MORPHOLOGICAL STUDY AND ECONOMIC CONSIDERATION OF CAULIFLOWER CULTIVATION ON ROOFTOP GARDEN USING VARIOUS COMPOSTS

AKHI AKTER

DEPARTMENT OF AGROFORESTRY AND ENVIRONMENTAL SCIENCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2021

MORPHOLOGICAL STUDY AND ECONOMIC CONSIDERATION OF CAULIFLOWER CULTIVATION ON ROOFTOP GARDEN USING VARIOUS COMPOSTS

BY

AKHI AKTER

REGISTRATION NO.: 14-05875

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE

IN

AGROFORESTRY AND ENVIRONMENTAL SCIENCE

SEMESTER: JANUARY-JUNE, 2021

APPROVED BY:

Dr. Md. Forhad Hossain **Professor** **Supervisor**	**Dr. Jubayer-Al-Mahmud** **Associate Professor** **Co-Supervisor**

Dr. Jubayer-Al-Mahmud
Chairman
Examination Committee

DEPARTMENT OF
AGROFORESTRY AND ENVIRONMENTAL SCIENCE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

*This is to certify that the thesis entitled **'MORPHOLOGICAL STUDY AND ECONOMIC CONSIDERATION OF CAULIFLOWER CULTIVATION ON ROOFTOP GARDEN USING VARIOUS COMPOSTS'** 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 (MS)** in **AGROFORESTRY AND ENVIRONMENTAL SCIENCE**, embodies the result of a piece of bona fide research work carried out by **AKHI AKTER**, Registration number: **14-05875,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:
Place: Dhaka, Bangladesh

Dr. Md. Forhad Hossain
Professor
Supervisor

Dedicated to My Beloved Parents

ACKNOWLEDGEMENTS

*Alhamdulillah, all praises are due to The Almighty **Allah Rabbul Al-Amin** for His gracious kindness and infinite mercy in all the endeavors the author to let her successfully completing the research work and the thesis leading to Master of Science degree.*

*The author would like to express her heartfelt gratitude and most sincere appreciations to her Supervisor **Prof. Dr. Md. Forhad Hossain**, Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka, for his valuable guidance, advice, immense help, encouragement and support throughout the study. Likewise grateful appreciation is conveyed to Co-supervisor **Assoc. Prof. Dr. Jubayer-Al-Mahmud**, Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka, for his constant encouragement, cordial suggestions, constructive criticisms and valuable advice to complete the thesis.*

The author would like to express her deepest respect and boundless gratitude to all the respected teachers of the Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic co-operation, and inspirations throughout the course of this study and research work.

The author wishes to extend her special thanks to her class mates and friends for their keen help as well as heartiest co-operation and encouragement during experimentation.

The author wishes to extend her special thanks to Md. Nurul Islam, honorable secretary, Ministry of Religion Affairs, Government of Bangladesh for his keen help as well as heartiest co-operation and encouragement during experimentation.

The author is deeply indebted and grateful to her parents and relatives; without whose love, affection, inspiration and sacrifice this work would have not been completed.

Finally the author appreciates the assistance rendered by the staff members of the Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University Farm staff, Dhaka, who have helped her during the period of study.

June, 2021
SAU, Dhaka

The Author

MORPHOLOGICAL STUDY AND ECONOMIC CONSIDERATION OF CAULIFLOWER CULTIVATION ON ROOFTOP GARDEN USING VARIOUS COMPOSTS

ABSTRACT

The experiment was conducted at the sixth floor of housing no. 64, road no. 6/A, Dhanmondi 13 during the period from November 2019 to July 2020. The experiment was laid out in CRD having single factors with three replications. The treatments of this experiment were T_0= Control (recommended dose of chemical fertilizers), T_1= Vermicompost (10 t ha^{-1}) + recommended dose of chemical fertilizers, T_2= Sawdust (15 t ha^{-1}) + recommended dose of chemical fertilizers and T_3= Cowdung (20 t ha^{-1}) + recommended dose of chemical fertilizers. The seedlings of the vegetable (BARI Fulkopi-2) was collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. From the results the maximum pure curd weight per plant (551.60 g), yield per plot (3.95 kg) and yield per hectare (19.75 t) were observed from T_1 (vermicompost @ 10 t ha^{-1} + recommended dose of chemical fertilizers) treatment. The benefit cost ratio (BCR) was found to be the highest (3.33) in the treatment of T_1 (vermicompost @ 10 t ha^{-1} + recommended dose of chemical fertilizers). Thus it was apparent that vermicompost treatment gave the highest yield per hectare (19.75 t) than the other treatments (sawdust and cowdung) and the highest gross return (Tk. 395000.00). The results clearly showed that rooftop is suitable for vegetables production and yield at the rooftop garden.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF APPENDICES (Cont'd)

LIST OF PLATES

LIST OF ACRONYMS

Acronym		Full meanings
AEZ	=	Agro-Ecological Zone
%	=	Percent
^{0}C	=	Degree Celsius
BARI	=	Bangladesh Agricultural Research Institute
BCR	=	Benefit Cost Ratio
cm	=	Centimeter
CRC	=	Chrysanthemum Residue Compost
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAP	=	Days after planting
DAT	=	Days after transplanting
EFBC	=	Empty Fruit Bunches Compost
et al.	=	And others
g	=	Gram
GWV	=	Green Waste Vermicompost
ha^{-1}	=	Per hectare
kg	=	Kilogram
klux	=	Kilolux
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
RAJUK	=	Rajdhani Unnayan Kartripakkha
RDF	=	Recommended dose of fertilizer
RGA	=	Roof Garden Association
RTGs	=	Rooftop Gardenings
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resource and Development Institute
SWC	=	Soybean Waste Compost
t	=	Ton
TSP	=	Triple Super Phosphate
UA	=	Urban Agriculture
viz.	=	Videlicet (namely)
VWV	=	Vegetable Waste Vermicompost
Wt.	=	Weight

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Vegetables play a vital role in human nutrition as it provides carbohydrates, fat, minerals, vitamins, and so on which is very essential for the human health. In Bangladesh, 407.93 thousand hectares of land covered by vegetables (BBS, 2018). 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.

Cauliflower (*Brassica oleracea* var. *botrytis*) is the most important cole crop belongs to the family Cruciferae in the tropic and temperate regions of the world (Siddique, 2004). Cauliflower was introduced and widely in India (Saha *et al.*, 2015). Cauliflower is a very tasty and much popular vegetable in Bangladesh as well as all over the world. 100 g edible part of cauliflower contains 89% moisture, 8.0 g carbohydrate, 2.3 g protein, 40 IU carotene, 0.13 mg B1, 0.11 mg B2, 50 mg vitamin C, 30 mg calcium and 0.8 mg iron and also contains 30 calorie (Rashid, 1999). Edible part of cauliflower is commonly known as 'Curd'. In the year 2017-2018 cauliflower covers an area 19425.33 hectares with a total production of 274000 tons (BBS, 2019). According to FAO (2018), the production of cauliflower is about 140962 kg per hectare.

Farming on rooftop of the buildings in urban areas is usually done by using green roof, hydroponics, organic, aeroponics or container gardens (Asad and Roy, 2014). Supply of fresh local food is the first benefit of this practice. It is possible to attain social, economic and environmental sustainability for the buildings in urban cities by utilizing rooftops for urban farming. It can contribute to the development of urban food systems by increasing local food production and meet the nutrition demand of the people by access to nutritious food. It can mitigate the 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).

Implementing rooftop farming in Dhaka, one of the world's fastest growing mega cities, 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 as agricultural land has been decreased at an alarming rate (Islam and Ahmed, 2011). 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).

Growth and yield of cauliflower depend on nutrient availability in soil, which is related to the judicious application of manures and fertilizers. Nutrient may be applied through two sources *viz.* organic and inorganic. Utilization of compost has been well documented to improve physical, chemical and biological properties of soil and increase the vegetables production (Whalen *et al.*, 2000; Tejada and Gonzalez, 2003).

The benefits of organic production on food quality and safety have created high global demand for organic products. Utilization of composts and organic wastes from agriculture as organic fertilizer for growing crops commercially is very much dependent on the availability of organic wastes and comparability with chemical fertilizers in plant growth and yield performance. The addition of compost to soil generally improves tilth, soil structure, infiltration, drainage and water holding capacity. Organic fertilizer such as composts has far served as a formidable alternative to synthetic fertilizer. Many research works have shown that many organic wastes produced in the tropics have the ability to provide nutrients and enhance soil quality and increase the production of vegetables (Cook *et al.*, 1994).

The use of compost and vermicompost improves plant growth and quality. The vermicompost promote growth from 50-100% over conventional compost and 30-40% over chemical fertilizers and the production cost will be low (Sinha *et al.*, 2010).

Cowdung contains a number of nutrients that can improve physical, chemical and biological properties of soil (Suparman and Supiati, 2004). The use of cowdung can improve the growth and yield some crops such as maize, soybean, cucumber, and some vegetable crops (Mucheru-Muna and Mugendi, 2007; Ghorbani *et al.*, 2008; Mahmoud *et al.*, 2009; Jahan *et al.*, 2014). Chipped wood or wood shavings from certain trees or shrub species is becoming an increasingly important source of organic amendment in agricultural soils (Owolabi *et al.*, 2003). Application of wood chips or sawdust as an amendment was investigated by some research workers and their results indicated the usefulness of this material in crop production on sandy soils by improving soil fertility status (Chiroma *et al.*, 2005). Odedina *et al.* (2003) studied and showed that sawdust had a significant 10 effect on yield of vegetable and N, P, K, Ca and Mg contents. Odedina *et al.* (2003) stated that there is scarcity of information on the optimum level at which sawdust ash and wood ash can be used to raise crop seedling in the nursery.

Considering the above facts, the present research was under taken with the following objectives:

1. To assess the effects of vermicompost, sawdust and cowdung on growth and yield of cauliflower on rooftop.
2. To compare the suitability of different composts on growth and yield of cauliflower on rooftop.
3. To evaluate the economic performance of various composts on the yield of cauliflower.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The aim of this chapter is to describe the review of the past research conducted in line of the major focus of the study. The literature review chapter consists of three sections. The first section illustrates the role and importance of urban agriculture, rooftop garden in terms of intensive and extensive green roof in the second section, effects of different composts on growth and yield of cauliflower in the third section. Literatures related of rooftop gardens and vegetable which were collected through reviewing of journals, thesis, internet browsing, reports, newspapers, periodicals and other form of publications are presented in this chapter under the following headings-

2.1 Role and importance of urban agriculture

Urban agriculture is the act of developing, cultivating, handling, and conveying nourishment in or around a village, town, or city. Urban agriculture can likewise include animal husbandry, aquaculture, agroforestry, urban beekeeping and horticulture. These activities happen in peri-urban territories too urban areas (FAO, 2013). The current worldwide urban population is expected to double by 2050, with 90 percent of urban development occurring in developing countries (Wikipedia, 2019). This quick urbanization process goes connected with increasing food insecurity and lack of healthy sustenance in urban areas, particularly on the side of the simultaneously increasing population living in poverty. Local governments need to develop new systems to guarantee water, energy and food security for their citizens.

Hodgon *et al.* (2011) revealed that urban agriculture is substantially more than private nurseries and community gardens, and numerous communities are starting to see the guarantee of different types of urban agriculture. This paper is to furnish funders with a review of urban agriculture and its different structures, measurements, and advantages; its associations with the more extensive community based food framework.

Urban agriculture is a key component to a sustainable community food system and can remove the diet related diseases associated with food deserts because healthy foods are not available at affordable prices (Cano, 2011). Urban agriculture provides ecological habitats (Cosier, 2011). On account of the quick development of urbanization in today's world the sustainable agriculture become a challenge. Because of the draw elements of cities over 50 % of the world population is presently living in urban regions which would be 70% before the end of 2030 (Eigenbrod and Gruda, 2015). In case of developing world this proportion will be 80% (Bakker *et al.*, 2000).

More population mean more food production which needs increasingly arable land and it has been discovered that, 109 million hectares of new land would be required to nourish the world population in 2050 by traditional farming (Dickson, 2013 and Juniawati, 2017). But a study shows that the agricultural area decreased by 0.19% in between 2005 and 2011 (Foley *et al.*, 2011). It is a typical practice to utilize the suburb zone to fulfill the daily nourishment demand of city dwellers fundamentally fruits and vegetable. Food production sites should be progressively located near major consumption centers as the rate of urbanization expands (Grigoletti and Pereira, 2014). Due to urban sprawl and settlement scheme for the expanding population, the rate of land transformation in these territories is very high which demonstrate a great threat to meet the demand of urban citizens with adequate nutritious food (Thornbush, 2015).

Today in this urban planet, 54% of the world's population are living in urban territories and the share is relied upon to increase to 66% by 2050 (United Nations, 2014). Quick urbanization and urban development is putting profoundly demand on urban food supply frameworks. In addition, numerous cities in the world are facing problems like rapid decrease in green space and increase in heat island effects. Urban agriculture or farming is promoted as a potential solution to these problems (Smit *et al.*, 2001). As the food is produced locally, there is no need to travel far to get fresh foods which reduces use of fossil and consequently has a positive impact on the environment (Sprouting Good Urban Farming Sydney, 2014). The vital role played by urban vegetable gardens in improving human well-being through the provision of both ecosystem services and food supply to the city dwellers (Orsini *et al.*, 2014 and McClintock, 2010).

Tabassum and Sharmin (2010) discovered that less green space creates an urban heat island effect due to increased reflection of solar radiation and open air temperature in Dhaka's denser developed territory is 1°C-1.5°C higher than the prompt urban zones with less green inclusion and furthermore can be higher at a scope of 0.5-1°C than the normal meteorological record. This exploration additionally demonstrated that indoor temperature of private structures in less green secured neighborhoods ascend at a scope of 1°C-2°C along these lines makes warm uneasiness among inhabitants.

According to Kulak *et al.* (2013) urban agriculture diminishes the emissions of greenhouse gas by selecting the right crops and a significant amount of greenhouse gas emissions can be saved. In the United Kingdom, an analysis of life cycle showed that the conversion of 26 hectares of fallow land to community farming could diminish greenhouse gas emissions by 881 tons of CO_2 equivalent per acre.

"Roof gardening as a strategy of urban agriculture for food security': the case of Dhaka city, Bangladesh." an article published by Islam (2001) has reported that urban agriculture of developing countries in the cities are growing rapidly which indicates the number of low-income consumers is increasing. Because of food insecurity in these cities is increasing. Urban agriculture (UA) contributes to food security by increasing the supply of food and by enhancing the quality of perishable foods reaching urban consumers. The necessity of urban agriculture in ensuring a sustainable and secured food supply is now approved by worldwide. It is a very fact for a city of a developing country like Dhaka where the rate of urbanization is very high but the quantity of arable land to ensure the sufficient food supply is becoming less. Among the different models of urban agriculture RTG is the suitable for densely populated Dhaka city as many buildings do not have space for the other types of gardening.

2.2 Rooftop garden in terms of intensive and extensive green roof

A rooftop garden is a garden on a building's roof. Roof plantings may provide food, temperature regulation, hydrological benefits, architectural enhancement, wildlife habitats or corridors, recreational activities, and on a larger scale, ecological benefits. Rooftop farming refers to the practice of planting food on the roofs of buildings. Rooftop vegetable production is the cultivation of many types of vegetables on the roofs of major city buildings (Sustainability Television, 2019). 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. Depending on the weather conditions various plants can be grown in a rooftop garden in that particular region. Rooftop gardening can provide a yearly income through the vegetables and fruits growing in it. Rooftop gardens are an immensely easy, cathartic, accessible way to grow plants and vegetables and they accompany various advantages (Safayet, 2017).

Rooftop farming can help to reduce the temperature of rooftops and surrounding air, which contributes to overall cooling of a local climate (RIES, 2014) and can help to reduce the urban heat island effect (Hui, 2011). Rooftop farms can also help to reduce carbon emissions and noise pollution (Dubbeling, 2014; Hui, 2011). Rain water is captured and consumed by the plants and overflowing impact on infrastructure is diminished (RIES, 2014). Rooftops filled with vegetation can be an incredible spot to relax. These sorts of farming can easily offer work to individuals (Sprouting Good Urban Farming Sydney, 2014).

Rooftop farming assists with the increasing biodiversity and can provide habitat for a variety of insects and birds (Miller, 2005). Executing rooftop farming can be a potential solution to reduce the food supply problems, make urban living more self-sufficient and make fresh vegetables more accessible to urban citizens. It is evaluated 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% 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 significant improvement work, sometimes just need a few modifications (Islam, 2004). Rooftop gardening (RTG) can be an effective method in ensuring food and nutrient supply and satisfying nutritional needs of the inhabitants as well as can reduce the cost of heating and cooling and simultaneously improving urban air quality (Peck, 2003; Walters and Midden, 2018). Moreover, RTGs, while being aesthetically appealing, can play a significant role to biodiversity conservation in the urban condition, achieving sustainable cities, including those necessary for the production of food and nutrient supply and improve the overall quality of urban life (Khandaker, 2004; Sanye-Mengual *et al.*, 2015).

Rahman *et al.* (2014) expressed that RTG has a strong positive and remarkable relationship with the nature of land use. Having garden at the rooftop may likewise get impacted by the aesthetic sense, moral and ethical values and personal likings of the individuals where it is seen that people are interested in RTG mainly for mental satisfaction (95.3%), relaxation time activity (87.8%), aesthetic value (82.9%) and ecological enhancement (54.9%). Rain water is captured and absorbed or consumed by the plants and overflowing impact on infrastructure is reduced (RIES, 2014). Keeping the soils healthy and productive may also be challenging as rooftop structural soils are not the same from ground-bed soils (Green, 2011). Rooftops filled with vegetation can be an incredible place for relaxation and this kind of farming can easily offer work to people (SGUFS, 2014). Rooftop vegetable farming could benefit the environment and give a significant proportion of vegetables for urbanites (Liu *et al.*, 2016). Rooftop gardens are turning into a significant part of the recent regeneration of urban farming, and give alternative spaces to grow and develop vegetable products for urban markets (Ouellette *et al.,* 2013).

Many cities are now producing more than 20% of their vegetable needs within city limits. Urban agriculture is widely used in developing countries, although some cities in developed countries worldwide endeavor to source at least a portion of their food requirements locally (MacRae *et al.*, 2010). The contributions of urban agricultural activities to local food supplies is currently huge in several cities, including Bologna (Italy), Chicago (USA), Cleveland (USA), Hong Kong (China), Montreal (Canada), New York (USA), Portland (USA), Seattle (USA), Shanghai (China), Taipei (Taiwan), Tokyo (Japan), Toronto (Canada), and Vancouver (Canada) to give some examples (MacRae *et al.*, 2010). Additionally, through the spread of greenery on the rooftop, these people are also contributing to creating a healthy environment in urban areas (The daily star, 2019). Around 25 vegetables are grown in the rooftop gardening in Bangladesh. It is evaluated that in Dhaka city brinjal (61%), Indian spinach (47.8%) and chilli (45.3%) and gourds (25%) are cultivated in rooftop farming. It is additionally determined that in Chattogram city brinjal (48%), Indian spinach (35.7%), gourds (35.6%), lady's finger (31%), tomato (23.7%), red amaranth (23%), bean (18%), cabbage and cauliflower (7%) are cultivated (Uddin *et al.,* 2016).

The Agricultural Extension Division provides individuals with training and the necessary logistics for roof gardening and horticultural development. Roof Garden Association (RGA) in Bangladesh is conducting "Green Roof Movement" which focuses on technical and financial aspects of roof gardening (Uddin *et al.*, 2016).

It is possible to achieve social, economic, and environmental sustainability for urban buildings by using rooftops for vegetable production. Because it can contribute to the development of urban food systems by increasing local food production, meeting people's nutritional needs through access to nutritious food, reducing air pollution, increasing storm water retention capacity, improving public health, improving the aesthetic value of the urban environment, and amplification of community functions (Localize, 2007).

The vegetable production on rooftops should not be thought of as an alternative for massive-scale vegetable production in rural areas (Gaglione *et al.*, 2010). In Bologna, Italy, if all suitable flat roof space is used for urban agriculture, rooftop gardens in the city would produce around 12,500 tons of vegetables annually which would meet 77% of residents' needs for vegetables and an estimated 624 tons of CO_2 would be captured each year (Science for Environment Policy, 2015). Kamrujjaman (2015) wrote a Book name "Green Banking" with respect to the Rooftop Gardening. The book contains 7 chapters depicting the thermal advantages of rooftop gardens and the overall techniques and farming procedures of vegetables, fruits, flowers/ornamental plants and multipurpose use of Rooftop garden. Orsini *et al*. (2014) was done an investigation of addressing the quantification of the capability of rooftop vegetable production in the city of Bologna (Italy) as related to its citizen's needs. The potential advantages to urban biodiversity and ecosystem service provision were evaluated. RTGs could give more than 12,000 t year^{-1} vegetables to Bologna, fulfilling 77 % of the inhabitants' requirements.

High winds and temperatures are frequently a problem; windbreaks and heat-tolerant crops must be installed on rooftops. Pesticide use in densely populated areas can be problematic, so many rooftop gardeners prefer for organic farming (Tiller, 2008). Rashid and Ahmed (2010) tested the thermal performance of rooftop garden in a six storied building established in 2003. They found that the temperature of this building is 3°C lower than other encompassing buildings and this Green application can diminish the indoor air temperature 6.8°C from outdoor during the hottest summer Period. Many of the city occupants do not have training in agriculture. Beginning gardening without proper training may lead to frustrating outcomes, which may bring about reluctance of the people in starting new projects (Islam, 2004).

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

Krupka (1992) wrote a book named “Rooftop gardening: use of plants and vegetation on buildings.” This book discusses the history and significance of growing plants on buildings from architectural and urban planning perspectives, advances in rooftop gardening techniques for the ecological value of cultivating plants on buildings, habitat restrictions of vegetation on buildings, arranging factors, preventing damage to buildings, preparing and insuring the habitat, and various forms of greening.

Shuvo (2000) proposed for a conceptual framework dependent on an obligatory on-site adaptation to ‘long-term greening’ and discussed how this framework should enable a sustainable mainstreaming of the violated constructions ensuring fiscal benefits for RAJUK, building owner and the ‘green industry’ alike. Bennett (2003) revealed that RTGs, while being aesthetically appealing, can add to biodiversity in the urban condition, attain more sustainable conditions, including those important for the production of food and improve the overall quality of urban life. Rooftop agriculture can decrease the urban heat island effect. The urban heat island effect is the elevated temperature (~ 2 to 4 degrees Celsius) within cities or other urban areas compared with surrounding rural areas caused by non-reflective surfaces that store incoming infrared radiation ultimately storing heat. Increased vegetation on rooftops cools the surface more cost effectively than the installation of light roofs which increase reflectivity (Urban Design Lab, 2012).

2.3 Effects of different composts on growth and yield attributes of crop

Mutalib *et al.* (2013) conducted an experiment on the effects of vermicomposts and composts on the nutrient status, growth and yield of cauliflower to assess the potential of these organic fertilizers in replacing the chemical fertilizer for cauliflower production under protected structure. They observed that the yield and curd production were significantly higher in vegetable waste vermicomposting than the chemical fertilizers using and the curd formation were 7 days earlier than the chemically fertilized plants. The growth and yield of cauliflower remarkably influenced by organic and inorganic fertilizer management, for which an integrated approach for maintaining yield sustainability and soil fertility (Noor *et al.*, 2007).

Tripathi and Sharma (1991) conducted an experiment on growth and yield of cauliflower and showed that plant height (35.73 cm), number of leaves per plant (17.4), diameter of main shoot (5.02 cm), root length (18.42 cm) and plant spread (24.22 cm), respectively in seedlings planted at 6 weeks old. But curd weight (0.54 kg) and diameter (13.31 cm) were in seedlings planted at 5 weeks old. Pathak and Nishi Keshari (2003) conducted a pot experiment of cauliflower with the supply of neem seed cake, mustard cake and reported that the highest plant height (28.6 cm) and root length (19.3 cm) were obtained. The highest fresh shoot (30.3 g) and root weight (6.8 g) were obtained with 25 kg need seed cake /kg soil. Khanam *et al.* (2009) expressed that the application of vermicompost along with the mineral fertilizer increased the yield of vegetable like brinjal, tomato, cauliflower etc. and improved the soil fertility. Ushakumari *et al.* (2006) reported that vermicomposting is a viable, cost effective and rapid technique for the efficient management of solid wastes in the production of vegetable like cauliflower.

Pattnaik and Reddy (2009) carried out an experiment and reported that the nutrients-N, P, K, Ca and Mg increased from vermicompost and compost while the organic carbon, C: N and C: P ratios decreased. The nutrient status of vermicompost of all earthworm species produced from both the wastes was more than that of the compost and that of their respective substrates. The nutrient status of vermicompost produced by all earthworm species from both wastes was higher than that of compost and their respective substrates. Another type of compost that is gaining popularity is vermicompost, which is formed by earthworm activities from organic residues, primarily animal manures. Earthworm casts help to stabilize organic residues by producing soil conditioners that are highly available for plant growth. Vermicompost works well as a "soil conditioner" and has been used for many years to improve soil and farmland quality, including degraded and soiled soils. Vermicompost application @ 6 tons/ha reduced sodium (ESP) by 73.68 and increased to 829.33 kg/ha of nitrogen available (N), significantly improving the quality of the soil (Sinha *et al.,* 2008).

Suhane (2007) revealed that vermicompost contained more than 95 percent more exchangeable potassium (K) than compost. There is also a healthy supply of calcium (Ca), magnesium (Mg), zinc (Zn), and manganese (Mn). Furthermore, vermicompost contains enzymes such as amylase, lipase, cellulose, and chitinase, which continue to break down organic matter in the soil (releasing nutrients and making them available to plant roots) even after they have been excreted. An adequate amount of vermicompost applied annually results in a significant increase in soil enzyme activities such as urease, phosphomonoesterase, arylsulphatase and phosphodiesterase. The soil treated with vermicompost has significantly higher electrical conductivity (EC) and a pH that is close to neutral. Vermicompost has a high level of porosity, aeration, drainage, and water holding capacity. They have a large surface area, which allows for good nutrient absorption and retention. They appear to be able to retain more nutrients for a longer period of time. The study found that soil amended with vermicompost had significantly higher soil bulk density, making it porous, lighter, and never compacted. The increased porosity has been due to an increase in the number of pores in the 30-50 pm and 50-500 size ranges, as well as a decline in the number of pores larger than 500 pm.

Bashyal (2011) detailed that biofertilizers and vermicomposts increased the efficiency of nitrogen fertilizer, and subsequently increases the yield and quality of cauliflower. Sharma and Sharma (2010) reported significant improvement in plant height, number of leaves per plant, curd diameter, curd depth, gross weight/plant and marketable curd yield when cauliflower was treated with inorganic fertilizers in presence of bio-fertilizers. Cowdung contains a number of nutrients that can improve physical, chemical and biological properties of soil (Suparman and Supiati, 2004). The use of cowdung can improve the growth and yield some crops such as maize, soybean, cucumber, cauliflower and some vegetable crops (Mucheru-Muna *et al.*, 2007; Ghorbani *et al.*, 2008; Mahmoud *et al.*, 2009; Jahan *et al.*, 2014).

Simarmata *et al.* (2016) experimented that 50% of recommended dose of mineral fertilizer along with compost of trailing-daisy weeds at 10 ton ha^{-1} increased the plant height and shoot fresh weight in cauliflower. Mineral fertilizer at 50% of the recommended dose and cowdung at 20 t ha^{-1} can increase the curd fresh weight of cauliflower.

Uddin *et al.* (2009) studied the effect of different organic manures on kohlrabi plant growth and yield at Sher-e-Bangla Agricultural University’s Horticultural Farm in Dhaka, Bangladesh, from October to December 2007. The maximum plant height (36.50 cm), as well as the plant canopy (63.50 cm). With poultry manure application, leaf length (30.42 cm), leaf breadth (14.25 cm), fresh leaves weight per plant (131.10 g), knob diameter (8.23 cm), knob weight (366.60 g), and yield (22.90 t ha^{-1}) were observed. In the control treatment, only the maximum number of leaves (20.00) was noticed. The minimum plant height (32.25 cm), plant canopy (55.75 cm), and leaf length (24.92 cm), leaf breadth (10.75 cm), fresh leaves weight per plant (86.97g), knob diameter (7.95 cm), knob weight (177.50 g), and yield (15.40 t ha^{-1}) were found in the control treatment. Cowdung application resulted in the lowest number of leaves (14.33).

Farahzety and Aishah (2013) conducted an experiment to assess the potentiality of organic fertilizers in replacing the chemical fertilizer for cauliflower production under protected structure. Three composts and two vermicomposts used were oil palm empty fruit bunches compost (EFBC), chrysanthemum residue compost (CRC), soybean waste compost (SWC), green waste vermicompost (GWV) and vegetable waste vermicompost (VWV). A chemical fertilizer (N: P_2O_5: K_2O; 12:12:17) was used as control. The amount of fertilizer applied was calculated based on 180 kg/ha of N. It was observed that VWV and EFBC were comparable to the chemical fertilizer based on their effects on the growth and yield performance of cauliflower. VWV and EFBC indicated promising results and can be used to replace chemical fertilizers in fulfilling the nutrient requirements of cauliflower. The yield and curd size of VWV and EFBC treated cauliflower were similar to chemically fertilized plants. Besides, curds of VWV treated plants can be harvested 7 days earlier than chemically fertilized plants. The use of compost and vermicompost have positive effects on the growth and crop yield of cauliflower, and have great potential to improve vegetable production in Malaysia.

According to Khan *et al.* (2008), organic and inorganic fertilizers have a positive impact on cabbage and broccoli production. A field experiment at Bangladesh Agricultural Research Institute (BARI) found that using poultry manure (5-10 t ha^{-1}) in accordance with the 50-75 recommended doses of chemical fertilizers resulted in significantly higher yields of cabbage and broccoli. The use of a moderate dose of poultry manure in combination with chemical fertilizer appeared to be cost-effective, resulting in a higher economic return.

Hsieh (2004) conducted an experiment to evaluate growth and yield of cabbage and cauliflower. Cauliflower in the organic treatments was greater than in the control. Poultry manure compost treatment gave the highest weight/plant, head diameter and yield, which was 26.28% higher than that of the control, followed by pig manure compost treatment, which was 18.38% higher. The compost treatments additionally altogether increased soil organic carbon and soil quality including soil structural stability, exchangeable cations and soil biological properties. Significantly, the compost treatment was effective in diminishing the rate of accumulation of extractable soil P compared with the traditional vegetable cultivating practice. The results highlight the potential for using compost produced from source separated garden organics in reversing the trend of soil degradation observed under current vegetable production, without sacrificing yield (Chan *et al*., 2008).

Hochmuth *et al.* (1993) conducted an experiment to investigate the effect of poultry manure fertilization on cabbage yields, head quality, and leaf nutrient status. During 1990, the marketable yield of cabbage responded quadratically to increasing rates of poultry manure, with 18.8 t ha-1 acquiring the maximum yield (28.4 t ha^{-1}). Yields obtained with 1.0 to 1.4 kg of conventional NPK fertilizer/ha were the same as those obtained with the highest rate of manure. The results showed that manuring efficiency was initially higher with commercial fertilizer than with poultry manure alone, because commercial fertilizer applied lower amounts of total nutrients.

Roe (1998) carried out an experiment by utilizing compost, acquired from dairy manure and municipal solid waste to discover the advantageous effects on cauliflower. He discovered helpful impacts on development, yields and supplement substance with compost application in the cauliflower cultivation.

Devliegher and Rooster (1997) conducted an experiment in Belgium on cauliflower, utilizing standard peat-based compost alone or enhanced with green compost or a GFT-compost. They saw that plant development was the best for plants increased in standard compost and harvest date was earlier. Hossain *et al.* (2011) reported a significant increase in diameter of head 17.19 cm in cauliflower by application of vermicompost. Moniruzzaman *et al.* (2008) conducted experiment in cauliflower and reported significant increase in head diameter with increase in levels of vermicompost at 3 t ha^{-1}.

Ferreira *et al.* (2002) did an experiment on Brassica crop because of their significance as food for human utilization, particularly comparable to their healthy benefit. Both yield and utilization were high. The yield of this assortment was broke down under three sorts of compost and three spacing with a view to its production on a business scale. The leaf region, dry matter mass, and total development rate were higher with mineral than natural compost. High qualities for relative development rate and net assimilation rate were recorded in plants developing in more noteworthy spacing (30 cm × 20 cm and 30 cm × 30 cm). The most elevated estimation of agronomic yield (21.5 t/ha) was reached in the smallest spacing (30 cm × 10 cm), with vermicompost application.

Jana and Mukhopadhyay (2006) carried out a field experiment to assess the impact of different fertilizers and composts on the development and curd yield of various cauliflower cultivars (Early Kunwari, First Crop, Kartika, Aghani and Improved Japanese). Among the cultivars, Aghani gave the most elevated curd yield of 15.76 t/ha. Aghani created the most noteworthy attractive curd yield of 16.67 t/ha with the use of vermicompost. They also found that applying decomposed cowdung gave the most elevated fresh weight of shoot and delay to mature.

Kumar *et al.* (2010) observed significant contrasts among different genotypes in early Indian cauliflower for yield and quality characters, they found that genotypes DC-98-4, DC-98-10 and DC-124 were better over different genotypes with deference than yield and quality characters, where yield was adversely connected with span of curd accessibility and days to half curd development. Significant variation was observed among genotypes for yield and quality characters. The highest ascorbic acid content (103.23 mg/100 g of crisp weight) was observed in the genotype DC-98-10 and lowest in CC-12 (17.68 mg/100 g of fresh weight). Alam (2006) reported that the largest leaf breadth of cabbage was found by 5 t ha^{-1} vermicompost + 100% recommended doses of chemical fertilizers.

Kumar *et al.* (2002) observed that the vegetative characters, for example, stalk length and leaf number of cauliflower essentially vary for different utilization of manures. Cauliflower cv. Pusa Early Synthetic under the terai zone of West Bengal gave most elevated curd weight (384.17 g), curd diameter (22.38 cm), curd length (15.86 cm) when developed with vermicompost but declined slowly with cowdung and sawdusts. Ghuge *et al.* (2007) conducted a field experiment in Parbhani, Maharashtra, India, in 2003-04 at the Department of Horticulture, Marathwada Agricultural University to determine the effects of inorganic fertilizers and organic manures separately and in combination on soil dry matter, uptake, and nutrient availability after cabbage harvest. In comparison to other treatments, 50 % RDF combined with 50 % vermicompost at 2.5 t ha^{-1} produced the highest yield (379.87 q ha^{-1}), maximum N, P, and K nutrient uptake (66.17, 13.22, and 34.22 kg ha^{-1}), and more N, P, and K availability (259.45, 27.77, and 369.67 kg ha^{-1}). Treatments involving 50 % RDF+50 % Terrace at 1.25 t ha^{-1} and 50 % RDF+50 % organic booster at 1.0 t ha^{-1} after transplanting also performed well.

As indicated by Ara *et al.* (2009) all the vegetative development parameters like plant height, number of leaves per plant, entire plant weight, weight of marketable curd per plant and yield t/ha were impacted altogether by the utilization of various composts alongside mineral fertilizers. But days to curd initiation, days to curd harvest, curd length and curd expansiveness and curd yield expanded altogether as in vermicompost treatment in summer season.

Ouda and Mahadeen (2008) led an experiment with nitrogen @ 0, 30 and 60 kg/ha alongside manures to discover impacts of treatment and fertilizer on development, yield quality and certain supplement substance in cauliflower. It was determined that a combination of organic and inorganic fertilizer increased head number per plant, chlorophyll content, head diameter, and total yield when compared to their individual addition. The use of 60 kg nitrogen as inorganic fertilizers with 60 tons of organic composts per hectare resulted in the highest cauliflower yield (40.05 t/ha), while the fresh and dry weight of cauliflower shoots were unaffected by the various dosages. Rodrigues and Casali (1999) discovered that 37.7 t/ha organic compost/ha with no mineral fertilizer application, 18.9 t organic compost/ha with half the recommended mineral fertilizer rate, and 13 t organic compost/ha with the recommended mineral fertilizer rate produced the highest estimated yields of 119.5, 119.4 and 153.9 g/plant. When compared to mineral fertilizer application, organic compost application resulted in lower foliar N and Ca concentrations and higher foliar P, K, and Na concentrations.

Ghosh *et al.* (1999) observed that the effect of different fertilizers showed significant increase of the fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches, number of fruits and yields in terms of fruit production in all the treatments in comparison to controlled one. The yield of vermicompost treated plants was found to be 28,665 Kg/hectare, which was 47% more than the plants in control plots and was very nearer to inorganic fertilizer treated plants (Kg/hectare). It was also observed that the plants treated with vermicompost supplemented with chemical fertilizers displayed better results than the plants treated separately with vermicompost, chemical fertilizers, F.Y.M and F.Y.M. supplemented with chemical fertilizers treated plants. In this field trial experiment, it was observed that the plants treated with vermicompost supplemented with chemical fertilizers displayed better results than the plants treated separately with vermicompost, chemical fertilizer, F.Y.M and F.Y.M supplemented with chemical fertilizers treated plant.

The use of compost and vermicompost has also been observed to improve plant growth and quality. Numerous studies on vermicompost and compost from various sources have been found to promote root formation (Arancon *et al.*, 2005), increase fruit setting and yield (Atiyeh *et al.*, 2002; Arancon *et al.*, 2004) and also increase plant dry mass (Subler *et al.*, 1998). It has also been reported that the increase in yield, chlorophyll content production and fruit quality of tomatoes was due to improvement of uptake of N, P and K from vermicompost (Tejada *et al.*, 2007). In addition, vermicompost and manure were reported to affect the chemical composition and quality of the marketable produce (Lazcano *et al.*, 2011).

The response of vermicompost and inorganic fertilizers on growth, yield and quality of sprouting broccoli was studied during 2011-13 at UBKV, Pundibari, West Bengal, India. The treatments comprised of five levels of vermicompost (0, 2.5, 5, 7.5 and 10 t ha^{-1}) and four levels of inorganic fertilizers (0, 50, 75 and

100% of recommended dose) were evaluated. The result revealed that successive increase in vermicompost level significantly increased the growth and yield attributes and application of highest level of vermicompost (10 t ha^{-1}) registered 38% and 43% improvement of central head weight and total head yield respectively over control, whereas application of 100% recommended fertilizers enhanced the head weight and total head yield by 32% and 35% respectively over control. The nutrient schedule comprising of higher level of vermicompost (10 t ha^{-1}) and 100% of recommended inorganic fertilizers emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, early head initiation, advanced head maturity and higher yield as well as superior quality of head as compared other nutrient combination (Mal *et al.*, 2015).

Rabbee *et al.* (2020) carried out an experiment at Agricultural Research field, Noakahali Science and Technology University, Noakhali, Bangladesh during the period from September 2018 to February 2019 to find out the effects of vermicompost and farmyard manure growth and yield of broccoli. Three treatments *viz.,* T_0= Control, T_1= Vermicompost and T_2= Farm Yard Manure as well as Centeuro variety were used. All the recorded parameters were statistically significant among the treatments. The tallest plant (43.67 cm) can be recorded from T_1 (vermicompost) whereas lower plant height (38.10 cm) was notified from control (T_0). The maximum number of leaves (16.03) recorded from vermicompost treated plant where minimum from control (T_0; 13.28). the highest leaf length (40.67 cm), leaf diameter (16.22 cm), plant spread (47.91 cm), early curd initiation (73.22 days), early curd maturation (89.72 days), curd diameter (16.16 cm), marketable curd weight (452.67 g), net curd weight (361.43 g) and yield/plot (3.94 kg) was found from vermicompost treated plant is compared with farmyard manure whereas lowest data recorded from control. Observing the results it can be stated that using of 10 ton vermicompost per hectare treated plants gave better growth and yield contributing characters of broccoli in contemporary with other treatments.

Bhadra *et al.* (2019) conducted an experiment to study the effects of cowdung and boron on growth and yield of broccoli. The experiment consisted of two factors; Factor A: cowdung - 4 levels such as C_0: no cowdung (control), C_1: cowdung 10 ton/ha, C_2: cowdung 15 ton/ha and C_3: cowdung 20 ton/ha. Factor B: boron- 4 levels, such as B_0- no boron (control), B_1: boron 1 kg/ha, B_2: boron 2 kg/ha and B_3: boron 3 kg/ha. In case of cowdung the maximum plant height at 60 DAT (61.47 cm), spread of plant at 60 DAT (50.00 cm), number of leaves per plant at 60 DAT (11.39), length of the largest leaf at 60 DAT (57.69 cm), primary curd weight (374.58 g), yield per hectare (15.74 t/ha) were recorded from C_3 (cowdung 20 ton/ha) treatment and the lowest was recorded from the control (C_0) treatment. Regarding combination of cowdung and boron the maximum plant height at 60 DAT (63.11 cm), spread of plant at 60 DAT (52.33 cm), number of leaves per plant at 60 DAT (12.97), length of the largest leaf at 60 DAT (60.25 cm), primary curd weight (399.33 g), yield per hectare (16.71 t/ha) and the minimum days required for curd initiation (50.10 DAT), were recorded from C_3B_2 (cowdung 20 t/ha and boron 2 kg/ha) treatment and the lowest was recorded from C_0B_0 (no cowdung and no boron) treatment. The highest production of broccoli is obtained from 20 ton/ha cowdung and 2 kg/ha boron.

The increased importance of wood shavings or sawdusts necessitates that the management strategies that focus on maximizing the benefits of its incorporation in the soil the amendments increased total soil porosity, and thus increased the amount of water retained at field capacity. Wood waste materials have been successfully used in the field to control erosion on slopes and exposed soil surface (Chiroma *et al.*, 2006). Their primary benefits are to enhance the ability of soil to support plant growth by fostering the various activities that plants need from water retention to microbial life (Ojeniyi and Adejobi, 2002; Owolabi *et al.*, 2003). Odedina *et al.* (2003) studied and showed that sawdust had a significant effect on yield of vegetable and N, P, K, Ca and Mg contents.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND MATHODS

This experiment was conducted at the sixth floor of housing no. 64, road no. 6/A, Dhanmondi 13 during the period from November 2019 to July 2020 to study the performance of morphological and economic consideration of cauliflower cultivation. The materials and methods that were used for conducting the experiment are presented under the following headings:

3.1 Experimental site

The study was conducted at the sixth floor of housing no. 64, road no. 6/A, Dhanmondi 13. Geographically the experimental area is located at 23°75′ N latitude and 90°22.6′ E longitudes at the elevation of 23 m above the sea level. The map showing the experimental sites in Appendix I.

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 experiment were collected from Savar Upazilla, which is known as vitimati. This collected soil had a sandy loam texture and a grayish color. The collected soils were chemically tested in Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Planting material

The cole crop was used as planting material *viz.* BARI Fulcopi-2 (*Brassica oleracea* var. *botrytis*) variety. Seedlings of cauliflower cultivars were used in the experiment. Seedlings were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur.

3.5 Treatments of the experiment

The experiment consisted of four treatments

T_0: Control (recommended dose of chemical fertilizers)

T_1: Vermicompost (10 t/ha) + recommended dose of chemical fertilizers

T_2: Sawdust (15 t/ha) + recommended dose of chemical fertilizers

T_3: Cowdung (20 t/ha) + recommended dose of chemical fertilizers

3.6 Experimental design and layout

The experiment was laid out in Complete Randomized Design (CRD) having single factor with three replications. Total experimental area was divided into three replications. An area of 9 m × 4 m was divided into three equal blocks. Each block was consists of 4 plots where 4 treatments were allotted randomly. There were 12 unit plots in the experiment. The size of each plot was 2 m × 1 m, which accommodated 8 plants at a spacing 0.6 m × 0.45 m. The distance between two blocks and two plots were kept 1.5 m and 0.25 m respectively.

3.7 Preparation of the block on rooftop

The entire experimental site (rooftop) was divided into three blocks which was made by brick wall. The measurement of each block was 9 m × 1 m × 0.50 m. Each block was divided into 2 m × 1 m plot leaving 0.25 m area in plots. So, total experimental plots were twelve in three blocks containing four treatments with three replications. Before starting the experiment the collected soils and cowdung, vermicompost and sawdust (recommended) were well mixtured and previously incorporated in the blocks. Weeds and stubbles were removed and finally obtained a desirable tilth of soil for planting of cauliflower 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 blocks were first filled at 25th October, 2019. 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 28th October, 2019. The soil was treated with insecticides (Furadan 5G @ 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. A pictorial view of preparation of block is presented in Plate 1.

3.8 Application of manures and fertilizers

The following amount of manures and fertilizers were used as par treatments of the experiment. The crop was fertilized 275 Kg urea, 175 Kg triple superphosphate (TSP), 220 Kg muriate of potash (MoP) per hectare. The sources of N_2, P_2O_5, K_2O as urea, TSP and MoP 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, vermicompost and sawdust were applied during final block preparation as par treatments.

3.9 Transplanting of seedlings

Healthy and uniform 30 days old seedlings of cauliflower was transplanted in the experimental plots in 27th November 2019 maintaining a spacing of 60 cm × 45 cm between the plants and rows, respectively. All seedlings were collected from BARI. This way of transplanting allowed an accommodation of 32 plants in each replication. The seedlings were watered after transplanting. Some seedlings were also planted around the border area of the experimental plots for gap filling.

3.10 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 cauliflower seedlings.

3.10.1 Gap filling

The seedlings in the experimental plot were carefully monitored. After planting, only a few seedlings were destroyed, and these seedlings were replaced with new seedlings from the same stock. To reduce planting shock, those seedlings were planted in a large mass of soil with roots. Healthy seedlings with a boll of earth were planted on the same date by the side of the unit plot as a replacement. For proper establishment, the plants were given shade and watered as required. A pictorial view of transplanting seedlings is presented in Plate 2.

3.10.2 Weeding

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

3.10.3 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.

3.10.4 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. A pictorial view of irrigation on experimental field is presented in Plate 3.

3.11 Harvesting

Only the compact mature curd of cauliflower was 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).

3.12 Data collection

5 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 leaves per plant, length of leaf and breadth of leaf, canopy area, fresh weight of leaves per plant, stem diameter, root length and light intensity were collected at 30, 45 and 60 days after planting (DAT). All other yield contributing characters and yield parameters were recorded during harvest and after harvest (at 60 DAT).

3.12.1 Plant height

Plant height of cauliflower 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 15 days interval starting from 30 days after planting (DAT) up to 60 days and at harvest to observe the growth rate of plants.

3.12.2 Number of leaves per plant

The number of leaves per plant of cauliflower was counted from each selected plant with the observation of fully open leaves. Data were recorded as the average of 5 plants of each plot at 15 days interval starting from 30 days after planting (DAT) up to 60 days and at harvest.

3.12.3 Length of the largest leaf per plant

The length of the largest leaf per plant of cauliflower was counted from each selected plant with the observation of fully open leaves. Data were recorded as the average of 5 plants of each plot and block at 15 days interval starting from 30 days after transplanting (DAT) up to 60 days and at harvest.

3.12.4 Breadth of the largest leaf per plant

The breadth of the largest leaf per plant of cauliflower was counted from each selected plant with the observation of fully open leaves. Data were recorded as the average of 5 plants of each plot and block at 15 days interval starting from 30 days after transplanting (DAT) up to 60 days and at harvest.

3.12.5 Canopy area per plant

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

3.12.6 Fresh weight of leaves per plant

Fresh weight of leaves per plant was recorded at 30, 45 and 60 DAT in gram.

3.12.7 Dry weight of leaves per plant

At first the fresh weight of leaves per plant was recorded then all leaves were chopped and sun dried. Sun dried sample was then dried in an oven at 70°C for 72 hours.

3.12.8 Stem diameter per plant

Stem diameter per plant was measured at 30, 45 and 60 DAT with a measuring scale placing it vertically at the widest point of the stem. It was expressed in centimeter.

3.12.9 Root length per plant

A distance between the bases to the tip of the root was measured in cm at 30, 45 and 60 DAT with the help of scale for determining the length of root per plant.

3.12.10 Height of curd per plant

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

3.12.11 Diameter of curd per plant

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

3.12.12 Weight of curd with leaves

Curd weight with leaves per plant was recorded at 30, 45 and 60 DAT in gram with a beam balance from the average of five randomly selected plants.

3.12.13 Weight of curd per plant

The weight of curd per plant of cauliflower was recorded in gram (g) by a beam balance.

3.12.14 Yield per plot

The yield per unit plot was calculated by adding the yields of all plants of each unit plot and expressed in kilogram (kg).

3.12.15 Yield

It consisted of only quality curd of cauliflower and was also calculated in ton per hectare by converting the total yield of curd per plot.

3.12.16 Soil moisture measurement

Soil moisture was measured by soil moisture meter on each crop rows (Plate 6). It was expressed as percentage (%). Soil moisture was measured at 10 cm depth of soil adjacent to main root of vegetable crop rows at 10.00 am, 1.00 pm and 4.00 pm at 30, 45, 60 days after transplanting (DAT).

3.12.17 Soil temperature measurement

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

3.13 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the morphological characteristics and economic consideration of cauliflower cultivation on rooftop garden using various composts. The mean values of all the characters were calculated. MSTAT-C was used for processing and analysis of data. The mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

3.14 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of different composts. All input cost included the cost for net house and interests of running capital in computing the cost of production. The interests were calculated @ 15% in simple rate. The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The results have been presented, discussed and possible interpretations were given in tabular and graphical forms. The results obtained from the experiment have been presented under separate headings and sub-headings as follows:

4.1 Plant height

The plant height of cauliflower was recorded at different stages of growth at 30, 45 and 60 days after transplanting (DAT). The plant height varied significantly due to application of different composts on rooftop garden. During the period of plant growth the maximum plant height (26.47, 39.17, 49.27 cm at 30, 45 and 60 DAT, respectively) was observed in T_1 (vermicompost) treatment. On the other hand, the shortest plant height (20.20, 32.53 and 41.33 cm at 30, 45 and 60 DAT, respectively) was observed in T_0 (control) treatment (Table 1). The findings of the experiment was coincided with the findings of Sharma and Sharma (2010), Simarmata *et al.* (2016) and Ara *et al.* (2009) reported that plant height is one of the important parameter, which regulate crop yield. Composts ensure the available essential nutrients for the plant for that vermicompost gave the highest plant height compare to control. Among the different composts vermicompost was found more effective than the other compost on plant height.

Table 1. Effect on plant height of cauliflower at different days after transplanting (DAT) in rooftop garden

Treatments	Plant height (cm) at		
	30 DAT	45 DAT	60 DAT
Control (T_0)	20.20 b	32.53 b	41.33 b
Vermicompost (T_1)	26.47 a	39.17 a	49.27 a
Sawdust (T_2)	21.87 b	33.70 b	42.80 b
Cowdung (T_3)	24.43 ab	36.81 ab	45.06 ab
$LSD_{0.05}$	**4.35**	**4.90**	**5.76**
CV%	**9.96**	**7.33**	**6.86**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.2 Number of leaves per plant

Applications of different composts significantly increase the production of leaves per plant at 30, 45 and 60 DAT in rooftop garden. The maximum number of leaves per plant at 30 DAT (17.53) was produced by vermicompost (T_1) treatment. At 45 and 60 DAT, the maximum number of leaves per plant (22.23 and 26.28, respectively) was produced by vermicompost (T_1) treatment which was statistically similar with cowdung (T_3) treatment and the minimum (13.33, 16.77 and 20.08 at 30, 45 and 60 DAT, respectively) was produced by the control (T_0) treatment (Table 2). Similar results also found by Sharma and Sharma (2010) who reported that in presence of bio-fertilizers soil ensured available essential nutrients for the plant for that compost gave the highest number of leaves per plant compared to control condition. The results was also as per with the findings of Ara *et al.* (2009). Ara *et al.* (2009) reported that all the vegetative development parameters like plant height, number of leaves per plant, entire plant weight, weight of marketable curd per plant and yield t/ha were impacted altogether by the utilization of various composts alongside mineral fertilizers.

Table 2. Effects on number of leaves per plant of cauliflower at different days after transplanting (DAT) in rooftop garden

Treatments	Number of leaves per plant at		
	30 DAT	**45 DAT**	**60 DAT**
Control (T_0)	13.33 b	16.77 b	20.08 b
Vermicompost (T_1)	17.53 a	22.23 a	26.28 a
Sawdust (T_2)	15.02 ab	18.91 ab	23.17 ab
Cowdung (T_3)	15.87 ab	20.52 a	25.00 a
$LSD_{0.05}$	**2.87**	**3.68**	**3.91**
CV%	**9.90**	**9.98**	**8.78**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.3 Length of the largest leaf per plant

Statistically significant variation on length of largest leaf at 30, 45 and 60 different days after transplanting was observed due to application of different compost. The maximum length of largest leaf at 30 DAT and 60 DAT (25.36 and 42.10, respectively) was observed from vermicompost (T_1) treatment which was statistically similar to cowdung (T_3) treatment. The minimum length of the largest leaf (20.38, 30.65 and 35.59 cm at 30, 45 and 60 DAT, respectively) was recorded on control treatment (Table 3). The results also similar with the findings of Kumar *et al.* (2002) who reported that vermicompost gave the maximum leaves length which declined with sawdusts.

Table 3. Effect of different composts on largest leaf length of cauliflower at different days after transplanting (DAT) in rooftop garden

Treatments	Largest leaf length (cm) at		
	30 DAT	**45 DAT**	**60 DAT**
Control (T_0)	20.38 b	30.65 c	35.59 b
Vermicompost (T_1)	25.36 a	36.61 a	42.10 a
Sawdust (T_2)	22.61 ab	32.26 bc	36.51 b
Cowdung (T_3)	24.04 a	34.96 ab	40.80 a
$LSD_{0.05}$	**3.00**	**4.26**	**3.94**
CV%	**6.90**	**6.74**	**5.42**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.4 Breadth of the largest leaf per plant

The effect of different compost was significant in this regard. The maximum breadth of the largest leaf per plant (12.17, 17.33 and 20.50 cm at 30, 45 and 60 DAT, respectively) was observed from vermicompost (T_1) treatment which was statistically similar to cowdung (T_0) treatment at 30, 45 and 60 DAT, respectively. On the other hand the minimum breadth of the largest leaf per plant (9.57, 14.11 and 17.00 cm at 30, 45 and 60 DAT, respectively) was observed from T_0 treatment (Table 4). Kumar *et al.* (2002) found the similar results who reported that leaf length and leaf breadth of cauliflower essentially vary for different utilization of compost. Alam (2006) reported that the largest leaf breadth of cabbage was found by vermicompost + 100% recommended doses of chemical fertilizers.

Table 4. Effect of different composts on largest leaf breadth of cauliflower at different days after transplanting (DAT) in rooftop garden

Treatment	**Largest leaf breadth (cm) at**		
	30 DAT	**45 DAT**	**60 DAT**
Control (T_0)	9.57 c	14.11 b	17.00 b
Vermicompost (T_1)	12.17 a	17.33 a	20.50 a
Sawdust (T_2)	10.10 bc	15.44 ab	17.93 b
Cowdung (T_3)	11.44 ab	16.20 ab	18.90 ab
$LSD_{0.05}$	**1.71**	**2.12**	**2.48**
CV%	**8.40**	**7.15**	**7.10**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.5 Canopy area per plant

The results on effects of various compost showed that compost had significant effect on canopy area per plant at 30, 45 and 60 different days after transplanting. The vermicompost (T_1) gave the maximum canopy area per plant (26.07, 37.97 and 49.18 cm at 30, 45 and 60 DAT, respectively) which was statistically similar with T_3 treatment at 30, 45 and 60 DAT, respectively. The control treatment gave minimum (19.33, 31.71 and 40.86 cm at 30, 45 and 60 DAT, respectively) canopy area per plant which was statistically similar to T_2 treatment (Table 5). Similar result was also observed by Uddin *et al.* (2009) who reported that the maximum plant height (36.50 cm) as well as the plant canopy (63.50 cm) was observed from compost treatment on kohlrabi than control treatment.

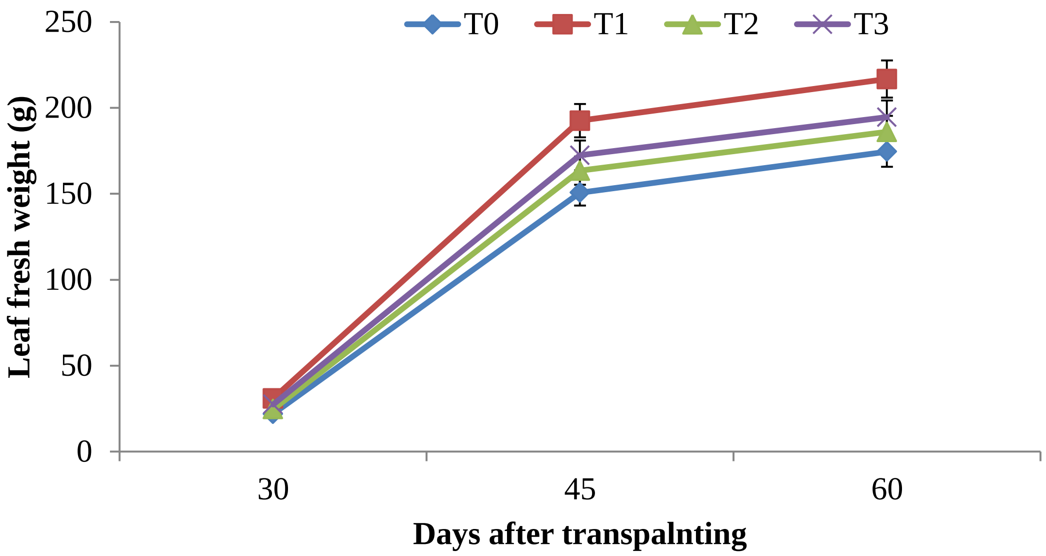
Table 5. Effect of different composts on canopy area per plant of cauliflower at different days after transplanting (DAT) in rooftop garden

Treatment	Canopy area per plant (cm) at		
	30 DAT	**45 DAT**	**60 DAT**
Control (T_0)	19.33 b	31.71 b	40.86 b
Vermicompost (T_1)	26.07 a	37.97 a	49.18 a
Sawdust (T_2)	20.75 b	32.97 b	42.51 b
Cowdung (T_3)	23.43 ab	35.53 ab	45.06 ab
$LSD_{0.05}$	**4.16**	**4.60**	**6.23**
CV%	**9.87**	**7.09**	**7.45**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.6 Fresh weight of leaves per plant

The fresh weight of leaves per plant was significantly influenced by different composts application in the production of cauliflower on rooftop garden. Result from the experiment showed that vermicompost (T_1) produced the highest fresh weight of leaves per plant (30.92, 192.54 and 216.71 g at 30, 45 and 60 DAT, respectively) which was statistically similar with T_3 treatment at 30, 45 and 60 DAT, respectively. On the other hand the lowest fresh weight of leaves per plant (21.98, 150.68 and 174.49 g at 30, 45 and 60 DAT, respectively) was observed from control (T_0) treatment (Figure 1). Similar results was also found by Simarmata *et al.* (2016) who reported that mineral fertilizer at 50% of the recommended dose and cowdung at 20 t ha^{-1} can increase the fresh leaves weight and curd fresh weight of cauliflower.

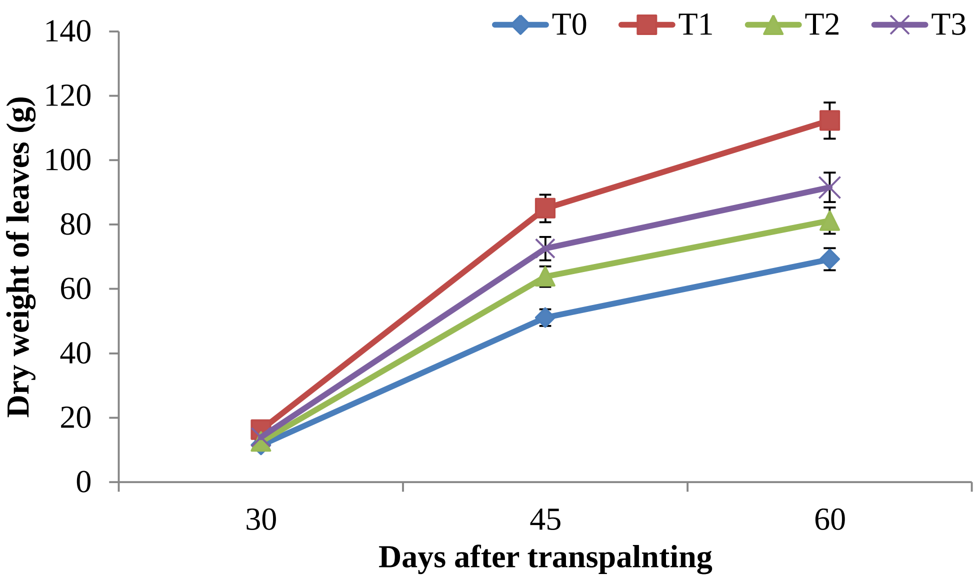


T_0= Control, T_1= Vermicompost, T_2= Sawdust and T_3= Cowdung

Figure 1. Effect of different composts on fresh weight of leaves per plant of cauliflower at different days after transplanting (DAT) in rooftop garden

4.7 Dry weight of leaves per plant

The dry weight of leaves per plant was significantly influenced by different composts application in the production of cauliflower on rooftop garden. Result of the experiment showed that vermicompost (T_1) produced the highest dry weight of leaves per plant (16.20, 85.00 and 112.28 g at 30, 45 and 60 DAT, respectively). On the other hand the lowest dry weight of leaves per plant (11.45, 51.08 and 69.22 g at 30, 45 and 60 DAT, respectively) was observed from control (T_0) treatment (Figure 2). The results was also similar with the findings of Ouda and Mahadeen (2008) who reported that dry weight of cauliflower shoots were influenced by the utilization of various dosages of composts with mineral fertilizers. Ghosh *et al.* (1999) reported that the fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches, number of fruits and yields in terms of fruit production were maximum with compost treatments in comparison to controlled one.



T_0= Control, T_1= Vermicompost, T_2= Sawdust and T_3= Cowdung

Figure 2. Effect of different composts on dry weight of leaves per plant of cauliflower at different days after transplanting (DAT) in rooftop garden

4.8 Stem diameter per plant

The stem diameter per plant was significantly influenced by different composts application in the production of cauliflower on rooftop garden. Vermicompost (T_1) produced the highest stem diameter per plant (1.85, 1.87 and 1.90 cm at 30, 45 and 60 DAT, respectively) which was statistically similar to T_3 treatment at 30, 45 and 60 DAT, respectively. On the other hand the lowest stem diameter per plant (1.56, 1.58 and 1.61 cm at 30, 45 and 60 DAT, respectively) was noted from control (T_0) treatment (Table 6). The results of the experiment was also coincide with the findings of Ghorbani *et al.* (2008), Mahmoud *et al.* (2009) and Jahan *et al.* (2014) who reported that composts and organic manures can improve the growth characters and yield of cauliflower.

Table 6. Effect of different composts on stem diameter per plant of cauliflower at different days after transplanting (DAT) in rooftop garden

Treatment	**Stem diameter per plant (cm) at**		
	30 DAT	**45 DAT**	**60 DAT**
Control (T_0)	1.56 b	1.58 b	1.61 b
Vermicompost (T_1)	1.85 a	1.87 a	1.90 a
Sawdust (T_2)	1.63 b	1.66 b	1.68 b
Cowdung (T_3)	1.71 ab	1.74 ab	1.76 ab
$LSD_{0.05}$	**0.17**	**0.17**	**0.20**
CV%	**5.61**	**5.37**	**6.19**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.9 Root length per plant

Different compost significantly influenced the root length per plant at 30, 45 and 60 DAT, respectively. Result from the experiment showed that vermicompost (T_1) treatment produced the highest root length per plant (23.90, 24.80 and 26.10 cm at 30, 45 and 60 DAT, respectively) which was statistically similar to T_3 treatment at 30, 45 and 60 DAT, respectively. On the other hand the lowest root length per plant (20.50, 21.40 and 22.67 cm at 30, 45 and 60 DAT, respectively) was recorded from T_0 treatment (Table 7). Similar results was also found by Pathak and Nishi Keshari (2003) and Tripathi and Sharma (1991) who reported that the supply of organic manures can increase the root length of cauliflower.

Table 7. Effect of different composts on root length per plant of cauliflower at different days after transplanting (DAT) in rooftop garden

Treatment	**Root length per plant (cm) at**		
	30 DAT	**45 DAT**	**60 DAT**
Control (T_0)	20.50 b	21.40 b	22.67 c
Vermicompost (T_1)	23.90 a	24.80 a	26.10 a
Sawdust (T_2)	21.17 b	22.28 b	23.43 bc
Cowdung (T_3)	22.06 ab	23.09 ab	24.80 ab
$LSD_{0.05}$	**2.25**	**2.06**	**1.86**
CV%	**5.46**	**4.79**	**4.09**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.10 Curd height per plant

The pure curd height per plant of cauliflower was recorded at 60 days after transplanting (DAT). The pure curd height per plant varied significantly due to the application of different compost (Figure 3). During the period of plant growth the maximum pure curd height per plant (17.18 cm at 60 DAT) was observed in vermicompost (T_1) treatment. On the other hand, shortest pure curd height per plant (11.94 cm at 60 DAT) was observed in T_0 (control) treatment. Similar results were also found by Ara *et al.* (2009) and Kumar *et al.* (2002) who reported that compost ensures available essential nutrients for the plant for that compost gave the highest pure curd height per plant compare to control. Days to curd initiation, days to curd harvest, curd length and curd expansiveness and curd yield increased in vermicompost treatment than control treatment.

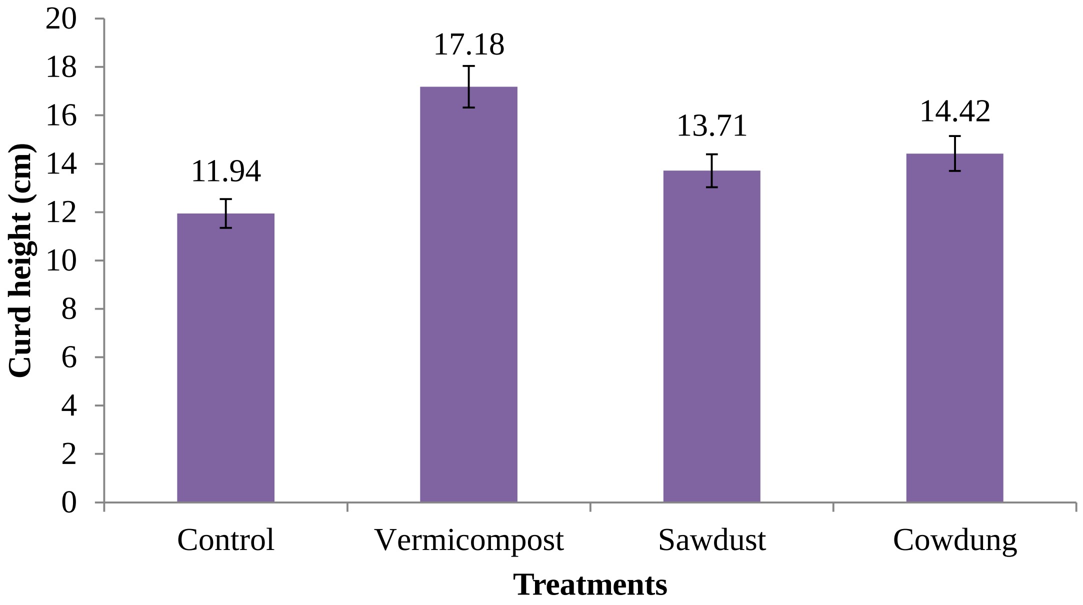


Figure 3. Effect of different composts on curd height per plant of cauliflower in rooftop garden

4.11 Diameter of curd per plant

The curd diameter per plant was recorded at 60 days after transplanting (DAT). The curd diameter varied significantly due to the application of different compost (Figure 4). During the period of plant growth the maximum curd diameter per plant (15.25 cm at 60 DAT) was observed in T_1 (vermicompost) treatment. On the other hand the shortest curd diameter per plant (12.02 cm at 60 DAT) was observed in T_0 (control) treatment. Among the different compost vermicompost was found more effective than other compost under the study. Similar trends was also found by Sharma and Sharma (2010), Kumar *et al.* (2002), Kodithuwakku and Kirthisinghel (2009), Mahamud (2006), Ghorbani *et al.* (2008), Mahmoud *et al.* (2009) and Jahan *et al.* (2014) who reported that cow manure contains a number of nutrients that can improve the growth and yield of cauliflower.

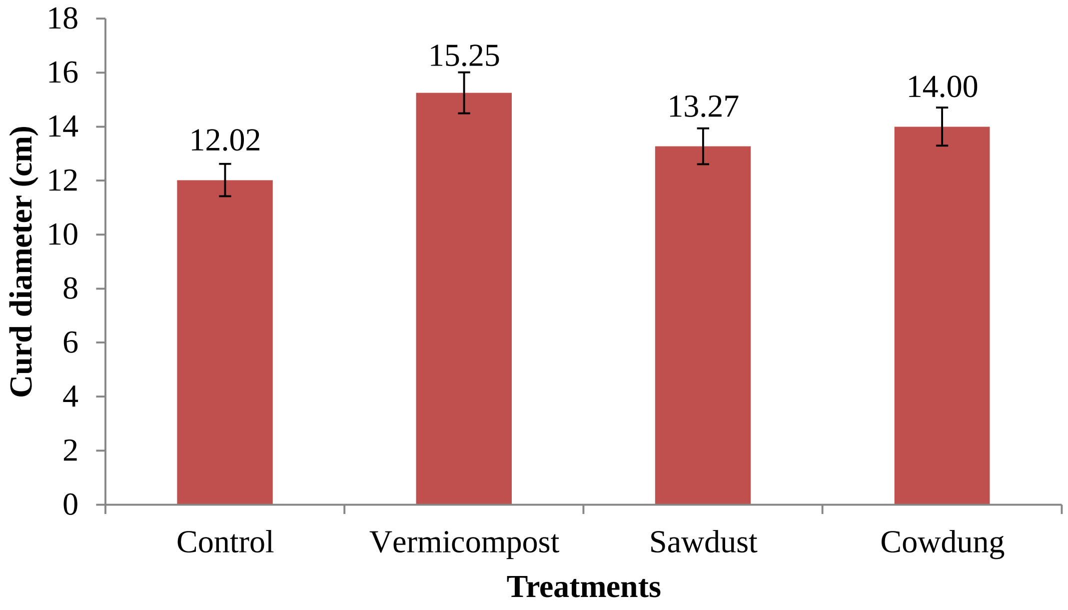


Figure 4. Effect of different composts on curd diameter per plant of cauliflower in rooftop garden

4.12 Curd weight with leaves per plant

A significant variation was observed on curd weight with leaves per plant due to the effect of different compost in the production of cauliflower on rooftop garden. The maximum curd weight with leaves per plant (634.65 g) was recorded from vermicompost (T_1) treatment while the minimum curd weight with leaves per plant (410.04 g) was from the control (T_0) treatment (Figure 5). The results of the experiment were also similar with the findings of Simarmata *et al.* (2016). Ara *et al.* (2009) reported that all the vegetative development parameters like number of leaves per plant, entire plant weight, curd weight and yield were impacted altogether by the utilization of various composts alongside mineral fertilizers. 50% of recommended dose of mineral fertilizers along with compost can increase the curd weight of cauliflower.

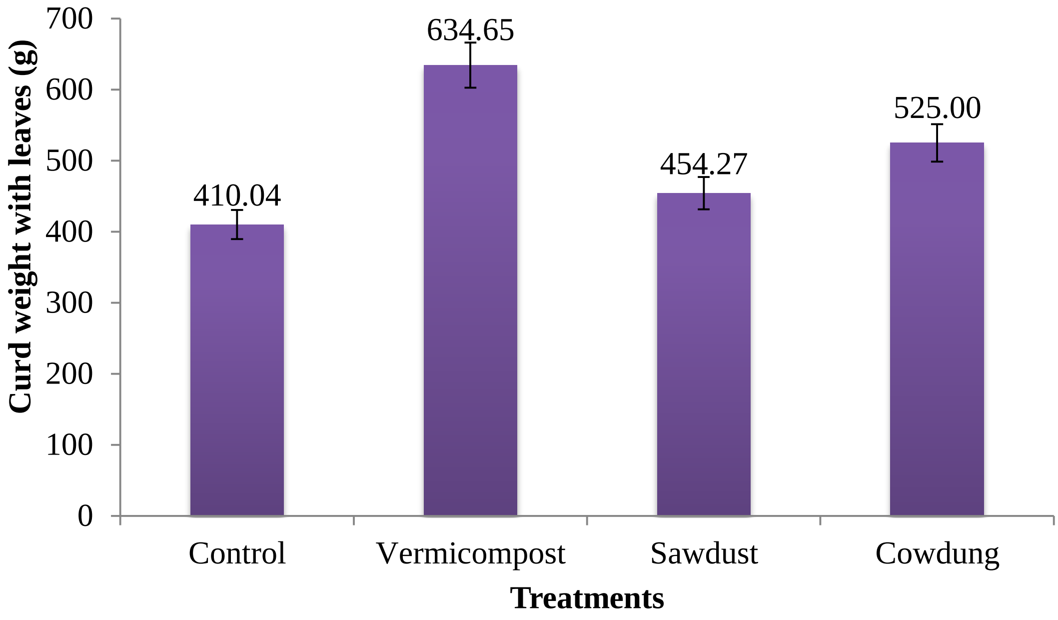


Figure 5. Effect of different composts on curd weight with leaves per plant of cauliflower in rooftop garden

4.13 Pure curd weight per plant

A significant variation was observed on curd weight per plant due to the effect of different compost in cauliflower production on rooftop garden. The maximum curd weight per plant (551.60 g) was recorded from vermicompost (T_1) treatment. On the other hand the minimum curd weight per plant (335.02 g) was recorded from control (T_0) treatment (Figure 6). Similar results were also found by Simarmata *et al.* (2016) and Ara *et al.* (2009) who reported that curd weight and yield were increased by the utilization of various composts alongside mineral fertilizers. 50% of recommended dose of mineral fertilizers along with compost can increase the curd weight of cauliflower. Rabbee *et al.* (2020) reported that marketable curd weight, net curd weight and yield/plot was maximum from vermicompost treated plant is compared with farmyard manure whereas lowest data recorded from control.

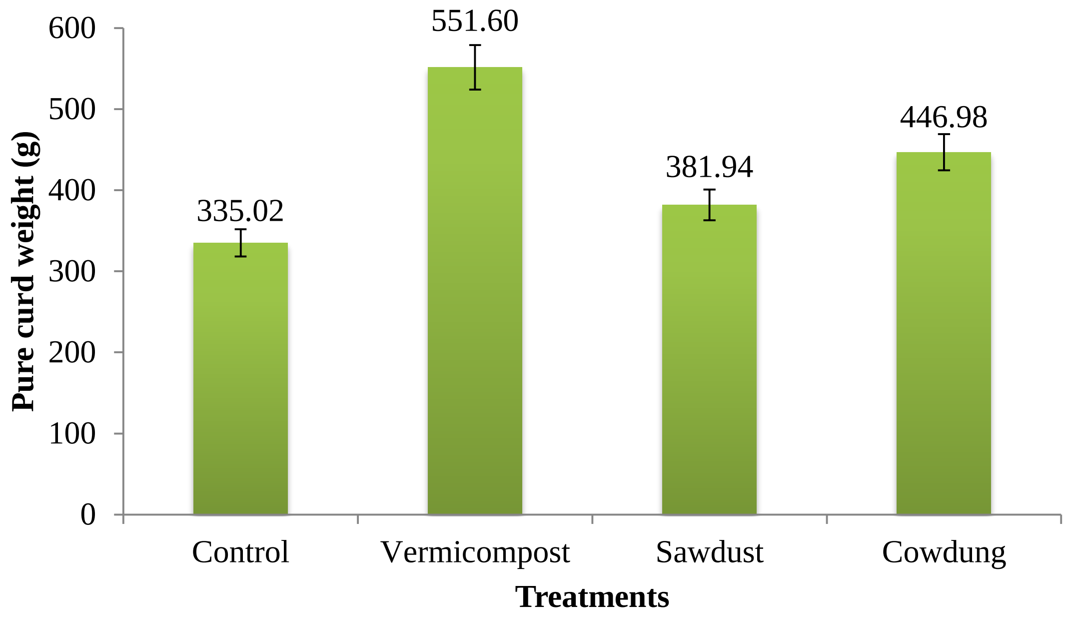


Figure 6. Effect of different composts on pure curd weight per plant of cauliflower in rooftop garden

4.14 Yield per plot

Yield per plot of cauliflower varied significantly due to the effect of different compost in rooftop garden. The maximum curd yield per plot (3.95 kg) was found from vermicompost (T_1) treatment. The minimum curd yield per plot (2.17 kg) in this respect was found from control (T_0) treatment (Figure 7). Similar results was also found by Noor *et al.* (2007) who reported in respect of yield per plot that yield of cauliflower remarkably influenced by organic and inorganic fertilizer management, for which an integrated approach for maintaining yield sustainability and soil fertility. Ara *et al.* (2009) also reported that weight of marketable curd per plant and yield per plot were impacted altogether by the utilization of various composts alongside mineral fertilizers. But days to curd initiation, days to curd harvest, curd length and curd expansiveness and curd yield expanded altogether as in vermicompost treatment in summer season. Mal *et al.* (2015) reported that the nutrient schedule comprising of higher level of vermicompost (10 t ha^{-1}) and 100% of recommended inorganic fertilizers emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, early head initiation, advanced head maturity and higher yield as well as superior quality of head as compared other nutrient combination.

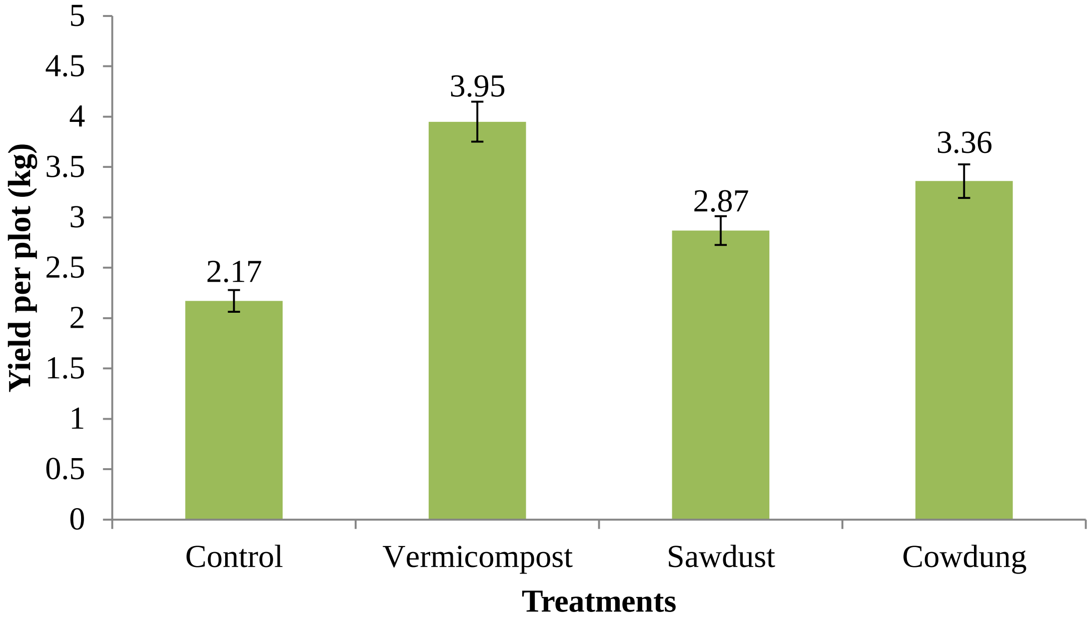


Figure 7. Effect of different composts on curd yield per plot of cauliflower in rooftop garden

4.15 Yield per hectare

Yields of cauliflower varied significantly due to different compost in rooftop garden. The maximum curd yield (19.75 t ha^{-1}) was found from vermicompost (T_1) treatment. The minimum curd yield (10.85 t ha^{-1}) in this respect was recorded from control (T_0) treatment (Figure 8). Similar results was also found by Ara *et al.* (2009) who reported that weight of marketable curd per plant and yield t/ha were impacted altogether by the utilization of various composts alongside mineral fertilizers. But days to curd initiation, days to curd harvest, curd length and curd expansiveness and curd yield expanded altogether as in vermicompost treatment in summer season. Mutalib *et al.* (2013) also found the similar trends who reported that the yield and curd production were significantly higher in vegetable waste vermicomposting than control treatment. Noor *et al.* (2007) also reported in respect of yield that yield of cauliflower remarkably influenced by organic and inorganic fertilizer management, for which an integrated approach for maintaining yield sustainability and soil fertility.

Khanam *et al.* (2009) found the similar trends who observed that the application of vermicompost along with the mineral fertilizer increased the yield of vegetable like brinjal, tomato, cauliflower etc. and improved the soil fertility. Bashyal (2011) detailed that biofertilizers and vermicomposts increased the efficiency of nitrogen fertilizer, and subsequently increases the yield and quality of cauliflower. Mal *et al.* (2015) reported that the nutrient schedule comprising of higher level of vermicompost (10 t ha^{-1}) and 100% of recommended inorganic fertilizers emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, early head initiation, advanced head maturity and higher yield as well as superior quality of head as compared other nutrient combination.

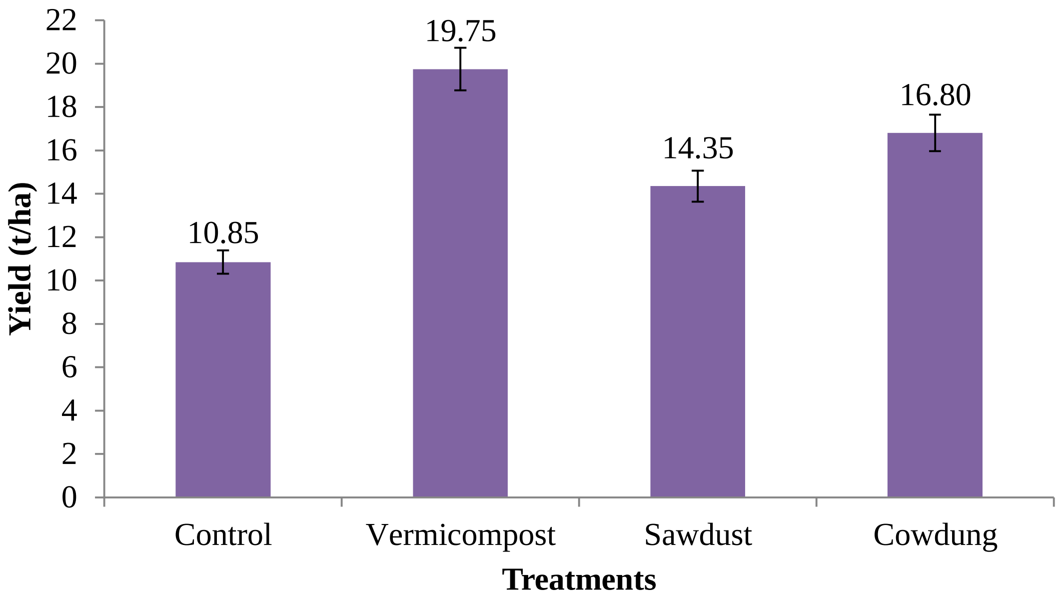


Figure 8. Effect of different composts on curd yield per hectare of cauliflower in rooftop garden

4.16 Soil moisture

A significant variation was observed on soil moisture due to the use of different composts in cauliflower production on rooftop garden. The maximum soil moisture percentage (20.60) was recorded from vermicompost (T_1) treatment where the minimum soil moisture percentage (15.42) was recorded from control (T_0) treatment (Figure 9). Vermicompost retains more moisture than control that increases the nutrient availability to the plants.

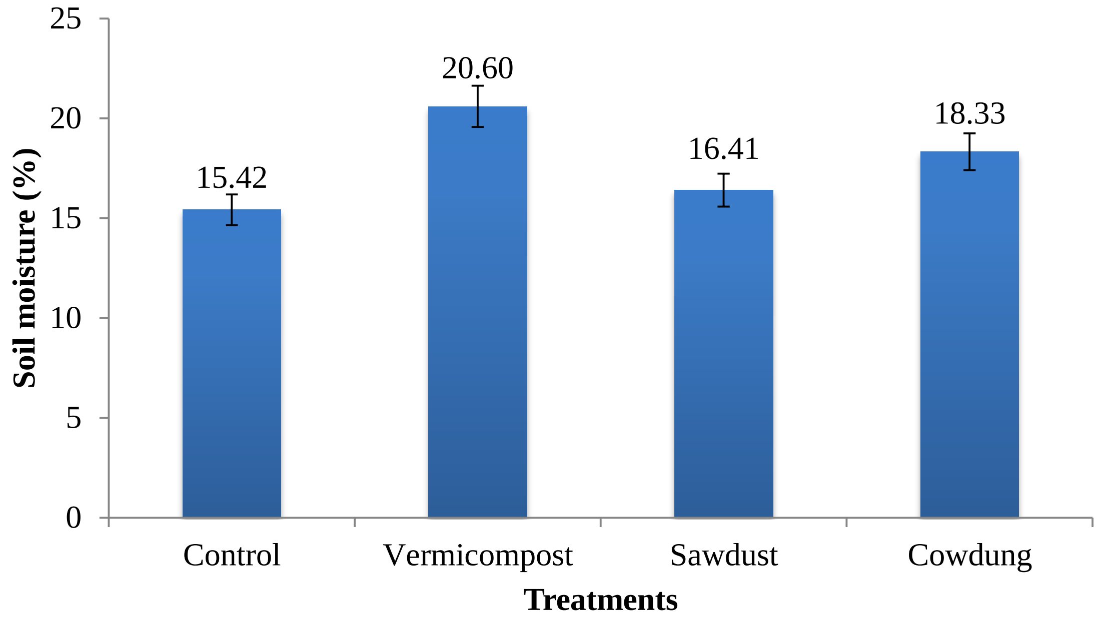


Figure 9. Effect of different composts on soil moisture of cauliflower in rooftop garden

4.17 Soil temperature

A significant variation was observed on soil temperature due to the effect of different compost in cauliflower production on rooftop garden. The maximum soil temperature (20.80°C) was recorded from control (T_0) treatment, while the minimum soil temperature (15.62°C) was recorded from the vermicompost (T_1) treatment (Figure 10). Vermicompost decreases the soil temperature that increases the nutrient availability to plant. Soil temperature alters the rate of organic matter decomposition and mineralization of different organic materials. It also affects soil water content, its conductivity and availability to plants. Soil temperature affects soil moisture. Higher soil temperature induces the soil moisture that related to the nutrient uptake by plants. The higher soil temperature decreases the plant growth and yield.

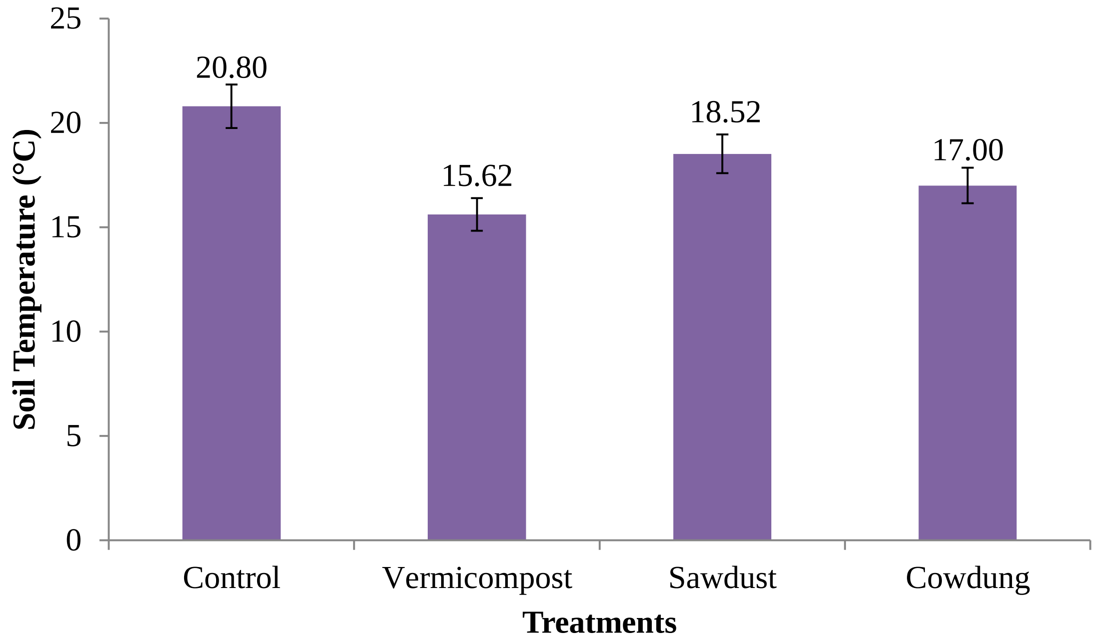


Figure 10. Effect of different composts on soil temperature of cauliflower in rooftop garden

4.18 Cost and return analysis

The cost and return analysis were done and have been presented in table 8. Materials (A), non-materials (B) and overhead costs (C) were recorded for all the treatments of unit plot and calculated on per hectare basis the price of cauliflower at the local market rate were considered.

The total cost of production ranges between Tk. 84850 and Tk. 118600 per hectare among the different treatment combinations. The variation was due to different cost of different types of composts. The highest cost of production Tk. 118600 per ha was involved in the treatment of vermicompost (T_1), while the lowest cost of production Tk. 84850 per ha was involved in the combination of no composts (T_0). Gross return from the different treatments ranges between Tk. 395000 and Tk. 217000 per ha.

Among the different treatments vermicompost (T_1) gave the highest return Tk. 276400 per ha while the lowest net return Tk. 132150 was obtained from the treatment combination of control (T_0).

The benefit cost ratio (BCR) was measured by dividing the gross return per hectare (Tk.) to total cost of production (Tk.). It was found to be the highest (3.33) in the treatment of vermicompost (T_1) and the lowest (2.55) was observed from the treatment of control (T_0). Thus it was apparent that although vermicompost (T_1) treatment gave the highest yield (19.75 t ha^{-1}) and the highest gross return (Tk. 395000.00). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

(A): Material cost (Tk.)

Treatments	**Seed (kg/ha)**	**Composts**			**Sub Total 1 (A)**
		Cowdung	**Sawdust**	**Vermicompost**	
Control (T_0)	8000	0	0	0	8000
Vermicompost (T_1)	8000	0	0	30000	38000
Sawdust (T_2)	8000	0	22500	0	30500
Cowdung (T_3)	8000	20000	0	0	28000

Cauliflower seed @ Tk. 8000 kg^{-1}
Vermicompost @ Tk. 3000 t^{-1}
Sawdust @ Tk. 1500 t^{-1}
Cowdung @ Tk. 1000 t^{-1}

B) Non-material cost (Tk. / ha)

Treatments	Land preparation	Seed sowing and transplanting	Intercultural operation	Harvesting	Sub total	Total input cost 1 (A) + 1 (B)
Control (T_0)	20000	7200	8000	10000	45200	53200
Vermicompost (T_1)	20000	7200	8000	10000	45200	83200
Sawdust (T_2)	20000	7200	8000	10000	45200	75700
Cowdung (T_3)	20000	7200	8000	10000	45200	73200

C) Overhead cost and total cost of production (Tk.)

Treatments	Cost of Net	Miscellaneous cost (5% of input cost)	Interest on running capital for 6 months (15% of the total input cost)	Total	Total cost of production (input cost + interest on running capital, Tk./ha)
Control (T_0)	25000	2660	3990	31650	84850
Vermicompost (T_1)	25000	4160	6240	35400	118600
Sawdust (T_2)	25000	3785	5677	34462	110162
Cowdung (T_3)	25000	3660	5490	34150	107350

Table 8. Cost and return of cauliflower using different composts

Treatments	Yield (t/ha)	Gross return (Tk./ha)	Total cost of production (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
Control (T_0)	10.85	217000	84850	132150	**2.55**
Vermicompost (T_1)	19.75	395000	118600	276400	**3.33**
Sawdust (T_2)	14.35	287000	110162	176838	**2.60**
Cowdung (T_3)	16.80	336000	107350	228650	**3.12**

Price of cauliflower: 20000 taka per ton

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

The experiment was conducted at the sixth floor of housing no. 64, road no. 6/A, Dhanmondi 13 during the period from November 2019 to July 2019. The experiment was laid out in Completely Randomized Design (CRD) having single factors with three replications. An area of 9 m × 4 m was divided into three equal blocks. Each block was consists of 4 plots where 4 treatments were allotted randomly. There were 12 unit plots in the experiment. The size of each plot was 2 m × 1 m, which accommodated 8 plants at a spacing 0.6 m × 0.45 m. The distance between two blocks and two plots were kept 1.5 m and 0.25 m respectively. The treatment of this experiment is T_0= Control (recommended dose of chemical fertilizers), T_1= Vermicompost (10 t/ha) + recommended dose of chemical fertilizers, T_2= Sawdust (15 t/ha) + recommended dose of chemical fertilizers and T_3= Cowdung (20 t/ha) + recommended dose of chemical fertilizers. The seeds of BARI fulkopi-2 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Collected data were significantly influenced due to the application of different compost treatment on rooftop garden.

The effect of compost demonstrated that the vermicompost (T_1) produced the tallest plant (26.47, 39.17, and 49.27 cm at 30, 45 and 60 DAT, respectively). On the other hand, control (T_0) treatment produced the shortest plant (20.20, 32.53 and 41.33 cm at 30, 45 and 60 DAT, respectively). Significant influence on number of leaves plant^{-1} was observed due to different composts. The maximum number of leaves plant^{-1} (17.53, 22.23 and 26.28 at 30, 45 and 60 DAT, respectively) was obtained from the vermicompost (T_1) while the minimum number of leaves plant^{-1} (13.33, 16.77 and 20.08 at 30, 45 and 60 DAT, respectively) was produced by the control (T_0) treatment. The results on effects of compost showed that different compost had significant effect on length of leaf at different days after transplanting on cauliflower in rooftop garden. The vermicompost (T_1) gave the maximum length of the largest leaf (25.36, 36.61 and 42.10 cm at 30, 45 and 60 DAT, respectively) while control treatment (T_0) gave minimum length of largest leaf (20.38, 30.65 and 35.59 cm at 30, 45 and 60 DAT, respectively).

Vermicompost (T_1) produced the widest leaf (12.17, 17.33 and 20.50 cm at 30, 45 and 60 DAT, respectively). On the other hand, control (T_0) treatment produced narrowest leaf (9.57, 14.11 and 17.00 cm at 30, 45 and 60 DAT, respectively). Compost significantly influenced on the canopy area of plant. It was observed that canopy area was increased with the increasing of days after transplanting. The maximum canopy area per plant was obtained by vermicompost (T_1) and it was observed 26.07, 37.97 and 49.18 cm at 30, 45 and 60 DAT, respectively where control treatment (T_0) gave minimum canopy area per plant (19.33, 31.71 and 40.86 cm at 30, 45 and 60 DAT, respectively).

Various composts exerted significant influenced on the fresh weight of leaves per plant. Vermicompost (T_1) produced the maximum fresh weight of leaves per plant (30.92, 192.54 and 216.71 g at 30, 45 and 60 DAT, respectively). On the other hand, control (T_0) treatment produced lowest fresh weight of leaves per plant (21.98, 150.68 and 174.49 g at 30, 45 and 60 DAT, respectively). Significant influence on dry weight of leaves per plant was observed due to compost. The maximum dry weight of leaves per plant (16.20, 85.00 and 112.28 g at 30, 45 and 60 DAT, respectively) was observed from vermicompost (T_1) treatment where control (T_0) treatment produced lowest dry weight of leaves per plant (11.45, 51.08 and 69.22 g at 30, 45 and 60 DAT, respectively).

Compost exerted significant influenced on stem diameter in the production of cauliflower on rooftop garden. The result showed that vermicompost (T_1) produced the highest stem diameter per plant (1.85, 1.87 and 1.90 cm at 30, 45 and 60 DAT, respectively). On the other hand, control (T_0) treatment produced lowest stem diameter per plant (1.56, 1.58 and 1.61 cm at 30, 45 and 60 DAT, respectively).

Vermicompost (T_1) produced the longest root length per plant (23.90, 24.80 and 26.10 cm at 30, 45 and 60 DAT, respectively) where control (T_0) treatment produced lowest root length per plant (20.50, 21.40 and 22.67 cm at 30, 45 and 60 DAT, respectively). The pure curd height per plant varied significantly due to the application of different compost. Vermicompost (T_1) gave the maximum pure curd height per plant (17.18 cm at 60 DAT) as it ensures available essential nutrients for the plant for that vermicompost gave the highest pure curd height compare to control (T_0) because shortest pure curd height per plant (11.94 cm at 60 DAT) was observed in T_0 (control) treatment. Compost ensures the available nutrients for the plant and influence on curd diameter significantly. Vermicompost (T_1) produced the maximum curd diameter per plant (15.25 cm at 60 DAT) as it more effective than the other composts. On the other hand, shortest curd diameter per plant (12.02 cm at 60 DAT) was observed in T_0 (control) treatment.

The maximum weight of curd with fresh leaves per plant (634.65 g) was observed in vermicompost (T_1) treatment where the minimum curd with fresh leaves per plant (410.04 g) was from the control (T_0) treatment. The maximum pure curd weight per plant (551.60 g) was observed in vermicompost (T_1) treatment. On the other hand, the minimum pure curd weight per plant (335.02 g) was obtained from the control (T_0) treatment.

Yield per plot and yield per hectare of cauliflower varied significantly due to different compost in rooftop garden. The maximum curd yield per plot (3.95 kg) was found from vermicompost (T_1) treatment where the minimum curd yield per plot (2.17 kg) was found from control (T_0) treatment. In respect of curd yield per hectare (19.75 t) found from vermicompost (T_1) treatment where the minimum curd yield per hectare (10.85 t) was recorded from control (T_0) treatment.

The benefit cost ratio (BCR) was found to be the highest (3.33) in the treatment of vermicompost (T_1). Thus it was apparent that although vermicompost (T_1) treatment gave the highest yield (19.75 t ha^{-1}) and the highest gross return (Tk. 395000.00).

CONCLUSION

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

It can be concluded that vermicompost (T_1) gave the maximum curd yield (19.75 t ha^{-1}) of cauliflower than the other composts (cowdung, sawdust) as well as control treatment. The temperature and moisture content etc. also found more in vermicompost application. Moreover, the economic output considering BCR was also found more in vermicompost applied plots. Therefore, in rooftop vermicompost may be a good compost option for cauliflower production.

RECOMMENDATIONS

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

1. Vegetables production is suitable in rooftop with proper care and management. In this experiment results showed that rooftop is suitable for cauliflower production.
2. Other crops can grow in rooftop garden with more treatments in future study for better understanding and accurate results.

REFERENCES

REFERENCES

Alam, M.N. (2006). Effect of vermicompost and some chemical fertilizers on yield and yield components of selective vegetable crops. Ph.D. Thesis, Faculty of Agriculture, University of Rajshahi, Bangladesh. Pp. 122-176.

Ara, N., Kaisar, M.O., Khalequzzaman, K.M., Kohinoor, H., Ahamed, K.U. (2009). Effect of different dates of planting and lines on the growth, yield and yield contributing characteristics of cauliflower. *J. Soil Nat.* **3**(1): 16-19.

Arancon, N.Q., Edwards, C.A., Bierman, P., Metzger, J.D. and Lucht, C. (2005). Effect of vermicomposts produced from cattle manure, food waste and paper waste on the growth and yield of peppers in the field. *Pedobiologia*. **49**(4): 297-306.

Arancon, N.Q., Edwards, C.A., Bierman, P., Welch, C. and Metzger, J.D. (2004). The influence of vermicompost applications to strawberries: Part 1. Effects on growth and yield. *Biores. Technol.* **93**:145 – 153

Asad, K.M. and Roy, M.R. (2014). Urban Greening and Roof Top Gardening: Scope and Opportunities in Bangladesh. Retrieved from gobeshona.net: ⟨ http:// gobeshona.net/wp-content/uploads/2015/01/Urban-Greening-and-Roof-Top-Gardening-Scope-and-Opportunities-in-Bangladesh.pdf⟩.

Atiyeh, R.M., Lee, S., Edward, C.A., Arancon, N.Q. and Metzger, J.D. (2002). The influence of humic acids derived from earthworm processed organic wastes on plant growth. *Biores. Technol.* **84**(1): 7-14.

Bakker, N., Dubbeling, M., Guendel, S., Koschella, U.S. and Zeeuw, H. (2000). Growing Cities, Growing Food, Urban Agriculture on the Policy Agenda.

Bashyal, L.N. (2011). Response of cauliflower to nitrogen fixing biofertilizer and graded levels of nitrogen. *J. Agric. Env*. **12**: 41-50.

BBS. (2018). Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics.

Ministry of Planning, Government of the people's Republic of Bangladesh, Dhaka, Bangladesh. p. 63.

BBS. (Bangladesh Bureau of Statistics), (2019). Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, GOB. Dhaka, Bangladesh. p. 79.

Bennett (2003). Linkages in the landscape: The role of corridors and connectivity in wildlife conservation. Gland: International Union for Conservation of Nature and Natural Resources.

Bhadra, R., Mehedi, M.N.H, Akter, S., Rouf, M.A. and Mohosina, F. (2019). Effect of cowdung and boron on growth and yield of broccoli (*Brassica oleracea*). *J. Biosci. Agric. Res.*, **22**(02): 1845-1851.

Cano, A. (2011). Is Urban Agriculture a Solution to the growing' Food Deserts '? Retrieved December 01, 2014, from http://organicjar.com/2011/2935/

Chan, K.Y., Dorahy, C. and Wells, T. (2008). Use of garden organic compost in vegetable production under contrasting soil P status. Collingwood, Australia: CSIRO Publishing. *Australian J. Agric. Res.* **59**(4): 374-382.

Chiroma, A.M., Folornso, O.A. and Alhassan, A.B. (2006). The effect of land configuration and wood shavings mulch on the properties of Sandy Loam Soil in Northeast Nigaria. *Tropicultura.* **24**: 129-134.

Cook, B.D., Halbach, T.R., Rosen, C.J. and Monerief, J.R. (1994). Effects of stream component on the agronomic properties of municipal solid waste compost. *Sei. Util.* **2**: 75-87.

Cosier, S. (2011). Urban Planting. *Audubon*. **113**(2): 50-54.

Daily Star. (2019). The dark side of Dhaka's urbanization. Retrieve from: https://www.thedailystar.net/supplements/28th-anniversary-supplements /avoiding-urban-nightmare-time-get-planning-right/news/the-dark-side-dhakas-urbanisation-1703425.

Devliegher, W. and Rooster, L.D. (1997). Cauliflower in continuous culture: Add supplementary GFT- compost sparingly. *Proeftuinnieuws*. **7**(18): 22.

Dickson, D. (2013). Vertical farming infographics. Retrieve from: https://verticalfarming.net/vertical-farming/vertical-farming-infographics/ (From FAO and NASA).

Dubbeling, M. (2014). Monitoring impacts of urban and peri-urban agriculture and forestry on climate change. Retrieved from ruaf.org: 〈 http://www.ruaf.org)

Eigenbrod, C. and Gruda, N. (2015). Urban vegetable for food security in cities. A review. *Agron. Sustain. Dev*. **35**(2): 483-498.

FAO (Statistics Division). (2018). Statistical Database. Food and Agricultural Organization of the United Nations, Rome, Italy. pp. 80.

FAO (2013). Resilient livelihoods-disaster risk reduction for food and nutrition security Framework Programme. Rome, Italy, FAO, pp. 93.

Farahzety, A.M. and Aishah, H.S. (2013). Effects of organic fertilizers on performance of cauliflower (*Brassica oleracea* var. *botrytis*) grown under protected structure. *J. Trop. Agric. Fd. Sci.* **41**(1): 15-25.

Ferreira, W.R., Ranal, M.A. and Filgucira, F.A.R. (2002). Fertilizers and spacing between plants on the yield of Malaysian cabbage. *Hort. Brasileira*. **20**(4): 635-640.

Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M. and Zaks, D.P. (2011). Solutions for a cultivated planet. *Intl. J. Sci.* **478**: 337-342.

Gaglione, S. and Bass, B. (2010). Increasing urban food security with extensive green roofs. *Living Archit. Monit*. **12**(1): 26-27.

Ghorbani, R., Koocheki, A. Jahan, M. and Asadi, G.A. (2008). Impact of organic amendements and compost extracts on tomato production and storability in agroecological system. *Agron. Sustain. Dev.* **8**: 307-311.

Ghosh, M., Chottopadhya, G.N., Baral, K. and Munsi, P.S. (1999). Possibility of using vermicompost in Agriculture for reconciling sustainability with productivity. Proceding of the Seminar on Agrotechnology and Environment. pp. 64-68.

Ghuge, T.D., Jadhav, S.B. and Gore, A.K. (2007). Effect of organic and inorganic sources of nutrients on uptake and nutrient availability of soil after harvesting of cabbage. *J. Soils Crops.* **17**(2): 294-298.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (Second Edn.). John Wiley and Sons, New York. pp. 139-240.

Green, J. (2011). December 16. Farm the Rooftops. Retrieved February 9, 2016, from dirt.asla.org: ⟨ http://dirt.asla.org/2011/12/16/farm-the-rooftops/⟩.

Grigoletti, G.D.C. and Pereira, M.F.B. (2014). Carbon dioxide emissions of green roofing-case study in southern Brazil. In 30th International Plea Conference, 1-8).

Hochmuth, R.C., Hocmuth, G.L. and Donley, M.E. (1993). Response of cabbage yields, head quality and leaf nutrient status and of second crop squash to poultry manure fertilization. *Proc. Soil Sci. Soc.* **52**: 125-130.

Hodgon, K., Campbell, M.C. and Bailkey, M. (2011). Investing in Healthy, Sustainable Places through Urban Agriculture. *Funders' Network for Smart Growth and Livable Communities*, p. 1-15.

Hossain, D., Haque, M.A., Abuyusuf, M., Riad, M.M. and Hussain, A.S.M. (2011). Response of cabbage to different levels of fertilizer application in salnasilty clay loam soil. *Bangladesh J. Res. Pub.* **6**(2): 155-166.

Hsieh, C. (2004). An experiment on the organic farming of cauliflower. Bulletin of Taichung District Agriculture Improvement Station. No. **53**(35-40):18.

Hui, D.C. (2011). Green roof urban farming for buildings in high-density urban cities the Hainan China World Green Roof Conference, pp. 1-9.

Islam, K.M.S. (2004). Rooftop Gardening as a Strategy of Urban Agriculture for Food Security: The Case of Dhaka City, Bangladesh. Proc. IC on Urban Horticulture, p. 241-247.

Islam, N.M. (2001). Homegarden Agroforestry in Bangladesh: A case study in Rangpur district. M.Sc. thesis, Agricultural University of Norway, Olso, Norway.

Islam, M.S. and Ahmed, R. (2011). Land use change prediction in Dhaka city using GIS aided. **6**: 81-89.

Jahan, F.N., Shahjalal, A.T.M., Paul, A.K., Mehraj, H. and Jamaluddin, A.F.M. (2014). Efficacy of vermicompost and conventional compost on growth and yield of cauliflower. *Bangladesh J. Res. Pub.* **10**(1): 33-38.

Jana, J.C. and Mukhopadhyay, T.P. (2006). Effect of sowing dates and varieties on growth and curd yield of cauliflower in Terai Zone of West Bengal. *Indian Agriculturist.* **47**(3/4): 235-239.

Juniawati, H.M. (2017). Urban Agriculture Development: A Strategy to Support Food Security Juniawati. 2nd International Conference on Sustainable Agriculture and Food Security: A Comprehensive Approach, *KnE Life Sci.* p. 701-713.

Kamrujjaman, R. (2015). Vertical farming: Social work and sustainable urban agriculture in an age of global food crises. *Australian Soc. Work.* **66**(2): 187-203.

Khan, M.S., Shil, N.C. and Noor, S. (2008). Integrated nutrient management for sustainable yield of major vegetable crops in Bangladesh. *Bangladesh J. Agric. Environ.* **4**: 81-94.

Khanam, D., Sen, R., Ali, E., Akhter, S. and Noor, S. (2009). Draft project report: Management and Utilization of Vermicompost on Soil Fertility and Vegetable Production. Ministry of Science and Information and Communication Technology, GOB, pp. 15.

Khandaker, M.S.I. (2004). Rooftop gardening as a strategy of urban agriculture for food security: The case of Dhaka City, Bangladesh. *Acta Hort*. **643**: 241-247.

Krupka, B. (1992). Roof Gardening: Use of Plants and Vegetation on Buildings. p. 508.

Kulak, M., Graves, A. and Chatterton, J. (2013). Reducing greenhouse gas emissions with urban agriculture: A Life Cycle Assessment perspective. *Landscape and Urban Planning*. **111**: 68-78.

Kumar, A., Parmar, D.K. and Suri, V.K. (2010). Effect of Boron fertilizers and organic manure on autumn cauliflower in western Himalayas. *Ann. Hort.* **5**(1): 17-24.

Kumar, P.T., Babu, S.D. and Aipe, K.C. (2002). Adaptability of cauliflower genotypes in the high ranges of Kerala. *J. Tropical Agric.* **40**: 45-47.

Lazcano, C., Revilla, P., Malvar, A. and Dominguez, J. (2011). Yield and fruit quality of four sweet corn hybrids (*Zea mays*) under conventional and integrated fertilization with vermicompost. *J. Sci. Food Agric.* **91**: 1244-1253.

Liu, T., Yang, M., Han, Z. and Ow, D.W. (2016). Rooftop production of leafy vegetables can be profitable and less contaminated than farm-grown vegetables. *Agron. Sustain. Dev.* **36**(3): 41.

Localize, B. (2007). Tapping the Potential of Urban Rooftops: Roof top Resources Neighborhood Assessment.

MacRae, R., Gallant, E., Patel, S., Michalak, M., Bunch, M. and Schaffner, S. (2010). Could Toronto provide 10% of its fresh vegetable requirements from within its own boundaries? Matching consumption requirements with growing spaces. *J. Agric. Food Sys. Comm. Dev.* **1**(2): 105-127.

Mahmoud, E., EL-Kader, N.A., Robin, P.N., Akkal-Corfini, and El-Rahman, L.A. (2009). Effects of different organic and inorganic fertilizers on cucumber yield and some soil properties. *World J. Agric. Sci.* **5**(4): 408-414.

Mal, D., Chatterjee, R. and Nimbalkar, K.H. (2015). Effect of vermicompost and inorganic fertilizers on growth, yield and quality of sprouting broccoli (*Brassica oleracea* L. var. *italica Plenck*). *Intl. J. Bio-res. Stress Manage.* **5**(4): 107-112.

McClintock, N. (2010). Why farm the city? Theorizing urban agriculture through alens of metabolic rift. *Cambridge J. Reg. Econ. Soc.* **3**(2): 191-207.

Miller, J.R. (2005). Biodiversity conservation and the extinction of experience. Trends in Ecology and Evolution. **20**(2): 430-434.

Moniruzzaman, M., Mahmud, S., Haider, J. and Islam, M.R. (2008). Optimization of fertilizer requirement for cauliflower under field. *Bangladesh J. Agril. Res.* **32**: 487-491.

Mucheru-Muna, M., Mugendi, D., Kungu, J., Mugwe, J. and Bationo, A. (2007). Effects of organic and mineral fertilizer inputs on maize yield and soil chemical properties in a maize cropping system in Meru South Distrit, Kenya. *Agrofor. Sys.* **69**: 189-197.

Mutalib, A., Farahzety, and Aishah, H.S. (2013). Effects of organic fertilizers on performance of cauliflower (*Brassica oleracea* var. *botrytis*) grown under protected structure. *J. Tropical Agric. Sci.* **41**: 15-25.

Noor, S., Farid, A.T.M., Shil, N.C. and Hossain, A.K.M. (2007). INM for Cauliflower 'In: *10 years Soil Science Research Activity and Future Strategies,* Soil Science Division, BARI, Joydebpur, Gazipur, Bangladesh. Pp. 8.

Odedine, S.A., Odedina, J.N., Ayeni, L.S., Arowojolu, S.A. and Ojeniyi, S.O. (2003). Effects of types of ash on soil fertility, nutrient availability and yield of tomato and pepper, *Nigerian J. Soil Sci.* **13**: 61-67.

Ojeniyi, S.O. and Adejobi, K.B. (2002). Effect of ash and goat dung manure composition, growth and yield of amaranthus. *Nigerian Agric. Res.* **33**: 46-57.

Onwuka, B. and Mang, B. (2018). Effects of soil temperature on some soil properties and plant growth. *Adv. Plants Agric. Res.* **8**(1): 34-37.

Orsini, F., Gasperi, D., Marchetti, L., Piovene, C., Draghetti, S., Ramazzotti, S., and Gianquinto, G. (2014). Exploring the production capacity of rooftop gardens (RTGs) in urban agriculture: the potential impact on food and nutrition security, biodiversity and other ecosystem services in the city of Bologna. *Food Security*. **6**(6): 781-792.

Ouda, B.A. and Mahadeen, A.Y. (2008). Effect of fertilizers on growth, yield components, quality and certain nutrient contents in cauliflower (*Brassica oleracea* var *brotrytis*). *Intl. J. Agric. Biol.* **10**: 627-632.

Ouellette, N. A., Walters, S. A. and Midden, K.S. (2013). Fertility management for tomato production on an extensive green. *J. Living Arch.* **1**(1): 2.

Owolabi, O.A., Adeyeye, B.T., Oladejo and Ojeniyi, S.O. (2003). Effect of wood ash on soil fertility and crop yield in southwest *Nigerian J. Soil Sci.* **13**: 55-60.

Pathak, K.N. and Nishi K. (2003). Management of root knot disease of Cauliflower by organic amendments and carbofuran. *Indian J. Nematol*. **33**(2): 191-193.

Pattnaik, S. and Reddy, V. (2009). Nutrient status of vermicompost of urban green waste processed by three earthworm species-*Eisenia fetida, Eudrilus eugeniac*, and *Perionyx excavatus*. Department of Ecology and Environmental Science, Pondicherrv University. Puducherry 605014, India.

Peck, S. (2003). Towards an integrated green roof infrastructure evaluation for Toronto. The Green Roof Infrastructure Monitor. **5**: 4-7.

Rabbee, H. E., Methela, N. J., Hossain, B. and Suhel, M. R. I. (2020). Growth and yield response of broccoli to vermicompost and farmyard manure. *J. Biosci. Agric. Res.* **25**(2): 2107-2113.

Rahman, A., Nabi, N.A.K.M., Amin, S.A.M., Abu, S.M., Rahman, S., Hossain, P.R., Rahman, M.H., Hossaine, S.M.M. and Mirza, M. (2014). Building Urban Resilience: Assessing Urban and Peri-urban Agriculture in Dhaka, Bangladesh. United Nations Environment Programme (UNEP), Nairobi, Kenya.

Rashid, H. and Ahmed, M.H.B. (2010). The passive cooling effect of green roof in high-rise residential building in Malaysia. Sustainable Architecture and Urban Development, CSAAR, 3-6 November.

Rashid, M.M. (1999). Sabji Bigan.Text Book Division, Bangla Academy, Dhaka, Bangladesh. 217.

RIES, A. (2014). April 23. Green *Roofs-Drawbacks and Benefits*. Retrieved February 8, 2016, from evstudio.com: 〈http://evstudio.com/green-roofs-%E2%80%93-drawbacks-and-benefits/.

Rodrigues, E.T. and Casali, V.W.D. (1999). Yield and nutrients concentration in lettuce in relation to organic and mineral fertilizer application. *Hort. Brasileira*. **17**(2): 125-128.

Roe, N. (1998). Analysing results on lawns and farm crops. *Biocycle*. **39**(20): 62-63. [Cited from *Hort. Abst.* **68**(8): 3927]

Roy, A. (2011). Consumption of vegetables and fruits and its importance. The DailyStar/sites/default/files/Report%201.1%20Report%20on%20potential%20UPAF%20impacts%20on%20Climate%20Change%20%20(Final)_1.pdf〉 .

Safayet, M. (2017).Present practice and future prospect of rooftop farming in Dhaka city: A step towards urban sustainability. *J. Urban Manage*. **6**: 105-113.

Saha, P., Kalia, P., and Joshi, S. (2015). Genetic analysis of yield components and curd color of midseason heat tolerant Indian cauliflower (*Brassica oleracea* var. *botrytis* L.). *SABRAO J. Breeding Gen.* **47**(2): 124-132.

Sanye-Mengual, E., Oliver-Solà1, J., Montero, J.I., Rieradevall, J. (2015). An environmental and economic life cycle assessment of Rooftop Greenhouse (RTG) implementation in Barcelona, Spain. *Intl. J. Life Cycle Assess.* **20**(3): 350-366.

Science for Environment Policy (2015). Rooftop gardens could grow three quarters of city's vegetables. Retrieved February 9, 2016, from ec.europa.eu:〈http://ec.europa.eu/environment/integration/research/newsalert/pdf/rooftop_gardens_could_grow_three_quarters_of_citys_vegetables_409na2_en.pdf〉

Setyowati, N., Muktamar, Z., Suryanti, B. and Simarmata, M. (2014). Growth and yield of chili pepper as affected by weed based organic compost and nitrogen fertilizer. *Intl. J. Adv. Sci. Eng. Inf. Tech.* **4**(2): 84-87.

SGUFS (Sprouting Good Urban Farming Sydney). (2014). Portable rooftop farm education centre. Retrieved February 8, 2016, from sproutinggood.com: ⟨http://sproutinggood.com/2014/01/23/urban-rooftop-farming-ischanging-the-world/⟩.

Sharma, K.C. and Sharma, L.K. (2010). Effect of biofertilizers and NPK levels on growth and yield of mid-maturity group of cauliflower under mid hill sub-humid conditions of Himachal Pradesh. *J. Hill Agric.* **1**: 19-22.

Shuvo, F.K. (2000). Investing in Healthy, Sustainable Places through Urban Agriculture. *Funders' Network for Smart Growth and Livable Communities*. Pp. 1-15.

Siddique, M.A.H. (2004). Effect of zinc, boron and molybdenum on seed production of cauliflower. An unpublished Thesis of Master of Science. Department of Horticulture, Bangladesh Agril. Univ., Mymensingh. pp. 1-3.

Simarmata, M. Susanti, L. and Setyowati, N. (2016). Utilization of manure and green organic composts as alternative fertilizers for cauliflower production. *J. Agril. Tech.* **12**(2): 311-319.

Sinha, A., Kumar, R., Srivastava, S. and Srivastava, M. (2010). Production of Organic Manure from Kitchen Waste: Ensuring livelihood of Resource Poor Women.

Sinha, Rajiv, K., Jaya, N., Gokul, B., Swapnil, P. and Bapat, P.D. (2008). Vermiculture Revolution. In James I. Daven and Robert N. Klein (Eds.). Progress in Waste Management Research: NOVA Science Publishers, NY. USA, Invited Paper. Pp. 157-227.

Smit, J., Nasr, J., and Ratta, A. (2001). Urban agriculture: Food, jobs and sustainable cities New York: The Urban Agriculture Network, Inc.

Sprouting Good Urban Farming Sydney. (2014). Portable rooftop farm education centre. Retrieved February 8, 2016, from sprouting good.com:http://sproutinggood.com/2014/01/23/urban-rooftop-farming-is-changing-the-world/.

Subler, S., Edwards, C.A. and Metzger, J.D. (1998). Comparing vermicomposts and composts. *BioCycle*. **39**(7): 63-66.

Suhane, R.K. (2007). Vermicompost (In Hindi); Pub. of Ralendra Agriculture University. Pusa, Bihar. Pp. 88.

Suparman, M. and Supiati. (2004). Chemical analysis on cows' feces using probotic technique. Proceedings of the Conference of National Technician of Agriculture (Indonesian). South Sulawesi. pp. 43-49.

Sustainability Television. (2019). Retrieved on 01 September, 2019. https://www.sustainabilitytelevision.com/news/what rooftop-farming.

Swarup, V. and Chatterjee, S.S. (1972). Cauliflower production. *Econ. Bot.* **26**: 81-93.

Tabassum, T. and Sharman, S. (2010). The Impact of Green Space Declination in Dhaka's Local Thermal Environment, Conference proceeding, urbanization, traffic jam and Bangladesh environment, ISBN: 978-984-33-5373-3.

Tejada, M. and Gonzalez, J.L. (2003). Effects of the application of a compost originating from crushed cotton gin residues on wheat yield under dry land conditions. *European J. Agron.* **19**: 357-368.

Tejada, M., Gonzalez, J.L., Hernandez, M. and Garcia, C. (2007). Agricultural use of leachates obtained from two different vermicomposting processes. *Bio-res. Technol*. **99**(14): 6228-6232.

Thompson. H.C. and Kelly, W.C. (1985). Vegetable Crops. Fifth edition, McGraw Hill. Book Co. New York, Toronto, London, p. 307.

Thornbush, M. (2015). Urban agriculture in the transition to low carbon cities through urban greening. *AIMS Environ. Sci.* **2**(3): 852-867.

Tiller, A. (2008). Rooftop Farms Could Feed City Slickers. Retrieved February, 9,2016,fromblog.alextiller.com:http://blog.alextiller.com/_blog/Alex_Tiller‟s_Blog_on_Agriculture_and_Farming/post/Rooftop_Farms_Could_Feed_City_Slickers/〉

Torstar News Service (2015). June 8. Rooftop farming could be the next step in Toronto architecture. Retrieved February 7, 2016, from metronews.ca.

Tripathi, P.K. and Sharma, R.K. (1991). Studies on the effect of age of seedling and spacing on the growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* Linn). New-Agriculturist. Dept. of Hort., Kulbhasker Ashram Post Graduate College, Allahabad, 211001, Uttar Pradesh, India. **2**: 177-182.

Uddin, D.M.J., Khondaker, D.N.A., Hossain, M.M.A., Das, D.A.K. and Masud, M.A.T.M.D. (2016). Baseline Study on Roof Top Gardening in Dhaka and Chittagong City of Bangladesh. A final technical report under the project of “Enhancing Urban Horticulture Production to Improve Food and Nutrition Security” (TCP/BGD/3503) funded by Food and Agriculture Organization of the United Nations.

Uddin, J., Rahman, M.J. and Hamidullah, A.T.M. (2009). Effect of different sources of organic manure on the yield of kohlrabi. *Bangladesh J. Agric. Environ.* **5**(1): 117-119.

United Nations (2014). World Urbanization Prospects: The 2014 Revision. Retrieved from http://esa.un.org/unpd/wup/Highlights/WUP2014.pdf.

Urban Design Lab. (2012). *The Potential for Urban Agriculture New York City*. New York City. Retrieved from http://www.urbandesignlab.columbia.edu /sitefiles/file/urban_agriculture_nyc.pdf

Ushakumari, K., Sailajakumari, M.S. and Sheeba, P.S. (2006). Vermicompost: A potential organic nutrient source for organic farming. Paper Presented at *18th World Congress of Soil Science;* July 9-15, 2006, Philadelphia, Pennsylvania, USA, Poster-162-16.

Walters, S.A., Midden, K.S. (2018). Sustainability of Urban Agriculture: Vegetable Production on Green Roofs. Agriculture, 8, 1-16. https://doi.org/10.3390/agriculture8110168.

Wardard, Y. (2014). Rooftop gardening can meet Dhaka's 10pc of vegetable demand. Retrieved from the financial express-bd.com:⟨ http://www. thefinancialexpress-bd.com/2014/11/19/66659/print⟩.

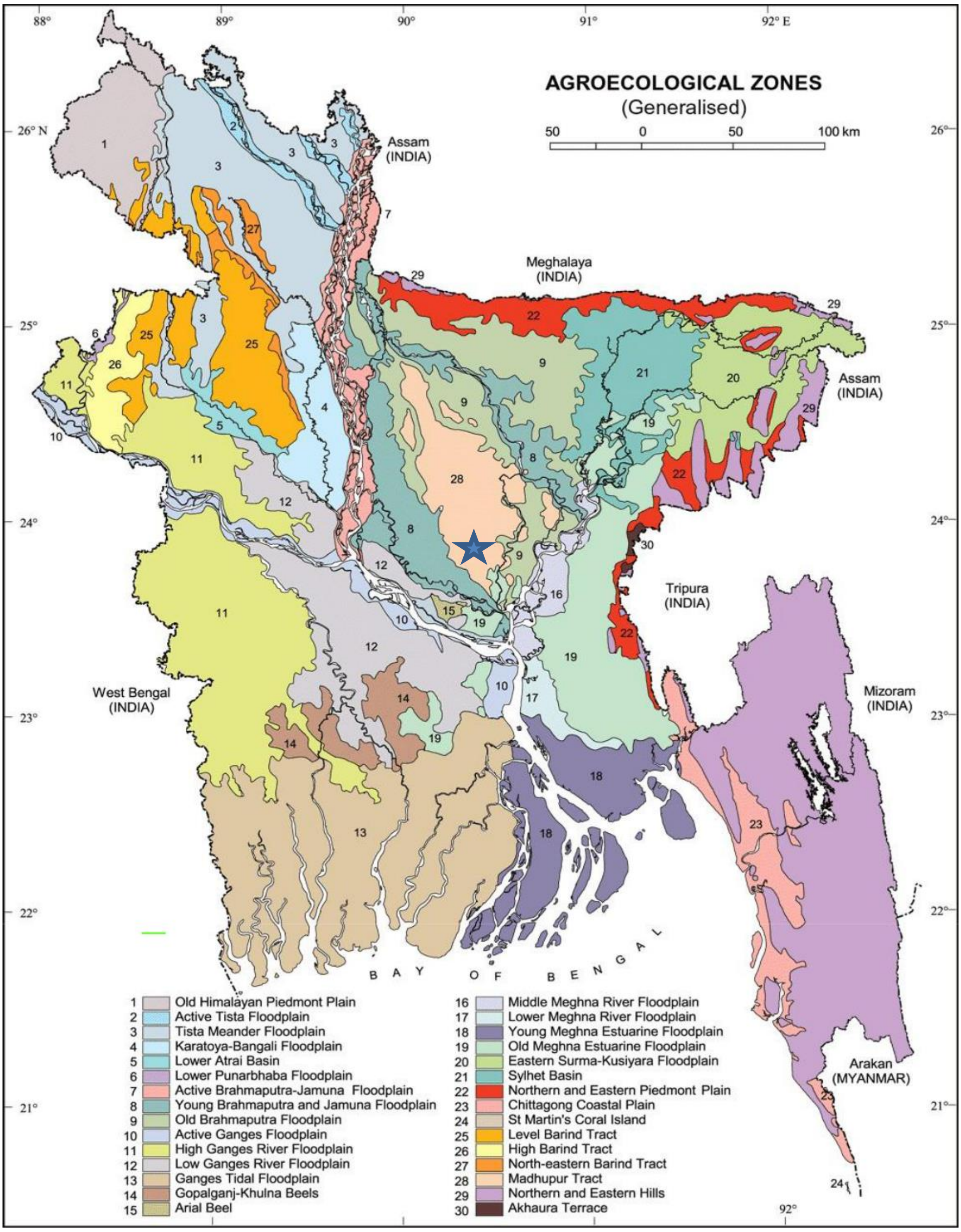
Whalen, J.K., Chang, C. Clayton, G.W. and Carefoot, J.P. (2000). Cattle manure amendments can increase the pH of acid soils. *American J. Soil Sci. Soc.* **64**: 962-966.

Wikipedia (2019). http://en.wikipedia.org/wiki/Dhaka, accessed on 05-12-2013. World Population Prospects, 2016.

APPENDICES

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location



★ **Experimental site**

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2019 to February 2020

Month and year	RH (%)	Air temperature (°C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
November, 2019	56.25	28.70	8.62	18.66	14.5
December, 2019	51.75	26.50	9.25	17.87	12.0
January, 2020	46.20	23.70	11.55	17.62	0.0
February, 2020	37.95	22.85	14.15	18.50	0.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Housing no. 64, Road no. 6/A, Dhanmondi
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Analysis of variance of plant height at different DAT of cauliflower production in rooftop garden

Source of variation	df	plant height at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	**3**	**68.90**	**22.97***	**81.71**	**27.23***	**107.86**	**35.95***
Error	**8**	**42.87**	**5.36**	**54.29**	**6.79**	**75.04**	**9.38**
Total	**11**	**111.78**		**135.99**		**182.89**	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix V. Analysis of variance of number of leaves plant^{-1} at different DAT of cauliflower production in rooftop garden

Source of variation	df	Number of leaves plant^{-1} at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	**3**	**27.48**	**9.16***	**48.75**	**16.25***	**65.14**	**21.71***
Error	**8**	**18.69**	**2.34**	**30.64**	**3.83**	**34.46**	**4.31**
Total	**11**	**46.17**		**79.40**		**99.60**	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix VI. Analysis of variance of largest leaf length at different DAT of cauliflower production in rooftop garden

Source of variation	df	Largest leaf length at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	**3**	**40.88**	**13.62***	**64.10**	**21.36***	**92.90**	**30.96***
Error	**8**	**20.32**	**2.54**	**41.11**	**5.13**	**35.18**	**4.39**
Total	**11**	**61.20**		**105.21**		**128.08**	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix VII. Analysis of variance of largest leaf breadth at different DAT of cauliflower production in rooftop garden

Source of variation	df	Largest leaf breadth at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	**3**	**12.86**	**4.29***	**16.45**	**5.48***	**20.06**	**6.69***
Error	**8**	**6.61**	**0.83**	**10.18**	**1.27**	**13.95**	**1.74**
Total	**11**	**19.47**		**26.63**		**34.01**	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix VIII. Analysis of variance of fresh weight of leaves per plant at different DAT of cauliflower production in rooftop garden

Source of variation	df	Fresh weight of leaves per plant at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	3	131.731	43.91*	2787.43	929.144*	2869.69	956.563*
Error	8	69.321	8.67	1250.00	156.250	1566.45	195.806
Total	11	201.052		4037.43		4436.14	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix IX. Analysis of variance of dry weight of leaves per plant at different DAT of cauliflower production in rooftop garden

Source of variation	df	Dry weight of leaves per plant at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	3	37.71	12.57*	1839.01	613.00*	2998.76	999.58*
Error	8	26.67	3.33	438.67	54.83	561.03	70.13
Total	11	64.38		2277.68		3559.79	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix X. Analysis of variance of canopy area per plant at different DAT of cauliflower production in rooftop garden

Source of variation	df	Canopy area per plant at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	**3**	**80.01**	**26.67***	**69.66**	**23.22***	**117.98**	**39.33***
Error	**8**	**39.10**	**4.89**	**47.95**	**5.99**	**87.66**	**10.96**
Total	**11**	**119.11**		**117.61**		**205.64**	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix XI. Analysis of variance of stem diameter per plant at different DAT of cauliflower production in rooftop garden

Source of variation	df	Stem diameter at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	**3**	**0.13**	**0.045***	**0.13**	**0.0441***	**0.14**	**0.0456***
Error	**8**	**0.07**	**0.008**	**0.07**	**0.008**	**0.09**	**0.0115**
Total	**11**	**0.20**		**0.20**		**0.23**	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix XII. Analysis of variance of root length per plant at different DAT of cauliflower production in rooftop garden

Source of variation	df	Root length at different DAT					
		30 DAT		45 DAT		60 DAT	
		SS	MS	SS	MS	SS	MS
Treatment	**3**	**19.56**	**6.52***	**18.84**	**6.28***	**20.68**	**6.89***
Error	**8**	**11.44**	**1.43**	**9.62**	**1.20**	**7.88**	**0.98**
Total	**11**	**31.00**		**28.46**		**28.56**	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

Appendix XIII. Analysis of variance of curd height per plant and curd diameter per plant of cauliflower production in rooftop garden

Source of variation	df	Curd height per plant		Curd diameter per plant	
		SS	MS	SS	MS
Treatment	**3**	**42.68**	**14.22***	**16.45**	**5.48***
Error	**8**	**27.39**	**3.42**	**10.84**	**1.36**
Total	**11**	**70.07**		**27.29**	

* significant at 5% level of probability
SS = sum of square, MS = mean sum of square

Appendix XIV. Analysis of variance of curd weight with leaves per plant and pure curd weight per plant of cauliflower production in rooftop garden

Source of variation	df	Curd weight with leaves per plant		Pure curd weight per plant	
		SS	MS	SS	MS
Treatment	**3**	**86386.50**	**28795.50***	**79203.90**	**26401.30***
Error	**8**	**10659.30**	**1332.40**	**7288.30**	**911.00**
Total	**11**	**97045.80**		**86492.20**	

* significant at 5% level of probability
SS = sum of square, MS = mean sum of square

Appendix XV. Analysis of variance of curd yield per plot and curd yield per hectare of cauliflower production in rooftop garden

Source of variation	df	Curd yield per plot		Curd yield per hectare	
		SS	MS	SS	MS
Treatment	**3**	**5.11**	**1.70***	**128.04**	**42.68***
Error	**8**	**0.82**	**0.10**	**36.00**	**4.50**
Total	**11**	**5.93**		**164.05**	

* significant at 5% level of probability
SS = sum of square, MS = mean sum of square

Appendix XVI. Analysis of variance of soil moisture and soil temperature of cauliflower production in rooftop garden

Source of variation	df	Soil moisture		Soil temperature	
		SS	MS	SS	MS
Treatment	**3**	**47.05**	**15.68***	**44.36**	**14.79***
Error	**8**	**12.47**	**1.56**	**20.95**	**2.62**
Total	**11**	**59.52**		**65.31**	

* significant at 5% level of probability
DAT = Days After Transplanting, SS = sum of square, MS = mean sum of square

SOME PICTORIAL VIEW DURING EXPERIMENT

Plate 1. Preparation of blocks

Plate 2. Transplanting of cauliflower seedlings in blocks

Plate 3. Irrigation on experimental plot   Plate 4. Vegetative growth of crop

Plate 5. General view of blocks on rooftop

Plate 6. Measuring the soil moisture in the experiment

Plate 7. Inspection of the experimental crop on rooftop garden

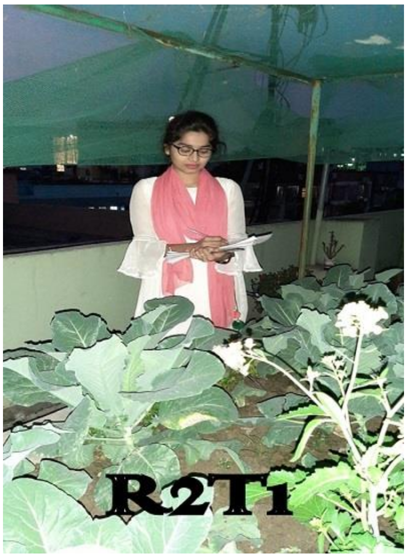


Plate 8. Data collection during experimentation on rooftop garden

Plate 9. Measuring the soil temperature

Plate 10. Curd formation of crop

Plate 11. Yield performance of cauliflower on rooftop garden