Program Based Research Grant (PBRG)

Sub-project Completion Report

on

Development of Production Package for Selected Horticultural Crops in Rooftop and Field Condition in Different Regions of Bangladesh

Sub-project Duration
October 2019 to December 2022

Implementing Organizations

Floriculture Division
Pomology Division
Horticulture Research Centre, BARI, Gazipur

Department of Horticulture
Sher-e-Bangla Agricultural University, Dhaka-1207

Project Implementation Unit

National Agricultural Technology Program (Phase II) Project
Bangladesh Agricultural Research Council
Farmgate, Dhaka 1215

December 2022

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Abbreviation and Acronyms

AEZ	Agro Ecological Zone
ANOVA	Analysis of Variance
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCR	Benefit cost ratio
CD	Cow-dung
CIF	Composite Inorganic Fertilizer
CRD	Completely Randomized Design
DAE	Department of Agricultural Extension
DAP	Days after Planting
DAS	Days after Sowing
DMRT	Duncan's Multiple Range Test
DP	Double pinching
FRG	Fertilizer Recommendation Guide
FYM	Farm Yard Manure
GAP	Good Agricultural Practices
GM	Gross Margin
GOB	Government of Bangladesh
GR	Gross Return
HQ	Head Quarter
HRC	Horticulture Research Centre
ICDDRB	International Centre for Diarrhoeal Disease Research, Bangladesh
IDA	International Development Agency
IFAD	International Fund for Agricultural Development
INM	Integrated nutrient management
IPM	Integrated Pest Management
LED	light-emitting diode
LSD	Least Significant Difference
LSP	Logistics Service Provider
MBCR	Marginal Benefit Cost Ration
MOP	muriate of potash
MSC	Mushroom Spent Compost
MT	Metric Tons
NATP	National Agricultural Technology Program
OFRD	On-Farm Research Division
PBRG	Program Based Research Grant
PCR	Project Compilation Report
PGR	Plant Growth Regulator
PI	Principal Investigator
PIU	Project Implementation Unit
PPFD	Photosynthetic photon flux density
ppm	Parts per Million
RCBD	Randomized Complete Block Design
RCC	reinforced cement concrete
SAU	Sher-e-Bangla Agricultural University
SP	Single pinching
TSP	Triple Super Phosphate
TVC	Total Variable Cost
VC	Vermicompost
WB	World Bank

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Executive Summary

Roof top gardening is one of the potential areas for vertical expansion of agriculture. However, people grow crops on the roof without knowing their proper production technologies just based on their random choice. As a result, they don't get the expected output. Therefore, this sub-project had been undertaken to develop production package of some selected horticultural crops for rooftop gardening, generation of technologies for soilless culture and dissemination of potential BARI developed varieties to farmer's field. The sub-project was started in October 2019 and implemented by four components including Coordination component. Floriculture Division, HRC, BARI (Component-1), SAU (Component-2) and Pomology Division, HRC, BARI (Component-3). First of all, a baseline field survey had been conducted in different locations of Gazipur and Dhaka city and for adaptive trials Bogura, Rajshahi, Jamalpur, Khagrachari, Rangpur and Sherpur districts within the 1st two months of the project in order to get basic information about the existing traditional and modern rooftop farming systems. Based on the findings of the survey with some new innovations the targeted research activities had been conducted.

Component-1 conducted 11 different research works for successful completion of the sub-project. Two crop management practices have been developed for quality production of Carnation and Chrysanthemum flowers. Production package of Chrysanthemum, Gerbera, Anthurium, Lilium, Rose, Orchid, Cactus, Succulents, Marigold and Lily for Rooftop gardening were developed. Considering flower production on rooftop garden, BARI Chrysanthemum-3 variety produced highest number of flower (27/plant). BARI Gerbera-1 (21), BARI Anthurium-1(6), BARI Lilium-1(11) and Hybrid rose R-003(16) yielded highest number of flower respectively. In respect of flower production, BARI Orchid-1(15), BARI Cactus-1(10), BARI Succulent-1(8), BARI Marigold-1(50) and BARI Lily-1(15) are recommended for rooftop gardening. Five most suitable growing media (soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v)), (coco dust + sand + FYM + vermicompost (2:1:1:0.5, v/v), (cocodust + perlite (1:1), (cocodust + sphagnum moss (1:1, v/v) and cocodust + vermicompost + mustard oil cake (1:1:1, v/v) + CIF (5g) for rose, aglaonema, anthurium, ground orchid and for lisianthus production on the field have been developed. Nine growing media have been standardized for Dianthus, Poinsettia, Cock's comb, Zinnia, Nephrolepsis Fern, Easter Cactus, Kalanchoe Succulent, Aster and Petunia for rooftop production. One soilless growing media (1.5 kg coco-dust with 0.5kg vermi-compost) has been standardized for selected five vegetables (Tomato, Capsicum, Cucumber, Bitter gourd and Lettuce) for rooftop production. Adaptive trials of different varieties of gladiolus, tuberose, gypsophila, lilium and marigold at farmer's field were conducted at Rajshahi, Bogura, Rangpur, Gazipur, Jamalpur and Khagrachari to popularize those flower varieties among the farmers. In case of gladiolus, maximum yield (no/ha) (193000) and BCR (4.5) were found in Rangpur. In Gazipur, BCR was highest (3.24) and (5.50) in BARI Tuberose-1 and BARI Lilium-1 respectively. On the other hand, BARI Gypsophila -1 (2.60) and BARI Marigold-1 (3.80) variety contributed more economic benefit in Jamalpur.

In component-2 (SAU), growing media combination of Cocodust + Mushroom Spant Compost + Soil (10:70:20) % as well as Cocodust + Vermicompost +Soil (10:70:20) % on upvc pipe vertical frame and square stair case vertical garden attained the highest yield in winter (Tomato, Cabbage, Spinach and Cauliflower) and Summer (Indian spinach, Red amaranth, Thankuni, Mint.) vegetables respectively. In addition, year round vegetable crops like-Bottle gourd, Bitter gourd, Sweet gourd and Brinjal performed best result in growth media containing coco-dust + vermi-compost + soil (10:70:20) % on semi stage half drum vertical frame. An innovative mixed garden landscape design was successfully established where 5 edible vegetable/medicinal (Coriander, Aloevera, Tomatoes, Chilli, Cucumber) and 2 flower crops (Petunia and Cosmos) were experimented in grow

bags (inside-black and outer white) with organic potting mix materials and the irrigation was done through dripper with timer controller (drip irrigation system). This landscape garden minimized insect pest attack and created aesthetic appearance with economic return. The maximum yield (18.22t ha^{-1}), brix percentages (12.50%) and vitamin-C percentages (37.30%) of BARI China Shak-1 (Pakchoi) was obtained from (Vermicompost + Soil) media combination on rooftop . The treatment T_{RB} (Red and Blue - 4:1) exhibited the highest total yield (1.29 kg) and total soluble solids (9.24 % brix) using hydroponic media of indoor growing conditions in BARI China shak-1 (Pakchoi). Application of tricholeachate (3000l/ha) + 1/4RDF) recorded the highest flower yield (29/plant) of gerbera.

Component-3 (Pomology Division) developed production package of Dragon fruit for rooftop gardening. Side by side, partial production technologies for rooftop gardening has also been developed for Guava and Golden apple. It was found that as a variety BARI Dragonfol-1 was the best and this variety performed better when large size (30 litre) geobag was used as a container in GI pipe based structure using soilless media (100% cocodust) was used. Considering growth, yield, load management on the roof and also economic benefit GI pipe+ geobag + soilless media (cocodust) based method of production was found to be the most suitable for dragon fruit production on the roof as it demonstrated 350% more number of fruits/pillar, 603% more yield, 68.92% less weight on the roof and 23,952 Tk. more income than other methods. In case of guava and golden apple, the results showed that the variety BARI Peyara-2 and BARI Amra-1 performed better considering growth, yield and yield contributing characters. However, plastic container performed better considering growth and yield of Guava for rooftop gardening as it produced 66% more yield/ plant. In strawberry, the highest yield (337.48 g/plant) was obtained from horizontal bed system and among the horizontal bed system cocksheet bed performed better as it contributes 27.5 % more yield. Considering an unit area plastic column system performed the best as it can accumulate more number of plants than any other system. It was found that fruit production on the roof is free from pathological hazards. BARI Dragonfol-1 and BARI Peayara-4 well established in Jhenaigati upazilla of Sherpur district and farmers are as happy as it improved their economic and social livelihood.

Overall, one full production package (variety, media, container type, container size, structure with recommended fertilizer application and other intercultural operations) of Dragon fruit for rooftop gardening had been developed. Partial production package of 15 different crops (3 fruits, 12 flowers) had been developed. Soilless culture of dragon fruit, strawberry and five different vegetables were established and different horticultural crops were demonstrated in farmer's field that significantly contributed to improve their livelihood.

Keywords: Rooftop farming, Fruits, Vegetables, Flowers, Soilless Culture.

PBRG Sub-project Completion Report (PCR)

A. Sub-project Description

1. Title of the PBRG sub-project

Development of Production Package for Horticultural Crops in Rooftop and Open Space in Urban Areas of Bangladesh

2. Implementing organization

Bangladesh Agricultural Research Institute (BARI) and Sher- e - Bangla- Agricultural University (SAU)

3. Name and full address with phone, cell and E-mail of Coordinator, Associate Coordinator and PI/Co-PI(s)

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4. **Sub-project budget (Tk.)**

4.1 Total (in Tk. as approved)	**:**	Tk. 21500000/- (Two Crore fifteen lakh taka only)
4.2 Latest Revised (if any) nine	**:**	Tk. 22064999/- (Two Crore twenty lakh sixty four thousand hundred ninety nine taka only)
5. Duration of the sub-project	**:**	October 2019 to December 2022
5.1 Start date (based on LoA signed)	**:**	22 October 2019
5.2 End date	**:**	29 December 2022

6. Background of the sub-project

Population has been increasing day by day in the urban areas of Bangladesh in general but in the Dhaka city in particular. Green areas have been shrinking to ensure the accommodation of mass population of the city. As a result, Green House effect has been increasing remarkably, resulting in climate change in the urban areas and everywhere. Rooftop is the only open space for urban people. If city people work on the rooftop for gardening that can ensure safe and fresh food, recreation, more oxygen, less carbon dioxide emission and eco- friendly green environment. Rooftop gardening is a space utilization technique to produce horticultural crops in the open space in the roof of a building. It is a means to utilize invaluable sun light and available home-made organic inputs to harvest fresh and healthy food. Rooftop gardening may be a solution to the worsening city environment and may turn the Urban Heat Island into a Green Belt for city dwellers. Ever rising concerns of chemical poisoning and food contamination that pose serious health hazards may be counterpoised with the introduction of rooftop gardening.

Ensuring a space for gardening in the urban areas is so difficult but rooftop is the only open space having more sunlight for gardening. Rooftop gardening assists in reducing overall heat absorption of the building as well as minimizing energy consumption. It may help to ensure better quality of life by supplying chemical free horticultural crops. It may also be a good scope to grow rare and unavailable vegetables, fruits and flowers. Pollution can also be reduced through maintaining the greenery. Rooftop garden is a source of Carbon sink; it helps to ensure cool environment and the habitat of biodiversity. Recent research findings showed that top floor's temperature of a building may go down upto 2-3^{0}C for cultivating different horticultural crops on rooftop. It also helps to provide mental recreation for the residents and increases the beauty of the building (Chowdhury, 2014). It can be mentioned here that the city corporation authority of agriculture friendly government has declared 10% holding tax exemption for promoting rooftop gardening in Dhaka city.

Through this process, one can use maximum space to cultivate diversified plants by using the containers of tub, nylon net, medium size drum, iron or steel frame, plastic pot and water proofed rod. Farming on the rooftop of the buildings in urban areas is usually done by using green roof, hydroponics, organic, aeroponics or container gardens (Asad and Roy, 2014). The first benefit of this practice is increased by local supply of fresh food and beautification. Different kinds of potting containers and soil media are being used by the gardener for growing different types of vegetables, fruits and flowers due to unavailability of package of technologies. If the rooftop gardener can use the roof top in a planned way like following a model with maximum number of vegetables, fruits and flowers in a small area and use appropriate soil media in appropriate pot/tub, the rooftop garden will not only be an attractive place for recreation but also will be a source of maximum amount of fresh horticultural products. But fact is that, there are no systematic research findings or even package of information related to rooftop gardening of horticultural crops.

As a matter of fact, it is necessary to investigate and standardize different issues on rooftop gardening in the context of Bangladesh. Therefore, the project has been designed to develop a package of some horticultural crop production, media standardization as well as rooftop gardening methods covering horticultural crops in urban areas and generate some technologies in field condition of Bangladesh.

7. Sub-project general objective (s).

i. To develop production package for selected fruits, vegetables and flowers;

ii. To develop methods for rooftop gardening with horticultural crops in Dhaka and Gazipur;

iii. To generate technologies for horticultural crops under soilless culture and in field condition

8. Sub-project specific objectives

Coordination Component (HRC, BARI):	❖ To organize events or activities in order to ensure the involved Organization/University work together effectively ❖ To coordinate the research, development and technology transfer activities of the implementing components ❖ To monitor and evaluate the activities of the participating Organization/ University
Component-1 (Floriculture Division, HRC, BARI)	❖ To develop appropriate production packages for quality flowers and ornamentals on rooftop and field conditions. ❖ To evaluate the performance of vegetables under soilless culture on rooftop and flower varieties in field conditions
Component-2 (SAU) (Dept. of Horticulture, SAU, Dhaka)	❖ Identify and establish methods for sustainable rooftop gardening ❖ To design and develop different systems and devices for rooftop gardening
Component-3 (Pomology Division, HRC, BARI)	❖ To develop production package of selected fruit crops for rooftop gardening ❖ To generate technologies for selected fruit crops under soilless culture on the roof and in field condition

9. Implementing locations

Component-1 (Floriculture Division, HRC, BARI)

Horticulture Research Centre rooftop, Bangladesh Agricultural Research Institute, Gazipur (On-Station trial) at 23.9920º N Latitude and 90.4045º E Longitudes having an elevation of 11.9 m from sea level under agro-ecological zone (AEZ) 28 and Rajshahi, Khagrachari, Gazipur, Jamalpur, Bogura and Rangpur (On-Farm Trial).

Component-2 (Dept. of Horticulture, SAU, Dhaka)

The implementing location Dr. M A Wazed Miah Research Centre rooftop SAU, Dhaka was located at 23°42′37″ N (Latitude), 90°24′26″ E (Longitude), and has an average elevation of 16.6 meters.

Component-3 (Pomology Division, HRC, BARI)

Horticulture Research Centre rooftop, Bangladesh Agricultural Research Institute, Gazipur (On-Station trial) at 23.9920º N Latitude and 90.4045º E Longitudes having an elevation of 11.9 m from sea level under agro-ecological zone (AEZ) 28 and field research (adaptive trial) was conducted at Jhenaigati and Nalitabari Upazila, Sherpur.

10. Methodology in brief:

Information of modern rooftop farming systems

A baseline field survey had been conducted in different locations of Gazipur and Dhaka city within the 1st two months of the project commencement in order to get basic information about the existing traditional and modern rooftop farming systems practiced in the proposed area, plant species and/or diversity and seasonal and year-round horticultural crop combination etc. Based on the findings of the survey, the targeted research activities had been conducted.

Selection of rooftop and farmers field for conducting the experiments

One roof top of HRC, BARI, Gazipur and another rooftop of Dr. M A Wazed Miah Research Centre, SAU, Dhaka were used for conducting the research activities of fruits, vegetable and flower related to rooftop gardening in 23.99°N and 90.42°W geographical position. Some field research activities were carried out at Floriculture field/shade house of HRC, BARI, Gazipur and another one at Horticulture Farm, SAU, Dhaka. Moreover, Adaptive trials on five different flower crops and two different fruit crops were conducted at seven different locations viz; Gazipur, Bogura, Rajshahi, Jamalpur, Khagrachari, Rangpur and Sherpur districts respectively.

System identification for roof top gardening

For system identification, information was collected from both primary (eg. rooftop gardeners) and secondary sources (eg. agriculture experts, literatures etc.). These were gathered by survey as well as non survey methods.

Methods to system intervention

The diversified horticultural crop species/types such as fruits, vegetables and flowers for rooftop gardening and field trials as well as experimental locations and different systems of production were selected by the researcher group (Fig. 1). The productivity and potentiality of the systems were also analyzed. Necessary planting materials, other inputs and technical supports were made available to the selected rooftop and for field trials. Close monitoring had been done frequently for the improvement of research works.

Fig. 1. Different systems of production followed in the sub-project

Researcher also followed some methods for roof protection (raise pot, plastic floor paint and regular surface cleaning etc.) for urban rooftop gardening. In this practice, first of all, the parts of floor were painted for placing container to avoid water stagnant situation in all season on the roof. Then containers were placed over the bricks as to avoid direct contact with the floor (Fig. 2).

Fig. 2. Roof protection practices

Research Activities of the sub-project:

Different types of experiments were conducted in the study area for obtaining the appropriate information for the fulfillment of the sub-project objectives. The experiments have been conducted by the following research activities.

Component 1 (Floriculture Division, HRC, BARI):

Experiment 1: Effect of pinching and boron on quality flower production of carnation

The experiment was carried out under polyhouse condition at the Floriculture Research Field of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during 2019-2020. One month aged tissue cultured plantlets of Carnation (DC-002) were transplanted in 2.0 × 1.5 m plots under poly house conditions. There were seven treatments i.e. T_0- Control, T_1- Single pinching (SP), T_2- Double pinching (DP), T_3- SP+ 0.05% boron, T_4- SP+ 0.1% boron, T_5- DP+ 0.05% boron and T_6- DP + 0.1% boron. In single pinching, pinching was done at 25 days after transplanting of plantlets. In case of double pinch (Fig. 3). when all shoots produced after single pinch were pinched after one month of single pinch. For preparation of 0.05 and 0.1 % boron solution, commercially available as 'Solubor' with 20 percent available boron was dissolved in 1 litre water and used as foliar spray at monthly intervals. All experimental plants received identical fertilizers, irrigation and other cultural practices during the period of investigation, except boron and pinching. Experiment was laid out in randomized block design with three replications. Carnation plantlets were planted at 15 × 15 cm spacing. Data on various vegetative and floral attributes were recorded. Results thus obtained were subjected to statistical analysis with the help of 'MSTAT' software. The difference between treatments means were compared by Duncan's Multiple Range Test (DMRT) according to Steel *et al*. (1997).

Fig. 3. Pinching of Carnation

Experiment 2: Effect of growth regulators on growth and flowering of chrysanthemum

The experiment was conducted at the Research field of Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during 2019- 2020. Four weeks old seedling of chrysanthemum (CM-019) were collected from field of Floriculture Division of Horticulture Research Centre (HRC) and transplanted in 10 x 12 cm earthen pot in the month of October 2019. The pompon type genotype (CM-019) was used in this study. The pots were filled with a mixture of media that consists of one part coarse sand, one part garden soil, one part cocodust, one part cowdung, a quarter part of wood ashes and two table spoonfuls of bone meal. Subsequently, 10 g TSP, 6 g MoP, 0.10 g B per pot were applied. The source of boron,

commercially available as 'Solubor' with 20 per cent available boron was used. Urea @ 2, 3 and 2 g per pot was applied at 30, 50 and 70 days after transplanting, respectively. The pots were kept under natural sunlight and distance were maintained 6 centimeter apart from one pot to another pot. The experiment was laid out in Randomized Complete Block (RCB) Design with 5 replications (one pot considered as one replication). The experiment consists of 7 treatments viz. BA, GA_3 and NAA @ 100 ppm and 200 ppm of each and control. The growth regulators were sprayed on plants in the morning at monthly interval starting after one month of seedling transplantation. Control treated plants were sprayed with water. All the cultural operations such as weeding, mulching, watering, disbudding, pinching, staking etc. were done as per the need of the crop. Ridomyl Gold (a.i. Metalaxyl & Mancozeb) was sprayed on the plants @ 2.0 g/L H_2O thrice at 15 days interval starting from 20 days after transplanting as protective measures against the incidence of diseases such as leaf spot and powdery mildew. Ripcord (a.i. Cypermethryn) was also sprayed on the plants @ 2.0 ml/L H_2O thrice at 15 days interval starting from 30 days after transplanting as protective measures against the attack of insects such as aphids, thrips, leaf miners etc. The data were recorded on plant height, number of leaves per plant, leaf area per plant, plant spread, days to flower initiation, number of flowers per plant, stalk length, rachis length, flower size, average weight of flower stalk after maturity indices of chrysanthemum flower. For observing post-harvest life of the cut flowers of chrysanthemum, GA_3, BA and NAA treated and untreated cut stalk were collected from the field in the morning to avoid excessive heat and brought to the laboratory in a bucket containing 3-4 liters of water. Before placing cut stalk in vase water, stalk were cut (slanting) to a uniform length of 25 cm and leaves near the bottom of the cut stalk were removed except for few leaves below the inflorescence. Cut stalk were placed in 250 ml conical flasks containing 200 ml of water and kept in laboratory conditions at a room temperature of 18±2ºC and relative humidity of 70±5%. Five flowers were taken randomly and vase life was recorded from all the treatments by counting number of days from the time, when the cut flowers lose their decorative value after complete opening or shedding of petals. The recorded data were statistically analyzed with the help of computer base MSTAT software and treatment means were separated by Duncan's Multiple Range Test (DMRT) according to Steel *et al*. (1997).

Experiment 3: Effect of potting media on growth and quality in aglaonema

The research work was carried out at Floriculture Shade Net House of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during 2020-2021. One-month old plants of Aglaonema obtained from a nursery located in Dhaka were used in the experiment. Six treatments T_1-Soil (Control), T_2-Vermicompost + perlite (1:1), T_3- FYM + perlite (1:1), T_4 - Cocodust + perlite (1:1), T_5-Cocodust + perlite + FYM (1:1:1) and T_6-Cocodust + perlite + vermicompost (1:1:1) were laid out in Completely Randomized Design (CRD) and replicated thrice. Each component of the mixture was added on the basis of volume while preparing the potting mixture which was added to pots of 10 cm size stopping at 2cm from the top. The study was carried out in a sub-tropical climate characterized by heavy rainfall during the period from July to September and scanty rainfall during the period from October to March. The average relative humidity (RH) inside the Shade Net House was measured by installing dry bulb and wet bulb thermometer which ranged from as high as 60 percent in October to as low as 35 percent in March. The potting media were made available two months before planting of suckers and kept in a shady place covering with polythene paper. At that time, cowdung, vermicompost, perlite and cocodust

were already decomposed. Watering was done to decompose media twice in a week for one month. The pots were washed and cleaned thoroughly before filling up of potting media.

Each plant in individual pot was applied with 4.0 g urea, 6.0 g single super phosphate, 4.0 g muriate of potash, 0.5 g zinc, 1.0 g sulphur and 0.1g boron at two months interval. Plants were hand watered immediately after planting and thereafter at two to three days interval with a rose can. Intercultural operations like forking and weeding were carried out at regular interval. Plants inside the shade net house were more or less free from any insect pest attack or fungal infestation. However, foliar spraying of autostin @ 2.0 g/l and Ripcord @ 1.0 ml was done occasionally to avoid any fungal disease or pest attack in the plants. Five plants per treatment under each replication were earmarked for recording various growth and quality parameters. The mean value of data collected on these five plants in respect of various parameters, viz plant height, leaf number, leaf length, leaf width, basal stem diameter, sucker number and plant growth index were recorded. For calculating plant growth index, height (base to maximum point of canopy) and width (distance between widest two points in canopy) of plants were measured at inception and again at the termination of experiment. Plant growth index was calculated using the formula of net change in plant height plus net change in plant width (Merrow, 1995). Data were statistically analyzed through analysis of variance with the help of MSTAT software. Difference between treatments means were compared by Duncan's Multiple Range Test (DMRT) according to Steel *et al*. (1997).

Foliage colour of a plant is a quality parameter which improves the aesthetic value of the plant. The leaves with their natural colour free from any blemishes were visually evaluated by five persons based on 1 to 5 point scale (poorest to best). The value of assessment was presented by the mean value of five observations. Visual plant grade which represented the overall appearance with respect to growth, colour and presentability were also visually assessed by five persons based on 1 to 5 (poorest to best) scale and the value of assessment were presented by the mean value of five observations by the grading system by Henny *et al*. (2008). Leaf nitrogen percent was determined by Kjeldhal method. Phosphorus content was determined as per Jackson (1973). Potassium percent was estimated by a microprocessor-based flame photometer, using specific filter and LPG flame.

Experiment 4: Effect of substrates on growth, yield and quality of anthurium in soilless culture

A pot experiment was conducted in the Floriculture Shade Net House under Horticulture Research Centre of Bangladesh Agricultural Research Institute, Gazipur during 2020-21 with four different substrates. Six weeks old hardened tissue cultured anthurium plantlets of BARI Anthurium-1 were used as planting material. Ten inches plastic pots were taken for the experiment. Four different potting substrates like soil, cocodust, perlite and sawdust were used as six treatment combinations. The treatment combinations were T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1), and T_6: Cocodust + sawdust (1:1). The experiment was laid out following Completely Randomized Design (CRD) with five replications. Before setting of the experiment the chemical composition of potting substrates were analyzed following standard method as outlined by Page *et al.* (1982). The chemical properties are presented in Table 1 and Table 2. Well- decomposed saw dust, perlite and cocodust were used singly and combinedly before 25 days of seedling transplanting. The seedlings of anthurium were transplanted singly in the respective treatment pot. The anthurium plants were nourished with Cooper's nutrient solution having EC of 1.5 dS/m throughout the growing period. Irrigation was done as and when required. Data on

survivability %, plant height, number of leaves, plant spread, sucker number, days to flowering, flower number, stalk length, flower weight, vase life and flowering duration were recorded from five randomly selected plants of each treatment and averaged. Treatment wise post-harvest potting substrates were analyzed following same method (Page *et al*., 1982). Data were statistically analyzed with the help of MSTAT software. Difference between treatments means were compared by Duncan's Multiple Range Test (DMRT) according to Steel *et.al*, (1997). The benefit cost ratio (BCR) was calculated for each treatment pot. Total variable costs were calculated by adding the cost incurred for labor and inputs for each treatment. Flower stick and sucker of anthurium was utilized to calculate gross return. Shadow prices were not considered. Gross return was estimated by multiplying following flower stick and sucker yield by unit price (Sher-e-Bangla Nagar) of anthurium flower and sucker. Net return was calculated by subtracting variable cost from gross return.

Table 1. Chemical properties of different potting substrates (initial)

Materials	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Mn	Zn
			(meq/100g)				(µg/g)						
Cocodust	7.5	28	1.1	0.3	1.5	1.65	1.0	2.0	0.015	0.005	0.80	0.020	0.012
Perlite	7.4	25	0.9	0.3	1.2	1.60	0.8	1.8	0.010	0.004	0.40	0.090	0.010
Sawdust	6.6	20	0.8	0.2	1.1	1.40	0.5	1.6	0.004	0.001	0.20	0.005	0.008

Table 2. Chemical properties of initial soil (potting substrate)

Material	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Mn	Zn
			(meq/100g)				(µg/g)						
Soil (Sandy loam)	7.2	0.50	13.0	3.0	0.20	0.03	11.0	10.0	0.18	1.10	20.0	17.0	0.90
*Critical level	-	-	2.0	0.5	0.12	0.10	8.0	8.0	0.16	0.20	3.0	1.0	0.50

*FRG (2018)

Experiment 5: Effect of potting media on plant growth and yield of ground orchid

The present study was conducted under shade net conditions at the Orchidarium House of Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) at Joydebpur, Gazipur during 2020-2021. Two months old tissue cultured plants of ground orchid were used as planting material for conducting experiment (Fig. 4). Planting was taken up in plastic pots of size 10 cm diameter. Orchids require a suitable potting medium for growth and development and it varies with type of orchid and the environmental conditions. This orchids were grown in different pots containing different potting media i.e. T_1- Soil (control), T_2 - Cocodust, T_3 - Sphagnum moss, T_4 - Perlite, T_5 - Cocodust + Sphagnum moss (1:1, v/v) and T_6 - Cocodust + Perlite (1:1, v/v). After planting, the potting media were immediately irrigated thoroughly to maintain the optimum

Fig. 4. Tissue cultured planlets of ground orchid used as planting material

moisture condition. During vegetative phase N, P_2O_5 and K_2O at the ratio of 3:1:1 and during blooming phase at the ratio of 1:2:2 (0.2% concentration) were provided weekly once. Nutrient combinations were made using ammonium nitrate, orthophosphoric acid and potassium nitrate. The commercially available water soluble fertilizers (19-19-19, 13-0-45) were also used as source for nutrients. Micronutrients were sprayed monthly once. Calcium nitrate and Magnesium sulphate @ 0.1% was given once in a month. Completely Randomized Design was set with three replications having five plants in each replication and each replication contains six different treatments. The data recorded on various parameters viz. Plant height, leave number, leaf area, shoot girth, sucker number, days to flowering, spike length, rachis length, floret number, spike weight, spike yield, flowering duration, vase life and were statistically analyzed with the help of MSTAT software.

Experiment 6: Effect of organic manures and fertilizers on growth, flowering and yield of lisianthus

The present study was conducted under Shade Net House of Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) at Joydebpur, Gazipur during 2020-2021. Two months old Lisianthus seedlings were collected from Metal Agro Ltd. and used as planting material were transplanted into uniform size of 10 cm × 10 cm pots filled with different types of organic manure for conducting experiment. Commercially available composite inorganic fertilizer (CIF) is a granular fertilizer (N-P_2O_5-K_2O = 15-15-15) @ 5g/pot were added with organic manure had been reported and recommended to improve growth, flowering and quality in potted lisianthus (Shimuzu *et al*., 2012). Weeds were removed manually. Potting media were loosed monthly to avoid compactness for better aeration. Irrigation, disbudding, staking etc. were done properly as per requirement. There were five treatments in the experiment with T_1- Soil (control), T_2 - Cocodust + Farmyard manure (1:1, v/v) + CIF(5g), T_3 - Cocodust + Vermicompost (1:1, v/v) + CIF(5g), T_4 -Cocodust + Farmyard manure + Mustard oil cake (1:1:1, v/v) + CIF(5g) and T_5 - Cocodust + Vermicompost + Mustard oil cake (1:1:1, v/v) + CIF(5g). The experiment was laid out following Completely Randomized Design (CRD) with three replications. Data on plant height, number of leaves, number of branches, plant spread, sucker number, days to flowering, flower number, petal number, stalk length, flower weight, and vase life were recorded from five randomly selected plants of each treatment and analyzed statistically. Difference between treatments means were compared by Duncan's Multiple Range Test (DMRT) according to Steel *et al.,* (1997).

Experiment 7: Effect of different growing media on growth and yield of rose

The experiment was conducted at the field of Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) at Gazipur during 2020-2021 with seven different growing media. A commercial variety of Dutch rose was collected from Moumita Flower Products Private Limited and plants (six months old) were transplanted into uniform size of 10 cm × 12 cm earthen pots filled with different types of growing media. The treatments media were T_1 = Soil + Farmyard manure (1:1, v/v), T_2 = Soil + cocodust (1:1, v/v), T_3= Soil + vermicompost (1:1, v/v), $T_{4=}$ Soil + perlite (1:1, v/v), $T_{5=}$ Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v), T_6= Soil + cocodust + vermicompost + perlite (1:1:1:1, v/v) and T_7= Soil (control) following Completely Randomized Design (CRD) with three replications. A light irrigation was applied immediately after transplanting in pots for proper establishment. Potting media were prepared two months before planting. Media were decomposed for two months with watering twice weekly. Treatment wise initial (before planting) and postharvest potting media were analyzed by standard methods (Page *et al.,* 1982).

Washed and cleaned pots were filled with potting media. Fertilizers N, P and K were applied @ 15-15-10 g/plant recommended by Bose *et al.* (2015). Commercial micronutrient grade Ormichem @ 0.5 g/plant was sprayed at 30 days interval. Weeds were removed manually. Potting media were loosed monthly to avoid compactness for better aeration. Irrigation, disbudding, staking etc. were done properly as per requirement. Diseases like leaf spot and powdery mildew were controlled by 3 sprayed of fungicide Ridomil Gold (a.i. Metalaxyl + Mancozeb) @ 2.0 g/L H_2O at 15 days interval started from 30 days after transplanting. Insects like aphids, thrips, leaf miners etc. were controlled by 3 applications of Ripcord (a.i. Cypermethrin) @ 2.0 ml/L H_2O at 15 days interval started from 30 days after transplanting. Flowers were harvested in morning at tight bud stage observed 2 to 3 petals unfurled. Secateurs were used for flower harvesting. Five plants were randomly selected from each treatment and tagged for data recording. Data on plant height, plant spread, leaf area, number of leaves per flowering stalk, number of branches per plant, stalk length, days to flowering, number of petals per flower, size of petals, size of flower, number of flowering, fresh weight of cut flower, dry weight of cut flower, flowering duration and vase life were recorded. Dutch rose cut flowers, cut stems were collected from pots in the morning to avoid excessive heat and brought to the laboratory in a bucket containing 3 to 4 liters of water for observing vase life. Stems were cut (slanting) to a uniform length 30 cm and leaves near the bottom of cut stems were removed avoiding few leaves below the inflorescence for placing in vase water. Cut stems were placed in 250 ml conical flasks containing 200 ml of water and kept in a laboratory room temperature 18±2ºC and relative humidity 70±5%. Five flowers have been taken randomly from each treatment and vase life was recorded by counting number of days from the time of cut flowers lose their decorative value after complete opening or shedding of petals. The recorded data were statistically analyzed with the help of MSTAT software and treatment means were separated by Duncan's Multiple Range Test (DMRT) at 5% level of probability according to Steel *et al.* (1997).

Experiment 8: Effect of different soilless media for vegetable production on rooftop gardening

The experiment was conducted at the rooftop of Horticulture Research Centre office building, Bangladesh Agricultural Research Institute, Gazipur during 2020-2021. Five types of vegetables viz. tomato, sweet peeper (Mistimorich), bitter gourd, cucumber and lettuce were included as crop varieties and soil, coco-dust, vermi-compost and cow-dung were considered as growing media materials. The experiment was laid out in RCB design with three replications. The treatment combinations were defined as : (vegetable crop & variety)-V_1= tomato (BARI Tomato-14), V_2= sweet eeper (BARI Mistimorich-1), V_3= bitter gourd (Tia), V_4= cucumber (Alavi) and V_5= lettuce (BARI Letuce-1) and growing media-T_0= 1.0 kg cow-dung + 1.0 kg soil (Traditional practice), T_1= 1.0 kg coco-dust with 1.0 kg vermi-compost, T_2= 1.25 kg coco-dust with 0.75 kg vermi-compost, T_3= 1.5 kg coco-dust with 0.5 kg vermi-compost, T_4= 1.75 kg coco-dust with 0.25 vermi-compost and T_5= 2.0 kg coco-dust with 0.0 kg vermi-compost. The 2.5 kg content bucket was filled with 2.0 kg media as of treatment. There were 25 days aged seedlings of tomato and sweet peeper and 20 days aged old lettuce while 15 days old cucumber and bitter gourd were transplanted in the media filled bucket properly. After filling up of pot with growing media Bradley Nutrient solution were applied (as of showing deficient symptom of plants) by dripping method as has been suggested by Bradley and Marulanda. The Bradley Nutrient solution was made with @ Urea 72.0 g, TSP 72.0 g and MoP 36.0 g/plot for each crop (for 18 pots of each crop). This solution was applied on 27.1.2021 and 11.2.2021 with an equal split. Irrigation regime and plant protection measures were

taken as and when necessary. Data on plant height at last harvest; number of leaves/plant, days to flowering (in case of fruited vegetable), yield/plant, insect and disease reaction were recorded. The recorded data were analyzed following Statics 10 software.

Experiment 9: Development of production package of some selected flower crops for rooftop gardening

An experiment was conducted on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during 2020-2021 to develop production package for selected flower crops on the roof. The experiment was laid out in a Randomized Complete Block (RCB) Design with 3 replications. The flowers were selected based on seasonality, height, growing habits and choice of rooftop gardener from base line survey etc. The flower crops such as Rose, Gerbera, Chrysanthemum, Lilium, lily, Orchid, Marigold, Anthurium, Cactus and Succulents were selected for performance trial on the roof. Growing media and fertilizer dose for every crops were applied as per recommendation of Soil Science Division of BARI, while plant protection measures were taken as and when necessary following recoomentation of Pathology and Entomology Division of BARI. For performance trial crop-wise variety/genotypes, relevant data have been collected and statistically analyzed with a statistical package program MSTAT-C. The treatment means were separated by Least Significant Difference (LSD) test at 5% level of significance.

***Experiment 10: Effect of media on growth and yield of flower and ornamental plants on* rooftop**

A pot experiment was conducted on the rooftop of Horticultural Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during 2020-2021. Nine types of ornamentals viz. Dianthus, Poinsettia, Cock's Comb, Zinnia, Nephrolepsis Fern, Easter cactus, Kalanchoe succulent, Aster and Petunia were included as ornamental crop and soil, coarse sand, cocodust, vermicompost, trichocompost, perlite and cowdung were considered as growing media. The treatment combinations were defined as Ornamental Crops (O_1 = Dianthus, O_2 = Poinsettia, O_3 = Cock's comb, O_4 =Zinnia, O_5= Nephrolepsis Fern, O_6= Easter cactus, O_7= Kalanchoe succulent, O_8= Aster and O_9= Petunia and growing media T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1). Four weeks old seedlings of ornamental plants were transplanted in the media filled ten inches pots as per treatment properly. The ornamental plants were nourished with Cooper's nutrient solution throughout the growing period. Data on plant height, number of leaves per plant, number of shoot/ plant, days to flowering, flower number per plant and flowering duration were recorded. Data were statistically analyzed through analysis of variance with the help of MSTAT software. Difference between treatment means were compared by Duncan's Multiple Range Test (DMRT) according to Steel *et al.* (1997).

EXPT. 11 (a): Adaptive trial of gladiolus varieties at farmer's field

A trial on gladiolus vaieties was conducted at Gazipur, Bogura, Rajshahi, Jamalpur, Khagrachari and Rangpur during Rabi 2020-2021. The experiment was laid out in RCB design with four dispersed replications. The unit plot was 2500 m^2 areas with plant spacing of 20 × 20 cm. Four varieties of gladiolus viz. BARI Gladiolus-1 (Red), BARI Gladiolus-3 (White), BARI Gladiolus-4 (Pink) and BARI Gladiolus-5 (Yellow) were included in the trial. The field was well prepared by adding 10 t cowdung and fertilized @ 200 Kg N, 50 Kg P, 150 Kg K, 20 Kg S, 2 kg B and 3 kg Zn/

ha. Cowdung, P, K, B, S and Zn were applied as basal and N was top-dressed in two equal splits at 4 leaf stage and spike initiation stage. Intercultural operations were done as and when necessary. Pest and other crop management practices were done as and when necessary. The spikes were cut when lower 2-3 florets showed their blushes of colour. The data on yield and yield contributing characters were taken and analyzed statistically and means were separated by LSD test at 5% level of significance. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Experiment 11 (b): Adaptive trial of tuberose varieties at farmer's field

A trial on tuberose varieties was conducted at Gazipur, Bogura, Rajshahi, Khagrachari, Rangpur and Jamalpur during 2020-2021. The experiment was laid out in RCB design with two dispersed replications. The unit plot was 1500 m^2 areas with plant spacing of 30 × 20 cm. Bulbs of BARI Tuberose-1 along with check (PT-001) were used as planting material. Manure, fertilizer, insecticide, fungicide, netted bag, secateurs, budding knife etc. were supplied for making availability of inputs among the farmers in time. The experimental field was well prepared by adding 10t cowdung and fertilized @ 435 kg urea, 400 kg TSP, 300 kg MoP, 12 kg boric acid and 8 kg $ZnSO_4$/ha. Cowdung, TSP, MoP, boric acid and $ZnSO_4$ were applied as basal and urea was top-dressed in two equal splits at 30 days after planting and spike initiation stage.

Experiment 11 (c): Adaptive trial of gypsophila variety at farmer's field

Adaptive trial on gypsophila variety was conducted at Gazipur, Bogura, Rajshahi, Jamalpur, Khagrachari and Rangpur during the Rabi season of 2021-2022. The unit plot was 500 m^2 areas with plant spacing of 15 × 15 cm. Seeds of BARI Gypsophila-1 was used as planting material. Manure, fertilizer, insecticide, fungicide, netted bag, secateurs etc. were supplied for making availability of inputs among the farmers in time. The experimental field was well prepared by adding 5t cowdung and fertilized @ 250 kg urea, 200 kg TSP, 215 kg MoP, 8 kg boric acid and 6 kg $ZnSo_4$/ha. Cowdung, TSP, MoP, boric acid and $ZnSo_4$ were applied as basal and urea was top-dressed in two equal splits at 30 days after planting and flower initiation stage.

Experiment 11 (d): Adaptive trial of lilium varieties at farmer's field

Trials on lilium varieties were conducted at Gazipur, Bogura, Rajshahi, Khagrachari, Rangpur and Jamalpur during 2020-2021. The experiment was laid out in RCB design with two dispersed replications. The unit plot was 1000 m^2 areas with plant spacing of 20 × 15 cm. Bulbs of BARI lilium-1and BARI lilium-2 were used as planting material. Manure, fertilizer, insecticide, fungicide, netted bag, shade net, secateurs etc. were supplied for making availability of inputs among the farmers in time. The experimental land was well prepared by adding cocodust (50:50 soil and cocodust), 10t cow dung/ha. Chemical fertilizers were not applied up to 3 weeks of bulb planting. After 3 weeks of bulb planting, NPK@30:20:20g/m^2 was applied. Urea and MoP @ 100kg/ha were top dressed before spike initiation stage and bulb lifting, respectively.When the lower most buds showed color, the spikes were harvested. After collecting flowers, the plants leaving 25-30 cm stem were kept in the field for bulb development.

Experiment 11 (e): Adaptive trial of marigold varieties at farmer's field

A trial on marigold varieties was conducted at Gazipur, Bogura, Rajshahi, Parachora Khagrachari, Rangpur and Jamalpur during 2021-2022. The experiment was laid out in RCB design with two dispersed replications. The unit plot size was 1500 m^2 areas with plant spacing of 30 × 20 cm.

Cuttings of BARI Marigold-1 along with check (PT-001) were used as panting materials. Manure fertilizer, insecticide, fungicide, netted bag, secateurs, budding knife etc. were supplied for making availability of inputs among with farmers in time. The experimental field was well prepared by adding 5t cowdung and fertilizer @ 250 kg urea, 200 kg TSP, 150 kg MoP, 8 kg boric acid and 5 kg Zn SO_4/ha. Cowdung, TSP, MoP, boric acid and Zn SO_4 were applied as basal and urea was top-dressed in two equal splits at 30 days after planting and spike initiation stage.

Component 2: Department of Horticulture, SAU, Dhaka

Experiment 1: Development of cropping patterns for different planting media in summer season

This experiment was executed in RCB design with 3 replications by making a vertical frame with MS angle iron where 12 numbers of 4" diameter uPVC pipe (36 inches long) were set over the triangle vertical frame. Each frame was considered a single replication where each uPVC pipe was considered as a single treatment. In these experiments, 12 different combinations of both factors were found. Two sets of each replication were prepared where in total 72 uPVC pipe were set. Data collection was done for specific treatment by collecting 3 plants of each treatment. There were 2 factors with summer horticultural crops like Indian spinach, Red amaranth, Thankuni, and mint with 3 planting media ex.: vermin-compost + soil (90:10), Cocodust + vermicom post+soil (10:70:20) and cocodust_ mushroom spent compost+soil (10:70:20). Data on different parameters was analyzed with the help of Statistix 10 program and means will be separated by Tukey's test at 5% level of significance.

Experiment 2: Performance of different winter horticultural crops in different planting materials

This experiment was comprised of 2 factors having winter horticultural crops eg., tomato, spinach, cabbage, and cauliflower with planting media of vermicom post+soil (90:10)**,** cocodust + Vermicompost + soil (10:70:20), and cocodust+mushroom spent compost+soil (10:70:20). It was laid out in RCB design with 3 replications on a vertically framed strain case, where each frame considered as one replication and each box considered as a single treatment. Here, 12 different treatments combination were prepared. Total of 12 sets of stair boxes were made and added different nutrient combinations as given rates. watering was done by a dripper. The nets and staking were done accordingly. Data on different parameters were collected and analyzed with the help of Statistix 10 program and means were separated by Tukey's test at 5% level of significance.

Experiment 3: Cultivation of different year-round horticultural crops in different planting materials

This experiment was comprised of 2 factors having year-round horticultural crops eg., bottle gourd, bitter gourd, sweet gourd and brinjal with planting media of vermicom post+soil (90:10)**,** cocodust + vermicompost + soil (10:70:20), and cocodust+mushroom spent compost+soil (10:70:20). This experiment was conducted on a vertically framed semi stage half drum where each frame was considered as one replication and each half drum considered as a single treatment. The design was in RCB design with 3-replications. Here, 12 different treatments combinations were prepared. Total 12 sets of stair drum were prepared and added different nutrient combinations as above given rates with watering by a dripper. The nets and staking were done accordingly. Data of different parameters were analyzed with the help of Statistix 10 program and means were separated by Tukey's test at 5% level of significance.

Experiment 4: Establishment of rooftop garden landscape with vegetables and flowers

This innovative mixed garden landscape design was experimented with few edible vegetables/ medicinal plants and 2 flower crops where, those were cultivated in grow bags (inside-black and outer white) with organic potting mix materials and the irrigation was done through a dripper with timer controller (drip irrigation system). This garden minimized the insect pest attack and give an aesthetic appearance to the roof.

Crops cultivated: Coriander, Aloe vera, Tomatoes, Chilli, Cucumber, Petunia, Cosmos. The experimental design was in RCB design with 3 replications.

Experimental site: The experiment conducted at the Rooftop of Dr. M A Wazed Miah Research Centre, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207.

Experiment 5a: Effects of different growing media on the growth and yield of potted pakchoi in Rooftop

The experiment was conducted during the period from December, 2020 to February, 2021 in the experimental field of Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. There were two developed variety from BARI (Bangladesh Agricultural research Institute) namely BARI China Shak -1 and BARI Batishak-1. For this experiment seeds were collected from BARI germplasm and selected variety was BARI Batishak-1. There were 8 different treatments level selected for this experiment such as, T_0 = Control; T_1 = Vermicompost + Soil (90:10); T_2 = Cocodust + Vermicompost + Soil (20:70:10); T_3 = Mushroom Spent Compost + Soil (90:10); T_4 = Vermicompost + Cowdung + Soil (45:45:10); T_5 = Vermicompost + Mushroom Spent Compost + Soil (45:45:10); T_6 = Vermicompost + Mushroom Spent Compost + Cowdung + Soil (50:20:20:10) and T_7 = Vermicompost + Biochar + Soil (45:45:10), following Completely Randomized Design (CRD) with three replications where the 24 pots were selected, the size of each pot was 16 cm x 30 cm. Seed were sown on 22 December, 2020. Before sowing they were soaked in water for 24 hours. Hence, two seeds per hill were planted in order to ensure a uniform stand of the crop harvesting stage. The amount of irrigation water was limited up to that quantity which did not leached out through the bottom. Harvesting of all the Pakchoi (Batishak) was not possible on a certain or particular date because the vegetables initiation as well as maturing in different plants were not uniform. Harvesting was started from January 24, 2021 and was continued up to February 03, 2021. Harvesting of the crop was done pot wise by uprooting the plants by hand carefully for data collection.

Experimental data were recorded from 14 days after sowing Pakchoi plant growth as well as Pakchoi production in different growing media and continued until harvest. Data on the following parameters were recorded after harvesting at 42 DAS. Two plants were sampled randomly from each pot for the collection of per plant data while the crop of whole pot was harvested to record per pot data as collection of plant growth and quality parameters. The data obtained for different characters were statistically analyzed by using MSTAT-C computer package program to find out the significance of the difference Pakchoi. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatments of means was estimated by Least Significant Difference at 5% level of probability (Gomez and Gomez, 1984).

Experiment 5b: Yield performance of pak-choi in hydroponic under rooftop or indoor growing conditions

In this experiment, the treatments were white t_5 (fluorescent as control) -L_1, white led -L_2, red light -L_3, blue light -L_4, 50% red+50% blue -L_5, 50% red+ 40% blue + 10% green -L_6. The experiment was conducted at the Indoor Room of Dr. M A Wazed Miah Research Centre, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. Plants were grown under indoor condition. The experiment conducted in Complete Randomized Design (CRD) with 3 replications. Lettuce grown in hydroponic solution with LED Light Spectrum. This experiment was conducted inside of a controlled environment and on 6 staged of iron rack. Each stage consists of single treatment means a led Spectrum. In total 18 treatments of 6 different LED spectrums were arranged in 3 replications. The Hydroponics nutrients solutions were added two times in whole crops life cycle with 30 days interval. pH, EC, Temp and humidity were checked every day and the room temperature was ranged from 18-20 degree centigrade where humidity was 85-90%. The data was collected in 7 days interval where total 5 data was collected and recorded. Data on different parameters was analyzed with the help of Statistix 10 program and means were separated by Tukey's test at 5% level of significance.

Experiment 6: Influence of organic amendments and bio-control agent on the production of gerbera

The experiment conducted by following CRD with 3 replications. This experiment was conducted inside of the poly-shed house and the temperature and the humidity could be slightly controlled as required of the plants. There, 5 different treatments were applied for each replication so, total number of 15 treatments were given to 3 replications. All sets of nutrients were added to the soil and the plot was watered by a dripper. The temperature inside of the shed was controlled by fogger. The five treatments which were used in the experiment was T_1-farmyard manure (3t/ha + 1/4rdf), T_2 -vermicompost (3t/ha + ¼ rdf), T_3-tricho-compost (3t/ha + ¼ rdf), T_4-tricho-leachate (3000l/ha + ¼ rdf) and T_5-control (recommended dose of fertilizer: cd-5t, n_{150}, p_{30}, k_{100} s_{20} b_1 zn_1 kg/ha). All P, K, B, Zn, vermicompost, tricho-compost and farmyard manure except the N were applied and mixed up well with the soil during final land preparation according to treatments. Nitrogen was applied in three equal installments at 40, 60, and 80 days after planting (DAT).

Data on different parameters was analyzed with the help of Statistix 10 program and means was separated by Tukey's test at 5% level of significance.

Component 3 : Pomology Division, HRC, BARI

Different types of experiments have been conducted in the study area for obtaining the appropriate information for the fulfillment of the sub-project objectives. The experiments have been conducted by the following research activities;

Experiment 1: Survey on the present status of rooftop gardening in Gazipur sadar

A baseline field survey had been conducted in different locations (North and the South Chayabithi, Shibbari and Police line) of Gazipur city within the 1st two months of the project commencement in order to get basic information about the existing traditional and modern rooftop farming systems practiced in the proposed area. Based on the findings of the survey, the targeted research activities had been conducted at HRC, BARI, Gazipur and in Sherpur district.

Experiment 2: Development of production package of some selected fruit crops for rooftop gardening

It is generally seen that; fruit crops are the most popular among the city roof top gardeners all over the country. People grow crops especially fruit crops on roof without knowing their productivity and seasonality just based on their random choice. As a result, they don't get the expected output. A proper selection of fruit crops based on season and their production package should be developed. Therefore, an experiment was conducted on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during April, 2020 to June, 2022 to develop production package of selected fruit crops for rooftop gardening. In this experiment different research activities had been done to develop production package for Dragon fruit, Guava and Golden apple for rooftop gardening. However, partial production technology had been developed for each fruit crop within this sub-project period and all the experiments will be continued as the core programs of BARI to develop complete production package. For every crop the experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The collected data were tabulated and statistically analyzed with the computer application Statistics 10. The treatment means were separated by Least Significant Difference (LSD) test at 5 % level of significance

Dragon fruit

Experiment 2(a): Performance of different dragon fruit varieties on the roof

A performance trial with BARI Dragon fol-1, BAU Dragon fruit-2 and Pink rose had been conducted to find out the suitable dragon fruit variety for rooftop gardening (Fig. 5). As a growing media mixture of 70% soil + 20% coco-dust + 10% vermicompost and 30 L container were used in this experiment. The experimental plot size was 10 m^2 with 9 container and 18 plants. Dragon fruit plants were transplanted into container on 2 June 2020. Vermi-compost was applied as organic manure at an interval of every two months at the rate of 2 kg/container. Chemical fertilizers such as Urea, TSP, MoP were applied once a month (12 times a year) at the rate of 50 g/container, 75 g/container and 50 g/container respectively. However, Boron (2 g/tub) was also applied at the rate of 5 gm/tub during final media preparation and after 6 month of planting. Irrigation and other intercultural operations were done as and when necessary.

Fig. 5. Experimental view of Dragon fruit varieties on the roof

Experiment 2(b): Effect of container type on the growth and yield of dragon fruit on the roof

An experiment was conducted on the rooftop of HRC, BARI to find out the sutable container type for dragon fruit production (Fig. 6). In this trial, two types of containers (each of 30 L) such as Geobag and Tin drum were used. The variety BARI Dragon fol-1 was used here and cuttings were transplanted into containers on 10 August 2020. The experimental plot size was 10 m^2 with 9 container and 18 plants. The mixture of 80% coco-dust and 20% vermicompost (Soilless) was used as growing media. Vermi-compost was applied as organic manure at an interval of two months at the rate of 2 kg/container. Chemical fertilizers such as Urea, TSP, MoP were applied once a month (12 times a year) at the rate of 50 gm/container, 75 g/container and 50 g/container respectively. However, Boron (Boric acid) was also applied at the rate of 5 g/container during final media preparation and after 6 month of planting. Irrigation and other intercultural operations were done as and when necessary.

Fig. 6. Dragon fruit production using different container on rooftop

Experiment 2(c): Effect of different sizes of container on the growth and yield of dragon fruit on the roof

An experiment was conducted on the rooftop of HRC, BARI to find out the most suitable container size for dragon fruit production. In this trial, three different sizes of container (Tin drum) such as Large (30 L), medium (20 L) and small (10 L) were used. The variety BARI Dragon fol-1 was selected for this experiment and cuttings were transplanted into containers on 10 August 2021. The experimental plot size was 10 m^2 with 9 container and 18 plants. The mixture of 80% coco-dust and 20% vermicompost (Soilless) was used as a growing media. Vermi-compost was applied as organic manure at two months interval at the rate of 2 kg/container. Chemical fertilizers such as urea, TSP, MoP were applied once a month (12 times a year) at the rate of 50 gm/container, 75 gm/container and 50 gm/container respectively. However, Boron (Boric acid) was also applied at the rate of 5 gm/container during final media preparation and after 6 month of planting. Irrigation and other intercultural operations were done as and when necessary.

Experiment 2(d): Combined effect of different growing methods on the growth, yield and load management for dragon fruit production on the roof

This experiment was conducted on the rooftop of HRC, BARI to find out the most suitable container size for dragon fruit production. In this trial, first of all the performance of different growing structures in combination with the best media and container has been tested. Secondly, it was compared that which methods of production is lighter to protect the roof. Finaly, economic analysis has been done. In this study Large (30 L) container was used. There were three treatments in the experiment viz; T_1 = GI pipe based structure + Geobag + media (80% cocodust + 20% vermicompost), T_2 = RCC pillar based structure + Tin drum + media (80% soil+20% vermicompost) and T_3 = No structure + Tin drum + media (80% soil+20% vermicompost). The experiment was laid out in Randomised Complete Block Design (RCBD) with three replications. The variety BARI Dragon fol-1 was selected for the experiment and cuttings were transplanted into container in 10 August 2021. The experimental plot size was 10 m^2 with 9 container and 18 plants. Vermi-compost was applied as organic manure at an interval of two months at the rate of 2 kg/container. Chemical fertilizers such as Urea, TSP, MoP were applied once a month (12 times a year) at the rate of 50 g/container, 75 g/container and 50 g/container respectively. However, Boron (Boric acid) was also applied at the rate of 5 g/container during final media preparation and after 6 month of planting. Irrigation and other intercultural operations were done as and when necessary.

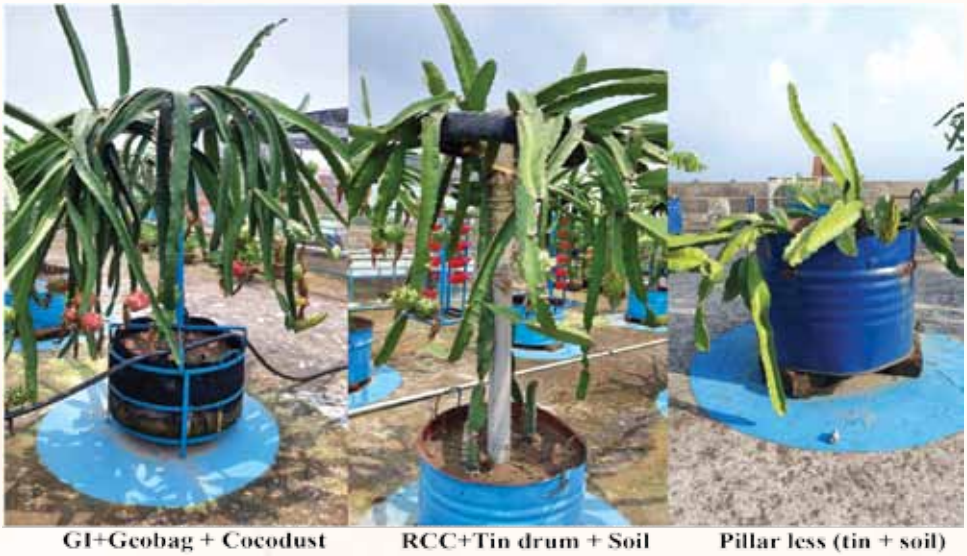


Fig. 7. Dragon fruit production using different container size on the roof

Golden Apple

Experiment 2(e): Performance trial of different golden apple varieties on the roof

A performance trial with BARI Amra-1 and BARI Amra-2 had been conducted to find out the suitable golden apple variety for rooftop gardening. Here, 30 L container and as a growing media the mixture of 70% soil, 20% coco-dust and 10% Vermicompost were used. The growing media was prepared on 5 April 2020. After 15 days of media preparation, the golden apple plant was transplanted in container in 20 April 2020. The experimental plot size was 10 m^2 with 9 containers and 1 plant/container.

Vermicompost was used as organic manure and applied three times a year at the rate of 2 kg/ container. Chemical fertilizers including Urea, TSP, MoP were applied 2 times a year at the rate of 100g/plant, 100g/plant, 150 g/plant respectively. Irrigation and other intercultural operations were done as and when necessary. During initial attack of hog plum beetle, hand picking was done but in severe cases, Confidor® (Imidacloprid) was applied @ 2gm/10 liter of water for three times at 10 days' interval. For controlling leaf spot disease, Autostin® (Carbendazim 50% WP) were applied @ 2.0 g/liter of water for three times at 15 days' interval. During pruning of the branches, Bordeaux paste (100g $CuSO_4$+ 100g CaO + 1liter of water) was used to reduce the fungal growth on the cutting portion of golden apple.

Guava

In all the research activities of Guava 30 L container and as a growing media the mixture of 70% soil, 20% coco-dust and 10% vermicompost were used**.** The experimental plot size was 10 m^2 with 9 containers and 1 plant/container. Vermicompost was used as organic manure and applied three times a year at the rate of 3 kg/container. Chemical fertilizers including Urea, TSP, MoP applied 2 times a year at the rate of 150g/plant, 150g/plant, 200 g/plant respectively. Irrigation and other intercultural operations were done as and when necessary. Wilt and Anthracnose was the common fungul disease of guava. For controlling wilt and anthracnose, Autostin® (Carbendazim 50 DDG) and Indofil-m-45® (Mancozeb 80 WP) were applied @ 0.20 g /liter and 2g/liter respectively at 15 days interval. For controlling white peach scale insects, Confidor® (Imidacloprid 70WG) were applied @2gm/10 liter of water for three times at every 7 days interval. During pruning of the branches, Bordeaux paste (100g $CuSO_4$+ 100g CaO + 1liter of water) was used to reduce the fungal growth on the cutting portion of guava.

Experiment 2(f): Performance trial of different guava varieties on the roof

A performance trial with BARI Peyara-2 and BARI Peyara-4 had been conducted to find out the suitable guava variety for rooftop gardening (Fig. 8). The growing media was prepared in 5 April 2020. After 15 days of media preparation, the guava plant was transplanted in container on 20th April 2020. The experimental plot size was 10 m^2 with 9 containers and 1 plant/container. The experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on growth, yield and yield contributing characters as well as economic parameters were collected.

BARI Peyara-2 BARI Peyara-4

Fig. 8. Performance trial of different guava varieties on the roof

Experiment 2(g): Effect of different types of container on the growth and yield of guava

An experiment was conducted to find out the most suitable type of container for guava poduction on the roof (Fig. 9). Here, 30 L container and as a growing media of the mixture of 70% soil, 20% coco-dust and 10% vermicompost were used. The experimental plot size was 10 m^2 with 9 containers and 1 plant/container. The growing media was prepared on 5 April 2020. After 15 days of media preparation, the guava plant was transplanted in container in 20 April 2020. There were three treatments in the experiment viz; T_1= Tin drum, T_2= Plastic drum and T_3= Geobag. The experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on growth, yield and yield contributing characters as well as economic parameters were collected. The collected data were tabulated and statistically analyzed with the computer application statistics 10. The treatment means were separated by Least Significant Difference (LSD) test at 5 % level of probability.

Fig. 9. Growth and yield of guava using different types of container on the roof

Experiment 3. Effect of different growing media for dragon fruit production on the roof

Dragon fruit is one of the very popular exotic fruits among the consumers in Bangladesh. City gardeners growing it on their roof due to its unique taste and quality, as it is one kind of cactus species and the fruit is highly nutritious and highly valued. So, there is a great scope for dragon fruit production on the roof. However, the best growing media for dragon fruit production on the roof yet not been recommended and even city gardeners are seeking for soilless media as because soil is so heavy for roof top. Therefore, the present study has been undertaken to know the performance of Dragon fruit production under different growing media (soil and soilless) on the roof (Fig. 10). The nutrient status of growing media were analyzed and presented in Table 3.

The experiment was carried out on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the period from August 2020

to June 2022. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experiment had been divided into two sets. In set-1, different combinations of media including soil had been applied whereas, in set-2, combination of different soilless media had been tested. BARI dragon fol-1 was selected for both sets of the experiment. In set-1, plot size was 35 m^2 with 20 container and 40 plants and in set-2, plot size was 25 m^2 with 9 container and 18 plants. There were four treatments in set-1 viz; T_1 (100 % loam soil), T_2 (50 % loam soil + 50 % coco dust), T_3 (50 % loam soil + 50 % bio-char) and T_4 (20% Loam soil + 40 % coco dust + 40 % bio-char) and in set-2, there were three soilless media as treatment such as T_1 (100 % Coco dust), T_2 (100 % Bio-char) and T_3 (50 % coco dust + 50 % bio-char). BARI dragon fol-1 was selected for both sets of the experiment. In this experiment, 30 Litre containers were used. A special structure was made by RCC pillar (8 fit in height and 1 inch in diameter) for creeping the stem to the top and a rounded structure was made by iron flat bar on the top of the pillar to hang out the brunches from the top for better growth and yield. The plants were transplanted in the container in 06 August 2020. Vermi-compost was applied as organic manure every two months interval at the rate of 1 kg/ tub. Chemical fertilizers such as urea, TSP, MoP were applied after every month (12 times a year) at the rate of 50 gm/container, 75gm/container and 50 gm/ container respectively. However, Boron was also applied at the rate of 5 gm/ container during final media preparation and after 6 month of planting. Irrigation and other intercultural operations were done as and when necessary. Though, there were no harmful insect and pests found on the roof in the case of Dragon fruit but only ants, and for controlling ant detergent was applied at 2gm/liter of water at 7 days' interval for three times. During pruning of the braches, Bordeaux paste (100g $CuSO_4$+ 100g CaO + 1liter of water) was used to reduce the fungal growth on the cutting portion of dragon fruit. Data on growth, yield and yield contributing characters as well as economic parameters were collected. The collected data were tabulated and statistically analyzed with the computer application statistics 10. The treatment means were separated by Least Significant Difference (LSD) test at 5 % level of significance.

Table 3. Nutrient status of growing media and/or compost

Name of the manure	pH	OM	Ca	Mg	K	Total N	P	S	B	Zn
						%				
Vermi-compost	6.93	33.5	2.18	1.01	0.78	2.32	1.42	0.58	0.019	0.037
Biochar	7.11	74.79	2.17	1.43	0.81	1.89	0.33	0.14	0.013	0.01
Cocodust	-	-	0.50	0.14	0.07	0.42	0.50	0.20	0.04	0.04

Cocodust

Vermicompost

Biochar Soil

Fig. 10. Different growing media for dragon fruit production on the roof

Experiment 4. Evaluation of strawberry production in different growing methods on the roof

Strawberry production on the roof by soilless culture may be an alternative to the traditional soil cropping system for many reasons: higher yield by area unit, less disease incidence in plants, more efficient use of water and fertilizers, more uniform fruits, better quality and healthy. There are many types of growing methods for strawberry production on the roof by using soilless media such as column system; vertical wall system, pot culture and horizontal bed system etc. practiced by the growers but all of them are not potential. Therefore, the present study has been undertaken to evaluate different growing methods for strawberry production on the roof

The experiment was carried out on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the period from November 2021 to February 2022. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. BARI Strawberry-3 was selected for the experiment. The experiment was divided into three sets of research activities. There were four treatments in set-I viz; T_1 (Column system), T_2 (Vertical wall mount system), T_3 (Horizontal bed system) and T_4 (Pot culture). In set-II there were two treatments such as T_1 = column system (Iron) and T_2 = column system (plastic). There were also two treatments in set-III viz; T_1 = Bed system (Geobag) and T_2 = Bed system (cocksheet). The size of horizontal bed of geo-bag was 2.0 m x 1.0 m and the cocksheet bed size was 5.0 m x 0.6 m. In column system, 5 inch sized plastic hanging pot of total 24 per column was used and for pot culture the size of pot was 4 inch. In every cases plot size was 25 m^2. The 40 days old saplings of strawberry were planted in 15 November 2021. As a basal dose, only Vermicompost was applied in the growing media. As a growing media coco-dust was used. Irrigation was done in everyday basis. Other intercultural operations were done as and when necessary. Data on the growth, yield and yield contributing characteristics and also quality were recorded. The recorded data for each parameter from the present experiment was analyzed statistically to find out the variation among the treatments using Statistics 10.

Experiment 5: Roof top gardening: A sustainable technology for quality and safe fruit production and consumption

Nowadays, rooftop gardening is becoming so much popular countrywide where gardeners use less amount of chemicals for pest control or even sometimes they use only the organic options for pest management. As a consequence, there is a great scope for chemical hazardous free crop production on the roof. Therefore, the present study has been undertaken to promote roof top gardening as a tool for safe food production and consumption

In this experiment, growth and yield performance and pathological hazards during marketing of dragon fruit were compared between rooftop production and the farmer's field. The trial was carried out on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and Jhenaigati, Sherpur during the period from May 2020 to June 2022. In rooftop, dragon fruit plants were transplanted into container on 2 June 2020 and in the field plants were planted on 10 may 2020. Sample fruits from rooftop and from the market were collected and tested for pathological hazards. Vermi-compost was applied as organic manure every two months interval at the rate of 2 kg/tub. Chemical fertilizers such as urea, TSP, MoP were applied every month (12 times a year) started from 20 days after planting at the rate of 50 gm/container, 75gm/container and 50 gm/ container respectively. However, Boron was also applied at the rate of 5 gm/ container during final media preparation and after 6 month of planting. Irrigation and other intercultural operations were done as and when necessary. Though, there were no harmful insect and pests found on the roof in the case of Dragon fruit but only ants. For controlling ant detergent was applied at 2gm/liter of water at 7 days' interval for three times. During pruning of the branches, Bordeaux paste (100g $CuSO_4$+ 100g CaO + 1liter of water) was used to reduce the fungal growth on the cutting portion of dragon fruit. Irrigation and other intercultural operations were done as and when necessary. Data on growth, yield and yield contributing characters were collected and analyzed statistically to find out the variation among the treatments using Software Statistics 10.

Experiment 6. Adaptive trial of selected crops at farmer's field

An adaptive trial was conducted at the farmer's field of Nalitabari and Jhenaigati upazilla in Sherpur district (Fig. 11). In this trial BARI dragon fruit-1 and BARI peyara-4 were demonstrated for both locations. The experimental fields were prepared in 20 April 2020 and plants were planted in the main field in 10 may 2020 in both places. In case of Dragon fruit field trial, there were 100 pillars with 400 plants in Jhenaigati upazilla and 80 pillars with 320 plants in Nalitabari upazilla were planted in the field and compared between these two regarding growth and yield characteristics. In case of guava, 50 plants were provided in each place to setup a garden for making growth and yield comparison between two locations. In this trial the variety BARI dragon fol-1 and BARI peyara-4 were used. An area of 15 m × 43 m was used for BARI dragon fol-1 and 15 m × 22 m used for BARI peyara-4. Line to line and plant to plant spacing was approximately 2.5 m each for both dragon fruit and guava. Land was ploughed 4 times until the soil achieves fine tilth. During final land preparation, cowdung and TSP was applied at the rate of 10 t/ha and 300 kg/ha. For both the crops the pit (1m x1m x 1m) was dug and about 15-20 kg Cowdung, 250g TSP, 250g MoP, 100g Gypsum, 15 g $ZnSO_4$ and 25g Boron was mixed with the loose soil and keep it for 15-20 days. In case of Dragon fruit a RCC pillar of 8 fit long was placed in the center of pit and 4 Dragon fruit plants were planted in four sides of the pillar. During pruning of the branches, Bordeaux paste (100g $CuSO_4$+ 100g CaO + 1liter of water) was used to reduce the fungal growth on the cutting portion of dragon fruit and Guava. For controlling insects like mealybug in guava Confidor® (Imidacloprid 70WG) was applied @2gm/10 liter of water for three times at 7 days' interval. Weeding and irrigation had been done at 7-10 days' interval. There were found no remarkable pest and diseases in dragon fruit field. However, for some fungal infection in the root Indofil-m-45® (Mancozeb 80 WP) and Autostin® (Carbendazim 50% WP) @ 2.0 g/liter and 2g/10 liter of water were applied respectively at 10 days' interval for three times. In Dragon fruit field, 50g each of Urea and MoP was applied per pillar every month (12 times a year) and 2 Kg organic manure (cowdung) and 50 g TSP were applied at two months interval started from 20 days after planting. For Guava, organic manure

(cowdung), Urea, MoP and TSP were applied three times (February, May and September) at the rate of 10-15 kg/plant and 150g/plant, 150 g/plant and 200 g/plant respectively. Other intercultural operations were done as and when necessary.

Fig. 11. Adaptive trial of Dragon fruit orchard in Sherpur

11. Results and Discussion

Component 1: Floriculture Division, HRC, BARI

Experiment 1. Effect of pinching and boron on quality flower production of carnation

All the growth parameters were influenced significantly by various treatments (Table 4). Maximum number of primary branches/plant (6.0) was exhibited with single pinching + 0.1% boron (T_4) application, whereas treatment T_6 (double pinching + 0.1% boron) resulted in maximum number of secondary (9.0) branches. Similar results were also obtained by Karthikeyan *et al*. (2009), they stated that by removal of apical portion, more energy might have been diverted for the development of a higher number of side branches per plant in carnation, while maximum plant height (61.0 cm) was observed in the treatment T_0 (control). Among the treatments, T_6 (double pinching + 0.1% boron) recorded the highest stem girth (2.2 cm). On the other hand, the lowest stem girth (1.1 cm) was recorded in T_0 (control). However, no significant impact of pinching and boron on carnation was noticed in case of stem girth during any of the observations. These results are in line with the findings of Maharnor *et al.* (2012) in carnation.

Table 4. Effect of pinching and boron on growth characteristics in carnation

Treatment	No. of primary branches/ plant	No. of secondary branches/ plant	Plant height (cm)	Stem girth (cm)	No. of leaves/ plant	Plant spread (cm)
T_0-Control (No pinching + No boron)	3.0 b	3.5 c	61.0 a	1.1	20.5 c	6.0 b
T_1-Single pinching (SP)	5.0 ab	4.5 bc	56.0 b	1.2	22.8 bc	8.1 ab
T_2-Double pinching (DP)	5.0 ab	6.9 bc	50.5 c	2.0	24.0 bc	8.4 ab
T_3-SP+ 0.05% boron	4.0 ab	5.4 bc	56.8 ab	1.3	26.0 b	8.5 ab
T_4-SP + 0.1 % boron	6.0 a	5.8 bc	57.5 ab	1.7	28.0 ab	8.7 ab
T_5-DP + 0.05% boron	4.5 ab	7.0 b	51.8 bc	1.8	29.0 ab	9.6 ab
T_6-DP + 0.1% boron	4.6 ab	9.0 a	52.0 bc	2.2	31.0 a	11.4 a
CV%	**8.0**	**7.4**	**8.7**	**5.4**	**8.3**	**7.5**

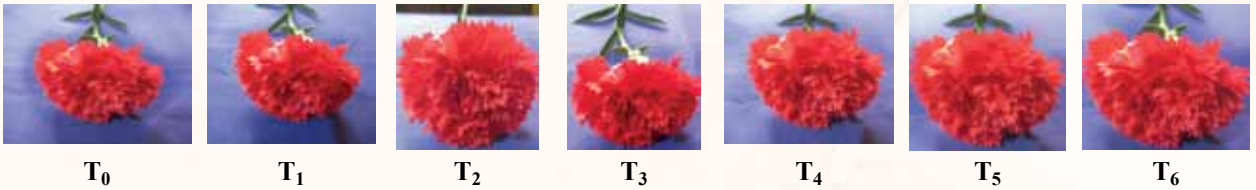
It was found that maximum number of leaves (31.0) were counted in treatment T_6 (double pinching +0.1% boron) followed by T_5 (double pinching+0.05% boron) (29.0). The least number (20.5) of

leaves were produced by treatment T_0-(control). These results are confirmed by the findings of Maharnor *et al.* (2012) in carnation. The data regarding plant spread showed significant results for all treatments (Table 4). Maximum plant spread of 11.4 cm was contributed by T_6 (double pinching + 0.1% boron). These results are supported by Singh and Kumar (2009) in carnation. However, when plants received 0.1% boron as foliar application along with double pinching (T_6) performed better on several growth attributes.

All the treatments failed to exert significant effect on diameter of flower, whereas days to flowering, length of stalk, number of flowers/plant, flower weight/plant and vase life were influenced due to different treatments (Fig. 12a-12b). Single pinching + 0.1% boron application (T_4) exhibited early flowering (38.0 days) preceded by single pinching +0.05% boron applications (40.0 days). Single pinched plants were able to initiate flower buds earlier as compared to double pinched plants on account of earlier accumulation of assimilates. The data presented in Table 5 showed that, significantly the maximum stalk length (50.0 cm) was observed under treatment T_4 - (SP + 0.1 % boron). The lowest stalk length (42.0 cm) was recorded in T_2 (Double pinching) in the present investigation was due to removal of apical portion. These results are supported by the findings of Chauhan *et al.,* (2005) in carnation.

Table 5. Effect of pinching and boron on flowering in carnation

Treatment	Days to flowering	Stalk length (cm)	Flower diameter (cm)	Number of flowers/ plant	Flower weight/ plant (g)	Vase life (days)
T_0-Control (No pinching + No boron)	41.0 bc	47.0 ab	5.4	4.0 c	158.0 c	6.5 b
T_1-Single pinching (SP)	42.0 bc	48.0 ab	5.5	6.0 bc	160.0 bc	8.0 ab
T_2-Double pinching(DP)	44.0 b	42.0 c	5.8	8.5 b	165.0 b	7.0 b
T_3-SP+ 0.05% boron	40.0 bc	48.5 ab	5.6	6.5 bc	162.0 bc	9.0 ab
T_4-SP + 0.1 % boron	38.0 c	50.0 a	5.7	7.0 bc	163.0 bc	10.0 a
T_5-DP + 0.05% boron	46.0 ab	43.2 bc	6.0	10.0 ab	163.5 bc	8.0 ab
T_6-DP + 0.1% boron	50.0 a	44.8 b	6.2	12.0 a	170.0 a	9.0 ab
CV%	**9.3**	**8.5**	**6.1**	**7.8**	**9.0**	**8.4**



T_0 T_1 T_2 T_3 T_4 T_5 T_6

Fig. 12a. Effect of pinching and boron on flower diameter in carnation

T_0 T_1 T_2 T_3 T_4 T_5 T_6

Fig. 12b. Effect of pinching and boron on stalk length of carnation

Double pinching + 0.1% boron application (T_6) resulted in maximum number of flowers/ plant (12.0) which was at par with double pinching + 0.05% boron (10.0). Similarly, weight of flowers/

plant (170.0g) was statistically higher with double pinching along with application of 0.1% boron (T_6). Following double pinching and application of 0.1% boron (T_6) accelerated growth and produced more number of secondary branches and the highest number of reproductive stalk per plant thus, increased more number of flowers (Fig. 13). The data pertaining to the effect of different type of pinching and boron level on vase life of carnation is presented in Table 5. Significant differences were observed in vase life among the treatments. Tabulated data clearly indicated that significantly the maximum vase life (10.0 days) was recorded in single pinched plants when treated with 0.1% boron (T_4). These results are supported by Maharnor *et al.* (2012) in carnation. Beneficial effect of pinching and application of boron on flower production and vase life prolongation were experimentally substantiated by earlier worker (Maharnor *et al.,* 2012) in carnation.

Fig. 13. Vegetative and flowering stage of carnation using boron and pinching (a. Vegetative. stage, b-c. Flowering stage)

From the present study, it is concluded that double pinching + foliar application of 0.1% boron (T_6) was superior for obtaining better vegetative growth of plants, production of maximum flower number with flower weight in carnation. Furthermore, single pinching + foliar application of 0.1% boron (T_4) also exhibited better results in early flowering, number of primary branches/plant, stalk length and vase life.

Experiment 2. Effect of growth regulators on growth and flowering of chrysanthemum

All the growth parameters were influenced significantly by various treatments (Table 6). The tallest chrysanthemum plant (70.0 cm) was recorded from the treatment GA_3 @ 100 ppm, whereas the shortest plant (52.0 cm) was recorded from BA @ 100 ppm which was closely followed by that of BA @ 200 ppm (55.0 cm) (Table 6). More or less similar results are reported by Singh *et al*. (2018) who obtained the tallest plant from GA_3 @ 150 ppm in chrysanthemum. On the other hand, Sahu *et al.* (2021) obtained the tallest plant from GA_3 @ 200 ppm in chrysanthemum. Foliar application of GA_3 at a proper concentration might have influenced plant height by stimulating cell division and elongation at internodal region, which resulted in more number of cells and increase in cell length. The shortest plant height with application of BA might be due to counteracting the apical dominance. The maximum number of leaves (50.0) per plant was recorded from GA_3 @ 100 ppm, followed by BA @ 200 ppm (48.0/plant) and BA @ 100 ppm (47.0/plant), whereas the minimum number of leaves per plant (39.0) was recorded from control. Sahu *et al.* (2021) reported that maximum number of leaves per plant in chrysanthemum was observed from the plants sprayed with treatment containing GA_3 @ 100 ppm and GA_3 @ 200 ppm, respectively. Singh *et al*. (2018)

reported that the result of higher number of leaves per plant might be due to GA_3 application at a proper concentration enhanced biosynthesis of protein and carbohydrates leading to enhancement of initiation of leaf primordial growth and consequently production of more leaves.

Table 6. Effect of growth regulators on vegetative growth parameters of chrysanthemum

Growth regulators (ppm)	Plant height (cm)	Number of leaves/ plant	Leaf area (cm^2)/ plant	Plant spread (cm)
BA @ 100 ppm	52.0 d	47.0 ab	6.5 ab	14.9 bc
BA @ 200 ppm	55.0 cd	48.0 ab	6.8ab	14.4 bc
GA_3 @ 100 ppm	70.0 a	50.0 a	7.5 a	23.0 a
GA_3 @ 200 ppm	65.0 b	44.8 b	7.0 ab	20.0 ab
NAA @ 100 ppm	63.0 bc	42.3 bc	6.4 ab	17.0 b
NAA @ 200 ppm	61.0 bc	42.0 bc	6.3 ab	15.0 bc
Control	58.0 c	39.0 c	5.0 b	12.0 c
CV (%)	**8.7**	**7.5**	**9.5**	**9.2**

In a column mean values with common letters do not differ significantly at 1% level of probability by DMRT

The maximum leaf area per plant (7.5 cm^2) was recorded from GA_3 @ 100 ppm closely followed by that of GA_3 @ 200 ppm (7.0 cm^2/plant), whereas, the minimum leaf area per plant (5.0 cm^2) was recorded in control. This might be due to rapid cell division and cell elongation at internodal region, which resulted in more number of cells, cell length and more number of leaves when plants are treated with GA_3 at a specific concentration. The maximum plant spread (23.0 cm) was noticed in GA_3 @ 100 ppm which was followed by GA_3 @ 200 ppm (20.0 cm) and the minimum plant spread (12.0) was recorded in control (Table 6). Singh *et al.* (2018) obtained maximum plant spread in chrysanthemum from GA_3 @ 100 ppm closely followed by GA_3 150 ppm. They explained that higher plant spread might be due to GA_3 which enhanced cell division and cell enlargement, promotion of protein synthesis coupled with dry matter accumulation.

There was a significant difference in days to flower initiation among the different treatments. The minimum days (50) required for flower initiation was observed in GA_3 @ 100 ppm which was closely followed by GA_3 @ 200 ppm (52 days) (Fig. 14). Application of BA @ 100 ppm took maximum days (69) to initiate flowers followed by control (66 days) and BA @ 200 ppm (64 days). Application of NAA @ 100 ppm took 58 days required for flower imitation followed by NAA @ 200 ppm (56 days). Singh *et al*. (2018) also reported that minimum number of days required for first flower bud appearance was recorded with 100 ppm concentration of GA_3 in chrysanthemum. It is evident that GA_3 @ 100 ppm and GA_3 @ 200 ppm reduced time to initiate flower by 16 and 14 days, respectively for early bloom compared to control. Irrespective of concentrations, NAA also took less time to initiate flower compared to control, but BA @ 100 ppm took more time to initiate flower compared to control, whereas BA @ 200 ppm reduced time only by two days compared to control. GA_3 decreased the concentration of abscisic acid in plant shoot, which might enhance flower initiation and early flowering. Moreover, as the leaf numbers were increased in present study, which improved photosynthetic activity to enhance early flowering. These findings are confirmed by those reported by Sharifuzzaman *et al*. (2011) who observed that plant treated with GA_3 took minimum time to initiate flower in chrysanthemum.

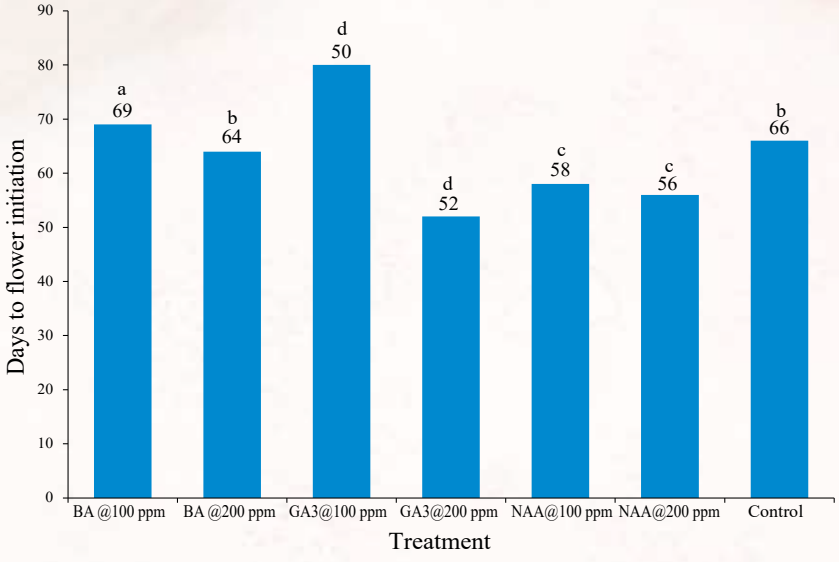


Fig. 14. Effect of growth regulators on flower initiation in chrysanthemum

Mean values on top of the bar with uncommon letter(s) are significantly different at 1% probability by DMRT

From marketing point of view, length of flower stalk is important parameters of flower growth. Using GA_3 at 100 ppm concentration gave the maximum stalk length (37.5 cm) and rachis length (29.0 cm), compared with other PGR (BA and NAA) concentrations and control, which were followed by GA_3 @ 200 ppm (34.6 cm and 25.0 cm). Minimum stalk length (26.5 cm) and rachis length (18.0 cm) were observed in BA @ 100 ppm. This is in close conformity with the result of Singh *et al.* (2018) who got maximum stalk length using GA_3 @ 100 ppm being identical with GA_3 @ 150 ppm in chrysanthemum. The increased stalk length with GA_3 @ 100 ppm treatment might be due to rapid internodal elongation, rapid cell division and cell elongation in the intercalary meristem. Singh *et al.* (2018) opined the reason of increased flowers stalk length due to redirecting the movement of organic metabolism and in establishing sink. The increase in rachis length with GA_3 @ 100 ppm might be due to increased activity of growth promoting enzymes by synthesizing more nucleic acid and other compounds. Whereas, the minimum rachis length with BA @ 100 ppm might be due to BA showed reduced plant height and stalk length, which directly influenced the rachis length.

Table 7. Effect of plant growth regulators on flowering parameters of chrysanthemum

Treatments	Stalk length (cm)	Rachis length (cm)	Flower number/plant	Flower size (cm)	Flower stalk weight (g)
BA @ 100 ppm	26.5 c	18.0c	15.0 c	6.7 ab	25.5 c
BA @200 ppm	30.0 bc	20.8 bc	19.0 bc	6.8 ab	26.8 bc
GA_3 @100 ppm	37.5 a	29.0 a	26.0 a	7.8 a	37.0 a
GA_3 @200 ppm	34.6 ab	25.0 ab	23.0 ab	7.2 ab	35.0 ab
NAA @100 ppm	31.8 bc	21.5 bc	18.5 ab	7.0 ab	29.0 ab
NAA @200 ppm	32.5 b	22.0 bc	20.0 b	7.1 ab	31.0 b
Control	31.0 bc	22.7 b	17.0 bc	6.0 b	26.0 bc
CV (%)	**7.5**	**7.2**	**8.6**	**6.9**	**8.7**

In a column mean values with common letters do not differ significantly at 1% level of probability by DMRT

Plants treated with GA_3 @ 100 ppm concentration produced maximum number of flowers per plant (26.0) followed by GA_3 @ 200 ppm (23.0/plant) (Fig. 16). BA @ 100 ppm treatment produced the lowest number of chrysanthemum flowers per plant (15.0) (Table 7). The increase in flower numbers by GA_3 with a specific concentration might be due to increase in leaf numbers and leaf area, which might have boosted the production and accumulation of assimilates that were translocated from source to sink for flower production (Fig. 18). Singh *et al*. (2018) obtained the highest number of flowers per plant from GA_3 @ 100 ppm being identical with GA_3 @ 150 ppm.

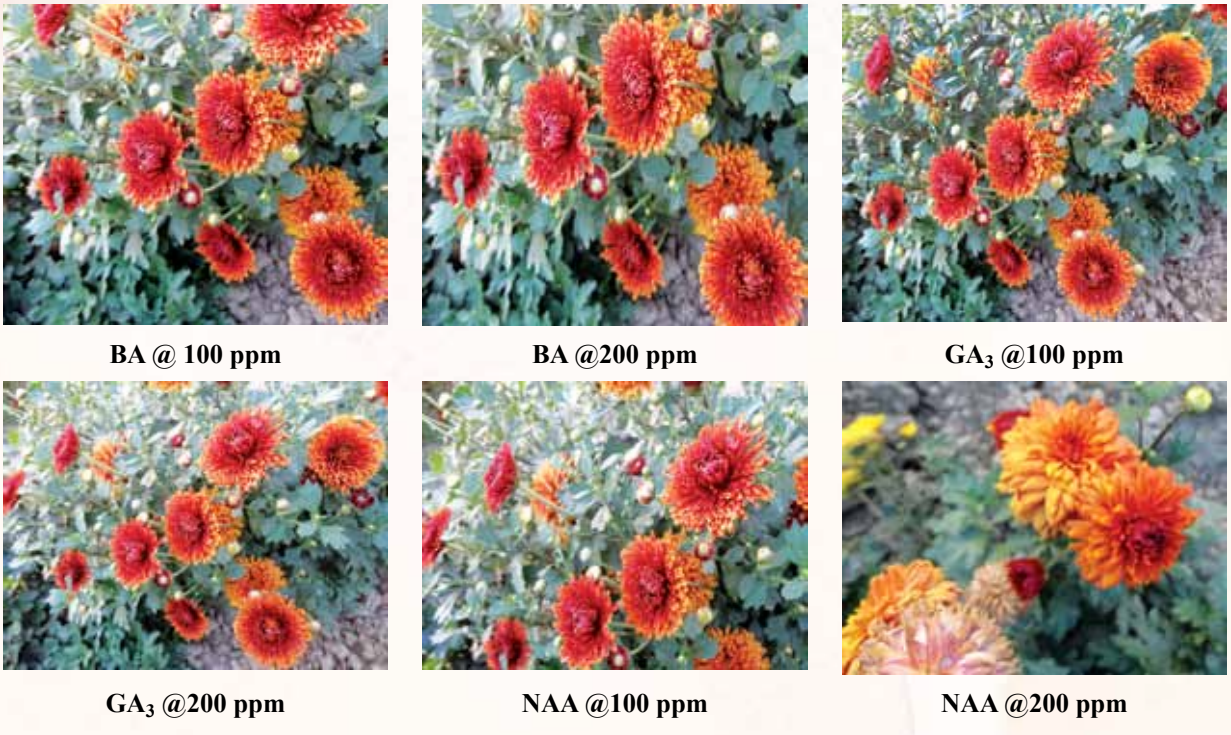


Fig. 15. Effect of plant growth regulators on flower number of chrysanthemum

Maximum size of flower (7.8 cm) was observed with GA_3 @ 100 ppm concentration which was closely followed by GA_3 @ 200 ppm (7.2 cm) and the lowest flower size was observed in control (6.0 cm) (Table 6). Singh *et al.* (2018) and Sharifuzzaman *et al.* (2011) got maximum flower size from GA_3 @ 100 and 150 ppm respectively. Singh *et al*. (2018) opined regarding the cause of increased flower size with GA_3 at a specific concentration that it may have been due to a close parallelism between vegetative growth and flowering and it is possible that stimulatory effect of GA_3 on vegetative growth associated with efficient mobilization capacity. The average fresh weight of stalk (37.0 g) was recorded to be the maximum with treatment involving GA_3 @ 100 ppm closely followed by 35.0 g weight with GA_3 @ 200 ppm, whereas the minimum weight (25.5 g) was recorded in stalk harvested from the pot where plants were sprayed with BA @ 100 ppm. Sharifuzzaman *et al.* (2011) got increased flower stalk weight compared to control when GA_3 was applied at the rate of 100 and 150 ppm. Increase in weight of flower stalk might be due to increased activity of enzymes which are involved in cell division and elongation process.

Treatment consisting of GA_3 @ 100 ppm significantly produced maximum vase life (flower life) (15 days) which was closely followed by that of GA_3 @ 200 ppm (14 days) and minimum vase life

was recorded in control treatment (10 days) (Fig. 16). It is observed that vase life was increased by 5 days when the solution of GA_3 @ 100 ppm was used. This is in perfect agreement with the results of Sharifuzzaman *et al.* (2011) who got maximum vase life from the chrysanthemum plants treated with 100 ppm GA_3 closely followed by 150 ppm GA_3.

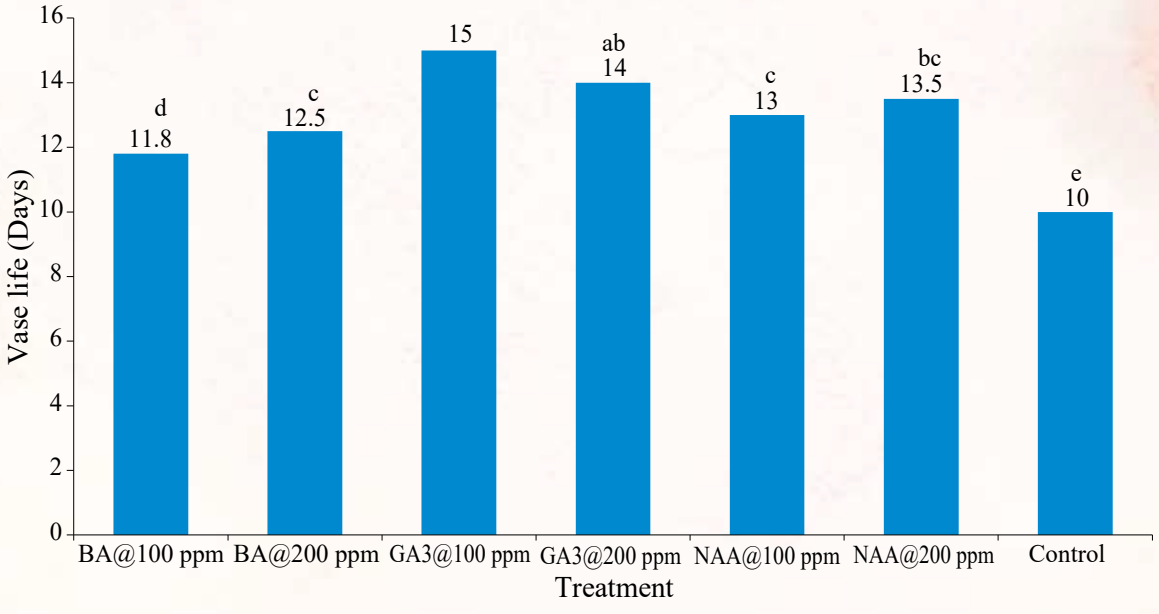


Fig. 16. Effect of growth regulators on vase life in chrysanthemum

Mean values on top of the bar with uncommon letter(s) are significantly different at 1% probability by DMRT

Singh *et al*. (2018) explained that the vase life could be correlated with ethylene production which is inhibited by the foliar application of GA_3, because it may had retarded the onset of senescence in whole cut flower stalk by containing higher amount of RNA content. Sajid *et al*. (2018) gave the same opinion that the increased vase life was probably due to that using GA_3 at a suitable concentration led to delay the flower's senescence and reduce ethylene production in the cut-flowers, consequently the flower duration in the vase could be increased.

Fig. 17. Flowering of chrysanthemum (a-c)

(a. Experimental view, b. Flowering stage, c. Stalk length)

These result reveal that GA_3 @ 100 ppm was superior regarding vegetative and flowering parameters of chrysanthemum.

Experiment 3: Effect of potting media on growth and quality in aglaonema

Observations on plant height, leaf number, leaf length, leaf width, basal stem diameter, sucker number and plant growth index under various potting media in aglaonema are presented in Table 8. Maximum plant height (80.0 cm) and highest number of leaves (14.6) was recorded in treatment T_5 - cocodust + sand+ vermicompost in 2:1:1 ratio (v/v) followed by T_6 - cocodust + sand + FYM + vermicompost in 2:1:1:0.5 ratio (v/v). High nitrogen content available to plants grown in cocodust, sand and vermicompost medium could be the reason for greatest plant height. Cocodust affords higher total pore space and water holding capacity and vermicompost is richer in humic compounds resulting maximum number of leaves. These results are in accordance with Henny *et al.* (2008) in aglaonema.

Table 8. Effect of potting media on growth and quality performance in aglaonema

Treatment	Plant height (cm)	No. of leaves	Leaf length (cm)	Leaf width (cm)	Basal stem dia. (cm)	No. of suckers	Plant growth index	Visual plant grade	Visual foliage colour grade
T_1	65.2c	9.0 b	34.5 c	7.0 b	1.8	3.0 b	40.0 c	3.0	2.0
T_2	70.0 bc	10.5 ab	36.2 bc	8.0 ab	2.0	4.0 ab	43.5 bc	3.0	3.0
T_3	68.9 bc	11.0 ab	38.0 bc	8.4 ab	2.0	4.0 ab	42.3bc	3.0	3.0
T_4	73.8 b	11.3 ab	40.0 b	8.8 ab	2.0	5.0 ab	45.2 b	4.0	4.0
T_5	80.0 a	15.0 a	45.0 a	10.5 a	2.5	8.0 a	51.0 a	5.0	5.0
T_6	77.0 ab	12.0 ab	42.5 ab	9.2 ab	2.3	6.0 ab	48.4 ab	4.0	4.0
CV%	**7.8**	**8.9**	**7.2**	**6.7**	**5.3**	**9.1**	**7.9**	**-**	**-**

T_1: Soil + Sand + FYM (2:1:1, v/v),T_2: Soil + Sand +Vermicompost (2:1:1, v/v),T_3: Soil + Sand + FYM +Vermicompost (2:1:1:0.5, v/v),T_4: Coco dust + Sand + FYM (2:1:1, v/v),T_5: Coco dust + Sand + Vermicompost (2:1:1, v/v) and T_6: Coco dust + Sand + FYM + Vermicompost (2:1:1:0.5, v/v); Plant grade system where 1=Dead, 2= Poor quality, 3=Fair quality, 4=Good quality and 5 = Excellent quality ; Colour grade system where 1= Poor, 2= Fair, 3= Good, 4= Very good and 5= Excellent

Longest leaf length (45.0 cm) and leaf width (10.5 cm) was recorded in T_5 - cocodust + sand + vermicompost in 2:1:1ratio (v/v) (45.0 cm) followed by T_6 - Cocodust + sand + FYM + Vermicompost (2:1:1:0.5, v/v). High water-holding capacity of cocodust and high nutrient content of vermicompost may have been responsible for maximum leaf length and leaf width. Scagel (2003) demonstrated positive correlation between water-holding capacity and increased top growth in several foliage species. The highest number of suckers per plant (8.0) was found in treatment T_5 - cocodust + sand + vermicompost in 2:1:1ratio (v/v) followed by T_6 - Coco dust + Sand + FYM + Vermicompost (2:1:1:0.5, v/v) (6.0). Henny *et al.* (2008) also reported that cocodust + sand + vermicompost in 2:1:1ratio (v/v) contain higher amount of plant nutrient and have potential for restoration of soil fertility resulting increase number of suckers per plant. Maximum plant growth index (51.0 cm) was observed in plants grown in a medium containing cocodust + sand + vermicompost in 2:1:1ratio (v/v) (T_5 treatment) followed by T_6 - Coco dust + Sand + FYM + Vermicompost (2:1:1:0.5, v/v) (48.4 cm). Medium containing cocodust + sand + vermicompost allows air, nutrients and water to reach the root surface, which may be the reasons for rapid and vigorous growth. These results are in accordance with Henny *et al.* (2008) in aglaonema. Effect of potting media in Aglaonema with respect to basal stem diameter is presented in Table 8. However, no significant impact of potting media on aglaonema was noticed in case of basal stem diameter during any of the observations. Among various combinations of potting media, maximum (2.5 cm)

basal stem diameter was recorded under T_5 treatment. On the other hand, the minimum diameter (1.8 cm) was recorded when aglaonema was grown in media T_1 composed of Soil + Sand + FYM (2:1:1, v/v). Data on visual plant grade and colour grade of aglaonema grown in different potting media are presented in Table 8. Highest plant grade and foliage colour grade was recorded in T_5 -cocodust + sand+ vermicompost (2:1:1 ratio, v/v) (5.0) (Fig. 18). Aglaonema growing in cocodust + sand+ vermicompost amended medium are shown to have higher production or accumulation of total protein and amino acids in their stem. This could be a reason for high visual plant grade. Improved nutrition from vermicompost changes biochemical properties of a plant like chlorophyll, enzymes, and protein synthesis which could be one of the reasons for high visual plant grade. Higher nitrogen available to plants in this medium may be the reason for higher colour intensity. These results are in accordance with Scagel (2003) in foliage plants where leaf of the plant grown in cocodust + sand + vermicompost (2:1:1) amended media had higher chlorophyll content than other media.

Table 9. Effect of potting media on leaf nitrogen, phosphorus and potassium content (%) in aglaonema

Treatment	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
T_1: Soil + Sand + FYM (2:1:1)	0.07	0.02	0.03
T_2: Soil + Sand +Vermicompost (2:1:1)	2.30	0.40	1.45
T_3: Soil + Sand + FYM +Vermicompost (2:1:1:0.5)	2.17	0.35	1.25
T_4: Coco dust + Sand + FYM (2:1:1)	2.70	0.56	1.60
T_5- Coco dust + Sand + Vermicompost (2:1:1)	3.45	0.99	1.90
T_6-Coco dust+ Sand + FYM + Vermicompost (2:1:1:0.5)	3.15	0.85	1.85
CV%	**7.8**	**8.9**	**7.2**

T_1: Soil + Sand + FYM (2:1:1, v/v),T_2: Soil + Sand +Vermicompost (2:1:1, v/v),T_3: Soil + Sand + FYM +Vermicompost (2:1:1:0.5, v/v),T_4: Coco dust + Sand + FYM (2:1:1, v/v),T_5: Coco dust + Sand + Vermicompost (2:1:1, v/v) and T_6: Coco dust + Sand + FYM + Vermicompost (2:1:1:0.5, v/v)

Data on nitrogen, phosphorus and potassium in leaves of aglaonema treated with different potting media (Table 9) showed that maximum percentage of nitrogen was recorded in T_5 - cocodust + sand + vermicompost + (2:1:1 ratio, v/v) (3.45**%)** followed by T_6 - Coco dust + Sand + FYM + Vermicompost (2:1:1:0.5) (3.15%**)**. High cation exchange capacity, low electrical conductivity and acceptable pH of cocodust, sand and vermicompost could be the reason for high N uptake. Maximum phosphorus content (0.99 %**)** was recorded in T_5 - cocodust + sand + vermicompost (2:1:1 ratio, v/v) followed by T_6 - Coco dust + Sand + FYM + Vermicompost (2:1:1:0.5) (0.85%**)**. Higher availability of P in cocodust + sand+ vermicompost (2:1:1 ratio, v/v) amended medium could be a result of greater P exchange sites or due to a higher activity of P-solubilizing and acid phosphate producing organisms. Maximum potassium content (1.90%) was recorded in T_5 - cocodust + sand + vermicompost + (2:1:1 ratio, v/v) followed by T_6 - Coco dust + Sand + FYM + Vermicompost (2:1:1:0.5) (1.85%**)**.This could be attributed to higher nutrient status provided by vermicompost, and excellent physical (water retention and aeration) and chemical properties (acceptable pH, low electrical conductivity, high CEC) of cocodust, which would have resulted in higher nutrient uptake.

Fig. 18. Growth and foliage quality of aglaonema (a-b)
(a. Experimental view, b. Best foliage quality in T_5 media)

These result reveal that potting media containing cocodust + sand+ vermicompost (2:1:1 ratio, v/v) showed in best growth parameters and improved quality in Aglaonema.

Experiment 4: Effect of substrates on growth, yield and quality of anthurium in soilless culture

Different potting substrates affected the percent survival of anthurium plantlets (Fig. 19). Among different treatments, T_5 (cocodust + perlite @ of 1:1) showed 100% survivability of the plants followed by T_2 (only cocodust) with 90% survivability. The reason for the best performance might be due to cocodust with the perlite is having the higher organic matter content, which increased water holding capacity and nutrient availability for easy uptake by the plant. The lowest survivability percentage (70%) was noted from T_1 (only soil) treatment. Similar observation was reported by Sharifuzzaman *et al.* (2010) in euphorbia house plant.

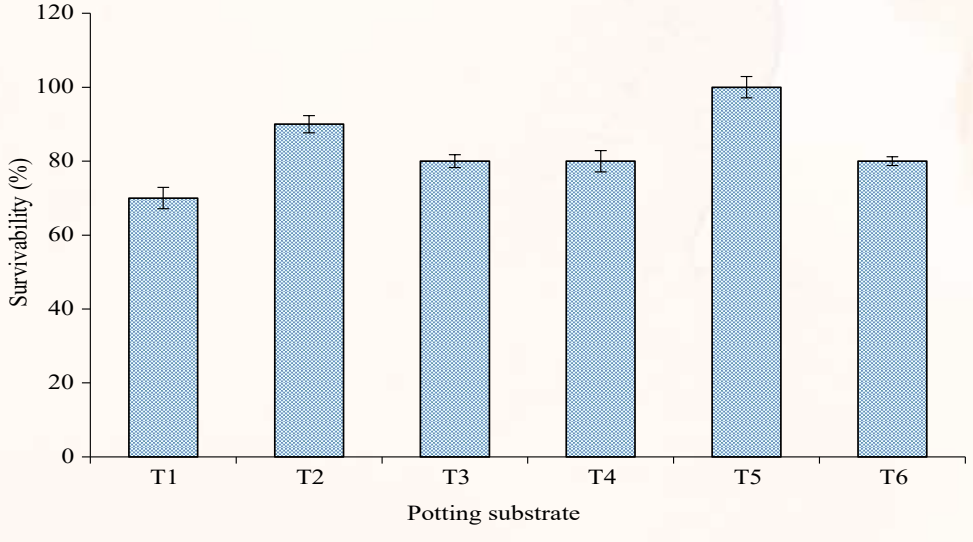


Fig. 19. Effect of potting substrates on survivability of anthurium

Error bars represent the standard error, Note: T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1), and T_6: Cocodust + Sawdust (1: 1).

Data on the Table 10 exhibited that the tallest plant (52.0 cm), maximum number of leaves per plant (8.0), maximum plant spread (30.5 cm) and highest number of suckers per plant (4.8) was recorded in the treatment T_5 (cocodust + perlite) contained more organic matter in decomposed form which release essential plant nutrient particularly nitrogen that accelerated the plant growth. Meyer and Anderson (2003) reported that nitrogen enhances cell division and formation of more plant tissues resulting in luxuriant vegetative growth and thereby increased plant height. The increase in number of leaves and suckers per plant might be due to cocodust enabled better aeration, moisture holding capacity and nutrient retention (Singh *et al*., 2019).

Table 10. Effect of potting substrates on growth parameters of anthurium

Treatments	Plant height (cm)	Number of leaves/ plant	Plant spread (cm)	Number of sucker/ plant
T_1	45.0b	4.5b	20.9 c	2.5b
T_2	50.0ab	8.0 a	30.5 a	4.0ab
T_3	49.0ab	6.5ab	27.9ab	3.5ab
T_4	48.8ab	6.0ab	25.7 b	3.3ab
T_5	52.0a	6.7ab	30.0 a	4.8a
T_6	49.0ab	6.0ab	27.2 ab	3.4ab
CV %	**5.9**	**6.9**	**7.5**	**8.7**

Means within the same column with a common letter do not differ significantly (P≤0.05)

T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + Perlite (1:1, v/v), and T_6: Cocodust + Sawdust (1:1, v/v).

The highest number of flowers per plant (8.0) was recorded from T_5 followed by T_2 (6.0) treatment (Fig. 19a). Plants of the treatment T_1 produced the lowest number of flowers (7.0) (Fig. 19b). Maximum number of flowers was also obtained using cocodust alone or cocodust with perlite reported by Sindhu *et al*. (2010) in gerbera. Considering the chemical properties of different potting substrates, T_5 (cocodust + perlite) and T_2 (cocodust) provided higher amount of N, P, K, B and Zn nutrient. This is in line with the findings of Keshav and Dubey (2008) anthurium production.

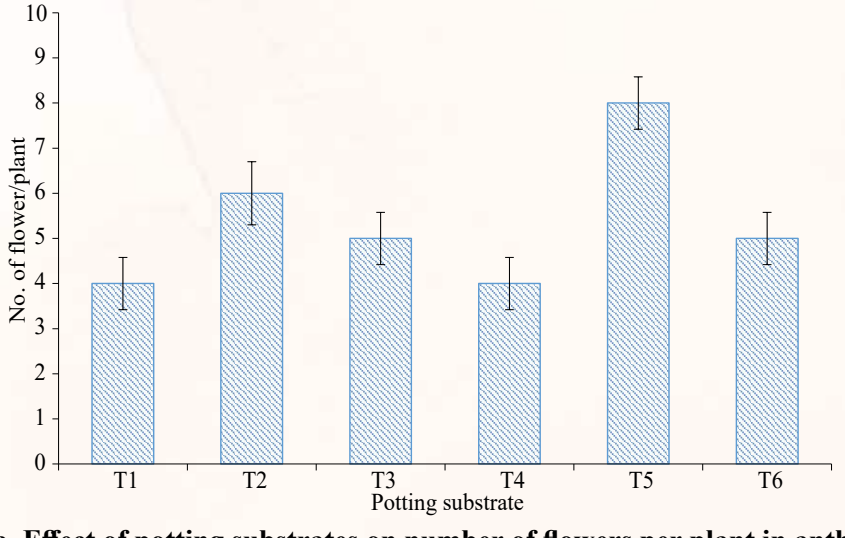


Fig. 19a. Effect of potting substrates on number of flowers per plant in anthurium

Error bars represent the standard error, Note: T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + Perlite (1:1), and T_6: Cocodust + Sawdust (1:1).

T_1 T_2 T_3

T_4 T_5 T_6

Fig. 19b. Effect of potting substrates on number of flowers per plant in anthurium

Days to flowering were significantly affected by different potting substrates (Table 11). Plants took more time (74.0 days) for flowering in T_1 treatment where the nutrients availability was restricted i.e. T_1 (only soil). On the other hand, plants grown in nutrient enriched media took less time for flowering that means 64.0 and 65.0 days for flowering in T_2 (cocodust) and T_5 (cocodust + perlite), respectively. Present results are in agreement with the findings of Ahmad *et al.* (2012) where the mixture of cocodust + perlite and cocodust singly resulted early flowering in gerbera. Maximum stalk length (25.0 cm) and stalk weight (27.0g) of anthurium were produced by the treatment T_5 which was followed by T_2, T_3 and T_4 treatment and shortest stalk was observed from T_1 followed by T_6 treatment (Table 11). The media cocodust singly or along with perlite had more phosphorus content which was facilitated to produce longer and thicker stalks of anthurium as compared to other treatments. Phosphorus is the key nutrient involved in stimulating and enhancing the bud development and blooming. The mentioned findings also confirmed by the findings of Sindhu *et al*. (2010) in gerbera. The parameter vase life is related to post-harvest handling of cut flowers. This is one of the most important commercial aspects of anthurium production. The longer vase life (20.0 days) (Table 11) and maximum flowering duration of anthurium of 28 days (Fig. 20) was observed in cocodust with perlite media (T_5) followed by cocodust singly (T_2). The shorter (14.0 days) vase life and minimum flowering duration of 23 days was recorded from the plants grown in T_1 (soil). Ahmad *et al.* (2012) also reported similar results who stating that the combination of cocodust + perlite had eventually increased the vase life and flowering duration of gerbera flower.

Table 11. Effect of different potting substrates on flower parameters of anthurium

Treatments	Days to flowering	Stalk length (cm)	Stalk weight (g)	Vase life (days)
T_1	74.0a	19.8b	16.0 c	14.0 b
T_2	64.0c	23.7 ab	25.0 ab	17.8 ab
T_3	68.0bc	23.0 ab	18.8 bc	15.8 ab
T_4	70.0b	22.0 ab	17.5 bc	15.5 ab
T_5	65.0c	25.0 a	27.0 a	20.0 a
T_6	70.0b	20.0 b	22.0 b	15.9ab
CV %	**8.1**	**6.9**	**7.8**	**7.6**

Means within the same column with a common letter do not differ significantly (P≤0.05)

Note: T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + Perlite (1:1, v/v) and T_6: Cocodust + Sawdust (1:1, v/v)

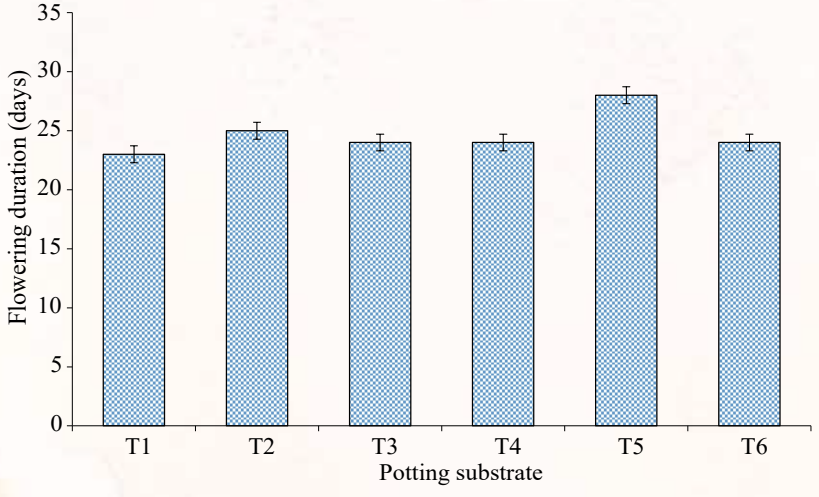


Fig. 20. Effect of potting substrates on flowering duration (days) of anthurium

Error bars represent the standard error, Note: T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + Perlite (1:1), and T_6: Cocodust + Sawdust (1:1).

Most of the nutrients showed variation among the treatments (Table 12). The highest OM (9.80%) was obtained from T_5 followed by T_2 treatment and lowest organic matter from T_1 treatment. Total N content was highest (0.45%) in T_2 treatment followed by T_5 treatment. Table 11 indicated that most of the nutrient content exhibited comparatively higher in cocodust alone (T_2) or cocodust+perlite (1:1) (T_5) treatment than the other treatments (Table 12).

Table 12. Nutrient status in post-harvest potting substrates

Treatments	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Mn	Zn
			(meq/100g)				(µg/g)						
T_1	7.7	0.45	12.0	3.2	0.15	0.024	10.5	12.0	0.015	1.0	19	17	2.0
T_2	7.0	9.75	10.5	2.5	0.38	0.450	14.3	15.0	0.070	1.2	30	12	2.3
T_3	7.6	8.00	10.0	2.3	0.28	0.250	13.0	13.0	0.050	1.8	36	13	2.4
T_4	7.8	5.50	8.5	2.0	0.26	0.035	12.5	12.5	0.023	1.7	40	25	2.3
T_5	7.2	9.80	10.8	2.6	0.35	0.400	14.0	15.2	0.075	1.3	35	14	2.5
T_6	7.7	6.10	9.0	2.5	0.25	0.010	13.0	13.0	0.030	0.7	48	25	2.3

Note: T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + Perlite (1:1, v/v), T_6: Cocodust+Sawdust (1:1, v/v)

Application of different substrates in pot had a positive impact on gross return of anthurium (Table 13). The highest increase of gross return and margin were from application of cocodust with perlite (T_5) in pot. Both were the lowest from T_1 treatment. The calculated benefit cost ratio (BCR) was the highest (2.38) in T_5 treatment.

Table 13. Effect of different potting substrates on partial economics of anthurium

Treatments	*TVC (BDT/pot/yr)	Gross return (BDT/pot/yr)	Gross margin (BDT/pot/yr)	BCR
T_1	1533	1900	367	1.24
T_2	1540	3000	1460	1.95
T_3	1545	2600	1055	1.68
T_4	1540	2380	840	1.54
T_5	1543	3680	2137	2.38
T_6	1540	2540	1000	1.65

Note: T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + Perlite (1:1, v/v) and T_6: Cocodust + Sawdust (1:1, v/v)

Inputs price: Plastic pot= BDT 30/pot, Sandy loam soil= BDT 3/pot, Wage rate= BDT 100/hour, Autostin= BDT 160/100g, Ripcord=BDT 130/100ml, Output price: Flower stick=BDT 100/stick, Sucker= BDT 400/sucker, TVC= Total variable cost, BDT is Bangladesh currency.

Fig. 21. Flowering of Anthurium (a-c)

(a. Experimental view b. Flowering stage c. Stalk length)

Among the substrates used in the present experiment, cocodust + perlite (1:1) was the best and suitable potting substrate followed by cocodust (100%) on the basis of growth, yield, economics and flower parameters of anthurium (Fig. 21).

Experiment 5: Effect of potting media on plant growth and yield of ground orchid

The data pertaining to the effect of different potting media on growth characteristics of ground orchid is presented in Table 14. Among all the treatments, T_5 - Cocodust + sphagnum moss (1:1, v/v) has recorded significantly the highest plant height (60.5 cm), maximum number of leaves (10.0) and maximum number of shoots (6.0) per plant while the lowest plant height, lowest number of leaves and shoots were observed in T_1- soil as compared to other treatments. It might be due to the fact that growing media T_5 contained more organic matter in decomposed form which release essential plant nutrient particularly nitrogen that accelerated the plant growth. The increase in number of leaves and number of shoot per plant might be due to media containing cocodust and sphagnum moss

which enabled better aeration, moisture holding capacity and nutrient retention. It was conformity by Gufran and Saravanan (2014) in orchid. Leaf area is considered to be an important character which has marked effect on growth of plant. From the Table 14, it was observed that leaf area (40.5 cm^2), shoot girth (2.9 cm) and sucker number (8.0) was found highest in T_5 - cocodust + sphagnum moss (1:1, v/v) which was followed by treatment T_6 - cocodust + perlite (1:1, v/v). Similar trend was found in orchids (Rajeveen *et al.*, 2008).

Table 14. Effect of potting media on growth characteristics of ground orchid

Potting media	Plant height (cm)	No. of leaves	No. of shoot	Leaf area (cm^2)	Shoot girth (cm)	No. of sucker
T_1	50.0 c	6.0 b	2.0 b	30.0 c	1.3 b	3.0 b
T_2	53.0 bc	7.4 ab	3.6 ab	34.8 bc	2.2 ab	5.0 ab
T_3	56.7 ab	7.8 ab	3.5 ab	34.0 bc	2.1 ab	4.0 ab
T_4	55.0 b	7.5 ab	3.7 ab	35.5 b	2.1 ab	4.0 ab
T_5	60.5 a	10.0 a	6.0 a	40.5 a	2.9 a	8.0 a
T_6	58.0 ab	8.0 ab	4.0 ab	37.8 ab	2.3 ab	6.0 ab
CV%	**9.2**	**8.3**	**7.5**	**8.1**	**6.0**	**7.5**

T_1- Garden soil (control), T_2 - Cocodust, T_3 - Sphagnum moss, T_4 - Perlite, T_5 - Cocodust + Sphagnum moss (1:1, v/v) and T_6 – Cocodust + perlite (1:1, v/v)

The minimum time (65.0 days) required for flowering was observed in T_5-Cocodust + sphagnum moss (1:1) while, plant grown in soil (T_1) required maximum days (82.0 days) (Table 15). This might be due to vigorous growth of the plant growing in the media and the rapid uptake of nutrients and water has a pronounce effect on early production. Moreover, as the leaf numbers were increased in present study, which also attributed to accumulation of more photosynthate in this media might have induced early flowering. These results are in accordance with the findings of Gufran and Saravanan (2014) in orchid.

Plant grown in a mixture of cocodust + sphagnum moss (1:1) (T_5) has recorded significantly the longest spike length (45.0 cm) and rachis length (30.0 cm) having better physical properties, improved photosynthetic efficiency and higher carbohydrate accumulation in plants which ultimately produced longest spike and rachis length. Maximum numbers of florets per spike (14.0) and flower per plant (8.0) (Fig. 22-23) were produced in treatment T_5 containing the growing media with cocodust + sphagnum moss (1:1) . Cocodust and sphagnum moss has been reported to contain some amount of major, secondary and micronutrients (Rajeveen and Valsalakumari, 2008), free from any admixture of heavy metals and due to higher porosity, adequate nutrient availability and lower pH and EC in the media enhanced plant growth and flower yield. The lowest number of florets and flowers were recorded in soil media (T_1) might be due to the fact that soil contains low nitrogen and phosphorus resulting in poor root and vegetative growth that ultimately affected the reproductive growth and thus produced the lowest number of florets and flowers per plant.

T_1 T_2 T_3 T_4 T_5 T_6

Fig. 22. Effect of potting media on floret number of ground orchid

Table 15. Effect of potting media on floral characteristics of ground orchid

Potting media	Days to flowering	Spike length (cm)	Rachis length (cm)	Floret number/ spike	Flowernumber /plant	Spike weight (g)	Flowering duration (days)	Vase life (days)
T_1	82.0 a	34.0 c	21.0 c	10.0 b	3.0 b	51.5c	14.0b	10.0 b
T_2	72.0 bc	36.0 bc	23.6 bc	12.0 ab	5.0 ab	59.0ab	16.4ab	13.0 ab
T_3	76.0 b	37.2 bc	25.5 b	12.0 ab	4.5 ab	57.0b	17.0 ab	14.0 ab
T_4	70.0 c	40.0 b	26.8 ab	12.5 ab	4.5 ab	58.8ab	17.8 ab	14.0 ab
T_5	65.0 d	45.0 a	30.0 a	14.0 a	8.0 a	63.0a	20.0 a	17.0 a
T_6	68.0 cd	43.0 ab	27.3 ab	13.0 ab	6.0 ab	60.5ab	18.5 ab	15.0 ab
CV%	**7.8**	**8.0**	**9.0**	**7.8**	**6.7**	**7.3**	**6.9**	**7.1**

T_1- Soil (control), T_2 - Cocodust, T_3 - Sphagnum moss, T_4 - Perlite, T_5 - Cocodust + Sphagnum moss (1:1, v/v) and T_6 - Cocodust + perlite (1:1, v/v)

The spike weight (63.0 g) was recorded the highest with treatment T_5 - cocodust +sphagnum moss (1:1) whereas the lowest spike weight (45.5 g) was recorded in soil media (T_1). This is in close conformity with the result of Gufran and Saravanan (2014) who got the highest spike weight using potting mixture of cocodust + sphagnum moss (1:1). The increase in spike weight might be due to plants were provided with adequate supply of nutrient and water. Among all the treatments, T_5 - cocodust + sphagnum moss (1:1) has recorded significantly the maximum vase life (17.0 days) and flowering duration (20.0 days) which might be due to increase in internal carbohydrate content of the flowers which enhanced vase life and flowering durability. Similar results were obtained by Paul and Rajeevan (2009) in orchids.

Application of different media in pot had a positive impact on gross return of ground orchid (Table 16). The highest increase of gross return and margin were from application of cocodust with sphagnum moss (1:1) (T_5) in pot. Both were the lowest from T_1 treatment. The calculated benefit cost ratio (BCR) was the highest (2.39) in T_5 treatment.

Table 16. Effect of different potting substrates on partial economics of ground orchid

Treatments	*TVC (BDT/pot/yr)	Gross return (BDT/ pot/yr)	Gross margin (BDT/ pot/yr)	BCR
T_1	1500	1850	350	1.23
T_2	1530	3100	1570	2.10
T_3	1540	2800	860	1.90
T_4	1540	2400	840	1.55
T_5	1545	3700	2155	2.39
T_6	1540	2550	1010	1.65

Note: T_1- soil (control), T_2 - Cocodust, T_3 - Sphagnum moss , T_4 - Perlite, T_5 - Cocodust + Sphagnum moss (1:1, v/v) and T_6 - Cocodust + perlite (1:1, v/v);Inputs price: Plastic pot= BDT 20/pot, Soil= BDT 2/pot, Wage rate= BDT 100/ hour, Autostin= BDT 160/100g, Ripcord=BDT 130/100ml, Output price: Flower stick=BDT 100/stick, Sucker= BDT 450/sucker, TVC= Total variable cost, BDT is Bangladesh currency.

Fig. 23. Flowering of ground orchid (a-c)

T_5 media having (a) maximum flowering (b) longest spike length and (c) maximum vase life

Cocodust + sphagnum moss (1:1) was the best and suitable potting media on the basis of growth, yield, economics and flower parameters of ground orchid

Experiment 6: Effect of organic manures and fertilizers on growth, flowering and yield of lisianthus

All the growth parameters were influenced significantly in lisianthus by various treatments (Table 17). Application of T_2 - Cocodust + Farmyard manure (1:1, v/v) + CIF resulted in maximum plant height (64.0 cm). These results are in line with the findings of Bose *et al*. (2015) in lisianthus who had recorded maximum plant height in T_2 media because of high nutritional level in cocodust and farmyard manure with recommended doses of composite inorganic fertilizer. Highest number of leaves (25.0), branches (9.0) and sucker production (8.0) exhibited with T_5-Cocodust+ Vermicompost + Mustard oil cake (1:1:1) + CIF treatment. Similar results were obtained by Shimizu *et al*. (2012), they stated that T_5 treatment was more appropriate medium for production of the highest number of leaves, branches and sucker due to high water holding capacity, good aeration and cation exchange capacity of the nutrient combination. Among the treatments, T_5 (Cocodust+ vermicompost + mustard oil cake (1:1:1) + CIF) also recorded maximum leave area (7.5 cm^2) and plant spread (7.6 cm) followed by T_4-(Cocodust+ Vermicompost + Mustard oil cake (1:1:1) + CIF) treatment. On the other hand, minimum leave area (4.4 cm^2) and plant spread (4.6 cm) was recorded in T_1 (control). The positive effect of cocodust, vermicompost, mustard oil cake with recommended doses of composite inorganic fertilizer on plant growth has been reported in lisianthus (Shimizu *et al*., 2012).

Table 17. Effect of organic manures and fertilizers on growth characteristics of lisianthus

Treatment	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	Leave area (cm)	Plant spread (cm)	No. of sucker/ plant
T_1- Soil (control)	50.0 b	15.0 c	3.0 c	4.4 b	4.6 b	4.0 b
T_2 - Cocodust + F YM (1:1) + CIF(5g)	56.0 a	19.0 b	5.0 bc	5.9 bc	6.2 bc	5.0 ab
T_3 - Cocodust + Vermicompost (1:1) + CIF (5g)	53.5 ab	21.0 ab	5.0 bc	6.1 bc	6.4 bc	5.0 ab
T_4 -Cocodust + FYM + Mustard oil cake (1:1:1) + CIF (5g)	54.8 ab	22.0 ab	6.0 b	6.9 ab	7.0 ab	6.0 ab
T_5-Cocodust+ Vermicompost + Mustard oil cake (1:1:1) + CIF (5g)	54.3 ab	25.0 a	9.0 a	7.5 a	7.6 a	8.0 a
CV%	**8.6**	**8.0**	**8.2**	**9.2**	**7.5**	**9.0**

Significant difference with respect to flowering characters was observed in response of lisianthus towards different combinations of organic manure and fertilizer application (Table 21). Application of T_5 - Cocodust+ vermicompost + mustard oil cake (1:1:1) + CIF were taken lesser number of days for flowering (48.0 days) preceded by T_4 -Cocodust + FYM + Mustard oil cake (1:1:1) + CIF (51.0 days) These results are supported by the findings of Chauhan *et al.* (2005) in carnation. This might be due to vigorous growth of the plant growing in T_5 treatment and rapid uptake of nutrients and water has a pronounced effect on early production.

It was found that maximum number of flowers (29.0) and highest stalk length (50.5 cm) were recdorded in treatment T_5 (cocodust+ vermicompost + mustard oil cake (1:1:1) + CIF) followed by T_4 - (cocodust+ vermicompost + mustard oil cake (1:1:1) + CIF) (27.0 and 48.0 cm respectively) (Fig. 24). These results are confirmed by the findings of Shimizu *et al.*, (2012) in lisianthus. The data regarding flower size showed significant results for all treatments (Table 18). Maximum flower size of 8.0 cm was contributed by T_5 (cocodust+ vermicompost + mustard oil cake (1:1:1) + CIF) treatment. These results are supported by Bose *et al.* (2015) in lisianthus.

Table 18. Effect of organic manures and fertilizers on flowering of lisianthus

Treatment	Days to flowering	Stalk length (cm)	Number of flowers/ plant	Flower size (cm)	Vase life (days)
T_1- Soil (control)	66.0 a	40.0 c	19.0 c	5.4b	6.0 c
T_2 - Cocodust + F YM (1:1) + CIF (5g)	61.0 b	43.4 bc	22 0 bc	6.5 ab	8.0 bc
T_3 - Cocodust + Vermicompost (1:1) +CIF(5g)	54.0 c	45.0 b	25.0 b	6.9 ab	8.0 bc
T_4 -Cocodust + FYM + Mustard oil cake (1:1:1) + CIF(5g)	51.0 cd	48.0 ab	27.0 ab	7.3ab	10.0 b
T_5-Cocodust+ Vermicompost + Mustard oil cake (1:1:1) + CIF(5g)	48.0 d	50.5 a	29.0 a	8.0 a	14.0 a
CV%	**9.3**	**8.5**	**7.8**	**NS**	**8.4**

Significant differences were observed in vase life among the treatments (Table 18). Tabulated data clearly indicated that significantly the maximum vase life (14.0 days) was recorded in T_5 - Cocodust+ vermicompost + mustard oil cake (1:1:1) + RDCIF. These results are supported by Bose *et al.* (2015) in lisianthus. Positive effect of different combinations of organic manure and fertilizer application on flower production and vase life prolongation were experimentally substantiated by earlier worker (Shimizu *et al.,* 2005) in lisianthus.

T_1 T_2 T_3 T_4 T_5

Fig. 24. Effect of organic manures and fertilizers on flower number of lisianthus

Experiment 7: Effect of different growing media on growth and yield of rose

Growth parameters like plant height, leaf area, plant spread, number of leaves per plant, number of branches per plant and stalk length of Dutch rose were significantly influenced by different growing media (Table 19). Among the treatments, T_5 =Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) treatment gave the highest plant height (52.0 cm) followed by T_6= Soil + cocodust+ vermicompost + perlite (1:1:1:1, v/v) treatment (48.0 cm) and T_7= soil treatment exhibited the lowest plant height (35.5 cm). Growing media T_5 might have more organic matter which released essential plant nutrient particularly nitrogen that accelerated the plant height. Barman *et al*. (2006) corroborated that nitrogen enhances cell division and formation of more plant tissues resulting in luxuriant vegetative growth and thereby increased plant height. Leaf area was markedly influenced by the different growing media. The highest leaf area (16.4 cm^2) was found in T_5 treatment which was statistically similar to T_6 (14.5 cm^2), T_3 (12.8 cm^2) and T_2 (12.4 cm^2) treatments (Table 18). Leaf area increased causes the higher net assimilation rate ultimately augmented the plant growth. The result is in agreement with the previous findings of Younis *et al.* (2015) in rose. Significantly the highest plant spread (32.4 cm), highest number of leaves per plant (41.0) and highest number of branches per plant (9.0) was measured from the treatment T_5= Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) and the lowest was measured in control (19.0 cm) treatment (Table 19). Treatment T_5 contributed through supplying higher nutrient to plant as well as higher water holding capacity which might be responsible for maximum plant spread, highest number of leaves and branches per plant In addition to, this result is supported by findings of Ysmeen *et al.* (2012) in rose.

From marketing point of view, length of flower stalk is important for flower growth parameter. Treatment T_5= Soil + cocodust + vermicompost +leaf compost (1:1:1:1, v/v) produced the highest stalk length (33.5 cm) followed by T_6 (29.5 cm) T_3 (28.6 cm) and T_2 (28.0 cm) treatments (Table 18). A good amount of leaves coupled with conducive root environment might have led to proper nutrient uptake from media resulted in greater accumulation of nutrient leading to increase the rose stalk length. The statement is supported by Younis *et al.* (2015).

Table 19. Effect of growing media on growth parameters of rose

Potting media	Plant height (cm)	Leaf area(cm^2)	Plant spread (cm)	Number of leaves/ plant	Number of branches/ plant	Stalk length (cm)
T_1	40.0 c	9.20 bc	23.5 c	30.0 c	6.0 ab	24.5 bc
T_2	42.5 bc	12.4 ab	25.2 bc	33.0 bc	6.0 ab	28.0 ab
T_3	43.0 bc	12.8 ab	26.0 bc	35.0 b	6.0 ab	28.6 ab
T_4	45.5 b	10.9 b	25.0 bc	32.0 bc	6.0 ab	26.0 b
T_5	52.0 a	16.4 a	32.4 a	41.0 a	9.0 a	33.5 a
T_6	48.0 ab	14.5 ab	28.2 b	38.0 ab	7.0 ab	29.5 ab
T_7	35.5 d	7.00 c	19.0 d	26.0 d	4.5 b	22.2 c
CV (%)	**11.5**	**8.4**	**11.7**	**10.3**	**9.8**	**12.6**

Means within the same column with a common letter do not differ significantly (P≤0.05)

T_1: Soil + Farmyard Manure (1:1, v/v), T_2: Soil + Vermicompost (1:1, v/v), T_3: Soil + Farmyard Manure + cocodust(1:1:1, v/v), T_4: Soil + Vermicompost + cocodust(1:1:1, v/v), T_5= Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v), T_6 = Soil + cocodust + vermicompost + perlite (1:1:1:1, v/v) and T_7= Soil (control)

Those growing media were significantly varied on days to flowering, petal size, number of petals per flower, flower size and number of flowers per plant of Dutch rose (Table 19).The lowest days to flowering (55.0 days) was exhibited in T_5= Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) treatment followed by T_6= Soil + cocodust + vermicompost + perlite (1:1:1:1) treatment (58.0 days) (Table 20). This day's reduction for flowering in T_5 growing media might be due to vigorous growth of plant, rapid uptake of nutrients and water resulted early flowering. In the study, T_5= Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) treatment contributed to produce the biggest size of petal (4.5 cm^2) and maximum flower size (9.8 cm) comparable with most of the treatments (Table 20). Growing media may contain higher potassium, which has good physicochemical properties like high porosity, good water holding capacity and higher retention of moisture that leads to improve the size of petal and flower (Khandaker *et al*., 2020). The highest number of petals (21.0) and flowers per plant (20.0) was counted from T_5= Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) treatment. Appropriate quantities of vermicompost in growing media has synergistic effects and cocodust and leaf compost were found to improve the physical properties of the media, decrease compaction and enable better growth of plant that was beneficial for increasing the number of petals and flowers per plant. Result is in agreement with earlier findings of Younis *et al.* (2015) and Ahmed *et al.* (2012) in rose.

Table 20. Effect of growing media on flower characteristics in rose

Growing media	Days to flowering	Petal size (cm^2) /flower	Number of petals/flower	Flower size (cm^2)	Number of flowers/plant
T_1	66.0ab	3.0 ab	14.0 bc	8.0 ab	15.0ab
T_2	64.0 b	3.1 ab	15.0 bc	8.1 ab	15.0 ab
T_3	60.0 c	3.2 ab	16.0 b	8.2 ab	16.0 ab
T_4	62.0 bc	3.3 ab	14.0 bc	8.0 ab	15.0 ab
T_5	55.0 d	4.5 a	21.0 a	9.8 a	20.0 a
T_6	58.0 cd	3.5ab	18.0 ab	8.6 ab	17.0 ab
T_7	70.0 a	2.4 b	11.0 c	6.5 b	13.0 b
CV (%)	**9.60**	**10.8**	**10.9**	**9.3**	**10.2**

Means within the same column with a common letter do not differ significantly (P≤0.05)

T_1: Soil + Farmyard Manure (1:1, v/v), T_2: Soil + Vermicompost (1:1, v/v), T_3: Soil + Farmyard Manure + cocodust(1:1:1, v/v), T_4: Soil + Vermicompost + cocodust(1:1:1, v/v), T_5= Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v), T_6 = Soil + cocodust + vermicompost + perlite (1:1:1:1, v/v) and T_7= Soil (control)

The quality parameters such as fresh weight of cut flower, dry weight of cut flower, flowering duration (days) and vase life of cut flower (days) were significantly influenced by different growing media (Table 21). Fresh weight (2.5 g) and dry weight (1.3 g) of cut flower showed highest in T_5= Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) treatment which was statistically at par with most of the treatments while lowest was in T_7 (soil) treatment. The result is matched with the finding of Chavada *et al.* (2017) in rose grown in soil, cocodust, vermicompost and leaf compost growing media. Maximum flowering duration (21 days) and vase life (17 days) was recorded considerably in T_5= Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) treatment followed by T_6 and T_3 treatment (Fig. 25). The increased flowering duration and vase life might be related to internal carbohydrate content of flowers. The T_5 growing media (Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) also having better physical properties, influence the absorption of nutrients by the plants which ultimately helped to produced long stems and more turgid flowers. Similar results were found by and Ahmad *et al.* (2012) in rose.

Table 21. Effect of growing media on quality parameters of rose

Growing media	Fresh wt. of cut flower (g)	Dry weight of cut flower (g)	Flowering duration (days)	Vase life of cut flowers (days)
T_1	1.2ab	0.5ab	14.0 bc	11.0 bc
T_2	1.3ab	0.6ab	16.0 b	13.0 b
T_3	1.4ab	0.7ab	17.0 ab	14.0 ab
T_4	1.3ab	0.6 ab	16.0 b	13.0 b
T_5	2.5 a	1.3 a	21.0 a	17.0 a
T_6	1.6 ab	0.8 ab	18.0 ab	15.0 ab
T_7	0.7 b	0.3 b	11.0 c	9.0 c
CV (%)	**7.5**	**8.3**	**7.2**	**8.4**

Means within the same column with a common letter do not differ significantly (P≤0.05)

T_1: Soil + Farmyard Manure (1:1, v/v), T_2: Soil + Vermicompost (1:1, v/v), T_3: Soil + Farmyard Manure + cocodust(1:1:1, v/v), T_4: Soil + Vermicompost + cocodust(1:1:1, v/v), $T_{5=}$ Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v), T_6 = Soil + cocodust + vermicompost + perlite (1:1:1:1, v/v) and T_7= Soil (control)

Different growing media were analyzed for pH, OM, EC, N, P and K content before planting and after harvest. The results of nutrient content varied among the treatments. The pH of growing media after harvest was almost acidic except T_1 and T_7 treatment (Table 22). The lowest pH (5.80) was noted from T_5= Soil + cocodust + vermicompost + leaf compost treatment preceded by T_6 (5.87) treatment (Table 22). The pH of different media after harvest was showed decreasing trend with reference to initial (before planting). The EC was also lowest (0.22) in the media soil + cocodust +vermicompost + leaf compost (T_5) preceded by media Soil + cocodust + vermicompost + perlite (0.25) (T_6). Organic matter, N, P and K content were maximum (2.95%, 3.50%, 0.97% and 2.35%) in T_5= Soil + cocodust + vermicompost + leaf compost followed by T_6 (2.86%, 3.38%, 0.83% and 2.24%) treatment (Table 22). Usually rose require acidic condition for their growth and yield, although T_5= Soil + cocodust + vermicompost + leaf compost treatment was suitable. These results are in conformity with the earlier findings of Ahmad *et al.* (2012) in rose. The media soil + cocodust + vermicompost + leaf compost had higher N, P and K content which increases the N, K and uptake availability of P could be resulted of more P exchange sites or higher activity of P-solubilizing organisms. The results are in agreement with the findings of Younis *et al.* (2015) in rose.

Table 22. Postharvest change of nutrient status in growing media with reference to initial status

Treatments	pH	OM (%)	EC (dS/m)	N (%)	P (%)	K (%)
Initial						
T_1 = Soil + Farmyard manure	7.40	0.98	0.70	0.60	0.51	0.56
T_2 = Soil + vermicompost	6.80	1.70	0.60	1.18	0.85	0.98
T_3= Soil + FYM + cocodust	6.50	1.80	0.56	0.95	0.75	1.13
$T_{4=}$ Soil + vermicompost + cocodust	6.60	2.00	0.58	1.10	0.81	0.90
T_5= Soil + cocodust + vermicompost + leaf compost	6.10	2.48	0.35	1.61	1.32	1.42
T_6= Soil + cocodust + vermicompost + perlite	6.20	2.30	0.42	1.50	1.24	1.29
T_7= Soil (control)	7.20	0.67	0.77	0.42	0.45	0.52
Post-harvest						
T_1 = Soil + Farmyard manure	7.20	1.70	0.65	1.90	0.40	0.52
T_2 = Soil + vermicompost	6.50	2.29	0.48	2.89	0.64	1.20
T_3= Soil + FYM + cocodust	6.30	2.24	0.50	2.30	0.60	1.25
$T_{4=}$ Soil + vermicompost + cocodust	6.20	2.20	0.45	2.70	0.62	1.18
T_5= Soil + cocodust + vermicompost + leaf compost	5.80	2.95	0.22	3.50	0.97	2.35
T_6= Soil + cocodust +vermicompost + perlite	5.87	2.84	0.25	3.38	0.83	2.24
T_7= Soil (control)	7.16	0.72	0.61	0.41	0.37	0.55

Fig. 25. Stalk length and vase life of rose (a-b)

T_5 media having (a) longest stalk length and (b) maximum vase life

Among the various growing media, combination of soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) media was the best for plant growth, flower yield and quality improvement of rose.

Experiment 8: Effect of different soilless media for vegetable production on rooftop gardening

The results of the experiment have been shown crop wise in the Tables 23-27 (Fig. 26). Different characters showed statistically differences. Among the parameters studied, the plant height was varied ranged from 69.00 to 100.00cm. The highest height (100.00cm) was measured from the treatment T_3 (1.5kg coco-dust with 0.5kg vermi-compost) while, the shortest (69.00cm) plant height was recorded from the treatment T_5 (2.0 kg coco-dust with 0.0 kg vermi-compost). The treatment T_3 exhibited the maximum (20.00) number of leaves and early (55.00 days) flowering habit. The maximum number of flower cluster per plant (10.00) and the higher number of fruit per plant (17.00) were also recorded from the treatment T_3 (Fig. 27a). The highest fruit yield (0.95 kg/pot) of tomato obtained from the treatment T_3 while, the lowest yield (0.42 kg/plot) was recorded from the treatment T_5 (2.0 kg coco-dust with 0.0 kg vermi-compost) (Table 23).

Table 23. Yield and yield contributing characters of tomato in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 1st flowering	No. of flower cluster/plant	No. of fruit/ plant	Fruit yield/ plant (kg)
T_0	88.00 b	14.00 b	59.33 b	6.00 b	12.33 b	0.64 b
T_1	82.67 b	10.00 c	59.33 b	4.00 c	9.00 c	0.51 b
T_2	85.33 b	11.67 bc	61.00 a	3.00 c	9.67 c	0.57 b
T_3	100.00 a	20.00 a	55.00 c	10.00 a	17.00 a	0.95 a
T_4	82.67 b	12.00 bc	58.00 b	4.33 bc	10.33 bc	0.51 b
T_5	69.00 c	10.00 c	58.67 b	4.00 c	9.00 c	0.42 b
CV(%)	**6.16**	**10.14**	**1.35**	**18.05**	**10.50**	**25.36**

T_0= 1.0 kg cow-dung + 1.0kg soil (traditional practice); T_1= 1.0 kg coco-dust with 1.0 kg vermi-compost; T_2= 1.25 kg coco-dust with 0.75 kg vermi-compost; T_3= 1.5 kg coco-dust with 0.5 kg vermi-compost; T_4= 1.75 kg coco-dust with 0.25 vermi-compost; and T_5= 2.0 kg coco-dust with 0.0 kg vermi-compost.

In the case of sweet pepper, there had been significant differences observed among the different parameters. The plant height was varied ranged from 24.33 to 43.33cm. The highest height (43.33cm) was measured from the treatment T_3 (1.5kg coco-dust with 0.5kg vermi-compost) while, the shortest (24.33cm) plant height was recorded from the treatment T_2 (1.25 kg coco-dust with 0.75 kg vermi-compost). The same treatment (T_3) exhibited the maximum (19.00) number of leaves and early (44.33 days) flowering habit. The maximum number of flower cluster per plant (11.00) and the higher number of fruit per plant (6.67) were also recorded from the treatment T_3 (Fig. 27b). The highest fruit yield (0.72 kg/pot) of sweet pepper obtained from the treatment T_3 while, the lowest yield (0.34 kg/plot) was recorded from the treatment T_4 (Table 24).

Table 24. Yield and yield contributing characters of sweet pepper in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 1st flowering	No. of flower cluster/plant	No. of fruit/ plant	Fruit yield/ plant (kg)
T_0	43.33 a	16.00 ab	46.00 c	6.67 b	4.00 b	0.41 b
T_1	32.33 abc	14.33 b	46.33 c	6.33 b	4.00 b	0.43 b
T_2	24.33 c	13.33 b	48.00 b	6.00 b	4.33 b	0.39 b
T_3	37.67 ab	19.00 a	44.33 d	11.00 a	6.67 a	0.72 a
T_4	31.00 bc	15.67 ab	49.67 a	6.00 b	4.00 b	0.34 b
T_5	31.67 abc	16.67 ab	48.67 ab	5.67 b	4.67 b	0.48 b
CV(%)	**20.09**	**15.22**	**1.40**	**16.97**	**16.64**	**18.09**

T_0= 1.0 kg cow-dung + 1.0kg soil (traditional practice); T_1= 1.0 kg coco-dust with 1.0 kg vermi-compost; T_2= 1.25 kg coco-dust with 0.75 kg vermi-compost; T_3= 1.5 kg coco-dust with 0.5 kg vermi-compost; T_4= 1.75 kg coco-dust with 0.25 vermi-compost; and T_5= 2.0 kg coco-dust with 0.0 kg vermi-compost

The results of bitter gourd revealed that the plant height varied ranged from 169.00 to 220.00cm. The highest height (220.00cm) was measured from the treatment T_3 (1.5kg coco-dust with 0.5kg vermi-compost) while, the shortest (169.00cm) plant height was recorded from the treatment T_5 (2.0 kg coco-dust with 0.0 kg vermi-compost). The treatment T_3 showed early flowering within 33.00 days (DAS). The maximum number of flower cluster per plant (16.33) and the higher number of fruit per plant (12.33) were also recorded from the treatment T_3 (Fig. 27c). The highest fruit yield (0.75 kg/pot) of bitter gourd obtained from the treatment T_3 while, the lowest yield (0.20 kg/plot) was recorded from the treatment T_5 (Table 25).

Table 25. Yield and yield contributing characters of bitter gourd in different growing media at rooftop gardening

Treatment	Plant height (cm)	Days to 1st flowering	No. of flower cluster/plant	No. of fruit/ plant	Fruit yield/ plant (kg)
T_0	179.33 b	37.33 a	10.33 b	5.00 b	0.27 b
T_1	175.00 b	36.67 a	9.67 b	5.33 b	0.30 b
T_2	176.00 b	36.67 a	10.67 b	3.67 b	0.22 b
T_3	220.00 a	33.00 b	16.33 a	12.33 a	0.75 a
T_4	173.33 b	37.00 a	10.67 b	3.67 b	0.21 b
T_5	169.00 b	37.67 a	8.67 b	3.33 b	0.20 b
CV(%)	**5.63**	**2.91**	**13.38**	**23.62**	**20.97**

T_0= 1.0 kg cow-dung + 1.0kg soil (traditional practice); T_1= 1.0 kg coco-dust with 1.0 kg vermi-compost;

T_2= 1.25 kg coco-dust with 0.75 kg vermi-compost; T_3= 1.5 kg coco-dust with 0.5 kg vermi-compost;

T_4= 1.75 kg coco-dust with 0.25 vermi-compost; and T_5= 2.0 kg coco-dust with 0.0 kg vermi-compost

For cucumber, the plant height was varied ranged from 135.33 to 193.33cm. The highest height (193.33cm) was measured from the treatment T_3 (1.5kg coco-dust with 0.5kg vermi-compost) while, the shortest (135.33cm) plant height was recorded from the control T_0 (1.0 kg cow-dung + 1.0kg soil (traditional practice). The treatment T_3 exhibited the maximum (17.33) number of leaves but early flowering (34.75 days) was recorded from the treatment T_1 (1.0 kg coco-dust with 1.0 kg vermi-compost). The maximum number of flower cluster per plant (8.33) and the higher number of fruit per plant (5.67) were also recorded from the treatment T_3. The highest fruit yield (0.59 kg/pot) of cucumber obtained from the treatment T_3 while, the lowest yield (0.23 kg/plot) was recorded from the treatment T_5 (2.0 kg coco-dust with 0.0 kg vermi-compost) (Table 26).

Table 26. Yield and yield contributing characters of cucumber in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 1st flowering	No. of flower cluster/plant	No. of fruit/ plant	Fruit yield/ plant (kg)
T_0	135.33 b	11.33 b	39.00 a	5.00 bc	2.33 bc	0.28 bc
T_1	139.00 b	9.00 b	34.75 a	4.67 c	3.00 b	0.32 b
T_2	137.00 b	11.00 b	38.33 a	5.00 bc	2.33 bc	0.30 b
T_3	193.33 a	17.33 a	37.33 a	8.33 a	5.67 a	0.59 a
T_4	140.00 b	10.33 b	38.33 a	6.33 b	3.00 b	0.30 b
T_5	136.67 b	11.33 b	38.67 a	4.67 c	1.67 c	0.23 c
CV(%)	**9.93**	**13.55**	**5.00**	**13.64**	**16.1**	**15.11**

T_0= 1.0 kg cow-dung + 1.0kg soil (traditional practice); T_1= 1.0 kg coco-dust with 1.0 kg vermi-compost; T_2= 1.25 kg coco-dust with 0.75 kg vermi-compost; T_3= 1.5 kg coco-dust with 0.5 kg vermi-compost; T_4= 1.75 kg coco-dust with 0.25 vermi-compost; and T_5= 2.0 kg coco-dust with 0.0 kg vermi-compost

In the case of lettuce, the highest number of leaves (44.00) was counted from the treatment T_3 (1.5 kg coco-dust with 0.5 kg vermi-compost) (Fig. 27d), while the lowest number of leaves (19.00) was recorded from the treatment T_0 (1.0 kg cow-dung + 1.0kg soil) (traditional practice). The maximum leaves yield (307.00g) was obtained from the treatment T_3 and the lowest yield (135.33g) was exhibited from the treatment T_1 when 1.0 kg coco-dust with 1.0 kg vermi-compost were used as growing media (Table 27).

Table 27. Yield and yield contributing characters of lettuce in different growing media at rooftop gardening

Treatment	No. of leaves/plant	Yield/plant(g)
T_0	19.00 c	137.33 b
T_1	19.67 c	135.33 b
T_2	23.67 bc	142.67 b
T_3	44.00 a	307.00 a
T_4	29.67 b	165.00 b
T_5	22.00 bc	139.33 b
CV(%)	**16.6**	**52.86**

T_0= 1.0 kg cow-dung + 1.0kg soil (traditional practice); T_1= 1.0 kg coco-dust with 1.0 kg vermi-compost; T_2= 1.25 kg coco-dust with 0.75 kg vermi-compost; T_3= 1.5 kg coco-dust with 0.5 kg vermi-compost; T_4= 1.75 kg coco-dust with 0.25 vermi-compost; and T_5= 2.0 kg coco-dust with 0.0 kg vermi-compost

There was no major infestation and infection of insects and diseases found to be attacked during conducting experiment. But there was presence of blossom end rot (physiological disorder due to lack of calcium) of tomato was recorded. It may be mentioned here that the yield all crops little bit low because of sudden water crisis the building premises.

Fig. 26. Experimental view of vegetable production on Rooftop gardening (a-b)

Fig. 27. Effect of different soilless media for vegetable production on rooftop gardening (a-d)

Best T_3 media containing 1.5 kg coco-dust with 0.5 kg vermi-compost a. Tomato plant with fruits, b. Sweet peeper plant with fruits, c. Bitter gourd with fruits and d. Lettuce plant

Experiment 9: Development of production package of some selected flower crops for rooftop gardening

The results of the experiment have been shown in Table 28-37 and (Fig. 28-29). The performance of five varieties/ genotypes of chrysanthemum presented in Table 28 exhibited variation on different vegetative and floral parameters. In respect of flower colour, the observed varieties showed remarkable variation such as yellow, white, magenta, red and orange. The tallest plant was produced by BARI Chrysanthemum-3 variety (72.0 cm) closely followed by BARI Chrysanthemum-2 variety (68.0 cm) which significantly differed from other varieties. On the other hand, the shortest plant (53.0 cm) was recorded in CM-012. The variation might be due to difference in genetic constituents among the varieties along with environmental effects. Number of leave and sucker per plant significantly varied with different varieties of Chrysanthemum. Maximum number of leave (41.0) and sucker (15.0) production was obtained in BARI Chrysanthemum-3 variety followed by BARI Chrysanthemum-2 variety (39.0 and 13.0). Similar results were reported by Kumar *et al.,* (2014) in Chrysanthemum. The number of days taken for flowering was found to be significantly minimum (55.0 days) in BARI Chrysanthemum -1 variety while BARI Chrysanthemum-4 variety took maximum days (60.0 days). Maximum stalk length (39.5 cm) was observed in BARI Chrysanthemum -3 followed by BARI Chrysanthemum-2 (32.8 cm) and minimum stalk length (27.0 cm) was observed in BARI Chrysanthemum-1. The variation in stalk length might be due to difference in genetic makeup of varieties. A wide genetic variation was observed in case of flower number and durability of flower. Among the varieties, BARI Chrysanthemum-3 exhibited longest flowering duration (25.0 days) and maximum number of flower production (27.0). The present findings are more or less in agreement with Mahapatra *et al*., (2000) in Chrysanthemum cultivation in rooftop garden.

Table 28. Performance on vegetative and floral traits of Chrysanthemum varieties/ genotypes

Treatment (variety/genotype)	Flower colour	Plant height (cm)	No. of leave/ plant	No. of sucker/ plant	Stalk length (cm)	Days to flowering	No. of flower/ plant	Flowering duration (days)
BARI Chrysanthemum-1	Yellow	59.5.0c	38.0ab	10.0b	27.0c	55.0b	24.0ab	16.0c
BARI Chrysanthemum -2	White	68.0ab	39.0ab	13.0ab	32.8b	58.0ab	23.0ab	22.0ab
BARI Chrysanthemum -3	Majenta	72.0a	41.0a	15.0a	39.5a	57.0ab	27.0a	25.0a
BARI Chrysanthemum -4	Red	65.5b	36.0b	12.0ab	34.5ab	60.0a	21.0b	20.0b
CM-012	Orange	53.0 d	39. ab	13.0 ab	29.0 bc	58.0 ab	25.0 ab	23.0 ab
CV (%)	**-**	**10.8**	**11.0**	**12.0**	**9.4**	**9.1**	**10.0**	**11.5**

The performance of five varieties/genotypes of gerbera revealed significant difference for all characters on rooftop gardening study. Variation was observed in respect of flower colour viz. red, white, pink, yellow and orange (Table 29). The tallest plant was produced by GJ-023 (31.0 cm) closely followed by GJ-024 (28.0 cm). On the other hand, the shortest plant (24.0 cm) was recorded in BARI Gerbera-2 variety. This variation might be due to difference in genetic constituents among the genotypes along with the environmental effects. Maximum number of leaves per plant (31.0) was produced by BARI Gerbera-1 closely followed by GJ-023 (29.0). On the contrary, GJ-024 produced minimum number of leaves/plant (25.0). Among the varieties, maximum number of sucker production per plant was observed in BARI Gerbera-1 (7.0). There was significant difference among the genotypes for floral traits of gerbera. Early flowering (90 days) was recorded in BARI Gerbera-1. Stalk length is one of the most important character that are considered while garding cut flowers. The data related to stalk length revealed that maximum stalk length was recorded in BARI Gerbera-1 (33.0cm) closely followed by GJ-023 (32.0cm). Kandpal *et al*. (2003)

reported the variation in stalk length among the genotypes due to genetic characters of particular genotypes. Flower yield and its quality parameters decide the significance of the particular variety or genotype, which are suitable for commercial cultivation in the roof. In the present investigation, BARI Gerbera-1 produced maximum number of flowers/plant (21.0) followed by GJ-023 (18.0). Same trend also observed in case of maximum flowering duration (22.0 days) by BARI Gerbera-1 followed by GJ-023 (20.0 days). The results are in accordance with the findings of Nair and Medhi (2002) in gerbera.

Table 29. Performance on vegetative and floral traits of Gerbera varieties/genotypes

Treatment (variety/ genotype)	Flower colour	Plant height (cm)	No. of leaves/ plant	No. of sucker/ plant	Stalk length (cm)	Days to flowering (days)	No. of flower/ plant	Flowering duration (days)
BARI Gerbera-1	Red	26.0ab	31.0a	8.0a	33.0a	90.0c	21.0a	22.0a
BARI Gerbera-2	White	24.0b	27.0ab	6.0ab	30.0ab	95.0b	17.0ab	19.0ab
GJ-023	Pink	31.0a	29.0a	5.0ab	32.0a	93.0bc	18.0ab	20.0ab
GJ-024	Yellow	28.0ab	25.0b	4.0b	27.0b	100.0a	15.0b	16.0b
GJ-025	Orange	27.0 ab	28.0 ab	5.0 ab	31.0 ab	93.0 bc	18.0 ab	18.0 ab
CV (%)	**-**	**15.0**	**15.0**	**13.0**	**12.6**	**10.9**	**14.0**	**10.8**

Variation was observed in leaf colour and flower colour of five anthurium varieties and genotypes which are presented in Table 30. In respect of leaf colour the observed genotypes were categorzed into two groups: green and light green. One variety (BARI Anthurium-1) and four genotypes (AA-005, AA-006, AA-007 and AA-008) produced green leaf and light green respectively. In respect of flower colour, the observed varieties/genotypes showed remarkable variation such as red, violet, pinkish white and orange. The production of maximum number of leave (8.0), flower (6.0), sucker (7.0) and maximum flowering duration (31.0 days) were observed in BARI Anthurium-1.

Table 30. Performance on vegetative, floral and quality aspects of Anthurium varieties/ genotypes

Treatment (variety/ genotype)	Plant height (cm)	leaf colour	Flower colour	Leaf number/ plant	Stalk length (cm)	No. of flower/ plant	No. of sucker/ plant	Flowering duration (days)
BARI Anthurium-1	21.0a	Green	Red	8.0a	22.0a	6.0a	7.0a	31.0a
AA-005	17.0ab	Light green	Violet	5.0ab	17.0ab	5.0ab	5.0ab	25.0b
AA-006	18.0ab	Light green	Pinkish white	6.0ab	18.0ab	5.0ab	5.0ab	22.0bc
AA-007	14.0 b	Light green	Orange	3.0b	14.0b	3.0b	3.0b	20.0c
AA-008	16.0 ab	Light green	Red	5.0 ab	17.0 ab	5.0 ab	5.0 ab	27.0 ab
CV (%)	**8.9**	**-**	**-**	**11.0**	**12.2**	**13.0**	**10.7**	**10.4**

A performance trial of five lilium varieties and genotypes has been conducted to find out the best variety/genotype for rooftop gardening. The performance of five varieties/genotypes of lilium presented in Table 31 exhibited variation on different parameters. In respect of flower colour, the observed varieties/genotypes showed remarkable variation such as creamy white, yellow, pink and snow white. The tallest plant of 65.0 cm recorded in genotype Lil-034 and shortest of 50.0 cm in

Lil-035. The production of maximum number of leaves (31.0), florets number (11.0) and maximum number of bulblet (8.0) was recorded in BARI lilium-1 followed by BARI Lilium-2 (6.0). The number of days taken for flowering was found to be significantly minimum (45.0days) in BARI Lilium-2 variety, whereas maximum stalk length (74.0cm) and flowering duration (16.0 days) were observed in BARI Lilium-1 followed by BARI Lilium-2 (69.0 cm and 11.0 days) respectively.

Table 31. Performance on vegetative, yield and quality traits of Lilium varieties/genotypes

Treatment (variety/ genotype)	Flower colour	Plant height (cm)	No. of leave/ plant	Stalk length (cm)	Days to flowering	No. of florets/ stick	Flowering duration (days)	No. of bulblet/ plant
BARI Lilium -1	Creamy white	60.0b	31.0a	74.0a	54.0a	11.0a	16.0a	8.0a
BARI Lilium -2	Yellow	55.0c	28.0ab	69.0b	45.0c	8.0ab	11.0 b	6.0ab
Lil-033	Pink	53.0bc	20.0c	66.0c	53.0ab	4.0 b	6.0 c	5.0ab
Lil-034	Snow white	65.0a	26.0b	67.0bc	50.0b	6.0ab	8.0 bc	3.0 b
Lil-035	Orange	50.0 d	22.0 bc	61.0 d	48.0 bc	9.0 ab	9.0 bc	5.0 ab
CV (%)	**-**	**10.9**	**12.6**	**15.6**	**13.5**	**14.0**	**14.8**	**15.1**

A performance trial on five genotypes of rose has been conducted to findout the best rose genotype for roof top gardening. The performance of five genotypes of rose presented in Table 32 exhibited variation on different parameters. In respect of flower colour, the observed genotypes showed remarkable variation such as yellow, orange, pink, red and light pink. The tallest plant of 93.6 cm recorded in the genotype R-003 (Hybrid Tea) and shortest of 66.0 cm in R-006 (Miniature). The genotype R-003 produced the longest stalk length (14.0cm). However production of maximum number of branch (7.0), flower number (16.0) and flowering duration (20.0 days) were observed in genotype R-006 (Miniature rose).

Table 32. Performance of vegetative and floral traits of Rose genotypes

Treatment (Genotype and type)	Flower colour	Plant height (cm)	No. of branch/ plant	Stalk length (cm)	No. of flower/ plant	Flowering duration (days)
R-001(Hybrid-T)	Pink	81.0c	4.0b	9.0ab	11.0ab	19.0ab
R-002 (Hybrid-T)	Orange	86.0b	5.0ab	10.0ab	10.0ab	19.0ab
R-003 (Hybrid-T)	Yellow	93.0a	7.0a	14.0a	14.0ab	24.0a
R-006 (Miniature)	Red	66.0d	5.0ab	8.5ab	16.0a	20.0ab
R-007 (Hybrid-T)	Light pink	85.0bc	6.0ab	7.0b	10.0b	18.0b
CV (%)	**-**	**10.9**	**12.0**	**13.0**	**14.2**	**11.5**

Variations were observed in respect of flower colour among the varieties/genotypes of ground orchid (Table 33) such as white, yellow, orange and pink. The tallest plant of 65.0cm recorded in the BARI Orchid-1 variety and shortest of 57.0cm in S-002 genotype. The production of maximum number of leave (10.0), spike number (4.0), floret number (15.0), sucker number (8.0) and flowering duration (28.0 days) were recorded in BARI Orchid-1. Early flowering also was observed in BARI Orchid-1 variety (95.0 days).

Table 33. Performance on vegetative, yield and quality traits of ground orchid varieties/ genotypes

Treatment (variety/ genotype)	Flower colour	Plant height (cm)	No. of leave/ plant	Stalk length (cm)	Days to flowering	No. of florets/ stick	No. of spike/ plant	Flowering duration (days)	No. of sucker/ plant
BARI Orchid -1	White	65.0a	10.0a	50.0a	95.0c	15.0a	4.0 a	28.0a	8.0a
S-001	Yellow	63.0ab	8.5ab	48.0ab	98.0bc	13.5ab	3.0 ab	25.0ab	7.0ab
S-002	Orange	57.0 b	6.0b	45.0b	106.0a	10.0b	3.0 ab	18.0c	4.0b
S-003	Pink	62.0ab	7.5ab	47.0ab	100.0b	13.0ab	2.0 b	23.0b	6.0ab
S-004	White	61.0ab	7.8ab	47.0ab	98.0bc	13.5ab	3.0 ab	24.0 ab	6.0 ab
CV (%)	**-**	**11.7**	**12.0**	**10.9**	**18.9**	**11.5**	**10.5**	**10.7**	**19.8**

Variation was observed in stem, spine and flower colour of five cactus varieties/genotypes which are presented in Table 34. In respect of stem colour, the observed variety and genotypes were categorized into three groups: Green, olive and dark green. The variety BARI Cactus-1 and genotype CaC-013 and Cac-029 produced green stem whereas CaC-027 and CaC-028 genotypes produced olive and dark green colour stem respectively. Maximum number of offshoot (9.0 and 6.0) and flower (10.0 and 7.0) were produced by BARI Cactus-1 followed by CaC-028. Maximum flowering duration (5.0 days) and early flower bud initiation (184 days) were also observed in BARI Cactus-1.

Table 34. Performance on vegetative, yield and quality traits of cactus varieties/ genotypes

Treatment (variety/ genotype)	Stem colour	No. of offshoot/ plant	Spine colour	Days to flower bud initiation	Flower colour	No. of flower	Durability of flower (days)
BARI Cactus-1	Green	9.0a	Creamy	184.0c	Yellow	10.0a	5.0a
Cac-013	Green	3.0b	Grey spines	192.0ab	Orange yellow	4.0b	2.5ab
Cac-027	Olive	4.0ab	Light grey spines	195.0a	Orange	5.0ab	2.0b
Cac-028	Dark green	6.0ab	Creamy spines	190.0b	Red	7.0ab	4.0ab
Cac-029	Green	5.0 ab	Creamy spines	193.0 ab	Orange	6.0 ab	3.0 ab
CV (%)	**-**	**11.5**	**-**	**12.0**	**-**	**8.9**	**10.1**

A performance trial of five succulent variety and genotypes has been conducted to find out the best variety/genotype for rooftop gardening. The performance of five variety/genotypes of succulent presented in Table 35 exhibited variation on different parameters. In respect of leaf and flower colour, the observed variety/genotypes showed remarkable variation such as olive green, bronzy green, coffee, light green and green leave colour as well as white and cream flower colour in BARI Cryptanthes-1 and other genotypes (S-021, S-022, S-023 S-024) respectively. Maximum number of offshoot (7.0), leave number (40.0), leaf area (8.5 cm^2), flower number (8.0) and flower durability (16.0 days) were observed in BARI Succulent-1. Early flower opening was also observed in BARI Succulent-1.

Table 35. Performance on vegetative and yield contributing characters of Succulent varieties/ genotypes

Treatment (variety/ genotype)	Leaf colour	No. of offshoot/ plant	No. of leaves/ plant	Leaf area (cm^2)	Leaf shape	Days to flower opening	Flower colour	No. of flower/ plant	Durability of flower (days)
BARI Succulent-1	Olive green	7.0a	40.0a	8.5a	Elongated	185.0c	White	8.0a	16.0a
S-021	Bronzy green	4.0ab	35.0b	6.0ab	Elongated	190.0b	Cream	4.0ab	12.0ab
S-022	Coffee	3.0b	30.0c	7.0ab	Elongated	192.0ab	Cream	3.0b	10.0b
S-023	Light green	4.0ab	32.0ab	5.0b	Elongated	195.0a	Cream	5.0ab	11.0ab
S-024	Green	5.0 ab	33.0 ab	6.5 ab	Elongated	193.0 ab	Cream	4.0 ab	12.0 ab
CV (%)	**-**	**10.5**	**8.9**	**9.9**	**-**	**12.0**	**-**	**10.8**	**11.5**

The performance of five variety/genotypes of marigold revealed significant difference for all characters on rooftop gardening study. The tallest plant was obtained by BARI Marigold-1 (67.0cm) and shortest (51.0cm) in M-005 (Table 36). This variation might be due to difference in genetic constituents among the variety and genotypes along with environmental effects. Highest number of leave (62.0) flower number (50.0) and maximum flower durability (60.0 days) were produced by BARI Marigold-1. Maximum flower size (10.5 cm) and early flower initiation was recorded in M-002 (80.0 days) and M-003 (81.0) genotypes.

Table 36. Performance on vegetative, yield and quality traits of Marigold varieties/genotypes

Treatment (variety/ genotype)	Flower colour	Plant height (cm)	No. of leave/ plant	Flower initiation (days)	No. of flower/ plant	Flower size (cm^2)	Flowering duration (days)
BARI Marigold-1	Orange	67.0 a	62.0 a	90.0 a	50.0 a	7.5 ab	57.0 ab
M-002	Yellow	58.0 b	56.0 ab	80.0 c	46.0 ab	10.5 a	60.0 a
M-003	Orange	55.0 bc	54.0 b	81.0 c	43.0 b	10.5 a	60.0 a
M-004	White	54.0 bc	51.0 bc	83.0 bc	40.0 bc	9.0 ab	54.0 ab
M-005	Bicolour	51.0 c	47.0 c	85.0 b	37.0 c	6.0 b	50.0 b
CV (%)	**-**	**8.9**	**10.4**	**11.0**	**11.8**	**9.5**	**10.8**

The vegetative and flower characteristics of lily variety/genotypes are presented in Table 37. The colour of flower was categorized into red, orange and white. The BARI Lily-1 variety had dark green leaf. Rest of the genotypes had green leaf. Maximum number of shoot (7.0), leave number (15.0), flower number (15.0) and flowering duration (8.0 days) were observed in BARI Lily-1.

Table 37. Performance on vegetative and flower characters of Lily varieties/genotypes

Treatment (variety/ genotype)	Leaf colour	No. of shoot/ plant	No. of leaves/ plant	Leaf area (cm^2)	Days to flowering	Flower colour	No. of flower/ plant	Flowering Duration (days)
BARI Lily-1	Dark green	7.0 a	15.0 a	12.0 a	70.0 c	Red	15.0 a	8.0 a
L-004	Green	5.0ab	12.0ab	10.5ab	76.0 b	Orange	10.0 ab	7.0 ab
L-005	Green	5.0ab	10.0 b	8.8 ab	72.0 bc	Red	8.0 b	5.0 ab
L-006	Green	3.0 b	8.0 bc	9.0 ab	78.0 ab	Red	12.0 ab	5.0 ab
L-007	Green	5.0ab	7.0 c	6.5 b	80.0 a	White	13.0 ab	4.0 b
CV (%)	**-**	**8.5**	**9.1**	**9.5**	**8.2**	**-**	**9.1**	**9.3**

Fig. 28. Experimental view on performance study of some selected flower crops for rooftop gardening

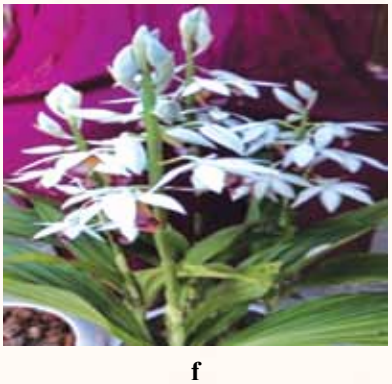
a

b

c

d

e



f

g

h

i

J

Fig. 29. Best performance of some selected flower crops for rooftop gardening (a-j)

a. Rose (R-003) b. Gerbera (BARI Gerbera-1) c. Chrysanthenmum (BARI Chrysanthenmum-3) d. Lilium (BARI Lilium-1) e. Anthurium (BARI Anthurium-1) f. Ground orchid (BARI Orchid-1) g. Cactus (BARI Cactus-1) h. Succulent (BARI Succulent-1), i. Marigold (BARI Marigold-1) j. Lily (BARI Lily-1)

Experiment 10: Effect of media on growth and yield of flower and ornamental plants on rooftop

The results of the experiment have been shown crop wise in Table 38-46 and Fig. 30-31. For dianthus, different characters showed statistically differences. Among the parameters studied, the plant height was varied ranged from 44.0 to 55.0 cm. The highest plant height (55.0cm) was measured from the treatment T_3 (Cocodust+ Vermicompost + Coarse sand) (2:2:1) while, the shortest (44.0cm) plant height was recorded from the treatment T_1 = Soil + FYM (1:1). Findings of studies conducted that Cocodust+ Vermicompost + Coarse sand (2:2:1) (T_3) gave maximum result in cases of number of shoot/plant (7.0), number of flowers/plant (25.0) and duration of flowering (35.0 days). The treatment T_3 also exhibited the maximum (20.0) number of leaves and early (55.0 days) flowering habit (Table 38).

Table 38. Yield and yield contributing characters of Dianthus in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	No. of shoot/ plant	Days to flowering	No. of flower/ plant	Flowering duration (days)
T_1	44.0c	14.0b	3.0b	57.0a	14.0b	24.0c
T_2	55.0a	16.0ab	5.0ab	48.0bc	18.0ab	30.0b
T_3	48.0bc	20.0a	7.0a	43.0c	20.0a	35.0a
T_4	46.0bc	17.0ab	4.0ab	49.0bc	17.0ab	32.0ab
T_5	50.0b	18.0ab	4.0ab	48.0bc	16.0ab	32.0ab
CV (%)	**5.9**	**8.0**	**7.5**	**8.5**	**7.9**	**8.3**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

In case of Poinsettia, there have been significant differences were observed in different parameters. The highest number of leaves (22.0), shoot number (7.0) and flower number /plant (25.0) was obtained from the treatment T_3-Cocodust+ Vermicompost + Coarse sand (2:2:1). The treatment T_3 also exhibited the maximum flower durability (34.0 days) (Table 39).

Table 39. Yield and yield contributing characters of Poinsettia in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	No. of shoot/ plant	Days to flowering	No. of flower/ plant	Flowering duration (days)
T_1	56.0c	15.0b	3.0b	49.0a	16.0c	22.0c
T_2	61.0b	18.0ab	5.0ab	50.0ab	20.0b	29.0b
T_3	67.0a	22.0a	7.0 a	47.0c	25.0a	34.0a
T_4	63.0ab	19.0ab	5.0ab	49.0bc	22.0ab	32.0ab
T_5	64.0ab	18.0ab	5.0ab	50.0ab	20.0b	29.0b
CV (%)	**7.9**	**8.4**	**7.4**	**6.4**	**6.9**	**8.0**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

Investigation on Cock's comb showed that the plant height varied ranged from 34.0 to 45.0 cm (Table 40). The highest plant height (45.0 cm) was measured from the treatment T_2 (Cocodust + Trichocompost + Coarse sand (2:2:1) while, the shortest (34.0 cm) plant height was recorded from

the treatment T_1 = Soil + FYM (1:1). The treatment T_2 (Cocodust + Trichocompost + Coarse sand (2:2:1) gave significantly the highest result in case of leave number (22.0), shoot number (7.0) and flower number (7.0). Early flowering (45.0 days) and maximum flowering duration (36.0 days) was also observed in the same treatment (T_2). More or less similar results were reported by Bose *et al*. (2015) in Cock's comb.

Table 40. Yield and yield contributing characters of Cock's comb in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ Plant	No. of shoot/ plant	Days to flowering	No. of flower/ plant	Flowering duration (days)
T_1	34.0c	10.0c	3.0b	55.0a	3.0b	22.0c
T_2	45.0a	22.0a	7.0a	45.0c	7.0a	36.0a
T_3	42.0ab	17.0ab	5.0ab	52.0ab	5.0ab	27.0bc
T_4	40.0b	14.0b	5.0ab	50.0b	5.0ab	30.0b
T_5	43.0ab	15.ab	5.0ab	48.0bc	5.0ab	26.0bc
CV (%)	**7.6**	**8.1**	**7.2**	**7.0**	**6.8**	**6.9**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

For Zinnia, different characters showed statistically differences. Among the parameters studied, the plant height varied ranged from 44.0 to 55.0cm. The highest plant height (55.0cm) was measured from the treatment T_4 (Cocodust + Perlite + Coarse sand (2:2:1) while, the shortest (44.0cm) plant height was recorded from the treatment T_1 = Soil + FYM (1:1) (Table 41). The treatment T_2 (Cocodust + Trichocompost + Coarse sand (2:2:1) gave the highest result in cases of number of leaves/plant (20.0), number of shoot/plant (7.0) and number of flowers/plant (25.0). Early flowering (43.0 days) and maximum durability of flowering (35.0 days) was also observed in the same treatment.

Table 41. Yield and yield contributing characters of Zinnia in different growth media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	No. of shoot/ plant	Days to flowering	No. of flower/ plant	Flowering duration (days)
T_1	44.0c	14.0b	3.0b	57.0a	19.0b	24.0c
T_2	48.0bc	20.0a	7.0a	43.0c	25.0a	35.0a
T_3	53.0ab	16.0ab	4.0ab	51.0b	23.0ab	32.0ab
T_4	55.0a	16.0ab	5.0ab	48.0bc	23.0ab	31.0b
T_5	50.0b	17.0ab	4.0ab	49.0bc	22.0ab	31.0b
CV (%)	**5.7**	**8.8**	**7.5**	**8.0**	**7.6**	**8.1**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

In case of Nephrolepsis fern, among the parameters studied, the plant height varied ranged from 14.0 to 25.0 cm (Table 42). The highest plant height (25.0cm) was measured from the treatment T_3-Cocodust+ Vermicompost + Coarse sand (2:2:1) while, the shortest (14.0cm) plant height was recorded from the treatment T_1 = Soil + FYM (1:1). However, the highest number of fronds (25.0), shoot number (9.0), plant spread (52.0 cm), cruziers number (4.8) and maximum vase life (15.0 days) was obtained from the same treatment T_3-Cocodust+ Vermicompost + Coarse sand (2:2:1).

Table 42. Yield and yield contributing characters of Nephrolepsis fern in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of fronds/ Plant	No. of shoot/ plant	Plant spread (cm)	No. of cruziers/ plant	Vase life (days)
T_1	14.0 c	39.0c	3.0b	44.5b	1.8b	10.0b
T_2	23.0ab	47.0ab	6.0ab	47.0ab	3.5 ab	13.0ab
T_3	25.0a	51.0a	9.0a	52.0a	4.8a	15.0a
T_4	20.0b	45.0b	5.0ab	46.2ab	3.4ab	12.0ab
T_5	22.0 ab	48.0ab	5.0ab	46.8.ab	3.3ab	12.0ab
CV (%)	**7.2**	**7.0**	**6.9**	**7.1**	**7.4**	**7.5**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

In case of Easter cactus, there have been significant differences were observed in different parameters. The highest number of leaves (13.0), number of shoot (10.0) and number of flower (10.0) was counted from the treatment T_4 (Cocodust + Perlite + Coarse sand) (2:2:1). Maximum flowering duration (30.0 days) was also observed in the same treatment (T_4) (Table 43).

Table 43. Yield and yield contributing characters of Easter cactus in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ Plant	No. of shoot/ plant	Days to flowering	No. of flower/ plant	Flowering duration (days)
T_1	5.0cb	4.0c	4.0b	68.0a	4.5b	18.0c
T_2	6.5ab	7.5ab	6.5 ab	66.0ab	6.3ab	26.0ab
T_3	6.8ab	8.5ab	7.0 ab	65.0ab	6.5ab	27.0ab
T_4	7.0a	13.0a	10.0a	56.0c	10.0a	30.0a
T_5	6.5ab	6.5ab	5.8ab	63.0ab	6.5ab	25.0b
CV (%)	**7.0**	**8.2**	**8.2**	**6.8**	**7.2**	**8.1**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

In case of Kalanchoe succulent, highest number of leaves (30.0), shoot (11.0) and flower (15.0) were counted in T_4 treatment (Cocodust + Perlite + Coarse sand) (2:2:1). Maxmimum flowering duration (30 days) was also observed in same treatment T_4 (Cocodust + Perlite + Coarse sand) (2:2:1).

Table 44. Yield and yield contributing characters of Kalanchoe succulents in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	No. of shoot/ plant	Days to flowering	No. of flower/ plant	Flowering duration (days)
T_1	30.0c	20.0c	6.0b	56.0a	9.0 b	45.0c
T_2	37.0ab	26.0 ab	7.0 ab	53.0ab	12.0 ab	52.0ab
T_3	38.0ab	27.0ab	8.0ab	50.0 b	13.0ab	53.0ab
T_4	40.0a	30.0a	11.0a	45.0c	15.0a	55.0a
T_5	35.0b	24.0b	7.0 ab	53.0ab	12.0ab	50.0 b
CV (%)	**7.0**	**6.8**	**6.9**	**7.4**	**7.2**	**7.1**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

The data presented in Table 45 revealed significant differences among the different growing media for all vegetative and floral chracteristics of Aster. The highest leave (36.0) production, branch number (11.0), flower number (19.0) and flowering duration (24.0 days) was observed in treatment T_3 (Cocodust+ Vermicompost + Coarse sand) (2:2:1).

Table 45. Yield and yield contributing characters of Aster in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	No. of branch/ plant	Days to flowering	No. of flower/ plant	Flowering duration (days)
T_1	24.0d	24.0d	5.0b	75.0a	9.0c	15.0c
T_2	27.0cd	28.0cd	7.0ab	73.0ab	12.0bc	17.0bc
T_3	40.0a	36.0a	11.0a	65.0c	19.0a	24.0a
T_4	35.5b	34.0b	9.0ab	70.0b	15.0b	19.0b
T_5	30.0c	30.0c	7.0 ab	72.0ab	13.0ab	21.0ab
CV (%)	**7.0**	**7.2**	**6.6**	**6.8**	**7.3**	**7.1**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

The results of Petunia in different growing media revealed that plant height varied ranged from 24.0 to 36.0cm. The highest height (36.0cm) was measured from the treatment T_3 (Cocodust+ Vermicompost + Coarse sand) (2:2:1) while, the shortest (24.0cm) plant height was recorded from the treatment T_1 = Soil + FYM (1:1). The treatment T_3 also showed early flowering within 48.0 days. The maximum number of flower per plant (20.0) and the highest flower durability (30.0) were also recorded from the same treatment T_3 (Table 46).

Table 46. Yield and yield contributing characters of Petunia in different growing media at rooftop gardening

Treatment	Plant height (cm)	No. of leaves/ plant	No. of branch/ plant	Days to flowering	No. of flower/ plant	Flowering duration (days)
T_1	24.0c	27.0c	9.0b	60.0a	10.0c	16.0 c
T_2	26.0bc	29.0bc	13.0ab	56.0ab	13.0bc	21.0 bc
T_3	36.0a	40.0a	15.0a	48.0c	20.0a	30.0 a
T_4	30.0b	34.0b	12.0ab	54.0b	18.0ab	24.0 b
T_5	27.0 bc	28.0 bc	13.0 ab	55.0 ab	15.0 b	20.0 bc
CV (%)	**7.0**	**7.5**	**6.8**	**6.9**	**7.2**	**7.0**

T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1)

There was no major diseases infection and insect infestation was observed during conducting the experiment.

Fig: 30. Expt. view on some flower & ornamental crops on rooftop using potting media

Zinnia (Cocodust + Trichocompost + Coarse and -2:2:1)

Dianthus (Cocodust + Vermicompost + Coarse sand -2:2:1)

Kalanchoe (Cocodust + Perlite + Coarse sand -2:2:1)

Aster (Cocodust + Vermicompost + Coarse sand -2:2:1)

Petunia (Cocodust + Vermicompost + Coarse sand -2:2:1)

Fig. 31. Flowering of some flower & ornamental crops on rooftop using best potting media (a-e)

Experiment 11(a): Adaptive trial of gladiolus varieties at farmers field

Farmers demonstrated BARI Gladiolus varieties for getting higher yield and economic return (Fig. 32).

Gazipur:

Yield and yield attributing characters differed significantly among the varieties (Table 47). Early flowering was observed in BARI Gladiolus-5 (74.0 days) followed by BARI Gladiolus-3 (77.0 days). The highest floret number (14.4) was observed in BARI Gladiolus-3 and BARI Gladiolus-5. Spike length (102.0 cm) and Rachis length (55.0 cm) was highest in BARI Gladiolus-3. However, maximum weight of flower (105.0 g) was recorded in BARI Gladiolus-5. Maximum yield/ha (188000) was observed in BARI Gladiolus-5 which differed significantly from other varieties. BARI Gladiolus-1 showed poor performances in all the parameters. Highest gross margin (Tk. 1300000/- and 1250000/-) and gross return (Tk. 1900000/- and 18500000/-) were recorded from BARI Gladiolus-5 (Table 48) followed by BARI Gladiolus-3 respectively.

Table 47. Yield and yield component of different gladiolus varieties at Gazipur

Variety	Days to 50% spike initiation	Floret no./ spike	Spike length (cm)	Rachis length (cm)	Flower stick wt. (g)	Yield (no/ ha) ('000)
BARI Gladiolus-3	77 bc	14.6 a	100.0 a	56.0 a	93.0 b	185 b
BARI Gladiolus-4	84 a	12.7 ab	90.0 c	48.0 bc	88.0 c	180 c
BARI Gladiolus-5	74 c	14.5 a	96.0 b	51.0 b	100.0 a	188 a
BARI Gladiolus-1 (Check)	80 b	10.2 b	85.0 d	45.0 c	80.0 d	176 d
CV (%)	**9.0**	**8.8**	**7.5**	**8.8**	**8.9**	**10.2**

* Significant at 5% level

Table 48. Economic performances of different gladiolus varieties at Gazipur

Variety	Yield (no/ha) ('000)	Gross return (Tk./ha)	Variable cost (Tk./ha)	Gross margin (Tk./ ha)	BCR (Tk./ Tk.)
BARI Gladiolus-3	185 b	1850000/-	600000/-	1250000/-	3.1
BARI Gladiolus-4	180 c	1800000/-	600000/-	1200000/-	3.0
BARI Gladiolus-5	188 a	1900000/-	600000/-	1300000/-	3.2
BARI Gladiolus-1 (Check)	175 d	1050000/-	450000/-	600000/-	2.3

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gladiolus corm= BDT 2/- pc^{-1}.

Outpur Price : BARI Gladiolus-1 (4 Tk./stick, 2 Tk./corm), BARI Gladiolus-3 (7 Tk./stick, 3 Tk./corm), BARI Gladiolus-4 (7 Tk./stick, 3 Tk./corm) and BARI Gladiolus-5 (7 Tk./stick, 3 Tk./corm)

Rajshahi:

The variety BARI Gladiolus-5 gave higher yield (190000/ha) compared to other varieties. Other yield contributing characters viz. floret number, spike length and rachis length were higher in BARI Gladiolus-3 (Table 49). Benefit cost ratio was maximum in BARI Gladiolus-3 (Table 50).

Table 49. Yield and yield component of different gladiolus varieties at Rajshahi

Variety	Days to 50% spike initiation	Floret no./ spike	Spike length (cm)	Rachis length (cm)	Flower stick wt. (g)	Yield (no/ ha) ('000)
BARI Gladiolus-3	75 bc	14.3 a	100.0 a	64.0 a	88.0 b	186 ab
BARI Gladiolus-4	83 a	12.5 ab	90.0 c	49.5 bc	79.0 c	185 b
BARI Gladiolus-5	73 c	14.4 a	95.0 b	58.0 b	102.0 a	190 a
BARI Gladiolus-1 (Check)	78 b	9.7 b	84.0 d	47.0 c	70.0 d	176 c
CV (%)	**8.7**	**6.9**	**7.2**	**7.4**	**6.8**	**10.3**

* Significant at 5% level

Table 50. Economic performances of different gladiolus varieties at Rajshahi

Variety	Yield (no/ ha) ('000)	Gross return (Tk./ha)	Variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./ Tk.)
BARI Gladiolus-3	186 ab	2418000/-	600000/-	1818000/-	4.1
BARI Gladiolus-4	185 b	2035000/-	600000/-	1435000/-	3.4
BARI Gladiolus-5	190 a	2090000/-	600000/-	1490000/-	3.5
BARI Gladiolus-1 (Check)	176 c	1232000/-	450000/-	782000/-	2.7

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gladiolus corm= BDT 2/- pc^{-1}.

Outpur Price : BARI Gladiolus-1 (4 Tk./stick, 2 Tk./corm), BARI Gladiolus-3 (7 Tk./stick, 3 Tk./corm), BARI Gladiolus-4 (7 Tk./stick, 3 Tk./corm) and BARI Gladiolus-5 (7 Tk./stick, 3 Tk./corm)

Bogura:

Yield and yield contributing characters are presented in Table 51. Flower yield was found more in BARI Gladiolus-5 followed by BARI Gladiolus-3. However cost and return analysis showed that BARI Gladiolus-3 gave the highest gross margin, which was economically profitable (Table 52).

Table 51. Yield and yield component of different gladiolus varieties at Bogura

Variety	Days to 50% spike initiation	Floret no./ spike	Spike length (cm)	Rachis length (cm)	Flower stick wt. (g)	Yield (no/ ha) ('000)
BARI Gladiolus-3	72 bc	14.3 a	102.0 a	58.5 a	88.8 b	188 ab
BARI Gladiolus-4	82 a	12.5 ab	92.0 c	46.5 bc	75.2 c	186 b
BARI Gladiolus-5	68 c	14.3 a	97.0 b	53.5 b	100.0 a	191 a
BARI Gladiolus-1 (Check)	76 b	10.0 b	88.0 d	45.0 c	69.3 d	177 c
CV (%)	**7.5**	**6.8**	**7.2**	**7.4**	**7.1**	**10.2**

* Significant at 5% level

Table 52. Economic performances of different gladiolus varieties at Bogura

Variety	Yield (no/ha) ('000)	Gross return (Tk./ha)	Variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./ Tk.)
BARI Gladiolus-3	188 ab	2068000/-	600000/-	1468000/-	3.5
BARI Gladiolus-4	186 b	1860000/-	600000/-	1260000/-	3.1
BARI Gladiolus-5	191 a	1910000/-	600000/-	1310000/-	3.2
BARI Gladiolus-1 (Check)	177 c	1239000/-	450000/-	7890000/-	2.8

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gladiolus corm= BDT 2/- pc^{-1}.

Outpur Price : BARI Gladiolus-1 (4 Tk./stick, 2 Tk./corm), BARI Gladiolus-3 (7 Tk./stick, 3 Tk./corm), BARI Gladiolus-4 (7 Tk./stick, 3 Tk./corm) and BARI Gladiolus-5 (7 Tk./stick, 3 Tk./corm)

Rangpur:

Yield and yield contributing characteristics of gladiolus are presented in Table 53. Significant variation was observed among all the characteristics studied. However the highest yield was observed in BARI Gladiolus-4. Gross return (Tk. 2700000/ha) and benefit cost ratio (4.5) were also maximum in BARI Gladiolus-4 (Table 54). BARI Gladiolus-1 gave the lowest gross return due to lower yield than other varieties.

Table 53. Yield and yield component of different gladiolus varieties at Rangpur

Variety	Days to 50% spike initiation	Floret no./ spike	Spike length (cm)	Rachis length (cm)	Flower stick wt. (g)	Yield (no/ ha) ('000)
BARI Gladiolus-3	67 bc	14.5 a	103.5 a	58.0 a	83.4 b	185 b
BARI Gladiolus-4	74 a	12.7 ab	94.5 bc	46.3 c	65.9 c	193 a
BARI Gladiolus-5	65 c	14.2 a	96.5 b	52.2 b	105.0 a	187 ab
BARI Gladiolus-1 (Check)	70 b	10.1 b	88.5 c	42.2 d	59.5 d	180 c
CV (%)	**8.5**	**6.9**	**7.8**	**7.9**	**7.4**	**10.2**

* Significant at 5% level

Table 54. Economic performances of different gladiolus varieties at Rangpur

Variety	Yield (no/ha) ('000)	Gross return (Tk./ha)	Variable cost (Tk./ha)	Gross margin (Tk./ ha)	BCR (Tk./ Tk.)
BARI Gladiolus-3	185 b	1850000/-	600000/-	1250000/-	3.1
BARI Gladiolus-4	193 a	2700000/-	600000/-	1490000/-	4.5
BARI Gladiolus-5	187 ab	1683000/-	600000/-	1830000/-	2.8
BARI Gladiolus-1 (Check)	180 c	1080000/-	450000/-	1630000/-	2.4

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gladiolus corm= BDT 2/- pc^{-1}.

Outpur Price : BARI Gladiolus-1 (4 Tk./stick, 2 Tk./corm), BARI Gladiolus-3 (7 Tk./stick, 3 Tk./corm), BARI Gladiolus-4 (7 Tk./stick, 3 Tk./corm) and BARI Gladiolus-5 (7 Tk./stick, 3 Tk./corm)

Khagrachari:

BARI Gladiolus-5 gave higher yield (190000/ha) compared to other varieties. Other yield contributing characters viz. floret number, spike length and rachis length were higher in BARI Gladiolus-3 (Table 55). Benefit cost ratio was maximum in BARI Gladiolus-3 (Table 56).

Table 55. Yield and yield component of different gladiolus varieties at Khagrachari

Variety	Days to 50% spike initiation	Floret no./ spike	Spike length (cm)	Rachis length (cm)	Flower stick wt. (g)	Yield (no/ ha) ('000)
BARI Gladiolus-3	72 bc	14.1 a	102.0 a	58.0 a	84.0 b	186 ab
BARI Gladiolus-4	80 a	12.5 ab	94.0 c	47.5 bc	69.0 c	185 b
BARI Gladiolus-5	68 c	14.0 a	99.0 b	52.0 b	102.0 a	190 a
BARI Gladiolus-1 (Check)	74 b	9.5 b	87.0 d	46.0 c	61.0 d	176 c
CV (%)	**8.7**	**6.9**	**7.2**	**7.4**	**6.8**	**10.3**

* Significant at 5% level

Table 56. Economic performances of different gladiolus varieties at Khagrachari

Variety	Yield (no/ha) ('000)	Gross return (Tk./ha)	Variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Gladiolus-3	186 ab	2418000/-	600000/-	1818000/-	4.1
BARI Gladiolus-4	185 b	2035000/-	600000/-	1435000/-	3.4
BARI Gladiolus-5	190 a	2090000/-	600000/-	1490000/-	3.5
BARI Gladiolus-1 (Check)	176 c	1232000/-	450000/-	782000/-	2.7

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gladiolus corm= BDT 2/- pc^{-1}.

Outpur Price : BARI Gladiolus-1 (4 Tk./stick, 2 Tk./corm), BARI Gladiolus-3 (7 Tk./stick, 3 Tk./corm), BARI Gladiolus-4 (7 Tk./stick, 3 Tk./corm) and BARI Gladiolus-5 (7 Tk./stick, 3 Tk./corm)

Jamalpur:

The result revealed that higher yield was found in BARI Gladiolus-4, followed by BARI Gladiolus-5 and BARI Gladiolus-3. However other yield contributing characters like floret number, spike length and rachis length were higher in BARI Gladiolus-3 (Table 57). Benefit cost ratio was also higher in BARI Gladiolus-4 (Table 58).

Table 57. Yield and yield component of different gladiolus varieties at Jamalpur

Variety	Days to 50% spike initiation	Floret no./ spike	Spike length (cm)	Rachis length (cm)	Flower stick wt. (g)	Yield (no/ ha) ('000)
BARI Gladiolus-3	67 b	14.5 a	102.0 a	58.9 a	89.0 b	187 ab
BARI Gladiolus-4	72 a	12.6 ab	89.0 c	46.6 c	76.0 c	192 a
BARI Gladiolus-5	66 b	14.5 a	94.0 b	52.5 b	105.2 a	188 ab
BARI Gladiolus-1 (Check)	71 ab	10.4 b	84.5 d	42.2 d	68.8 d	182 b
CV (%)	**8.7**	**6.8**	**7.2**	**7.5**	**6.7**	**9.7**

* Significant at 5% level

Table 58. Economic performances of different gladiolus varieties at Jamalpur

Variety	Yield (no/ha) ('000)	Gross return (Tk./ha)	Variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./ Tk.)
BARI Gladiolus-3	187 ab	1870000/-	600000/-	1270000/-	3.1
BARI Gladiolus-4	192 a	1920000/-	600000/-	1320000/-	3.2
BARI Gladiolus-5	188 ab	16920000/-	600000/-	1392000/-	2.9
BARI Gladiolus-1 (Check)	182 b	10920000/-	450000/-	642000/-	2.4

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gladiolus corm= BDT 2/- pc^{-1}.

Outpur Price : BARI Gladiolus-1 (4 Tk./stick, 2 Tk./corm), BARI Gladiolus-3 (7 Tk./stick, 3 Tk./corm), BARI Gladiolus-4 (7 Tk./stick, 3 Tk./corm) and BARI Gladiolus-5 (7 Tk./stick, 3 Tk./corm)

Farmer's Opinion

Gazipur : Farmers showed their keen interest to grow BARI Gladiolus-3 and BARI Gladiolus-5 due to their higher yield potentialities, shorter duration and economic profit.

Rajshahi : Considering different flower character like floret number, spike length as well as economic value, farmers preferred BARI Gladiolus-3.

Bogura : Farmers of this area are interested to cultivate BARI Gladiolus-3 and BARI Gladiolus-5 due to its higher yield potentiality, early flowering and economic profit.

Rangpur : Farmers were very positive to cultivate BARI Gladiolus-4 due to its attractive colour and economic profit.

Khagrachari : Considering different flower character like floret number, spike length as well as economic value, farmers preferred BARI Gladiolus-5.

Jamalpur : Farmers are interested and happy on cultivation of BARI Gladiolus-3 and BARI Gladiolus-4 due to it's higher yield potentiality and better market price over local variety. They preferred both the gladiolus varieties that there was no incidence of disease and insect in these varieties.

a. Gazipur **b. Rajshahi** **c. Bogura**

d. Rangpur **e. Khagrachari** **f. Jamalpur**

Fig. 32. Adaptive trial of Gladiolus varieties at different locations (a-f)

Experiment 11(b): Adaptive trial of tuberose varieties at farmer's field

Results and Discussion

Farmers are interested to cultivate the variety of BARI Tuberose-1 for getting higher yield over local variety at all locations (Table 59-64) (Fig. 33). They also preferred BARI Tuberose-1 because there was no incidence of pest and disease recorded in the field. On the other hand, benefit cost ratio was also higher in BARI Tuberose-1.

Table 59. Economic performances of different tuberose varieties at Gazipur

Variety	Yield (no./ha)		Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Tuberose -1	Flower Bulb	215000 490000	1947500	600000	1347500	3.24
PT-001	Flower Bulb	145000 270000	840000	500000	340000	1.68

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Tuberose bulb= BDT 1/- pc^{-1}.

Outpur Price : BARI Tuberose - 1 (4.5 Tk./stick, 2.0 Tk./bulb), PT-001 (3.0 Tk./stick, 1.5 Tk./bulb)

Table 60. Economic performances of different tuberose varieties at Bogura

Variety	Yield (no./ha)		Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Tuberose -1	Flower Bulb	220000 480000	1600000	500000	1100000	3.20
PT-001	Flower Bulb	150000 275000	937500	430000	507500	2.18

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Tuberose bulb= BDT 1/- pc^{-1}.

Outpur Price : BARI Tuberose - 1 (4.5 Tk./stick, 2.0 Tk./bulb), PT-001 (3.0 Tk./stick, 1.5 Tk./bulb)

Table 61. Economic performances of different tuberose varieties at Rangpur

Variety	Yield (no./ha)		Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Tuberose -1	Flower Bulb	225000 490000	1635000	500000	1135000	3.27
PT-001	Flower Bulb	155000 280000	962500	430000	532500	2.23

Source : Farmer's Field (2020-2021)

Input prices : Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Tuberose bulb= BDT 1/- pc^{-1}.

Outpur Price : BARI Tuberose - 1 (4.5 Tk./stick, 2.0 Tk./bulb), PT-001 (3.0 Tk./stick, 1.5 Tk./bulb)

Table 62. Economic performances of different tuberose varieties at Rajshahi

Variety	Yield (no./ha)		Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Tuberose-1	Flower Bulb	228000 490000	1647000	500000	1147000	3.29
PT-001	Flower Bulb	155000 270000	735000	430000	305000	1.70

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Tuberose bulb= BDT 1/- pc^{-1}.

Outpur Price : BARI Tuberose - 1 (4.5 Tk./stick, 2.0 Tk./bulb), PT-001 (3.0 Tk./stick, 1.5 Tk./bulb)

Table 63. Economic performances of different tuberose varieties at Khagrachari

Variety	Yield (no./ha)		Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Tuberose-1	Flower	230000	1515000	500000	1015000	3.03
	Bulb	550000				
PT-001	Flower	160000	750000	430000	320000	1.74
	Bulb	350000				

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Tuberose bulb= BDT 1/- pc^{-1}.

Outpur Price : BARI Tuberose - 1 (4.5 Tk./stick, 2.0 Tk./bulb), PT-001 (3.0 Tk./stick, 1.5 Tk./bulb)

Table 64. Economic performances of different tuberose varieties at Jamalpur

Variety	Yield (no./ha)		Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Tuberose -1	Flower	220000	1600000	500000	1100000	3.20
	Bulb	480000				
PT-001	Flower	150000	937500	430000	507500	2.18
	Bulb	275000				

Source : Farmer's Field (2020-2021)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Tuberose bulb= BDT 1/- pc^{-1}.

Outpur Price : BARI Tuberose - 1 (4.5 Tk./stick, 2.0 Tk./bulb), PT-001 (3.0 Tk./stick, 1.5 Tk./bulb)

a. Gazipur

b. Bogura

c. Rangpur

d. Rajshahi

e. Khagrachari

f. Jamalpur

Fig. 33. Adaptive trial of Tuberose variety (a-f) at different location

Experiment 11(c): Adaptive trial of gypsophila variety at farmers field

Farmers are very much interested to cultivate the new variety of BARI Gypsophila-1 for getting higher yield and better market price at all locations (Table 65-70) (Fig. 34). They also preferred BARI Gypsophila-1 because there was no incidence of pest and disease recorded in the field. On the other hand, benefit cost ratio both from cutflower and seed was also higher in BARI Gypsophila-1.

Table 65. Economic performance of gypsophila cut flower and seed at Gazipur

Variety	Yield (ha)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Gypsophila -1	Bunch no. 85010	222012	966687	883413	2.30
	Seed(kg) 1003	2607800	966687	1641113	2.70

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin= BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gypsophila seed= BDT 2600 kg^{-1}

Output price: Cut flower bunch = BDT 12 bunch^{-1}. Seed= BDT 2600 kg^{-1} Gross returns were calculated on the Gazipur price (Gazipur, Bangladesh) BCR: Benefit Cost Ratio

Table 66. Economic performance of gypsophila cut flower and seed at Bogura

Variety	Yield (ha)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Gypsophila -1	Bunch no. 85010	1850100	966687	883413	1.91 [1]
	Seed(kg) 1003	2607800	966687	1641113	2.70

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin= BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gypsophila seed= BDT 2600 kg^{-1}

Output price: Cut flower bunch = BDT 10 bunch^{-1}, Seed= BDT 2600 kg^{-1} Gross returns were calculated on the Sathmatha price (Sathmatha, Bogura) BCR: Benefit Cost Ratio

Table 67. Economic performance of gypsophila cut flower and seed at Rajshahi

Variety	Yield (ha)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Gypsophila -1	Bunch no. 85010	1850100	966687	883413	1.91
	Seed(kg) 1003	2507500	966687	1540813	2.60

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin= BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gypsophila seed= BDT 2500 kg^{-1}

Output price: Cut flower bunch = BDT 10 bunch^{-1}, seed= BDT 2500 kg^{-1} Gross returns were calculated on the Upushahor price (Upushahor, Rajshahi) BCR: Benefit Cost Ratio

Table 68. Economic performance of gypsophila cut flower and seed at Rangpur

Variety	Yield (ha)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Gypsophila -1	Bunch no. 85010	2035110	966687	883413	2.11
	Seed(kg) 1003	2607800	966687	1641113	2.70

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gypsophila seed= BDT 2600 kg^{-1}

Output price: Cut flower bunch = BDT 11 bunch^{-1}, seed= BDT 2600 kg^{-1} Gross returns were calculated on the Rangpur price (Rangpur, Bangladesh) BCR: Benefit Cost Ratio

Table 69. Economic performance of gypsophila cut flower and seed at Jamalpur

Variety	Yield (ha)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Gypsophila -1	Bunch no. 185010	2035110	966687	883413	2.11
	Seed (kg) 1003	2607800	966687	1641113	2.70

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gypsophila seed= BDT 2600 kg^{-1}

Output price: Cut flower bunch = BDT 11 $bunch^{-1}$, seed= BDT 2600 kg^{-1} Gross returns were calculated on the Jamalpur price (Jamalpur, Bangladesh) BCR: Benefit Cost Ratio

Table 70. Economic performance of gypsophila cut flower and seed at Khagrachari

Variety	Yield (ha)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Gypsophila -1	Bunch no. 185010	1850100	966687	883413	1.91
	Seed(kg) 1003	2507500	966687	1540813	2.60

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin= BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gypsophila seed= BDT 2500 kg^{-}

Output price: Cut flower bunch = BDT 10 $bunch^{-1}$, seed= BDT 2500 kg^{-1} Gross returns were calculated on the Khagrachari price (Khagrachari, Bangladesh) BCR: Benefit Cost Ratio

a. **Gazipur** **b. Bogura** c. **Rajshahi**

d. **Rangpur** **e. Jamalpur** f. **Khagrachari**

Fig. 34. Adaptive trial of Gypsophila variety at different locations (a-f)

Experiment 11(d): Adaptive trial of lilium variety at farmers field

Farmers are very much interested to cultivate the new variety of BARI lilium-1 and BARI Lilium-2 for getting higher yield and better market price at all locations (Table 71-82) (Fig. 35). They also preferred both BARI Lilium-1 and BARI Lilium-2 varieties because there was no incidence of pest and disease recorded in the field. On the other hand, benefit cost ratio was also higher in BARI Lilium-1 and BARI Lilium-2.

Table 71. Yield and yield component of Lilium varieties at Gazipur

Variety	Days to 50% spike initiation	Floret no./ stalk	Stalk length (cm)	Rachis length (cm)	Yield (no/ha) ('000)
BARI lilium-1	40	4.2	51.4	20.3	165
BARI lilium-2	33	2.3	44.2	20.0	160

Table 72. Economic performances of Lilium varieties at Gazipur

Variety	Yield (no/ha) ('000))	Gross return (Tk.)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI lilium-1	165	8250000	1500000	6750000	5.50
BARI lilium-2	160	6525000	1500000	5025000	4.35

Source : Farmer's Field (2020-2021)

Input prices: Cocodust= BDT 30 kg^{1}, Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Lilium bulb= BDT 40/- pc^{-1}, RCC Pillar= BDT 1800/-, Plastic shade net= BDT 150/sq.m.

Output Price : BARI lilium-1 (50 Tk./stick), BARI lilium-2 (45 Tk./stick)

Gazipur:

BARI lilium-1gave higher yield (165000/ha) compared to BARI lilium-2 (160000/ha) Other yield contributing characters viz. floret number, spike length and rachis length were also higher in BARI lilium-1 (Table 71-72).

Table 73. Yield and yield component of Lilium varieties at Bogura

Variety	Days to 50% spike initiation	Floret no./ stalk	Stalk length (cm)	Rachis length (cm)	Yield (no/ha) ('000)
BARI lilium-1	45	3.1	50.3	18.5	170
BARI lilium-2	36	2.4	47.7	15.8	160

Table 74. Economic performances of Lilium varieties at Bogura

Variety	Yield (no/ha) ('000)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI lilium-1	170	7650000	1500000	6150000	5.10
BARI lilium-2	160	6400000	1500000	4900000	4.30

Source : Farmer's Field (2020-2021)

Input prices: Cocodust= BDT 30 kg^{1}, Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Lilium bulb= BDT 40/- pc^{-1}, RCC Pillar= BDT 1800/-, Plastic shade net= BDT 150/sq.m.

Output Price: BARI lilium-1 (45 Tk./stick), BARI lilium-2 (40 Tk./stick)

Bogura:

BARI lilium-1 gave higher yield (170000/ha) compared to BARI lilium-2 (160000/ha). Other yield contributing characters viz. floret number, spike length and rachis length were also higher in BARI lilium-1 (Table 73-74).

Table 75. Yield and yield component of Lilium varieties at Jamalpur

Variety	Days to 50% spike initiation	Floret no./ stalk	Stalk length (cm)	Rachis length (cm)	Yield (no/ha) ('000)
BARI lilium-1	40	4	53.4	21.3	170
BARI lilium-2	39	2	48	20	160

Table 76. Economic performances of Lilium varieties at Jamalpur

Variety	Yield (no/ha) ('000)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI lilium-1	170	7650000	1500000	6150000	5.10
BARI lilium-2	160	6400000	1500000	4900000	4.30

Source : Farmer's Field (2020-2021)

Input prices: Cocodust= BDT 30 kg^{1}, Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Lilium bulb= BDT 40/- pc^{-1}., RCC Pillar= BDT 1800/-, Plastic shade net= BDT 150/sq.m

Output Price: BARI lilium-1 (45 Tk./stick), BARI lilium-2 (40 Tk./stick)

Jamalpur:

BARI lilium-1gave higher yield (170000/ha) compared to BARI lilium-2(160000/ha). Other yield contributing characters viz. floret number, spike length and rachis length were also higher in BARI lilium-1 (Table 75-76).

Table 77. Yield and yield component of Lilium varieties at Rangpur

Variety	Days to 50% spike initiation	Floret no./ stalk	Stalk length (cm)	Rachis length (cm)	Yield (no/ha) ('000)
BARI lilium-1	42	4.5	60.6	20.5	180
BARI lilium-2	33	2.5	50	21.4	170

Table 78. Economic performances of Lilium varieties at Rangpur

Variety	Yield (no/ha) ('000)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI lilium-1	180	7200000	1500000	5700000	4.80
BARI lilium-2	170	5950000	1500000	4450000	3.40

Source : Farmer's Field (2020-2021)

Input prices: Cocodust= BDT 30 kg^{1}, Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Lilium bulb= BDT 40/- pc^{-1}., RCC Pillar= BDT 1800/-, Plastic shade net= BDT 150/sq.m

Output Price : BARI lilium-1 (40 Tk./stick), BARI lilium-2 (35 Tk./stick)

Rangpur

BARI lilium-1gave higher yield (180000/ha) compared to BARI lilium-2. Other yield contributing characters viz. floret number, spike length and rachis length were also higher in BARI lilium-1 (Table 77-78).

Rajshahi:

Table 79. Yield and yield component of Lilium varieties at Rajshahi

Variety	Days to 50% spike initiation	Floret no./ stalk	Stalk length (cm)	Rachis length (cm)	Yield (no/ha) ('000)
BARI lilium-1	42	4.5	60.6	20.5	165
BARI lilium-2	33	2.5	50.0	21.4	155

Table 80. Economic performances of Lilium varieties at Rajshahi

Variety	Yield (no/ha) ('000)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI lilium-1	165	7425000	1500000	5925000	4.95
BARI lilium-2	155	6200000	1500000	4700000	4.13

Source : Farmer's Field (2020-2021)

Input prices: Cocodust= BDT 30 kg^{1}, Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Lilium bulb= BDT 40/- pc^{-1}., RCC Pillar= BDT 1800/-, Plastic shade net= BDT 150/sq.m

Output Price : BARI lilium-1 (45 Tk./stick), BARI lilium-2 (40 Tk./stick)

Rajshahi:

BARI lilium-1gave higher yield (165000/ha) compared to BARI lilium-2 (155000/ha). Other yield contributing characters viz. floret number, spike length and rachis length were also higher in BARI lilium-1 (Table 79-80).

Table 81. Yield and yield component of Lilium varieties at Khagrachari

Variety	Days to 50% spike initiation	Floret no./ stalk	Stalk length (cm)	Rachis length (cm)	Yield (no/ha) ('000)
BARI lilium-1	42	4.5	60.6	20.5	165
BARI lilium-2	33	2.5	50.0	21.4	160

Table 82. Economic performances of Lilium varieties at Khagrachari

Variety	Yield (no/ha) ('000)	Gross return	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI lilium-1	165	6600000	1500000	5100000	4.40
BARI lilium-2	160	5600000	1500000	4100000	3.80

Source : Farmer's Field (2020-2021)

Input prices: Cocodust= BDT 30 kg^{1}, Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Lilium bulb= BDT 40/- pc^{-1}., RCC Pillar= BDT 1800/-, Plastic shade net= BDT 150/sq.m

Output Price : BARI lilium-1 (40 Tk./stick), BARI lilium-2 (35 Tk. /stick)

Khagrachari

BARI lilium-1gave higher yield (165000/ha) compared to BARI lilium-2 (155000/ha). Other yield contributing characters viz. floret number, spike length and rachis length were also higher in BARI lilium-1 (Table 81-82).

Farmers Opinion

Farmers showed their keen interest to grow BARI lilium-1 and BARI lilium-2 due to their higher yield potentialities, shorter duration, no incidence of pest and disease recorded in the field as well as better market price at all locations.

a. Gazipur b. Bogura c. Jamalpur

d. Rangpur e. Rajshahi f. Khagrachari

Fig. 35. Adaptive trial of Lilium varieties at different locations (a-f)

Experiment 11(e): Adaptive trial of marigold varieties at farmer's field

Farmers are interested to cultivate the variety of BARI Marigold-1 for getting higher yield over local variety at all locations (Table 83-88) (Fig. 36). They also preferred BARI Marigold-1 because there was no incidence of pest and disease recorded in the field. On the other hand, benefit cost ratio was also higher in BARI Marigold-1.

Table 83. Economic performances of different marigold varieties at Gazipur

Variety	Yield (no./ha)		Gross return (Tk)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Marigold-1	Flower Seedling	4,50,000 200000	560000	180000	380000	3.1
TE-001	Flower Seedling	3,00000 150000	450000	180000	270000	2.5

Source : Farmer's Field (2021-2022)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Marigold seed= BDT 1000 kg^{-1}

Output Price : BARI Marigold- 1 (0.8 Tk./flower, 1.0 Tk./seedling), TE-001 (0.4 Tk./flower, 0.8Tk./ seedling)

Table 84. Economic performances of different marigold varieties at Bogura

Variety	Yield (no./ha)		Gross return (Tk)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Marigold-1	Flower	4,51,000	435500	180000	255500	2.4
	Seedling	210000				
TE-001	Flower	3,10000	283000	180000	103000	1.6
	Seedling	160000				

Source : Farmer's Field (2021-2022)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Marigold seed= BDT 1000 kg^{-1}

Output Price : BARI Marigold- 1 (0.8 Tk./flower, 1.0 Tk./seedling), TE-001 (0.4 Tk./flower, 0.8Tk./ seedling)

Table 85. Economic performances of different marigold varieties at Rangpur

Variety	Yield (no./ha)		Gross return (Tk)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Marigold-1	Flower	4,75,000	447500	180000	267500	2.4
	Seedling	210000				
TE-001	Flower	3,25000	302500	180000	122500	1.7
	Seedling	175000				

Source : Farmer's Field (2021-2022)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Marigold seed= BDT 1000 kg^{-1}

Output Price : BARI Marigold- 1 (0.8 Tk./flower, 1.0 Tk./seedling), TE-001 (0.4 Tk./flower, 0.8Tk./ seedling)

Table 86. Economic performances of different marigold varieties at Rajshahi

Variety	Yield (no./ha)		Gross return (Tk)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Marigold-1	Flower	4,65,000	489000	180000	255500	2.4
	Seedling	210000				
TE-001	Flower	3,25,000	290500	180000	110500	1.6
	Seedling	160000				

Source : Farmer's Field (2021-2022)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Marigold seed= BDT 1000 kg^{-1}

Output Price : BARI Marigold- 1 (0.8 Tk./flower, 1.0 Tk./seedling), TE-001 (0.4 Tk./flower, 0.8Tk./ seedling)

Table 87. Economic performances of different marigold varieties at Khagrachari

Variety	Yield (no./ha)		Gross return (Tk)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Marigold-1	Flower	4,00,000	202500	120000	82500	1.7
	Seedling	205000				
TE-001	Flower	3,00000	150000	120000	30000	1.3
	Seedling	150000				

Source : Farmer's Field (2021-2022)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 pass^{-1}, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Marigold seed= BDT 1000 kg^{-1}

Output Price : BARI Marigold- 1 (0.8 Tk./flower, 1.0 Tk./seedling), TE-001 (0.4 Tk./flower, 0.8Tk./ seedling)

Table 88. Economic performances of different marigold varieties at Jamalpur

Variety	Yield (no./ha)		Gross return (Tk)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR (Tk./Tk.)
BARI Marigold-1	Flower Seedling	4,60,000 210000	683000	180000	503000	3.8
TE-001	Flower Seedling	3,50000 160000	303000	180000	123000	1.6

Source : Farmer's Field (2021-2022)

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Autostin = BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Marigold seed= BDT 1000 kg^{-1}

Output Price : BARI Marigold- 1 (0.8 Tk./flower, 1.0 Tk./seedling), TE-001 (0.4 Tk./flower, 0.8Tk./ seedling)

a. Gazipur

b. Bogura

c. Rangpur

d. Rajshahi

e. Khagrachari

f. Jamalpur

Fig. 36. Adaptive trial of Marigold variety at different locations (a-f)

Component 2: Department of Horticulture, SAU, Dhaka

Experiment 12: Cultivation of different horticultural crops in different planting media in summer season

Four different crops cultivated in the different planting media with vertical PVC pipe structure where, the tallest plant was observed in the treatment N_2 and statistically similar results were recorded in N_3. While, the shortest plant was found in N_1 treatment (Fig. 37). Other crops like Red Amaranth, Mint and Thankuni showed the similar result in three different planting mediums. In N1 treatments, statistically significant differences on number of leaves were recorded while treated with the different planting media on the vertical structure of four crops. Among the crops, thankuni gave the maximum number of leaves (120). Besides, Indian spinach, red amaranth and mint showed statistically dissimilar number of leaves where mint gave the bushy appearance with maximum leaves. On the contrary, the lowest number of leaves were found in Red Amaranth (Table 89).

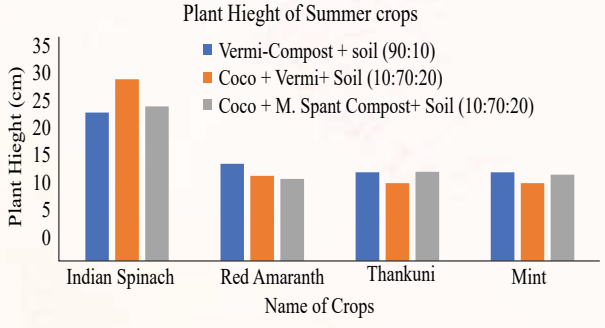


Fig. 37. Plant height (cm) of four vegetables as influenced by three growing media

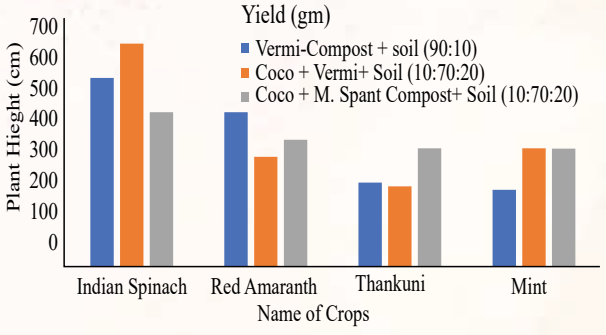


Fig. 38. Yield (g) of four summer vegetables as influenced by three growing media

In the case of number of branches, N_1 treatments showed significant variation on number of leaves by the planting media on the vertical structure of four crops. Among the crops, the highest branches occurred in thankuni may be because of their growth habit and creeper type of characters. The lowest number of leaves was found in red amaranth, may be this PVC structure may not be the perfect for growing red amaranth as they need to go beneath the soil in some extent.

Table 89. Effect of different growing media on the leaf and branch numbers of four summer vegetables

Branch numbers	Indian Spinach(C_1)	Red Amaranth (C_2)	Thankuni (C_3)	Mint (C_4)
N_1	4	1	10	4
N_2	6	1	6	8
N_3	4	1	7	9
Leaf numbers				
N_1	30	24	120	48
N_2	35	21	72	96
N_3	28	23	84	108

Here, N_1-VC + soil (90:10); N_2-Cocodust + VC +Soil (10:70:20); and N_3-Cocodust + MSC + Soil (10:70:20)

For total yield/pot, there is no significant difference among the treatments where the highest yield was found in N2 (Fig. 38). But no similar result was found in N1. On the other hand, the lowest yield was found in N3. The other three crops, red amaranth, Thankuni, Mint showed almost similar yield performance regarding the effect of different planting media (Fig. 39).

Fig. 39. Vertical Frame for summer crops production under rooftop cultivation package

Experiment 13: Performance of different winter horticultural crops in different planting materials

Square stair box gardening system in winter season

For plant height, tomato (75.807 cm), spinach (18.173 cm), Cabbage (29.077 cm), and Cauliflower (32.667 cm) were observed to give the longest plant in treatment T_3 (Coco-dust + MSC + Soil @ 10:70:20) in Table 90.

For yield/plant, tomato gave the maximum yield (2.0367 kg/p) in T_3 and minimum (1.853kg/p) in T_2; Spinach yielded most (1.2167 kg) in T_2 but the lowest (1.0133 kg) was found in treatment T_3. For cabbage, highest yield/plant (2.3967 kg) was recorded in growing media T_3. Cauliflower yielded maximum (2.1867 kg) in T_3 (Fig. 40).

Table 90. Effect of different growing media on growth and yield parameters of different winter crops in rooftop stair box gardening system

Treatments	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf breath (cm)	Fruit length (cm)	Yield per plant (kg)
T_1 C_1	69.33b	57.1b	7.700d	4.600cd	3.963c	1.8933a
T_2 C_1	64.27c	51.963c	7.303d	4.807cd	3.557c	1.8533ab
T_3 C_1	75.807a	63.00a	8.137cd	5.927bc	3.527c	2.0367a
T_1 C_2	15.553i	10.620h	9.197cd	2.977e	2.977c	1.1040c
T_2 C_2	13.697i	8.087i	8.137cd	3.423de	3.423c	1.2167bc
T_3 C_2	18.173h	12.930fg	10.470c	3.653de	3.653c	1.0133c
T_1 C_3	27.447fg	14.547ef	23.047a	7.06b	9.657b	1.1200c
T_2 C^3	25.630g	13.477efg	22.483a	6.293b	9.743b	1.0200c
T_3 C_3	29.077ef	16.567d	22.330ab	7.030b	11.000ab	2.3967a
T_1 C_4	30.14e	13.357efg	20.910ab	13.967a	10.913ab	1.1533c
T_2 C_4	27.917efg	12.320gh	20.910ab	13.540a	11.070ab	0.6900c
T_3 C_4	32.667d	15.197de	21.593ab	14.690a	11.333a	2.1867a

Here, T_1 - VC + soil @ (90:10) %; T_2 – Cocodust + VC + Soil @ (10:70:20) %; T_3-Coco+MSC+Soil @ (10:70:20) %; and C_1-Tomato, C_2-Spinach, C_3-Cabbage, C_4-Cauliflower

Growing media T_3 gave the highest yield for tomato, cabbage and cauliflower compare to other treatments except Spinach which, showed higher yield in the treatment T_2. But treatment T_2 gave lowest yield for tomato, cabbage and cauliflower. On the other hand, T_3 (Coco + M. Spant Compost + Soil (10:70:20)) showed higher results for plant height, number of leaves, leaf length and fruit

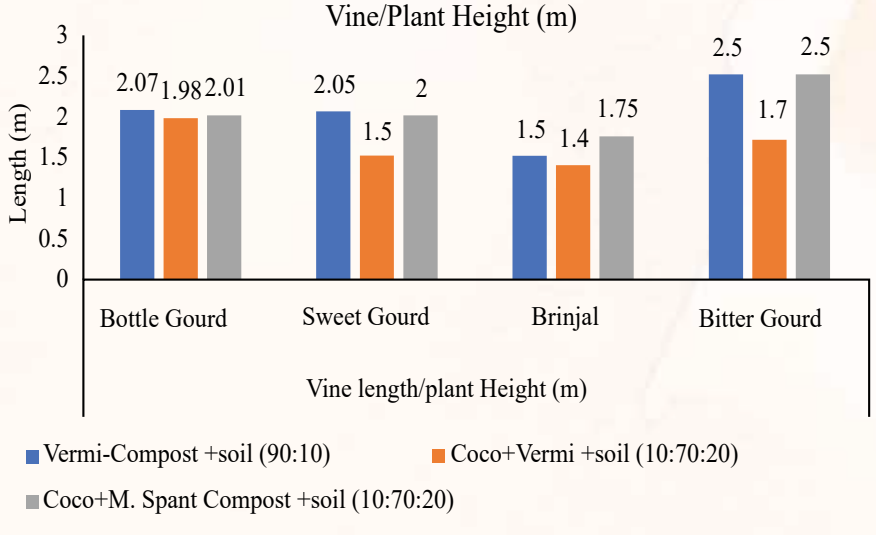
length for most of the crops. So, it could be suggested to use T_3 (Coco + M. Spant Compost + Soil (10:70:20) for the good yield of horticultural crops in roof-top.

Fig. 40. Stair box garden system showing the performance of winter vegetable crops

Experiment 14: Performance of different year-round horticultural crops in different growing media on vertical gardening model

Half-drum gardening system for year-round vegetable crops

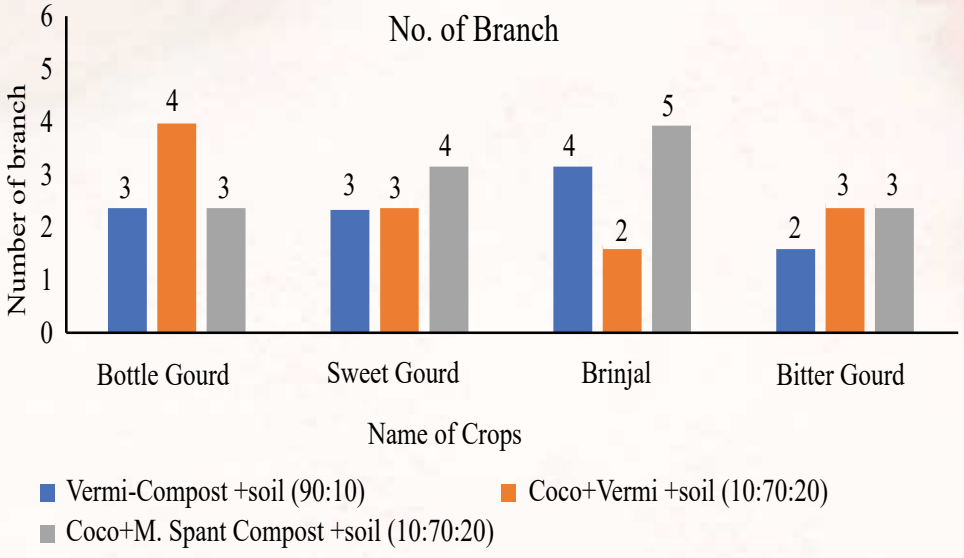
For vine length of climbing vegetable plant was not significantly influenced by the application of growing media for year-round cultivation in half drum (Fig. 41). The similar results were found in case of two different crops while the other two gave the minimum length in vine elongation in half-drum structure.



Here, N1-VC + soil (90:10); N2-Cocodust + VC +Soil (10:70:20); and N3-Cocodust + MSC + Soil (10:70:20)

Fig. 41. Effect of different growing media on vine length/plant height of different winter crops in rooftop half-drum gardening system

In the three different growing media, number of branches showed significant differences among the treatments. The bottle gourd exhibited the maximum branches per plant at T_2; sweet gourd and brinjal showed maximum branches in T_4. Bitter gourd showed similar and highest result both in T_2 and T_3 (Fig. 42).



Here, N1-VC + soil (90:10); N2-Cocodust + VC +Soil (10:70:20); and N3-Cocodust + MSC + Soil (10:70:20)

Fig. 42. Effect of different growing media on branches numbers of different winter crops in rooftop half-drum gardening system

In the experiment, treatments T_3 produced highest number of fruits for all the crops than the other treatment of planting media. Among the cucurbits, bitter gourd gave the maximum (50) fruits, and then sweet gourd (13) followed by bottle gourd (12). In case of brinjal, highest number of fruits (45) in half-drum on rooftop (Table 91).

Table 91. Effect of growing media on number of fruits per plant of year-round vegetable crops grown in half-drum gardening system in rooftop

Treatments	Bottle gourd	Sweet gourd	Brinjal	Bitter gourd
T_1	9	10	40	35
T_2	8	8	30	35
T_3	12	13	45	50

In the individual fruit weight, there were no significant variations among the treatments though the fruits were divided in cucurbits and other fruit vegetables like brinjal. In the case of total fruit yield, bottle gourd did not show any significant variations among the treatments (Table 92)

Table 92. Effect of growing media on the individual fruit weight of year-round vegetable crops grown in half-drum gardening system in rooftop

Treatments	Bottle gourd	Sweet gourd	Brinjal	Bitter gourd
T_1	0.9	0.345	0.1	0.05
T_2	0.8	0.235	0.07	0.045
T_3	0.85	0.3	0.045	0.56

For total yield per plant, all the cucurbits and the brinjal showed maximum yield in T_1. Here, maximum yield per plant for bottle gourd (8.5 kg); sweet gourd (3.5 kg); brinjal (4 kg) and bitter gourd (3.5 kg) were observed (Table 93).

Table 93. Effect of growing media on the total yield per plant contributing characters of year-round vegetable crops grown in half-drum gardening system in rooftop

Treatments	Bottle gourd	Sweet gourd	Brinjal	Bitter gourd
T_1	8.5	3.5	4	3.5
T_2	8.1	3	3.2	2.8
T_3	8	3.2	3	2.9

Here, T_1-VC+ soil (90:10)%, T_2- Cocodust + VC+Soil (10:70:20)%, T_3-Cocodust + MSC + Soil (10:70:20)%

Fig. 43. Year-round vegetable crop production in half-drum gardening system in rooftop

As being cultivated with growing media in half-drum structure, it was found that the physical growth of the four crops was increased compared to other cultivation techniques (Fig. 43). The drip irrigation was applied timely and increased plant height and yield.

A. Multiple horticultural crop garden-landscape in rooftop

Experiment 15: Establishment of rooftop garden landscape with vegetables and flowers

Considerable variations were observed for all the character of the vegetables. Seven different crops were cultivated in grow bag with organic potting mixed materials where, maximum plant height was found in Cucumber (201.96 cm) and the minimum plant height was found in Thankuni (31.105 cm). Maximum number of branches per plant were present in Thankuni (11.935) and lowest number of branches per plant were observed in Zinnia (4.6350). Maximum number of fruits per plant were observed in Coriander (44.132) and minimum number of fruits were found in both Petunia and Zinnia (0.00). Among the seven cultivating in grow bags with organic potting mix materials, it was observed that maximum yield was given by Tomato (1875.6 gm) and minimum yield was given by Zinnia (5.1100 gm) (Table 94).

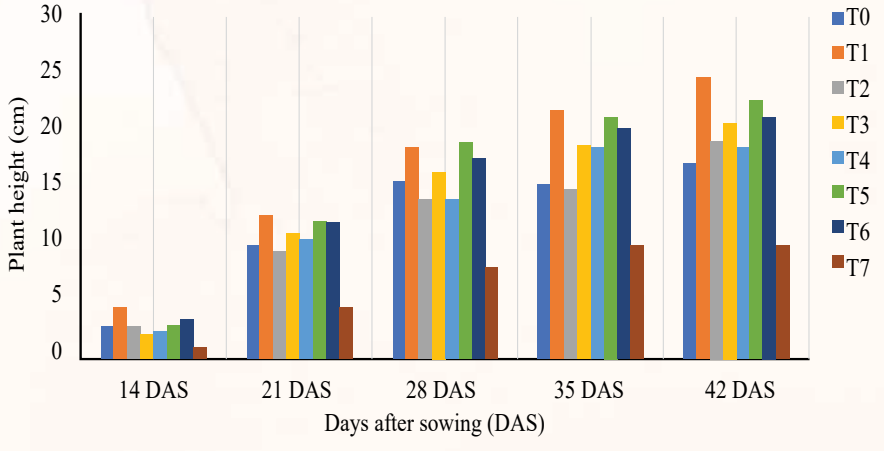
Table 94. Growth and yield variation of different crops in edible landscape

Crops	Plant height (cm)	Number of branches/ plant	Number of leaves/plant	Leaf length(cm)	Number of flowers/ plant	Number of fruits/plant	Yield/plant (g)
Coriander	65.273c	10.698b	23.588d	5.9117d	47.878c	44.132a	9.9667f
Thankuni	31.105f	11.935a	10.978e	12.708a	12.500e	9.8333c	252.44c
Tomatoes	71.845b	7.7133d	56.868b	7.0867c	52.860b	37.367b	1875.6a
Chili	59.902d	7.0950d	170.29a	7.0650c	51.512b	38.035b	172.41d
Cucumber	201.96a	9.3767c	31.547c	8.7600b	19.692d	9.3850c	911.33d
Petunia	43.157e	4.7350e	31.033c	2.8683e	66.080a	0.00d	66.080e
Zinnia	42.378e	4.6350e	29.872c	3.2180e	5.1100f	0.00d	5.1100f

B. Protected Indoor garden with hydroponic technology and open pot cultivation in rooftop.

Experiment 15(a): Effects of different growing media on the growth and yield of potted pakchoi in Rooftop

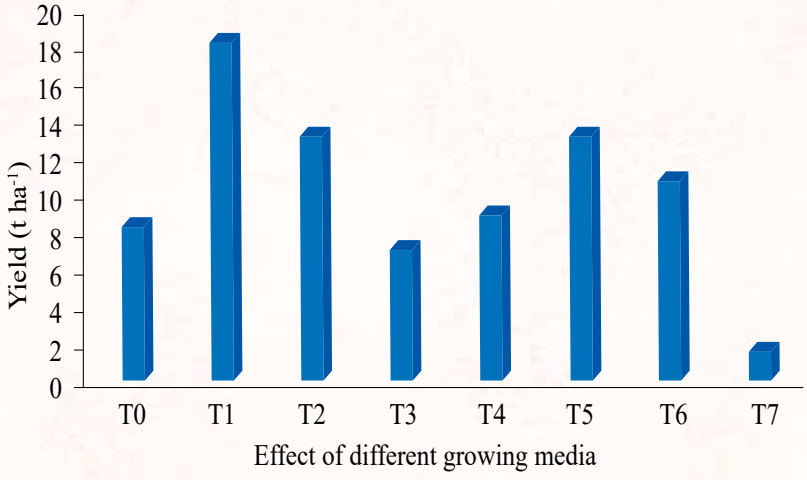
Plant height of Pakchoi was significantly influenced by different growing media at different days after sowing (DAS). At 14 DAS, the maximum plant height (4.50 cm) was recorded from T_1 (Vermicompost + Soil) treatment which was statistically identical to T_6 (3.50 cm) treatment and minimum plant height (1.00 cm) was observed from T_7 (Vermicompost + Biochar + Soil) treatment (Fig. 44). At 21 DAS, the tallest plant (12.51 cm) was recorded from T_1 (Vermicompost + Soil) treatment which was statistically identical with T_5, T_6, T_3, T_4 and T_0 (12.00, 11.90, 11.00, 10.50 and 10.00 cm) treatment. On the other hand, the lowest plant height (4.50 cm) was observed from T_7 (Vermicompost + Biochar + Soil) treatment. At 28 DAS, the tallest plant (18.90 cm) was recorded from T_5 (Vermicompost + Mushroom Spent Compost + Soil) treatment followed by T_1 (18.50 cm) treatment while the lowest plant height (8.00 cm) was observed from T_7 (Vermicompost + Biochar + Soil) treatment. At 35 DAS, the tallest plant (21.61 cm) was recorded from T_1 (Vermicompost + Soil) treatment followed by T_5 (21.04 cm) treatment while the lowest plant height (10.00 cm) was observed from T_7 (Vermicompost + Biochar + Soil) treatment. At 42 DAS, the tallest plant (24.50 cm) was recorded from T_1 (Vermicompost + Soil) treatment followed by T_5 (22.50 cm) treatment while the lowest plant height (10.00 cm) was observed from T_7 (Vermicompost + Biochar + Soil) treatment.



[T_0 = Control, T_1 = Vermicompost + Soil (90:10), T_2 = Cocodust + Vermicompost + Soil (20:70:10), T_3 = Mushroom Spent Compost + Soil (90:10), T_4 = Vermicompost + Cowdung + Soil (45:45:10), T_5 = Vermicompost + Mushroom Spent Compost + Soil (45:45:10), T_6 = Vermicompost + Mushroom Spent Compost + Cowdung + Soil (50:20:20:10) and T_7 = Vermicompost + Biochar + Soil (45:45:10)]

Fig. 44. Effect of different growing media on plant height of pakchoi at different days after sowing (DAS)

Growing media exhibited a significant influence on yield of Pakchoi. The maximum yield t ha^{-1} of Pakchoi (18.22 t ha^{-1}) was found from T_1 (Vermicompost + Soil) treatment which was statistically identical to that of T_2 and T_5 (13.18 and 13.16 t ha^{-1}) treatment while the minimum yield t ha^{-1} (1.67 t ha^{-1}) was recorded from T_7 (Vermicompost + Biochar + Soil) treatment (Fig. 45).



[T_0 = Control, T_1 = Vermicompost + Soil (90:10), T_2 = Cocodust + Vermicompost + Soil (20:70:10), T_3 = Mushroom Spent Compost + Soil (90:10), T_4 = Vermicompost + Cowdung + Soil (45:45:10), T_5 = Vermicompost + Mushroom Spent Compost + Soil (45:45:10), T_6 = Vermicompost + Mushroom Spent Compost + Cowdung + Soil (50:20:20:10) and T_7 = Vermicompost + Biochar + Soil (45:45:10)]

Fig. 45. Effect of different growing media on yield of Pakchoi

Quality parameters

Brix percentages (%)

Considering the brix content of Pakchoi significant variation was found in different growing media (Table 95). Maximum brix percentages (12.50%) were observed in T_7 which was statistically similar to T_0, T_3 and T_2 (12.00, 11.20 and 9.50 %) treatment whereas minimum (3.90%) in T_1.

Vitamin-C

Vitamin-C percentages of Pakchoi showed variation in different growing media (Table 95). Maximum Vitamin-C percentages (37.30%) were observed in T_1 which was statistically similar with others except T_2 treatment whereas minimum (36.00%) in T_2.

Moisture content

Considering the moisture content percentages of Pakchoi significant variation was found in different growing media (Table 95). Maximum moisture content percentages (92.42%) were observed in T_1 which was statistically similar with others except T_2 treatment whereas minimum (87.10%) in T_5.

Table 95. Effect of different growing media on brix value, vitamin-C content and moisture content of Pakchoi

Treatments	Brix value (%)	Vitamin-C (%)	Moisture content (%)
T_0	12.00 a	36.90	88.29 c
T_1	3.90 d	37.30	92.42 a
T_2	9.50 a	36.00	91.40 b

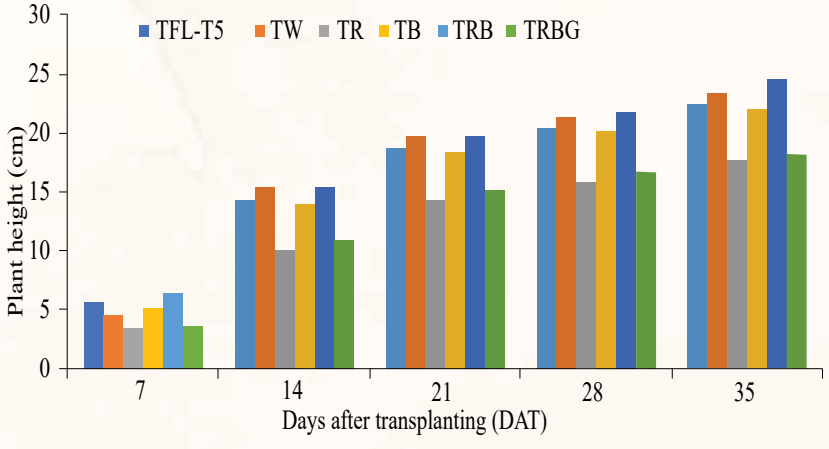
Treatments	Brix value (%)	Vitamin-C (%)	Moisture content (%)
T_3	11.20 a	37.10	87.64 cd
T_4	6.80 bc	36.40	90.89 b
T_5	5.40 cd	36.55	87.10 e
T_6	8.20 b	36.49	92.35 ab
T_7	12.50 a	36.99	87.70 cd

[T_0 = Control, T_1 = Vermicompost + Soil (90:10), T_2 = Cocodust + Vermicompost + Soil (20:70:10), T_3 = Mushroom Spent Compost + Soil (90:10), T_4 = Vermicompost + Cowdung + Soil (45:45:10), T_5 = Vermicompost + Mushroom Spent Compost + Soil (45:45:10), T_6 = Vermicompost + Mushroom Spent Compost + Cowdung + Soil (50:20:20:10) and T_7 = Vermicompost + Biochar + Soil (45:45:10)]

It was revealed that Vermicompost + soil was more potential in regarding yield contributing characters and yield of Pakchoi. The maximum yield of Pakchoi (18.22 t ha-1) was found from T_1 (Vermicompost + soil) treatment, while the minimum yield (1.67 t ha-1) was recorded from T_7 (Vermicompost + Biochar + Soil) treatment. Maximum brix content (12.50%) was observed in T_7 treatment whereas minimum (3.90%) was found in T_1 treatment. Maximum Vitamin-C content (37.30%) were observed in T_1 treatment whereas minimum (36.00%) was found in T_2 treatment. Maximum moisture content (92.42%) was observed in T_1 which was statistically similar with others except T_2 treatment whereas minimum (87.10%) was found in T_5 treatment. Therefore, it may be concluded that T1 treatment with Bari China shak-1(Pakchoi) variety can be commercially utilized for better yield in Bangladesh.

Experiment 15(b): Yield performance of pak-choi in hydroponic under rooftop and indoor conditions

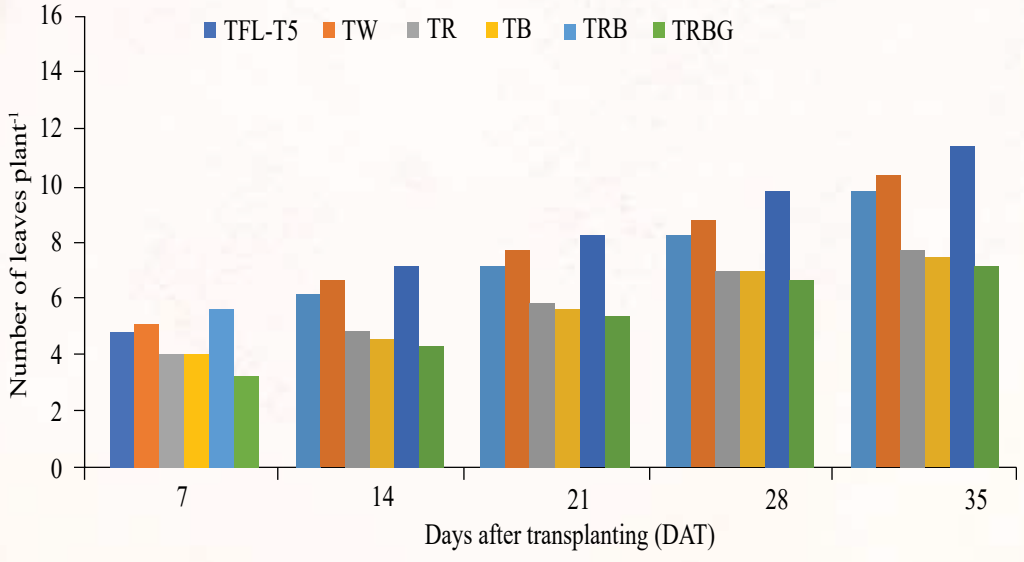
Significant variation was found for plant height of pakchoi at different growth stages as influenced by different LED-light spectral ratios (Fig. 46). Results exhibited that the highest plant height at 7, 14, 21, 28 and 35 DAT (6.43, 15.50, 19.85, 21.75 and 24.41 cm, respectively) was recorded from the treatment T_{RB} (Red and Blue - 4:1) whereas the lowest plant height (3.39, 10.07, 14.41, 15.81 and 17.68 cm, respectively) T_R (Red - Full) which was statistically identical with T_{RBG} (Red, Blue with Green - 4:1:1). The result obtained from the present study was similar with the findings of Bose *et al*. (2015) and they found that light supplementation can increase crop yield in greenhouses by promoting photosynthesis and plant growth and also obtained higher plant growth with red and blue LED light combination in pakchoi.



Here, T_{FL-T5} = Fluorescent light (control) - Full, T_W = White - Full, T_R = Red - Full, T_B = Blue - Full, T_{RB} = Red and Blue - 4:1, T_{RBG} = Red, Blue with Green - 4:1:1

Fig. 46. Plant height of pakchoi at different growth stages influenced by different LED-light spectral ratios in indoor grow-house

Number of leaves plant^{-1} of pakchoi at different growth stages varied significantly due to different LED-light spectral ratios (Fig. 47). It was observed that the highest number of leaves plant^{-1} (7.00, 9.00, 10.33, 12.33 and 14.33 at 7, 14, 21, 28 and 35 DAT, respectively) was found from the treatment T_{RB} (Red and Blue - 4:1) followed by T_W (White - Full) whereas the lowest number of leaves plant^{-1} (34.00, 5.33, 6.67, 8.33 and 9.00 at 7, 14, 21, 28 and 35 DAT, respectively) was found from the treatment T_R (Red - Full). Supported result was also observed by Chowdhury *et al*. (2021) and reported that two-leaf color pakchoi receiving alternating red and blue light exhibited more compact canopies than those under the control treatment.



Here, T_{FL-T5} = Fluorescent light (control) - Full, T_W = White - Full, T_R = Red - Full, T_B = Blue - Full, T_{RB} = Red and Blue - 4:1, T_{RBG} = Red, Blue with Green - 4:1:1

Fig. 47. Number of leaves plant^{-1} of pakchoi at different growth stages influenced by different LED-light spectral ratios

Statistically significant difference among the treatment was found on total yield of pakchoi in the experiment area per treatment as influenced by different LED-light spectral ratios (Table 96). Results exhibited that the highest total yield (1.29 kg) was found from the treatment T_{RB} (Red and Blue - 4:1) which was significantly similar with control treatment T_{FL-T5} (Fluorescent light - Full). Reversely, the lowest total yield (0.18 kg) was recorded from the treatment T_{RBG} (Red, Blue with Green - 4:1:1) which was significantly different from other treatments.

Table 96. Yield contributing parameters and yield of pakchoi at harvest influenced by different LED-light spectral ratios

Treatments	Stem diameter (cm)	Fresh weight plant^{-1} (g)	Total yield (kg)
T_{FL-T5}	0.97 abc	276.67 b	1.04 ab
T_W	1.10 ab	164.00 c	0.49 c
T_R	0.80 c	236.67 b	0.78 b
T_B	0.70 c	256.67 b	0.92 b
T_{RB}	1.20 a	336.67 a	1.29 a
T_{RBG}	0.83 bc	120.00 c	0.18 d

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, T_{FL-T5} - Fluorescent light (control) - Full, T_W -White - Full, T_R -Red - Full, T_B-Blue - Full, T_{RB}-Red and Blue - 4:1, T_{RBG}-Red, Blue with Green - 4:1:1

Quality parameters

For pakchoi, few quality parameters were investigated that are mentioned below-

SPAD value: SPAD value of pakchoi showed statistically significant variation as affected by different LED-light spectral ratios (Table 97). Results revealed that the highest SPAD value (42.04) was found from the treatment T_B (Blue - Full) which was significantly similar with T_{FL-T5} (Fluorescent light - Full), T_R (Red - Full), T_{RB} (Red and Blue - 4:1) and T_{RBG} (Red, Blue with Green - 4:1:1). BL influences photosynthetic activity by inducing stomatal opening and affecting chloroplast movement within the cell) in the short term while increasing stomata number and leaf thickness in the long term.

Vitamin-C, P, K and Zn content content (mg/100g): The highest vitamin-C content (41.81 mg/100g) was recorded from the treatment T_{RBG} (Red, Blue with Green - 4:1:1) which was statistically similar with controltreatment T_{FL-T5} (Fluorescent light - Full), T_W (White - Full) andT_{RB} (Red and Blue - 4:1) whereas the lowest vitamin-C content (38.24mg/100g) was found from the treatment T_R (Red - Full). The highest P content (35.52 mg/100g) was found from the treatment T_{RB} (Red and Blue - 4:1). The highest K content (241.81 mg/100g) was recorded from the treatment T_{RB} (Red and Blue - 4:1) which was significantly same with control treatment T_{FL-T5} (Fluorescent light - Full). The highest Zn content (0.38 mg/100g) was found from the treatment T_{RB} (Red and Blue - 4:1) whereas the lowest Zn content (0.067 mg/100g) was recorded from the treatment T_R (Red - Full) (Table 97). It is reported that manipulating the light conditions of artificial light sources is essential for growing plants in vertical farming to obtain electricity cost savings and balance the yield and quality of plants.

Table 97. Quality parameters of pakchoi at harvest influenced by different LED-light spectral ratios

Treatment	SPAD value	Vitamin-C content (mg/100g)	P content (mg/100g)	K content (mg/100g)	Zn content (mg/100g)
T_{FL-T5}	36.45 ab	40.67 ab	34.48 ab	240.38 a	0.120
T_W	34.60 b	40.43 ab	33.48 bc	234.86 b	0.110
T_R	38.82 ab	38.24 c	31.71 de	227.86 c	0.067
T_B	42.04 a	39.81 b	31.10 e	223.52 d	0.103
T_{RB}	41.30 ab	41.00 ab	35.52 a	241.81 a	0.380
T_{RBG}	38.68 ab	41.81 a	32.48 cd	230.57 c	0.133

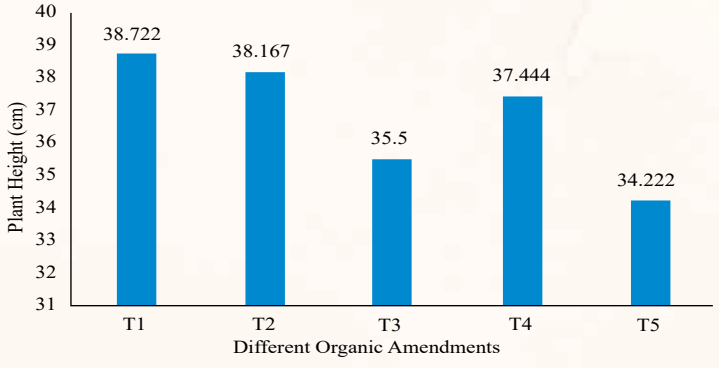
In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, T_{FL-T5} = Fluorescent light (control) - Full, T_W = White - Full, T_R = Red - Full, T_B = Blue - Full, T_{RB} = Red and Blue - 4:1, T_{RBG} = Red, Blue with Green - 4:1:1

From the above results, it can be concluded that among the treatments of different LED-light spectrum in vertical farming, the treatment T_{RB} (Red and Blue - 4:1) had best significant positive effect on growth, yield contributing parameters and yield and quality parameters of pakchoi and resulted highest fresh weight plant^{-1} (336.67 g) and total yield (1.29 kg) compared to all other treatments. So, the treatment T_{RB} (Red and Blue - 4:1) can be considered as the best treatment followed by control treatment T_{FL-T5} (Fluorescent light - Full) among all the treatments (Fig. 48).

Fig. 48. Yield performance of pak-choi in hydroponic under rooftop and indoor conditions

Experiment 16: Influence of organic amendments and bio-control agent on the production of gerbera

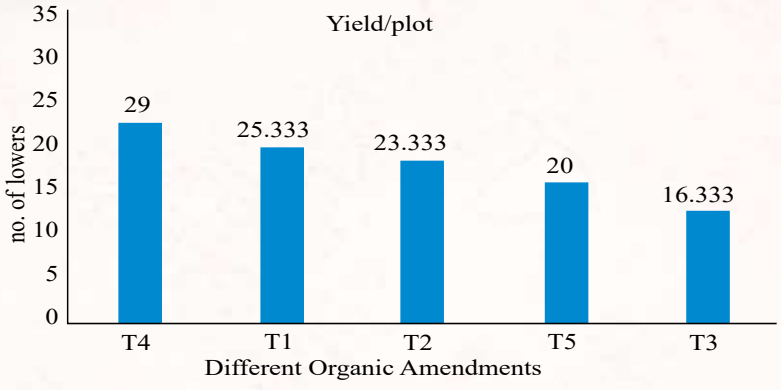
Longest gerbera plant (38.72cm) was found in the T_1 treatments with farmyard manure (3t ha^{-1} + 1/4rdf) (Fig. 49). For gerbera cultivation with different organic nutrients/ amendments or bio-agents where it was found that the highest plant height (38.722 cm) was in treatment T_1 (farmyard manure (3t/ha + 1/4rdf), T_2= vermicompost (3t/ha + ¼ rdf)) as in near similar results in T_2 and T_4. The lowest height (34.22 cm) in T_5 (treat as control) and similar with T_3. In control cultivation the influence of organic amendments on gerbera where is most suitable and its increase the productivity as well.



Here, T1= farmyard manure (3t/ha + 1/4rdf), T2= vermicompost (3t/ha + ¼ rdf); T3= tricho-compost (3t/ha + ¼ rdf), T4= tricho-leachate (3000l/ha + ¼ rdf); T5= control (recommended dose of fertilizer: cd-5t, n_{150}, p_{30}, k_{100} s_{20} b_1 zn_1 kg/ha)

Fig. 49. Plant height of gerbera influenced by different organic amendments and bio-control agent

For Total yield/plot, there is significant different among yields for the treatments. The highest yield was found in T_4= tricho-leachate (3000l/ha + ¼ rdf). But the lowest yield found in T_3= tricho-compost (3t/ha + ¼ rdf) (Fig 50).



Here, T_1= Farmyard manure (3 t ha^{-1} + 1/4rdf), T_2= Vermicompost (3 t ha^{-1} + ¼ rdf); T_3= Tricho-compost (3 t ha^{-1} + ¼ rdf), T_4= Tricho-leachate (3000l/ha + ¼ rdf) and T_5= Control (Recommended dose: CD-5t, N_{150}, P_{30}, K_{100} s_{20} B_1 Zn_1 kg/ha)

Fig. 50. Yield/plot of gerbera influenced by different organic amendments and bio-control agent

Fig. 51. Data collection in the shed house experimented with gerbera

As gerbera were cultivated with control shaded condition, it was found that the physiological growth and the flowers number were increased compared to other cultivation technique. The application of bio-control agents and organic amendments where gave the best flower size and showed maximum self-life of the gerbera to increase the total yield and as well as total growth rate of the gerbera. Trichoderma leachate was the best for higher yield of Gerbera compare to other treatments where we found that the T_2 and T_4 are similar result shown for leaves number. For plant height T_1 is best result compare to others but we seen that for flower production of T_1 T_2 and T_5 was similar results where we could suggest to use both of them for flower production.

Fig. 52. Shed House and Gerbera cultivation with bio amendments

Component 3: Pomology Division, HRC, BARI

Experiment 17: Survey on the present status of rooftop gardening in Gazipur sadar

A baseline survey was carried out (Table 98-102) among the rooftop gardeners to understand the present scenario through a prescribed questioner format. One hundred rooftop gardens of four different locations of Gazipur Sadar (North and the South Chayabithi, Shibbari and Police line) were surveyed and one hundred rooftop gardeners were interviewed. It was found that all of the respondents grown flower (100%), vegetable (100%) and fruit plants (100%) in their roof garden and among them about 88% also grow spices, medicinal other crops. Among the fruit crops, the most popular fruit grown by the rooftop gardener was Mango (89%) followed by lemon (83%), guava (75%), papaya (64%), dragon fruit (57%), golden apple (45%), Malta (30%) and so on. The least preferable fruit is litchi followed by Apple (9%), Orange (10%) and so on. Normally all the growers use soil as a growing media. In the case of container type most of the growers use plastic tub (49 %) followed by tyre/wood (21 %) and half tin drum (12.7 %) and most of them (51.9 %) use small container followed by large container (28.5 %). From the experience of survey and based on the emerging demand, Dragon fruit, Guava, Golden apple and strawberry were selected for the development of production package with some innovations under this sub-project.

Table 98. Distribution of the respondents based on the types of plants grown in roof garden of the study area

Categories	Respondent (N=100)	
	Number of rooftop garden containing the crop	Percent
Flower	100	100
Vegetable	100	100
Fruit	100	100
Others	88	88

Table 99. Distribution of the respondents based on the types of fruit plants grown in roof garden of the study area

Fruits name	Respondent (N=100)	
	Number of rooftop garden containing the crop	Percent
Mango	89	89
Lemon	83	83
Guava	75	75
Papaya	64	64
Dragon Fruit	57	57
Golden Apple	45	45
Sweet orange	30	30
Wax apple	28	28
Aonla	28	28
Banana	15	15
Sapota	15	15
Pomegranate	14	14
Carambula	13	13
Pummelo	13	13
Strawberry	11	11
Jamun	11	11
Mandarin	10	10
Apple	9	9
Litchi	4	4

Table 100. Distribution of the respondents according to the media used in roof garden preparation

Categories	Respondent (N=100)	
	Media used by the respondents	Percent
Soil	100	100
Soil + Coco dust	5	5
Others (Bio-char)	0	0

Table 101. Distribution of the respondents according to the types of pot used in roof garden

Categories	Total cite (rooftop garden) visited	Total Amount	Percentage
Plastic tub	100	2117	49.0
Soil tub	32	338	7.8
Tin half drum	45	545	12.7
Concrete structure	86	386	8.9
Others (Tire, wood tub etc.)	65	922	21.4

Table 102. Distribution of the respondents according to the size of the tub used in roof garden

Categories	Total cite (rooftop garden) visited	Total Amount	Percentage
Small	100	2122	51.9
Medium	87	797	19.5
Large	85	1162/4081	28.5

Experiment 18: Development of production package of some selected fruit crops for rooftop gardening

Dragon fruit

Experiment 18(a): Performance of different dragon fruit varieties on the roof

In respect of growth parameters the plant height and canopy spread were not significantly varied by treatments (Table 103). Though, the maximum brunches per pillar (61) was found in Pink rose variety followed by BARI Dragon fol-1 (39) but the highest number of fruits per pillar (48.33) was obtained from BARI Dragon fol-1. The variations in yield and quality parameters among the varieties have shown in Table 104. Individual fruit weight was not varied significantly by the treatments nevertheless; BARI Dragon fol-1 produced the haviest fruit (243.9 g). Maximum edible portion (82.99 %) was found in BARI Dragon fol-1 and minimum in Pink rose (65.93 %). The highest yield (11.83 Kg/pillar) was also harvested from BARI Dragon fol-1 followed by Pink rose (5.31 Kg/pillar). In every case the lowest result was found in BAU Dragon fruit-2.

Table 103. Growth performance of different Dragon fruit varieties on the roof

Treatments	Plant height (cm)	No. of brunches/ pillar	Canopy spread (cm)		No. of fruits/ pillar
			N-S	E-W	
T_1 (BARI Dragon fol-1)	306.63	39.33	146.7	193.4	48.33
T_2 (BAU Dragon fruit-2)	270.47	23.33	143.4	128.4	17.33
T_3 (Pink rose)	264.43	61.00	187.0	174.6	27.53
Level of Significance (5%)	NS	**	NS	NS	*
CV (%)	**13.54**	**11.58**	**19.49**	**16.05**	**32.63**

* Significant at 5% level ** Significant at 1% level NS: Non significant

Table 104. Performance of different Dragon fruit varieties regarding yield and quality on the roof

Treatments	Fruit size (cm)		Individual fruit weight. (g)	Edible portion (%)	TSS%	Yield/pillar (Kg)
	Length	Breadth				
T_1 (BARI Dragon fol-1)	8.60	6.81	243.9	82.99	17.50	11.83
T_2 (BAU Dragon fruit-2)	8.18	6.52	203.5	76.00	15.09	3.33
T_3 (Pink rose)	9.01	6.94	190.1	65.93	14.91	5.31
Level of Significance (5%)	NS	NS	NS	*	NS	*
CV (%)	**21.67**	**11.10**	**12.04**	**6.18**	**9.46**	**38.80**

* Significant at 5% level NS: Non significant

Considering all the growth and yield parameters BARI Dragonfol-1 performed better than other varieties (Fig. 53-54). Therefore, BARI Dragon fol-1 was the best variety for rooftop gardening.

Fig. 53. Rooftop experimental view of varietal performance of dragon fruit

Fig 54. Fruit characteristics of different dragon fruit varieties

Experiment 18(b): Effect of container type on the growth and yield of dragon fruit on the roof

In respect of all the growth parameters, plant height, number of brunches per pillar, canopy spread (N-S and E-W) and numbers of fruits per pillar were found higher in the treatment T_1 (Geobag) by 295.73 cm, 46.00, 211.50 cm, 214.10 cm and 45 respectively compared to treatment T_2 (Tin drum) (Table 105).

Table 105. Effect of container type on the growth characters of dragon fruit on the roof

Treatments	Plant height (cm)	No. of brunches/pillar	Canopy spread (cm)		No. of fruits/ pillar
			N-S	E-W	
T_1 (Geobag)	295.73	46.00	211.5	214.1	45
T_2 (Tin drum)	273.67	22.33	201.7	128.3	36

Yield and quality parameters have demonstrated in Table 106. In terms of fruit length and breadth, the bigger fruits were obtained from T_1 i.e. 9.78 cm and 9.40 cm, respectively. The havier fruit was obtained from T_1 (286.8 g) compared to T_2 (250.4 g). Considering edible portion (%), TSS (%) and yield per pillar (kg) T_1 (Geobag) performed the best which were 78.57%, 17.24% and 13.01 kg respectively. Lower yield (9.13 kg/pillar) was obtained from the treatment T_2 (Tin drum).

Table 106. Effect of container type on the yield and quality of dragon fruit on the roof

Treatments	Fruit size (cm)		Individual fruit weight. (g)	Edible portion (%)	TSS%	Yield/pillar (Kg)
	Length	Breadth				
T_1 (Geobag)	9.78	9.40	286.8	78.57	17.24	13.01
T_2 (Tin drum)	8.27	7.12	250.4	71.19	14.87	9.13

Considering all the growth and yield parameters geobag performed better than other types of container (Fig. 55). Therefore, geobag would be the best type of container for Dragon fruit production on the roof.

Fig. 55. Yield and quality of dragon fruit using different container type on the roof

Experiment 18(c). Effect of different sizes of container on the growth and yield of dragon fruit on the roof

In case of different container sizes, statistical variation was identified in respect of all the parameters (Table 107). In case of plant height, number of brunches/pillar, canopy spread N-S and E-W, the highest result (264.73 cm, 45.00 per pillar, 172.2 cm and 195.4 cm, respectively) was observed from T_1 (Large container) treatment, followed by T_2 (Medium container). However, in every case the lowest result was obtained from T_3 (small container) treatment. The highest number of fruits/pillar was obtained from T_1 (15.67 fruits per pillar) and the lowest was in T_3 i.e. 5.33 fruits per pillar**.**

No significant variations were observed in case of fruit size, individual fruit weight, edible portion (%) and TSS (%) (Table 108). In terms of fruit length and breadth, the biggest fruits were obtained from T_1 i.e. 8.70 cm and 6.81 cm, respectively, followed by T_2.

Table 107. Effect of different container sizes on the growth characteristics of dragon fruit on the roof

Treatments	Plant height (cm)	No. of brunches/pillar	Canopy spread (cm)		No. of fruits/pillar
			N-S	E-W	
T_1	264.73	45.00	172.2	195.4	15.67
T_2	244.90	25.33	160.3	175.6	7.33
T_3	218.67	14.33	149.5	124.0	5.33
Level of Sig. (5%)	**	**	*	**	**
CV (%)	**3.86**	**17.10**	**4.38**	**7.95**	**11.16**

* Significant at 5% level ** Significant at 1% level T_1 = Large container (30 L); T_2 = Medium container (20 L); T_3 = Small container (10 L)

The highest fruit weight was obtained from T_1 (314 g) and the lowest fruit weight was observed in T_2 (240g). Considering edible portion (%), TSS (%) and yield per pillar (kg) T_1 (100 % Coco dust) performed the best which were 84.00 %, 15.79 % and 3.81 kg respectively. The lowest yield was obtained from the T_3 i.e. 1.67 kg fruits per pillar.

Table 108. Effect of different container sizes on the yield and quality of dragon fruit on the roof

Treatments	Fruit size (cm)		Individual fruit weight. (g)	Edible portion (%)	TSS%	Yield/pillar (Kg)
	Length	Breadth				
T_1	8.70	6.81	314	84.00	15.79	3.81
T_2	8.34	6.09	240	80.67	15.06	1.82
T_3	8.22	6.16	244	80.33	14.80	1.67
Level of Significance (5%)	NS	NS	**	NS	NS	**
CV (%)	**8.25**	**10.29**	**3.80**	**2.91**	**7.02**	**7.45**

** Significant at 1% level NS: Non significant

T_1 = Large container (30 L); T_2 = Medium container (20 L); T_3 = Small container (10 L)

In final, it was clear that large sized container performed better than other sizes of container considering all the growth and yield parameters for Dragon fruit production. Therefore, large sized container would be the best option for Dragon fruit production on the roof.

Experiment 18(d): Combined effect of different growing methods on the growth, yield and load management for dragon fruit production on the roof

Highly significant differences were observed in case of plant height, number of brunches/pillar and number of fruits per pillar (Table 109).

Table 109. Effect of different methods of production on the growth characteristics of dragon fruit on the roof

Treatments	Plant height (cm)	No. of branches/ pillar	Canopy spread (cm)		No. of fruits/pillar
			N-S	E-W	
T_1 (GI pipe+geobag+soilless media)	295.73	46.00	211.5	214.1	45
T_2 (RCC+Tin drum+soil)	262.33	23.00	146.7	193.4	18
T_3 (Tin drum+soil)	116.67	17.67	168.3	177.3	10
Level of Significance (5%)	**	**	*	NS	**
CV (%)	**7.69**	**9.65**	**12.89**	**24.70**	**13.22**

** Significant at 1% level * Significant at 5% level NS: Non significant

The highest results were manifested from the T_1 (GI pipe+geobag+soilless) in terms of all the parameters such as plant height (295.73 cm), number of branches per pillar (46.00), canopy spread both N-S and E-W (211.5 and 214.1 cm respectively), number of fruits per pillar (45). The T_1 (GI pipe+geobag+soilless) was followed by T_2 (RCC+Tin drum+soil). The lowest plant height (116.67 cm), number of branches per pillar (17.67), canopy spread E-W (177.3 cm) and number of fruits per pillar 10 were obtained from T_3 (Tin drum+soil).

In terms of fruit sizes, individual fruit weight, TSS (%) and yield kg/plant significant differences were noticed, but no significant difference was observed in case of edible portion (Table 110). The highest fruit length, breadth, individual fruit weight, edible portion (%), TSS (%) and yield kg/plant were obtained from T_1 (GI pipe+geobag+soilless) i.e. 9.78 cm, 9.40 cm, 286.8 g, 78.57, 17.24% and 13.01 kg, respectively, followed by T_2 (RCC+Tin drum+soil). The lowest fruit length (6.77

cm), breadth (6.77 cm), individual fruit weight (1.88 g), edible portion (75.97%), TSS (15.58%) and yield 1.85 kg/plant were obtained from T_3 (Tin drum+soil).

Table 110. Effect of different methods of production on the yield and quality of dragon fruit on the roof

Treatments	Fruit size (cm)		Individual fruit weight. (g)	Edible portion (%)	TSS%	Yield/pillar (Kg)
	Length	Breadth				
T_1 (GI pipe+Geobag+soilless media)	9.78	9.40	286.8	78.57	17.24	13.01
T_2 (RCC+Tin drum+soil)	8.61	6.71	243.9	76.19	15.79	4.39
T_3 (Tin drum+soil)	6.77	6.77	188.9	75.97	15.58	1.85
Level of Significance (5%)	**	*	**	**NS**	*	**
CV (%)	**5.04**	**12.42**	**5.04**	**1.76**	**3.11**	**17.84**

** Significant at 1% level * Significant at 5% level NS: Non significant

The effect of different methods of dragon fruit production on the weight management for rooftop protection has been demonstrated in Table 111. The remarkably lowest weight (only 700 gm) of container is Geobag where the weight of tin drum was 9.35 kg. In case of growing media, the lowest weight (23 kg) was found in treatment T_1, where cocodust was used as a media and which approaximately 63 kg less weighted than T_2 and T_3, where soil was used as a media. Though, there was no structure in treatment T_3 but the weight of GI pipe based structure in treatment T_1 was 5.94 kg lees weighted than T_2. Overall, it was observed that the treatment T_1 contributed 68.92% and 63.31% less weight to the roof comparing T_2 and T_3 respectively.

Table 111. Weight (load) analysis of different methods of dragon fruit production on the roof

Treatments	Container/Geobag weight (Kg)	Media weight (Kg)	Structure weight (kg)	Total weight (Kg)	Percent weight reduced
T_1	0.70	23	11.28	34.98	-
T_2	9.35	86	17.22	112.57	68.92
T_3	9.35	86	-	95.35	63.31

Here, T_1 = GI pipe+geobag+soilless media, T_2 = RCC+Tin drum+soil and T_3 = Tin drum+soil

Economic analysis has been shown in Table 112. This economic analysis has been done for 36 m^2 rooftop area with 9 pillars (18 plants). According to the Table 10, the cost of Dragon fruit production on the roof was found more in treatment T_1 (12,675 Tk.) than other methods but the highest net return and BCR were obtained from treatment T_1 by 26,355 Tk and 3.08 respectively which was approaximately 997% and 152% higher than treatment T_2.

Table 112. Economic analysis of different methods of dragon fruit production on the roof

Treatments	Total cost (Tk.)	Total return (Tk.)	Net return (Tk.)	BCR
T_1	12,675	39,030	26,355	3.08
T_2	10,767	13,170	2,403	1.22
T_3	9,807	5,550	-4,257	-

T_1 = GI pipe+Geobag+soilless media, T_2 = RCC+Tin drum+soil and T_3 = Tin drum+soil

Here,

1. The cost of pillar and modern structure have been divided into 15 years
2. The cost of Geobag and tin drum have been divided into 10 and 5 years respectively
3. Market price of Dragon fruit is 250 tk/kg

In final, considering all the growth and yield parameters the treatment T_1 (GI pipe+geobag+soilless media) performed the best for Dragon fruit production on the roof. In case of weight management and also economically the treatment T_1 (GI pipe+geobag+soilless media) was the best option.

Considering all the growth and yield parameters BARI Dragonfol-1 performed better than BAU Dragon fruit-2. However, further study is needed for the confirmation.

Fig. 56. Different methods of production on the yield and quality of dragon fruit on the roof

Golden Apple

Experiment 18 (e). Performance trial of different golden apple varieties on the roof

A performance trial with BARI Amra-1 and BARI Amra-2 has been conducted to find out the best golden apple variety for rooftop gardening (Table 113) (Fig. 57). No significant difference was observed in case of number of leaves per plant between the two varieties. The higher plant height (197 cm), stem diameter (18.7 cm) and canopy spread from the North to the South (165.3 cm) was found in BARI Amra-2. But, BARI Amra-1 produced flowers approximately 371 days earlier than BARI Amra-2 and the higher no of fruits/plant (158) was also obtained from BARI Amra-1.

Table 113. Performance on growth characteristics of different golden apple varieties

Variety	Plant height (cm)	Stem Diameter (cm)	Number of leaves/ plant	Number of branches/ plant	Canopy spread (cm)		Days To 1st Flowering	No. of fruits/ plant
					N-S	E-W		
BARI Amra-1	135	15.3	273	26	151.6	185.0	54	158
BARI Amra-2	197	18.7	272	16	165.3	147.6	425	22

According to the Table 114, individual fruit weight, fruit length and fruit breadth were observed higher in BARI Amra-2 by 66 g, 5.00 cm and 4.26 cm respectively. However, the higher edible portion, yield and also TSS were obtained from BARI Amra-1 by 74%, 6.64 kg/plant and 9.5% respectively.

Table 114. Performance of golden apple varieties on the yield and yield contributing characters

Variety	Individual fruit weight (g)	Fruit size (cm)		Edible portion (%)	Yield kg/ plant	TSS (%)
		Length	Breadth			
BARI Amra-1	42	4.52	3.74	74	6.64	9.5
BARI Amra-2	66	5.00	4.26	63	1.45	5.0

Considering growth, yield and quality it can be concluded that for rooftop gardening the variety BARI Amra-1 performed better than the variety BARI Amra-2.

BARI Amra-1 BARI Amra-2

Fig. 57. Growth, yield and fruit characteristics of different golden apple varieties

Guava

Experiment 18(f): Performance trial of different guava varieties on the roof

The results revealed that there was no statistical variation among the varieties in terms of all growth parameters, except plant height (Table 115). However, higher plant height and base girth was found in V_2 (164.00cm and 13.63 cm, respectively) and lower was observed in V_1 (113.33cm and 9.90 cm, respectively). Canopy spread in terms of N-S was found higher in V_2 (1.58 m) and lower in V_1 (1.37 m), but E-W canopy spread was recorded higher in V_1 and lower in V_2. In case of number of brunches/pillar V_2 exhibited higher number of brunches (32.33) per pillar and lower was observed in V_1 (24.67). The maximum number of fruits per pillar was found in V_1 (35.67) and the minimum was observed in V_2 (12.33).

Table 115. Growth performances of different guava varieties on the roof

Variety	Plant height (cm)	Base girth (cm)	Canopy Spread (m)		No. of branches/ plant	No. of fruits/ plant
			N-S	E-W		
V_1 (BARI Peyara-2)	113.33b	9.90	1.37	1.44	24.67	35.67
V_2(BARI Peyara-4)	164.00a	13.63	1.58	1.34	32.33	12.33
Level of sig.	*	NS	NS	NS	NS	NS
CV (%)	**8.16**	**18.03**	**20.20**	**26.19**	**12.49**	**55.46**

* Significant at 5% level NS: Non significant

The effect of guava variety on yield and yield contributing characters has been stated in Table 116. In terms of individual fruit length and weight, the biggest sized fruit (Length-7.89 cm and weight 149.03 g) was obtained from V_2 (BARI Peyara-4) but higher fruit breadth was observed in V_1 (BARI Peyara-2)(6.05 cm)(Table 116). V_1 (BARI Peyara-2) had higher (4.29 kg/ plant) yield than V_2 (BARI Peyara-4) i.e. 2.86 kg/plant (Fig. 58).

Table 116. Yield performances of different guava varieties on the roof

Variety	Fruit size (cm)		Individual fruit weight. (g)	Yield/plant (Kg)
	Length	Breadth		
V_1 (BARI Peyara-2)	5.69	6.05	100.44	4.29
V_2(BARI Peyara-4)	7.89	5.53	149.03	2.86
CV (%)	**10.02**	**5.25**	**22.67**	**35.59**

Fig. 58. Growth, yield and fruit characteristics of different guava varieties

Experiment 18(g): Performance of variety on growth characteristics of guava

There was no significant variation among the treatments in terms of plant height (cm), basegirth (cm), canopy spread (m), no. of branches/plant, no. of fruits/plant (Table 117). The highest results were manifested from the T_2 (Plastic drum) in case of plant height and base girth i.e. 140.33 cm and 10.40 cm respectively, where the lowest results were obtained from T_3 (Geobag) 120.00 cm and 8.53 cm respectively. Number of branches per plant (46.00), canopy spread both N-S and E-W and number of fruits per plant were minimum in T_3 (Geobag) i.e. 23.00, 122.00 m, 120.00 m and 17.67 fruits per plant, respectively.Canopy spread both N-S and E-W was the highest in T_1 (Tin drum) (137.33 m and 148.00 m). The highest number branches was obtained from T_2 (Plastic drum) 28.33 per plant. Maximum number of fruits was recorded in T_1 (Tin drum) i.e. 22.67.

Table 117. Effect of container type on the growth characteristics of different guava varieties on the roof

Treatments	Plant height (cm)	Base girth (cm)	Canopy Spread (m)		No. of branches/ plant	No. of fruits/ plant
			N-S	E-W		
T_1 (Tin drum)	128.33	9.90	137.33	148.00	24.67	22.67
T_2(Plastic drum)	140.33	10.40	126.67	132.67	28.33	19.00
T_3 (Geobag)	120.00	8.53	122.00	120.00	23.00	17.67
Level of sig.	NS	NS	NS	NS	NS	NS
CV (%)	**23.67**	**7.95**	**18.25**	**14.74**	**18.02**	**42.74**

NS: Not Significant

The effect of container type on yield and yield contributing characters has been stated in Table 118. No significant differences were observed in terms of individual fruit length weight and yield, but significant difference was noticed in case of fruit breadth. The biggest sized fruit (Length-5.74 cm, breadth 6.61 cm and weight 126.50 g) was obtained from T_2 (Plastic drum), followed by T_1. But fruit length-5.29 cm and breadth-5.56 cm was found minimum in T_3 (Geobag). Individual fruitweight (100.44 g) was the lowest in T_1 (Tin drum). Yield kg per plant was manifested as the highest in T_2 (2.42 kg), followed by T_1 and the lowest yield was obtained from T_3 (1.46 kg per plant) (Fig. 59).

Table 118. Effect of container type on the yield characteristics of different guava varieties on the roof

Treatments	Fruit size (cm)		Individual fruit weight. (g)	Yield/plant (Kg)
	Length	Breadth		
T_1 (Tin drum)	5.69	6.05	100.44	2.31
T_2(Plastic drum)	5.74	6.61	126.50	2.42
T_3 (Geobag)	5.29	5.56	102.50	1.46
Level of sig.(5%)	NS	*	NS	NS
CV (%)	**10.33**	**4.79**	**24.78**	**46.87**

Fig. Tin drum

Fig. Geobag

Fig. Plastic drum

Fig. 59. Yield characteristics of different guava varieties using container type on the roof

Experiment 19(a): Effect of different soil media for dragon fruit production on the roof. (SET 1)

The results revealed that there was no statistical variation among the treatments in terms of all growth parameters (Table 119). However, the highest plant height was found in treatment T_1 (282.0 cm), followed by T_2 and T_3 (271.9 cm and 271.8 cm respectively) and the lowest was observed in T_4 (255.3 cm). In case of number of brunches/pillar T_4 exhibited the highest number of brunches per pillar (22.00) and the lowest was observed in T_1 (16.00). The maximum number of fruits per pillar was found in T_2 (13.67) and the minimum was observed in T_1 (5.66).

Table 119. Effect of different soil media on growth characteristics of dragon fruit

Treatments	Plant height (cm)	No. of brunches/ pillar	Canopy spread (cm)		No. of fruits/ pillar
			N-S	E-W	
T_1	282.0	12.67	130.2	171.9	5.66
T_2	271.9	16.00	145.3	170.2	13.67
T_3	271.8	21.00	141.9	155.3	10.33
T_4	255.3	22.00	146.3	158.9	12.00
Level of Significance (5%)	NS	NS	NS	NS	NS
CV (%)	**5.50**	**37.07**	**13.78**	**21.32**	**45.11**

* Significant at 5% level NS: Non significant

Here, T_1 = 100 % loam soil; T_2 = 50 % loam soil + 50 % coco dust; T_3 = 50 % loam soil + 50 % bio-char; T_4 = 20 % loam soil + 40 % coco dust + 50 % bio-char

The effect of treatments on yield and yield contributing characters has been shown in Fig. 60. In terms of fruit length and breadth, the biggest sized fruit (Length-8.62 cm and breadth-6.98 cm) was obtained from the T_2 (50 % loam soil + 50 % coco dust) treatment but the highest fruit weight was observed in T_4 (269.2 g), followed by T_3 and the lowest was noted in T_1 (205.6 g) (Table 120). Significant variations were observed in case of edible portion and yield per pillar. Edible portion (79.13 %) was noted the highest in T_2 and the lowest was in T_3 (65.93 %). The highest yield per pillar (3.83 kg) was obtained from T_2 (50 % loam soil + 50 % coco dust) followed by T_4 and the lowest yield was noted in T_1 (1.33 kg/pillar).

Table 120. Effect of different soil media on the yield and yield contributing characters of dragon fruit

Treatments	Fruit size (cm)		Individual fruit weight. (g)	Edible portion (%)	TSS%	Yield/pillar (Kg)
	Length	Breadth				
T_1	8.25	6.70	205.6	68.29	14.57	1.33
T_2	8.62	6.98	247.5	79.13	12.99	3.83
T_3	7.83	6.77	254.7	65.93	16.52	2.63
T_4	8.30	6.79	269.2	71.52	13.98	3.17
Level of Sig. (5%)	NS	NS	NS	**	NS	*
CV (%)	**9.49**	**5.00**	**21.01**	**5.62**	**11.03**	**41.12**

* Significant at 5% level NS: Non significant

Here, T_1 = 100 % loam soil; T_2 = 50 % loam soil + 50 % coco dust; T_3 = 50 % loam soil + 50 % bio-char; T_4 = 20 % loam soil + 40 % coco dust + 50 % bio-char

Experiment field view

Fig. 60. Different soil media on the yield and yield contributing characters of dragon fruit

Experiment 19(b): Effect of different soilless media for dragon fruit production on the roof. (SET II)

In case of soilless media, no statistical variation was identified until now in respect of all the parameters except E-W canopy spread (Table 121). In case of number of brunches/pillar, canopy spread both N-S and E-W, the highest results (22.33, 161.7 cm, 155 cm respectively) was observed from T_1 treatment. However, in every case the lowest result was obtained from T_3 (50 % coco dust + 50 % Bio-char) treatment. But minimum days required to 1st flower initiation observed in T_3 i.e. 259 days. The highest number of fruits/pillar was obtained from T_1 (24.67 fruits per pillar) and the lowest was in T_3 i.e. 13.33 fruits per pillar (Fig. 61).

Table 121. Effect of different soilless media on growth characteristics of dragon fruit

Treatments	No. of brunches/ pillar	Canopy spread (cm)		Days to 1st flowering	No. of fruits/pillar
		N-S	E-W		
T_1	22.33	161.7	155.0	264	24.67
T_2	16.67	135.2	130.2	266	15.00
T_3	16.67	126.8	123.6	259	13.33
Level of Sig. (5%)	NS	NS	*	NS	NS
CV (%)	**29.08**	**28.57**	**7.14**	**3.93**	**52.24**

* Significant at 5% level NS: Non significant

T_1 = 100 % Coco dust; T_2 = 100 % Bio-char; T_3 = 50 % coco dust + 50 % Bio-char

No significant variations were observed in case of fruit size, individual fruit weight, edible portion (%), TSS (%) and yield (kg) per pillar (Table 122). In terms of fruit length and weight, the biggest fruits were obtained from T_3 i.e. 9.66 cm and 316.4 g followed by T_2. The lowest fruit weight was observed in T_1 (281.8 g). Considering edible portion (%), TSS (%) and yield per pillar (kg) T_1 (100 % Coco dust) performed the best which were 75.92 %, 13.18 % and 9.39 kg respectively. The lowest yield was obtained from the T_2 i.e. 7.38 kg fruits per pillar.

Table 122. Effect of different soilless media on the yield and yield contributing characters of dragon fruit

Treatments	Fruit size (cm)		Individual fruit weight. (g)	Edible portion (%)	TSS%	Yield/pillar (Kg)
	Length	Breadth				
T_1	9.54	9.16	281.8	75.92	13.18	9.39
T_2	9.66	7.25	311.5	73.94	12.07	7.38
T_3	9.66	6.98	316.4	72.12	11.37	8.37
Level of Significance (5%)	NS	NS	NS	NS	NS	NS
CV (%)	**10.52**	**11.05**	**19.49**	**4.71**	**15.38**	**11.95**

* Significant at 5% level NS: Non significant

T_1 = 100 % Coco dust; T_2 = 100 % Bio-char; T_3 = 50 % coco dust + 50 % Bio-char

Fig. 61. Effect of different soilless media for Dragon fruit production on the roof

By considering growth and yield parameters in set-1 (soil media) experiment, the treatment T_2 (50 % loam soil + 50 % coco) performed the best and in the case of set-2 (soilless media) the treatment T_1 (100 % Coco dust) showed the best result. Further study is highly needed for the confirmation of the data.

Experiment 20(a): Effect of different growing methods on the growth and yield of strawberry grown on the roof (SET 1)

The effect of different growing methods on the growth characteristics of strawberry on the roof has shown in Table 123-125 and Fig. 62. The results revealed that most of the growth parameters were significantly varied among the treatments except canopy spread. The tallest plant was found in treatment T_3 (11.00 cm) closely followed by treatment T_1 (10.11 cm) while, the shortest one was observed in treatment T_4 (8.25 cm). In case of number of leaves/plant, the treatment T_3 produced the maximum number of leaves/plant (11.30) and the minimum was observed in T_2 (7.15). However, the treatment T_1 and T_3 required short period of time for flowering (40 days) which was closely followed by T_4 (41 days), whereas, the treatment T_2 required longer period of time (44 days).

Table 123. Effect of different treatments on the growth of strawberry

Treatment	Plant height (cm)	Canopy spread (cm)		No. of leaves/ plant	Days to 1st flowering
		N-S	E-W		
T_1 (Column system)	10.11	19.36	11.83	7.98	40
T_2 (Vertical wall mount)	9.93	16.83	13.84	7.15	44
T_3 (Horizontal bed)	11.00	21.72	14.03	11.30	40
T_4 (Pot culture)	8.25	17.25	10.95	8.36	41
LSD (5%)	1.53	NS	NS	1.83	0.57
CV (%)	**7.84**	**11.05**	**11.74**	**10.55**	**0.70**

NS: Non significant

Table 124 shows the effect of different growing methods on the yield and yield contributing characters of strawberry on the roof. According to the results it is clear that most of the parameters under study were non-significant except TSS (%). Nevertheless, the highest no. of fruits/plant (29.75) and the heaviest fruit (21.00 g) were harvested from the treatment T_3. Though the yield was also not significantly varied, however, the highest yield (624.75 g/plant) was obtained from the treatment T_3. TSS (%) was found the highest in T_2 (7.08 %). The lowest result in respect of all the parameters except no. of fruits/plant was found in treatment T_4.

Table 124. Effect of different treatments on the yield and yield contributing characters of strawberry

Treatment	No. of fruits/ plant	Fruit size (cm)		Individual fruit weight (g)	Yield g/plant	TSS (%)
		Length	Breadth			
T_1 (Column system)	20.93	3.40	2.34	15.40	322.32	6.28
T_2 (Vertical wall)	26.03	3.20	2.37	16.90	439.40	7.08
T_3 (Horizontal bed)	29.75	3.20	2.45	21.00	624.75	6.90
T_4 (Pot culture)	19.08	2.85	2.30	15.10	288.11	5.67
LSD (5%)	NS	NS	NS	NS	NS	0.89
CV (%)	**43.32**	**6.62**	**6.01**	**9.19**	**52.11**	**6.90**

NS: Non significant

From the Table 125 it can be shown that benefit cost ratio (BCR) was far better (2.18) when strawberries were planted in column system than other methods.

Table 125. Economic analysis of different methods of strawberry production (25m² area)

Treatment	Cost of production (Tk.)	Gross margin (Tk.)	Net return (Tk.)	BCR
T_1 (Column system)	40,520	88,187	47,667	2.18
T_2 (Vertical wall)	19,044	29,528	10484	1.6
T_3 (Horizontal bed)	27,340	29988	2,648	1.09
T_4 (Pot culture)	17,672	12,446	-5226	-1.4

Fig. 62. Different growing system for strawberry production on the roof

Experiment 20(b): Performance of strawberries in different column systems on the roof (SET II)

The growth performance of strawberry in column system has demonstrated in Fig. 64 and Table 126. Though in both the cases plant exhibited flowering within the same period. However, plant height and no. of leaves/plant were little higher in T_2 by 11.20 cm and 9.25 respectively than in T_1. In case of canopy spread in N-S and E-W orientation both the treatment performed almost similar. According to the yield and yield contributing characters shown in Table 119, the taller plant (36.37 cm), more yield (599.01 g/plant) and also TSS% (7.56) were obtained from the treatment T_2. The canopy spread was more or less similar in both the cases. More economic benefit was also obtained from Plastic column syatem (BCR-2.81).

Table 126. Effect of different column systems on the growth of strawberry

Treatment	Plant height (cm)	Canopy spread (cm)		No. leaves/ plant	Days to 1st flowering
		N-S	E-W		
T_1 Column system (Iron)	10.13	19.75	16.92	9	40
T_2 Column system (Plastic)	11.20	19.85	16.51	9.25	40

Table 127. Effect of different column systems on the yield and yield contributing characters of strawberry

Treatment	No. of fruits/ plant	Fruit size (cm)		Individual fruit weight (g)	Yield g/plant	TSS (%)	BCR (25m² area)
		Length	Breadth				
T_1 Column system (Iron)	25.75	3.18	2.09	14.59	375..69	6.15	1.04
T_2 Column system (Plastic)	36.37	3.10	2.16	16.47	599.01	7.56	2.81

Column system (Iron) Column system (Plastic)

Fig. 63. Different column systems on the yield and yield contributing characters of strawberry

Experiment 20(c): Performance of strawberries in different bed systems on the roof (SET III)

In this experiment performance of strawberry was observed in two different bed systems and the results (growth and yield) have been shown in Table 128-129 and Fig. 64 respectively. The taller plant (15.23 cm) was observed in treatment T_2. In case of canopy spread both N-S and E-W were found also higher in treatment T_2 by 24.04 cm and 23.27 cm respectively. No. of leaves/plant and days to first flowering were almost similar in both the cases. However, in respect of all yield and yield contributing parameters such as no. of fruits/plant, fruit size (length and breadth), individual fruit weight g/plant, yield g/plant and TSS %, the treatment T_2 performed better (Table 129) by 32.25, 4.19 cm, 3.20 cm, 21.96 g, 708.21 g and 6.79% respectively. Strawberry production in bed system (cock sheet) was also found economically more benefited (BCR-1.5).

Table 128. Effect of different bed systems on the growth of strawberry

Treatment	Plant height (cm)	Canopy spread(cm)		No. leaves/ plant	Days to 1st flowering
		N-S	E-W		
T_1 Bed system (Geo-bag)	11.67	22.48	22.95	13.67	39
T_2 Bed system (Cocksheet)	15.23	24.04	23.27	13.15	40

Table 129. Effect of different bed systems on the yield and yield contributing characters of strawberry

Treatment	No. of fruits/ plant	Fruit size (cm)		Individual fruit weight (g)	Yield g/plant	TSS (%)	BCR (25m² area)
		Length	Breadth				
T_1 Bed system (Geo-bag)	16.65	3.3	2.77	19.48	334.7	6.75	1.09
T_2 Bed system (Cocksheet)	32.25	4.19	3.20	21.96	708.21	6.79	1.5

Fig. 64. Performance of strawberries in different bed systems on the roof

Among the different methods of strawberry production on the roof, the horizontal bed system performed the best (Set-I) and between different bed systems the cocksheet bed performed better (set-III) by considering growth and yield parameters. However, in between two column systems the performance of plastic column was found better considering growth and yield of strawberry. As this is a first year experiment, it should be continued with economic analysis and environmental issues for further study for the confirmation of the results.

Experiment 21. Roof top gardening: a sustainable technology for quality and safe fruit production and consumption

Results showed that, in every cases of growth characteristics such as plant height, base girth, canopy spread (N-S and E-W), number of brunches/plant and also number of fruits/plant the higher results were obtained from farmer's field by 198.10 cm, 14.43 cm, 1.77cm, 1.66 cm, 46.33 and 53.33 respectively (Table 130).

Table 130. Growth performances of different guava varieties on the roof

Variety	Plant height (cm)	Base girth (cm)	Canopy Spread (m)		No. of branches/plant	No. of fruits/ plant
			N-S	E-W		
Rooftop gardening	110.54	8.70	1.43	1.56	26.36	36.57
Farmar's field	198.10	14.43	1.77	1.66	46.33	53.33

The effect of locations on yield and yield contributing characters has been stated in Table 131. In terms of individual fruit length and weight, the bigger sized fruit (Length-6.33 cm and breadth-5.96 cm) was obtained from the farmer's field. The higher individual fruit weight (157.50 g) and also higher yield/plant (8.39 kg) were also obtained from the farmer's field.

Table 131. Yield performances of different guava varieties on the roof

Variety	Fruit size (cm)		Individual fruit weight. (g)	Yield/plant (Kg)
	Length	Breadth		
Rooftop gardening	5.75	5.35	114.33	4.18
Farmar's field	6.33	5.96	157.50	8.39

The test report of Dragon fruits for food-borne pathogen has been demonstrated in Table 132. The results show that fruits from rooftop gardening contained no colonies of *E. coli* and thus mentioned as less than 10 CFU. *Salmonella* spp. was also not found in fruits collected from rooftop garden. However, the marketable fruits collected from farmar's field demonstrated significant amount of *E.coli* colonies (1.3×10^3), though *Salmonella* spp. was also not detected as like as fruits from rooftop garden.

Table 132. Enumeration of β-glucuronidase positive *E. coli* and detection of *Salmonella* spp.

Treatments	Test name	Unit	Method used	Results
Rooftop gardening	*E. coli*	CFU/3 fruits*	ISO 16649-2	<10**
	Salmonella spp.	Detected/not detected	ISO 6579	Not detected
Farmar's field	*E. coli*	CFU/3 fruits*	ISO 16649-2	$1.3x10^3$
	Salmonella spp.	Detected/not detected	ISO 6579	Not detected

* The enumeration is expressed as CFU/ 3 fruits as fruits were washed with buffer and inoculated

** None of the plates (duplicate plates for each dilution) contained any colonies thus the result is reported as less than 10 CFU/g (as 1 ml of first dilution of sample was inoculated per plate) according to the standard document ISO 7218.

Experiment 22. Adaptive trial of selected crops at farmer's field

The growth and yield performance of BARI Dragon fol-1 has shown in Table 133 and Table 134 respectively, whereas, the growth and yield performance of BARI Peyara-4 has demonstrated in Table 3 and Table 4 respectively. From Table 133 and Fig. 65 it can be seen that the variety BARI Dragon fol-1 exhibit flowering approximately 13 days earlier in Jhenaigati Upazilla than in Nalitabari. The taller plant (298.33 cm) was observed in Jhenaigati and the canopy spread from the East to the West as well as North to the South direction was also found higher in Jhenaigati Upazilla than in Nalitabari. In Jhenaigati BARI Dragon fol-1 produced 172% more brunches and 216% more fruits/pillar than in Nalitabari Upazilla. by 154.3 cm and 165.4 cm respectively higher plant height (278.23 cm), number of branches/pillar (16), number of fruit per pillar (12) and also yield (7.4 kg/pillar) of BARI Dragon fol-1 was found in Jhenaigati Upazilla than Nalitabari Upazila. may be due to the soil and climatic conditions and proper management of the garden.

Table 133. Growth characteristics of BARI Dragon fruit-1 in different locations

Location	Date of planting	Plant height (cm)	No. of brunches/ pillar	Canopy spread		No. of fruits/pillar
				N-S	E-W	
Jhenaigati	10.05.22	298.33	49	199.7	208.0	38
Nalitabari	23.05.22	124.00	18	90.23	87.50	12

In Table 134, yield performance of BARI Dragon fol-1 in two different locations has been compared. The yield and quality performances of BARI Dragonfol-1 in Jhinaigati upazilla was found significantly better than in Nalitabari Upazilla. In Jhenaigati Upazilla individual fruit weight, fruit size (length and breadth) were 220.7 g, 7.40 cm, 7.13 cm respectively, whereas, in Nalitabari they were 130.3 g, 5.60 cm and 5.45 cm respectively. BARI Dragon fol-1 yielded 437.8 % higher in Jhenaigati than in Nalitabari. Higher edible portion (66.32 %) and TSS (10.89 %) was also found in Jheanaigati.

Table 134. Yield and yield contributing characteristics of BARI Dragon fol-1 in different locations

Location	Individual fruit weight (g)	Fruit size (cm)		Yield kg/ pillar	Edible portion (%)	TSS (%)
		Length	Breadth			
Jhenaigati	220.7	7.40	7.13	8.39	66.32	10.89
Nalitabari	130.3	5.60	5.45	1.56	60.00	9.70

In Table 135, growth performance of BARI peyara-4 in two different locations has been compared. The growth performances of BARI peyara-4 in Jhinaigati upazilla was found better than in Nalitabari Upazilla. In Jhenaigati Upazilla plant height, number of branches/plant, canopy spread (N-S and E-w) and number of leaves/plant were 167.43cm, 23, 120.6 cm, 134.5 cm and 453 respectively, whereas, in Nalitabari they were 101.32 cm, 8, 26.75 cm, 25.00 cm and 56, respectively. The higher no. of fruits/plant was also obtained from Jhenaigati (26) compared to Nalitabari (7). Yield performance of BARI Peyara-4 has been tabulaed in Table 136. Individual fruit weight, fruit size and also yield were found remarkably higher in Jhenaigati (258.33 g, 7.89 cm, 6.53 cm and 6.72 kg/plant respectively) than in Nalitabari (150.32 g, 5.60 cm, 5.45 cm and 1.07 kg/plant respectively).

Table 135. Growth performance of BARI Peyara-4 in different locations

Location	Plant height (cm)	No. of brunches/ plant	Canopy spread		No. of leaves/ plant	No. of fruits/ plant
			N-S	E-W		
Jhenaigati	167.43	23	120.6	134.5	453	26
Nalitabari	101.32	8	26.75	25.00	56	7

Table 136. Yield performance of BARI Peyara-4 in different locations

Location	Individual fruit weight (g)	Fruit size (cm)		Yield kg/pillar
		Length	Breadth	
Jhenaigati	258.33	7.89	6.53	6.72
Nalitabari	150.32	5.60	5.45	1.07

Fig. 65. Adaptive trial of BARI Dragon fruit-1 and BARI Peyara-4 in Jhenaigati, Sherpur

Considering growth and yield characteristics, it can be concluded that, in every cases the performance of BARI dragon fol-1 and BARI Peayara-4 was found comparatively better in Jhenaigati Upazilla than in Nalitabari Upazilla. However, further study is required for confirmation.

12. Research Highlights

Component 1: (Floriculture Division, HRC, BARI)

12.1. Effect of pinching and boron on quality flower production of carnation

Background:

Carnation (*Dianthus caryophyllus* L.) is colourful long lasting flower. It has gained importance as a major cutflower of the modern world. Pinching is one of the most important cultural practices has direct relationship with production of flower and regulation of flowering for successful marketing. Quality is one of the most important characters in the cut flower industry and this is influenced by the application of micronutrients especially boron. Calyx splitting is a complex disorder in carnation. Boron deficiency can aggravate the disorder. On the other hand, excess boron has been found toxic to the plants which expresses as leaf tip burn symptoms. Therefore, it is needed to standardize the dose of boron so that it controls calyx splitting without causing leaf tip burn and other toxicity symptoms. Work on pinching has been done on carnation and it responded well for flower production but limited information is available on effect of double pinching in carnation. In view of the above mentioned facts, the experiment was designed to standardize the type of pinching and the concentration of boron to study growth, flowering and quality in carnation.

Objective

To standardize the pinching and dose of boron for quality flower production of carnation

Methodology

The experiment was carried out under polyhouse condition at the Floriculture Research Field of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during 2019-2020. One month aged tissue cultured plantlets of Carnation (DC-002) were transplanted in 2.0 × 1.5 m plots under poly house conditions. There were seven treatments i.e. T_0- Control, T_1- Single pinching (SP), T_2- Double pinching (DP), T_3- SP + 0.05% boron, T_4- SP+ 0.1% boron, T_5- DP+ 0.05% boron and T_6- DP + 0.1% boron. All experimental plants received identical fertilizers, irrigation and other cultural practices during the period of investigation, except boron and pinching. Experiment was laid out in a randomized block design with three replications. Carnation plantlets were planted at 15 x 15 cm spacing. Data on various vegetative and floral attributes were recorded and analyzed statistically.

Key findings

- From the present study, it is concluded that double pinching + foliar application of 0.1% boron (T_6) was superior for obtaining better vegetative growth of plants, production of maximum flower number with flower weight in carnation. Furthermore, single pinching + foliar application of 0.1% boron (T_4) also exhibited better results in early flowering, number of primary branches/ plant, stalk length and vase life.

Keywords: Carnation, Polyhouse, Pinching, Boron, Growth, Flower Quality

12.2. Effect of growth regulators on growth and flowering of chrysanthemum

Background

Chrysanthemum is a popular flower of commercial importance which belongs to the family Compositae. It is grown commercially for cut-flowers for vases and for loose flowers for social and religious offerings, garland making and interior decorations at ceremonies. Recently chrysanthemum is becoming attractive to the growers as well as users, as it has great potential for local and export market. The potential use of growth regulators in flower production has created considerable scientific interest in recent years. In Bangladesh a few studies were done regarding the use of growth regulators for growth, flowering and sucker production of chrysanthemum. Hence, the present study was conducted to find out the optimum concentration of growth regulators as foliar spray to improve yield and quality of chrysanthemum flowers.

Objective

To find out suitable growth regulator level for maximizing yield and quality of chrysanthemum

Methodology

The experiment was conducted at the Research field of Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during 2019-2020. Four weeks old seedling of chrysanthemum genotype (CM-019) were collected from field of Floriculture Division of Horticulture Research Centre (HRC) and transplanted in 10 × 12 cm earthen pot. The experiment was laid out in Randomized Complete Block (RCB) Design with 5 replications (one pot considered as one replication). The experiment consists of 7 treatments viz. BA, GA_3 and NAA @ 100 ppm and 200 ppm of each and control. The growth regulators were sprayed on plants in the morning at monthly interval starting after one month of seedling transplantation. Control treated plants were sprayed with water. All the cultural operations such as weeding, mulching, watering, fertilization, disbudding, pinching, staking etc. were done as per the need of the crop. The data were recorded on plant height, number of leaves per plant, leaf area per plant, plant spread, days to flower initiation, number of flowers per plant, stalk length, rachis length, flower size, flower stalk weight and vase life and analyzed statistically.

Key findings

- GA_3 @ 100 ppm was superior regarding vegetative parameters like plant height (70 cm), number of leaves/ plant (50), leaf area (7.5 cm^2) and plant spread (23.0 cm).
- Regarding flowering traits like stalk length (37.5 cm), rachis length (29.0 cm), flower number (26.0), flower size (7.8 cm) and flower stalk weight (37.0 cm) were also performed best through the application of GA_3 @ 100 ppm.
- Early flower initiation (50.0 days) was observed in GA_3 @ 100 ppm which reduced 16 days compared to control (66.0 days). On the other hand, in case of vase life, 5 days were enhanced (15 days) than control (10 days) in the same treatment.

Keywords: Chrysanthemum, Growth Regulators, Vegetative Growth, Flower Quality

12.3. Effect of potting media on growth and quality in aglaonema

Background

Aglaonema belongs to the family Araceae is an important and popular foliage plant which is widely used by the people for its attractive variegated foliage, tolerance to low light and easy culture (Henny *et al.,* 2008). It and is native to South East Asia. For successful growing of this foliage plant in addition to providing ideal environmental condition, suitable potting media is also equally important which enhances its yield and look thus making the plants more attractive and economic. Various potting media compositions have been tried by the researchers for pot culture of these foliage plants with varying degrees of success. The key factors in selecting potting media include aeration, moisture retention and nutrient status. The present investigation was carried out to study the impact of different media compositions and to find out the most suitable potting media for successful culture of indoor foliage plants Aglaonema.

Objective

i) To find out the suitable media for Aglaonema production
ii) To produce the quality foliage of Aglaonema

Methodology

The research work was carried out at Floriculture Shade Net House of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during 2020-2021. One-month old plants of Aglaonema obtained from a nursery located in Dhaka were used in the experiment. Six treatments T_1: Soil + Sand + FYM (2:1:1, v/v),T_2: Soil + Sand +Vermicompost (2:1:1, v/v),T_3: Soil + Sand + FYM +Vermicompost (2:1:1:0.5, v/v),T_4: Coco dust + Sand + FYM (2:1:1, v/v),T_5: Coco dust + Sand + Vermicompost (2:1:1, v/v) and T_6: Coco dust + Sand + FYM + Vermicompost (2:1:1:0.5, v/v) were laid out in Completely Randomized Design and replicated thrice. Intercultural operations like weeding, mulching, watering, fertilization etc. were done as per the need of the crop. Five plants per treatment under each replication were earmarked for recording various growth and quality parameters. The mean value of data collected on these five plants in respect of various parameters, viz plant height, leaf number, leaf length, leaf width, basal stem diameter, sucker number and plant growth index were recorded and analyzed.

Key findings

- Maximum plant height (80.0 cm), number of leaves (14.6), leaf length (45.0 cm), leaf width (10.5 cm), basal stem diameter (2.5 cm), number of suckers (8.0), plant growth index (51.0 cm), N (3.45%**),** P (0.99%**)** and K (1.90%) content in leaf of aglaonema were recorded with the potting media T_6 containing coco dust + sand + FYM + vermicompost (2:1:1:0.5, v/v) combination.
- The same potting media coco dust + sand + FYM + vermicompost (2:1:1:0.5, v/v) also improved plant grade (5) and foliage colour grade (5) quality in Aglaonema.

Keywords: Aglaonema, Cocodust, Sand, FYM, Vermicompost, Plant Grade, Foliage Colour Grade

12.4. Effect of substrates on growth, yield and quality of anthurium in soilless culture

Background

Anthurium is highly praised flowering plant belongs to Araceae family. Anthurium has been recently introduced in Bangladesh and gaining its demand day by day. It has wide ranges of form, size and colour. Anthurium are now cultivated for dramatic indoor garden display, home decoration, cut-flowers, bedding, floral arrangement and other useful purposes. Soil alone as a growing medium does not fulfill all requirements for its higher yield and quality. The introduction of the soilless medium has brought radical change in its cultivation and is gaining importance day by day. Anthurium grows well in substrates such as coco peat, cocodust, vermicompost, perlite etc. (Sindhu *et al.,* 2010). The cocodust, perlite and sawdust have been identified as an agricultural by product which can be a suitable substrate component for flower crops. Growing in artificial substrates has many advantages over soil as mixes contain the same composition, diseases and weed free, light in weight and porous with low salt content, good water-holding capacity, ion exchange capacity and near neutral pH (Singh *et al*., 2019). So keeping in view, an attempt has been made to study the performance of different substrates on growth, yield and flowering of anthurium.

Objective

To find out the suitable substrate for quality anthurium production

Methodology

A pot experiment was conducted in the Floriculture Shade Net House under Horticulture Research Centre of Bangladesh Agricultural Research Institute, Gazipur during 2020-21 with four different substrates. Six weeks old hardened tissue cultured anthurium plantlets of BARI Anthurium-1 were used as planting material. Four different potting substrates like soil, cocodust, perlite and sawdust were used as six treatment combinations. The treatment combinations were T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + Perlite (1:1), and T_6: Cocodust + Sawdust (1:1). The experiment was laid out following Completely Randomized Design (CRD) with five replications. Data on survivability %, plant height, number of leaves, plant spread, sucker number, days to flowering, flower number, stalk length, flower weight, vase life and flowering duration were recorded from five randomly selected plants of each treatment, averaged and analyzed statistically.

Key findings

- Four different potting substrates like soil, cocodust, perlite and sawdust were used as six treatment combinations in anthurium. However, among the substrates used in the present experiment, cocodust + perlite (1:1) was the best and suitable potting substrate followed by cocodust (100%) on the basis of growth, yield, economics and flower parameters of anthurium.
- This finding can support for urban people and commercial entrepreneurs for successfully cultivation of anthurium.

Keywords: Anthurium, Substrates, Cocodust, Perlite, Growth, Yield, Quality

12.5. Effect of potting media on plant growth and yield of ground orchid

Background

Ground orchids, particularly *Spathoglottis* orchid is gaining momentum in Bangladesh valued for cut flower production and as potted plant in commercial floriculture owing to wide range of colours, shapes, sizes and fragrance they display. They are also suitable for interior decoration and remain fresh for many days (Rajeveen *et al.,* 2008). An ideal growing media facilitates proper aeration, adequate drainage and good anchorage to the plant and should provide healthy environment for roots. It should be inert, porous and resistant to organic decomposition. It should be cheap, retard disease and pathogenic factors, keep the plant free from rotting and provide a bit of nutrient, eco-friendly and readily available (Bhattachajee, 2015). Therefore, the present study was aimed to investigate the effect of potting media on growth and yield of ground orchid.

Objective

To find out the suitable potting media for quality ground orchid production

Methodology

The present study was conducted under Shade Net conditions at the Orchidarium House of Landscape, Ornamental and Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) at Joydebpur, Gazipur during 2020-2021. Two months old tissue cultured plants of ground orchid were used as planting material for conducting experiment. Planting was taken up in plastic pots of size 10 cm diameter. Orchids require a suitable potting medium for growth and development and it varies with type of orchid and the environmental conditions. This orchids were grown in four different potting media i.e. T_1- Soil (control), T_2 - Cocodust , T_3 - Sphagnum moss , T_4 - Perlite, T_5 - Cocodust + Sphagnum moss (1:1, v/v) and T_6 - Cocodust + Perlite (1:1, v/v). Completely Randomized Design was set with three replications having five plants in each replication and each replication contains six different treatments. The data recorded on various parameters viz. plant height, leave number, leaf area, shoot girth, sucker number, days to flowering, spike length, rachis length, floret number, spike weight, spike yield, flowering duration, vase life and were analyzed statistically.

Key findings

- Vegetative growth and yield parameters of ground orchids were influenced by the application of potting media namely cocodust, perlite and sphagnum moss singly and in various proportion. Among all the treatments, T_5- cocodust + sphagnum moss (1:1) was the best and suitable potting media on the basis of growth, yield, economics and flower parameters of ground orchid cv. Spathoglottis.
- This finding would be very helpful for urban people and commercial entrepreneurs for successfully cultivation of high value ground orchids.

Keywords: Ground orchids, Potting media, Plant growth, Flowering, Yield, Quality

12.6. Effect of organic manures and fertilizers on growth, flowering and yield of lisianthus

Background

Lisianthus (*Eustoma grandiflorum* Grise, Bengali name- Nandini) is a valuable commercial flower crop, belongs to family Gentianaceae. Both cut flowers and potted plants have high economic value. Potted Lisianthus are popular choices for beautifying living spaces, balconies and terraces. Lisianthus can also be used in bedding, border plants and hanging baskets. This flower is popular and used at all occasion of festivals, religious or social function owing to its diversified colour and forms. To meet the ever-increasing domestic market demand, and there is a need to increase the productivity of this crop. It has been established by several investigation that integration of both organic and inorganic source of nutrient increases growth and yield of crop than using organic or inorganic fertilizer alone (Gangadharan and Gopinath, 2002). Composite inorganic fertilizer (CIF) is a granular fertilizer ($N\text{-}P_2O_5\text{-}K_2O$ = 15-15-15) @ 5g/pot added with organic manure had been reported to improve growth, flowering and quality in potted lisianthus (Bose *et al*., 2021). Therefore, the present investigation was carried out taking account of above situation.

Objective

To standardize the nutrient for better growth and yield of lisianthus.

Methodology

The present study was conducted under Shade Net House of Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) at Joydebpur, Gazipur during 2020-2021. Two months old Lisianthus seedlings were collected from Metal Agro Ltd. and used as planting material were transplanted into uniform size of 10 cm × 10 cm pots filled with different types of organic manure for conducting experiment. Commercially available composite inorganic fertilizer (CIF) is a granular fertilizer ($N\text{-}P_2O_5\text{-}K_2O$ = 15-15-15) @ 5g/pot were added with organic manure had been reported and recommended to improve growth, flowering and quality in potted lisianthus (Shimuzu *et al*., 2012). Weeds were removed manually. Potting media were loosed monthly to avoid compactness for better aeration. Irrigation, disbudding, staking etc. were done properly as per requirement. There were five treatments in the experiment with T_1- Soil (control), T_2 - Cocodust + Farmyard manure (1:1, v/v) + CIF(5g), T_3 - Cocodust + Vermicompost (1:1, v/v) + CIF(5g), T_4 -Cocodust + Farmyard manure + Mustard oil cake (1:1:1, v/v) + CIF(5g) and T_5 - Cocodust + Vermicompost + Mustard oil cake (1:1:1, v/v) + CIF(5g). The experiment was laid out following Completely Randomized Design (CRD) with three replications. Data on plant height, number of leaves, number of branches, plant spread, sucker number, days to flowering, flower number, petal number, stalk length, flower weight, and vase life were recorded from five randomly selected plants of each treatment and analyzed statistically.

Key findings:

- Vegetative growth and flower parameters of lisianthus were influenced by the integrated application of organic manure and fertilizers in various proportion.
- T_5 containing Cocodust + Vermicompost + Mustard oil cake (1:1:1, v/v) + CIF (5g) was found the best and suitable nutrient treatment on the basis of growth, yield and flower parameters of lisianthus.

Keywords: Lisianthus, Organic Manure, Composite Inorganic Fertilizer, Growth, Flowering, Yield

12.7. Effect of different growing media on growth and yield of rose

Background

Rose is a symbol of affection, elegance, inspiration and an important source for aesthetic gratification. Potted plants are highly valued for urbanization and flat system of housing. Potted plants are the only group of plants which can provide freshness even in small space and good source for decreasing the air pollution in indoor. Growing media always play vital role in growth and quality of pot plants. Rose is one such a classical plant requires good medium for better growth and quality of flower production. Although several media have been successfully used for growing of roses since long back. A light, rich, porous and well drained media is considered ideal for growing of roses. Therefore, the present research was undertaken to find out the suitable media for quality production of rose plants

Objective

To find out suitable growing media for maximizing yield and quality

Methodology

The experiment was conducted at the field of Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) at Joydebpur, Gazipur during 2020-21 with seven different growing media. Six months old Dutch rose cv. Top Secret seedlings was collected from Moumita Flower Products Private Limited and used as planting material for conducting experiment. There were seven treatments in the experiment with the treatments media were T_1- Soil (control), T_2: Soil + Farmyard Manure (1:1, v/v), T_3: Soil + Vermicompost (1:1, v/v), T_4: Soil + Farmyard Manure + cocodust(1:1:1, v/v), T_5: Soil + Vermicompost + cocodust(1:1:1, v/v), $T_{6=}$ Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) and T_7 = Soil + cocodust + vermicompost + perlite (1:1:1:1, v/v).The experiment was laid out following Completely Randomized Design (CRD) with three replications. Data on plant height, plant spread, leaf area, number of leaves per flowering stalk, number of branches per plant, stalk length, days to flowering, number of petals per flower, size of petals, size of flower, number of flowering, fresh weight of cut flower, dry weight of cut flower, flowering duration and vase life were recorded and analyzed statistically.

Key findings

- Among the various growing media, combination of Soil + cocodust + vermicompost + leaf compost (1:1:1:1, v/v) was the best for plant growth, flower yield and quality improvement of Dutch rose cv. Top Secret.

Keywords: Dutch rose Growing Media, Growth, Yield, Flower Quality

12.8. Effect of different soilless media for vegetable production on rooftop gardening

Background

Day by day, rooftop gardening is appearing as popular practices in urban areas of Bangladesh. Traditionally, this gardening with different horticultural crops (mostly-fruit, vegetable and flowers) is being practiced by building owners having mixing of some soil and cowdung or compost as growing media with some common fertilizers that lead to poor growth of plants resulting low yield after certain period of time. Due to using soil media building bears a heavy load which may cause damage of building. Availability or collection of soil and cowdung is also a little bit cumbersome in urban areas. The growers are not familiar with other growing media and organic fertilizer like coco-dust, vermicompost and liquid nutrient solution (Bose *et al*, 2015). Therefore, light weight growing media with nutrient solution may be a good option for rooftop gardening. Therefore, the present experiment was under taken.

Objective

To find out the suitable growing media for producing selected vegetables on rooftop gardening.

Methodology

The experiment was conducted at the rooftop of Horticulture Research 's office building, Bangladesh Agricultural Research Institute, Gazipur during 2020- 2021. Five types of vegetables viz. tomato, sweet peeper (Mistimorich), bitter gourd, cucumber and lettuce were included as crop varieties and soil, coco-dust, vermi-compost and cow-dung were considered as growing media materials. The experiment was laid out in RCB design with three replications. The treatment combinations were defined as: (vegetable crop & variety)-V_1= tomato (BARI Tomato-14), V_2= sweet peeper (BARI Mistimorich-1, V_3= bitter gourd (Tia), V_4= cucumber (Alavi) and V_5= lettuce (BARI Lettuce-1) and growing media-T_0= 1.0 kg cow-dung + 1.0kg soil (Traditional practice), T_1= 1.0 kg coco-dust with 1.0 kg vermi-compost, T_2= 1.25 kg coco-dust with 0.75 kg vermi-compost, T_3= 1.5 kg coco-dust with 0.5 kg vermi-compost, T_4= 1.75 kg coco-dust with 0.25 vermi-compost and T_5= 2.0 kg coco-dust with 0.0 kg vermi-compost. Bradley Nutrient solution were applied (as of showing deficient symptom of plants) by dripping method. Irrigation regime and plant protection measures were taken as and when necessary. Data on plant height at last harvest; number of leaves/plant, days to flowering (in case of fruited vegetable), yield/plant, insect and disease reaction were recorded and analyzed.

Key findings

- The highest yield was recorded in all vegetable crops such as tomato, sweet peeper, bitter gourd, cucumber and lettuce when 1.5 kg coco-dust with 0.5 kg vermi-compost was used in bucket or pot as growing media providing Bradley's nutrient solution.

Keywords: Vegetable Production, Soilless Media, Bradley's Nutrient Solution, Yield, Rooftop

12.9. Development production packages of some selected flowers for rooftop gardening

Background

Flower crops are popular in the city roof top gardeners all over the country. People grow flower crops on roof without knowing their productivity just based on their random choice. As a result, they don't get the expected output. Thereby, a proper selection of flower crops and their production package should be developed. Therefore, the present study has been undertaken.

Objective

To develop the production package for selected flower crops on the roof.

Methodology

The experiment was conducted on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during 2020-2022 to develop production package for selected flower crops on the roof. Each of flowers plants were selected as a treatment. The flowers were selected based on seasonality, height, growing habits and choice of rooftop gardener from base line survey etc. The flower crops such as Rose, Gerbera, Chrysanthemum, Lilium, Orchid, lily, Marigold, Anthurium, Cactus and Succulents were selected for performance trial on the roof. Intercultural operations like weeding, mulching, watering, fertilization, disease and insect pest management etc. were done as per need of the crop. The experiment was laid out in CRD design with three replications and data related to growth and yield parameters of all crops has been recorded and analyzed.

Key findings

- ❖ Considering flower production and quality aspects of chrysanthemum varieties, BARI Chrysanthemum-3 performed well on rooftop garden. BARI Gerbera-1 attained the important growth and floral traits and emerged more suitable than other varieties/genotypes of gerbera. Considering flower production and quality aspects, the lily variety BARI Lily-1 was suitable for rooftop gardening.
- ❖ In case of anthurium, BARI Anthurium-1 was recommended for rooftop cultivation. BARI Lilium-1 variety performed well on rooftop garden. Hybrid-T rose (R-003) performed better than other types of rose. Considering flower production and quality aspects, BARI Orchid-1 variety can be recommended for rooftop gardening.
- ❖ Considering cactus flower production and quality aspects, BARI Cactus-1 as well as BARI succulent-1 are recommended for rooftop gardening. In case of marigold, BARI Marigold-1 were suitable for rooftop gardening.

Keywords: Production Package, Flowers, Rooftop garden

12.10. Effect of media on growth and yield of ornamental plants on rooftop

Background

Now a days, rooftop gardening is appearing as popular practices in urban areas of Bangladesh. Due to using soil media building bears a heavy load which may cause damage of building. Avaialability or collection of soil and cowdung is also a little bit cumbersome in urban areas.The growers are not farmiliar with other growing media like cocodust, vermicompost, neemcake, sand, perlite etc. which are light in weight and porus with low salt content, good water holding capacity, ion exchange capacity and near neutral pH. So, keeping in view, the present experiment has been conducted.

Objective

To find out the best media on ornamental crop for growing on the rooftop.

Methodology

A pot experiment was conducted on the rooftop of Horticultural Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during October 2020 -2022. Eight types of ornamentals viz. Zinnia, Dianthus, Poinsettia, Cock's Comb, Chinese Aster, Fern, Cactus, Succulents and Petunia were included as ornamental crop and soil, coarse sand, cocodust, vermicompost, trichocompost, perlite and cowdung were considered as growing media. The treatment combinations were defined as Ornamental Crops (O_1 = Dianthus, O_2 = Poinsettia, O_3 = Cock's comb , O_4 = Zinnia, O_5 = Nephrolepsis fern, O_6 = Easter cactus, O_7 = Kalanchoe Succulent, O_8 =Aster and O_9 = Petunia and growing media T_1 = Soil + FYM (1:1), T_2 = Cocodust + Trichocompost + Coarse sand (2:2:1), T_3 = Cocodust+ Vermicompost + Coarse sand (2:2:1), T_4 = Cocodust + Perlite + Coarse sand (2:2:1) and T_5 = Cocodust + Neemcake + Coarse sand (2:2:1). The ornamental plants were nourished with Cooper's nutrient solution throughout the growing period. Data on plant height, number of leaves per plant, number of shoot/plant, days to flowering, flower number per plant and flowering duration were recorded and analyzed.

Key findings

- The result revealed that the plants which are grown in the media containing Cocodust + Trichocompost + Coarse sand (2:2:1) recorded the best growth and yield parameters and improved quality in Zinnia, Cock's comb, Aster and Petunia.
- Application of media containing Cocodust+ Vermicompost + Coarse sand (2:2:1) are more suitable to improve growth, yield and quality parameters of Dianthus, Poinsettia and Nephrolepsis fern.
- Easter cactus and Kalanchoe succulent performed best in media Cocodust + Trichocompost + Coarse sand (2:2:1) which enhanced growth, flower yield and quality.

Keywords: Ornamental crops, Growing Media, Growth, Yield, Rooftop

12.11 (a). Adaptive trial of gladiolus varieties at farmers' field

Background

Gladiolus is an economically important cut flower in Bangladesh. The major production belts of this flower in the country are Jashore Sadar, Sharsha, Chowgacha, Kushtia, Chuadanga, Satkhira, Khulna, Chattogram, Mymensingh, Dhaka, Savar, Narayanganj and Gazipur regions. Now a days, farmers are cultivating different cultivars of gladiolus in different locations. However, yield potential of those cultivars is not known and some of them are not performing well in our country. BARI has developed 5 varieties of gladiolus which have high potential in yield and other characters but these varieties are not widely cultivated in Bangladesh. Therefore, quick dissemination and popularization of BARI released gladiolus variety is urgently needed. Widespread and effective demonstration of them at farmers' field will lead to ensure availability of gladiolus flowers in Bangladesh.

Methodology

A trial was conducted at Gazipur, Bogura, Rajshahi, Jamalpur, Khagrachari and Rangpur during Rabi 2020-2021. The experiment was laid out in RCB design with four dispersed replications. The unit plot was 2500 m^2 areas with plant spacing of 20 × 20 cm. Four varieties of gladiolus viz. BARI Gladiolus-1 (Red), BARI Gladiolus-3 (White), BARI Gladiolus-4 (Pink) and BARI Gladiolus-5 (Yellow) were included in the trial. Intercultural operations like weeding, fertilization, disease -pest and other crop management practices were done as and when necessary. The data on yield and yield contributing characters were taken and analyzed statistically. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Key findings

Gazipur : Farmers showed their keen interest to grow BARI Gladiolus-3 and BARI Gladiolus-5 varieties due to their higher yield potentialities, shorter duration and economic profit.

Rajshahi : Considering different flower character like floret number, spike length as well as economic value, farmers preferred BARI Gladiolus-3 variety.

Bogura : Farmers of this area are interested to cultivate BARI Gladiolus-3 and BARI Gladiolus-5 varieties due to its higher yield potentiality, early flowering and economic profit.

Rangpur : Farmers were very positive to cultivate BARI Gladiolus-4 varieties due to its attractive colour and economic profit.

Khagrachari : Considering different flower character like floret number, spike length as well as economic value, farmers preferred BARI Gladiolus-5 variety.

Jamalpur : Farmers are interested and happy on cultivation of BARI Gladiolus-3 and BARI Gladiolus-4 varieties due to its higher yield potentiality and better market price over local variety. They preferred both the gladiolus varieties that there was no incidence of disease and insect in these varieties.

Keywords: Adaptive Trial, Gladiolus varieties, Economic return

12.11 (b). Adaptive trial of tuberose varieties at farmers field

Background

Tuberose (*Polianthes tuberosa* L.) is an important cut flower in Bangladesh from aesthetic as well as commercial point of view. It is suitable for use in herbaceous borders, beddings, pots and for cut flowers. The major production belts of this flower in the country are Jashore sadar, Sharsha, Chowgacha, Kushtia, Chuadanga, Rangpur, Bogura, Satkhira, Khulna, Chattogram, Dhaka, Savar and Gazipur regions. Now a days, farmers are cultivating different cultivars of tuberose in different locations. However, yield potential of those cultivars is not known and some of them are not performing well in our country. BARI developed tuberose variety that need to be popularize among the farmers. To do so, on-farm trial is one of the ways to demonstrate better performance of the variety. Therefore, trials on BARI Tuberose-1 with promising line PT-001 as check were conducted at Gazipur, Rajshahi, Bogura, Rangpur Khagrachari and Jamalpur to evaluate the performance of tuberose varieties and to popularize among the farmers.

Methodology

A trial was conducted at Gazipur, Bogura, Rajshahi, Khagrachari, Rangpur and Jamalpur during 2020-2022. The experiment was laid out in RCB design with four dispersed replications. The unit plot was 2500 m^2 areas with plant spacing of 30 × 20 cm. Bulbs of BARI Tuberose-1 along with check (PT-001) were used as planting material. Intercultural operations like weeding, fertilization, disease -pest and other crop management practices were done as and when necessary. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Key findings

- ❖ BARI Tuberose-1 showed better performance and produced higher yield over the locations.
- ❖ BARI Tuberose-1 found more profitable as compared to famers' traditional tuberose cultivar (PT-001).

Keywords: Adaptive trial, Tuberose variety, Economic return.

12.11 (c). Adaptive trial of gypsophila variety at farmers field

Background

Gypsophila (*Gypsophila sp.*) belongs to Caryiophilaceae family, an important flower now commercially grown in Bangladesh as cut flower and in flower arrangements such as bouquets. It has great economic value for cut flower trade for beauty and loving people because of its prettiness. It is also used in herbal medicine and food. Due to its aesthetic and medicinal values for mankind and economic importance, BARI developed Gypsophila variety that needs to be popularizing among the farmers. To do so, on-farm trial is one of the way to demonstrate better performance of the variety. Therefore, trial on BARI Gypsophila-1 was conducted at Gazipur, Jamalpur, Bogura, Rajshahi, Khagrachari and Rangpur to evaluate the performance of Gypsophila variety and to popularize among the farmers.

Methodology

Trials were conducted at Gazipur, Bogura, Rajshahi, Jamalpur, Khagrachari and Rangpur during the Rabi season of 2020-2021. The experiment was laid out in RCB design with four dispersed replications. The unit plot was 1500 m^2 areas with plant spacing of 15 × 15 cm. Seeds of BARI Gypsophila-1 was used as planting material. Intercultural operations like weeding, fertilization, disease-pest and other crop management practices were done as and when necessary. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Key findings

BARI Gypsophila-1 performed well at all locations.

Farmers' opinion

Farmers preferred BARI Gypsophila-1 over the locations due to its higher yield potentialities, short duration, economic profit and no incidence of pest and disease.

Keywords: Adaptive trial, Gypsophila variety, Economic return.

12.11 (d). Adaptive trial of lilium varieties at farmer's field

Background

Lilium (*Lilium* sp.) belong to Liliaceae family is a lucrative flower has recently been introduced in Bangladesh due to its high demand and profitability. BARI developed lilium varieties that need to be popularize among the farmers. To do so, on-farm trial is one of the ways to demonstrate better performance of these varieties. Therefore, trial on BARI lilium-1and BARI lilium-2 were demonstrated at Gazipur, Rajshahi, Bogura, Rangpur Khagrachari and Jamalpur to evaluate the performance of lilium varieties and to popularize among the farmers.

Methodology

Trials were conducted at Gazipur, Bogura, Rajshahi, Khagrachari, Rangpur and Jamalpur during 2020-2021.The experiment was laid out in RCB design with four dispersed replications. The unit plot size was 1000 m^2. Bulbs of BARI lilium-1 and BARI lilium-2 was used as planting material. Intercultural operations like weeding, fertilization, disease-pest and other crop management practices were done as and when necessary. Spacing was maintained at 20cm from row to row and 15cm from plant to plant. When the lower most buds showed color, the spikes were harvested. After collecting flowers, the plants leaving 25-30cm stem were kept in the field for bulb development. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Key findings

Farmers are interested to cultivate BARI lilium-1 and BARI lilium-2 considering floret number, spike length and flower colour. Moreover, they preferred to its higher yield potentiality, shorter duration and better market price at all locations. They showed their keen interest to grow new flower BARI lilium-1 and BARI lilium-2 varieties because there was no incidence of pest and disease recorded in the field.

Keywords: Adaptive trial, Lilium variety, Economic return.

12.11 (e). Adaptive trial of marigold varieties at farmers field

Background

Marigold gained popularity amongst gardeners and flower growers on account of its easy culture and wide adaptability. Its habit of free flowering to produce marketable flowers, wide spectrum of attractive colour, shape, size and good keeping quality attracted the attention of flower growers. BARI developed marigold variety that needs to be popularize among the farmers. To do so, on-farm trial is one of the way to demonstrate better performance of the variety. Therefore, trial on BARI Marigold-1 was conducted at Gazipur, Rajshahi, Bogura, Rangpur, Khargrachori and Jamalpur during 2021-22 to evaluate the performance of marigold variety and to popularize among the farmers.

Methodology

A trial on marigold was conducted at Gazipur, Bogura, Rajshahi, Khagrachari, Rangpur and Jamalpur during 2021-2022. The experiment was laid out in RCB design with four dispersed replications. The unit plot size was 2500 m^2 areas with plant spacing of 30 × 20 cm. Cuttings of BARI Marigold-1 along with check (M-001) were used as panting materials. Intercultural operations like weeding, fertilization, disease -pest and other crop management practices were done as and when necessary. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Key findings

- ❖ BARI Marigold-1 gave higher yield over local variety at all locations.
- ❖ There was no incidence of pest and disease in BARI Marigold-1.
- ❖ Economic return was higher in BARI Marigold-1.

Keywords: Adaptive trial, Marigold variety, Economic return.

Component 2: Department of Horticulture, SAU, Dhaka

12.1 Cultivation of different horticultural crops in different planting media in summer season. (Vertical gardening)

Back-ground:

Rooftop gardening is expected to reduce temperature and excessive heat energy absorption from solar radiation, thus resulting in a significant energy saving for air-conditioning in a building. In addition growing vegetable on roof top reduces the expenditure on purchase of vegetable from the market. It also provides minerals rich good quality fresh organic vegetable free from chemical, thus contributing to nutritional security. Rapid urbanization and expansion are putting a pressure on city food supply systems. Today in this urban planet, 54 percentage of the world's population are living in urban areas and the share is expected to increase to 66 percentages by 2050 (United Nations, 2014). Rapid urbanization and urban growth is placing massive demand on urban food supply systems. Moreover, many cities in the world are facing problems like rapid decrease in green space and increase in heat island effects. Urban agriculture or farming is promoted as a potential solution to these problems. For city dwellers, urban agriculture can provide a source of fresh produce, a healthier diet, and significant financial savings. Vegetated surfaces offer important sound-insulating capabilities and are frequently employed in urban contexts for noise reduction. Green roofs can help buildings reduce noise pollution significantly. Through its backward and forward relations, it can also provide jobs and economic opportunities (Islam and Ahmed, 2011). Rooftop gardening can be an effective way to provide food security and meet people's nutritional needs. Understanding the problems and opportunities associated with policy of insurance adoption will go a long way towards improving the city's food supply.

Objectives:

* To find out the effect of growing media on the production of summer vegetables
* To investigate the production of summer vegetables in the vertical uPVC frame vertically.

Methodology:

There were four summer vegetables viz., Indian Spinach, Red Amaranth, Thankuni and Mint were cultivated with three different growing media viz., Vermi-Compost + soil (90:10) %; Coco + Vermi +Soil (10:70:20) %; Coco + M. Spant Compost + Soil (10:70:20) on upvc pipe vertical frame. This experiment was conducted in RCBD with three replications and making vertical frame with MS angle iron where 12 numbers of 4" diameter uPVC pipe (91.45cm long) set over the triangle vertical frame. In this study 12 different combinations were created. There were 2 sets of each replication where in total uPVC pipe 72 sets. Data collection was done by specific treatment to collect 3 plants of each treatment and took data accordingly.

Key findings:

Total yield/frame (696.77cm^2), there were no significant difference among the treatments statistically where the highest yield was in Coco + Vermi +Soil (10:70:20) %; and similar results were found in Vermi-Compost + soil (90:10) %. Indian spinach showed better results than other three crops like, red amaranth, Thankuni, Mint.

Keywords: Rooftop vertical garden, uPVC pipe gardening system, Growing media, Summer vegetables

12.1 Performance of different winter horticultural crops in different growing media (square stair case vertical garden)

Back-ground:

A rooftop garden can be the primary way of our urban agriculture to keep the environment calm and cool. It can be a great source of our local food system, employment and daily engagement with nature (Jahan, 2016). A survey found that the majority of Dhaka city's rooftops are suitable for gardening and do not require costly renovations; in some cases, modest alterations are all that is required (Islam, 2002).

Objectives:

* To find out the effect of growing media on the production of winter vegetables
* To investigate the production of winter vegetables in the square stair case vertical frame

Methodology:

There were four winter vegetables like Tomato, Spinach, Cabbage, and Cauliflower cultivating with three growing media mixtures like, Vermi-Compost + soil (90:10) %; Coco + Vermi +Soil (10:70:20) %; Coco + Mushroom Spent Compost + Soil (10:70:20). This experiment was conducted on strain case vertical frame where each frame considers one replication and each box consider single treatment. Here we made 12 different treatments combination. We make total 12 sets of stair box and add different nutrient combination as above rates with watering by dripper. The nets and staking were done accordingly.

Key findings:

Growing media mixtures of T_3-Mushroom spent compost + Soil at the percent ratio of 10:70:20 was the best for Tomato, Cabbage and Cauliflower compared to other treatments except Spinach, which showed higher yield in the treatment T_2 of Cocodust + Vermicompost +Soil @(10:70:20) %).

Keywords: Rooftop vertical garden, Stair-case gardening system, Growing media, Winter vegetables

12.2 Cultivation of different year-round horticultural crops in different growing media or planting materials in half-drum gardening system/model

Back-ground

In Dhaka, one of the world's fastest growing megacities, open and cultivable land has been unlawfully changed to built-up area, resulting in an alarming loss of agricultural l and (Islam and Ahmed, 2011). Using rooftop farming to alleviate food shortages, enhance urban self-sufficiency, and make fresh vegetables more available to city people could be a viable option. RTGs might provide Bologna (Italy) with more than 12,000 t of vegetables per year, satisfying 77 percent of the cities demands.

Objectives:

* To find out the effect of growing media/planting media on the yield of year-round vegetables
* To investigate the production of year-round horticultural crops on half-drum gardening system in roof-top.

Methodology:

As factor-1, four type of year round vegetable crops like-Bottle gourd, Bitter gourd, Sweet gourd, Brinjal were taken to study the effect of the growing media/planting media like-Vermi-compost + soil (90:10) %; Coco-dust + Vermi-compost +Soil (10:70:20) %; Cocodust + Mushroom spent compost + Soil (10:70:20) as factor-2. This experiment was conducted on semi stage half drum vertical frame where each frame considers one replication and each half drum consider single treatment. There were 12 different treatments combination. The 12 sets of half-drum were filled with different media as above rates and watering was done by dripper. The nets and staking were done accordingly to keep the climbers and plants straight and framing was created on rooftop.

Key findings:

In the experiment, treatments T_3- Cocodust + Mushroom spent compost + Soil (10:70:20) % produced the highest number of fruits. Among the cucurbits, bitter gourd gave the most (50), and then sweet gourd (13) followed by bottle gourd (12). There were 45 brinjal fruits which was excellent showed in the experiment. As it was cultivated with planting media in vertical structure the physical growth of the four crops was increased compared to other cultivation techniques. The drip irrigation was applied timely and recorded the increased plant height and yield.

Key-words: Half-drum gardening system, Growing media, Mushroom spent compost, Year-round vegetables.

12.3 Establishment of rooftop garden landscape with vegetables and flowers;

Back-ground:

The roof garden is a garden on the roof. This means that each roof covers with plants such as trees, shrubs, bushes and grasses. Roof gardening can also be defined as 'environment or nature in the sky'. Similarly, if vegetables are allowed to grow on the roof in place of other ornamental plants than it is called roof top vegetable garden. Green roofs are roofs of buildings covered with a growth substrate and plants, which are also known as roof gardens, living roofs, and eco-roofs. Urban communities face many challenges related to the health and well-being of citizens. Many of these challenges arise as the direct consequence of dense urban environments. Industry, automobiles, and impermeable concrete and asphalt surfaces combine to negatively impact upon the air and water quality, while due to climate change there is a continuous increase in the atmospheric temperature because of global warming. A survey shows that most of the roofs of Dhaka city are suitable for gardening and do not require major improvement work, sometimes only need some modifications. A rooftop garden can supplement diets of a community as it supplies with fresh produce and provide a tangible benefits tie to food production. With rapid and unplanned urbanization, incidence of urban poverty and food insecurity has been also increasing alarmingly in Dhaka. The landscape design with diversified crops may reduce the pest attack and may increase the aesthetic value of the rooftop with flowers and medicinal plants obviously with crops.

Objectives:

* To beautify and accommodate maximum types of horticultural crops in an unit area;
* To reduce the pest attack as the diversified crops will be in a systemic design with balanced landscape.

Methodology:

In this Experiment diversified horticultural crops like- Coriander, Aloe vera, Tomatoes, Chilli, Cucumber, Petunia, Cosmos flower were planted in growing bag in a systematic design. This innovative mixed garden landscape design were experimented with few edible vegetable/medicinal and 2 flower crops where those have been cultivated in grow bags (inside-black and outer white) with organic potting mix materials and the irrigation will be done through dripper with timer controller (drip irrigation system). This garden will reduce insect pest attack and roof requires an aesthetic appearance and this technology will fulfill that with return.

Key-findings:

Tomato shows the highest yield while, the flower crops- petunia and zinnia were planted for beautification. Tankuni gave highest result for number of branches per plant and leaf length (cm). Maximum leaf yield with 4 times harvest were collected from coriander. On the other hand, the two flowers plant petunia and zinnia showed no fruits but flower was the main interest from them for the rooftop beatification and petunia gave the maximum number of flowers.

Keywords: Multi-layered landscape, Diversified cultivation, Rooftop landscape

12.4 Yield performance of pakchoi in indoor grow house and in open rooftop as affected by different growing media

12.5 (a) Effects of different growing media on the growth and yield of potted pakchoi in rooftop

Background:

Pakchoi (*Brassica rapa* L. *Chinensis*), is a short duration cropping plant and contains many nutrients that we need in everyday life, one of them is beta carotene. On 100 grams (3.53 oz) Pakchoi plants contain a variety of nutrients and vitamins that are needed by the body: proteins (25%), potassium (6%), calcium (36%), iron (15%), vitamin A (7%), as well as vitamin C (9%). Nowadays, the public demands of Pakchoi vegetable are increases. According to the survey, vegetable needs in Indonesia was 10.12 million tons/year, while production was only 6.3 million tons/year. The availability of vegetable production should be enhanced through farming technologies. The Chinese cabbage cultivar "Pak Choi" (*Brassica chinensis* L. var. *chinensis Mansf.*) and is the most popular vegetables in the Thailand (BAC, 2014). The total vegetable growing area is about 0.176–0.288 million hectares per year, with the total yield of 1.8–2.8MT. This consumption vegetables more than 45 kg/capita/year (Tongaram, 2004). Some of these consumed vegetables are derived from soilless culture, particularly the substrate culture (Khamwongsa, 2010). Substrate culture is the use of planting media substituted for soils in which plants can grow normally as they do when grown in soils. Wiangsamut *et al.* (2016) reported that the planting medium of rice husk ash: sand: cow dung (1:1:1) gave the tallest plants and highest fresh weight of new tubers of "Thao Yai Mom" (*Tacca leontopetaloides* Ktze.) compared with the other planting media. Stems with narrow and wide plant spacing. Considering the above facts, the present experiment was undertaken to study the effect of different growing media on growth & yield of potted Pakchoi.

Objectives:

1. To know the performance of different growing media on the growth and yield of pak-choi
2. To find out the quality parameters of Pakchoi in different growing media

Methodology:

The experiment was conducted during the period from December, 2020 to February, 2021 in the experimental field of Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. There are two developed variety from BARI (Bangladesh Agricultural research Institute namely BARI China Shak -1 and BARI Batishak-1. For this experiment seeds were collected from BARI germplasm and variety selected was BARI Batishak-1. There were 8 different treatments level selected for this experiment such as T_0 = Control; T_1 = Vermicompost + Soil (90:10); T_2 = Cocodust + Vermicompost + Soil (20:70:10); T_3 = Mushroom Spent Compost + Soil (90:10); T_4 = Vermicompost + Cowdung + Soil (45:45:10); T_5 = Vermicompost + Mushroom Spent Compost + Soil (45:45:10); T_6 = Vermicompost + Mushroom Spent Compost + Cowdung + Soil (50:20:20:10) and T_7 = Vermicompost + Biochar + Soil (45:45:10), following Completely Randomized Design (CRD) with three replications where the 24 pots were selected, the size of each pot is 16 cm x 30 cm. Seed were sown on 22 December, 2020. Before sowing they were soaked in water for 24 hours. Hence, two seeds per hill was planted in order to ensure a uniform stand of the crop harvesting stage. The amount of irrigation water was limited up to that quantity which does not leached out through the bottom. Harvesting of all the Pakchoi (Batishak) was not possible on a certain or particular date because the vegetables initiation as well as maturing in different plants were not uniform. Harvesting was started from January 24, 2021 and was continued up to February 03, 2021. Harvesting of the crop was done pot wise by uprooting the plants by hand carefully for data collection.

Experimental data were recorded from 14 days after sowing Pakchoi plant growth as well as Pakchoi production in different growing media and continued until harvest. Data on the following parameters were recorded after harvesting at 42 DAS. 2 plants were sampled randomly from each pot for the collection of per plant data while the crop of whole pot was harvested to record per pot data as collection of plant growth characteristics including: plant height (cm) plant^{-1}, number of leaves plant^{-1}, leaf area (cm^2), leaf length(cm) , leaf breadth(cm), Fresh weight with root yield plant^{-1} (g), Fresh weight (g), dry weight without root yield plant-1 (g), root weight (g), root length(cm), shoot diameter (cm), stem length (cm) and yield (ton/ha) and quality parameters including : color measurement, determination of Total soluble solid (TSS), Vitamin C content (mg. 100 g^{-1} FW), moisture content (%)

Key findings:

- Growing media exhibited a significant influence on yield of Pakchoi. The maximum yield t ha^{-1} of Pakchoi (18.22 t ha^{-1}) was found from T_1 (Vermicompost + Soil) treatment.
- Maximum brix percentage (12.50%) was observed in T_7 which was statistically similar to T_0, T_3 and T_2 (12.00, 11.20 and 9.50 %) treatment.
- Maximum Vitamin-C percentages (37.30%) were observed in T_1 which was statistically similar with others except T_2 treatment whereas minimum (36.00%) in T_2.
- Therefore, it may be concluded that T1 treatment with Bari china shak -1(Pakchoi) variety can be commercially utilized for better yield in Bangladesh.

Key-words: Rooftop pakchoi cultivation, Growing media, Yield and quality

12.5 (b): Yield performance of pak-choi in indoor grow house hydroponically as influenced by different LEDs light spectrum

Background:

Pakchoi (*Brassica campestris L. ssp. chinensis var. communis*) is an annual leaf vegetable belonging to the Brassicaceae family that originated in China, whose leaves are rich in nutritional and functional health-related compounds (minerals, vitamins, flavonoids, glucosinolates, and anthocyanins. It is grown successfully under protected environments. Light is a major limiting factor on the productivity of greenhouse vegetables during a prolonged series of cloudy days, especially in the winter.

Recent technological advances in protected culture in artificial light sources have introduced Light Emitting Diodes (LED). It reported a great success among growers during last few years as it is a promising greenhouse lighting solution, over traditional lighting sources. The main advantage of LEDs over all other lamp types is its energy saving ability. Other than that, fast switching, higher durability, longer life time, lower thermal radiation, narrow variation in specific wavelength for targeted crops, etc. make them more applicable for protected culture. The LEDs have become the best choice for highly intensive forms of vertical farming as a viable artificial lighting solution. In commercial horticulture industry, light-emitting diodes (LEDs) have tremendous potentiality owing to flexibility of spectral configuration, long life spans, and high energy conversion efficiency.

LEDs provide various advantages over the traditional lighting systems, (e.g., greenhouse and open-field) for leafy greens, herbs, and transplants production such as longer lifetime, smaller size, higher photosynthetic efficiency, lesser thermal radiation and higher safety performance and its year-round cultivation. The direct radiation of heat by LEDs is not seen, but LEDs do produce heat that has to be effectively removed from the system for better functionality. The potentials of LED lighting are many, of which the development of a species-specific light recipe for optimizing plant growth and other desirable traits are promising. To identify the amounts of supplemental red lights, blue lights, or both, combination of white with different fractions of red LEDs, blue LEDs, or both were examined in sweet basil, strawberry, begonia seedlings, geranium seedlings, petunia seedlings, and snapdragon seedlings. This research will be helpful for future smart farming encouraging locally produced, sustainable Controlled Environment Agriculture (CEA).

Objectives:

- To investigate the effect of LED light on the growth yield and quality of pakchoi in indoor hydroponically
- To find out the effects of LED light on growth and quality for pak-choi

Methodology:

The indoor grow-house established with air-conditioning system and vertical racks where two thousand seedlings can be planted of any crops. Here pakchoi seedlings were placed in hydroponic solution and the effect of different light on growth was investigated. The Treatments were white (fluorescent as control) -L_1, White LED - L_2, Red light -L_3; Blue light-L_4; 50% Red+50% Blue-L5; and 50% Red+ 40% Blue + 10% Green-L6. This experiment was conducted inside a controlled environment and 6 stage of iron rack. Each stage consists of single treatment mean LED Spectrum. In total 18 treatments of 6 different LED spectrum in 3 replications. PPFD of different LED light was maintained at 115 µmol/m^2/s and duration was 16 hrs per day. The Hydroponics nutrient solutions are added in the planting box in 30 days interval were added two times in whole crops life

cycle. pH, EC, Temp and humidity was checked every day and sets the room temperature ranges from 18-20 degree centigrade where humidity 85-90%.The data was collected in 7 days interval where total 5 data was collected and recorded.

Key findings:

- Treatment T_{RB} (Red and Blue - 4:1) exhibited the highest total yield (1.29 kg) and total soluble solids (9.24 °Brix) but the highest vitamin-C content (41.81 mg/100g) was achieved from T_{RBG} (Red, Blue with Green - 4:1:1) whereas T_B (Blue - Full) gave the highest SPAD value (42.04) and moisture content (94.12%).
- The treatments of different LED-light spectrum in vertical farming, T_{RB} (Red and Blue - 4:1) can be considered as the best treatment followed by control treatment $T_{FL\text{-}T5}$ (Fluorescent light - Full) among all the treatments.

Key-words:

Indoor grow-house, hydroponic technology, Pakchoi, Yield, Quality, LED light spectrum

12.6 Influence of organic amendments and bio-control agent on the production of gerbera

Background:

Gerbera is an important flower crop in Bangladesh and popular owing to its diversified color. It has been investigated earlier those organic amendments like crop residues, poultry manure, green manure, mustard oil cake, vermicompost etc. are helpful in improving soil productivity and fertility. Again, using bio-control agent in soil enhancing growth, yield and disease insect resistance. There are little or no studies regarding organic amendment and biocontrol agent on gerbera in Bangladesh. However, a number of investigations has been done abroad.

Objectives:

- To find out the effect of organic amendments and biocontrol agents on the growth and yield of gerbera
- To produce year-round gerbera under protected controlled shed -house

Methodology:

The experiment conducted by following CRD with 3 replications. This experiment was conducted inside of poly-shed house and the temperature and humidity could be be controlled slightly as required of the plants. There 5 different treatments were given to each replication so, total 15 plot of treatments were arranged in 3 replications. All sets nutrients were applied in the soil and watered in the plot by Dripper and controlled over the temperature inside of the shed by fogger. There were five treatments in the experiment. They are- T_1= farmyard manure (3t/ha + 1/4rdf), T_2= vermicompost (3t/ha + ¼ rdf), T_3= tricho-compost (3t/ha + ¼ rdf), T_4= tricho-leachate (3000l/ha + ¼ rdf) and T5= control (recommended dose of fertilizer: cd-5t, n_{150}, p_{30}, k_{100} s_{20} b_1 zn_1 kg/ha). All P, K, B, Zn, vermicompost, tricho-compost and farmyard manure except the N were applied and mixed up well with the soils during final land preparation according to treatments. Nitrogen was applied in three equal installments at 40, 60, and 80 days after planting.

Key findings:

- For Total yield/plot (1 m^2), the highest yield was found in T_4. The lowest yield found in T_3.

- The application of bio-control agents and organic amendments where gave the best flower size and showed maximum self-life of the gerbera to increase the total yield and as well as total growth rate of the gerbera.

Keywords: Shed house cultivation, Year-round, Gerbera, Fogging.

Component 3: Pomology Division, HRC, BARI

12.1. Development of production package of some selected fruit crops for rooftop gardening

Background:

Total land area of Bangladesh is about 14.3 million hectare and of which about 59.8% is available for cultivation. During the last twelve years the agricultural land has been decreasing on an average rate of one percent. On the other hand, due to continuous migration of people from rural area to city populations in the cities are growing very rapidly therefore the numbers of low-income customers are gradually growing in the cities. Urban agriculture can supply farm produce to city-dwellers, accelerated food plan and save family budget. Without proper and unplanned urbanization, the incidence of city poverty and food insecurity has been growing alarmingly in most of the cities of Bangladesh. It is generally seen that; fruits crops are the most popular among the city roof top gardeners all over the country. People grow crops especially fruit crops on roof without knowing their productivity and seasonality just based on their random choice. As a result, they don't get the expected output. Thereby, a proper selection of fruit crops based on season and their production package should be developed. Therefore, the present study has been undertaken to develop the production package for selected fruit crops (Dragon fruit, Golden apple and Guava) for rooftop gardening.

Objectives:

- To identify the appropriate fruit crops for roof top gardening
- To develop production package for Dragon fruit, Guava and Golden apple on the roof

Methodology:

Dragon fruit

In general, for all the research activities of Dragon fruit fertilizer dose was applied as per the recommendation of Soil Science Division. Hence, vermi-compost was applied as organic manure at an interval of two months at the rate of 2 kg/container. Chemical fertilizers such as urea, TSP, MoP were applied once a month (12 times a year) at the rate of 50 gm/container, 75gm/container and 50 gm/container respectively. However, Boron (2 gm/tub) was also applied at the rate of 5 gm/tub during final media preparation and after 6 month of planting. Pest management was done according to the established technology developed by BARI. Irrigation and other intercultural operations were done as and when necessary. Data related to growth and yield parameters of were tabulated and statistically analyzed with the software 'Statistics 10'. The treatment means were separated by Least Significant Difference (LSD) test at 5 % level of significance. Other methodologies have been discussed below according to the research activity.

Experiment 1: Performance of different dragon fruit varieties on the roof

A performance trial with BARI Dragon fol-1, BAU Dragon fruit-2 and Pink rose had been conducted to find out the suitable dragon fruit variety for rooftop gardening. Here, 30 L container and as a

growing media mixture of 70% soil + 20% coco-dust + 10% vermicompost wer used. Dragon fruit plants were transplanted into container in 2 June

Experiment 2: Effect of container type on the growth and yield of dragon fruit on the roof

An experiment was conducted on the rooftop of HRC, BARI to find out the sutable container type for dragon fruit production. In this trial, two types of container (each of 30 Litre) such as Geobag and Tin drum were used. The variety BARI Dragon fol-1 was used in this experiment and cuttings were transplanted into container in 10 August 2020. The mixture of 80% coco-dust and 20% vermicompost (Soilless) was used as a growing media.

Experiment 3: Effect of container size on the growth and yield of dragon fruit on the roof

An experiment was conducted on the rooftop of HRC, BARI to find out the most suitable container size for dragon fruit production. In this trial, three different sizes of container (Tin drum) such as Large (30 L), medium (20 L) and small (10 L) were used. The variety BARI Dragon fol-1 was selected for this experiment and cuttings were transplanted into container in 10 August 2020. The mixture of 80% coco-dust and 20% vermicompost (Soilless) was used as a growing media.

Experiment 4: Combined effect of different growing methods on the growth, yield and load management for dragon fruit production on the roof

This experiment was conducted on the rooftop of HRC, BARI to find out the most suitable container size for dragon fruit production. In this trial, first of all the performance of different growing structures in combination with the best media and container has been tested. Secondly, it was compared that which methods of production is lighter to protect the roof. Finaly, economic analysis has been done. In this study Large (30 L) container was used. There were three treatments in the experiment viz; T_1 = GI pipe based structure + Geobag + media (80% cocodust + 20% vermicompost), T_2 = RCC pillar based structure + Tin drum + media (80% soil+20% vermicompost) and T_3 = Tin drum + media (80% soil+20% vermicompost). The experiment was laid out in Randomised Complete Block Design (RCBD) with three replications. The variety BARI Dragon fol-1 was selected for the experiment and cuttings were transplanted into container in 10 August 2020.

Guava

A performance trial with BARI Peyara-2 and BARI Peyara-4 had been conducted to find out the suitable guava variety for rooftop gardening. Here, 30 L container and as a growing media, mixture of 70% soil + 20% coco-dust + 10% vermicompost were used. The growing media was prepared in 5 April 2020. After 15 days of media preparation, the guava plant was transplanted in container in 20 April 2020. Vermicompost was used as organic manure and applied three times a year at the rate of 3 kg/container. Chemical fertilizers including Urea, TSP, MoP applied 2 times a year at the rate of 150g/plant, 150g/plant, 200 g/plant respectively. Irrigation and other intercultural operations were done as and when necessary.

Golden Apple

A performance trial with BARI Amra-1 and BARI Amra-2 had been conducted to find out the suitable golden apple variety for rooftop gardening. Here, 30 L container and as a growing media, mixture of 70% soil + 20% coco-dust + 10% vermicompost were used. The growing media was prepared in 5 April 2020. After 15 days of media preparation, the guava plant was transplanted in container in 20 April 2020. Vermicompost was used as organic manure applied three times a year

at the rate of 2 kg/container. Chemical fertilizers including Urea, TSP, MoP applied 2 times a year at the rate of 100g/plant, 100g/plant, 150 g/plant respectively. Irrigation and other intercultural operations were done as and when necessary.

Key findings:

Dragon fruit

- Considering all the growth and yield parameters, GI pipe, Geobag and soilless media based growing method performed the best as it produced about 69% and 85% more yield than RCC pillar based and ordinary methods of Dragon fruit production respectively. GI pipe+Geobag+soilless media combination not only reduced about 68.92% and 63.31% weight on the roof respectively but also it was economically viable (BCR-3.08).

Golden apple

- The higher no of fruits/plant (185) and yield (6.64 kg/plant) were also obtained from BARI Amra-1 which were about 86% and 78% more than BARI Amra-2 respectively.

Guava

- The higher plant height and base girth were found in BARI Peyara-4 (164.00cm and 13.63 cm, respectively) but the higher number of fruits per plant was obtained from BARI Peyara-2 (35.67) which was about 67% more than BARI Peyara-4. However, the higher yield (33% more) was also obtained from BARI Peyara-2. Hence, BARI Peyara-2 was more promising for rooftop gardening.

Keywords: Rooftop gardening, Fruits, Media, variety, Geobag, Dragon fruit, Guava, Golden apple

12.2. Effect of different growing media for dragon fruit production on the roof

Background:

Roof top gardening is one of the potential areas for vertical expansion. Dragon fruit is one of the very popular exotic fruits among the consumers in Bangladesh. City gardeners growing it on their roof due to its unique taste and quality, as it is one kind of cactus species and the fruit is highly nutritious and highly valued. So, there is a great scope for dragon fruit production on the roof. However, the best growing media for dragon fruit production on the roof yet not been recommended and even city gardeners are seeking for soilless media as because soil is so heavy for roof top. Therefore, the present study has been undertaken to know the performance of Dragon fruit production under different growing media (soil and soilless) on the roof.

Objectives:

- To find out the best rooting media for dragon fruit production on the roof
- To know the performance of dragon fruit under soilless media
- To find out the best soilless media for dragon fruit production on the roof

Methodology:

The experiment was conducted on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during August 2020 to June 2022. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

The experiment had been divided into two sets. In set-1, the different combinations of media including soil had been applied whereas, in set-2, combination of different soilless media had been used. BARI Dragon fol-1 was selected for both sets of the experiment. There were four treatments in set-1 viz; T_1 (100 % loam soil), T_2 (50 % loam soil + 50 % coco dust), T_3 (50 % loam soil + 50 % bio-char) and T_4 (20% Loam soil + 40 % coco dust + 40 % bio-char) and in set-2, there were three soilless media as treatment such as T_1 (100 % Coco dust), T_2 (100 % Bio-char) and T_3 (50 % coco dust + 50 % bio-char). 30 L container was used in this experiment and irrigation and other intercultural operation were done as and when necessary.

Key findings:

- By considering growth and yield parameters in set-1 (soil media) experiment, the treatment T_2 (50 % loam soil + 50 % coco) performed the best as soilless media in set-2, the treatment T_1 (100 % Coco dust) showed the best result.

Keywords: Growing media, Soilless media, Cocodust, Biochar, Dragon fruit

12.3. Evaluation of strawberry production in different growing methods on the roof

Background:

Strawberry is one of the nutritious and high value fruits preferred by the consumers due to its unique taste and color. But the production of strawberries in the field is challenging and sometimes unsuccessful. Hence, Strawberry production on the roof by soilless culture may be an alternative to the traditional soil cropping system for many reasons: higher yield by area unit, less disease incidence in plants, more efficient use of water and fertilizers, more uniform fruits, better quality and healthy. There are many types of growing methods for strawberry production on the roof by using soilless media such as column system; vertical wall system, pot culture and horizontal bed system etc. practiced by the growers but all of them are not potential. Therefore, the present study has been undertaken to evaluate different growing methods for strawberry production on the roof

Objectives:

i) Finding out the best system for strawberry production on the roof
ii) Familiarize strawberry production on the roof
iii) Create income opportunities

Methodology:

An experiment was conducted on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during November 2021 to February 2022. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. BARI Strawberry-3 was selected for the experiment. The experiment was divided into three sets of research activities. There were four treatments in set-I viz; T_1 (Column system), T_2 (Vertical wall mount system), T_3 (Horizontal bed system) and T_4 (Pot culture). In set-II there were two treatments such as T_1 = column system (Iron) and T_2 = column system (plastic). There were also two treatments in set-III viz; T_1 = Bed system (Geobag) and T_2 = Bed system (cocksheet). The size of horizontal bed of geo-bag was 2.0 m x 1.0 m and the cocksheet size was 5.0 m x 0.6 m. In column system, 5 inch sized plastic hanging pot of total 20 per column was used and for pot culture

the size of pot was 4 inch. The 40 days old seedlings of strawberry were planted in 15 November 2021. As a basal fertilizer only Vermicompost was applied in the growing media of coco-dust. Other intercultural operations were done as and when necessary.

Key findings:

- Among the growing methods horizontal bedding system was found the most suitable, as the tallest plant (11.00 cm), highest number of fruits/plant (23.75) and also the highest yield (337.48 g/plant) was obtained from this system. On the other hand, the shortest plant (8.25 cm) and the lowest yield (134.25 g/plant) were observed in pot culture.
- In case of column systems, plastic column performed better than iron made collumn. Plants planted in plastic column produced 36.37 fruits/plant and the yield was 342.5 g/plant whereas, in iron made column system they were only 8.75 fruits/plant and 86.67 g/plant.
- Though, there were no significant difference in geobag bed system and cocksheet bed system, nevertheless, in cocksheet bed system plants performed better. Plants planted in cocksheet bed system produced 48.37% more fruits/plant and 21.46% more yield than its counterpart.

Keywords: Strawberry, Rooftop farming, Methods of Production, Methods

12.4. Rooftop gardening: A sustainable technology for quality and safe fruit production and consumption

Background:

Farmers of Bangladesh usually apply more chemical pesticides than the standard requirements in their field for controlling pest. Also they knowingly or unknowingly do not follow the safety of their use. As a result, food becomes unsafe for consumption. Nowadays, rooftop gardening is becoming so much popular countrywide where gardeners use less amount of chemicals for pest control or even sometimes they use only the organic options for pest management. As a consequence, there is a great scope for chemical hazardous free crop production on the roof as there is a less chance of contamination by the nearer field because of altitude and environment. Therefore, the present study has been undertaken to promote roof top gardening as a tool for safe food production and consumption.

Objective:

- To study the role of rooftop gardening for safe fruit production and consumption
- To ensure safe and environmentally friendly vertical agriculture

Methodology:

In this experiment, growth and yield performance, chemical and pathological hazards during marketing of Guava were compared with rooftop production and in the farmer's field. The trial was carried out on the rooftop of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and Jhenaigati, Sherpur during the period from May 2020 to June 2022. In this experiment Good Agricultural Practices (GAP) was followed during production, harvesting and postharvest handlings such as INM, IPM, washing and personal hygiene practices etc. IPM practices were applied based on the recommendations to avoid chemical toxicity. In case of soil media, the mixture of 40% coco dust, 20% vermicompost and 40% loamy soil was used. The pathological tests and chemical residual tests had been tested from ICDDRB (Mohakhali, Dhaka) and Toxicology laboratory, Entomology Division, BARI respectively.

Key findings:

- Considering all the growth and yield parameters the plants grown in the field performed better than in rooftop. However, fruits collected from rooftop gardening contained no colonies of *E. coli* (less than 10 CFU) but the marketable fruits collected from farmar's field demonstrated significant amount of *E.coli* colonies ($1.3x10^3$).

Keywords: Rooftop gardening, GAP**,** INM, IPM, Safe food, Fruits

12.5. Adaptive trial of selected fruit crops at farmer's field

Background:

Dragon fruit is one of the very popular exotic fruits among the consumers in Bangladesh. The demand of this fruit is increasing day by day due to its unique taste and quality as it is one kind of cactus species and the fruit is highly nutritious and highly valued. But yet now the production area of this crop is not diversified. On the other hand, BARI Peyera-4 is a newly developed seedless guava variety which is not also spread all over the country. Therefore, the present study has been undertaken to promote dragon fruit and guava production at new region.

Objective:

- To study the performance of selected fruit crops in the selected region
- . To popularize selected fruit varieties in a new region with new growers

Methodology:

An adaptive trial was conducted at the farmer's field of Nalitabari and Jhenaigati upazilla in Sherpur district during April 2020 to June 2022. In this trial BARI dragon fruit-1 and BARI peyara-4 were selected for both locations. In case of Dragon fruit field trial, there were 100 pillars with 400 plants in Jhenaigati upazilla and 80 pillars with 320 plants in Nalitabari upazilla were planted in the field and compared between these two regarding growth characteristics. In case of guava, 50 plants were provided in each place to setup a garden for making growth comparison between two places. In this trial the variety BARI dragon fruit-1 and BARI peyara-4 were used. An area of 15m × 43m was used for BARI dragon fruit-1 and 15m × 22m used for BARI peyara-4. Line to line and plant to plant spacing was approximately 2.5m each for both dragon fruit and guava. For both the crops the pit (1 m x 1 m x 1 m) was dug and about 15-20 kg Cowdung, 250 g TSP, 250 g MoP, 100g Gypsum, 15 g $ZnSO_4$ and 25 g Boron was mixed with the loose soil and keep it for 15-20 days. In case of Dragon fruit a RCC pillar of 8 fit long was placed in the center of pit and 4 Dragon fruit plants were planted in four sides of the pillar.

Key findings:

- In the both cases of Dragon fruit (BARI Dragon fol-1) and Guava (BARI peyara-4) the higher growth and yield were observed in Jhenaigati Upazilla than in Nalitabari.

Keywords: Dragon fruit, Guava, Variety, Adaptive Trial

B. Implementation status

1. Procurement (Component wise):

Component 1: Floriculture Division, HRC, BARI

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Furniture*	08	113000.00	08	113000.00	
(b) Equipment, Tools, etc.*	110	843000.00	110	843000.00	
(c) Small Transport (Two-wheeler: Motor cycle/ Bicycle)*	02	24000.00	02	24000.00	

Component 2: Department of Horticulture, Sher-e-Bangla Agricultural University

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office equipment	15	97000.00	15	97000.00	
(b) Lab &field equipment	6	405000.00	6	405000.00	
(c) Other capital items	8	575000.00	8	575000.00	

Component 3: Pomology Division, HRC, BARI

Description of equipment and capital items	PP Target		Achievement		PP Target
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office/lab equipment					
1. Procurement of Chemicals (Annex A)	1 set	264350	1 set	264350	100%
2. Procurement of Apparatus (Annex B)					
3. Procurement of office /lab equipments	1 set	163500	1 set	163500	100%
a) Digital fruit penetrometer					
b) Digital refractomter	1	20000	1	20000	100%
c) Micropipette	1	85000	1	85000	100%
	1	220000	1	220000	100%
(b) Field equipment/facilities					
4. Procurement for development of vertical and horizontal structure	1 set	250000	1 set	250000	100%
5. Procurement for restructuring of roof	1 roof	150000	1 roof	150000	100%
(c) Other capital items					
6. Procurement of Furniture					100%
a. Almirah	1	30000	1	30000	
b. File Cabinet	1	50000	1	50000	
c. Executive Chair	1	15000	1	15000	
d. Visitor Chair	6	36000	6	36000	
e. Executive table	1	20000	1	20000	
f. Computer table	1	8000	1	8000	
g. Book shelve	1	25000	1	25000	
7. Procurement of Computer and accessories					
a) Laptop					100%
b) Desktop	1	60000	1	60000	
c) Scanner	1	60000	1	60000	
d) HP Laser Printer	1	10000	1	10000	
e) DSLR Camera	1	20000	1	20000	
	1	25000	1	25000	

2. Establishment/renovation facilities:

Component 1. (Floriculture Division, HRC, BARI): N/A

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Shade Structure	750000.00	100%	745845.00	100%	

There were no project activities under this section.

Component 2. Department of Horticulture, Sher-e-Bangla Agricultural University

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
a. Roof, indoor and shed Renovation	810000.00	810000.00	100	100%	

Component 3. (Pomology Division, HRC, BARI): N/A

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

There were no project activitites under this section

3. Training/study tour/ seminar/workshop/conference organized:

Coordination component (Director, HRC, BARI):

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop	45	15	60	1 day	
(c) Others (if any)					

Component 1. Floriculture Division, HRC, BARI

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	170	70	240	1 day	
(b) Workshop	-	-	-	-	
(c) Others (Field day)	260	100	360	1 day	

Component 2. Department of Horticulture, Sher-e-Bangla Agricultural University

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	35	15	50	1 day	
(b) Workshop	-	-	-	-	
(c) Others (if any)	-	-	-	-	

Component 3. Pomology Division, HRC, BARI

Description	Number of participants			Duration (Days/ weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	50	30	80	1 day	-
(b) Workshop	-	-	-	-	-
(c) Others	-	-	-	-	-

C. Financial and physical progress (Combined and Component wise)

Coordination component (Director, HRC, BARI):

Head of Expenditure/Activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)
A. Contractual Staff Salary	250300	138770	133770	5000	96.40
B. Field Research / Lab expenses and supplies	0	0	0	0	0
C. Operating Expenses	170000	75001	65609.50	9391.50	87.48
D. Vehicle Hire and Fuel, Oil & Maintenance	39700	20000	29900	-9900	149.50
E. Training/Workshop/ Seminar etc.	495000	165000	165000	0	100.00
F. Publications and printing	200000	0	0	0	0
G. Miscellaneous	0	0	0	0	0
H. Capital Expenses	0	0	0	0	0
Total	**1155000**	**398771**	**394279.50**	**4491.50**	**98.87**

Component 1. Floriculture Division, HRC, BARI

Head of Expenditure/Activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)
A. Contractual Staff Salary	2242358	1922045	1922044.33	0.67	100.00
B. Field Research / Lab expenses and supplies	6313266	5558563	5555143.7	3419.3	99.94
C. Operating Expenses	488113	423592	423591.8	0.2	100.00
D. Vehicle Hire and Fuel, Oil & Maintenance	478390	478390	478390	0	100.00
E. Training/Workshop/ Seminar etc.	160000	160000	160000	0	100.00
F. Publications and printing	25000	25000	25000	0	100.00
G. Miscellaneous	78872	61400	61400	0	100.00
H. Capital Expenses	980000	799750	799750	0	100.00
Total	**10765999**	**9428740**	**9425319.83**	**3420.17**	**99.96**

Component 2. Department of Horticulture, Sher-e-Bangla Agricultural University

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	932150	606640	887580	-280940		Salary for 2nd year
b. Field research/lab expenses and supplies	2402800	2184000	2202400	-18400		
c. Operating expenses	143847	195000	68037.5	126962.5		
d. Vehicle hire and fuel, oil & maintenance	38600	70000	13600	56400		
e. Training/workshop /seminar etc.	79200	85000	73530	11470		
f. Publications and printing	0	25000	0	25000		
g. Miscellaneous	11903	40000	0	40000		
h. Capital expenses	1062500	1102623	1062500	40123		
Total	**4671000**	**4308263**	**4307647.5**	**615.5**		

Component 3. Pomology Division, HRC, BARI

Fig. in Tk.

Items of expenditure/ activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual Staff Salary	1473790	1253650	1253650	0	100	During bank account closing it will be paid
B. Field Research / Lab expenses and supplies	1981850	2275716	2275716	0	100	
C. Operating Expenses	300000	220574	217346	3,228	98.53	
D. Vehicle Hire and Fuel, Oil & Maintenance	160000	297600	297600	0	100	
E. Training/Workshop/ Seminar etc.	140000	140000	140000	0	100	
F. Publications and printing	50000	50000	50000	0	100	
G. Miscellaneous	89360	79360	79360	0	100	
H. Capital Expenses	1278000	684000	684000	0	100	
Total	**5473000**	**5000900**	**49,97,672**	**3,228**	**99.82**	

D. Achievement of Sub-project by objectives (Tangible form): Technology generated/ developed

Component 1. Floriculture Division, HRC, BARI

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e., product obtained, visible, measurable)	Outcome (short term effect of the research)
a) Specific objectives: (i) To develop production packages for selected flowers and ornamentals on rooftop and field conditions.	Development of production package of selected flowers for rooftop gardening and field condition: • Varietal performance trial of Rose, Chrysanthemum, Lilium, Gerbera, lily, Marigold, Anthurium, Orchid, Cactus and Succulents on the roof. • Effect of different growing media for Rose, Anthurium, Aglaonema, Lisianthus, Ground orchid on the field. • Effect of different growing media for Dianthus, Poinsettia, Cock's comb, Zinnia, Aster, Fern, Cactus, Succulent and Petunia on the roof. • Effect of different crop management (pinching and boron application) for carnation and growth regulator application on chrysanthemum for maximizing yield and quality in the field.	• Enhancement of 2 to 3 fold production and income from rooftop gardening over ordinary production system through the development of the following technologies; • Varieties of two suitable Chrysanthemum, 2 Gerbera, 2 lilies, 1 Anthurium, 1 Rose genotype, 1 Orchid, 2 Cactus, 1 succulent and 2 Marigold have been identified for rooftop gardening. • Five growing media for Rose, Anthurium, Aglaonema, Lisianthus, Ground orchid production on the field have been developed, • Nine growing media have been standardized for Dianthus, Poinsettia, Cock's comb, Zinnia, Aster, Fern, Cactus, Succulent and Petunia for rooftop production. • Two crop management practices have developed for quality production of Carnation and Chrysanthemum flowers.	• Higher production, higher income from rooftop gardening and field condition • Creates more aesthetic values among flower lovers • Feelings of mental peace

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e., product obtained, visible, measurable)	Outcome (short term effect of the research)
(ii) To evaluate the performance of vegetables under soilless culture on rooftop and flower varieties in field conditions	• Effect of different growing media for different vegetable production on the roof. • Soilless production of vegetable • Adaptive trial of BARI Gladiolus-1, BARI Gladiolus-3, BARI Gladiolus-4, BARI Gladiolus-5; Adaptive trial of BARI Tuberose-1 and Promising genotype of tuberose; Adaptive trial of BARI Gypsophila-1; Adaptive trial of BARI Lilium-1, BARI Lilium-2 and Adaptive trial of BARI Marigold-1 and Promising genotype of Marigold.	• One soilless growing media has been standardized for selected five vegetables (Tomato, Capsicum, Cucumber, Bitter gourd and Lettuce) production on the roof. • 50% income of farmer has been increased by the production of vegetables and flower following soil less culture technique. • Fifty farmers of six locations have become interested to grow BARI developed flower varieties	• More interest in rooftop farming • Higher production and higher income • More expansion of BARI released flower varieties to new farmers in a new area. • More farmers are engaged and popularity is increasing

Component 2. Department of Horticulture, SAU, Dhaka

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
Identify and establish sustainable rooftop garden models.	i. Roof-surface management with 3-layers damp-proof membrane ii. Growing media for rooftop farming	- Roof surface damp proofing - Growing media for rooftop farming	- Safe crop cultivation in covid time - Safe vegetables, fruits, herbs farming practices staying home
To design and develop different garden models and devices for rooftop	- Vertical farming technology adopted	- Vertical device made with low cost uPVC pipes	- Vertical Farming technology
Establishment of indoor farm to grow safe vegetables	- Indoor farm with LED light with hydroponic solution	- Indoor farm	- Safe farming - Indoor cultivation with LED light - hydroponic soiless farming
Protected year-round gerbera cultivation	Year-round flower production green-house with fogging irrigation technology	- Semi-automated green house - Fogging irrigation technology	- Year-round flower production with low-cost semi-automated greenhouse establishment - Fogging irrigation technology

Component 3. Pomology Division, HRC, BARI

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e., product obtained, visible, measurable)	Outcome (short term effect of the research)
b) Specific objective: (i) To develop production package of selected fruit crops for rooftop gardening	Development of production package of selected fruits for rooftop gardening: • Varietal performance trial of Dargonfruit, Guava and Goldenaple on the roof. • Performance trial of different types of container for Dragon fruit, Guava and Strawberry on the roof • Effect of different growing media for dragon fruit production on the roof. • Effect of different size of container for dragon fruit production on the roof. • Effect of different methods of dragon fruit production on the roof.	- Enhancement of 2 to 3 fold production and income from rooftop gardening over ordinary production system through the development of the following technologies; -1 most suitable variety for each Dragon fruit, Guava and Golden apple has been findout for rooftop gardening - 1 most suitable container for each Dragon fruit and Guava has been developed. - 2 growing media (soil and soilless) for Dragon fruit production on the roof have been developed, - Methods of Dragon fruit production has been developed through which reduction of 63.31% weight on the roof as well as 3 fold production and income can be achieved.	-Higher production, higher income from rooftop gardening -creates more acces to food and nutrition security -Higher production, higher income from rooftop gardening -creates more acces to food and nutrition security - consumption of safe food
(ii) To generate technologies for selected fruit crops under soilless culture on the roof and in field condition	• Effect of different growing media for dragon fruit production on the roof. • Soilless production of strawberry • Adaptive trial of BARI Dragon fol-1 and BARI Peyara-4	-2 growing media (soil and soilless) for Dragon fruit and 1 media for strawberry production on the roof have been developed. - 50 % income of farmer has been increased by the production of BARI Dragon fol-1 and BARI Peyara-4	- More interest in rooftop farming -Higher production and higher income -More expansion of BARI released fruit varieties to new farmers in a new area. -More farmers are engaged and popularity is increasing

E. Information/knowledge generated/policy generated

Component 1. Floriculture Division, HRC, BARI

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
a) General objective: Improved livelihood of urban and rural horticultural crop growers on the roof and in field condition.	• Provide formal and informal training • Visit innovative rooftop garden • Participatory planning	• Build up capacity of urban and rural crop growers and new entrepreneurs • Gain knowledge on the production technologies of different flower crops for rooftop gardening as well as field condition	• Motivated neighboring farmers for adoption of technologies
b) Specific objective: i) To develop production packages for quality flowers and ornamentals on rooftop and field conditions.	• Joint planning with OFRD team, DAE personnel, NGO representative and Urban growers • Discussion on different technical issues of rooftop gardening	• The most demandable flower crops for rooftop gardening were selected for the development of production package	• Implemented different production methods • Development of activities for rooftop gardening
(ii) To evaluate the performance of vegetables under soilless culture on rooftop and flower varieties in field conditions	• Discussion on different issues with the existing rooftop gardener • Discussion with local building owners • Observation on existing production system	• Information on actual enhancement of production and income	• Improvement in rooftop farming • Higher production and income

Component 2. Department of Horticulture, SAU, Dhaka.

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
Identify and establish sustainable rooftop garden models.	i. Roof-surface management with 3-layers damp-proof membrane ii. Growing media for rooftop farming	- Roof surface damp proofing - Growing media for rooftop farming	- Safe crop cultivation in covid time - Safe vegetables, fruits, herbs farming practices staying home
To design and develop different garden models and devices for rooftop	Vertical farming technology adopted	- Vertical device made with low cost uPVC pipes	Vertical Farming technology
Establishment of indoor farm to grow safe vegetables	Indoor farm with LED light with hydroponic solution	- Indoor farm	- Safe farming - Indoor cultivation with LED light - hydroponic soilless farming
Protected gerbera cultivation year-round	Year-round flower production green-house with fogging irrigation technology	- Semi-automated green house - Fogging irrigation technology	- Year-round flower production with low-cost semi-automated greenhouse establishment - Fogging irrigation technology

Component 3. Pomology Division, HRC, BARI

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
a) General objective: Improved livelihood of urban and rural horticultural crop growers on the roof and in field condition.	- Provide formal and informal training - Visit innovative rooftop garden - Participatory planning	- Build up capacity of urban and ruaral crop growers and new etrepreneurs - Gain knowledge on the production technologies of different fruit crops for rooftop gardening as well as fieldcondition	- Motivated neighboring farmers adopted technologies
b) Specific objective: (i) To develop production package of selected fruit crops for rooftop gardening	- Joint planning with Pomology Division, HRC team, DAE personnel, NGO representative and Urban growers - Discussion on different technical issues of rooftop gardening	- The most demandable crops for rooftop gardening were selected for the development of production package	- Implemented different methods of production and other activities for rooftop gardening
(ii) To generate technologies for selected fruit crops under soilless culture on the roof and in field condition	- Discussion on different issues with the existing rooftop gardener - Discussion with local house owners - Observation on existing production system	- Information on actual enhancement of production and income	- Improvement in rooftop farming - Higher production and income

F. Materials Development/Publication made under the Sub-project:

Component 1. Floriculture Division, HRC, BARI

Publication	Number of publications		Remarks (e.g., paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/ leaflet/flyer etc.		Booklet-01	ছাদে ফুল চাষ
Journal publication	01	2	K. A Ara, M. T. Rashid K, Kabir, M. A. Sadia and S.M. Sharifuzzaman 2021. Effect of substrates on growth, yield and quality of anthurium in soiless culture. B.J.Agric. Res. 46(4): 435-440. K.A Ara, K. Kabir, M. T. Rashid, S.M. Sharifuzzaman and M. A. Sadia. 2022. Influence of foliar application of growth regulators on chrysanthemum. B. J. Agric. Res. 47(1): 69-80.

Publication	Number of publications		Remarks (e.g., paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Video clip/TV program		TV program-4 Video clip-1	BTV, Channel 24, Independent TV, (Youtube channel)
News Paper/Popular Article	2	5	ফুল চাষে খরচ কম, লাভ বেশী। তৈ দৈনিক করতোয়া, ১৪ এপ্রিল ২০২০ সোনাতলায় ৫ গ্রামের ফুলচাষীরা ফুল বিক্রি করে এখন স্বাবলম্বী। দৈনিক করতোয়া, ১ জানুয়ারী ২০২১ গঙ্গাচড়ায় ফুল চাষে সাফল্য দৈনিক ইত্তেফাক, ১৪ ফেব্রুয়ারী ২০২২ ছাদ বাগান: আধুনিক নগর কৃষির সম্ভাবনা সংবাদ, ২৫ আগষ্ট ২০২২ Rooftop gardening. The Daily Observer, October 4, 2022
Other publications, if any			N/A

Component 2. Department of Horticulture, SAU, Dhaka.

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.		2	ছাদে সবজি চাষ পলি হাউজে জারবেরা চাষ
Journal publication			
Video clip/TV program		1	Indoor Farming in Krishi o Jibon Boishakhi TV on aired on 12-07-2021. This episode can be found in youtube channel.
News Paper/Popular Article			
Other publications, if any			N/A

Component 3. Pomology Division, HRC, BARI

Publication	Number of publications		Remarks (e.g., paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/ leaflet/ flyer etc.		1	Improved production technology of Dragon fruit for rooftop gardenng
Journal publication	-	-	-
Video clip/TV program		TV program-7 Video clip-8	DBC, Boishakhi Tv, Asian TV, Desh TV, Bangla TV and Agamir Krishi (Youtube channel)
News Paper/Popular Article		3	১. বীজমুক্ত পেয়ারা চাষে সফল কৃষক (আজকের পত্রিকা, তারিখ: ০২/১০/২০২১) ২. দেশে প্রথম বীজমুক্ত পেয়ারা চাষ করে সফল শেরপুরের আল-আমিন (সাম্প্রতিক দেশকাল, তারিখ: ২৭/০৯/২০২১) ৩. শেরপুরে কৃষককে নতুন স্বপ্ন দেখাচ্ছে ড্রাগন (আলোকিত বাংলাদেশ, তারিখ: ১৮/০৯/২০২১)
Other publications, if any			N/A

G. Description of generated Technology/knowledge/policy:

(i). Technology Fact Sheet (title, introduction, description, suitable location/ecosystem, benefits, name and contact address of author) N/A

Component 3. Pomology Division, HRC, BARI:

Fact Sheet-1

Title: Development of production package for Dragon fruit production on the roof

Introduction

- Roof top gardening is one of the potential areas for vertical expansion. Dragon fruit is one of the very popular exotic fruits among the consumers in Bangladesh. City gardeners growing it on their roof due to its unique taste and quality, as it is one kind of cactus species and the fruit is highly nutritious and highly valued. So, there is a great scope for dragon fruit production on the roof.
- In this regard, proper knowledge on production technology of dragon fruit production for rooftop gardening is so essencial to get the expected yield and income.

Description

- First of all, cuttings of BARI Dragon fol-1 needs to be collected for planting. 30-40 cm long cutting is the best for planting and the best time is April to May.
- GI pipe and geobag based structure is needed for the proper growth of the plants.
- 30 L geobag is perfect for better growth and yield of dragon fruit on the roof.
- 2 cuttings are planted per container. After planting side brunches must be removed time to time until it reaches to the top for allowing quick growth.
- Vermi-compost should be applied as organic manure every two months after planting at the rate of 1 kg/tub. Chemical fertilizers such as urea, TSP, MoP should be applied every month (12 times a year) at the rate of 50 gm/tub, 75gm/tub and 50 gm/tub respectively. However, Boron (2 gm/tub) also can be applied at the rate of 5 gm/tub during final media preparation and after 6 month of planting
- For increasing fruit size flower and fruit thining is necessary and its better to allow nomore than 2 fruits/bruch at a time and maintain atleast 1fit distance between tow fruits.
- For ensuring fruiting success hand pollination is must.
- The harvesting of Dragon fruit is initiated on mid-June and continued up to November.
- The average yield of BARI Dragon fol-1 (3 years old) is 15 kg/pillar.

Suitable areas: High lands in all over the country.

Benefit of the technology:

- BARI Dragon fol-1 with GI pipe and geobag based structure is more productive and profitable than any other system.
- GI pipe+Geobag+soilless media combination not only reduce about 68.92% weight on the roof but also boost up yield by 723% more than normal drum system by with BCR-3.08.

(ii) Effectiveness in policy support (if applicable)

- This technology could effectively be disseminated to all over the country which can support family nutrition and income.

H. Technology/Knowledge generation/Policy Support (as applied)

Component 3. (Pomology Division, HRC, BARI):

i. Immediate impact on generated technology (commodity and non-commodity)

- Increases options for family nutrition and economic return in the vertical space due to adoption of rooftop gardening with such high value fruit crops.
- Develop enterpreneurship to supply safe fruits to the urban consumer through the greater extension of rooftop farming.
- It will create employment opportunity and enhance income generation for urban women.

ii. Generation of new knowledge that help in developing more technology in future

- Community based seedling raising by women will open new concept for community based nursery management and income generation
- Relatively safe food production under rooftop farming can develop supply chain for safe food market outlets
- Due to higher and safe production of fruits it will create an opportunity for unemployed youth lead community market.
- Greater adoption of agroforestry system and eventual benefit will help efficient land use system
- Rapidly growing rooftop gardens with fruit crops open greater scope for different kinds of research activities on rooftop gardening by NARS scientists in future.

iii. Technology transferred that help increased agricultural productivity and farmers' income

- Through the demonstration of Dragon fruit variety BARI Dragon fol-1 the farmer's income has been increased by 50% than the previous year and the new growers are creating that chabges the livelihood.
- Seedless guava BARI Peyara-4 creates a new vibes among the growers.
- Through the development of the production technologies of dragon fruit production on the roof the new gardeners are producing dragon fruit on the roof that in fact, converting fallow roof into edible roof.

iv. Policy Support

- Development of production package of different horticultural crops specially fruit crops can play a pivotal role regarding meetigation of climate change induced crop failure, enhancing vertical productivity for achieving SDGs.
- Rooftop farming reduces green house effect through C sequestration by crops and trees.
- Rooftop farming with fruits is a great scope for uplifting food and nutrition security and hence it will attract greater attention to formulate policy planning for poverty reduction.

I. Information regarding Desk and field Monitoring

i. Desk Monitoring [description and output of consultation meeting, monitoring workshops/ seminars etc.): N/A

ii. Field monitoring

Component 1. (Floriculture Division, HRC, BARI):

Year	No of visit	Place of visit	Name and address	Remarks
2020	01	HRC, BARI, Gazipur	Dr. Shaikh Mohammad Bokhtiar, Executive Chairman, BARC,Farmgate, Dhaka	He was highly satisfied after visiting of this project activities
2020	01	HRC, BARI, Gazipur	Dr. Md. Abdul Jalil Bhuyan, Research Management Specialist	Need to especial emphasis on production package of flower and ornamentals on rooftop
2021	01	HRC, BARI, Gazipur	Dr. Md. Harunur Rashid, Director, PIU-BARC, NATP-2 Dr. Md. Abdul Jalil Bhuyan, Research Management Specialist	Need special emphasis to complete the rest of task using alternate plan overcoming the losses due to COVID-19 pandemic situation
2021	01	HRC, BARI, Gazipur	1. Dr. Md. Abdul Jalil Bhuyan, Research Management Specialist BARC, Farmgate, Dhaka 2. Md. Ashikur Rahman, Assistant Manager Accounts BARC, Farmgate, Dhaka 3. Dipak Kumar, Monitoring Associate, BARC, Farmgate, Dhaka 4. Md. Hasan Mahmud, Capacity Development Associate BARC, Farmgate, Dhaka	Visitors expressed their high satisfaction and suggested for further improvement
2022	01	RARS, Burirhat, Rangpur	1. Munshi Mamunur Rahman Documentation Associate, PIU-BARC, NATP-2 2. A. K. M. Rakib Ullah, Resource Management Associate, PIU-BARC, NATP-2 3. S. K. Humaun Kabir. Assistant ICT Specialist, PIU-BARC, NATP-2	Visitors expressed their high satisfaction on dissemination of different flower varieties and farmer's economic return. They suggested to follow crop rotation
2022	01	HRC, BARI, Gazipur	1. Dr. Md. Serajul Islam, Environmental and Social safeguard specialist, PIU-BARC, NATP-2 2. Munshi Mamunur Rahman, Documentation Associate, PIU-BARC, NATP-2 3. A. K. M. Rakib Ullah, Resource Management Associate, PIU-BARC, NATP-2	Visitors express their greater interest on rooftop farming and suggested to disseminate different technologies and also suggested to properly label the different items purchased by the sub-project.
2022	02	RARS, Burirhat, Rangpur	1. A. K. M. Rakib Ullah, Resource Management Associate, PIU-BARC, NATP-2 2. S. K. Humaun Kabir, Assistant ICT Specialist, PIU-BARC, NATP-2	Visitors expressed their high satisfaction on dissemination of different flower varieties and suggested to follow clean cultivation
2022	03	ARS, Rajshahi	1. Dr. Md. Serajul Islam, Environmental and Social safeguard specialist, PIU-BARC, NATP-2 2. Munshi Mamunur Rahman, Documentation Associate, PIU-BARC, NATP-2 3. S. K. Humaun Kabir. Assistant ICT Specialist, PIU-BARC, NATP-2	Visitors expressed their high satisfaction on dissemination of different flower varieties and suggested to farmer's maintaing postharvest quality of the produce to get high economic return

Fig. 66. Monitoring by NATP BARC & Other High Officials (Component-1)

Component 2. Department of Horticulture, SAU, Dhaka.

ii. Field monitoring

Year	No of visit	Name and address	Remarks
2021	01	1. Dr. Md. Harun -ur-Rashid, Director, PIU-BARC-NATP-2, Farmgate, Dhaka-1215 2. Md. Shahidul Islam, Procurement Specialist, PIU-BARC-NATP-2, Farmgate, Dhaka-1215 3. Dr. Md. Abdullah Al Faruk, Assistant Director (Admin), PIU-BARC-NATP-2, Farmgate, Dhaka-1215 4. Md. Ashikur Rahman, Assistant Director (Accounts), PIU-BARC-NATP-2, Farmgate, Dhaka-1215	Visitors express their high satisfactiontion and suggested for further improvement

Fig. 67. Monitoring by NATP BARC & Other High Officials (Component-2)

Component 3. Pomology Division, HRC, BARI:

ii. Field monitoring

Year	No of visit	Name and address	Remarks
2021	01	1. **Dr. Md. Abdul Jalil Bhuyan,** Research Management Specialist 2. **Md. Ashikur Rahman,** Assistant Manager Accounts 3. **Dipak Kumar,** Monitoring Associate 4. **Md. Hasan Mahmud,** Capacity Development Associate	Visitors express their high satisfaction and suggested for further improvement
2022	02	1. **Dr. Md. Serajul Islam,** Environmental and Social safeguard specialist, PIU-BARC, NATP-2 2. **Munshi Mamunur Rahman,** Documentation Associate, PIU-BARC, NATP-2 3. **A. K. M. Rakib Ullah,** Resource Management Associate, PIU-BARC, NATP-2	Visitors express their greater interest on rooftop farming and suggested to disseminate different technologies and also suggested to properly label the different items purchased by the sub-project.



Fig. 68. Monitoring by NATP BARC & Other High Officials (Component-3)

J. Sub-project auditing (covers all types of audit performed)

Coordination component (Director, HRC, BARI)

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Financial Audit by FAPAD	No issues			

Component 1. (Floriculture Division, HRC, BARI)

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Financial Audit by FAPAD	No issues			

Component 2. (Department of Horticulture, Sher-e-Bangla Agricultural University)

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
M I Chowdhury & Co Chartered Accountant	No issues			
Financial Audit by FAPAD	No issues			

Component 3. (Pomology Division HRC, BARI)

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Financial Audit by FAPAD	No issues			

K. Lessons Learned

Component 1 (Floriculture Division, HRC, BARI):

i. Prior to sat up a rooftop gardening, building should be constructed in planned way;

ii. Enhance development of entrepreneurship for quality seed/seedling production of flower and ornamental crops and their marketing; and

iii. Motivational program/Training/Group discussion/Development of LSP would be helpful for widescale adoption of rooftop technologies.

Component 3 (Pomology Division, HRC, BARI):

iv. Rooftop gardening is so potential production system which ensures year round production, nutrient supply and cash income.

v. Rapidly growing rooftop gardens can be brought under core agriculture system which will enhance total production and income generation of urban farming.

vi. New building should be well planned beforehead for rooftop gardening

vii. Enhance development of enterpreneurship for selling safe fruits and their marketing.

viii. Motivational program/Training/Group discussion/Development of LSP would be helpful for widescale adoption of rooftop technologies.

L. Challenges (if any)

Component 1 (Floriculture Division, HRC, BARI):

i. Research activities were hampered due to Corona Pandemic;

ii. Environmental stress and hazards like viz. - excess rain, drought, cyclone, storms are difficulties for rooftop gardening; and

iii. Sometimes lower market price of the produce make the farmers disinterested to produce flower

Component 3 (Pomology Division, HRC, BARI):

1. Problems/ Constraints

Component 1 (Floriculture Division, HRC, BARI):

i. Lack of labour in crop growing season
ii. Little difficult in management of fruit trees due to lack of proper space
iii. Lack of skillness of farmers on crop and fruit tree management in rooftop gardening.
iv. Lack of scientific staff having good understanding of necessary data collection from rooftop farming system.
v. Lack of training facility for gardeners, scientific staff and scientific personnel on rooftop farming
vi. Sometimes sudden storms difficulties for rooftop gardening.

M. Suggestions for future planning (if any)

Component 1 (Floriculture Division, HRC, BARI):

- Optimum growing media should be identified for flower production
- Marketing channel needs to develop for ensuring maximum profit of farmer's product
- Multidisciplinary research scientists should be involved for more effective research.

Component 3 (Pomology Division, HRC, BARI):

- Provision of long-term support to a greater number of household will help for continuing rooftop gardening.
- Multidisciplinary team including crop scientist, soil researcher, environmental expert and economist should be involved at each research site for more effective research..
- Farming system should be digitalized through Data Driven Decision Making Tools (Models), crop monitoring tools through GIS (Geological Information System) and IoT (Internet of Things), Integration options way out through ML (Machine learning), DL (Deep Learning) and ANN (Artificial Nural Network) in cloud computing platform.

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Signature of the Coordinator
Date : December 2022
Seal

Dr. Gobinda Chandra Biswas
Director (C.C.)
Horticultural Research Center
BARI, Gazipur-1701

Counter signature of the Head of the organization/authorized representative
Date : December 2022
Seal

Dr. Debasish Sarker
Director General
Bangladesh Agricultural Research Institute
Gazipur-1701

Annexture 1

Project activities published in local/ National Dailies by Component 1. Floriculture Division, HRC, BARI, Gazipur

দৈনিক
করতোয়া

ফুল চাষে খরচ কম, লাভ বেশি

‘গ্লাডিওলাস’ হতে পারে চাষির ঘরে নতুন ফসল

বগুড়ার সোনাতলায় ৫ গ্রামে বাণিজ্যিকভাবে ফুলের চাষ হচ্ছে —করতোয়া

সোনাতলায় ৫ গ্রামের ফুলচাষিরা ফুল বিক্রি করে এখন স্বাবলম্বী

বগুড়া-অফিস থেকে,সোনাতলা (বগুড়া) : বগুড়ার সোনাতলায় বাণিজ্যিক ভাবে ফুল চাষ করা হচ্ছে। তবে লাভজনক ফসল হওয়ায় অনেক বেকার যুবক ফুল বিক্রি করে স্বাবলম্বী হয়েছে।

গত বুধবার সরজমিনে উপজেলার চন্দনগাছা এলাকায় গিয়ে দেখা গেছে, ওই গ্রামের মোস্তেজার রহমান তার ৫০ শতক জমিতে ফুলের চাষ করেন। তার ওই জমি থেকে এবার প্রায় আড়াই লাখ টাকা আয় করবেন বলে তিনি আশাবাদ ব্যক্ত করেন। একই গ্রামের নূরে আলম শিশু জানান, তার ৯০ শতক জমিতে গ্লাডিওলাস, রজনী গন্ধা ও গাঁদা ফুলের চাষ করেন। এছাড়াও খুজাইকপুর গ্রামের শফিকুজ্জামান তার ৬০ শতক জমিতে গত কয়েক বছর ধরে ফুল চাষ করে মুখের হাসানা ফিরে পেয়েছেন। এছাড়াও বাদুনিয়া ও নলর পাড়ার অনেক কৃষক ও বেকার যুবক ফুল চাষ করে স্বাবলম্বী হয়েছেন। ওই গ্রামের কৃষকেরা জানান, ফুল চাষে উৎপাদন খরচ কম লাভ বেশি। তাই দিনদিন সোনাতলা উপজেলার বিভিন্ন এলাকায় কৃষকেরা ফুল চাষে ঝুঁকে পড়ছেন।

এ বিষয়ে উপজেলা কৃষি কর্মকর্তা কৃষিবিদ সালাহ উদ্দিন সরদার জানান, এবার সোনাতলা উপজেলার বিভিন্ন এলাকায় ব্যাপক ফুলের চাষ হয়েছে। এটি একটি লাভজনক ফসল। কৃষক ফুলের বীজ বপনের ৩ মাসের মধ্যে ফুল বিক্রি করতে পারে। ফুল চাষে উৎপাদন খরচ কম লাভ বেশি। তাই দিন দিন কৃষকেরা অন্য ফসলের চেয়ে ফুল চাষে ঝুঁকে পড়ছে। ওই উপজেলার ৫ গ্রামের কৃষকেরা বিশ্ব ভালবাসা দিবসকে সামনে রেখে ফুল চাষের পরিচর্যায় ব্যস্ত হয়ে পড়েছেন পাশাপাশি কৃষি বিজ্ঞান ও কৃষি কর্মকর্তা সদা তাদেরকে পরামর্শ দিয়ে সহযোগিতা করে যাচ্ছেন। উপজেলার বিভিন্ন গ্রাম ঘুরে ফুলচাষীদের গ্লাডিওলাস,রজনীগন্ধা ও গাঁদা ফুলের বেশি চাষ করতে দেখা গেছে। আবার কিছু কিছু এলাকায় ছায়াঘেরা ফুল বিক্রেতারা বিভিন্ন শিক্ষা প্রতিষ্ঠানের ফুল ফটকে জমা যোগে ফুলের চারা ও ফুল এনে বিক্রি করছে। কথা হয় তাদের কয়েক জনের সাথে। উপজেলার শামসুপুর গ্রামের তুহিন মিয়াকে (২৩) মুখাদপুকুর দাদিয়া উচ্চ বিদ্যালয়ের ফুল ফটকে ফুল বিক্রি করতে দেখা গেছে। তুহিন জানায় তাদের অজানী সংসারে ১০/১১ বছর আগে তার পিতার অকাল মৃত্যু ঘটে। সেই থেকে সংসারের হাল ধরে সে। পরিবারে মা ও ছোট দুইবোন। ফোনমিন ও জনি। ওরা দুই জন গ্রামীক বিদ্যালয়ে ৯ম ও ৪র্থ শ্রেণীতে অধ্যয়নরত। পাড়ির ২/৩ শতক জমি ছাড়া তাদের জমি নেই তার। সামান্যতম ফুল বিক্রি করে সংসার চলে বেশ ভালো। অপরদিকে উপজেলার মহিষবন্দ বহুমুখী উচ্চ বিদ্যালয় এলাকার পরীক্ষা কেন্দ্রের সামনে কয়েকজন ফুল বিক্রেতাকে ফুল বিক্রি করতে দেখা গেছে। শিক্ষার্থীরা ফুলের গাছের চারা কিনছে বেশ ভালো। এভাবে ওই উপজেলার বিভিন্ন এলাকার প্রায় শতাধিক বেকার যুবক ফুলের চারা বিক্রি করে সুখের হাসানা ফিরে পেয়েছেন।

daily observer

Rooftop gardening

দৈনিক ইত্তেফাক

গাছচড়ায় ফুল চাষে রশিদের ৩ লাখ টাকা মুনাফা

সংবাদ

ছাদ বাগান : আধুনিক নগর কৃষির সম্ভাবনা

NEWAGE

SUNDAY, JANUARY 3, 2021, PAUSH 19, 1427 BS

Foreign affairs secretary Masud Bin Momen inspects a cactus nursery during his visit to Bangladesh Agricultural Research Institute in Joydevpur in Gazipur on Saturday. —Press release

কালের কণ্ঠ

ছাদ উদ্যানে ফসল চাষের প্রযুক্তি উদ্ভাবন

বাংলাদেশ কৃষি গবেষণা ইনস্টিটিউটের (বারি) উদ্যানতত্ত্ব গবেষণা কেন্দ্রের আয়োজনে 'বাংলাদেশে শহরাঞ্চলের মাঠ ও ছাদে উদ্যানে ফসল চাষের প্রযুক্তি উদ্ভাবন' শীর্ষক দিনব্যাপী এক কর্মশালা গতকাল অনুষ্ঠিত হয়েছে। বাংলাদেশ কৃষি গবেষণা কাউন্সিলের (বিএআরসি) এনএটিপি ফেজ-২ প্রকল্পের অর্থায়নে এ কর্মশালার আয়োজন করা হয়।

Annexture 2

Component 1. Floriculture Division, HRC, BARI, Gazipur
(Project activities)

Pic: Propagule distribution

Pic: Field Day

Pic: Training

Annexture 3

Component 2. Dept. of Horticulture, SAU, Dhaka

Project activities: Roof-top visit and interviewing during base-line survey work

Component 2. Dept. of Horticulture, SAU, Dhaka

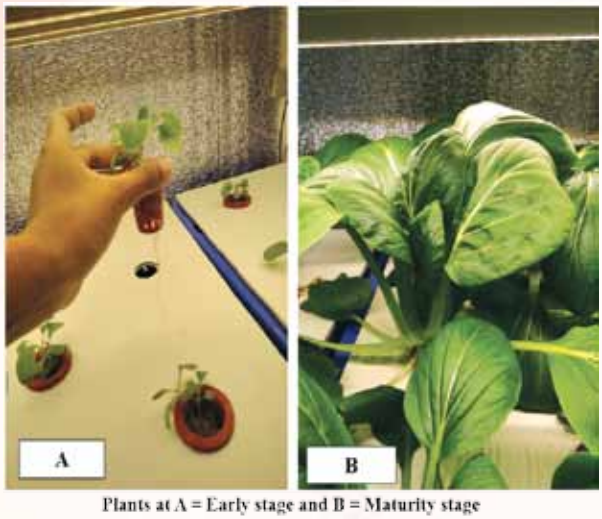
(Project activities)

Constructed semi-automated shed-house with fogging irrigation system

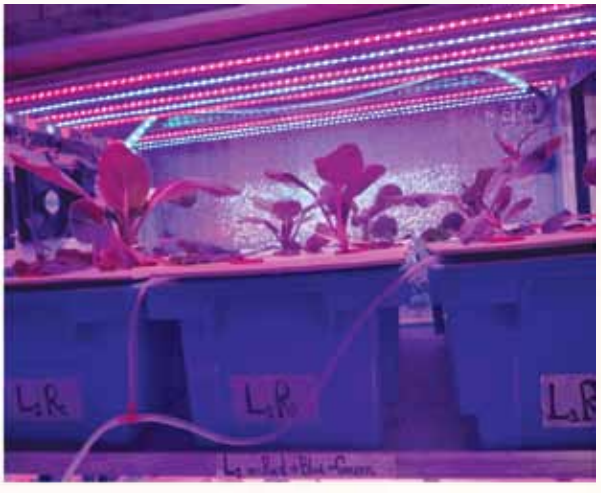
Constructed indoor grow-house for growing year-round horticultural crops

Annexture 5

Component 2. Dept. of Horticulture, SAU, Dhaka
(Project activities)



Plants at A = Early stage and B = Maturity stage



Plant growth under red + blue + green at 4:1:1 ration (L_1)

Plant growth under white - Full light (L_5)

Plant growth under Fluorescent light (control) - Full (L_6 - Warm)

Evaluation of plant growth and yield of pakchoi under different led-light spectrum in indoor vertical grow-house

Annexture 6

(Project activities published in local/ National Dailies by Component 3: Pomology Division, HRC, BARI, Gazipur)

সুসংবাদ প্রতিদিন alokito2013@gmail.com

শেরপুরে কৃষককে রঙিন স্বপ্ন দেখাচ্ছে ড্রাগন

বীজমুক্ত পেয়ারা চাষ করে সফল ঝিনাইগাতীর আল আমিন

শেরপুর প্রতিনিধি

দৈনিক দেশচিত্র

deshchitro.com

শেরপুরের ঝিনাইগাতীতে কৃষি মেলার সমাপনী ও পুরস্কার বিতরণ অনুষ্ঠিত

আজকের পত্রিকা

ঝিনাইগাতীতে বীজমুক্ত পেয়ারা চাষে সফল আল আমিন। আজকের পত্রিকা

বীজমুক্ত পেয়ারা চাষে সফল কৃষক

Annexture 7

Component 3. Pomology Division, HRC, BARI, Gazipur

Farmers Training

Field Monitoring