PERFORMANCE OF SOME SELECTED WINTER VEGETABLES IN ROOFTOP GARDEN

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CERTIFICATE

This is to certify that the thesis entitled, "Performance of some selected winter vegetables in rooftop garden" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN AGROFORESTRY AND ENVIRONMENTAL SCIENCE, embodies the result of a piece of bonafide research work carried out by SANGEETA KARMAKAR, Registration No. 10-04112 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information, as has been availed of during the course of this investigation have duly been acknowledged.

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DEDICATED
TO
MY BELOVED PARENTS

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The Author

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ABSTRACT

Roof top garden is suitable for vegetables cultivation in our country. Cabbage, cauliflower and broccoli are important vegetables of robi season in our country. This experiment was conducted at roof of third floor of Biotechnology Department of Sher-e-Bangla Agricultural University, Dhaka during October 2016 to March 2017. The experiment was laid out in CRD having single factors with three replications. The treatment of this experiment were T_1= Cabbage, T_2= Cauliflower and T_3=broccoli. The seedlings of three vegetables (BARI Badakopi 1, BARI Fulkopi 1 and BARI Broccoli 1) were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Yield and yield parameters value were increased with increasing days after transplanting for cabbage, cauliflower and broccoli with all of the traits studied plant except few parameter. For cabbage the highest plant height (26.87 cm) was observed at 45 DAT and leaf length (26.67 cm) was observed at 60 DAT.In cabbage the head length, breadth and yield per plant were observed of 8.37cm, 14.96 cm and 1091.33 g respectively. The light intensity was more in upper canopy than beneath the canopy. The maximum (272.26 klux) light intensity was measured at 1.0 PM at 30 DAT upper canopies.Soil moisture was fluctuated slightly at different time of a day. Soil temperature was high at 1.00PM and then less for all observations. In case of

cauliflower the highest plant height (41.33 cm) and number of leaves per plant (25.00) was recorded at 60 DAT. In addition highest leaf length (40.20 cm), leaf breadth (20.5 cm) and canopy area (41.33 cm) was observed at 60 DAT. Curd length, breadth and yield per plant were measured of 19.68 cm, 17.65 cm and 274.12 g respectively. For broccoli plant height (48.60 cm) and leaves per plant (17.33) was highest at 60 DAT. Curd length, breadth and yield per plant were found 15.20 cm, 13.83 cm and 155.83 g, respectively. Highest light intensity was observed as 252.13 klux at 1.00PM at 60 DAT in upper canopy. Less fluctuation of soil moisture was observed for different time of day. Therefore it was suggested that the yield components and yield of cabbage, cauliflower and broccoli were positively increased on rooftop garden which create favorable condition in soil environment.

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SOME COMMONLY USED ABREVIATIONS

Full word	Abbreviation
Percent	%
Degree Celsius	^0C
At the rate	@
Agro Ecological Zone	AEZ
Agriculture	Agric.
Agricultural	Agril.
Agronomy	Agron.
Analysis of variance	ANOVA
Bangladesh Agricultural Research Institute	BARI
Bangladesh Bureau of Statistics	BBS
Bangladesh	BD
Centimeter	cm
Cultivars	cv.
Degrees of Freedom	Df
And others	*et al.*
Etcetera	etc.
Food and Agricultural Organization	FAO
Gram	g
Journal	J.
Kilogram	Kg
Meter	m
For example	e.g.
Hectare	Ha
Square meter	M^2
Days after transplanting	DAT
Mean sum of square	MS
Murate of Potash	MoP
Ministry of Agriculture	MoA
Complete Randomized Design	CRD

Sher-e-Bnagla Agicultural University	SAU
Triple Super Phosphate	TSP

CHAPTER I
INTRODUCTION

A rooftop garden is a garden on the roof of a building. Besides the attractive benefit, roof plantings may offer food, temperature manage, hydrological benefits, architectural enrichment, habitats or corridors for wildlife, entertaining opportunities, and in extensively it may even have conservation benefits (Sajjaduzzaman *et al.*, 2005). Rooftop garden can supplement the diets of the community it feeds with fresh produce and provide a tangible benefits tie to food production. Also contributes to food security by increasing the supply of food and by enhancing the quality of perishable foods reaching urban consumers (Koc *et al.*, 1999; Mann, 2001; Bellows and Hamm, 2003). Rooftop food gardens have many of the benefits, if not more, that other forms of urban agriculture that occur on the ground have including carbon dioxide abatement, less expired roofing material being sent to the landfill, storm water retention, and noise reduction (Rowe, 2011). In exploring the UA activities in Dhaka and found that, inner city Urban Agriculture favors production activities that require a minimum of land and a maximum of the most readily available resources, labor. In the heart of residential and business district Dhaka, where land has its highest cost. Urban Agriculture tends to be synonymous with opportunistic planting of trees or annuals, plants that use little or no land such as vines and hanging cucurbits grown from roof gardens or hanging pots, various branches of high valued horticulture, including vegetables, flowers, herbs, and potted shrubs, economically useful tree varieties that provide fruit, nuts, flowers, borders and shade, and small scale livestock production built on exploitation of 'free' organic waste (Remenyi, 2000). Although UA has been in the city for many years and it has contributed to additional income of the households, it is still no more than a "sideline subsistence activity". However, this is not unique to Dhaka and similar findings are reported in other studies of food security. For the poor of the city, "the potential in Urban Agriculture yet to be exploited as a strategy of poverty alleviation" (Remenyi, 2000).

Rooftop farming is suitable for vegetables crop growing in our country. Vegetables play an important role in balance diet of human beings. It is rich in vitamins and minerals as well as a good source of carbohydrates. Vegetables of Bangladesh are grouped into summer, winter and year round on the basis of growing season. Total production of vegetables meets up to 45-50% of the requirement of the country. Cabbage, cauliflower and broccoli are important high value crops among vegetables in winter season of Bangladesh. These are common and economically important vegetables in Bangladesh (BBS, 2010). Due to follow of vegetable production on rooftop garden food production will be increased which meet the demand of urban people and also reduce the meal costs of transport as well as enlarge the fresher and healthy food production. However, the practically of green roof agriculture has not been extensively tested. This is a new research work that ever performed at this university in these crops. In this research work the suitability of three vegetable crops on rooftop conditions is evaluated. Rooftop develops a sense of self identity and independence, where one can primarily achieve self and emotion regulation viewing different flower indifferent seasons (Rashid and Ahmed, 2009) and affords restorative experience from demanding everyday activities in urban high rise residential building.

Keeping these in mind, this research was undertaken with following objectives:

- To study the morphological characteristics and yield performance of different winter vegetables in rooftop garden; and
- To find out the microclimatic condition in rooftop garden in relation to yield performance of winter vegetables.

CHAPTER II

REVIEW OF LITERATURE

The present investigation was carried out to study the winter vegetables production in rooftop garden. The pertinent literature in relation to the proposed work is reviewed in this chapter:

2.1 Urban agriculture

Urban agriculture reduces the urban heat island effect which is the elevated temperatures of urban areas and improves the air quality in cities because particulates are removed from the air (Unger & Wooten, 2006).

The long and rich history of urban gardening movements in America is feeding the current urban agriculture movement. A new generation of leaders, citizens, gardeners, activists, planners and designers are finding sustainable methods to support growing urban populations (Roehr and Kunigk, 2009).

In 2009, the city of Vancouver, British Columbia, developed a “multi disciplinary taskforce representing various government offices and tasked it with developing recommendations for urban agriculture throughout the city” (Mukherji and Morales, 2010).

Urban agriculture is a key component to a sustainable community food system and can remove the diet related diseases associated with food deserts because healthy foods are not available at affordable prices (Cano, 2011). Urban agriculture provides ecological habitats (Cosier, 2011).

Urban agriculture is the practice of cultivating, processing, and distributing food in or around a village, town, or city. It can also involve animal husbandry, aquaculture, agroforestry, urban beekeeping and horticulture. These activities occur in peri-urban areas as well as urban areas (FAO, 2013).

Urban agriculture reduces greenhouse gas emissions by selecting the right crops and a significant amount of greenhouse gas emissions can be saved. In the United Kingdom, a life cycle analysis showed that the conversion of 26 hectares of vacant land to community farming could reduce greenhouse gas emissions by 881 tons of carbon dioxide equivalent per acre (Kulak *et al.*, 2013).

Conventional systems for producing fruits and vegetables are extremely energy intensive and the need to transport the produce to smaller markets by heavy good vehicles, ships, and planes (Kulak *et al*., 2013). Urban agriculture can reduce these negative effects because the food is grown and sold locally.

2.3 Rooftop Agriculture

Shuvo (2000), projected for a theoretical skeleton based on an mandatory on-site revision to 'long-term greening' and discussed how this framework should permit a sustainable mainstreaming of the violated constructions ensuring fiscal reimbursement for RAJUK, edifice owner and the 'green industry' identical.

Islam (2001), studied that urban inhabitants in the cities of rising countries are growing fast which also means the quantity of low-income consumers is escalating. Because of this, food insecurity in these cities is rising. Urban agriculture contributes to food defense by growing the supply of food and by enhancing the quality of fragile foods attainment urban consumers. In this study he was try to recognize the potential for and barriers to UA with orientation to rooftop gardening and to discover strategies to encourage food security in Dhaka.

Kamron (2006), has published an article named 'Adoption of roof gardening at Mirpur-10 area under Dhaka city'. She revealed that the preferred distinctiveness of the respondents, family size, roof gardening knowledge, use of information sources, approach towards roof gardening and familiarity of roof gardening had encouraging consequence of relationship with their acceptance of roof gardening. Other characteristics namely: age, family education and family earnings did not show any significant relationship with the respondent's adoption of roof gardening.

Lundholm and oberndorfer (2007), verified that without difficulty measured plant traits (height, individual leaf area, specific leaf area, and leaf dry matter content) can be used to choose species to optimize green roof performance across manifold key services.

Moustier (2007), provides an widespread summary of the significance of urban agriculture in 14 African and Asian cities. Among the consequences they found that 90 % of all vegetables consumed in Dares Salaam (Jacobi *et al.*, 2000) and 60 % of vegetables consumed in Dakar create from urban agriculture.

Rooftops are ubiquitous and underutilized components of this urban landscape. With advancements in technology, desire for increased green space in a time of economic turmoil, and the public and political will to support urban gardens, the opportunity for rooftop food production has never been greater (Burros, 2009).

Rashid and Ahmed (2010), presented the thermal performance of rooftop garden in a six storied building established in 2003. He found that the temperature of this construction is 3°C lower than other surrounding buildings and this green appliance can lessen the interior air temperature 6.8°C from open-air throughout the hottest summer Period.

Some advantages of rooftop gardening over growing food on the ground area that contamination can be controlled, soil composition can be controlled, soil composition can be managed, and the growth of nuisance weeds are less likely (Urban Design Lab, 2012).

Sharmin (2013), has reported in a case study on green roof and revealed that it is an innovative approach to attain environmental sustainability and thermal comfort in Dhaka. She found that green areas (like parks, gardens, vegetation, play fields) in cities and urban lands are being replaced with impervious surfaces resulting from pressure of urbanization which is creating broad and varied urban ecological degradations. She was focuses on this paper about the potential of widespread over deep exhaustive green roof in conservation the urban built environment and improving environmental sustainability and the local thermal comfort level in impenetrable urban areas of Dhaka city.

Mostafa *et al.,* (2013); established in his study of present status of rooftop farming in Sylhet City Corporation of Bangladesh that each gardener was paying attention in growing of rooftop garden as they think that home gardens could facilitate them to earnings and keep money 29.8% respondents were occupied in gardening for monetary point, 54.9% respondents for green amelioration, 95.3% was in support of mental happiness, aesthetic value (82.5%) and relaxation time activity (87.8%).

Orsini *et al*., (2014); conducted an experiment to study the quantification of the prospective rooftop vegetable production in the city of Bologna (Italy) as related to its citizen's needs. The prospective benefits to urban biodiversity and ecosystem service prerequisite were estimated. RTGs could afford more than 12,000 t year^{-1} vegetables to Bologna, satisfying 77 % of the inhabitants' requirements.

Kamrujjaman (2017), wrote a book name "Green Banking" regarding the rooftop gardening. The book contains seven chapters describing the thermal profit of roof gardens and the overall techniques and farming procedures of vegetables, fruits, flowers/ornamental plants and multipurpose use of roof garden.

2.4 Performance of studied crop in plain land

2.3.1 Cabbage

A field experiment was conducted in Mymensingh, Bangladesh, on cabbage cv. Atlas-70 and reported that the highest gross yield was 118.72 t/ha and the highest fresh weight of individual head was 2.376 kg. The highest marketable yield was 79.69 t/ha and harvest index was 80.17 with a spacing of 50 cm × 50 cm (Mannan *et al*., 2001).

Kumar (2002), conducted a field experiment on the quality and yield of cabbage cv. Pride of India. The highest total soluble solid (8.80%) and chlorophyll (0.29 mg/g) contents and head diameter (14.30 cm), the highest mean head weight (1127.22 g) and head yield (312.42 q/ha)was observed from the growth of cabbage.

Kumar and Rawat (2002), conducted an experiment in Horticulture farm, Rajasthan College of Agriculture, Udanipur on cabbage cv. "Pride of India" and found that the highest head weight was 1127.22 g and yield was 312.42 q/ha.

Meena (2003), conducted an experiment and found that the average head weight was the highest 831.3 g and the lowest 766.3 g. The percent harvest index was the highest 71.3 and the lowest 70.3 in cabbage.

Pramanik (2007), conducted an experiment in Sher-e-Bangla Agricultural University and reported that at harvest cabbage shown the plant height of 34.76 cm and thickness of head was 17.06 cm in the field level.

Alam (2007), reported that canopy area was measured as 22.43 cm in cabbage. The head diameter ranged from 10.87 to 18.23cm. The head weight was observed 811.3 g in this crop.

An experiment was carried out by Khatun (2008) on the growth and yield of cabbage and revealed that the highest plant height, maximum diameter of head, fresh weight head and gross yield were 37.70 cm, 19.05 cm, 1.87 kg and 71.20 t/ha, respectively; and marketable yield was 53.97 t/ha recorded from 60 cm x 40 cm spacing.

An experiment was carried out by Ullah (2011) on the growth and yield of cabbage. The plant height (31.5 cm), maximum diameter of head (19.4 cm) and the highest fresh weight (1.00 kg) and the lowest weight (0.53 kg) were found from suitable growth of cabbage.

Paul (2011), conducted an experiment in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2010 to February 2011. He found that the maximum thickness and highest yield was 20.11cm and 62.55 t/ha respectively in cabbage cultivation. At 30 DAT the maximum plant height was 30.42 cm and the minimum was 27.61. The maximum plant height was 36.76 cm and the minimum was 31.43 cm at 60 DAT. At 30 DAT the number of leaves per plant was 12.28 and it was 15.05 at 60 DAT. The canopy area was

44.48 cm at 30 DAT. At 60 DAT canopy area was 54.99 cm. Leaf length was 33.10 cm and leaf breadth was 26.39 cm. Head diameter was 10.73 cm and head weight was 1337 g.

Afrin (2013), conducted an experiment Horticultural Farm of Sher-e-Bangla Agricultural University during October 2012 to March 2013 on cabbage. She reported that the plant height was 18.46 and 36.73 cm for 30 and 60 DAT, respectively. The number of leaves per plant was 8.20 and 17.98 at 30 and 60 DAT respectively. The canopy area was observed as 20.24 and 35.33 cm at 30 and 60 DAT. Head breadth was recorded as 9.89 cm. The head weight with leaves was 1.29 kg.

Majumdar (2013), conducted an experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka on cabbage. She found that the plant hight was 19.0 and 41.5 cm at 30 and 60 DAT. The canopy area was 24.4 and 42.6 cm at 30 and 60 DAT, respectively. Head diameter was 11.5 cm and head weight with leaves was 1.42 kg. Yield per plant was recorded as 1.09 kg.

2.3.2 Cauliflower

Tripathi and Sharma (1991), studied on growth and yield of Cauliflower and showed that plant height, number of leaf sheaths, diameter of main shoot, root length and plant spread were 35.73 cm, 17.4, 5.02 cm, 18.42 cm and 24.22 cm, respectively in seedlings planted at 6 weeks old, but curd weight and diameter were 0.54 kg and 13.31 cm, respectively in seedlings planted at 5 weeks old.

Pathak and Nishi Keshari (2003), conducted a pot experiments of cauliflower with the supply of neem seed cake, mustard cake and reported that the highest plant height (28.6 cm) and root length (19.3 cm) were obtained. The highest fresh shoot (30.3 g) and root weight (6.8 g) were obtained with 25 kg need seed cake /kg soil.

Mahamud (2006), studied on cauliflower in Sher-e-Bangla Agricultural University, Dhaka and reported that the maximum plant height was observed as 52.25 cm. At harvest the maximum number of leaves per plant was found as 17.83. The longest leaf length per plant was recorded 43.70 cm and leaf breadth was 18.73 cm. Curd weight with leaves was 893.28 g. Yield per pant was 613.48g. At harvest the maximum curd diameter was 17.02 cm and the maximum curd height was 15.98 cm. The maximum curd weight per plant was 406.05 g.

Kodithuwakku and Kirthisinghel (2009), conducted a field experiment on growth, yield and post harvest life of cauliflower (*Brassica oleracea* L) using a RCD Design at the University, University of Peradeniya, Peradeniya, Sri Lanka. The average cauliflower curd yield in the field varied between 90 - 125 g/plant (3.6 – 5.0 t/ha). The mean curd diameter of the plots varying from of 11.8-13.0 cm. The highest mean height of the cauliflower plant was obtained 10.16 cm and lowest was 8.88 cm.

Kakani (2012), conducted an experiment in Horticultural college and research institute, Dr. Y. S. R. Horticultural University, West Godavari on cauliflower. He found at harvest that superior plant height was 56.03 cm and lowest plant height was noted as 52.10 cm. Highest canopy area was recorded as 59.75 cm lowest plant spread was 48.13 cm.

2.3.3 Broccoli

Mathur *et al.*, (1976); observed in their experiments conducted in India on the effect of different spacing-cum-nitrogen doses on the yield of Broccoli that, plants spaced at 45 x 45,61 x 61 and 76 x 76 cm yielded 14317,10331 and 8077 kg/ha respectively.

Roy (1981), reported that ranged of curd diameter from 15.1-20.2 cm and yields from 1083-2614 kg/ha of broccoli with cv. Dania.

Rodrigues and Casali (1999), Showed that the highest estimated yields of 119.5, 119.4 and 153.9 g/ plant were obtained with 37.7 t/ha organic compost t/ha with no mineral fertilizer application in broccoli.

Waltert and Theiler (2003), conducted on the effects of growth of different cultivars of Broccoli and revealed that the correlation was high between the diameter of stem and plant biomass and diameter of stem and curd. Growth of stem and curd diameter is dependent on days after transplantation in the field, but dependence is even stronger if related to the sum of maximum daily temperature. Growth of curd showed higher cultivar variation and was more sensitive to environmental factors than growth of stem.

Mahamud (2006), found that the longest (43.70 cm) leaf was recorded at harvest in broccoli when studied experiment.

2.4 Role of microclimatic condition on rooftop

Green roofs also increase habitat and biodiversity, from a microbial level to that of plants and animals. There are also resource and economic savings attributed to green roofs. By acting as self-regulating insulation they reduce heating and cooling costs for buildings. Also, by blocking harmful UV rays, they can increase the lifespan of waterproofing membranes by 2.5 to 3 times (McIntyre, 2007; Dunnett and Kingsbury, 2004; Barnes, 2007).

Carter and Butler (2008), reported how storm water preservation, building energy and temperature, and rooftop habitation are subjective by the use of green roofs using test plots in Georgia and Massachusetts. Green roofs were revealed to restore part of the predevelopment hydrology through escalating interception, storm water storage, evaporation, and transpiration on the rooftop and worked extremely well for small storm events. Temperature reductions were found on the green rooftop as compared to an asphalt surface.

Green roofs are gaining popularity as a tool to mitigate many of the negative environmental effects caused by urbanization. They have been proven to reduce the urban heat island effect, absorb storm water, decrease energy used for heating and cooling, improve air quality, and sequester and store carbon and other greenhouse gases contributing to global climate change (Sohn, 2009).

Rashid and Ahmed (2009), reported that green roof reduces the ceiling surface temperature by a maximum of 3°C and mean 1.7°C, in association to bare roof. The typical indoor air temperature is reduced by 2.4°C with roof during sunshine hours. The sum of solar heat energy incoming into the indoors throughout green roof in comparison with the bare roof is reduced by more than three times. Daily mean indoor air temperature is 33.0°C with bare roof. This is reduced by 3.0°C with green roof, so falling the mean indoor air temperature to 30.0°C.

Tabassum and Sharmin (2010), reported that less green space creates urban heat island effect due to more reflection of solar emission and open-air temperature of denser built up area in Dhaka is 1˚C-1.5˚C upper than the immediate urban zones with less green coverage and also can be higher at a range of 0.5-1˚C than the mean meteorological documentation. This study also showed that inside temperature of inhabited buildings in less green enclosed neighborhoods get higher at a range of 1˚C-2˚C thus creates thermal distress among occupants.

A vegetated roof provides habitats for birds and insects which increases biodiversity within an urban area. "Then can provide food, habitat, shelter, nesting opportunities, and a safe resting place for spiders, beetles, butterflies, birds, and other invertebrates" (Foss *et al.*, 2011). On average, green roofs have had temperatures 3 to 4 degrees Celsius cooler than surrounding traditional roofs (Foss *et al.*, 2011). Green roofs are sustainable infrastructure features that should be implemented throughout urban areas to mitigate some of the increased heat (Berger, 2013).

Rooftop agriculture can reduce the urban heat island effect. The urban heat island effect is the elevated temperature (~ 2 to 4 degrees Celsius) within cities or other urban areas compared with surrounding rural areas caused by non-reflective surfaces that store incoming infrared radiation, ultimately storing heat. Increased vegetation on rooftops cools the surface more cost effectively than the installation of light roofs which increase reflectivity (Urban Design Lab, 2012).

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The entire experimental site (rooftop) was divided into three blocks which was made by brick wall. The measurement of each block was 12 m x 1m x 0.5 m. Each block was divided into 3 m x 1 m plot leaving 1.5 m area in plots. So, total experimental plots were nine in three blocks containing three treatments with three replications. The experiment was conducted at the roof of third floor of Biotechnology Department of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October 2016 to March 2017. Photograph showing the experimental site (Appendix 20).

3.2 Soil and Climate

The soils used in this experimentation was collected from Savar Upazilla which is called vitimati. The texture class of this collected soil was Sandy loam with grayish color. The pre collected soils was chemically tested in the Soil Science Laboratory, SAU and the composition of the soil was given in the Appendix 21. The climate of the experimental site is characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). The records of air temperature, humidity and rainfall during the period of experiment were noted from the Bangladesh Meteorological Department, Agargaon, Dhaka (Appendix 22).

3.3Experimental materials

The healthy seedlings of three crops viz.BARI Badacopi 1,BARI Fulcopi 1,and BARI Broccoli 1 were collected from BARI. Gazipur which was used as experimental materials.

3.4 Treatments of the experiment

Three crops were used as treatments.

T_1= Cabbage

T_2= Cauliflower

T_3= Broccoli

3.5 Experimental design and layout

The experiment was laid out in Complete Randomized Design (CRD) having single factor with three replications. Total experimental area was divided into three replications. A design of experimental plot presented in Plate 1. Each replication size was 12 m x 1 m, and the distance between replications was 1.5 m. Total treatments were three and total plots were nine. The size of each plot was 3 m x 1 m, which accommodated eighteen plants at a spacing of 0.3 m x 0.3 m. A pictorial view of experimental field at vegetative stage is presented in Plate 2.

3.6 Land preparation

Before starting the experiment the collected soils and cowdung (recommended) were well mixtured and previously incorporated in the blocks. The supplied soils were free of stubbles and weed roots. The soil were spaded well and necessary labeling was done.

3.7 Application of manure and fertilizer

The crop was fertilized as the rate of 15 tons of cowdung, 275 Kg urea, 175 Kg triple super phosphate (TSP), 220 Kg murate of potash (MoP) per hectare. The one third amount of urea, total amount of cowdung, MoP and TSP were applied during final land preparation. Rest of urea fertilizer applied in two installments. First installment was applied 10 days after transplanting and second installment was applied after 30 days of transplanting.

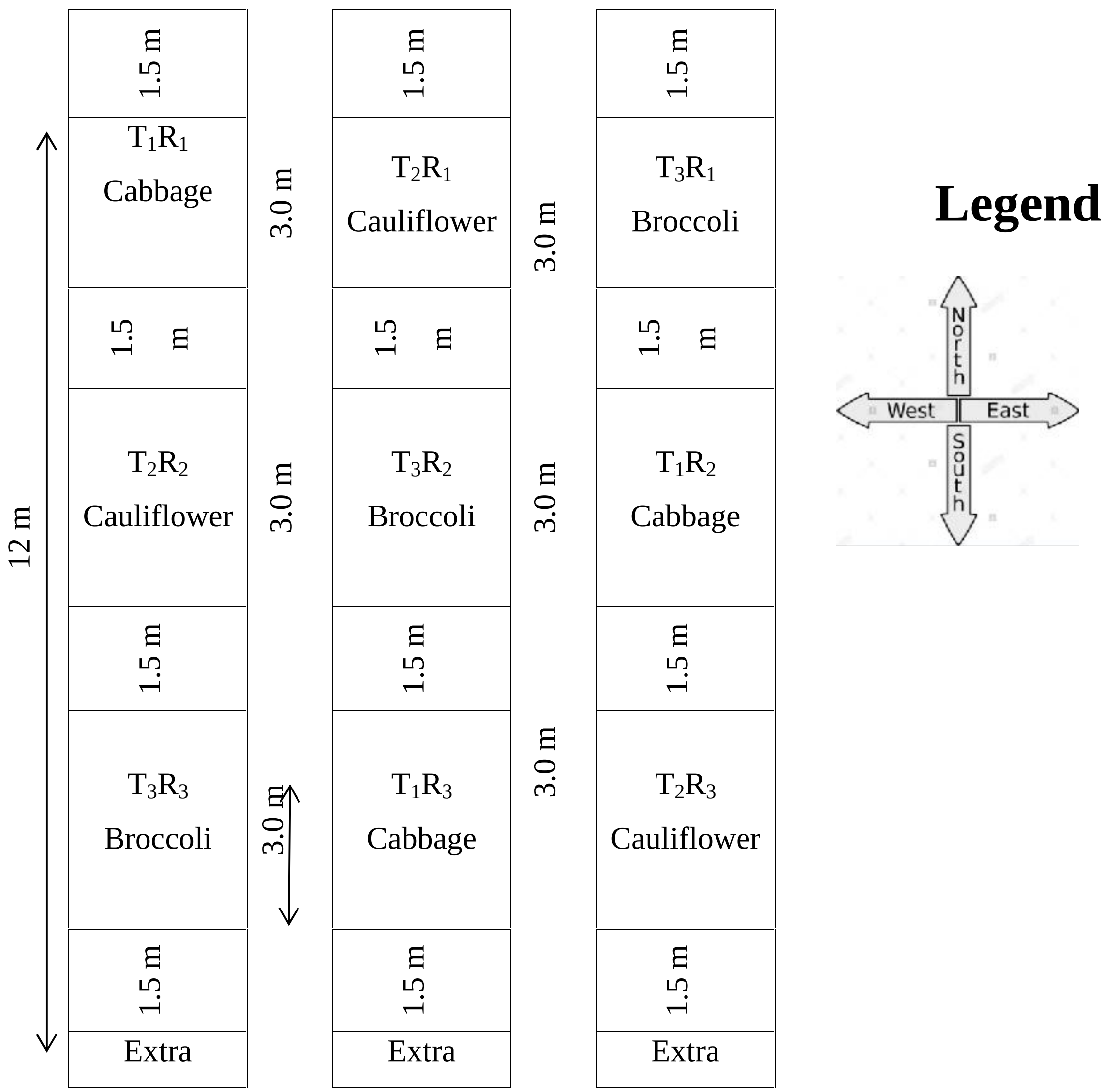

Plate 1. Layout of the experimental plot

Total population: 162

Total Treatments: 3

Total Replication: 3

Total Plot: 9

Plot size: 12 m x 1 m

T_1 = Cabbage

T_2 = Cauliflower

T_3 = Broccoli

Plate 2. Experiment of rooftop garden

Plate 3: Structure of rooftop garden

Plate 4: Transplanting of seedlings

3.8 Transplanting of seedlings

Healthy and uniform 30 days old seedlings of the vegetables (cabbage, cauliflower and broccoli) were transplanted in the experimental plots in 27thNovember 2016 maintaining a spacing of 30 cm x 30 cm between the plants and rows, respectively. All seedlings were collected from BARI. This way of transplanting allowed an accommodation of eighteen plants in each replication. The seedlings were watered after transplanting. Some seedlings were also planted around the border area of the experimental plots for gap filling (Plate 4).

3.9 Intercultural operations

Intercultural operations, such as gap filling, weeding and irrigation etc. were done uniformly in all the plots for better growth and development of the plants, which are as follows:

a) Gap filling

When the seedlings were well established, the soil around the base of each seedling was pulverized. A few gap filling was done by strong and healthy seedlings of the same stock where initial planted seedling failed to survive.

b) Weeding

Weeding were accomplished as and whenever necessary to keep the crop free from weeds for better soil aeration and to break the crust of soil.

c) Irrigation

Light irrigation was provided immediately after transplanting the seedlings and it was continued till the seedlings established in the field. Thereafter irrigation was provided as per when needed (Plate 6).

3.10 Harvesting

The compact matured curd of cauliflower was harvested during 10 January to 12 February, 2017. In case of broccoli matured curd was harvested during 20 February to 02 March, 2017.

Cabbage was harvested during the period from 20 to 30 March, 2017 when the plants formed compacted heads. Harvesting was done plot wise after testing the compactness of the cabbage head by thumb. The compact head showed comparatively a hard feeling. Each head was collected by cutting at the base of the plant.

3.11 Data collection

Five plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

3.11.1 Plant height

Plant height was measured in centimeter (cm) by a meter scale at 30, 45, 60 days after transplanting (DAT) from the point of ground level up to the tip of the longest leaf.

3.11.2 Number of leaves per plant

Number of leaves were counted from five randomly selected plants at 30, 45, 60 days after transplanting (DAT). All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of five plants gave number of leaves per plant.

Plate 5: Vegetative growth of experimental crops

Plate 6: Irrigation in rooftop garden

Plate 7: Yield performance of experimental crops

3.11.3 Leaf length

Leaf length of five randomly selected plants was measured in centimeter (cm). It was measured from the base of the petiole to the tip of the leaf of each plant were measured separately with a meter scale. Only the smallest young leaves at the growing point of the plant were excluded from counting.

3.11.4 Leaf breadth

Leaf breadth of five randomly selected plants was measured from the widest central and two terminal portion of the lamina with a meter scale and average breadth was recorded in centimeter (cm). Leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from counting.

3.11.5 Canopy area

Measurement of canopy area was done by visual estimates (Richardson *et al.*, 1973). It is estimated in cm of five randomly selected plants at 30, 45, 60 days after transplanting (DAT).

3.11.6 Curd length

Length (cm) of the curd of cauliflower and broccoli were recorded from the junction of last upper leaves to tip of curd at matured stage from five randomly selected plants. It was measured in centimeter (cm) and each of plant was measured separately.

3.11.7 Head length

Length of head of cabbage was measured in cm with the help of a scale placed vertically along the head.

3.11.8 Curd breadth

Curd breadth of cauliflower and broccoli were recorded in equatorial directions with a meter scale at matured stage from five randomly selected plants and measured in centimeter (cm) and each of plant was measured separately.

3.11.9 Head breadth

The harvested head of cabbage was placed on a table in flat position and the diameter was measured in (cm) with a meter scale.

3.11.10 Curd weight with leaves

Cauliflower and broccoli curd were weighted from five randomly selected plants excluding roots and outer leaves. It was measured in gram per curd with leaves and each of curd was measured separately. It was denoted as g.

3.11.11 Head weight with leaves

The cabbage head was weighted excluding roots and outer leaves from selected plant. It was measured in gram and denoted as g.

3.11.12 Curd yield per plant

Cauliflower and broccoli curd were weighted from five randomly selected plants excluding all leaves and roots except curd. It was measured in gram per curd without leaves and each of curd was measured separately. It was denoted as g.

3.11.13 Head yield per plant

Cabbage head was weighted from five randomly selected plants excluding all leaves and roots except head. It was measured in gram per head without leaves and each of head was measured separately. It was denoted as g.

3.11.14 Light measurement

Light was measured by Lux meter on each vegetable crop rows.It was done to determine the availability of light and expressed as Klux. Light intensities were measured above and beneath the canopy of vegetable crops at 10.00 am, 1.00 pm and 4.00 pm using Lux meter at 30, 45, 60 days after transplanting (DAT).(Plate 8)

3.11.15 Soil moisture measurement

Soil moisture was measured by Soil Moisture Meter on each vegetable crop rows (Plate 9). It was expressed as percentage (%). Soil moisture was measured at 10 cm depth of soil adjacent to main root of vegetable crop rows at 10.00 am, 1.00 pm and 4.00 pm at 30, 45, 60 days after transplanting (DAT).

3.11.16 Soil temperature measurement

Soil temperature was measured by Soil Temperature Meter on each vegetable crop rows (Plate 9). It was expressed as degree centigrade (˚C). Soil temperature was measured at 10 cm deep soil adjacent to main root of vegetable crop rows at 10.00 am, 1.00 pm and 4.00 pm at 30, 45, 60 days after transplanting (DAT).

3.12 Statistical analysis

The data collected from the experimental plots were statistically analyzed by using MSTAT software. The mean values for all the treatments were calculated and the analysis of variance (ANOVA) for most of the characters was accaccomplished by DMRT. The significance of difference between pair of means was tested by the least significant difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

Plate 8: Measuring the light intensity in experimental crops.

Plate 9: Measuring the soil moisture and soil temperature in the experiment

CHAPTER IV
RESULTS AND DISCUSSIONS

The results of the present study have been presented and discussed in this chapter under the following heading.

4.1 Cabbage

4.1.1 Plant height (cm)

Cabbage grown in the rooftop garden showed significant differences in terms of plant height at different days after transplanting (DAT) (Appendix 1). The highest plant height (26.87 cm) was recorded at 60 DAT while the shortest one (19.37 cm) was observed at 30 DAT (Table 1). It was increased 27.91% from 30 DAT to 45 DAT for cabbage and 17.67% from 30 DAT to 60 DAT. The decreased of plant height in 60 DAT because of standing leaves were closed together compact and produced head in cabbage. Pramanik (2007) reported that at harvest cabbage shown the plant height was 34.76 cm.

4.1.2 Number of leaves per plant

Number of leaves per plant is an important factor for increasing production. Number of leaves per plant increased with the increasing days after transplanting (DAT). In cabbage number of leaves per plant was found the highest (26.4) at 60 DAT and the lowest

(15.33) at 30 DAT (Table 1). Tripathi and Sharma (1991) reported the number of leaves per plant was 17.4 at harvest in cabbage in plain land.

Table 1. Effect of cabbage on plant height, number of leaves per plant and leaf length at different days after transplanting (DAT) in rooftop garden

Days after transplanting (DAT)	Plant height (cm)	Number of leaves per plant	Leaf length
30	19.367±0.95	15.333±0.18	21.367±1.18
45	26.867± 1.48	20.933±0.93	25.700±1.78
60	23.533±2.03	26.400±1.42	26.667±0.38
CV (%)	16.16	26.49	11.48

SE = standard error, CV (%) = coefficient of variation

Table 2. Effect of cabbage on leaf breadth and canopy at different days after transplanting (DAT) in rooftop garden

Days after transplanting (DAT)	Leaf breadth (cm)	Canopy area (cm)
30	13.47±0.80	19.37±2.95
45	19.07±0.58	26.87±1.53
60	20.93±0.23	23.53±0.46
CV (%)	21.79	16.16

SE = standard error, CV (%) = coefficient of variation

4.1.3 Leaf length

Significant variation was observed for leaf length (Appendix 1). The highest leaf length (26.67 cm) was observed at 60 DAT and lowest (21.37 cm) at 30 DAT (Table 1). It was observed that leaf length was increased with the increasing of days after transplanting for cabbage.

4.1.4 Leaf breadth (cm)

Leaf breadth was found significantly different for cabbage production. The highest (20.93 cm) leaf breadth was recorded at 60 DAT and lowest (13.46 cm) was found at 30 DAT. These results revealed that the leaf breadth is increased with the increasing days after transplanting. Increasing of leaf breadth was observed 29.38% from 30 DAT to 45 DAT and 35.69% from 30 DAT to 60 DAT for this crop.

4.1.5 Canopy area (cm)

The maximum (26.87 cm) canopy area was obtained at 45 DAT for cabbage and it was minimum (19.37 cm) at 30 DAT (Table 2). It was observed that canopy area was increased with the increasing of days after transplanting for this crop but in case of 45 DAT to 60 DAT it was reduced. In case of cabbage it was increased 27.91% from 30

DAT to 45 DAT and 17.67% from 30 DAT to 60 DAT. The increasing trend was reduced for cabbage at 60 DAT because when cabbage at harvest stage the head become compact and all leaves are close together. So, canopy area at 60 DAT was reduced than the 45 DAT. Alam (2007) reported that canopy area was measure as 22.43 cm. Majumdar (2013) reported that the canopy area was 24.4 and 42.6 cm at 30 and 60 DAT, respectively in cabbage.

4.1.6 Head length (cm)

Head length for cabbage varied significantly (Appendix 3). The head length was observed 8.37 cm (Table 3). Pramanik (2007) reported that cabbage head length was 17.06 cm in the field level.

4.1.7 Head breadth (cm)

Head breadth for cabbage varied significantly produced in rooftop garden (Appendix 3). Head breadth was performed as 14.96 cm (Table 3). An experiment was carried out by Ullah (2011) in cabbage and found that maximum diameter of head was 19.4 cm. Kumar (2002) reported that head diameter was 14.30 cm for cabbage.

4.1.8 Head weight with leaves (g)

Head weight with leaves for cabbage differ significantly when produced in rooftop garden (Appendix 3). The head weight with leaves was recorded in cabbage of 1348.33 g when produced in rooftop garden in this experiment (Table 3). Kumar and Rawat (2002) conducted an experiment on cabbage with cv. "Pride of India" and found that the highest head weight was 1127.22 g at harvest. Khatun (2008) found that the highest fresh weight of head was 1.87 kg of cabbage.

4.1.9 Head yield per plant (g)

Head yield per plant of cabbage that means head weight without leaves varied significantly produced in rooftop garden (Appendix 4). The head yield per plant was 1091.33 g in cabbage production (Table 4). Meena (2003) conducted an experiment and found that the average head weight of cabbage was the highest 831.3 g and the lowest 766.3 g. Majumdar (2013) reported that head yield per plant was recorded as 1.09 kg in cabbage.

Table 3. Morphological characteristics of cabbage grown at rooftop garden

Traits	Mean±SE	CV (%)
Head length (cm)	8.37±0.26	2.28
Head breadth (cm)	14.96±0.71	6.94
Head weight with leaves (g)	1348.33±173.02	22.23

Table 4. Yield performance of cabbage grown at rooftop garden

Crop	Head yield per plant (g)	Head yield (t/ha)
Cabbage	1091.33±73.09	40.42±1.65
CV (%)	11.60	5.34

Table 5. Available light intensity near cabbage canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	**45**	**60**
10.00 AM	240.46±30.01	11.30±0.59	218.86±7.86
1.00 PM	272.26±18.83	10.96±0.15	9.12±1.61
4.00 PM	41.00±3.82	2.01±0.18	23.53±1.17

SE = standard error, CV (%) = coefficient of variation

4.1.10 Head yield (t/ha)

Head yield tons per hectare means total head weight without leaves in a hectare varied significantly produced in rooftop garden. The head yield tons per hectare was 40.42 tons in cabbage production. Meena (2003) found that the average head yield per hectare was the highest 70.3 tons and the lowest 61.45 tons per hectare in plain land. Majumdar (2013) reported that head yield per hectare was recorded as 65.21 tons in cabbage in plain land.

4.1.11 Light availability (klux)

Light availability of cabbage was observed in this study in two place upper canopy and beneath the canopy at 30, 45 and 60 DAT. Light intensity was measure in three different time viz. 10 AM, 1 PM and 4 PM.

4.1.11.1 Light intensity in upper canopy at 30 DAT

Significant difference of light intensity was found for cabbage production in rooftop garden measuring upper the canopy at 30 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. The maximum (272.26 klux and 41.00 klux) light intensity was measure by cabbage at 1.0 PM and 4.0 PM respectively (Figure 5).

4.1.11.2 Light intensity in upper canopy at 45 DAT

Significant difference of light intensity was found for cabbage production in rooftop garden measuring upper the canopy at 45 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. Lowest light intensity was observed by cabbage at 1.00 PM (10.961 klux) and 4.00 PM (2.01 klux).

4.1.11.3 Light intensity in upper canopy at 60 DAT

The study of light intensity on cabbage was significant difference for growing in rooftop garden measuring upper the canopy at 60 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. The lowest light intensity was observed by cabbage at 1.00 PM (9.12 klux).

4.1.12 Soil moisture

The soil moisture (%) availability of different crops were observed in this study at 30, 45 and 60 DAT. Soil moisture (%) was measure in three different time viz. 10.00AM, 1.0 PM and 4.00 PM.

4.1.12.1 Soil moisture at 30 DAT

Non significant variation was observed on cabbage for soil moisture (%) grown in rooftop garden measuring at 30 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM. The highest soil moisture (%) was measure by cabbage at 1.00 PM (22.99%) and 4.00 PM (21.27%) (Figure 6).

4.1.12.2 Soil moisture at 45 DAT

Non significant variation was observed for cabbage for soil moisture (%) grown in rooftop garden measuring at 45 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM. The lowest soil moisture (%) was measured by cabbage at 10.00 AM (16.33%) and 1.00 PM (15.49%).

4.1.12.3 Soil moisture at 60 DAT

Significant variation was observed for cabbage for soil moisture (%) grown in rooftop garden measuring at 60 DAT in two times 1.00 PM and 4.00 PM (Table 6). The highest soil moisture (%) was measure by cabbage at 1.00 PM (19.28%) and 4.000 PM (20.05%) (Table 6).

Table 6. Available soil moisture near cabbage canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	45	60
10.00 AM	18.92±2.25	16.33±2.34	18.94±2.97
1.00 PM	22.99±1.18	15.49±2.12	19.28±1.76
4.00 PM	21.27±1.43	18.23±1.65	20.06±2.24
CV (%)	9.70	8.41	2.96

Table 7. Available soil temperature near cabbage canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	45	60
10.00 AM	24.08±0.68	25.14±0.75	22.18±0.69
1.00 PM	25.89±0.87	27.48±0.98	23.80±.54
4.00 PM	23.69±1.65	27.26±1.13	24.51±1.54
CV (%)	4.78	4.85	5.08

SE = standard error, CV (%) = coefficient of variation

4.1.13 Soil temperature

The effect of soil temperature (%) of cabbage was observed in this study at 30, 45 and 60 DAT. Soil temperature (%) was measure in three different time viz. 10.00 AM, 1.00 PM and 4.00 PM.

4.1.13.1 Soil temperature at 30 DAT

Significant variation was observed for cabbage for soil temperature (%) grown in rooftop garden measuring at 30 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 7). The lowest soil temperature (%) was measured by cabbage at 4.00 PM (23.68%).

4.13.2 Soil temperature at 45 DAT

Significant variation was observed for cabbage for soil temperature (%) grown in rooftop garden measuring at 45 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 7). The highest soil temperature (%) was measure by cabbage at 10.00 AM (25.14%), 1.00 AM (27.48%) and 4.00 PM (27.25%) (Table 7).

4.13.3 Soil temperature at 60 DAT

Significant variation was observed for cabbage for soil temperature (%) grown in rooftop garden measuring at 60 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 7). The lowest soil temperature (%) was measured by cabbage at 10.00 AM (22.18%) and 1.00 PM (23.80%).

4.2 Cauliflower

4.2.1 Plant height (cm)

Cauliflower grown in the rooftop garden showed significant differences in terms of plant height at different days after transplanting (DAT) (Table 8). The highest (41.33 cm) plant height was observed at 60 DAT while the lowest plant height (22.70 cm) was recorded at 30 DAT. Plant height is one of the important parameter, which regulate crop yield. Tripathi and Sharma (1991) studied on growth and yield of Cauliflower and showed that plant height was 35.73 cm at harvest in plain land. Pathak and Nishi Keshari (2003) revealed that the highest plant height of cauliflower was 28.6 cm at harvest in plain land.

4.2.2 Number of leaves per plant

Number of leaves per plant is an important factor for increasing production. Number of leaves per plant increased with the increasing days after transplanting (DAT). In cauliflower the highest (25.00) number of leaves per plant was recorded at 60 DAT and lowest was observed at 30 DAT. Number of leaves per plant was increased 20.82% from 30 DAT to 45 DAT and 33.08% from 30 DAT to 60 DAT in case of cauliflower production.

4.2.3 Leaf length

It was observed that highest (40.20 cm) leaf length at 60 DAT and lowest (23.78 cm) at 30 DAT. It was observed that leaf length was increased with the increasing of days after transplanting for cauliflower. Increasing of leaf length was observed 33.53% from 30 DAT to 45 DAT and 45.10% from 30 DAT to 60 DAT for this crop.

Table 8. Effect of cauliflower on plant height, number of leaves per plant and leaf length at different days after transplanting (DAT) in rooftop garden

Days after transplanting (DAT)	Plant height (cm)	Number of leaves per plant	Leaf length (cm)
30	22.700±0.68	16.733±1.01	23.780±0.49
45	33.533±1.07	21.133±0.81	35.333±2.28
60	41.333±3.07	25.000±0.81	40.200±3.29
CV (%)	28.77	19.74	25.48

SE = standard error, CV (%) = coefficient of variation

Table 9. Effect of cauliflower on leaf breadth and canopy area at different days after transplanting (DAT) in rooftop garden

Days after transplanting (DAT)	Leaf breadth (cm)	Canopy area (cm)
30 DAT	11.37±2.89	22.70±1.54
45 DAT	17.33±1.66	33.53±0.92
60 DAT	20.50±1.78	41.33±2.77
CV (%)	28.77	19.74

SE = standard error, CV (%) = coefficient of variation

Table 10. Morphological characteristics of cauliflower grown at rooftop garden

Traits	Mean±SE	CV (%)
Curd length (cm)	19.68±0.41	8.48
Curd breadth (cm)	17.65±0.12	1.39
Curd weight with leaves (g)	486±112.65	40.15

SE = standard error, CV (%) = coefficient of variation

4.2.4 Leaf breadth (cm)

Leaf breadth was found significantly different for cauliflower production. Highest leaf breadth (20.50) was observed at 60 DAT and lowest (11.36 cm) at 30 DAT for this crop (Table 9). These results revealed that the leaf breadth is increased with the increasing days after transplanting. For cauliflower this increasing trend was 34.44% and 44.57% from 30 DAT to 45 DAT and 30 DAT to 60 DAT respectively.

4.2.5 Canopy area (cm)

At 60 DAT the maximum (41.33 cm) canopy area was obtained by cauliflower and minimum (22.70 cm) was measure at 30 DAT for this crop. It was observed that canopy area was increased with the increasing of days after transplanting for this crop. Increasing of canopy area was observed 32.30% from 30 DAT to 45 DAT and 45.08% from 30 DAT to 60 DAT.

4.2.6 Curd length (cm)

Curd length of cauliflower varied significantly (Table 10). Curd length was measured 19.68 cm. Kannan *et al.*, (2016) studied and revealed that curd length was 12.82 cm in cauliflower.

4.2.7 Curd breadth (cm)

Curd breadth in case of cauliflower varied significantly produced in rooftop garden . The curd breadth was obtained from cauliflower of 17.65 cm (Table 10). Kannan *et al.* (2016) studied and revealed that curd breadth was 6.94 cm in this crop and Roy (1981) reported that ranged of curd diameter from 15.10-20.20 cm.

4.2.8 Curd weight with leaves (g)

Curd weight with leaves different significantly produced in rooftop garden (Table 10). Curd weight with leaves was obtained from cauliflower as 486 g.

4.2.9 Curd yield per plant (g)

Curd yield per plant that means curd weight without leaves in case of cauliflower varied significantly produced in rooftop garden. The value of curd yield per plant was 274.12 g in cauliflower (Table 11). The average cauliflower curd yield in the field varied between 90 - 125 g per plant reported by Kodithuwakku and Kirthisinghe1 (2009). Mahamud (2006) found that curd yield per plant was 613.48g in case for this crop.

4.2.10 Light availability (klux)

Light availability of cauliflower was observed in this study in two place upper canopy and beneath the canopy at 30, 45 and 60 DAT. Light intensity was measure in three different time viz. 10 AM, 1 PM and 4 PM.

4.2.10.1 Light intensity in upper canopy at 30 DAT

Significant difference of light intensity was found for cauliflower production in rooftop garden measuring upper the canopy at 30 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. The maximum light intensity was measured at 10.00 AM and it was observed 279.40 klux by treatment cauliflower (Table 12). Lowest light intensity was measured by cauliflower at 1.00 PM (10.78 klux).

Table 11. Yield performance of cauliflower grown at rooftop garden

Crop	Curd yield per plant (g)	Curd yield (t/ha)
Cauliflower	274.12±16.48	10.15±2.13
CV (%)	10.41	4.57

Table 12. Available light intensity near cauliflower canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	45	60
10.00 AM	279.4±37.64	268.67±31.43	9.97±0.99
1.00 PM	10.78 ±0.86	231.67±8.58	10.5±0.67
4.00 PM	31.6±5.03	40.13±3.08	1.73±0.07
CV (%)	139.33	68.09	66.45

Table 13. Available soil moisture near cauliflower canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	45	60
10.00 AM	20.60±0.42	18.23±0.99	16.96±1.06
1.00 PM	20.07±0.97	19.60±2.76	14.64±0.61
4.00 PM	20.10±0.81	18.01±1.23	14.82±0.24
CV (%)	1.47	4.63	8.34

4.2.10.2 Light intensity in upper canopy at 45 DAT

Significant difference of light intensity was found for cauliflower production in rooftop garden measuring upper the canopy at 45 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. Highest (268.66 klux and 40.13 klux) light intensity was measure by cauliflower at 10.00 AM and 4.00 PM respectively.

4.2.10.3 Light intensity in upper canopy at 60 DAT

The study of light intensity on cauliflower was significant difference for light intensity grown in rooftop garden measuring upper the canopy at 60 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. The lowest light intensity was observed by cauliflower at 10.00 AM (9.97 klux) and 4.00 PM (1.73 klux).

4.2.11 Soil moisture

The soil moisture (%) availability of cauliflower was observed in this study at 30, 45 and 60 DAT. Soil moisture (%) was measure in three different time viz. 10.00 AM, 1.00 PM and 4.00 PM.

4.2.11.1 Soil moisture at 30 DAT

Non significant variation was observed on cauliflower for soil moisture (%) grown in rooftop garden measuring at 30 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 13). Soil moisture was highest for cauliflower at 10.00 AM (20.60%).

4.2.11.2 Soil moisture at 45 DAT

Non significant variation was observed for cauliflower for soil moisture (%) grown in rooftop garden measuring at 45 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 13). The highest soil moisture (%) was measure by cauliflower at 10.00 AM (18.23%) and 1.00 PM (19.60%).

4.2.11.3 Soil moisture at 60 DAT

Significant variation was observed for cauliflower for soil moisture (%) grown in rooftop garden measuring at 60 DAT in two times 1.00 PM and 4.00 PM (Table 13). The lowest soil moisture (%) was measured by cauliflower at 10.00 AM (16.95%), 1.00 PM (14.643%) and 4.00 PM (14.82%).

4.1.12 Soil temperature

The effect of soil temperature (%) of cauliflower was observed in this study at 30, 45 and 60 DAT. Soil temperature (%) was measure in three different time viz. 10.00 AM, 1.00 PM and 4.00 PM.

4.1.12.1 Soil temperature at 30 DAT

Significant variation was observed for cauliflower for soil temperature (%) grown in rooftop garden measuring at 30 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 14). The lowest soil temperature (%) was measured by cauliflower at 10.00 AM (22.62%) and 1.00 PM (23.78%).

4.1.12.2 Soil temperature at 45 DAT

Significant variation was observed for cauliflower for soil temperature (%) grown in rooftop garden measuring at 45 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 14).

4.12.3 Soil temperature at 60 DAT

Significant variation was observed for cauliflower for soil temperature (%) grown in rooftop garden measuring at 60 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 14). The highest soil temperature (%) was measure by cauliflower at 10.00 AM (24.29%), 1.00 AM (27.06%) and 4.00 PM (27.03%).

Table 14. Available soil temperature near cauliflower canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	45	60
10.00 AM	22.62±0.12	24.02±0.55	24.29±0.39
1.00 PM	23.78±0.35	25.08±0.34	27.07±0.53
4.00 PM	23.74±0.18	24.16±0.51	27.04±0.27
CV (%)	2.82	2.36	6.11

Table 15. Effect of broccoli on plant height, number of leaves per plant and leaf length at different days after transplanting (DAT) in rooftop garden

Days after transplanting (DAT)	Plant height (cm)	Number of leaves per plant	Leaf length (cm)
30	22.80±1.36	10.867±0.13	22.067±0.22
45	33.80±1.91	14.933±0.58	37.867±1.87
60	48.60±3.22	17.333 ±0.33	39.667±1.47
CV (%)	36.92	22.73	29.17

CV (%) = coefficient of variation

Table 16. Effect of broccoli on leaf breadth and canopy area at different days after transplanting (DAT) in rooftop garden

Days after transplanting (DAT)	Leaf breadth (cm)	Canopy area (cm)
30 DAT	9.33±0.27	22.80±0.06
45 DAT	15.03±0.74	33.80±1.21
60 DAT	16.03±0.78	48.60±1.29
CV (%)	26.85	36.92

CV (%) = coefficient of variation

4.3 Broccoli

4.3.1 Plant height (cm)

Broccoli grown in the rooftop garden showed significant differences in terms of plant height at different days after transplanting (DAT) (Table 15). Plant height increased with the increased of DAT.

4.3.2 Number of leaves per plant

Number of leaves per plant is an important factor for increasing production. Number of leaves per plant increased with the increasing days after transplanting (DAT).

4.3.3 Leaf length

Highest leaf length was observed 39.67 cm at 60 DAT and lowest was 22.07 cm at 30 DAT. It was observed that leaf length was increased with the increasing of days after transplanting for broccoli. Increasing of leaf length was observed 41.72% from 30 DAT to 45 DAT and 44.37% from 30 DAT to 60 DAT for this crop. Mahamud (2006) found that the highest (43.70 cm) leaf length was recorded at harvest in broccoli when studied experiment.

4.3.4 Leaf breadth (cm)

Leaf breadth was found significantly different for broccoli production. The leaf breadth was observed most (16.03 cm) at 60 DAT and least (9.33 cm) at 30 DAT. These results revealed that the leaf breadth is increased with the increasing days after transplanting.

4.3.5 Canopy area (cm)

In broccoli, 48.60 cm of canopy area was measured at 60 DAT as highest and as lowest it was measured 22.80 cm at 30 DAT. It was observed that canopy area was increased with the increasing of days after transplanting for this crop. Increasing trend was 32.54% and 53.09% from 30 DAT to 45 DAT and 30 DAT to 60 DAT respectively.

4.3.6 Curd length (cm)

Curd length of broccoli varied significantly (Table 17). Curd length was found 15.20 cm.

4.3.7 Curd breadth (cm)

Curd breadth in case of broccoli varied significantly produced in rooftop garden. In broccoli curd breadth was observed 13.83 cm.

4.3.8 Curd weight with leaves (g)

Curd weight with leaves different significantly produced in rooftop garden. The curd weight with leaves was obtained as 233.33 g for this crop (Table 17). Curd weight with leaves was 893.28 g reported by Mahamud (2006).

4.3.9 Curd yield per plant (g)

Curd yield per plant that means curd weight without leaves for broccoli varied significantly produced in rooftop garden. The value of curd yield per plant was 155.83 g for this crop (Table 17).

Table 17. Morphological characteristics of broccoli grown at rooftop garden

Traits	Mean±SE	CV (%)
Curd length (cm)	15.20±0.35	3.95
Curd breadth (cm)	13.83±0.40	4.98
Curd weight with leaves (g)	233.33±60.09	44.61

SE = standard error, CV (%) = coefficient of variation

Table 18. Yield performance of broccoli grown at rooftop garden

Crop	Curd yield per plant (g)	Curd yield (t/ha)
Broccoli	155.83±14.86	5.77±2.34
CV (%)	16.52	8,23

CV (%) = coefficient of variation

Table 19. Available light intensity near broccoli canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	45	60
10.00 AM	12.17±0.56	10.41±2.81	223.67±31.33
1.00 PM	11.7±0.14	284.53±0.29	252.13±19.23
4.00 PM	1.97±0.26	39.73±9.61	35.73±2.99
CV (%)	66.85	134.92	68.96

CV (%) = coefficient of variation

4.3.10 Light availability (klux)

Light availability of broccoli was observed in this study in two place upper canopy and beneath the canopy at 30, 45 and 60 DAT. Light intensity was measure in three different time viz. 10 AM, 1 PM and 4 PM.

4.3.10.1 Light intensity in upper canopy at 30 DAT

Significant difference of light intensity was found for broccoli production in rooftop garden measuring upper the canopy at 31 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. Lowest light intensity was observed by broccoli at 10.00 AM (12.17 klux) and 4.00 PM (1.97 klux).

4.3.10.2 Light intensity in upper canopy at 45 DAT

Significant difference of light intensity was found for broccoli production in rooftop garden measuring upper the canopy at 45 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. Highest light intensity was measured at 1.00 PM and it was observed 284.53 klux by broccoli (Table 19). Lowest light intensity was measured by broccoli at 10.00 AM (10.41 klux).

4.3.10.3 Light intensity in upper canopy at 60 DAT

The study of light intensity on broccoli was significant difference for light intensity grown in rooftop garden measuring upper the canopy at 60 DAT in three times 10.00 AM. 1.00 PM and 4.00 PM. The highest light intensity was measured by broccoli at 10.00 AM (223.66 klux), 1.00 PM (252.13 klux) and 4.00 PM (35.73 klux) (Table 19).

4.3.11 Soil moisture

The soil moisture (%) availability of broccoli was observed in this study at 30, 45 and 60 DAT. Soil moisture (%) was measure in three different time viz. 10.00 AM, 1.00 PM and 4.00 PM.

4.3.11.1 Soil moisture at 30 DAT

Non significant variation was observed on broccoli for soil moisture (%) grown in rooftop garden measuring at 30 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 20). The soil moisture (%) was measured in broccoli at 10.00 AM (18.04%), 1.00 PM (16.89%) and 4.00 PM (17.24%).

4.3.11.2 Soil moisture at 45 DAT

Non significant variation was observed for broccoli for soil moisture (%) grown in rooftop garden measuring at 45 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 20). Highest soil moisture was measured by broccoli at 4.00 PM (18.41%).

4.3.11.3 Soil moisture at 60 DAT

Significant variation was observed for broccoli for soil moisture (%) grown in rooftop garden measuring at 60 DAT in two times 1.00 PM and 4.00 PM (Table 20). The highest soil moisture (%) was measure broccoli at 10.00 AM (19.14%).

Table 20. Available soil moisture near broccoli canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	45	60
10.00 AM	18.04±1.44	17.38±1.39	19.14±1.47
1.00 PM	16.89±1.30	18.71±0.41	19.12±1.22
4.00 PM	17.24±1.18	18.41±0.81	17.66±0.41
CV (%)	3.39	3.84	4.55

Table 21. Available soil temperature near broccoli canopy grown at rooftop garden at different time period

Time	Days After Transplanting (DAT)		
	30	45	60
10.00 AM	24.81±0.57	22.91±0.17	23.04±0.22
1.00 PM	25.92±0.13	24.88±0.29	24.79±0.75
4.00 PM	26.92±0.83	23.54±0.18	23.66±0.17
CV (%)	4.08	4.23	3.72

4.3.12 Soil temperature

The effect of soil temperature (%) of broccoli was observed in this study at 30, 45 and 60 DAT. Soil temperature (%) was measure in three different time viz. 10.00 AM, 1.00 PM and 4.00 PM.

4.3.12.1 Soil temperature at 30 DAT

Significant variation was observed for broccoli for soil temperature (%) grown in rooftop garden measuring at 30 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM. The highest soil temperature (%) was measure by broccoli at 10.00 AM (24.81%), 1.00 AM (25.92%) and 4.00 PM (26.92%) (Table 21).

4.3.12.2 Soil temperature at 45 DAT

Significant variation was observed for broccoli for soil temperature (%) grown in rooftop garden measuring at 45 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 21). The lowest soil temperature (%) was measured by broccoli at 10.00 AM (22.91%), 1.00 PM (24.87%) and 4.00 PM (23.54%).

4.3.12.3 Soil temperature at 60 DAT

Significant variation was observed for broccoli for soil temperature (%) grown in rooftop garden measuring at 60 DAT in three times 10.00 AM, 1.00 PM and 4.00 PM (Table 21). The lowest soil temperature (%) was measured by broccoli at 4.00 PM (23.65%).

CHAPTER V

SUMMARY AND CONCLUSION

Summary

In cabbage yield parameters value were increased with increasing days after transplanting for all of the traits studied like plant height, number of leaves per pant, leaf length, leaf breadth, canopy area, head length and breadth and yield per plant. The highest (26.87 cm) plant height was observed at 45 DAT. Plant height was increased 27.91% from 30 DAT to 45 DAT. Leaf length was found high (26.67 cm) at 60 DAT. Increasing of leaf breadth was observed 35.69% from 30 DAT to 60 DAT. The maximum (26.87 cm) canopy area was obtained at 45 DAT and at 60 DAT the head became compact and all leaves are close together and results less canopy. The head length and breadth were observed 8.37 cm and 14.96 cm respectively. The head yield per plant was 1091.33 g. The light intensity was more in upper canopy than beneath canopy in cabbage field. The maximum (272.26 klux) light intensity was measured at 1.0 PM at 30 DAT and then reduced. But highest light intensity (218.86 klux) was observed at 10.00 AM for 60 DAT then reduced at 1.00PM (9.12 klux). Soil moisture was fluctuated slightly at different time of a day. At 60 DAT soil moisture wasn`t fluctuated and maintained more or less equal value in different time of a day. Soil temperature was high at 1.00PM and then less for all observations.

Yield parameters value was increased with increasing days after transplanting for all of the traits studied for cauliflower. The highest plant height (41.33 cm) and number of leaves per plant (25.00) was recorded at 60 DAT. Leaves per plant was increased 33.08% from 30 DAT to 60 DAT. Leaf length (40.20 cm) and leaf breadth (20.5 cm) was observed highest at 60 DAT. The maximum (41.33 cm) canopy area was obtained at 60 DAT. Curd length and breadth were

measured of 19.68 cm and 17.65 cm respectively. The value of curd yield per plant was 274.12 g. Light intensity was fluctuate high at 45 DAT and ranged 268.66 klux to 40.13 klux at 10.00AM and 4.00PM, respectively. Upper canopy light intensity at 60 DAT was observed as straight line. In case of beneath canopy at 30 DAT, light intensity started with high then reduced. At 45 DAT light intensity was fluctuated started with high and end with less in end of day.

In broccoli yield and yield related traits value was increased with increasing days after transplanting for all of the traits studied. Plant height (48.60 cm) and leaves per plant (17.33) was highest at 60 DAT. Increasing of leaf length was 44.37% from 30 DAT to 60 DAT. Increasing trend of canopy area was 53.09% from 30 DAT to 60 DAT. Curd length and breadth were found 15.20 cm and 13.83 cm respectively and curd yield per plant was 155.83 g. Highest upper canopy light intensity was observed as 223.67 klux at 10.00AM at 60 DAT. Less fluctuation of soil moisture was observed for different time of day.

Conclusion

Considering the above result of this experiment the following conclusions can be drawn:

1. The yield components and yield of cabbage, cauliflower and broccoli were positively recorded producing on rooftop garden. The highest yield was produced from cabbage followed by cauliflower.
2. Cauliflower was retaining more moisture in soil and it is decrease soil temperature which creates favorable climatic condition. Highest curd length produced by cauliflower.
3. Cauliflower also reduces light intensity upper and beneath canopy.
4. Cauliflower can reduce soil temperature. It is help to reduce building surrounding temperature.
5. The results clearly showed that rooftop is suitable for vegetables production and yield at the rooftop garden.

Recommendations

Vegetables production is suitable in rooftop with proper care and management. In this experiment results showed that rooftop is suitable for cabbage, cauliflower and broccoli production. These crops again grow in rooftop garden with more treatments in future study for better understanding and accurate results. Other crops may be included in rooftop garden to see their performance.

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APPENDICES

Appendix I. Analysis of variance of plant height at different DAT of vegetable production in rooftop garden

Source of Variation	DF	Plant Height (cm) at 31 DAT		Plant Height (cm) at 45 DAT		Plant Height (cm) at 60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	2	22.909	11.45	92.586	46.293*	997.982	498.991**
Error	6	19.307	3.21	41.873	6.979	143.252	23.875
Total	8	42.216		134.459		1,141.234	

* & ** significant at 5% and 1% level of probability, respectively

DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 2. Analysis of variance of leaf number at different DAT of vegetable production in rooftop garden

Source of Variation	**DF**	Leaf Number at 30 DAT		Leaf Number at 45 DAT		Leaf Number at 60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	2	56.329	28.164**	74.480	37.240**	142.942	71.471
Error	6	6.400	1.067	12.400	2.067	16.667	2.778
Total	8	62.729		86.879		159.609	

** significant at 1% level of probability

Appendix 3. Analysis of variance of leaf length at different DAT of vegetable production in rooftop garden

Source of Variation	**DF**	Leaf length (cm) 31 DAT		Leaf length (cm) 45 DAT		Leaf length (cm) 60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	2	9.249	4.625	247.248	123.624**	352.438	176.219**
Error	6	10.120	1.687	71.033	11.839	78.753	13.126
Total	8	19.369		318.281		431.191	

** significant at 1% level of probability

Appendix 4. Analysis of variance of leaf breadth at different DAT of vegetable production in rooftop garden

Source of Variation	**DF**	Leaf breadth (cm) at 31 DAT		Leaf breadth (cm) at 45 DAT		Leaf breadth (cm) at 60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	2	25.629	12.814	24.562	12.281	44.149	22.074*
Error	6	54.520	9.087	21.760	3.627	22.993	3.832
Total	8	80.149		46.322		67.142	

* significant at 5% level of probability

Appendix 5. Analysis of variance of canopy area at different DAT of vegetable production in rooftop garden

Source of Variation	**DF**	Canopy Area (cm) 31 DAT		Canopy Area (cm) 45 DAT		Canopy Area (cm) 60 DAT	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	53.60	26.80	2.72	1.36	43.41	21.70
Error	6	66.55	11.09	27.86	4.64	57.32	9.55
Total	8	120.16		30.59		100.73	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 6. Analysis of variance of curd length and breadth of vegetable production in rooftop garden

Source of	**DF**	Curd Length (cm)	Curd breadth (cm)

Variation					
		SS	MS	SS	**MS**
Treatment	2	194.730	97.365**	23.035	11.518**
Error	6	2.130	0.355	4.037	0.673
Total	8	196.860		27.073	

SS = sum of square, MS = mean sum of square

** significant at 1% level of probability

Appendix 7. Analysis of variance of curd weight of vegetable production in rooftop garden

Source of Variation	**DF**	Curd Weight with leaf (g)		Curd Weight without leaf (g)	
		SS	MS	SS	MS
Treatment	2	2,050,684.222	1,025,342.111**	1,556,987.794	778,493.897**
Error	6	277,427.333	46,237.889	35,005.221	5,834.204
Total	8	2,328,111.556		1,591,993.016	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square
** significant at 1% level of probability

Appendix 8. Analysis of variance of light intensity at 31 DAT in different time of vegetable production in rooftop garden (upper the canopy)

Source of Variation	**DF**	**light intensity** (Klux) 31 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	125,040.43	62,520.21**	136,261.34	68,130.67**	2,489.455	1,244.72**
Error	6	13,909.07	2,318.18	2,132.26	355.37	239.776	39.96
Total	8	138,949.51		138,393.60		2,729.231	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 9. Analysis of variance of light intensity at 45 DAT in different time of vegetable production in rooftop garden (upper the canopy)

Source of Variation	DF	light intensity (Klux) 45 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	132,934.899	66,467.45**	126,348.071	63,174.03**	2,876.598	1,438.29**
Error	6	441.956	73.65	5,977.967	996.32	610.728	101.78
Total	8	133,376.855		132,326.038		3,487.326	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 10. Analysis of variance of light intensity at 60 DAT in different time of vegetable production in rooftop garden (upper the canopy)

Source of Variation	DF	light intensity (Klux) 60 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	89,320.919	44,660.46**	117,436.970	58,718.48**	1,780.080	890.04**
Error	6	6,266.818	1,044.47	2,236.358	372.72	61.845	10.30
Total	8	95,587.738		119,673.328		1,841.925	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 11. Analysis of variance of soil moisture (%) at 31 DAT in different time of vegetable production in rooftop garden

Source of Variation	DF	soil moisture (%) at 31 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	10.116	5.058	55.970	27.985	25.674	12.837
Error	6	43.879	7.313	99.851	16.642	21.071	3.512
Total	8	53.995		155.821		46.745	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 12. Analysis of variance of soil moisture (%) at 45 DAT in different time of vegetable production in rooftop garden

Source of Variation	DF	**soil moisture (%) at** 45 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	5.433	2.717	28.086	14.043	0.241	0.120
Error	6	31.936	5.323	55.138	9.190	13.599	2.266
Total	8	37.369		83.224		13.839	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 13. Analysis of variance of soil moisture (%) at 60 DAT in different time of vegetable production in rooftop garden

Source of Variation	DF	**soil moisture (%) at** 60 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	8.768	4.384	41.565	20.78**	41.176	20.58**
Error	6	24.247	4.041	13.096	2.18	12.453	2.07
Total	8	33.016		54.661		53.629	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 14. Analysis of variance of soil temperature (%) at 31 DAT in different time of vegetable production in rooftop garden

Source of Variation	DF	**soil temperature (%) at** 31 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	7.432	3.71**	9.047	4.52*	20.632	10.31**
Error	6	2.123	0.35	3.742	0.62	4.717	0.78
Total	8	9.554		12.789		25.349	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 15. Analysis of variance of soil temperature (%) at 45 DAT in different time of vegetable production in rooftop garden

Source of Variation	DF	soil temperature (%) at 45 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	7.481	3.74*	12.593	6.29**	23.792	11.89**
Error	6	3.269	0.54	2.841	0.47	4.892	0.81
Total	8	10.750		15.434		28.684	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 16. Analysis of variance of soil temperature (%) at 60 DAT in different time of vegetable production in rooftop garden

Source of Variation	DF	soil temperature (%) at 60 DAT					
		10AM		**1PM**		4PM	
		SS	MS	SS	**MS**	SS	MS
Treatment	2	6.781	3.39**	16.805	8.40**	18.537	9.26**
Error	6	2.216	0.36	5.530	0.92	4.086	0.68
Total	8	8.997		22.335		22.623	

DAT = Days to After Transplanting, SS = sum of square, MS = mean sum of square

Appendix 17. Map showing the experimental site under the study

Appendix 18: Physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site

A. Physical composition of the soil

Soil separates	%	Methods employed
Sand	26	Hydrometer method (Day, 1915)
Silt	45	Do
Clay	29	Do
Texture class	Silty loam	Do

B. Chemical composition of the soil

Sl. No.	Soil characteristics	Analytical data	Methods employed
1	Organic carbon (%)	0.45	Walkley and Black, 1947
2	Total N (%)	0.03	Bremner and Mulvaney, 1965
3	Total S (ppm)	225.00	Bardsley and Lanester, 1965
4	Total P (ppm)	840.00	Olsen and Sommers, 1982
5	Available N (kg/ha)	54.00	Bremner, 1965
6	Available P (ppm)	20.54	Olsen and Dean, 1965
7	Exchangeable K (me/100 g soil)	0.10	Pratt, 1965
8	Available S (ppm)	16.00	Hunter, 1984
9	pH (1:2.5 soil to water)	5.6	Jackson, 1958
10	CEC	11.23	Chapman, 1965

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

Appendix 19. Monthly average temperature, relative humidity and total rainfall and sunshine of the experimental site during the period from November, 2015 to February, 2016.

Month	Air temperature (ºc)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
November, 2015	34.7	18.0	77	227	**5.8**
December, 2015	32.4	16.3	69	0	**7.9**
January, 2016	29.1	13.0	79	0	**3.9**
February, 2016	**28.1**	**11.1**	**72**	**1**	**5.7**

Source: Bangladesh Meteorological Department (Climate & Weather Division), Agargoan, Dhaka – 1212