STUDY ON PERFORMANCE OF SELECTED VEGETABLES CULTIVATED ON ROOFTOP AND FARM CONDITIONS

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DHAKA -1207

JUNE, 2018

STUDY ON PERFORMANCE OF SELECTED VEGETABLES CULTIVATED ON ROOFTOP AND FARM CONDITIONS

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A Thesis
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

SEMESTER: JANUARY-JUNE, 2018

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CERTIFICATE

This is to certify that thesis entitled, "**STUDY ON PERFORMANCE OF SELECTED VEGETABLES CULTIVATED ON ROOFTOP AND FARM CONDITIONS**" 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 **MST. ANISA SULTANA**, **REGISTRATION No. 12-05071** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June 2018
Dhaka, Bangladesh

Prof. Dr. Md. Forhad Hossain
Supervisor

Dedicated to

My

Beloved Parents

And

Son

ACKNOWLEDGEMENTS

All praises and thanks are due to the supreme ruler of the universe, the almighty ALLAH for his grace bestowed upon the author for accomplishment of this research study.

The author expresses the deepest sense of respect and heartiest gratitude to her respectable supervisor **Prof. Dr. Md. Forhad Hossain,** Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University for his efficient and scholastic guidance, constructive criticism, valuable suggestions and immense help to carry out the research work towards successful completion and preparation of the thesis by necessary corrections and modification through reviewing the text.

She wishes to express her sincere appreciation and heartfelt gratitude to her co-supervisor **Assoc. Prof. Dr. Jubayer-Al-Mahmud,** Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, for his valuable suggestions, constant cooperation, inspiration and sincere advice to improve the quality of the thesis.

Cordial thanks to **Prof. Dr. Nazmun Naher**, Chairman, Department of Agroforestry and Environmental Science and all respected teachers of the Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University for their help and co-operation during the study and research.

She is grateful to all those people who contributed to this research work although it is not possible to mention all by their names.

Last but not the least, the author expresses her immense indebtedness and the deepest senses of gratitude to her beloved parents and younger brother who sacrificed all their happiness during the whole study period. The author is grateful to all the respondents in the study area for their cooperation and help in accomplishing the objectives of this research work. Finally, She wishes to extend her heartfelt thanks and gratitude to all of her relatives for their inspiration, blessing and encouragement that opened the gate of her higher study.

Date: June, 2018 **The author**

STUDY ON PERFORMANCE OF SELECTED VEGETABLES CULTIVATED ON ROOFTOP AND FARM CONDITIONS

ABSTRACT

Our agricultural land is decreasing day by day. In modern days rooftop farming can provide solution to mitigate this problem. We can use our roof of building to cultivate crops and increase food demand. This experiment was conducted at the roof of third floor of Biotechnology Department and Agroforestry farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2017 to March 2018 to study on performance of selected vegetables (cabbage, cauliflower and broccoli) cultivated on rooftop and farm conditions. Data on plant height, number of leaf, leaf length, leaf breadth, head height, diameter and weight of cabbage, cauliflower and broccoli were collected. The field and roof top experiment were conducted in RCBD design with three replications. MSTAT-C computer package was used for processing and analysis of data. The mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance. In cabbage, cauliflower and broccoli, yield parameters value were increased with increasing days after planting .In cabbage cultivation, plant height, leaf number, leaf length, leaf breadth, head height, head diameter and head weight were 36.65 cm, 12.52 cm, 22.69 cm, 21.29 cm, 18.39 cm, 54.81 cm and 939.72 g respectively at 60 DAT but in farm condition it were 27.66 cm, 9.84 cm, 18.31 cm, 17.44 cm, 16.24 cm, 50.74 cm and 865.61 g respectively at 60 DAT. In cauliflower cultivation, plant height, leaf number, leaf length, leaf breadth, head height, head diameter and head weight were 43.19 cm, 12.32 cm, 32.21 cm, 22.31 cm, 18.04 cm, 54.85 cm and 888.85 g at 60 DAT but in farm condition it were 38.64 cm, 9.96 cm, 26.43 cm, 18.21 cm, 16.15 cm, 50.26 cm and 740.43 gat 60 DAT. In broccoli cultivation, plant height, leaf number, leaf length, leaf breadth, head height, head diameter and head weight were 42.98 cm, 10.44 cm, 29.67 cm, 21.69 cm, 17.60 cm, 51.85 cm and 816.48 g at 60 DAT but in farm condition they were 34.12 cm, 8.43 cm, 22.46 cm, 19.47 cm, 16.28 cm, 47.54 cm and 574.13 g. For all species plant height, leaf number, leaf length, leaf breadth, head height, head diameter and head weight were recorded in roof top condition. Also, the highest curd length, curd diameter and yield was produced by cabbage followed by cauliflower and broccoli produced in roof top condition. The yield components and yield of cabbage, cauliflower and broccoli were highest in rooftop and lowest in farm.

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INTRODUCTION

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INTRODUCTION

Vegetables play an important role in human nutrition. It provides carbohydrates, fat, minerals, vitamins, and roughages, which constitute the essentials of a balanced diet. In Bangladesh, out of 260.32 thousand hectares of vegetables growing area, cabbage and cauliflower covers 9.64% of the total land and contributes 13.97% of total production (BBS, 2004). The curd (white head of cauliflower) is an early stage of inflorescence development as its formation invariably precedes floral initiation (Bose and Som, 1986). But vegetable consumption in Bangladesh is very low and only 80g per person per day against the minimum recommended quantity of 220g per day (Roy, 2011). The total vegetable production is far below the requirement. To fulfill the nutritional requirement of people, total production as well as number of vegetables should be increased. Cabbage (*Brassica oleracea var. capitata)*, cauliflower (*Brassica oleracea var. botrytis*) and broccoli (*Brassica oleracea var. italica*) are the most important members of cole crops in the tropic and temperate regions of the world (Siddique, 2004). They are popular for their nutritional benefits such as are high in carotenoids, vitamins A and C, calcium, iron, magnesium, and dietary fiber (Guerena, 2006). Broccoli is a nutritious vegetable than any other cole crops (Nieuwh of, 1969). Vitamin C content in fresh broccoli is almost twice that in cauliflower (Lisiewska and Kmiecik, 1969).

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 local supply of fresh food. By utilizing rooftops for urban farming, it is possible to attain social, economic and environmental sustainability for the buildings in urban cities. Because it can contribute to the development of urban food systems by increasing local food production, meet the nutrition demand of the people by access to nutritious food, mitigation of air pollution, increasing storm water retention capacity, improvement of public health, enhancement of the aesthetic value of the urban environment and enhancement of community functions (Bay Localize, 2007).

Rooftop farming can reduce the temperature of roofs and the surrounding air that contribute to overall cooling a local climate (RIES, 2014) and can help reduce urban

heat island effect (Hui,2011). Roof farms can also absorb carbon emissions and noise (Dubbeling, 2014 and Hui, 2011). Rain water is captured and absorbed by the plants and overflowing impact on infrastructure is reduced (RIES, 2014). Rooftops filled with vegetation can be a great placeto relax. This kind of farming can easily offer employment to people (Sprouting Good Urban Farming Sydney, 2014).

In Dhaka, one of the world's fastest growing mega cities, open and cultivable land has been converting to built-up area indiscriminately and thus agricultural land has been decreased at an alarming rate (Islam and Ahmed 2011). Implementing rooftop farming can be a possible solution to reduce the food supply problems, make urban living more self-sufficient and make fresh vegetables more accessible to urban individuals. It is estimated that 10,000 ha space of Dhaka city can be brought under rooftop farming and the residents of the city can taste fresh vegetables as well as over 10 percent of the demand can be fulfilled through rooftop farming (Wardard, 2014). 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 (Islam, 2004).

Fresh vegetables are considered for the sign of novel health and good source of nutritional supplement for the human body. Due to important role of vegetables in human diet, its importance is increasing. Nowadays agricultural land is decreasing day by day. But on the other hand, with the pace of urbanization built-up areas are increasing; hence supply of roof space is also increasing. Rooftop farming can provide solution to increased food demand and also can promote a sustainable and livable city. Local fresh and safe food can be ensured through roof gardens in Dhaka city. The aim of the study is to explore the present practice and challenges of rooftop farming that was encountered by practitioners. The research title is to find out the morphological changes of selected crops in rooftop and farm conditions.

OBJECTIVES

i) To find out the morphological and yield attributes of selected vegetables produced on rooftop and farm conditions.

ii) To compare and contrast the changes of selected vegetables produced on rooftop and farm conditions.

CHAPTER-II

REVIEW OF LITERATURE

CHAPTER -II

REVIEW OF LITERATURE

The present investigation was carried out to study the performance of selected vegetables cultivated to rooftop and farm conditions. The pertinent literature in relation to the proposed work is reviewed in this chapter.

2.1 Review related to Rooftop farming

Though there are numerous benefits of rooftop farming, rooftop gardeners are facing several challenges, too. Slope of the roof, load bearing capacity of the building and roof etc. are important considerations. So, it is important to look at the structural composition of the building and retrofit them accordingly or design of new building should consider it from the very beginning (Hui, 2011).

Roof weight can increase by as much as 30–950 kg per square meter for roof gardens depending on depth of soil, when saturated by heavy rain. Most roofs need strengthening to take such weight (Dixon n.d.). Keeping the soils healthy and productive may also be challenging as rooftop structural soils are different from ground-bed soils (Green, 2011).

High winds and high temperatures are often a problem; windbreaks and heat-tolerant crops have to be deployed in the rooftop environment. Pesticide use in densely populated areas can be a problem and many rooftop gardeners go with organic farming for this reason (Tiller, 2008).

Sometime, maintenance may be costly (Dixon n.d.). Many of the city residents do not have training in agriculture. Starting gardening without proper training may lead to frustrating outcomes, which might result in unwillingness of the people in initiating new projects (Islam, 2004).

However, recently some policy and field supports are being offered to the practitioners. The Milan Urban Food Policy Pact, resulting from Expo 2015 with theme “Feeding the

Planet, Energy for Life", has been a boost to support innovative projects in cities (Milan's Food Policy, 2015).

Tokyo i s the first city to mandate building vegetation that must constitute 20% of all new construction. Recently, urban agriculture and food security have attracted considerable interest in many cities of Canada. The green roof by law passed in 2009 states that all new buildings over six stories tall and with more than 2000 m^2 of floor space must have minimum 20 percent rooftop greenery (Torstar News Service, 2015).

Portland's Eco-roof Incentive Program offers to pay for $5 per square foot of rooftop green space created. Austin recently passed rooftop greenery density bonus, which can give a density bonus of up to eight square feet for every square foot of rooftop greenery installed (Plant Connection Inc., 2016).

2.2 Review related to cabbage

Significant increase in growth parameters of cabbage was reported by Nagada and Chauhan (1987) by the application of sulphur. Bhagavatagoudra and Rokhade (2001) found that levels of sulphur had significantly influenced plant height of cabbage to the extend of 24.18 cm by the application of 40 kg ha^{-1}, compared to other levels of sulphur. Skwierawska *et al.* (2008) found the most beneficial effect of sulphur at 40 kg ha^{-1} and 80 kg ha^{-1} in cabbage, onion and barley.

Hossain *et al.* (2011) reported a significant increase in plant height to the extend of 37.45 cm in cabbage by application of sulphur upto 45 kg ha^{-1}. However Dhar *et al.*(1999) found in cabbage a non significant effect on plant height with the application of sulphur at different levels, all treatments exhibited more values over control.

Mona (2012) found in cabbage that application of different levels of sulphur brought out significant increase in plant height. Maximum plant height to the extend of 17.81 cm was recorded by the application of sulphur at 60 kg ha^{-1} with respect to control at 40 DAT.

In an experiment on application of sulphur at 90 kg S ha^{-1}Dhar *et al.* (1999)found a significant increase in number of non wrapper leaves to the extend of 13. Bhagavatagoudra and Rokhade (2001) conducted an experiment in cabbage and found that levels of sulphur had significant influence on number of outer leaves to the extend of 21.49 by the application of sulphur at 40 kg ha^{-1}, compared to other levels of sulphur. Hossain *et al.* (2011) reported a significant increase in number of loose leaves to the extend of 12.57 in cabbage by application of sulphur upto 45 $kgha^{-1}$. Mona (2012) found in cabbage that application of different levels of sulphur brought out significant increase in number of non wrapper leaves to the extend of16.08 by the application of sulphur at 60 kg ha^{-1} with respect to control.

Meena (2003) reported that the increasing levels of N (0, 120, 150,180 $kgha^{-1}$) and S (0,40, 50 and 60 kg ha^{-1}) significantly increased the number of leaves and maximum number of leaves were recorded with 180 and 60 kg ha^{-1} nitrogen and sulphur, respectively in sprouting broccoli. In an experiment with broccoli, Moniruzzaman *et al.* (2007) reported significant increase in number of leaves with increase in levels of sulphur upto 30 kg ha^{-1}.Matiar Rahman *et al.* (1992) found that sulphur application of 40 kg ha^{-1} in cauliflower results in significant increase in number of leaves to the extend of 24 incombination with 1 kg ha^{-1} of each boron and molybdenum.

In an experiment with cabbage, Dhar *et al.* (1999) found a significant effect on head diameter with the application of sulphur at 60 kg ha^{-1} to the extend of 20.43cm. Similarly, Hunashikatti *et al.* (2000) found a significant increase in head diameter to the extend of 14.91cm by single application of sulphur at 25 kg ha^{-1}incombination with molybdenum at 1000 g ha^{-1}. Bhagavatagoudra and Rokhade(2001) reported that levels of sulplhur had significantly influence on head diameter of cabbage to the extend of 15.8 cm by the application of 40 kg ha^{-1}, compared to other levels of sulphur.

Hossain *et al.* (2011) reported a significant increase in diameter of head, to the extend of 17.19 cm in cabbage by application of Sulphur upto 45 kg^{-1}. Mona (2012) found that application of different levels of Sulphur brought out significant increase in head diameter to the extend of 13.04 cm, which was recorded by the application of sulphur at 60 kg ha^{-1} with respect to control. Moniruzzaman *et al.* (2008) conducted

experiment in broccoli and reported significant increase in head diameter with increase in levels of sulphur upto 30 kgha^{-1}.

Dhar *et al.* (1999) found that application of sulphur at 20 kg ha^{-1} in cabbage results in significant increase in head height to the extend of 15.43cm with the application of S at 90 kg S ha^{-1}.

Dhar *et al.* (1999) reported significant increase in weight of the head of cabbage to the extend of 2.59 kg ha^{-1} by the application of sulphur upto 60 kg ha^{-1}. Similarly, Hossain *et al.* (2011) reported a significant increase in head weight o f cabbage to the extend of 2147g plant-1 by application of sulphur at 45 kg ha^{-1}.Moniruzzaman *et al.* (2008) reported a significant increase in main head weight of broccoli to the extend of 20 kg ha^{-1} with the application of sulphur at 30 kgha^{-1}.

2.3. Review related to cauliflower

Sharma *et al*. (2000) carried out an experiment at New Delhi on stability of early Indian cauliflower (Group I A) cultivar grown in late kharif (May-October) seasons. Characters namely yield per plot, maturity days, harvest index and ricehness showed that the varieties DC 41-5 and DC 98-4 and the hybrids namely, CH 341, CH 541 and CH 598 were best and suitable in less favourable environments. According to Cadinanos (2001) at Spain it is possible to obtain uniform and continuous supply of cauliflower curd by using hybrid cultivars as their better adaptability. Thakur and Veerpal (2001) conducted an experiment in Himachal Pradesh to determine the effect of cauliflower varieties (RSK-1301, White Fox, RS-119, SWI-1 and PHJ as control) for production in summer months and found that among the cultivars SWI-1 had highest average yield of 38.72 t/ha, net curd weight, good curd quality, good size as well as the lowest number of outer leaves and largest curd size was given by White Fox. when transplanted during May.

At Plovdiv in Bulgaria condition Mihov Antonova (2001) observed that the highest number of rosette leaves (22.94) and the longest curd (14.72 cm) were obtained by the Batsman F1 hybrid. Heaviest curd (1.99 kg) and the highest curd diameter (23.28 cm)

were observed in the Torina F1 hybrid. Heaviest rosette leaves (1.867 kg) was observed in Horseman F1 hybrid. According to Sharma *et al*. (2001) among the 7 open pollinated varieties and 8 hybrids of cauliflower the open pollinated variety Sel 476 had the best performance while hybrids showed unstable performance.

Nathoo (2003) carried out an experiment with four varieties (Cashmere, Hybrid Rami, White Contesa and Splender) to assess their yield potential in two agro climatic condition (Reduit and Wooton) with 3 planting dates (March, October and July) and observed significant interaction effect between planting date and site and between planting date and variety. He also recommended that better yield can be obtained by adjusting the planting date in a particular region, there was a significant difference in the curd compactness among the varieties tested and Cashmere, Hybrid Rami and White Contessa had relatively higher compactness than local cultivar.

Hamid *et al*. (2005) worked with cauliflower cultivars Express, Reagent, Shehzadi and Indus Holland to evaluate their performance in Rawalakot Valley of Jammu and Kashmir and they found that maximum plant height, leaf length, fresh root weight, fresh weight of plant and curd weight per plant was attained by Indus Holland, whereas the maximum number of leaves, stem diameter, root length, dry root weight and diameter of curd was attained by Reagent. Minimum plant height, number of leaves, fresh root weight, curd weight and fresh plant weight was observed in Express, whereas minimum leaf length, stem diameter, root length, dry root weight and curd diameter was observed in Shehzadi when compared to the other cultivars. Besides the growth parameters, Indus Holland also gained 61.87, 52.55 and 27.35% more curd weight when compared to Express, Reagent and Shehzadi, respectively, which indicated that this cultivar performed well in terms of yield and is suitable for cultivation under the climatic conditions of Rawalakot.

Jana and Mukhopadhyay (2006) conducted a field experiment at Cooch Behar, West Bengal, India, to evaluate the effect of sowing date (15 August, 31 August and 15 September) on the growth and curd yield of different cauliflower cultivars (Early Kunwari, First Crop, Kartika, Aghani and Improved Japanese). They found that among the cultivars, Aghani gave the highest curd yield of 15.76 t/ha. Aghani sown on 31

August produced the highest marketable curd yield of 16.67 t/ha. They also found that sowing on 15 August gave the highest curd yield (13.07 t/ha), which decreased with each delay in sowing time.

Idczak and Trautwein (2007) carried out an experiment with 22 cultivars at five locations of German to evaluate the suitability of cauliflower cultivars for the autumn season. They recommended that the earliest cultivars were Tetris and Steady, followed by Fremont. Kumar *et al*. (2010) observed significant differences among various genotypes in early Indian cauliflower for yield and quality characters, they found that genotypes DC-98-4, DC-98-10 and DC-124 were superior over other genotypes with respect to yield and quality characters, where yield was negatively correlated with duration of curd availability and days to 50% curd formation. Significant differences were observed among genotypes suggesting sufficient variability for yield and quality characters. They also observed that the highest ascorbic acid content (103.23 mg/100 g of fresh weight) in the genotype DC-98-10 and lowest in CC-12 (17.68 mg/100 g of fresh weight).

Gautam *et al*. (1998) undertaken a study at Jorhat (Assam) to determine the effect of sowing dates (15 and 30 July and 14 August) and varieties on growth and yield of early cauliflower and they found that early sown crops resulted in longer duration and produced taller plants with more number of leaves, higher plant spread, more leaf size index as well as the lowest percentage of abnormal curds than late sown crops and attributed to higher curd yield for the cultivars Pusa Katki, Pusa Deepali, Selected Early Dawn, Early Chinese Prince and Heavy Silver Plate of cauliflower. They recorded that among the 5 cultivars Heavy Silver Plate exhibited the highest curd yield (8.12 ton/ha) of marketable curd when sown on 15 July which was significantly declined with delay in sowing time. They also recommended that the reduction in total yield in the late shown crop might be due to the transition in weather towards lowering down the average maximum and minimum temperature and rainfall whereas higher yield in the early sown crop might also be due to the fact that the crop remained in the field for longer period and hereby accumulated more photosynthates for higher production.

Dutta (1999) carried out an experiment at North Lakhimpur (Assam) to determine the best time for planting different groups of cauliflowers and to select the most suitable cultivars for the North Bank Plains Zone of Assam. Nine cultivars (3 early, 3 mid-season and 3 late) were planted on 3 dates at 10-day intervals (1st, 11th and 21st September; 11th, 21st and 31st October; and 15th and 25th November and 5th December, respectively). They recorded that planting time exhibited a significant effect on days to curd formation, curd size, curd weight and yield. An increase in size and weight of curd associated with a rise in yield was registered by the gradual delay in planting time in early and mid-season cultivars while all these characters were superior in late cultivars at the mid planting date. The highest yield in early cultivars (117.0 q/ha) was obtained from the delayed planting on 21 September, in mid-season cultivars (129.6 q/ha) it was obtained from the delayed planting on 31 October, and in late cultivars, maximum yield of 68.3 q/ha was recorded with the medium late planting on 25 November.

Spehia and Korla (2000) worked with 13 advanced generation cauliflower lines and 2 control cultivars to evaluate yield and quality under three transplanting dates (5th October and 20th October and 5th November) at Nauni, Solan (HP). They found that all the characters of cauliflower viz., days to marketable maturity, curd solidity, gross weight and net curd weight were significantly influenced by genotypes as well as transplanting dates. The first transplanting date (5 October) gave the best performance while the third transplanting (5 November) was not suitable for commercial purposes. They also observed that genotypes JKK BC3-2-16, KJF4-4-11 and KJKBC3F2-2-65 were good yielders and early in nature while KJKBC3F2-2-64, KJF4-4-38 and KJKBC3F2-2-64 were also good yielders and comparatively late and all of these were almost *at par* with PSBK-1 in terms of performance and yield.

Kumar *et al*. (2002) recorded that the vegetative characters such as stalk length and leaf number of cauliflower significantly differ for various date of planting. Cauliflower cv. Pusa Early Synthetic under the terai zone of West Bengal gave highest curd weight (384.17 g), curd diameter (22.38 cm), curd length (15.86 cm) when transplanted on 15 September and performance declined gradually in each successive delay of transplanting date among the four transplanting dates (1 September, 15 September, 1 October and 15 October) (Chatterjee, 2006). Sharma *et al.* (2006) carried out an

experiment at Himachal Pradesh to determine the optimum time of transplanting for cauliflower covering 3 planting dates (18 May, 2 June and 17 June) and 3 cultivars (Pusa Snow ball K1, Palam Uphar and Pusa Himjyoti). They found that transplanting of cauliflower cultivars on 2 June gave the maximum plant survival the marketable curd yield (20.9 ton/ha) along with maximum net returns (Rs 0.211 million/ha). They also observed that the cultivar Pusa Snowball K1 (20.7 ton/ha) significantly out yielded the Palam Uphar (17.8 ton/ha) and Pusa Himjyoti (16.6 ton/ha) along with its better performance for curd and plant attributes when transplanting on 2 June. They also found that curd diameter produced by different varieties was different.

Swagatika *et al.* (2006) worked on cauliflower with 5 different dates (1 and 15 July, 1 and 15 August, and 1 September) under shade net and open conditions in Bhubaneswar, Orissa, they observed that plants sown on 15 September and grown under shade net recorded the highest values for plant height, number of leaves, girth and curd yield. A field experiment was conducted by Amoli *et al*. (2007) in Mazandaran province, Iran with respect to 3 planting dates (5 September, 20 September and 5 October) to determine the best planting date for high yield in cauliflower cv. Snow Crown. According to their result the highest yield (40 t/ha) was produced in treatment with planting date of 5 September plant density of 60 cm (55 000 plants/ha) and application of 90 kg N/ha and reduced yield was obtained with the further late planting.

Muhammad *et al.* (2007) conducted an experiment in Pakistan to evaluate the response of sowing dates on the growth and yield of cauliflower. In this experiment five sowing dates (1st June, 16th June, 1st July and 16th July) were evaluated and the significant variations were observed in different growth and yield parameters. Among the sowing dates, second sowing date (16th July) statistically showed maximum plant weight (2.6 kg/plant), head weight (1.4 kg/plant), number of marketable head (27.00 kg/plot) and head yield (37.83 t/ha).

According to Ara *et al.* (2009) all the vegetative growth parameters like plant height, number of leaves per plant, whole plant weight, weight of marketable curd per plant and yield t/ha were influenced significantly by the date of planting except days to curd initiation, days to curd harvest, curd length and curd breadth Curd yield increased

significantly as the planting delayed in summer season. They also observed that the late planting exposed the plants to shorter duration to favourable climate for vegetative growth while the lower temperature helped on set of reproductive phase earlier in summer season.

Nowbuth (1996) carried out an experiment to study the effect of temperature on curd initiation of cauliflower at Mauritius with two variety Revito and Local variety. He observed that warm temperature has an inhibitory action to curd development, curd initiation as well as expansion of curd diameter and warmer temperature seems to favourable leaf production. He also suggests that there are genetic differences in the developmental responses of cauliflower varieties to temperature. Jorgen *et al.* (1997) observed that the optimum vegetative growth of cauliflower is occurred at temperature of 21°C and more leaves are usually formed at high than low temperature. Wurr and Fellows (2000) observed that cauliflowers of early summer crops have the shortest period from planting to curd induction with lowest numbers of leaves whereas winter cauliflower have the longest period with higher numbers of leaves and also shown that in early summer cauliflowers curd induction occurs at lower ambient temperatures than in winter cauliflowers where the optimum temperature for induction of all types is relatively high, ranging from 9 to 14°C which Indicated that under optimum conditions the duration of curd induction increases from early summer to winter types.

Rahman *et al*. (2007) conducted two experiments to assess the response of cauliflower cv. Nautilus F1 hybrid to different constant temperatures after curd initiation by keeping the plants in six different temperature-controlled glasshouse compartments with heating set point temperatures of 6, 10, 14, 18, 22, and 26^{o}C (±^{o}C) under UK condition during winter and summer months. They observed that many of the growth parameters increased with increasing mean growing temperature up to an optimum temperature and then declined with further increases in temperature. Therefore, cauliflower's growth and development after curd initiation could be resolved into linear or curvilinear function of effective temperatures calculated with optimum temperatures between 19 and 23➡C and it was suggested that future warmer climates will be beneficial for winter cauliflower production rather than summer cauliflower production. Fritz *et al*. (2009) and Verma (2009) reported that high temperatures (days over 30°C

and nights of 26°C) delay and prevent proper curd development and affect subsequent quality of cauliflower.

2.3 Review related to broccoli

Singh and Singh (2000) in another study evaluated treatments containing nitrogen @ 0, 125, 150 and 175 kg/ha and potassium. They reported that N and K had a pronounced role on head yield and associated character of broccoli. They recorded a linear increase in plant height was due to synthesis of chlorophyll and amino acids. Delay in marketable maturity was observed due to nitrogen level beyond 150 kg/ha.

Karitonas (2001) also evaluated effects of nitrogen @ 60 to 300 kg/ha and reported that nitrogen supply was directly related to yield parameter and the optimum N supply was 240 kg/ha. Content of dry soluble in broccoli heads ranged within 6.8-7.0 % and an increased level of N supply slightly reduced vitamin C content from 83 mg/100 g fresh matter to 73 mg/100 g. They further noticed that in broccoli flowers as well as chlorophyll contents was improved in florets.

Babik et al. (2002) studied the effects of nitrogen @ 100, 200, 400 and 600 kg/ha on yield and quality of broccoli. They recorded that an increase in plant weight, total yield, as well as hastened the head formation and harvest time with the use of nitrogen @ 400 and 600 kg/ha. With high nitrogen fertilization the contents of sugars and nitrates in broccoli heads also increased but the level of ascorbic acid and dietary fiber dropped. In another experiment conducted by Feller and Fink (2005) to find out effects of nitrogen content and timing of nitrogen fertilization on growth and yield of broccoli. Results showed that total marketable yield increased significantly with increase in nitrogen application. They obtained maximum marketable yield when nitrogen was applied @ 80 to 118 kg N/ha. Wojciechowska *et al.*(2005) studied that the foliar urea application significantly lowered concentration of nitrates in broccoli heads in comparison with the plants not treated with urea. Additionally, the foliar nutrition increased soluble sugars content in all N treatments.

Agarwal *et al.*(2007) evaluated the effects of nitrogen and plant density on marketable head yield of broccoli. Four nitrogen fertilization doses were 50, 100, 150 and 200 kg

per hectare along with plant spacing of 60 × 45 cm and 45 × 45 cm. Results showed that increase in nitrogen level and plant densities had significant effect on head weight, quality and head yield. They obtained maximum head yield and quality @ 200 kg N/ha. While, increase in plant density decreased the head weight but increase in the head yield was noticed. Mahmud *et al* (2007) conducted an experiment for optimization of fertilizer requirement for broccoli with the use of nitrogen @ 0, 60, and 120 kg/ha in the form of urea. They recorded that increase in nitrogen level significantly influenced plant height and obtained maximum plant height of 51.59 cm with nitrogen @ of 120 kg/ha. However, leaf number increased by more than 5.67 % and 8.00 % compared to control with the use of nitrogen @ 60 and 120 kg/ha, respectively. The highest significant head yield of 16.57 t/ha was also recorded with N @ 120 kg/ha.

Yildirim *et al.*(2007) evaluated growth, yield and quality of broccoli affected by foliar application of urea. Larger heads, head weight and chlorophyll content were obtained by foliar applications of 0.8 and 1.0% urea concentration, with optimum yields 0.61 and 0.96%. Similarly Moniruzzaman *et al.*(2007) evaluated levels of nitrogen @ 100 and 200 kg/ha and reported that nitrogen i.e. 100 and 200 kg/ha significantly gave higher values for all growth and yield attributes.

Mellgren (2008) conducted a trial with nine nitrogen treatments, ranging from 0 to 225 kg/ha and two irrigation treatment. He reported that nitrogen had a curvilinear effect on marketable yield. An increase was seen up to an application of 165 kg N/ha where the response was plateau. Plant uptake of N was strongly affected by nitrogen application and a large effect from irrigation was observed at harvest.

Ouda and Mahadeen (2008) conducted an experiment with nitrogen @ 0, 30 and 60 kg/ha to find out effects of fertilization on growth, yield quality and certain nutrient contents in broccoli. It was reported that head number per plant, chlorophyll content, head diameter and total yield was significantly higher when a combination of organic and inorganic fertilizers was added as compared with their individual addition. Application of 60 kg nitrogen as inorganic fertilizers with 60 ton of organic manure per hectare produced the highest broccoli yield (40.05 t/ha), whereas fresh and dry weight of broccoli shoots were not significantly affected by the application of different doses

of fertilizers. Leaf macro-(N, P and K) and micronutrient (Fe, Mn and Zn) contents increased with the application of either organic manure or inorganic fertilizer compared to the control.

Yoldas *et al.*(2008) conducted an experiment to find out effect of nitrogen on yield, quality, and nutrient content in broccoli heads. Treatments consisted of 0, 150, 300, 450, and 600 kg N/ha. Application of nitrogen rates significantly increased yield, average weight of main and secondary heads, and the diameter in broccoli. The highest total yield (346.31 q/ha) was obtained at 300 kg N/ha. Potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn) content increased with increase in nitrogen treatments but, phosphorus (P), copper (Cu), manganese (Mn), boron (B), and sodium (Na) contents were not influenced. It also, removed nutrients by broccoli head.

Brahma *et al.*(2010) studied the effect of different levels of nitrogen fertilization on growth, yield in terms of growth, yield and economic of broccoli. Besides, it also saved fertilizers up to 40 % as compared to conventional fertilization to maintain the same yield levels in broccoli**.** Xu *et al.*(2010) conducted an experiment to find out effect of nitrogen on head size, shelf life, concentrations of ascorbic acid, glucoraphanin and quinine reductase (QR) activity of broccoli in two cultivars Youxiu and Lvlinghe. Nitrogen levels were 0, 100, 200, 300 and 400 kg/ha. Results showed that 200-300 kg N/ha could significantly increase the head size, the storage life, glucoraphanin concentration and QR activity.

Katiyar *et al.*(2011) conducted an experiment at C.S. Azad University of Agricultural and Technology Kalyanpur, Kanpur to find out effect of nitrogen on growth relating traits of broccoli. Nitrogen levels which were 30, 60, 90, and 120 kg/ha. It was reported that nitrogen showed direct response more pronounced at 90 kg N/ha of fertilization. The results revealed significantly increase in the head yield of broccoli i.e. 170.15 q/ha.
El-Helaly (2012) studied the effects of nitrogen, sulphur and growing seasons on yield and the content of nitrate and vitamin C on broccoli (*Brassica oleracea L. var. italica*). Three N fertilizers (ammonium sulphates, ammonium nitrate and urea) were side-dressed, while two levels of sulphur (0.0 and 0.5%) were sprayed on broccoli plants

grown in both spring and fall-winter seasons. It was reported that application of urea as N-source decreased the yield by approximately 13-15% than other N-source.

El-All and Elshabrawy (2013) studied the effects of nitrogen @ 0, 40, 80 and 120 kg/fed, phosphorus and potassium and their interaction on vegetative growth, yield and quality as well as chemical composition of broccoli. It was reported that an increase in nitrogen dose up to 80kg/fed considerably improved curd weight. While, dry matter was reduced with increased application of nitrogen led to improve vitamin C and sulforaphane by nitrogen levels up to 120kg/fed and 40 kg/fed respectively.

Fabek *et al.*(2012) studied the effect of nitrogen @ 0, 60, 120, 240 kg/ha on nitrate accumulation, the minerals and glucosinolates in two broccoli cultivar (Marathon and Parthenon). There was significant effect of cultivar and nitrogen fertilization on nutritional quality of broccoli top inflorescence for two seasons. It was reported that marathon applied with nitrogen @ 120 or 240 kg/ha gave the highest values of glucosinolates and some nitrate minerals with nitrate content in permissible limit.

El-Magd *et al.*(2014) recorded the highest yield of broccoli with the application of N @ 120 Kg/faddan, it was followed by nitrogen @ 90 kg/faddan. Application of biofertilizers along with nitrogen, phosphorus and potassium was quite beneficial in improving the vegetative growth of broccoli. Study conducted by Giri *et al* (2013) evaluated the effect of nitrogen rates on growth and yield of two varieties of broccoli i.e. Green sprouting and Calabrese in western chitwan, Nepal using 5 nitrogen levels @ 0, 50, 100, 150 and 200 kg/ha. It was reported that yield was significantly influenced with cultivar and nitrogen. There was increase in curd production up to 200 kg N/ha which was 14.47 t/ha. While, Green sprouting produced 11% higher total curd than another cultivar.

Aldrich *et al.*(1961) studied effects of spacing on both the total yield and the size of broccoli heads and reported that total yield increased to a maximum when spacing was reduced to 8 or 11 inches (depending on season and variety). In another study conducted by Gorski and Armstrong (1985) reported that closer spacing (40 cm to 20 cm) and higher plant densities increased yield/hectare but it reduced the head size of

broccoli. Among fertilizers increasing N rate (0 to 224 kg/ha) increased yield. The effect of variety, spacing and levels of nitrogen fertilization on the yield of broccoli was also investigated by Mullins and straw (1990) from USA suggested that a spacing of 6 inches (15 cm) was desirable for fresh market production, where a small head size is required. The use of multiple plants transplant decreases mean head weight and diameter. Similarly Griffith and Carling (1991) recorded the maximum yield of individual heads for fresh market at 45 × 30 cm spacing using single plant transplants. At this spacing yields for 'Green Valiant' and 'Emperor' were 18.3 and 15.0 t/ha, respectively.

Pornsuriya *et al.*(1997) conducted an experiment to find out various cultural methods to increase yield and quality of broccoli in Thailand. The best spacing was 40 × 60 cm, which gave the highest yield and quality. Kunicki et al. (1999) conducted an experiment under the climatic conditions of SE Poland. The effect of plant densities of 3.2, 4.0, 5.3 or 8.0 plants/m^2 were investigated for yield and quality of broccoli cultivars 'Kermit', 'Montilla' and 'Skiff'. They reported that plant density had a significant effect on marketable yield which ranged from 11.0 t/ha to 16.6 t/ha. Head weight was increased by 46% as planting density decreased from 8.0 to 3.2 plants/m^2. On the other hand, higher plant spacing led to the highest number of leaves and fresh weight and dry weight/plant.

Francescangeli *et al.*(2006) conducted an experiment in greenhouse in the seasons of 2002 and 2003 at different plant densities i.e. 2, 4, 6 or 8 plants/m^2. They reported no significant effect for total number of leaves, head diameter and fresh weight of broccoli. Whereas, the effects of plant density on dry weight partitioning was to decrease the dry weight allocated to the stem portion. Singh *et al* (2006) conducted an experiment to evaluate the effects of three spacing i.e. 45 × 30 cm, 45 × 45 cm and 45 × 60 cm on days to curd initiation, curd length, curd width, stalk length, stalk diameter and curd yield of broccoli cultivar 'Fiesta' for two years. Results showed that broccoli take less days to curd initiation, maximum curd length (11.06 cm and 10.07 cm), curd width (13.83 cm and 12.32 cm), stalk length (22.71cm and 20.73 cm) and stalk diameter (3.36 cm and 3.05 cm) as well as curd yield (130.25q/ha and 118.36 q/ha) when planted at 45 × 60 cm.

Munro *et al.*(2007) conducted an experiment during 2001-2003 in Odemis, Turkey, to investigate the effects of plant spacing (four plant spacing; 50 cm × 45 cm, 50 cm × 50 cm, 60 cm × 45 cm and 60 cm × 60 cm) on the growth and yield of three cultivars of broccoli ('Green Dome', 'KY-110' and 'Marathon') with recommended fertilizer dose of NPK at 150:100:80 kg/ha, respectively. Results showed that lowest plant spacing (50 cm × 45 cm) increased stem length and decreased stem diameter but the highest plant spacing (60 cm × 60 cm) process the highest leaf length and leaf breadth and as a result the highest plant height, weight of primary curd but the highest yield was obtained from the lowest spacing (50 cm × 45 cm).

Grabowska *et al.*(2009) conducted an experiment to assess the influence of the method of cultivation and spacing on nutritive quality of Lord F1 broccoli heads. It was reported that methods of cultivation (direct sowing or transplanting) and plant spacing of 20, 30, 40 and 50 cm had no significant effect on the dry matter content in the heads. The mean dry matter content in broccoli heads was 9.5%, and reducing sugar was 1.12% of fresh matter.

Schellenberg *et al.*(2009) evaluated the effects of planting density and rate of nitrogen fertilizer on yield characteristics of broccoli cultivar Everest and Gypsy. Planting density and rate of nitrogen fertilizer were 25, 60, and 100 kg/ha, respectively. Results showed that nitrogen application significantly improved head size, marketable yield, and leaf N accumulation. Maximum floret production was obtained at 12,500 plants/acre and N rate of 100 kg/ha. While, total yield and head weight was higher in midseason Gypsy. In another study conducted by Cordero *et al* (2010) transplanted broccoli cultivars on three plant densities i.e. 55, 65, 75 thousands plants/ha in 48 m2 plots and reported that plant densities had inversely proportional effect on floret diameter. At 55 thousand plants/ha floret diameter was at peak. While, 75 thousand plants/ hectare density produced the smallest floret diameter.

Bhangre *et al.*(2011) evaluated the effect of plant spacing i.e. 60 × 60 cm, 60 × 45 cm, 45 × 45 cm, 60 × 30 cm, 45 × 30 cm and cultivar on growth and yield of broccoli. Among plant spacing 60 × 60 cm showed maximum curd diameter, average weight of

curd and yield except days to 50% harvest (59.83 days), days to last harvest (74 days). While, 45 × 30 cm spacing gave minimum values of various parameters under study except days to 50% harvest (64.5 days), days to last harvest (79.33 days) and yield.

Solunke *et al.*(2011) conducted an experiment to find out effects of dates of planting and spacing on growth and yield of broccoli. Three dates of planting i.e.15th September, 30th September and 15th October, three spacing i.e. 60 × 30 cm, 60 × 45 cm and 60 × 60 cm were evaluated. Results showed that broccoli transplanted on 15th September gave maximum yield (14 q/ha) over the other dates of planting. While, 60 × 60 cm spacing showed maximum growth for height, number of leaves, stem diameter and leaf area. Arthur *et al.*(2012) evaluated the effect of spacing on broccoli yield, plant spacings were 0.2, 0.3, 0.4 and 0.5 m. Maximum head yield (22.08 t/ha) and florets yield (17.09 t/ha) was obtained with 0.20 m spacing.

Sari *et al.*(2000) evaluated five dates of sowing i.e. 15 June, 1 and 15 July and 2 and 16 August and concluded that early sowing significantly increased main head weight, head diameter and total yield. They obtained the highest yield of from 15 June sown crop. Trotta *et al.*(2000) reported from Italy that central head weight as well as yield of broccoli cultivars decreased when sowing was delayed from first fortnight of August to first fortnight of September. Singh (2001) conducted an experiment to assess the plant height and head yield of broccoli planted at weekly intervals from 20th October to 22nd December. The highest average values for plant height (41.75 cm) and head yield (99.05 q/ha) were recorded when the crop was transplanted on 27th October. These values were at par with those obtained from crops transplanted on 20th October and 3rd November. Whereas, transplanting beyond 10th November significantly reduced both parameters. Rekowska *et al.*(2002) assessed the effects of six different dates of sowing on the yield of Lord F1 broccoli head. They reported higher main head weight, head diameter and marketable yield when broccoli was sown on May 25, June 10 and 25, in comparison with April 10 and 25. For the secondary heads of broccoli, the best production and more robust heads were obtained on 10th June sown crop.

Wlazo and Kunicki (2003) carried out a field experiment in Poland to find out the effects of transplanting age (4, 6, 8 and 10 week old) and transplanting date (11th July

and 6th August) on the yield and quality of broccoli cv. Lord F1. The marketable yield of broccoli was the highest in July planting, whereas the dry matter and ascorbic acid content in broccoli heads were the highest in August planting. Among age of planting ten week old, and 4 and 8 week old transplant recorded the highest marketable yield in 2000 and 2001, respectively. Dry matter and ascorbic acid content were the highest in 6 and 4 week old transplants, respectively.

Ahmed and Siddique (2004) evaluated the effect of sowing dates on growth and yield of broccoli. Seeds were sown on 20th April, 5th May and 4th June. Results showed that sowing on 5th May produced more leaves (18.48), taller plants (30.79 cm), head diameter (14.97 cm) and weight (200.65 g) with maximum secondary heads (16) and total yield.

Acikgoz (2011) evaluated the change of vitamin C and minerals in three different sowing times i.e. 1st July, 1st August and 1st September in four broccoli cultivars. They reported that the vitamin C content ranged in between 52.6 g/100g and 32.4 g/100g and was highest in Marathon F1 cultivar of broccoli. Among different dates of sowing late season (1st September) had higher vitamin C content than the early sown (1st July, 1st August). In another experiment Sermenli *et al.*(2011) evaluated the most suitable transplant date of broccoli under Antakya conditions, for this seedlings were transplanted on four different dates i.e. 1st, 10th and 20th September and October for two year trial. They obtained highest total yield from 10th September transplanted broccoli for the first year which was 197.8 kg/ha and 186.3kg/ha for the second year. Thus, the results indicated that the first two weeks of September is most suitable period for broccoli transplanting under Antakya conditions.

Hossain *et al.*(2011) evaluated that time of sowing and plant spacing has significant effects on broccoli production. Crop was sown on 1st October, 15th October and 30th October at three plant spacing viz. 60 × 40 cm, 60 × 50 cm and 60 × 60 cm. It was reported that yield and yield characteristics were directly influenced by treatments. Highest yield (22.5 t/ha) was obtained in 1st October sowing and 60 × 40 cm plant spacing combination.

Dev (2012) evaluated effects of planting time and spacing on growth and yield in broccoli. Green head cultivar of broccoli was transplanted on 5th Oct, 15th Oct, 25th Oct and 5th Nov at three spacing 60 × 30 cm, 60 × 45 cm, 60 × 60 cm. Significant differences were observed for all the traits in term of gross yield (q/ha), yield per plant (g), primary head weight (g), secondary head weight (g), secondary heads per plant (number), plant height (cm), during both the years. It was reported that broccoli seedlings transplanted during the first fortnight of October at a spacing of 60 × 60 cm gave maximum gross yield. The delayed planting markedly reduced the yield whereas days to head initiation, maturity and harvest duration were least influenced by the planting time and spacing.

Kaluzewicz *et al.*(2012) studied influence of temperature by planting broccoli under different dates i.e. April, May, June, and July. Observations were taken for various plant growth parameters such as number of leaves, leaf area and stem diameter and days to head initiation. From the results it was concluded that the shortest period from planting to head initiation was when the plants were planted in April and June in the first year and the longest one for planting in April in the 2nd year of the study.

Khatun *et al.*(2012) conducted an experiment at the Horticultural Research Farm, of Sher-e Bangla Agricultural University, Dhaka to evaluate the effect of different transplanting dates i.e. October 5, October 25, November 14 and December 4 on the growth and yield of broccoli. They reported different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. Weight of curd/plant (319.11g), curd yield plot/ (7.83 kg) and curd yield/ha (13.04 tonnes) were decreased with delay in transplanting. The highest curd yield/ha was obtained from the 25th October transplant. While, the lowest from the 4th December transplanting. Karistsapol *et al.*(2013) conducted an experiment to evaluate suitable planting date and varieties for commercial production from January to June and it was reported that the Top Green, Green Queen and YokKheo had seedling survival rates of 76.53-100.00% except the cultivar Special. The YokKheo had the highest total yield of 12.31 and 10.65 t/ha when the planted in January and March, respectively.

Chandan *et al.*(2014) evaluated three hybrids namely Fiesta, Premier and an open pollinated variety KTS-1 at four dates of transplanting i.e. 27th June, 7th July, 17th July, and 27th July in mid hill conditions of Ranichauri. From results it was concluded among different transplanting dates, 27th July had best impact on head yield characters. While, among broccoli hybrids Premier and Fiesta were found at par superior for head yield.

Shapla *et al.*(2014) conducted an experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Bangladesh during the period from October 2011 to March 2012. The experiment consisted three different planting times as 3rd November, 18th November and 3rd December using Randomized Complete Block Design with three replications. They reported maximum weight of primary curd/plant (427.8 g), diameter of primary curd (10.1 cm), weight of secondary curd (66.8 g), dry matter content of leaves (13.6 g), yield/plot (9.9 kg) and yield (10.6 t/ha) from 18th November planting. While, minimum from 3rd December. So, planting at 18th November was better for the broccoli production in Bangladesh.

Valashkolaei *et al.*(2014) Studied factors containing three dates of sowing i.e. 23rd of September, 7th October and 23rd of October, in addition to complete fertilizer solution was sprayed in three levels i.e. once every week, once every two weeks and once every four weeks. From the above study it was concluded that the interaction of planting date and fertilizer was non significant in most physiological indexes. However some morphological parameters became significant such as stem length, dry and wet weight of root and yield. Maximum growth parameters were observed in the first planting date and no remarkable difference were seen among various levels of fertilizer treatments. Whereas, Maximum achieved yield 267.9 gram/bush was related to first planting date with once spray of fertilizer in every two weeks.

Chaudhari *et al.*(2015) conducted an experiment at Horticulture instructional Farm of Skrushinagar Dantiwad Agriculture University, S. K. Nagar during the period from rabi season of the year 2014-15 to determine the growth of knolkhol as influenced by different planting date and varieties. The study was conducted with three planting date *viz.,* 1st November, 15th November and 1st December. Among different planting dates

best results were recorded on the planting date of 15th November that significantly increased plant height, plant spread and other growth related characters.

Singh (2015) reported that 25-28th July planted crop was found to be the best as it gave maximum head yield 109.74q/ha, take 95.12 days after planting, maximum head weight of 305.69 g/plant with maximum number of leaves/plant (22.5). From the results it was concluded that July and November season was found to be better time for getting maximum broccoli production.

CHAPTER-III

MATERIALS AND MATHODS

CHAPTER- III

MATERIALS AND MATHODS

This experiment was conducted at roof of third floor of Biotechnology Department and Agroforestry research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2017 to March 2018 to study the performance of selected vegetables such as cabbage, cauliflower and broccoli cultivated on rooftop and farm conditions. The materials and methods that were used for conducting the experiment are presented under the following headings:

3.1 Experimental Site

The entire experimental site was divided into two parts. The first part of the experiment was conducted on the roof of biotechnology department. Here three concrete blocks were prepared using sand, brick, cement etc. Each block was 9 m x 1m x 0.5 m in size. Three vegetables like cabbage, cauliflower and broccoli were produced in three blocks maintaining three replications. Each block was divided into 2 m x 1 m plot leaving 0.5 m area between plots leaving 0.5 m area between plots. So, total experimental plots were nine where selected vegetables were cultivated. 2nd part of the experiment was conducted on the agroforestry farm maintaining same measurable areas. Cabbage, cauliflower and broccoli were produced on the farm maintaining same treatments and replications. All management practices were same for both rooftop and farm conditions.

3.2 Climate

The climate of the experimental site is characterized by heavy rainfall during the months from November to March (Rabi 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 II).

3.3 Characteristics of Soil

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 I.

3.4 Planting Materials

Three cole crops were used as planting materials viz. (i) BARI Badhacopy 1*(Brassica oleracea var. capitata)* variety ii) BARI Fulcopy 1(*Brassica oleracea var. botrytis)* variety iii) BARI Broccoli 1(*Brassica oleracea var. italica)* variety- . Seedlings of cabbage, cauliflower and broccoli cultivars, were used in the experiment. Seedlings were collected from Bangladesh Agricultural Research Institute, Gazipur.

3.5 Treatment of the experiment

The experiment consisted of two treatment

T_1: Farm condition

T_2: Rooftop condition

3.6 Experimental Design and Layout

The two factors experiment was with three replications. There were 6 unit plots and the size of the each unit plot was 9 m × 1 m. Three for rooftop cultivation and three for farm crop cultivation. The seeds were sown with maintaining distance row to row 50 cm and plant to plant 50 cm. The field experiment and roof top experiment was done by RCBD design.

3.7 Preparation of the main field and block of roof top

The selected experimental plot was opened in the 7th November 2017 with a power tiller and was exposed to the sun for a week. After 2 days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil for planting of cabbage, cauliflower and broccoli seedlings. The experimental plots and blocks were partitioned into the unit plots in accordance with the experimental design and organic and inorganic fertilizers were applied as per treatments of each unit plot. The soil was treated with fungicide cupravit against the fungal attack.

The experimental block were first filled at 7th November, 2017. Block soil was brought into desirable fine tilth by hand mixing. The stubble and weeds were removed from the soil. The final block preparation was done on 10th November. The soil was treated with insecticides (cinocarb 3G @ 4 kg/ha) at the time of final block preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.8 Application of manure and fertilizers

The crop was fertilized as the rate of 15 tons of cowdung, 275 Kg urea, 175 Kg triple superphosphate (TSP), 220 Kg murate of potash (MOP) per hectare. The sources of N_2, P_2O_5, K_2O as urea, TSP and MP were applied, respectively. The entire amounts of TSP and MP were applied during the final plot and block preparation. Urea was applied in three equal installments at 15, 30 and 45 days after seedling planting. Well-rotten cowdung 15 t/ha also applied during final land and block preparation. The following amount of manures and fertilizers were used recommended by BARI (2005).

3.9 Intercultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of cabbage, cauliflower and broccoli seedlings.

3.10 Gap filling

The seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after planting and such seedling were replaced by new seedlings from the same stock. Those seedlings were planted with a big mass of soil with roots to minimize planting shock. Replacement was done with healthy seedling having a boll of earth which was also planted on the same date by the side of the unit plot. The plants were given shading and watering as needed for their proper establishment.

3.11 Weeding

The hand weeding was done at 15, 30, 45 and 60 days after planting (DAT) to keep the plots free from weeds.

3.12 Earthing up

Earthing up was done at 20 and 40 days after planting on both sides of rows by taking the soil from the space between the rows by a small spade.

3.13 Irrigation

Light watering was given by a watering cane at every morning and afternoon. Following planting and it was continued for a week for rapid and well establishment of the planted seedlings.

3.14 Pest and disease control

In spite of Cirocarb 3G applications during final land preparation few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Birds pest such as nightingales (common Bulbuli) were seen visiting the cabbag , cauliflower and broccoli field and rooftop very frequently. The nightingale visited the fields in the morning and afternoon. The birds very found to puncture the soft levels and newly initiated curd and were controlled by striking a kerosene tin of metallic container frequently during day time.

3.15 Harvesting

Only the compact mature head of cabbage and curds of cauliflower and broccoli were harvested with 15 cm long fleshy stalk by using as sharp knife. To prevent the rotting of steam the cut portion were slanted, so that rain water could not stay. The curds and head were harvested in compact condition before the flower buds opened (Thomson and Kelly, 1985).

3.16 Data collection

12 plants were selected from each unit plot which was recorded. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of the experiment. Data on plant height, number of leaf, length of leaf and breadth of leaf were collected at 20, 40 and 60 days after planting (DAT). All other yield contributing characters and yield parameters were recorded during harvest and after harvest (at 60 DAT).

3.16.1 Plant height

Plant height of cabbage, cauliflower and broccoli was measured from sample plants in centimeter from the ground level to the tip of the longest leaf and mean value was calculated. Plant height was also recorded at 20 days interval starting from 20 days after planting (DAT) up to 40 days and at harvest to observe the growth rate of plants.

3.16.2 Number of leaf per plant

The number of leaf per plant of cabbage, cauliflower and broccoli was counted from each selected plant with the observation of fully open leaves. Data were recorded as the average of 12 plants of each plot at 20 days interval starting from 20 days after planting (DAT) up to 40 days and at harvest.

3.16.3 Length of leaf per plant

The length of leaf per plant of cabbage, cauliflower and broccoli was counted from each selected plant with the observation of fully open leaves. Data were recorded as the average of 12 plants of each plot and block at 20 days interval starting from 20 days after planting (DAT) up to 40 days and at harvest.

3.16.4 Breadth of leaf per plant

The breadth of leaf per plant of cabbage, cauliflower and broccoli was counted from each selected plant with the observation of fully open leaves. Data were recorded as the average of 12 plants of each plot and block at 20 days interval starting from 20 days after planting (DAT) up to 40 days and at harvest.

3.16.5 Height of head/curd

The height of head curd of cabbage, cauliflower and broccoli was measured in several directions with meter scale and the average of all directions was finally recorded and expressed in centimeter (cm).

3.16.6 Diameter of head/curd

The diameter of head curd of cabbage, cauliflower and broccoli was measured in several directions with meter scale and the average of all directions was finally recorded and expressed in centimeter (cm).

3.16.7 Weight of head/curd

The weight of head/ curd per plant of cabbage, cauliflower and broccoli was recorded in gram (g) by a beam balance.

3.17 Statistical Analysis

The data obtained for different parameters were statistically analyzed to find out the significance difference of farm and rooftop cultivation on yield and yield contributing characters of cabbage, cauliflower and broccoli. The mean values of all the characters were calculated. MSTAT-C was used for processing and analysis of data. Paired sample t- test was done for significant of the study. The mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance.

CHAPTER-IV

RESULTS AND DISCUSSION

CHAPTER- IV

RESULTS AND DISCUSSION

The experiment was conducted at the roof of third floor of Biotechnology department and Agroforestry farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2017 to March 2018 to study on the performance of selected vegetables (cabbage, cauliflower and broccoli) cultivated on rooftop and farm. conditions. The results of the present study have been presented and discussed in this chapter under the following heading.

4.1 Performance of cabbage in rooftop and farm conditions

4.1.1 Plant height

Plant height was significantly different from farm and roof top condition under the present study (Fig 4.1). It is evident that plant height was the highest in roof top condition at different growth stages of cabbage cultivars. The highest plant height was 14.89±0.34 cm, 20.13±0.54 cm and 36.65±1.53 cm at 20, 40 and 60 DAT, respectively. On the other hand, the lowest plant height (13.54±0.45 cm, 16.46±0.52 cm and 27.66±0.85 cm at 20, 40 and 60 DAT, respectively) was found in farm condition. Pramanik (2007) reported that at harvest cabbage shown the highest plant height of 34.76 cm in the farm condition. Khatun (2008) revealed that the highest plant height was 37.70 cm. Ullah (2011) revealed that the plant height 31.5 cm was found from suitable growth of cabbage. Afrin (2013) reported that the plant height was 18.46 cm and 36.73 cm for 40 and 60 DAT, respectively in farm condition.

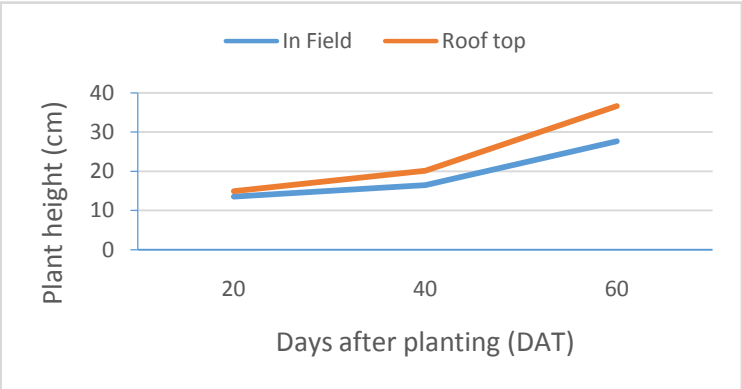

Figure 4.1 Plant height of cabbage cultivation in farm and roof top conditions at different DAT

4.1.2 Number of leaf

Significant variation was observed in case of number of leaf plant^{-1} of cabbage at 40 and 60 DAT but in-significant at 20 DAT as affected by farm and roof top conditions (Table 4.1). It was observed that the highest number of leaf plant^{-1} was obtained 7.26±0.47, 9.72±0.19 and 12.52±0.39 at 20, 40 and 60 DAT, respectively in rooftop condition. On the other hand, the lowest number of leaf plant^{-1} (6.19±0.28, 8.09±0.05 and 9.84±0.42 at 20, 40 and 60 DAT, respectively) was found in farm condition. Afrin (2013) reported that the number of leaf per plant was 8.20 and 17.98 at 40 and 60 DAT respectively in farm condition.

Table 4.1 Leaf number of cabbage plant^{-1} at 20, 40 and 60 DAT in rooftop and farm conditions

Location	Leaf number plant^{-1} at					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	6.19	±0.28	8.09	±0.05	9.84	±0.42
Roof top	7.26	±0.47	9.72	±0.19	12.52	±0.39
Significant level (t test)	NS		*		*	

* = Significant at 5% level of probability
NS= Not significant

4.1.3 Leaf length

Leaf length plant^{-1} is one of the important parameter for measuring yield performance of cabbage (Table 4.2). Under the present study, leaf length plant^{-1} with petiole was significantly influenced by different cultivation practices. It was measured that the highest length of leaf was obtained 13.63±0.37 cm, 18.95±0.55 cm and 22.69 ±0.36 cm at 20, 40 and 60 DAT, respectively on roof top condition. On the other hand, the lowest length of leaves 13.63±0.37 cm, 14.35±0.64 cm and 18.31±0.44 cm at 20, 40 and 60 DAT, respectively was found in farm condition.

Table 4.2 Performance of cabbage leaf length at 20, 40 and 60 DAT in rooftop and farm conditions

Location	Leaf length (cm)					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	11.65	±0.60	14.35	±0.64	18.31	±0.44
Roof top	13.63	±0.37	18.95	±0.55	22.69	±0.36
Significant level (t test)	*		*		*	

* = Significant at 5% level of probability

4.1.4 Leaf breadth

Leaf breadth plant^{-1} is also an important parameter for measuring yield performance of cabbage (Table 4.3). Under the present study, leaf breadth plant^{-1} was significantly influenced by different cultivation practices. The highest leaf breadth plant^{-1}10.54± 0.45 cm ,13.43±0.26 cm and 21.29±0.47 cm at 20, 40 and 60 DAT, respectively was found in roof top condition. On the other hand, the lowest leaf breadth plant^{-1} 8.76± 0.57 cm, 10.87±0.10 cm and 17.44±0.133 cm at 20, 40 and 60 DAT, respectively was found in farm condition. Afrin (2013) reported that the leaf breadth was recorded as 9.89 cm.

Table 4.3 Leaf breadth of cabbage at 20, 40 and 60 DAT in rooftop and farm conditions

Location	Leaf breadth at (cm)					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	8.76	±0.57	10.87	±0.10	17.44	±0.33
Roof top	10.54	±0.45	13.43	±0.26	21.29	±0.47
Significant level (t test)	**		**		NS	

** = Significant at 1% level of probability
NS= Not significant

4.1.5 Head height

Generally head height of cabbage cultivar control yield and quality of the crop and it is greatly influenced by different varietal characters. Under the present study, head height was significantly influenced by different cultivation practices. It was measured that the

highest head height was obtained 18.39± 0.18 cm at 60 DAT on roof top condition. On the other hand, the lowest head height was 16.24±0.13 cm at 60 DAT was found in farm condition.

4.1.6 Head diameter

Diameter of head is a measurement of the size of actual cabbage shape which indicates yield amount and market value. Head diameter of cabbage was significantly influenced by different cultivation practices. The highest head diameter 54.81± 0.43 cm was found in roof top condition. On the other hand, the lowest head diameter 50.74 ± 0.38 cm at 60 DAT was found in farm condition. Pramanik (2007) reported that at harvest cabbage shown thickness of head was 17.06 cm in the farm condition. Alam (2007) reported that the head diameter of cabbage ranged from 10.87 to 18.23 cm. Khatun (2008) revealed that the maximum diameter of head 19.05 cm. Ullah (2011) revealed that the maximum diameter of head (19.4 cm) was found from suitable growth of cabbage.

4.1.7 Head weight

Determination of weight of head is an important measurement for comparing yield performance among the cabbage cultivars under the present study. Significant variation was observed in case of number of head weight at 60 DAT as affected by farm and roof top condition (Table 4.4). The highest head weight 939.72±3.89 g was found in roof top condition. On the other hand, the lowest head weight 865.61±16.23 g at 60 DAT was found in farm condition. Alam (2007) reported that the head weight of cabbage was observed 811.3 g in this condition. Khatun (2008) revealed that the highest fresh weight head 1.87 kg in farm condition. Ullah (2011) revealed that the highest fresh weight (1.00 kg) and the lowest weight (0.53 kg) were found from suitable growth of cabbage. Afrin (2013) reported that the head weight with leaves was 1.29 kg.

Table 4.4 Head height, head diameter and head weight of cabbage at 60 DAT in rooftop and farm conditions

Location	Head height (cm)		Head diameter (cm)		Head weight (g)	
	Mean	SE	Mean	SE	Mean	SE
Field	16.24	±0.13	50.74	±0.38	865.61	±16.23
Roof top	18.39	±0.18	54.81	±0.43	939.72	±3.89
Significant level (t test)	*		**		*	

* = Significant at 5% level of probability

** = Significant at 1% level of probability

4.2 Performance of cauliflower in rooftop and farm conditions

4.2.1 Plant height

Plant height was significantly affected by farm and roof top conditions under the present study (Fig 4.2). It is evident that plant height was the highest in roof top cultivation at different growth stages of cauliflower cultivars. The highest plant height was 12.33±0.46 cm, 32.91±0.80 cm and 43.19±0.97 cm at 20, 40 and 60 DAT, respectively. On the other hand, the lowest plant height 11.59 ±0.37 cm, 26.46 ± 0.68 cm and 38.64±0.57 cm at 20, 40 and 60 DAT, respectively was found in farm condition. Kakani (2012) found at harvest that superior` plant height was 56.03 cm and lowest plant height was noted as 52.10 cm. Kdithuwakku and Kirthisinghel (2009) reavealed that the highest mean height of the cauliflower plant was obtained 10.16 cm and lowest was 8.88 cm.

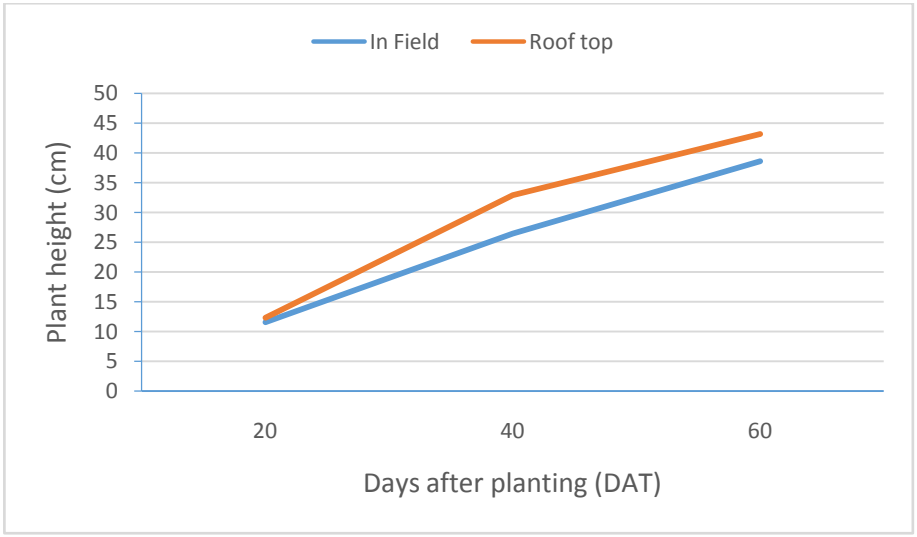

Figure 4.2 Plant height of cauliflower cultivation in farm and roof top conditions at different DAT

4.2.2 Number of leaf

Significant variation was observed in case of number of leaf plant^{-1} at 20 and 40 DAT as affected by farm and roof top conditions (Table 4.5). It was measured that the highest number of leaf plant^{-1} was obtained 8.65 ± 0.40 ,11.11 ± 0.28 and 12.32±0.29 at 20, 40 and 60 DAT, respectively in rooftop condition. On the other hand, the lowest number of leaf plant^{-1} 6.54±0.55, 9.09 ±0.26 and 9.96±0.35 at 20, 40 and 60 DAT, respectively) was found in farm condition. Mahamud (2006) revealed that at harvest the maximum number of leaf per plant of cauliflower was found as 17.83.

Table 4.5 Leaf number plant^{-1} at 20, 40 and 60 DAT of cauliflower in rooftop and farm conditions

Location	Leaf number plant^{-1} at					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	6.54	±0.55	9.09	±0.26	9.96	±0.35
Roof top	8.65	±0.40	11.11	±0.28	12.32	±0.29
Significant level (t test)	*		**		*	

* = Significant at 5% level of probability

**=Significant at 1% level of probability

4.2.3 Leaf length

Leaf length plant^{-1} is one of the important parameter for measuring yield performance of cauliflower (Table 4.6). Under the present study, leaf length plant^{-1} with petiole was significantly influenced by different cultivation practices. It was measured that the highest length of leaf was obtained 11.65±0.46 cm, 21.78±0.23 cm and 32.21±0.65 cm at 20, 40 and 60 DAT, respectively on roof top condition. On the other hand, the lowest length of leaves 9.66±0.34 cm, 26.43±0.41 cm and 18.97±0.91 cm at 20, 40 and 60 DAT, respectively was found in farm condition. Mahamud (2006) found that the longest leaf length per plant of cauliflower was recorded 43.70 cm and leaf breadth was 18.73 cm.

Table 4.6 Leaf length at 20, 40 and 60 DAT of cauliflower in rooftop and farm conditions

Location	Leaf length (cm) at					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	9.66	±0.34	18.97	±0.91	26.43	±0.41
Roof top	11.65	±0.46	21.78	±0.23	32.21	±0.65
Significant level (t test)	*		*		**	

* = Significant at 5% level of probability

**= Significant at 1% level of probability

4.2.4 Leaf breadth

Leaf breadth plant^{-1} is also an important parameter for measuring yield performance of cauliflower (Table 4.7). Under the present study, leaf breadth plant^{-1} was significantly influenced by different cultivation practices. The highest leaf breadth plant^{-1} 11.41 ± 0.78 cm, 14.48±0.81 cm and 22.31±0.24 cm at 20, 40 and 60 DAT, respectively was found in roof top condition. On the other hand, the lowest leaf breadth plant^{-1} 8.24 ±0.63 cm, 11.09 ±0.40 cm and 18.31 ±0.45 cm at 20, 40 and 60 DAT, respectively was found in farm condition. Mahamud (2006) found that the longest leaf breadth per plant of cauliflower was recorded 18.73 cm.

Table 4.7 Leaf breadth at 20, 40 and 60 DAT of cauliflower in rooftop and farm conditions

Location	Leaf breadth (cm) at					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	8.24	±0.63	11.09	±0.40	18.21	±0.24
Roof top	11.41	±0.78	14.48	±0.81	22.31	±0.45
Significant level (t test)	**		**		**	

** = Significant at 1% level of probability

4.2.5 Curd height

Generally curd height of cauliflower cultivar control yield and quality of the crop and it is greatly influenced by different varietal characters. Under the present study, curd height was significantly influenced by different cultivation practices. It was measured that the highest curd height was obtained 18.04 ± 0.47 cm at 60 DAT on roof top

condition (Table 4.8). On the other hand, the lowest curd height 16.15 ± 0.51 cm at 60 DAT was found in farm condition.

4.2.6 Curd diameter

Diameter of curd is a measurement of the size of actual cauliflower shape which indicates yield amount and market value. Curd diameter of cauliflower was significantly influenced by different cultivation practices. The highest curd diameter 54.85±0.50 cm was found in rooftop condition (Table 4.8). On the other hand, the lowest curd diameter 50.26±0.48 cm at 60 DAT was found in farm condition. Mahamud (2006) revealed that at harvest the maximum curd diameter of cauliflower was 17.02 cm and the maximum curd height was 15.98 cm. Kodithuwakku and Kirthisinghel (2009) found that the mean curd diameter of the plots varying from of 11.8-13.0 cm.

4.2.7 Curd weight

Determination of weight of curd is an important measurement for comparing yield performance among the cauliflower cultivars under the present study. Significant variation was observed in case of number of curd weight at 60 DAT as affected by farm and roof top conditions (Table 4.8). The highest curd weight 888.85 ± 25.38 g was found in roof top condition. On the other hand, the lowest curd weight 740.43 ± 28.83 g at 60 DAT was found in farm condition. Mahamud (2006) revealed that at harvest the maximum curd weight of cauliflower per plant was 406.05 g.

Table 4.8 Curd height, curd diameter and curd weight at 60 DAT of cauliflower in rooftop and farm conditions

Location	Curd height (cm)		Curd diameter (cm)		Curd weight (g)	
	Mean	SE	Mean	SE	Mean	SE
Field	16.15	±0.51	50.26	±0.48	740.43	±25.38
Roof top	18.04	±0.47	54.85	±0.50	888.85	±28.83
Significant level (t test)	**		**		*	

* = Significant at 5% level of probability

** = Significant at 1% level of probability

4.3 Performance of broccoli in rooftop and farm conditions

4.3.1 Plant height

Plant height was significantly affected by farm and roof top conditions under the present study (Fig 4.3). It is evident that plant height was the highest in roof top condition at different growth stages of broccoli cultivars. The highest plant height was 15.24±0.08 cm, 30.54±0.22 cm and 42.98±0.72 cm at 20, 40 and 60 DAT, respectively. On the other hand, the lowest plant height 14.13±0.08 cm, 25.44± 0.06 cm and 34.12 ± 076 cm at 20, 40 and 60 DAT respectively was found in farm condition. Mahamud (2006) found that the longest (43.70 cm) plant was recorded at harvest in broccoli.

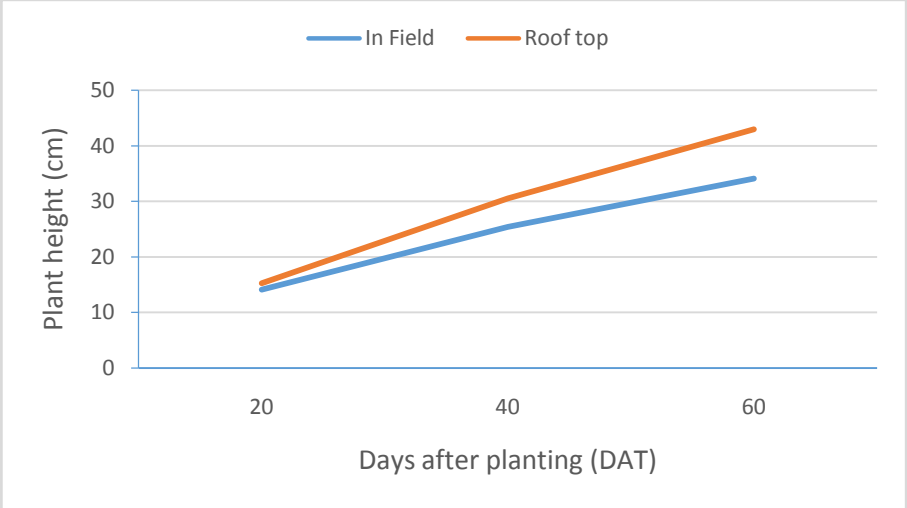

Figure 4.3 Plant height of broccoli in farm and in rooftop conditions at different *DAT*

4.3.2 Number of leaf

Significant variation was observed in case of number of leaf plant^{-1} at 20 and 40 DAT as affected by farm and roof top conditions (Table 4.9). It was measured that the highest number of leaf plant^{-1} was obtained 6.12 ± 0.09, 8.53± 0.10 and 10.44 ± 0.18 at 20, 40 and 60 DAT, respectively found in rooftop condition. On the other hand, the lowest number of leaves plant^{-1} 5.26±0.13, 7.19 ± 0.04 and 8.34 ± 0.12 at 20, 40 and 60 DAT, respectively) was found in farm condition.

Table 4.9 Leaf number plant^{-1} at 20, 40 and 60 DAT of broccoli in rooftop and farm conditions

Location	Leaf number plant^{-1} at					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	5.26	±0.13	7.19	±0.04	8.34	±0.12
Roof top	6.12	±0.09	8.53	±0.10	10.44	±0.18
Significant level (t test)	*		**		*	

* = Significant at 5% level of probability
**=Significant at 1% level of probability

4.3.3 Leaf length

Leaf length plant^{-1} is one of the important parameter for measuring yield performance of broccoli (Table 4.10). Under the present study, leaf length plant^{-1} with petiole was significantly influenced by different cultivation practices. It was measured that the highest length of leaf was obtained 13.46 ±0.46 cm, 18.22 ± 0.48 cm and 29.67 ± 0.76 cm at 20, 40 and 60 DAT, respectively on roof top condition. On the other hand, the lowest length of leaves 10.20 ± 0.27 cm, 14.78 ± 0.61 cm and 22.46 ± 0.55 cm at 20, 40 and 60 DAT, respectively was found in farm condition.

Table 4.10 Leaf length at 20, 40 and 60 DAT of broccoli in rooftop and farm conditions

Location	Leaf length (cm) at					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	10.20	±0.27	14.78	±0.61	22.46	±0.55
Roof top	13.46	±0.46	18.22	±0.48	29.67	±0.76
Significant level (t test)	*		*		*	

* = Significant at 5% level of probability

4.3.4 Leaf breadth

Leaf breadth plant^{-1} is also an important parameter for measuring yield performance of broccoli (Table 4.11). Under the present study, leaf breadth plant^{-1} was significantly influenced by different cultivation practices. The highest leaf breadth plant^{-1} 11.00± 0.40 cm, 12.65±0.36 cm and 21.69±0.49 cm at 20, 40 and 60 DAT, respectively was found in roof top condition. On the other hand, the lowest leaf breadth plant^{-1} 8.13± 0.52 cm, 10.30±0.38 cm and 19.47±0.22 cm at 20, 40 and 60 DAT, respectively was found in farm condition.

Table 4.11 Leaf breadth at 20, 40 and 60 DAT of broccoli in rooftop and farm conditions

Location	Leaf breadth (cm) at					
	20 DAT		40 DAT		60 DAT	
	Mean	SE	Mean	SE	Mean	SE
Field	8.13	±0.52	10.30	±0.38	19.47	±0.22
Roof top	11.00	±0.40	12.65	±0.36	21.69	±0.49
Significant level (t test)	**		**		**	

** = Significant at 1% level of probability

4.3.5 Curd height

Generally curd height of broccoli cultivar control yield and quality of the crop and it is greatly influenced by different varietal characters. Under the present study, curd height was significantly influenced by different cultivation practices (Table 4.12). It was measured that the highest curd height was obtained 17.60 ± 0.52 cm at 60 DAT on roof top cultivation. On the other hand, the lowest curd height 16.28 ± 0.48 cm at 60 DAT was found in farm condition.

4.3.6 Curd diameter

Diameter of curd is a measurement of the size of actual broccoli shape which indicates yield amount and market value. Curd diameter of broccoli was significantly influenced by different cultivation practices (Table 4.12). The highest curd diameter 51.85 ±1.50 cm was found in roof top condition. On the other hand, the lowest curd diameter 47.54±1.28 cm at 60 DAT was found in cultivation farm condition. 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.

4.3.7 Curd weight

Determination of weight of head is an important measurement for comparing yield performance among the broccoli cultivars under the present study. Significant variation was observed in case of number of curd weight at 60 DAT as affected by farm and roof top conditions (Table 4.12). The highest curd weight 816.48±70.55 g was found in roof top condition. On the other hand, the lowest curd weight 574.13±42.92 g at 60 DAT was found in cultivation farm condition.

Table 4.12 Curd height, curd diameter and curd weight at 60 DAT of broccoli in rooftop and farm conditions

Location	Curd height (cm)		Curd diameter (cm)		Curd weight (g)	
	Mean	SE	Mean	SE	Mean	SE
Field	16.28	±0.48	47.54	±1.28	574.13	±42.92
Roof top	17.60	±0.52	51.85	±1.50	816.48	±70.55
Significant level (t test)	**		**		*	

* = Significant at 5% level of probability

** = Significant at 1% level of probability

4.4 Yield performance of cabbage, cauliflower and broccoli

The yield performance of cole crops (Cabbage, cauliflower and broccoli) in farm and roof top conditions both are significant. In farm condition, the highest yield was recorded on cabbage (34.62 t ha^{-1}) and lowest yield was recorded in broccoli (22.96 t ha^{-1}). On roof top condition, the highest yield was recorded on cabbage (39.58 t ha^{-1}) and lowest yield was recorded in broccoli (32.65 t ha^{-1}). The pair sample t test was done both the farm and roof top conditions and the result was significant. Percent yield increased in cabbage, cauliflower and broccoli were 14.33, 20.06 and 42.20. The highest yield percent was recorded in broccoli and the lowest percentage was recorded in cabbage. This is might be in environmental factor issue. Khatun (2008) revealed that the yield was 53.97 t/ha recorded from 60 cm x 40 cm spacing in farm condition. Roy (1981) reported that 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.

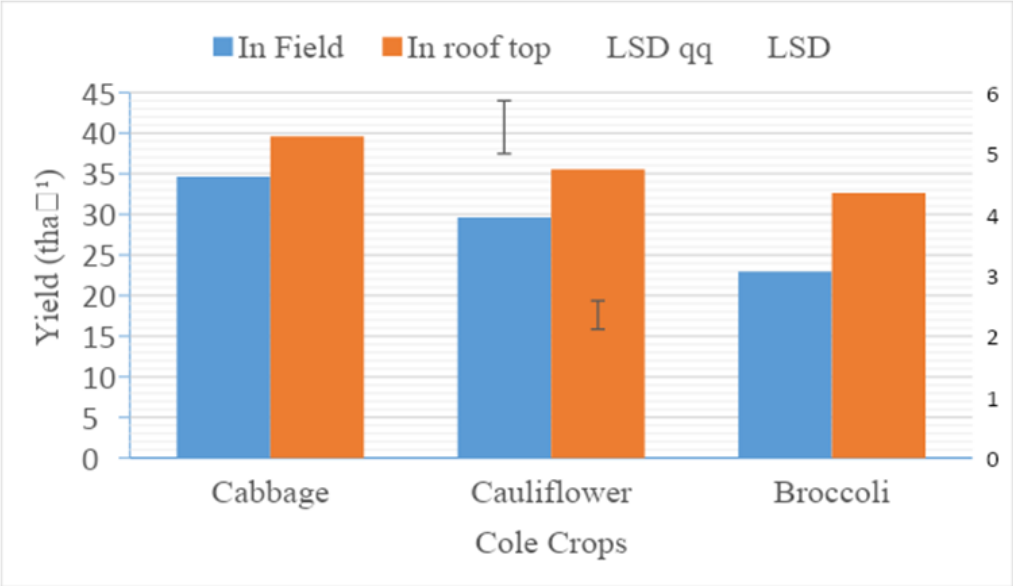

Fig. Yield performance of cabbage, cauliflower and broccoli under farm and rooftop Conditions. (Vertical bars represented LSD value at 0.05)

CHAPTER-V

SUMMARY, CONCLUSION, RECOMMENDATION, REFERENCES AND APENDICES

CHAPTER-V

SUMMARY, CONCLUSION AND RECOMMENDATION

SUMMARY

The experiment was conducted at the roof of third floor of Biotechnology Department and Agroforestry farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2017 to March 2018 to study the performance of selected vgetables (cabbage, cauliflower and broccoli) cultivated on rooftop and farm conditions. Three cole crops were used as planting materials viz. (i) Cabbage *(Brassica oleracea var. capitata)* variety –BARI Badhacopy 1 ii) Cauliflower (*Brassica oleracea var. botrytis)* variety- BARI Fulcopy 1, iii) Broccoli (*Brassica oleracea var. italica)* variety- BARI Broccoli 1. Data on plant height, number of leaf, leaf length, leaf breadth, head height, diameter and weight of cabbage, cauliflower and broccoli were collected. The farm experiment and roof top experiment was done by RCBD design with three replications. MSTAT-C was used for processing and analysis of data. Paired sample t- test was done for significant of the study. The mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance.

In cabbage, cauliflower and broccoli, yield parameters value were increased with increasing days after planting for all of the traits studied like plant height, number of leaf, leaf length, leaf breadth, head height, diameter and weight and the trend was significant in farm and roof top conditions.

In cabbage cultivation, plant height, number of leaf, leaf length, leaf breadth, head height, head diameter and head weight was significantly affected by farm and roof top conditions. The highest plant height was 14.89 cm, 20.13 cm and 36.65 cm and the lowest 13.54 cm, 16.46 cm and 27.66 cm at 20, 40 and 60 DAT, respectively was found in roof top and farm conditions. The highest number of leaf was 7.26, 9.72 and 12.52 cm and the lowest 6.19, 8.09 and 9.84 at 20, 40 and 60 DAT, respectively was found in roof top and farm conditions. The highest leaf length and breadth was 13.63 and 10.54, 18.95 and13.43; 22.69 and 21.29 cm and the lowest 13.63 and 8.76, 14.35 and10.87;18.31 and 17.44 cm at 20, 40 and 60 DAT, respectively was found in roof top and farm conditions. The highest head height, diameter and weight was 18.39,

54.81 cm and 939.72 g where as the lowest 16.24, 50.74 cm and 865.61 g was found in cultivation roof top and farm conditions.

In cauliflower cultivation, plant height, number of leaf, leaf length, leaf breadth, head height, head diameter and head weight was significantly affected by farm and roof top conditions. The highest plant height was 12.33, 32.91 and 43.19 cm and the lowest 11.59, 26.46 and 38.64 cm at 20, 40 and 60 DAT, respectively was found in roof top and farm conditions. The highest number of leaves was 8.65, 11.11 and 12.32 cm and the lowest 6.54, 9.09 and 9.96 cm at 20, 40 and 60 DAT, respectively was found in roof top and farm conditions. The highest leaf length and breadth was 11.65 and 11.41, 21.78 and 14.48; 32.21 and 22.31 cm and the lowest 9.66 and 8.24, 26.43 and 11.09; 18.97 and 18.31 cm at 20, 40 and 60 DAT, respectively was found in roof top and farm conditions. The highest head height, diameter and weight was 18.04, 54.85 cm and 888.85 g where was the lowest 16.15, 50.26 cm and 740.43 g was found in roof top and farm conditions.

In broccoli cultivation, plant height, number of leaf, leaf length, leaf breadth, head height, head diameter and head weight was significantly affected by farm and roof top conditions. The highest plant height was 15.24, 30.54 and 42.98 cm and the lowest 14.13, 25.44 and 34.12 cm at 20, 40 and 60 DAT, respectively was found in cultivation roof top and farm conditions. The highest number of leaves was 6.12, 8.53 and 10.44 cm and the lowest 5.26, 7.19 and 8.34 cm at 20, 40 and 60 DAT, respectively was found in cultivation roof top and farm conditions. The highest leaf length and breadth was 13.46 and 11.00, 18.22 and 12.65; 29.67 and 21.69 cm and the lowest was 10.20 and 8.13, 14.78 and 10.30; 22.46 and 19.47 cm at 20, 40 and 60 DAT, respectively was found in roof top and farm conditions. The highest head height, diameter and weight was 17.60, 51.85 cm and 816.48 g whereas the lowest 16.28, 47.54 cm and 574.13 g was found in cultivation roof top and farm conditions.

In farm condition, the highest yield was recorded on cabbage (34.62 t ha^{-1}) and lowest yield was recorded in broccoli (22.96 t ha^{-1}). On roof top condition, the highest yield was recorded on cabbage (39.58 t ha^{-1}) and lowest yield was recorded in broccoli (32.65)

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 conditions. The highest yield was produced from cabbage followed by cauliflower. On the other hand lowest yield was found in farm condition.
2. Highest curd length, curd diameter and yield was produced by cabbage followed by cauliflower and broccoli produced in roof top conditions
3. The results clearly showed that rooftop is suitable for vegetables production and getting best yield at the rooftop conditions.

RECOMMENDATION

Considering the situation of the present experiment, further studies in the following areas may be recommended:

1. These crops again grow in rooftop garden with more treatments in future study for better understanding and accurate results.
2. Other Summer variety can be included to conduct related experiment.
3. Some other plant growing structure can be included for further experiment in the rooftop.
4. Other crops may be included in rooftop conditions to see their performance.
5. Scope to conduct similar experiment for Rabi season in the rooftop.

CHAPTER-V

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CHAPTER-V

APPENDICES

Appendix I: Soil characteristics of experimental farm of Sher-e-Bangla Agricultural University are analyzed by soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Physical composition of the soil

SOIL separates	%
Sand	26
Silt	45
Clay	29
Texture class	Silty loam

B. Chemical composition of the soil

Soil characteristics	**Value**
Organic carbon	0.45
Total N (%)	0.03
Total S (ppm)	225.00
Total p (ppm)	840.00
Available N (kg/ha)	54.00
Available P (ppm)	20.54
Exchangeable K (me/100g soil)	0.10
Available S (ppm)	16.00
p^H	5.6
CEC	11.23

Source: SRDI

Appendix II : Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2017 to March 2018

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
November,17	21.15	13.72	56	4
December,17	20.13	14.47	54	0
January,18	17.45	11.44	43	0
February,18	27.34	16.71	67	3
March,18	31.43	19.63	54	12
April, 18	36.44	22.51	63	18

Source: Bangladesh Metrological Department (Climate and weather division)Agargaon, Dhaka