihood by catching and cultivating fish. From the Table 1, it also evident that 23.5% family in fisheries and 41.25% family in integrated agriculture (crop plus fisheries) had involved as their secondary occupation. As to the collected information of monthly income from the survey area families were 5.9% (up to Tk. 5,000), 58.9% (Tk. 6,000 to 10,000), 29.4% (Tk. 11,000 to15,000) and 5.9% (Tk. 16,000 to more), respectively. Average income of each family in per month was Tk.10, 676 only. According to the data of Bangladesh HEIS, (2016) reported that per household income in each month was 15,988 Tk. which had about 33.22% higher than that of per household income of survey area family. From the aforementioned comparative data of household income, which indicates that there didn't have enough opportunities to increase income of the farmers. As a result, a necessary step should be taken by the government to create employment opportunity for increasing their average income and improvement of their livelihood. It is evident from Table 1 that about 58.8% family took only training on duck rearing and hatchery management which may be implemented by

the government or non-government organizations, and rest of 41.2% family didn't get such kinds of opportunity to increase the technical knowledge. In this case also necessary steps should be taken by the government or non-government organizations (NGOs) to provide an adequate training among the farmers for development of technical knowledge on duck hatchery management.

Table 1. Socio-economic characteristics of the study area families (a total of 140 of the 200 families)

Parameter	Category	Frequency	%	Average
Land	Homestead land	129	64.7	4.47 dec.
	Cultivated land	71	35.3	192.17 dec.
Type of living house	Tin	200	100	-
	Shabby	0	0	0
Type of family	Nuclear	140	70	-
	Joint family	60	30	-
Number of family members	Up to 4	24	11.8	-
	5-6	94	47.1	-
	> 6	82	41	-
	Overall	200	100	6.23±2.07
Education (Excluding age below 15)	Illiterate	71	9.1	-
	Can sign only	306	39.4	-
	Primary	199	25.7	-
	Secondary	141	18.2	-
	Higher secondary and upper	59	7.6	-
Primary occupation	Hatching & selling duckling	153	76.5	-
	Fisheries	47	23.52	-
Secondary occupation	Fisheries	47	23.5	-
	Integrated Agriculture (Crop + Fisheries)	82	41.2	-
Income (monthly) in Tk.	Up to 5,000	12	5.9	-
	6,000 to 10,000	117	58.9	-
	11,000 to 15,000	59	29.4	-
	16,000 and more	12	5.9	-
	Overall	200	100	10676.00±3775
Training on duck hatchery	Yes	118	58.8	-
	No	82	41.2	-

Hatchability of duck eggs and price of duckling

It is also evident from Table 1 that around 80% (76.5%) family of the Vatiapara village was involved on duck hatchery and selling of duckling business occupation. In the study area, it had shown that most of the family could run hatchery operation just beside their bedding room and a very few numbers of family operated in adjacent place of bedding room. We also came to know by the interviewing data of respondents, they generally collected hatching eggs from the availability of nearby locations namely Markiloy, Azmeryganj and Lakhai upazills in Habiganj district, Nasirnagar upazila in Brahmanbaria district. In some cases, they also collected hatching eggs from a quite distance area which was part of the Kishorganj, Sylhet and Sunamganj district. It is evident from Table 2 that there minimum, maximum and overall number of hatching eggs capacity in the setter part per household were 7813, 12438 and 10125 number monthly, respectively. According to the respondent statements on egg hatchability, they obtained an average of about 70% hatchability from the total setting eggs. The hatchability percentage ranges from 50 to 75% in common ducks with an average 63%, following the data mentioned in earlier studies **(**Islam *et al*., 2002; Banerjee, 2013; Rahman *et al*., 2009; Makaremuzzaman *et al*., 2016), which was supported to the current data of survey area. Monthly day-old duckling productions per household as minimum, maximum and overall were 5469, 8706 and 7088 number, respectively. The selling prices of each day-old duckling as minimum, maximum and overall were 24, 26 and 25 Tk. respectively. Hatching operation with business is almost closed during winter period due to cold temperature and high humidity particularly from late November to mid-February. Above mentioned period, they pointed out that it is very difficult to maintain adequate temperature and humidity during hatchery operation in a traditional rice husk system.

Table 2. Collection of hatching eggs, production and selling price of ducklings in the study area of each family (Calculated based on140 families)

Parameter	Mean ± SD		
	Minimum	Maximum	Overall
Hatching egg set (No./month)	7813 ± 4593 (140)	12438 ± 6418 (140)	10125 ± 5972 (140)
Hatchability based on setting eggs (%)	70%	70%	70%
Duckling production (No./month))	5469±3215 (140)	8706±4493 (140)	7088±5338 (140)
Selling price of duckling (Tk)	24±0.00 (140)	26±0.00 (140)	25±1.02 (140)

Seasonal variation of hatching egg and duckling price

In the Table 3, according to the information of interviewing data, we have shown that the overall price of each hatching egg during late winter (February - March) was 11.5 Tk. followed by rainy season (June -August) was 9.5 Tk. Regarding to the the variation of hatching egg price, respondents of the survey area stated that during the period of late

winter the demand of hatching eggs were comparatively higher than that of other seasonal period. However, in this regard, they have highlighted a probable reason, both temperature and humidity are easily suitable for smooth hatchery operation using traditional rice-husk incubator. In addition, they also mentioned another possible reason for the lower production of duck eggs in the summer season, which is usually caused by the shortfall of natural feed and dried out of hoar. Resulting that, the hatching eggs price increased for the higher demand in duckling producers. It is evident from the Table 3, we have shown that the price of egg and duckling both was higher during late winter period as that of rainy season, which may be associated due to the cause of higher demand of hatching eggs and ducklings by the farmers. The overall duckling price between late winter and rainy season was 26 and 24 Tk. respectively, which indicated that duckling price was may be fluctuated for the variation of season.

Table 3. Seasonal variation of hatching eggs and day-old duckling price in Taka

Parameter	Mean ± SD (N=140)					
	Late winter (February- March)			Rainy season (June- August)		
	Min.	Max	Overall	Min.	Max.	Overall
Hatching egg (Tk.)	11.0±0.0	12.0±0.0	11.5±0.51	9.0±0.0	10.0±0.0	9.5±0.51
Day old duckling (Tk.)	-	-	26.0±0.0	-	-	24.0±0.0

Profitability of duckling producers using rice husk incubator

In the Table 4, we have presented as the variable cost such hatching eggs with involved transport, rice husk and miscellaneous items (hidden labor cost, carrying cost and other related cost) for the calculation of net profit margin, however, did not consider some fixed cost like bamboo dhole for setter, bed for hatcher, cloth and cotton lap etc.

Table 4. Profitability from traditional rice husk incubator hatchery in each family

Variable Cost	Cost per unit	Cost per thousand	Monthly
Hatching egg with transport (Tk.)	10.5	10500	106312.00
Rice husk (Tk.)	0.30	300.00	3037.00
Miscellaneous (Tk.)	0.13	130.00	1316.00
Total cost (Tk.)	10.93	10930	110666.00
Income from ducklings (Tk.)	25.00	7088.00	177200.00
Net profit (Tk)			66534.00

I USD= 85 BDT

According to the respondent information of interviewing data, we observed that majority of the farmers in the study area commonly used rice husk as a fuel material in the round soil container which locally called 'dhoop' as the replacement of kerosene oil in hurricane for maintaining temperature in the setter part of traditional rice husk incubator. As to the evident from Table 4, monthly a total cost of 106312 number hatchings eggs in per household was 110666 Tk. and total income from ducklings was 177200 Tk. according to the average day-old duckling price of 25 Tk. The net income in each family was found 66534 Tk. per month after subtraction all types of variable costs (hatching eggs, rice husk, hidden labor cost, carrying cost and other related cost), which indicated that duckling production in traditional rice husk system is profitable business in the study area. Whatever, it was the only main source of income of each household in the study area for improving their livelihood and, thus this system needs to be encouraged more among the farmers through providing an adequate training and technical support. In addition, some necessary steps should be taken by the government or non-government organizations to create a backward and forward linkage for selling ducklings. In order that they can get a fair price through marketing of ducklings and can improve their livelihood with creating a sustainable income.

Conclusion

Thus, from the findings of the study area, it is recommended that traditional rice husk incubator system for duckling production can be encouraged more among the farmers particularly haor and low-lying water reservoirs areas through providing an adequate technical knowledge, proper training on duckling production and hatchery management as a more profitable enterprise. Additionally, some necessary steps should be taken by the government or non-government organizations to create a proper marketing channel for selling ducklings as if they can get easily a fair price through marketing of ducklings and improve their socio-economic status with creating a sustainable income.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Afrin, H., R. Begum, M.J.U. Ahmed, M.A. Rahman and S. Haque. 2016. Profitability analysis and gender division of labour in duck rearing: a case of Kishoreganj district in Bangladesh. *Progressive Agriculture*. 27:482-489.

Banerjee, S. 2013. Morphological traits of duck and geese breeds of West-Bengal. *Animal Genetic Resources*. 52:1-16.

Bangladesh, HIES. 2016. Preliminary report on household income and expenditure Survey.

BBS. 2016. Literacy rate in Bangladesh by Bangladesh Bureau of Statistics.

Begum, M., M.S. Farid, M.M. Rahman, S. Barua, M. Begum and M.S. Sharkar. 2020. Competitive advantage and constraints associated with duck farming in north eastern region of Bangladesh. *IOSR J. Humanities and Social Sci*. 25:62-66.

Bureau of Statistics Division, Ministry of planning, Government of the People's Republic of Bangladesh, Dhaka.

Country economy. 2 016. Bangladesh Literacy rate. https:// Country-economy.com.

Das, S.C., S.D. Chowdhury, M.A. Khatun, M. Nishibori, N. Isobe and Y. Yoshimura. 2008. Poultry production profile and expected future projection in Bangladesh. *World's Poultry Sci. J.* 64:99-118.

DLS. 2020. Livestock Economic at a glance. DLS Report, Department of Livestock Services, Dhaka, Bangladesh.

Hamid, M.A., M.A. Rahman, S. Ahmed and K.M. Hossain. 2016. Status of Poultry industry in Bangladesh and the role of private sector for its development. *Asian J. Poultry Sci.* 11:1-13.

Islam, M.N., Q.M.E. Huque, M. Salahuddin and M.S.K. Sarker. 2003. Potentiality of native genotypes of ducks. Proceeding of the 3rd International Poultry Show and Seminar, WPSA-BB, 28 Feb-02 March 2003, Dhaka, Bangladesh, 3:25-29.

Islam, R., J.D. Mahanta, N. Barua and G. Zaman. 2002. Duck farming in North-Eastern India (Assam). *World's Poultry Sci. J.* 8:567-572.

Makaremuzzaman, M., M.R. Hasnath, M.Y. Miah, S.A. Belal and M.K. Hasan. 2016. Study on rice husk incubation for duckling production in Sunamganj of Bangladesh. *Int. J. Agricul. Biosci.* 5:291-295.

Rahman, M.M., M.J. Khan, S.D. Chowdhury and M.A. Akbar. 2009. Duck rearing system in souther coastal districts of Bangladesh**.** *Bangladesh J. Animal Sci.* 38:132-141.

Bangladesh J. Agri. 2022, 47(1):121-129 *DOI: https://doi.org/10.3329/bjagri.v47i1.60599*

Short Communication

EFFECTS OF ORGANIC MANURE AND CHEMICAL FERTILIZERS ON GROWTH AND YIELD OF GARDEN PEA

M. A. Haque[1*], S. M. Moniruzzaman[2], M. F. Hossain[3] and M. A. Alam[2]

[1]Practical Action Bangladesh, Dhanmondi, Dhaka; [2]Bangladesh Jute Research Institute (BJRI), Dhaka; [3]Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Bangladesh

Abstract

An experiment was conducted at Agronomy Farm of Bangladesh Agricultural University, Mymensingh (BAU) during rabi season of 2018−19 to see the response of garden pea to manure and fertilizers. The treatments were T_1: Control (no fertilizer or manure), T_2: Cowdung + Poultry manure + Mustard oilcake, T_3: Vermicompost + Poultry manure + Mustard oilcake, T_4: Urea + TSP + MoP + Gypsum and T_5: Cowdung + Urea + TSP + MoP + Gypsum. The experiment was designed in a factorial Randomized Complete Block Design (RCBD) with 4 replications. Urea, TSP, MoP and gypsum @ 45, 90, 40 and 50 kg ha^{-1} were used as sources of nitrogen, phosphorous, potassium and sulphur, respectively. Cow dung, poultry manure, vermicompost and mustard oilcake were applied @ 30, 25, 2.5 and 0.025 t ha^{-1}, respectively. The results showed that the treatment T_5 significantly gave the highest values of vegetative growth and yield attributing characters' i.e., plant height, number of branches per plant, number of pods per plant, pod length, pod breadth, number of seeds per pod, 100-seed weight, pod weight, pod yield and seed yield per hectare. The lowest values of growth and yield attributing characters were recorded with T_1. Sole chemical fertilizers (T_4) showed better performances than T_2 and T_3. Treatment T_5 gave higher result than T_4. So, for obtaining the highest growth and pod yield of pea (cv. BARI Motor3), treatment T_5 (Cowdung + Urea + TSP + MoP + Gypsum @ 30 t ha^{-1}, 45-90-40-50 kg ha^{-1}) could be the best combination.

Key words: Cowdung, Garden pea, Mustard oilcake, Pod, Poultry manure, Yield

Introduction

Pea (*Pisum sativum* L.) which belongs to family Fabaceae (formerly Leguminoseae) is one of the important winter vegetables grown in Bangladesh. rsally to fix atmospheric nitrogen with symbiotic activity of *Rhizobium leguminosarum*. Green pods are used for vegetable purpose and dried peas are used as pulse. Green peas straw is good source of nutritional fodder for livestock.In Bangladesh, the area under pea cultivation was 17,497 acres and the production was 7,191 metric tons (BBS, 2018). It is vegetable rich in protein, carbohydrates, phosphorus, iron, magnesium, calcium,

* Corresponding author: enam4656@gmail.com

riboflavin, niacin, thiamine and ascorbic acid (Watt and Merrill, 1993). Modern crop cultivation is getting more and more dependent upon the supply of synthetic inputs such as chemical fertilizers, pesticides and herbicides etc. which are inevitable to meet high food demand for growing population in the world. Chemical fertilizers are needed to get good crop yields but their abuse and overuse can be harmful to the environment and it would not be cost effective (Bobade *et al.,* 1992).

Several factors are responsible for low productivity, of them imbalance fertilization is an important one. So, to minimize the yield gap the use of organic manure and chemical fertilizers can play a good role in increasing nutrient availability to the plants, which in turn is reflected through the quality of the produce and yield maximization. The global trend is to words the use of organic materials with animal or plant origin as a source of fertilizer for the purpose of reducing environmental pollution as well as production of agricultural crops safe for humans and animals. Organic fertilizers additionally enhance soil physical and chemical properties and decrease the requirement for mineral fertilizers, which is reflected through increase of vegetative growth and yield of plants (Al-Taey *et al.,* 2018). The importance of FYM in increasing the yield and quality of crops on sustainable basis along with its residual effect on succeeding crops by improving the soil physical conditions and soil fertility is well recognized (Trudy *et al.,* 2018). Fertilizeris a key factor in influencing the growth, development and ultimately the yield of crops. Soil fertilization with chemical or organic fertilizer may lead to a significant increase in the number of pods per plant, pod length and seed yield of broad bean plants (Jasem *et al.,* 2015). Abo-Basha, (2016) found that addition 238 kg N ha^{-1} as chicken manure increased plant length, dry weight of vegetative growth, pod length, pod weight, seeds number per pod and total yield compared with NPK fertilizer (control). Therefore, the present investigation was undertaken to evaluate the effect of organic and chemical fertilizers on growth and yield of garden pea var. BARI motor-3.

Materials and Methods

The experiment was conducted during rabi season of 2018-2019 at Agronomy research farm of Bangladesh Agricultural University, Mymensingh. The field was moderately well drained with a silt loam soil texture and neutral soil pH . The land was prepared by ploughing and cross ploughing by a power tiller. The experiment was laid out in a factorial randomized complete block design with four replications. The pea variety used was BARI Motor-3. The experiment comprised 5 treatments i.e., T_1: Control (no fertilizer), T_2: Cowdung + Poultry manure + Mustard oilcake, T_3: Vermicompost + Poultry manure + Mustard oilcake, T_4: Urea + TSP + MoP + Gypsum and T_5: Cowdung + Urea + TSP + MoP + Gypsum. Urea, TSP, MoP and gypsum were used as sources of nitrogen, phosphorous, potassium and sulphur, respectively. They were applied @ 45, 90, 40 and 50 kg ha^{-1}, respectively. The rates of cowdung, poultry manure, vermicompost and mustard oilcake were 30, 25, 2.5 and 0.025 t ha^{-1}, respectively. All fertilizers except urea were applied during final land preparation. Urea was top dressed in two equal splits at 15 and 30 days after emergence. Seeds (var. BARI motor3) were sown on 12 December 2018 at a rate of 70 kg ha^{-1}. At 30 days after sowing (DAS) a light hoeing with

khurpi was done to remove the weeds along with the thinning operations maintaining a plant spacing of 8 to 10 cm. The second weeding was done at 60 DAS. The pods were harvested in three hand pickings at weekly intervals. Data were recorded on plant height (cm), number of branches plant^{-1}, number of pods plant$^{-1,}$ pod length (mm pod^{-1}), pod breadth (mm pod^{-1}), number of seeds pod^{-1}, 100- seed weight, pod weight (g pod^{-1}), pod yield (t ha^{-1}) and seed yield (t ha^{-1}). The results were statistically analysed and significance of the difference among the treatment means was determined by the Least Significant Difference (LSD) test at 5% level of probability.

Results and Discussion

Growth and yield parameters

Plant height

Plant height of BARI motor-3 was significantly influenced due to application of different organic and chemical fertilizers (Table 1). Plant height was measured at 30, 60 and 90 DAS. Plant height ranged from 12.6 to 22.3 cm at 30 DAS, 24.7 to 37.5 cm at 60 DAS and 35.11 to 52.13 cm at 90 DAS. The tallest plant was found in T_5 (Cowdung + Urea + TSP + MoP + Gypsum) at 90 DAS and the shortest plant was found in T_1 (control) at 30 DAS. Plant height increased with advancement of days after seeding up to 90 DAS. The highest plant height was recorded when the crop was grown with both organic and chemical nutrient sources. The plant height increased in the order of $T_5 > T_4 > T_2 > T_3 > T_1$. These results are in agreement with the findings of Sharma and Chauhan, (2011).

Table 1. Plant height of garden pea at different DAS under different treatments

Treatments	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
T_1	12.6 e	24.7 d	35.1 e
T_2	16.80 c	31.3 c	45.1 c
T_3	16.0 d	30.6 c	43.3 d
T_4	18.4 b	34.2 b	48.1 b
T_5	22.3 a	37.5 a	52.1 a
LSD (0.05)	0.72	1.09	0.89
CV (%)	2.29	1.83	1.07

LSD (0.05) = Least significant difference at 5% level of probability, CV (%) = Coefficient of variation

Number of branches plant^{-1}

Number of branches (primary) plant^{-1} increased significantly at all growth stages as a result of application of different organic and chemical fertilizers (Table 2). The branches were counted from 55 DAS at 15 days' interval and it was completed at 100 DAS. At 55 DAS, the maximum number of branches plant^{-1} (1.3) was recorded in treatment T_5 (Cowdung + Urea + TSP + MoP + Gypsum) and the minimum number of

branches plant^{-1} (1.01) was found in treatment T_1 (control). At 100 DAS treatment T_5 showed higher (1.41) against the minimum number of branches plant^{-1} (1.04) in treatment T_1. Sowing 85 DAS and 100 DAS showed similar number of branches plant^{-1}. This result agrees with Chongtham *et al.,* (2018) who reported increased number of branches of pea plant.

Table 2. Number of branches plant^{-1} of garden pea at different DAS

Treatments	No. of branches plant^{-1}			
	55 DAS	70 DAS	85 DAS	100 DAS
T_1	1.01 e	1.06 e	1.05 e	1.04 e
T_2	1.12 c	1.15 c	1.18 c	1.19 c
T_3	1.09 d	1.11 d	1.13 d	1.13 d
T_4	1.20 b	1.23 b	1.3 b	1.31 b
T_5	1.30 a	1.38 a	1.41 a	1.41 a
LSD (0.05)	0.03	0.02	0.02	0.02
CV (%)	1.72	1.13	1.004	0.87

LSD (0.05) = Least significant difference at 5% level of probability, CV (%) = Coefficient of variation

Number of pods plant^{-1}

The number of pods plant^{-1} is an important factor among the yield contributing characters. Application of different organic and chemical fertilizers showed statistically significant variation in the number of pods plant^{-1} of BARI Motor-3 (Table 3). The maximum number of pods plant^{-1} (8.04) was recorded at 85 DAS under treatment T5 (Cowdung + Urea + TSP + MoP + Gypsum) which was close to 100 DAS whereas the minimum number of pods plant^{-1} (4.82) was found at 55 DAS under treatment T_1 (control). The findings pertaining to the number of grains pod^{-1} are in close agreement with those reported by Chopra *et al.*, (2008) and Paul *et al.* (2011).

Table 3. Number of pods plant^{-1} of garden pea at different DAS

Treatments	Number of pods plant^{-1}			
	55 DAS	70 DAS	85 DAS	100 DAS
T_1	4.82 e	4.87 e	4.98 e	5.00 d
T_2	5.80 c	6.26 c	6.37 c	6.38 c
T_3	5.50 d	6.15 d	6.25 d	6.27 c
T_4	6.55 b	7.05 b	7.76 b	7.75 b
T_5	7.15 a	7.45 a	8.04 a	8.00 a
LSD (0.05)	0.15	0.06	0.04	0.06
CV (%)	1.30	0.49	0.37	0.57

LSD (0.05) = Least significant difference at 5% level of probability, CV (%) =Coefficient of variation

Pod length

Significant variation was recorded due to application of different organic and chemical fertilizers in terms of pod length (Table 4). The maximum pod length (58.1 mm) was recorded under treatment T_5 at 100 DAS whereas the minimum pod length (44.15 mm) was found under treatment T1 at 55 DAS. These results agree with Chongtham *et al., (*2018) which supported improved pod length of garden pea due to manure and fertilizer application.

Table 4. Pod length of garden pea at different DAS

Treatments	Pod length (mm pod^{-1})			
	55 DAS	70 DAS	85 DAS	100 DAS
T_1	44.2 d	46.1 e	47.3 c	47.2 d
T_2	48.0 c	50.1 c	50.8 b	51.0 c
T_3	47.3 c	48.3 0d	50.1 b	49.9 c
T_4	52.1 b	55.3 b	56.1 a	56.0 b
T5	56.0 a	57.5 a	5.00 a	58.1 a
LSD (0.05)	1.67	1.67	2.17	1.14
CV (%)	1.80	1.73	2.19	1.22

LSD (0.05) = Least significant difference at 5% level of probability, CV (%) = Coefficient of variation

Pod breadth

Pod breadth has been presented in Table 5. Pod breadth was taken at 55, 70, 85 and 100 DAS. The maximum pod breadth (12.5 mm) was recorded in treatment T_5 (Cowdung + Urea + TSP + MoP + Gypsum) at 100 DAS which was found superior over other treatments, whereas the minimum pod breath (9.12 mm) was found in treatment T_1 (control).

Table 5. Pod breadth of garden pea at different DAS

Treatments	Pod breadth (mm pod^{-1})			
	55 DAS	70 DAS	85 DAS	100 DAS
T_1	9.12 c	9.34 d	10.0 e	10.0 d
T_2	10.10 b	10.18 c	11.0 c	11.0 c
T_3	10.03 b	10.10 c	10.5 d	10.7 c
T_4	11.07 a	11.12 b	11.7 b	11.6 b
T_5	11.25 a	11.86 a	12.1 a	12.5 a
LSD (0.05)	0.50	0.48	0.23	0.58
CV (%)	2.57	2.42	1.09	2.75

LSD (0.05) = Least significant difference at 5% level of probability, CV (%) = Coefficient of variation

Number of seeds pod^{-1} and pod weight

Significant variation was recorded due to the effect of different organic and chemical fertilizers on the number of seeds pod^{-1} (Table 6). The maximum number of seeds pod^{-1} (5.3) was observed from T_5 (Cowdung + Urea+ TSP + MoP + Gypsum) at 100 DAS and the minimum number (3.78) was found from T_1 at 55 DAS. The pod (fresh) weight varied significantly for different treatments and harvesting time. (Table 7). The maximum pod weight (2.65g) was recorded in treatment T_5 (Cowdung + Urea + TSP + MoP + Gypsum) which was found superior over other treatments, whereas the minimum pod weight (2.01g) was noted for treatment T_1 (Control).

Table 6. No. of seeds pod^{-1} of garden pea at different DAS

Treatments	No. of seeds pod^{-1}			
	55 DAS	70 DAS	85 DAS	100 DAS
T_1	3.78 d	3.95 d	4.07 d	4.09 d
T_2	4.50 c	4.67 c	4.80 c	4.79 c
T_3	4.42 c	4.60 c	4.74 c	4.75 c
T_4	4.63 b	4.75 b	4.84 b	4.90 b
T_5	4.85 a	5.03 a	5.20 a	5.30 a
LSD (0.05)	0.17	0.11	0.12	0.11
CV (%)	2.11	1.25	1.26	1.32

LSD (0.05) = Least significant difference at 5% level of probability, CV (%) =Coefficient of variation

Table 7. Pod weight of garden pea at different DAS

Treatments	Pod weight (g pod^{-1})			
	55 DAS	70 DAS	85 DAS	100 DAS
T_1	2.01 d	2.09 c	2.16 d	2.19 d
T_2	2.26 bc	2.31 b	2.37 c	2.41 c
T_3	2.2 c	2.29 b	2.34 c	2.35 c
T_4	2.35 ab	2.42 a	2.50 b	2.49 b
T_5	2.41 a	2.50 a	2.64 a	2.65 a
LSD (0.05)	0.10	0.09	0.15	0.13
CV (%)	2.39	2.25	3.42	3.18

LSD (0.05) = Least significant difference at 5% level of probability and CV (%) = Coefficient of variation

100-seed weight, pod yield and seed yield

The 100-seed weight differed significantly from one treatment to another (Fig 1A). 100 seeds weight ranged from 19.66 to 23.7g. The highest 100- seed weight (23.7g) was found in T_5 (Cowdung + Urea + TSP + MoP + Gypsum) and the lowest weight

(19.7g) was obtained from T_1 (control) because the plants grew small seeds. Fig. 1B indicates that the maximum pod yield (3.81 t ha^{-1}) was recorded in treatment T_5 (Cowdung + Urea + TSP + MoP + Gypsum) which was found superior over other treatments whereas the minimum pod yield 2 t ha^{-1} was found in treatment T_1 (no fertilizer).

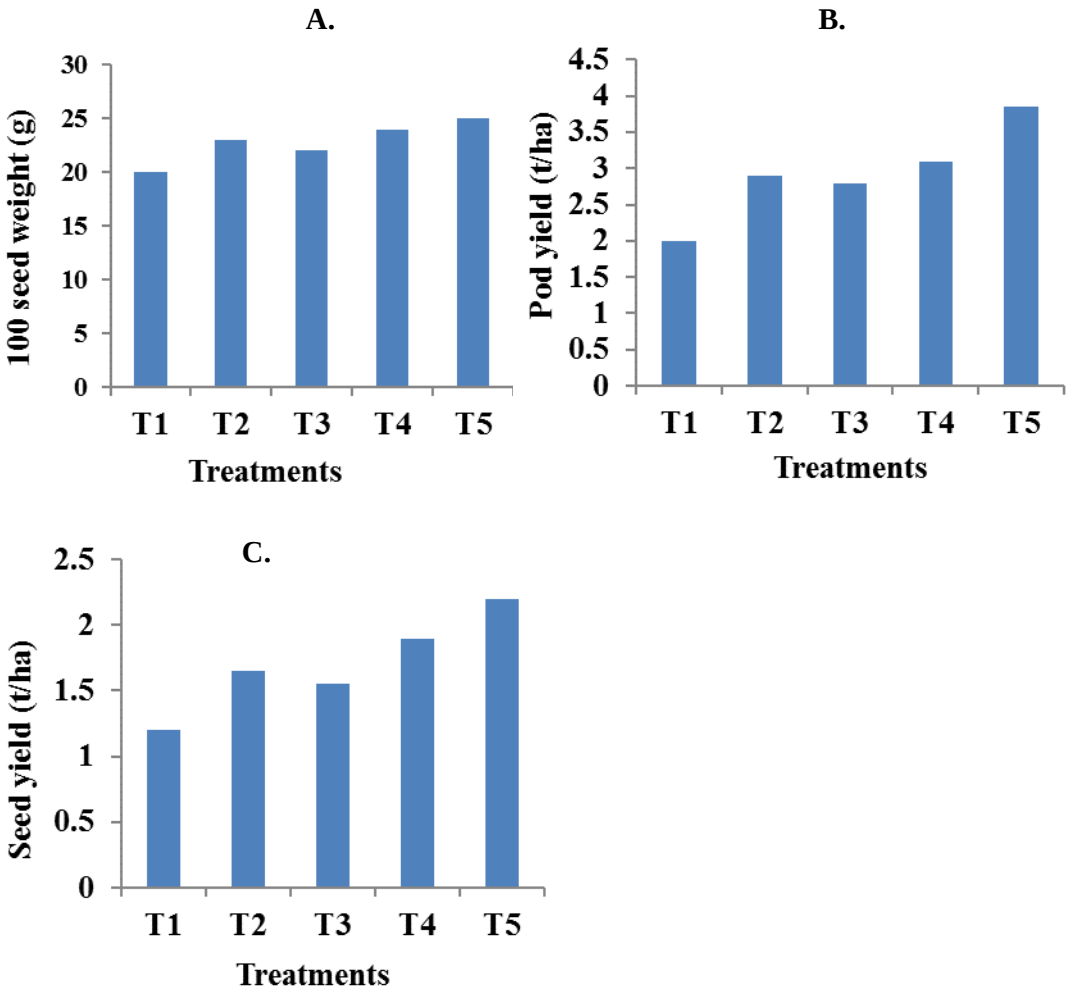

Fig. 1. Response of organic and chemical fertilizers on 100-seed weight, pod yield and seed yield of garden pea. A. 100-seeds weight; B. Pod yield and C. Seed yield

Seed yield is the ultimate result of the yield contributing characters of pea. It was found that the seed yield due to application of different organic and chemical fertilizers ranged from 1.16 to 2.06 t ha^{-1} (Fig. 1C). The highest seed yield was recorded in T_5 (Cowdung + Urea + TSP + MoP + Gypsum) and the lowest value (1.16 t ha^{-1}) in

T_1 (control). The seed yield in T_2 (Cowdung + Poultry manure + Mustard oilcake) and T_3 (Vermicompost + Poultry manure + Mustard oilcake) treatments with the value of 1.65 and 1.58 t ha^{-1}, respectively was identical, but lower than that of T_5 treatment.. The sink size gave significantly as reflected by more number of seeds per pod. Treatment T_5 comprises higher seed yield due to higher yield contributing characters. Only inorganic sources failed to show higher seed yield but combination of organic and inorganic fertilizer responded significantly. These results are in line with those reported by Hassan *et al.*. (2012); Feleafel and Mirdad, (2014).

Conclusion

Combined use of organic manure and chemical fertilizers (Cowdung + Urea + TSP + MoP + Gypsum) gave significantly the highest value of vegetative growth and yield attributing characters' i.e., plant height, number of branches $plant^{-1}$, number of pod length, pods $plant^{-1}$, pod breadth, number of seeds pod^{-1}, 100-seed weight, pod weight, pod yield and seed yield per hectare. The lowest value of growth and yield attributing characters were recorded with T_1. When only chemical fertilizers (T_4) were used for plants, they gave higher performance than only organic fertilizer (T_2 and T_3.). However, combination of organic and inorganic (Cowdung) and chemical fertilizer (T5) showed higher yield performances. So, cowdung 30 t ha^{-1}, 45-90-40-50 NPKS kg ha^{-1} could be used for higher productivity of pea (var. BARI Motor-1).

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

AL-Nuaimi, S.A. 1999. Soil Fertility and Fertilizers. Second Ed., Ministry of Higher Education and Science Research, Dar of Printed and Publication, Mosul University, Iraq.

AL-Taey, D.K.A., S.S.M. AL-Azawi, M.J.H. AL-Shareefi and A.R. AL-Tawaha. 2018. Effect of saline water, NPK and organic fertilizers on soil properties and growth, antioxidant enzymes in leaves and yield of lettuce (*Lactuca sativa* var. Parris Island). *Res. Crops* .19(3):441-449.

BBS. 2018. Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Statistics and Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh 108 p.

Bobade, K.P., S.O. Kolte and B.G. Patil. 1992. Affectivity of cyanobacterial technology for transplanted rice. *Phykos*. 31:33−35.

Chongtham, L., S. Bhandari, V. Sharma and S.K. Yadav. 2018. Effect of different organic and inorganic nitrogenous fertilizers on growth, yield and soil properties of pea. *Indian J. Pharma. Phytochemis.* 7(4):2114-2118.

Chopra, S., J.P. Sharma and K. Kumar. 2008. Influence of integrated nutrient management on growth, yield and quality of vegetable pea. *J. Plant Sci. Res.* 24(2):199-202.

Feleafel, M.N. and Z.M. Mirdad. 2014. Influence of organic nitrogen on the snap bean grown in sandy soil. *Int. J. Agricul. & Bio*. 16:65-72.

Hassan, M.M., A.G. Osman, Y.S. Osman, A.M. Sherif, A.M. Rugheim and M. ISA *et al*. 2012. Effects of bacterial strains and chicken manure on orobanche crenata infesting faba bean. *Int. J. Applied Sci. Technol*.2:122-29.

Jasem, A.H., H.A. Atab and H.M. Abed. 2015. Effect of organic and chemical fertilizers and their interaction with foliar fertilizers on yield of broad bean (*Visia faba* L.). *Euphrates J. Agric. Sci*. 7(4):44-48.

Paul. J., S. Sharma, A.K. Dixit and A.K. Sharma. 2011. Growth and yield of capsicum and garden pea as influenced by organic manures and biofertilizers. *Indian J. Agric. Sci*. 81(7):637-42.

Sharma, U. and J.K. Chauhan. 2011. Influence of integrated use of inorganic and organic sources of nutrients on growth and production of pea. *J. Farm Sci*. 1(1):14-18.

Trudy, T.A., S. Saikia, L. Rajen and B. Khatemenla. 2018. Organic and inorganic fertilizer amendments on sustainable health of garden Pea (*Pisum sativum* L.). *Int. J. Cur. Microbiology Appl. Sci*. 7(4):3664-3672.

Watt, B.K. and A.L. Merrill. 1993. Composition of Foods. U.S. Department of Agriculture. Handbook No. 8. 190 p.

Bangladesh Journal of Agriculture
Bangladesh Agricultural Research Council (BARC)

GUIDE FOR AUTHORS

Bangladesh Journal of Agriculture (BJA) is an official publication of the Bangladesh Agricultural Research Council (BARC). The journal publishes original research and review articles on the fundamental, applied and management aspects in all areas of agricultural sciences (crops, livestock, fisheries, natural resources, socio economics, etc.) and agricultural policy. It is an open accessed, peer- reviewed journal, published six-monthly (June and December). The aim of BJA is to advance and disseminate the knowledge in all spheres of agriculture towards achieving the sustainable development goals (SDG). Before publishing, the submitted paper will go through the process of reviewing, over-viewing and editorial board meeting.

Correspondence

All correspondences to the journal should be made to the
Executive Editor
Bangladesh Journal of Agriculture (BJA)
Agriculture Information Centre (AIC)
Bangladesh Agricultural Research Council (BARC)
Farmgate, Dhaka-15
Telephone:+880-2-9127407
E-mail: dir-aic@barc.gov.bd & bjabarcjournal@gmail.com

Guide for Authors

Contributions are being considered with an understanding that the submitted manuscript is original, has not been published before or under consideration for publication in any other scientific journal and the submitted manuscript has been approved by all co-authors. The author(s) are requested to follow the latest issue of the journal before submission of manuscript.

Length of article: A Full-length Manuscript should be within 5000 words and Short Communication within 2500 words including title, abstract and references. The abstract should be within 300 words for full-length paper and 200 words for short communication.

Typescript: Prepare manuscript using Times New Roman with 12 font size having double spacing and 2.5 cm margins on right and left sides in A4-sized paper. Preparation of the manuscript should conform to the style of the latest issue of the journal (BJA). Correct English, nomenclature and standard international units (SI) should be used.

Submission: The manuscript as both word and pdf files should be submitted to the Executive Editor of the journal through email (dir-aic@barc.gov.bd & bjabarcjournal@gmail.com) as attachment. A signed (scanned) cover letter, addressed to the Executive Editor, should be submitted along with the manuscript giving a statement that the manuscript has not been published or simultaneously submitted for publication elsewhere, and the author(s) declare(s) that that there are no conflicts of interest regarding publication of this paper.

Structure of the manuscript

Title page: The manuscript should have a title page which includes title of the article, name(s) and affiliation(s) of the author(s), and email address of the corresponding author. It should also contain running title and keywords. Then, the manuscript should follow the order: Title, Abstract, Keywords, Introduction, Materials and Methods, Results and Discussion, Conclusion, Acknowledgements (if needed) and References.

Title: The title should be precise with the fewest words possible and no abbreviation.

Running title: A short title of less than 50 characters, to be used as a running head at the top of the page, should be provided.

Abstract: The abstract should be concise and clear. It should be in one paragraph and structured with background, objectives, methods, key findings, and conclusion. At the end of Abstract, maximum five keywords should be written in alphabetical order with the first letter in upper case. Keywords preferably should not contain any word which is already present in the Title.

Divide your article into clearly defined and numbered sections. Subsections should be numbered as 2.1 (then 2.1.1, 2.1.2, ...), 2.2, etc. (Abstract is not included in section numbering). Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction: State the objectives of the work and provide background information including relevant literature which demonstrates the need for a new study. This section could be of 3-5 paragraphs in length.

Materials and Methods: State the materials and methods that used in the study. Only new methods and any modifications to existing methods should be described in detail, and the methods that are published should be summarized, and indicated by a reference. Statistical design with replications of each experiment needs to be mentioned.

Results and Discussion: The text should be clear, concise and simply stated. Statistically significant results from each table or illustration should be stated in the text. The text should be consistent with the data in tables and figures. Results should be interpreted and

compared with others, but not just repetition of results. Avoid extensive citations and discussion of published literature

Tables and Figures: Tables and figures should be placed at appropriate places of the manuscript. Figures should be black and white or colored with high resolution and adequate contrast.

Conclusion: This section should focus on the key results by concise and precise statements. It should be related to the objectives. Any recommendation and future research could be stated in this section.

Acknowledgements: It should be kept as minimum as possible including funding source and individuals who have provided help in carrying out the research.

References: References are listed chronologically by the author and year system without numbering; all entries in this list must correspond to references in the text. In the text, the names of 2 co-authors are linked by 'and'; for 3 or more, the first author's name is followed by *'et al.'*. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication. The reference list should be prepared alphabetically in the style as examples below.

Journal article

Alam, M.K., Bell, R.W., Haque, M.E., Islam, M.A., Kader, M.A. 2020. Soil nitrogen storage and availability to crops are increased by conservation agriculture practices in rice-based cropping systems in the Eastern Gangetic Plains. *Field Crops Res.* 250: 1-14.

Book

De Datta, S. K. 1981. Principles and Practices of Rice Production. John Wiley & Sons, New York, USA.

Book chapter

M. Jahiruddin. 2019. Natural Resource Management in South Asia. In: R. B. Shrestha, S. M. Bokhtiar, R. Khetarpal, Y. M. Thapa (Eds.), Agricultural Policy and Program Framework: Priority Areas for Research & Development in South Asia, Chapter 16, pp 347-357. SAARC Agriculture Centre, BARC Complex, Dhaka.

Conference proceedings

Islam, A.K.M. S., Haque, M. E., Hossain, M. M., Saleque, M. A., Bell, R.W. 2010. Water and fuel saving technologies: non-puddled bed and strip tillage for wet season rice cultivation in Bangladesh. In: Gilkes, R.J., Prakongkep, N. (Eds.), Proceedings of the 19th World Congress of Soil Science, Soil Solutions for a Changing World. 1-6 August 2010, Brisbane, Australia. Published on DVD, pp.169–172.

Review Process

All contributions will be initially assessed by the Editorial Desk to check its scope and format of publication in the BJA. The author(s) will provide name, affiliation and email

account of three potential reviewers. Papers deemed suitable are then sent to two expert reviewers to assess scientific merit of the article. The Editorial Desk will send the reviewed articles with comments from the reviewers to the corresponding author for major or minor revision. The corresponding author will submit the revised manuscript with changes marked by BLUE color, also a cleaned version and response letter in separate files. The final decision regarding acceptance or rejection of the article will be taken in the editorial board meeting. Author(s) will be notified of acceptance or rejection of the manuscript. The accepted papers will be published in the next available issue of the journal. Addition or deletion of author(s) during review process is not permitted.

Submission Checklist

Before submission of manuscript, the authors are requested to undertake final check, as follows:

(i) Cover letter

(ii) One author is designated as corresponding author with email address

(iii) Be sure, there are two files: Title page and Main manuscript including tables and figures.

(iv) Permission is taken for the use of copyright material, if any.

(v) All citations in the body of manuscript are listed in the reference section and vice versa.

Printed by: **Natundhara Printing Press**
314/A Elephant Road, Dhaka-1205. Cell: 01711019691, 01911294855