EFFECT OF DIFFERENT ORGANIC GROWING MEDIA ON GROWTH AND YIELD OF VERTICALLY GROWN BARI CHIVE-1

NOWSHIN AKHTER

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2022

EFFECT OF DIFFERENT ORGANIC GROWING MEDIA ON GROWTH AND YIELD OF VERTICALLY GROWN BARI CHIVE-1

BY

NOWSHIN AKHTER

REG. NO. 1506772
Mobile No. 01957201300
Email Address: nowshin.sau@gmail.com

A Thesis Submitted to
The Department of Horticulture, Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE
SEMESTER: JANUARY-JUNE, 2022

APPROVED BY:

Prof. Dr. A Hasnat M Solaiman	**Prof. Dr. Jasim Uddain**
Department of Horticulture	Department of Horticulture
SAU, Dhaka	SAU, Dhaka
Supervisor	**Co-Supervisor**

Prof. Dr. Khaleda Khatun
Chairman
Examination Committee

Department of Horticulture
Sher-e-Bangla Agricultural University (SAU)
Sher-e -Bangla Nagar, Dhaka-1207

Memo No: Dated:

CERTIFICATE

*This is to certify that the thesis entitled "**EFFECT OF DIFFERENT ORGANIC GROWING MEDIA ON GROWTH AND YIELD OF VERTICALLY GROWN BARI CHIVE-1**" was submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of authentic research work carried out by **NOWSHIN AKHTER**, Registration No. 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 been duly acknowledged.

Dated: June, 2022
Dhaka, Bangladesh

Dr. A Hasnat M Solaiman
Professor
Department of Horticulture
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka- 1207
Supervisor

"It is a fact that the remembrance of Allah brings peace to the heart. It is better to ponder over the verses to bring us even closer to Allah (swt)"

DEDICATED TO -

MY HONORABLE PARENTS,

MY FATHER-IN-LAW AND MOTHER-IN-LAW

ACKNOWLEDGEMENTS

The author is prostrated before almighty Allah, the most Merciful and most Beneficent, for giving the strength and courage to complete the research work successfully.

This thesis owes its existence to the help, support and inspiration of several people. Firstly, the author expresses her sincere gratitude and appreciation to her respected Supervisor, ***Prof. Dr. A Hasnat M Solaiman*** *for his continuous guidance and constant support during this research. Without his support and inspiring suggestions, it would not be possible to complete.*

The author is also indebted to her Co-Supervisor Prof. Dr. Jasim Uddain, ***Chairman, Prof. Dr. Khaleda Khatun*** *and all other teachers of* ***Department of Horticulture, Sher-e-Bangla Agricultural University****, who have been constant sources of encouragement and enthusiasm, not only during this thesis work but also during the two years of her Master program.*

The author cordially acknowledged the support of spices research sub-centre, BARI, Faridpur from where planting material was provided for carrying out this research work.

Cordial thanks are also due to all laboratory staff and field workers of SAU farm for their co-operation to complete this research work.

The author deeply acknowledges the profound dedication to her beloved Parents for their moral support, steadfast encouragement and continuous prayer in all phases of academic pursuit from the beginning to the completion of study successfully.

Furthermore, the author is heartily indebted to her fellow lab mates, well-wishers and friends specially surovi, ripa, monika, snigdha, nisat, konok, medha, akhi for their kind help and support which can never be forgotten.

Special thanks to my husband Md. Musfiqur Rahman Ayan, Scientific Officer, Spices research sub-centre, Faridpur for his immense support throughout the whole journey.

- ***The author***

EFFECT OF DIFFERENT ORGANIC GROWING MEDIA ON GROWTH AND YIELD OF VERTICALLY GROWN BARI CHIVE-1

BY

NOWSHIN AKHTER

An experiment was conducted at Sher-e-Bangla Agricultural University to evaluate the influence of organic growing media on growth, yield and quality performance of BARI Chive-1 variety in vertical garden. The experiment comprised of nine treatments, viz., G_0 = Control (100% Soil), G_1 = Soil + Vermicompost (50:50), G_2 = soil+ vermicompost + cowdung (50:25:25), G_3 = Soil+ Cowdung (50:50), G_4 = Soil+ Cowdung (75:25), G_5 = Soil+ Cowdung+ Kitchen compost (50:25:25), G_6= Soil + Kitchen compost + Cocopeat (50:25:25), G_7= Soil + Vermicompost + Biochar (50:25:25), G_8= Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10). The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. Among them the highest yield per pipe (71g) was found from G_2 and the lowest (22g) from G_8 treatment. According to all treatments G_2 performed significantly better in terms of plant height, leaf length, fresh and dry weight of individual plants and yield (t/ha). But the highest dry matter percentage found in control treatment. Another treatment G_6 performed almost statistically similar result with G_2. So, in vertical garden soil+ vermicompost + cowdung (50:25:25) and Soil + Kitchen compost + Cocopeat (50:25:25) can be very good for BARI chive-1 production.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS(Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

LIST OF ABBREVIATION AND ACRONYMS

AEZ = Agro-Ecological Zone

BARI = Bangladesh Agricultural Research Institute

BBS = Bangladesh Bureau of Statistics

FAO = Food and Agriculture Organization

et al. = And others

kg = Kilogram

SAU = Sher-e-Bangla Agricultural University

DF= Degrees of freedom

DAT = Days After Transplanting

g = Gram

cm = Centimeter

wt = Weight

LSD = Least Significant Difference

^{0}C = Degree Celsius

NS = Not significant

Max = Maximum

Min = Minimum

% = Percent

C: N = Carbon: Nitrogen

CV% = Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Effect of different organic growing media on growth and yield of vertically grown BARI Chive-1 on rooftop.

Chapter I

INTRODUCTION

"By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round and ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality" this is one of the major target for us to achieve the Sustainable Development Goals (SDGs) or Global Goals**.** On an average sixty-six thousands of agricultural land (0.29 percent of total agricultural land) has been decreased every year from Bangladesh. **(Alam *et al.*, 2015).** On the other hand, Bangladesh still now deficit in onion and garlic production. **(BBS,2021).**

Chive (*Allium tuberosum*) is a very new crop in Bangladesh. It is perennial type. Chives flavor is Like allium species especially onions and garlic **(Hashimoto *et al.*,1983)**. The Lillian shaped leaves are about 23-30cm with flat, smooth edges and the bulbs can grow up to 1.5cm. *Allium tuberosum* (garlic chives, Oriental garlic, Asian chives, Chinese chives, Chinese leek) is a species of plant native to the Chinese province of Shanxi, and cultivated and naturalized elsewhere in Asia and around the world **(Wikipedia, 2023)**. In Manipur and other northeastern states of India, it is grown and used as a substitute for garlic and onion in cooking and is known as *maroi nakuppi* in Manipuri. For culinary and medicinal properties of Chives, they are widely cultivated. Chives is that kind of crop which whole plant, leaves, stalk and flower can be used as a spice. The taste of chives is milder than onions, so they are the perfect choice for soups and savory dishes. Chives should be added at the end of cooking otherwise the flavor will disappear. It even has health benefits like helping digestion and disease prevention. It also prevents different types of cancer. It is rich in Vitamin C, Vitamin B-1, Vitamin B-2, Niacin, Carotene, and other minerals. Currently chives are cultivated in the hilly areas of Sylhet and Chittagong. Scientists find great potential in its cultivation in the onion producing areas of the country like Faridpur, Pabna, Rajbari, Meherpur, Kushtia, Magura, Bogra, and Lalmanirhat.

One should be able to cut chives down to 3cm off the ground multiple times a year to maintain a supply of succulent fresh leaves.

Vertical gardening has gained significant popularity in recent years, particularly in urban areas where space for traditional gardening is limited. It offers an innovative approach to urban sustainable food production and security. By using space-efficient growing systems, vertical gardens can be utilized in urban areas to produce fresh and healthy food, reducing the carbon footprint and ensuring access to locally sourced produce. Vertical gardens use less water, fertilizers and pesticides than traditional gardens, making them more sustainable and environmentally friendly. **Ortiz-Ribbing *et al.* (2020)** found that vertical gardens were an effective method of sustainable food production and helped to reduce greenhouse gas emissions. Vertical gardens can be set up in urban areas, providing an opportunity for local food production. A study by **Byrne *et al*. (2019)** found that urban agriculture was an effective method of improving access to fresh produce in low-income areas of cities. Vertical gardens can be designed to provide year-round food production, reducing the need for food imports and improving food security. **Debono *et al*. (2021)** mentioned that vertical gardens were an effective method of year-round food production in urban areas.

Organic growing media plays an important role in sustainable food production and food safety. Using organic growing media can reduce the environmental impact of food production and helps to ensure that the food produced is safe and healthy for consumption. Organic growing media contains organic matter that helps to improve soil health and fertility. This can reduce the need for synthetic fertilizers and other chemical inputs that can harm the environment and reduce the quality of the food produced. **Ciavatta *et al.* (2015)** showed that organic growing media improved soil structure, increased water retention, and enhanced nutrient availability. **Ibanez *et al.* (2021)** found that organic growing media reduced the risk of contamination of *Salmonella* compared to conventional growing media. Organic growing media are made from renewable resources and are biodegradable, reducing the environmental impact of food production. Organic growing media reduced greenhouse gas emissions and energy consumption compared to conventional growing media (**Souza *et al.*, 2019**). Organic growing media can also contribute to improved food safety by reducing the risk of exposure to harmful chemicals and pathogens. A study by **Antoniadis *et al.***

(2018) found that organic growing media reduced the presence of *Escherichia coli* in plant.

Using organic growing media in a vertical garden is not only beneficial for plant growth, but it also promotes sustainable and environmentally friendly gardening practices. Chives, a popular herb in cooking, can be grown in vertical gardens using organic growing media to ensure food security. Growing media plays a crucial role in the growth and yield of chives in vertical gardens. The right growing media can provide optimal moisture, nutrient retention, and aeration for the plants. Compost is a rich organic growing media that contains nutrients essential for plant growth. A study by **Borrelli *et al.* (2021)** found that using compost as a growing medium significantly increased chive biomass production in a vertical garden. Coco peat is a byproduct of coconut husk and is a popular growing medium due to its excellent water retention and aeration properties. **Kumar *et al.* (2019)** found that coco peat-based growing media promoted better growth and yield of chives in a vertical garden compared to soil-based media.

The choice of growing media is an important factor in the cultivation of garlic chives as it influences the plant's growth, yield and quality. Organic growing media such as compost, vermicompost, peat moss, and bio coir have gained popularity due to their environmentally friendly nature and potential to improve soil health. However, the effects of different organic growing media on chive growth and development have yet to be fully evaluated. The use of organic growing media in vertical gardens is a crucial aspect of the growth and development of plants. Chives are a popular herb that can be grown in vertical gardens and are valued for their culinary and medicinal properties. With conceiving the above outline in mind, the present research work has been undertaken in order to fulfilling the following objectives:

- to investigate the effect of different organic growing media on chive growth in a vertical garden.
- to examine the growth, yield and quality of chives grown in different organic growing media.

The findings of this study may be providing useful information for urban gardeners and farmers on how to optimize the growth of chives in vertical gardens, leading to more sustainable and healthier food production.

CHAPTER II

REVIEW

OF

LITERATURE

Chapter II

REVIEW OF LITERATURE

Chives (also known as Chinese chives or Garlic Chives) are a versatile garden plant commonly grown in culinary herb garden settings and as an ornamental flowering perennial. It belongs to the genus Allium and are a cold-tolerant perennial herbaceous ratoon plant. Most of the species in this genus are used around the world as food, spices, and medicinal materials (**Masiot *et al.*,1995**). Chemical investigations of the different parts of Chinese chives have shown that they contain vitamins, crude fibers, mineral compounds, and sulfur compounds, and have antibacterial properties when consumed by humans **(Zhang *et al.*, 2016; Moon *et al.*, 2003 & Imahori *et al.*, 2004)**. Chinese chives are becoming more economically valuable because of their nutritional and functional components **(Gao *et al.*, 2018)**. Scientists of the Bangladesh Agricultural Research Institute (BARI) are hoping that chives can be used as an alternative to garlic and onion. They released a high yielding variety of this crop named BARI Chive-1 in 2017 **(Akand, 2019).** What makes chives the ideal crop is that it can be grown all year round. Once planted, the crops can be collected multiple times from a single plant and can be grown easily in flower pots or backyards. Therefore, chive is very important and very new crop for Bangladesh and it has economic and nutritional importance as well for our food security.

Another most challenging issue for us is production of safe food in the densely populated areas of the developing countries. Every year annually one percent of cultivable land is decreased to urban development in Bangladesh **(The United Nations, 2017)**. As a result, to feed the people by producing food is becoming a big challenge. Another big issue is rural grown foods are highly contaminated by pesticide and preservative **(Siddique, 2017).**

Now a day vertical farming is becoming popular in urban area. Vertical farming could enable food production in a proficient and sustainable system, to save water and energy, reduce pollution and restore ecosystem and supply safe food **(The United Nations, 2017).**

But very few research works were done on organic chive production in vertical agriculture. Here in the section below, some past works related to this research are reviewed.

2.1 Effect of different organic growing media on Chives:

The use of organic growing media in the cultivation of garlic chives (*Allium tuberosum*) has gained popularity in recent years due to concerns over the environmental impact of synthetic growing media and the potential benefits of organic media for soil health.

Sagolsem *et al., (2022)* conducted an experiment on "Effect of organic compost and PSB on growth and yield of chives (*Allium tuberosum* L.)" at the Horticultural experimental field of the Department of Horticulture, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou from December 2018 to June 2019. They carried the experiment in Randomized Block Design (RBD) with three replications and seven treatments viz., control (T_1), Vermicompost (T_2), Phumdi (T_3), Phosphate Solubilizing Bacteria-PSB (T_4), Vermicompost + Phumdi (T_5), Vermicompost + Phosphate Solubilizing Bacteria (T_6) and Vermicompost + Phumdi +Phosphate Solubilizing Bacteria(T_7). Local cultivars of chives saplings were bought from a local market and were planted on a bed size of $1m^2$ at spacing of 15cm x 15cm respectively. The data revealed that the treatment T_7 (Vermicompost + Phumdi +Phosphate Solubilizing Bacteria) showed maximum significant effect on growth and yield parameters.

Ramos-González *et al.*, (2019), conducted a research in a vertical production system with chive, basil and oregano. They used two treatments (organic bocashi and vermicompost fertilizers) and one control (forest soil) which were applied to plant cultures. Results showed that, chives were growing better with vermicompost fertilizer compare with the other treatments. Basil had high production using an organic fertilizer rich in nitrogen and calcium (bocashi), while chive had it using a fertilizer rich in phosphorus (vermicompost).

Studies have shown that compost and vermicompost can improve soil structure and provide essential nutrients to plants. For example, a study by **Li *et al.* (2017)** found that the use of vermicompost as a growing medium significantly increased the growth and yield of garlic chives compared to the use of peat moss. The authors attributed the improved growth to the increased availability of nutrients, improved soil structure, and increased water-holding capacity of the vermicompost.

Similarly, a study by **Li and Chen (2019)** found that the use of compost as a growing medium improved the growth and yield of garlic chives compared to the use of peat moss. The authors attributed the improved growth to the increased availability of nutrients and improved soil structure provided by the compost.

In contrast, the use of peat moss as a growing medium has been shown to be acidic and may require adjustments to pH to ensure optimal growth of garlic chives. A study by **Shah and Uddin (2017)** found that the addition of lime to peat moss improved the growth and yield of garlic chives, but that the use of peat moss alone resulted in poor growth.

Coir, a byproduct of the coconut industry, has also been evaluated as a growing medium for garlic chives. A study by **Islam and Hossain (2018)** found that the use of coir as a growing medium improved root development and water-holding capacity, leading to improved growth and yield of garlic chives compared to the use of peat moss.

Xiangwei *et al.,* (2019) published a research work in Journal of Hazardous Materials. They conducted a pot experiment was carried out to study thiamethoxam (THI) dissipation and metabolite clothianidin (CLO) production in soil amended with wood-derived biochar produced at 450 °C (BC450), as well as THI and CLO uptake by Chinese chives. The soil samples amended with BC450 at 0 % and 1.5 % (w/w) were named as treatments CK and BC450, respectively. The air-dried soil samples and biochar samples were thoroughly homogenized by hand and passed through a 2-mm sieve to ensure homogeneity for subsequent experiments. Each plastic pot of 5 cm in diameter by 10 cm in height was packed with 0.5 kg of soil or a mixture of BC450 and soil. Then, 30 mL of 100 mg/L THI solution was added to the soil to reach a concentration of 6 mg/kg. Eight Chinese chive seedlings (∼15 cm in height) were transplanted into the pot and deionized water was added to reach 60 % of the maximum water holding capacity (WHC). All of the pots were randomly placed in a greenhouse for 42 days (14 h light at 25 ± 2 °C) with the positions of pots frequently randomized during the growth period. In total, 21 pots for each treatment were set up and at days 3, 5, 7, 14, 21, 35, and 42, three replicated pots from each treatment were destroyed to collect the soil and plant samples for pesticide residue analysis. BC450 addition decreased THI uptake and its metabolite clothianidin (CLO) by 22.8 % and 37.6 %, respectively. However, the half-life of THI in soil rose from 89.4–120 days, indicating that BC450 increased soil THI's persistence. The decreased bioavailability and increased persistence of THI resulted mainly from the higher sorption capacity of BC450 to THI and CLO, which, in turn, enhanced the soil sorption capacity. Consequently, the application of BC450 increased the soil microbial diversity and altered the structure of the microbial community. Although the abundance of *Actinobacteria* associated with the biodegradation of THI, increased the persistence of THI in the BC450-amended soil, mainly due to the decrease in bioavailable THI.

2.2 Effect of different organic growing media on Chives in vertical farming:

Vertical farming is an innovative approach to agriculture that involves growing crops in stacked layers in a controlled environment. The use of organic growing media in vertical farming is becoming increasingly popular as a way to reduce the environmental impact of synthetic growing media and improve soil health.

Studies have shown that the use of organic growing media, such as compost and vermicompost, in vertical farming can improve the growth and yield of garlic chives (*Allium tuberosum*). For example, a study by **Yang *et al.*, (2021)** found that the use of vermicompost as a growing medium in a vertical farm significantly increased the growth and yield of garlic chives compared to the use of peat moss. The authors attributed the improved growth to the increased availability of nutrients and improved soil structure provided by the vermicompost.

Similarly, a study by **Kim *et al.*, (2020)** found that the use of compost as a growing medium in a vertical farm improved the growth and yield of garlic chives compared to the use of peat moss. The authors attributed the improved growth to the increased availability of nutrients and improved soil structure provided by the compost.

Coir, a byproduct of the coconut industry, has also been evaluated as a growing medium for garlic chives in vertical farming. A study by **Kim and Lee (2022)** found that the use of coir as a growing medium in a vertical farm improved root development and water-holding capacity, leading to improved growth and yield of garlic chives compared to the use of peat moss.

2.3 Effect of growing media on different crops

A study was conducted by **Rinita *et al*., (2021)** on lettuce. they use two letuce cultivars (V1: Green wave and V2: New red fire) and and three organic growing media (P1: 40% soil + 40% vermicompost + 20% coir; P2: 50% soil + 50% vermicompost; P3: 20% soil + 40% vermicompost + 40% spent mushroom compost) along with control (P0:100% soil) as treatments. The results revealed that plant height, leaf area, fresh weight, dry weight, and total yield of leaf lettuce were significantly increased when the green-leafed cultivar (VI) was grown in the P1 compared to all other treatments, but V2 got maximum sensory attribute scores when grown in the P1. Lettuce leaves grown in the formulated growing media (P1, P2, and P3) had higher microbial infestation whereas, a lower content occurred in the P0. The higher economic return was observed in V1P1.

Abdani (2020) was conducted at Mindanao State University-Main Campus, Marawi City. Results of the study showed that T2 (Recommended Rate (RR) Inorganic Fertilizer) plants are the tallest while T1 (Control) plants are the shortest with a mean height of 14.56 and 8.66 cm, respectively. T2 plants also have the highest mean growth rate of 3.015 mm/day, and T7 (50% RR Organic Fertilizer + 50% RR Foliar Fertilizer) as the shortest with a mean growth rate of 1.237 mm/day. Further, T5 (50% RR Inorganic Fertilizer + 50% RR Organic Fertilizer) plants show the highest mean number of leaves of 10.197, and T1 plants are the least with a mean number of leaves of 6.867. Yield was also highest in T2 and lowest in T1 with a mean weight of 225.863 g and 50.853 g, respectively. Moreover, the results of the study are recommended to the Philippines' Department of Agriculture (DA) and Local Government Units (LGUs) to guide the farmers and consider adopting the recommendations of this study.

Cig (2019) the objective of this study was to investigate the effects of different growing media on plant growth and nutrient contents of petunia (*Petunia hybrida*). The experiment was conducted in a chamber room under controlled conditions at the laboratory. Seven different media (soil, 3:1 soil: peat (P1), 2:1 soil: peat (P2), 3:1 soil: barnyard manure (BYM1), 2:1 soil: barnyard manure (BYM2), 3:1 soil: sugar beet pulp (SBP1), 2:1 soil: sugar beet pulp (SBP2) was used as plant growing media. The experiment was ended after three months following transplanting of seedlings. Plant growth and flower parameters and macro-micro nutrient contents were determined in harvested plants. The highest stem diameter, branch number, flower diameter, flower stalk diameter, plant fresh weight and plant dry weight were in 2:1 ratio of soil: peat mixture as 7.00 mm, 6.33, 8.91 cm, 3.59 mm, 48.47 g and 4.52 g while the highest plant length, lateral branch number and flower number means were found as 27.43 cm, 24.67 and 24.67 in ratio of 3:1 soil: peat growing media respectively. The highest potassium, magnesium and zinc means of plants were obtained as 6.6%, 2.2% and 32.50 mg kg-1 in soil: barnyard manure (2:1) growing media while the highest phosphorus and calcium means of plants were found as 0.27% and 4.5% in soil and peat growing media respectively. The highest iron and copper means of plants were determined as 231 mg kg-1 and 32.50 mg kg-1 in ratios of 2:1 and 3:1 of soil: sugarbeet pulp growing media respectively.

Aslanpour *et al.*, (2019) an experiment was performed to investigate the factors affecting the growth and flowering in this plant. The first experiment investigates three growing media (peat, cocopeat: perlite and peat moss: perlite). All experiments were performed as a factorial experiment in a completely randomized factorial design with five replications. Most of the measured traits were significantly affected by the treatments of these three experiments. The use of peat moss: perlite growing medium with equal ratio along with the application of phosphate fertilizer provided the best yield.

Another experiment was carried out in a net-house to assess the impacts on plant growth of different biochar types in comparison with their biomass sources, Khan *et al.* (2018) reported a better growth of the kalmi plant (*Ipomea aquatica*) under cow dung biomass treatment than cow dung biochar. Under the other treatments with two biochar types, respectively, from poultry manure and sludge, plant growth was lower than the non-treated control. Three different types of biomasses and biochar's viz., cow dung, poultry manure and sewage sludge produced were used for the study. The biomass or biochar was applied to the soil at a rate of 5 t/ha and the pots were arranged following completely randomized design. A number of physical, chemical and physio-chemical properties of the soil, biochar, biomass and plant samples were analyzed in the laboratory. Biochar treated soils showed higher CEC than the corresponding biomass treated ones. Organic carbon in biochar treated soils was also higher. Total nitrogen contents of biomass treatments were higher than biochar treatments. Phosphorus, potassium and Sulphur concentrations of the treated soils increased after harvesting. The paper analyzed plant growth and agricultural crop production facing biochar application, indicating that the materials might not exert similar positive effects as their biomass sources.

Sardoei and Shahdadneghad (2015) the study was conducted to evaluate the effect of different growing media on the growth and flowering of *Zinnia elegans*. Seven different growth media including coconut compost, silt, soil loam, leaf manure, (leaf manure+silt; 2:1), (coconut compost+soil loam; 1:1) and (leaf manure+soil loam+silt; 1:1:1) were used for growing Zinnia. The experiment was laid out in Complete Randomized Design (CRD) giving equal importance to treatments. Number of flowers, length of lateral branches, number of lateral branches, stem diameter, plant height (cm), diameter of flower, vase life (day) and fresh and dry root, shoot and total were determined. The present study confirms the fact that selection of the appropriate medium of growth for potted flowering plants in this case *Zinnia elegans* was very important from aesthetic and marketing point of view. The medium must ensure the production of plants of the required quality on cost effective basis. In the present study, leaf manure produced significantly the maximum vase life and diameter of flower while the maximum vase life and diameter of flower was obtained with mix (coconut compost+soil loam; 1:1). Ghehsareh (2015) the experiment was conducted as factorial in a completely randomized block design with 9 treatments and 3 replications. Treatments included three sizes (S1 = <0.5, S2 = 0.5–1, and S3 = 1–2 cm) and three composting times (C1 = 0, C2 = 3, and C3 = 6 months) of date palm waste. Statistical analysis showed that the values of bulk density (BD) and water holding capacity (WHC) were significantly increased at the end of cultivation from culture media without plant in comparison to before and after planting ($p < 0.05$). Amounts of F t (total porosity) in culture media without plant were significantly higher than those in culture media before planting and with plant ($p < 0.05$). Also, during the experiment, an apparent shift in physical properties was recorded. The overall results of this research indicated that composting process changed the physical properties of the media before planting. Also, during the experiment, an apparent shift in physical properties was recorded. The results of the study showed that composting processes continued in culture media with and without plant, in the meantime, the composting processes were higher in culture media without plant.

Waseem *et al.*, (2013) a pot experiment was conducted to investigate the effect of different growing media on the growth and development of stock (*Matthiola incana*). Seven different growing media including soil (100%), leaf mold (100%), coconut husk (100%), soil + leaf mold (50:50), soil + coconut husk (50:50), leaf mold + coconut husk (50:50) and soil + leaf mold + coconut husk (33:33:33) were used to check the growth of Stock plants in pots. Data was recorded for different parameters including days to flower initiation, days to flowering, plant height (cm), leaves per plant, branches per plant, flowering clusters per plant, flowers per cluster, flowers per plant and flower persistence life (days), during this course of study. The overall performance of Stock was better in media having leaf mold as it took least days to flower initiation (75.83), maximum plant height (21.43 cm), flowering clusters per plant (4.11), number of flowers per cluster (8.45 days), flowers per plant (34.66). For better growth and flowering of Stock plant, leaf mold can be used as growing media in pots.

Riaz *et al.*, (2008) the study was conducted to evaluate the effect of different growing media on the growth and flowering of *Zinnia elegans* cv. Blue Point. Five different growth media including coconut compost, silt, soil, leaf manure, leaf manure mix (silt + leaf manure + coconut compost; 1:1:1) were used for growing zinnia. The experiment was laid out in Complete Randomized Design giving equal importance to treatments. Number of flowers, blooming period, number of lateral branches per plant, number of leaves per plant, plant height (cm), leaf area(cm2), days to first flower emergence, size of flower and flower quality were determined. The properties of each medium, including water holding capacity (saturation percentage), pH, total nitrogen, available phosphorus and available potassium were also determined. Plant height (cm), number of leaves per plant, number of side branches, days to first flower emergence and number of flowers were affected significantly when plants were grown in leaf manure mix. It is therefore opined that the utilization of coconut compost, silt and leaf manure is a good source of NPK. Therefore, utilization of growing media in combinations proves more effective for the good growth and flowering of zinnia.

Gül *et al.*, (2007) the research was carried out between the dates of October 30, 2002 and January 27, 2003. The objective was to compare the effects of clinoptilolite, which is a kind of zeolite, and perlite on growth and nutrient status of lettuce plants. Plant material was *Lactuca sativa* var. capitata cv. Brogan. Five different growing media; (1) perlite, (2) 3:1 perlite + zeolite, (3) 1:1 perlite + zeolite, (4) 1:3 perlite + zeolite and (5) zeolite was tested. Results showed that zeolite gave rise to increased plant growth and to reduced nitrate and nitrite contents in plant tissues. Mixing zeolite into the growing medium resulted in increased K, Fe, Cu and Mn, and decreased Mg content of the plants.

2.4 Productivity of vertical gardens

Rinita *et al.*, (2021) were driven a study to evaluate the agronomic properties and economic viability of lettuce grown vertically in the wall of building in Dhaka city, Bangladesh. They used two lettuce cultivars (V1: Green wave and V2: New red fire) and three organic growing media (P1: 40% soil + 40% vermicompost + 20% coir; P2: 50% soil + 50% vermicompost; P3: 20% soil + 40% vermicompost + 40% spent mushroom compost) along with control (P0:100% soil) as treatments. The results expressed that plant height, leaf area, fresh weight, dry weight, and total yield of leaf lettuce were significantly increased when the green-leafed cultivar (VI) was grown in the P1 compared to all other treatments, but V2 got maximum sensory attribute scores when grown in the P1. Lettuce leaves grown in the formulated growing media (P1, P2, and P3) had higher microbial infestation whereas, a lower content occurred in the P0. The higher economic return was observed in V1P1. These studies demonstrated the agronomic and economic potential for vertical farming in densely populated areas but emphasize the need for optimized food safety strategies.

Research was conducted in a vertical production system by **Ramos-González *et al.*, (2019).** They analysed the establishment of purple basil (*Ocimum basilicum* var. *purpurascens* L. Benth.), oregano (*Origanum vulgare* L.) and chive (*Allium schoenoprasum* L.), in a vertical production system, using vermicompost, bocashi as organic fertilizers and forest soil. For this, three walls were installed, each with a different substrate and with five individual plants per species. Results showed that, the basil was functional in the vertical production system, where the highest productivity was obtained using bocashi fertilizer; likewise, chives were fitted for the vertical production system, growing better with vermicompost fertilizer than with the other treatments. Oregano was not fitted for the proposed vertical system because its root needs more soil volume, so oregano culture is not recommended for this production model.

Nwosisi *et al.*, (2017) conducted a study on cultivar trials in organic vertical system on the certified organic farm of the Tennessee State University, Nashville. Several cultivars of lettuce, chard, kale, mustard-green, basil and coriander were grown in the vertical-grow system and were harvested successfully. Automated system called 'Drip Organics' provided organic nutrients to the plants. Perlite and coco fiber media were used in the stacked pots. It was concluded that although modern organic farming would remain a widely used food production method as evidenced by its global acceptance and steady growth, organic vertical farming would have a potential to provide food security, year-round produce and ease transportation of food within urban and semi urban areas.

Al-Chalabi (2015) prepared a paper with the purpose to examine the feasibility and plausibility of the vertical farming concept from a socio technical, mixed methods, research perspective. It included (1) examining energy requirement to power such a building and probability of renewable energy to meet the onsite demands of the building by constructing an energy model, (2) quantifying the carbon footprint of vertically grown produce and subsequently comparing that to conventionally grown produce, and (3) conducting interviews to explore how relevant stakeholders perceive the concept of vertical farming in order to identify the barriers and opportunities towards possible uptake of the technology. The findings indicated that vertical farming could be used as a tool to supply food to cities in a sustainable manner depending on the location and design.

Banerjee and Adenaeuer (2013) carried out a study to construct a Vertical Farm and thereof investigate the economic feasibility of it. In a concurrent Engineering Study initiated by DLR Bremen, a farm, 37 floors high, was designed and simulated in Berlin to estimate the cost of production and market potential of this technology. It yielded about 3,500 tons of fruits and vegetables and 140 tons of tilapia fillets, 516 times more than expected from a footprint area of 0.25 ha due to stacking and multiple harvests. The investment costs added up to € 200 million, and it required 80 million liters of water and 3.5 GWh of power per year. The produced food ranged between € 3.50 and

€ 4.00 per kilogram. In view of its feasibility, they estimated a market for about 50 farms in the short term and almost 3000 farms in the long term.

Utami and Jayadi (2012) were conducted another research at the Centre for Land Resources, Gadjah Mada University, Yogyakarta, Indonesia**.** Several of raised beds (shelf, a place holder) or growing beds were made with 6 levels of 6×4 m2 and 4 levels of 4×1.72 m^2. Nutrients were supplied by organic matter (manure and compost), while water was supplied as treated wastewater. Then several vegetables (Chinese cabbage, lettuce, water spinach, chili red) and fruits (lemon, guava, mango, passion fruit) were planted. The results showed that vertical gardening was best suited for plants that required maximum sunlight such as fruit and also several vegetables. Plants grown in a vertical garden were less accessible to diseases and pests, and crop harvesting and cultivation was easier. Vertical gardening provided adequate aeration to the plants and also increased the beauty of the garden. Overall, the yield of vertical gardening was higher than traditional plantation methods.

CHAPTER III

MATERIALS AND METHODS

Chapter III

MATERIALS AND METHODS

This chapter includes a brief description of different materials and methodologies followed during the experiment.

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from January to March 2022.

3.1.2 Climatic condition

The monthly average temperature, humidity and rainfall during the crop growing period were collected from "Bangladesh Meteorological Department (Climate and weather division), Agargaon, Dhaka-1207" and presented in Appendix IV. During this period the maximum highest temperature (31.7°C) and the minimum lowest (13.4°C) was recorded in March and February 2022, respectively.

3.1.3 Experimental location

The experiment was conducted on rooftop of Dr. MA Wazed Miah Research Centre building at the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. It is located at 90°22′ E longitude and 23°41′ N latitude at an altitude of 8.2 meters above the sea level.

3.2 Experimental details

3.2.1. Treatments

The experiment comprised of eight mixtures of growth media

G_0 = Control (100% Soil),

G_1 = Soil + Vermicompost (50:50)

G_2 = soil+ vermicompost + cowdung (50:25:25),

G_3 = Soil+ Cowdung (50:50),

G_4 = Soil+ Cowdung (75:25),

G_5 = Soil+ Cowdung+ Kitchen compost (50:25:25),

G_6= Soil + Kitchen compost + Cocopeat (50:25:25),

G_7= Soil + Vermicompost + Biochar (50:25:25),

G_8= Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

So, here 8 treatments including control were used in this experiment.

3.2.2. Design and layout of the experiment

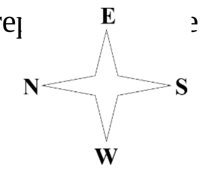
The experiment was laid out in a randomized complete block design (RCBD) having twenty-seven experimental units (9 treatments with 3 replications). The experiment was carried out in three triangular shape vertical structures **(Figure 1 & 2)**. Each structure was made of iron and it was divided into nine blocks which were considered as treatments and each structure was treated as replication.

3.2.3. Vertical growth device

The growing device is made of 4 inches (0.1016 m) diameter PVC Pipe. The length of individual growing device was 31 inches (0.7874 m). Plants were established in rectangle open space of PVC pipe's outer surface. Both ends of each piece were covered with pipe-end caps. This type of 12 devices were organized on a triangular structure made with iron. The length and width of triangular structure were 72 inches (1.83 m) and 36 inches (0.91 m) and height was 48 inches (1.21 m). The distance from device to device was 3.5 inches (0.09 m). Out of 12 devices 9 were used for 9 treatments and

Figure 1. Growth device, structure of vertical garden and a part of the experimental set up.

other three were unused and this one structure set was used as one rep e replication gap was 10 inches (0.254 m).



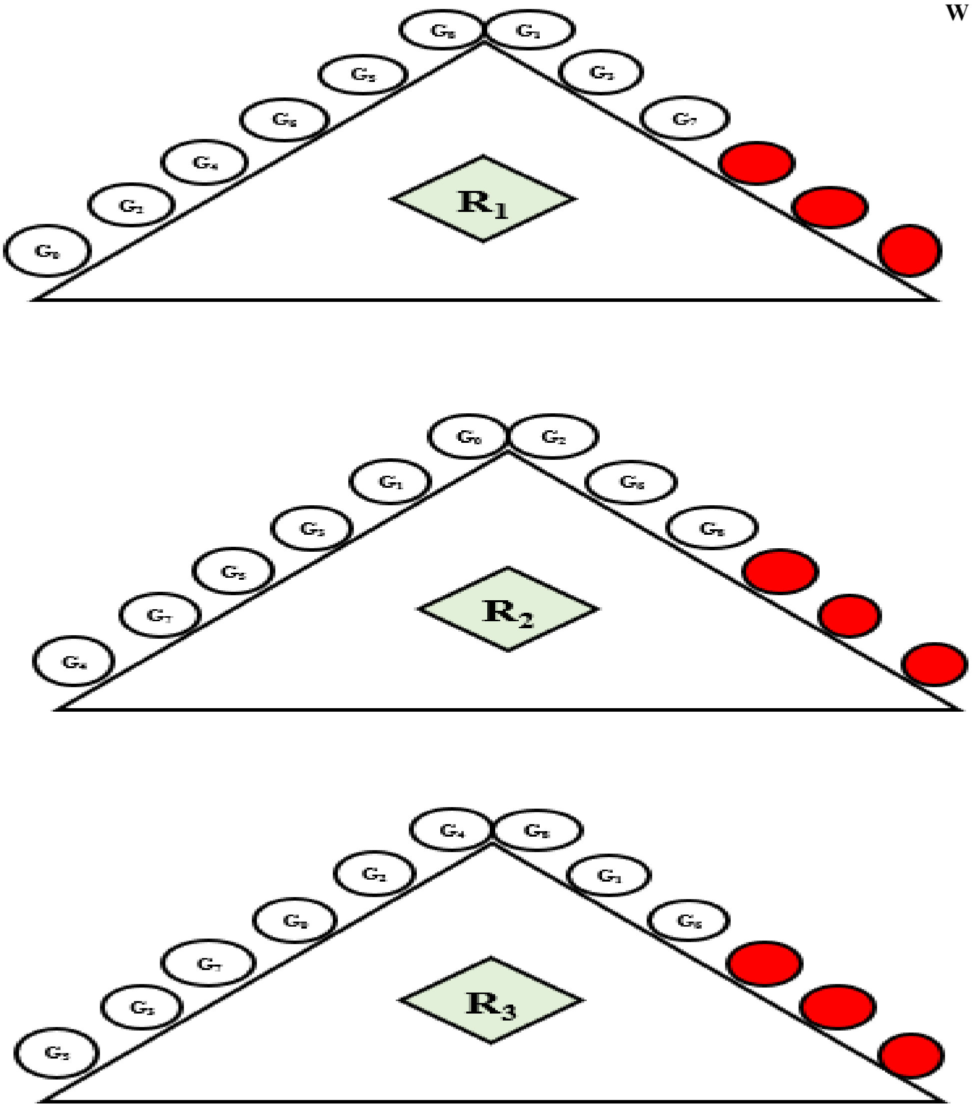


Figure 2: Schematic Layout of Experimental Set-up

Here, the area occupied by structure: 1.83 m × 0.91 m = 1.67 m^2

Number of structures: 3 considered as replications

Number of devices used: 27 PVC pipes, all were considered as treatments and red marked circles were not used in experiment.

Device size: 0.1016 m × 0.7874 m = 0.08 m^2

G_0 = Control (100% Soil),

G_1 = Soil + Vermicompost (50:50)

G_2 = soil+ vermicompost + cowdung (50:25:25),

G_3 = Soil+ Cowdung (50:50),

G_4 = Soil+ Cowdung (75:25),

G_5 = Soil+ Cowdung+ Kitchen compost (50:25:25),

G_6= Soil + Kitchen compost + Cocopeat (50:25:25),

G_7= Soil + Vermicompost + Biochar (50:25:25),

G_8= Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

R_1: Replication 1, R_2: Replication 2 and R_3: Replication 3

3.3 Cultivation of crop

3.3.1. Collection of planting materials

Suckers of BARI Chive-1 were collected from Spices Research Sub-Centre, BARI, Faridpur.

3.3.2. Collection of organic manure

Cowdung, vermicompost, kitchen compost, soil, cocopeat and field used biochar was derived from pyrolysis of wood, wood chips and sawdust were collected from horticulture farm (FABLAB SAU).

3.3.3. Growing media preparation

Nine different growing media were used in this experiment which were made off with different organic manure. They are Cowdung, vermicompost, kitchen compost, soil, cocopeat and field used biochar. Mixtures of this media in different ratio were used as treatments. The first treatment (G_0) contained only regular nursery soil. While the second media comprised of soil and vermicompost (50:50). The third media was made of soil, vermicompost and cowdung (50:25:25). Fourth was filled with soil and cowdung (50:50). Fifth treatment contained soil and cowdung mixture (75:25). Sixth growing device hold soil, cowdung and kitchen compost mixture (50:25:25). Seventh no device comprised of soil, kitchen compost and cocopeat (50:25:25). Soil, vermicompost and biochar mixture (50:25:25) was filled in eighth no growing device. Last growing device was filled with soil, vermicompost, biochar and kitchen compost mixture (50:30:10:10).

3.3.4. Nutrient content of cowdung, vermicompost, cocopeat, biochar, kitchen compost and soil

Here are some typical ranges for the percentage of nitrogen (N), phosphorus (P), and potassium (K) in of cowdung, vermicompost, cocopeat, biochar, kitchen compost and soil.

Table 1. N, P and K Composition of cowdung, vermicompost, cocopeat, biochar, kitchen compost and soil

Media	Nutrients			Sources
	N (%)	P (%)	K (%)	
Cowdung	1.0 - 3.0	0.5 - 1.0	1.0 - 2.0	Singh and Sharma (2012)
Vermicompost	2.0 – 3.0	1.85-2.25	1.55-2.25	Sinha *et al.,* (2009)
Cocopeat	0.2 - 2	0.1 - 0.5	0.2 - 2.5	Ramesh *et al.,* (2016)
Biochar	0.5 - 3	0.1 - 1	0.5- 10	J. Lehmann and S. Joseph (2015)
Kitchen compost	1.4 - 2.4	0.5 - 0.9	0.8 - 1.1	Bustamante *et al.,* (2008) Islam *et al.,* (2009)
Soil	0.1 - 0.5	0.01 - 0.1	0.1 - 0.5	Islam *et al.,* (2016)

3.3.5. Preparation of control media

The control media was prepared from light textured local sandy-loam soil. The soil was rich in nutrients and dark in color due to presence of higher organic matter. The pH of the soil was 6.5. Loose friable soil was poured in three growing devices, leaving the top most 5 cm of each device empty for irrigation and facilitation of other intercultural operation. The individual device weighted about 5.5 kg.

3.3.6. Preparation of vermicompost + soil (50:50)

This vermicompost and soil media was prepared by thoroughly mixing 6 kg and 6 kg of the respective components at 50:50 ratio (weight basis). It was rich in nutrients and dark in color due to presence of vermicompost. This media had alkaline pH (7.5) with good drainage property. This media was poured in three growing devices excluding the top most 5 cm of every device empty for irrigation and intercultural operations. The final weight of each device was 4.5 kg.

3.3.7. Preparation of soil+ vermicompost + cowdung (50:25:25)

This media was prepared by thoroughly mixing 6kg soil, 3kg vermicompost and 3kg cowdung at 50:25:25 ratio (weight basis). This media was rich in nutrients and dark in color due to presence of vermicompost and cowdung. This media had alkaline pH (7.5) with good drainage property. This media was poured in three growing device, leaving the top most 5cm of each device empty for irrigation and facilitation of other intercultural operation. The individual device weighted about 4.5 kg.

3.3.8. Preparation of soil + cowdung (50:50)

This media was prepared by thoroughly mixing 6kg soil and 6kg cowdung at 50:50 ratio (weight basis). This media was rich in nutrients and dark in color due to presence of vermicompost and cowdung. This media had pH 7.0 with good drainage property. This media was poured in three growing device, leaving the top most 5cm of each device empty for irrigation and facilitation of other intercultural operation. The individual device weighted about 4.5 kg.

3.3.9. Preparation of soil + cowdung (75:25)

This media was prepared by thoroughly mixing 9kg soil and 3kg cowdung at 75:25 ratio (weight basis). This media was rich in nutrients and dark in color due to presence of cowdung. This media had pH 7.0 with good drainage property. This media was poured in three growing device, leaving the top most 5cm of each device empty for irrigation and facilitation of other intercultural operation. The individual device weighted about 4.5 kg.

3.3.10. Preparation of soil+ cowdung + kitchen compost (50:25:25)

This media was prepared by thoroughly mixing 6kg soil, 3kg cowdung and 3kg kitchen compost at 50:25:25 ratio (weight basis). This media was rich in nutrients and dark in color due to presence of kitchen compost and cowdung. This media had pH 6.5 with good drainage property. This media was poured in three growing device, leaving the top most 5cm of each device empty for irrigation and facilitation of other intercultural operation. The individual device weighted about 4.5 kg.

3.3.11. Preparation of soil + kitchen compost + cocopeat (50:25:25)

This media was prepared by thoroughly mixing 6kg soil, 3kg kitchen compost and 3kg cocopeat at 50:25:25 ratio (weight basis). This media was rich in nutrients and dark in color due to presence of kitchen compost and cowdung. This media had slightly acidic pH (6.0) with good drainage property and lighter in color due to presence of cocopeat. This media was poured in three growing device, leaving the top most 5cm of each device empty for irrigation and facilitation of other intercultural operation. The individual device weighted about 4.5 kg.

3.3.12. Preparation of soil + vermicompost+ biochar (50:25:25)

This media was prepared by thoroughly mixing 6kg soil, 3kg vermicompost and 3kg biochar at 50:25:25 ratio (weight basis). This media had alkaline pH (8.0) with good drainage property. This media was poured in three growing device, leaving the top most 5cm of each device empty for irrigation and facilitation of other intercultural operation. The individual device weighted about 4.5 kg.

3.3.13. Preparation of soil+ vermicompost+ biochar+ kitchen compost (50:30:10:10)

This media was prepared by thoroughly mixing 6kg soil, 3.6kg vermicompost, 1.2kg biochar and 1.2kg kitchen compost at 50:30:10:10 ratio (weight basis). This media had alkaline pH (8.0) with good drainage property. This media was poured in three growing device, leaving the top most 5cm of each device empty for irrigation and facilitation of other intercultural operation. The individual device weighted about 4.5 kg.

3.3.14. Sucker planting

After cutting one third portion of leaf in every sucker, they were planted in growing device on January 07, 2022. Total 14 suckers were planted in one treatment and where two suckers were placed in one hole. 4inches distance was maintained from one hole to another. After planting, light irrigation was provided for their better establishment.

3.3.15. Gap filling

New vigorous suckers from the stock on extra planting devices were used to replace dead, injured and weak seedlings of the growth devices.

3.3.16. Weeding

The hand weeding was done according to necessity of keeping the devices free from weeds and to avoid crop-weed competition. Total four weeding was carried out.

3.3.17. Irrigation

Irrigation was given when soil was dried.

3.3.18. Pest and disease control

There was no incidence of insects during the experimental duration. However, **s**ome plants were infected by *Alternaria* leaf spot diseases onset of harvesting. The diseased leaves were also removed from the infested plant.

3.4 Harvesting

Chive was harvested at 70 Days after planting. Five plants were randomly harvested from each treatment combination and were used for data observation and recording regarding yield performance. But chive showed perennial nature in Bangladesh. If we had left the roots after harvesting the leaves in the growing media, we could have collected the leaves all year round.

3.5 Data collection

Five plants were randomly selected from each of the treatment. Data on different growth parameter, such as- plant height, leaf length and number of leaves/plant were collected at 30, 45, 60 and 70 days after transplanting (DAT). Yield parameters were recorded at harvest which included fresh weight, dry weight and yield per device. Total yield was calculated from yield per device. Dry weights of individual plant were recorded after harvest.

3.5.1 Plant height

The distance between the tips of the highest leaf from ground was considered as plant height and measured with a meter scale from five randomly selected plants at 30, 45, 60 and 70 days after transplanting (DAT). The units were expressed in cm.

3.5.2 Number of leaves per plant

Number of leaves per plant was counted from five randomly selected plants at 30, 45, 60 and 70 days after transplanting (DAT) and their mean was recorded.

3.5.3 Leaf length

The leaf length (distance from tip of the leaf to leaf-stalk base) was measured from randomly selected five plants with meter scale in centimeter at 30, 45, 60 and 70 days after transplanting (DAT).

3.5.4 Fresh weight (g) per plant with root

Plant fresh weight with root was recorded from five randomly selected plants in grams (g) with an electric balance.

3.5.5 Dry weight (g) per plant with root

At first selected plant with roots were collected, then roots, flat stem and leaves are cut separately and sun dried for 72 hours followed by drying in an oven at 70°C for 72 hours. The weight of the oven dried sample was taken and express in gram.

3.5.6 Dry matter (%) of plant with root

Dry Matter (%) is everything in the sample other than water including protein, fiber, fat, minerals, etc. Divided the weight of the dry plant with root by the weight of the fresh plant with root and multiply by 100 to get dry matter percentage of plant with root.

3.5.7 Fresh weight (g) per plant without root

Plant fresh weight without root was recorded from five randomly selected plants in grams (g) with an electric balance.

3.5.8 Dry weight (g) per plant without root

At first selected plant without roots were collected, then flat stem and leaves are cut separately and sun dried for 72 hours followed by drying in an oven at 70°C for 72 hours. The weight of the oven dried sample was taken and express in gram.

3.5.9 Dry matter (%) of plant without root

Divided the weight of the dry plant without root by the weight of the fresh plant without root and multiply by 100 to get dry matter percentage of plant without root.

3.5.10 Fibrous root number per plant

Fibrous roots were collected from five randomly selected plants and count them. Then divided it by five to get average root number per plant.

3.5.11 Fresh weight (g) of flat stem per plant

Flat stems of randomly selected five plants were separated from plants and weighing them with an electric balance, then calculate the average fresh weight (g) of flat stem per plant.

3.5.12 Dry weight (g) of flat stem per plant

At first selected flat stems were collected, then sun dried for 72 hours followed by drying in an oven at 70℃ for 72 hours. The weight of the oven dried sample was taken and express in gram.

3.5.13 Dry matter (%) of flat stem

Divided the weight of the dry flat stem by the weight of the fresh flat stem and multiply by 100 to get dry matter percentage of flat stem.

3.5.14 Fresh weight (g) of leaves per plant

Leaves of randomly selected five plants were separated from plants and weighing them with an electric balance, then calculate the fresh weight (g) of leaves per plant.

3.5.15 Dry weight (g) of leaves per plant

Selected leaves from five plants were collected, then sun dried for 72 hours followed by drying in an oven at 70℃ for 72 hours. The weight of the oven dried sample was taken and express in gram.

3.5.16 Dry matter (%) of leaf

Divided the weight of the dry leaves by the weight of the fresh leaves and multiply by 100 to get dry matter percentage of leaf.

3.5.17 Fresh weight (g) of root per plant

Roots were collected from randomly selected five plants and weighing them with an electric balance, then calculate the fresh weight (g) of roots per plant.

3.5.18 Dry weight (g) of root per plant

Collected roots sun dried for 72 hours followed by drying in an oven at 70℃ for 72 hours. The weight of the oven dried sample was taken and express in gram.

3.5.19 Dry matter (%) of root

Divided the weight of the dry roots by the weight of the fresh roots and multiply by 100 to get dry matter percentage of root.

3.5.20 Yield (g/pipe)

Yield of chive/pipe was recorded as the leaves of whole plant with flat stem at final harvest within a pipe and was expressed in gram.

3.5.21 Yield (t/ha)

First the length and width of the vertical structure were measured with a measuring tape. Then calculated the area in m^2. In this area 12 growing device/pipe were established so the yield per pipe was multiply by 12 to get the unit area yield and then this yield was converted to ton per hector.

3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for different treatments on BARI Chive-1. The mean values of all the recorded characters were evaluated and analysis of variance was performed by statistical package "R". The significance of the difference among the treatment combinations of means was estimated by Least Significant Difference (LSD) value at 5% level of probability and interpretation of the results were determined by Duncan's Multiple Range Test (DMRT) according to Gomez and Gomes, (1984).

CHAPTER IV

RESULTS

AND

DISCUSSIONS

Chapter IV

RESULTS AND DISCUSSIONS

The present experiment was conducted to find out the performance of different organic growing media on growth and yield of chive in vertical garden. BARI Chive -1 was evaluated in this regard. Data were collected on various growth and yield indicator and data were statistically analyzed with statistical software package "R". Appendices VII-XIV contains the analysis of variance (ANOVA) of the data on different growth and yield parameters. Figures, graphs and tables were used to discuss the findings of the study as well as their most probable interpretations were mentioned in this chapter under the following headings.

4.1. Results

4.1.1. Plant height

Plant height was recorded at 30, 45, 60 and 70 days after transplanting (DAT) of BARI Chive-1. Different growing media influenced plant height at different stages and plant height was increased gradually in every treatment. Results are showed in **Figure 3.**

At 30 DAT, the maximum plant height (19.00 cm) was recorded from G_2 (50%Soil + 25% Vermicompost+ 25% cowdung) followed by G_3 (50% soil + 50% cowdung) and lowest (8.85 cm) was found from G_0 (100% soil). And they are statistically different from each other.

At 45 DAT, the highest plant height (19.24 cm) was also found in G_2 (50% Soil + 25% Vermicompost+ 25% cowdung) followed by G_6 (50% soil+ 25% kitchen compost+ 25% cocopeat) but lowest (10.96 cm) was found in G_8 and G_2, G_3 and G_6 treatments were exhibited statistically similar results.

At 60 DAT, G_1, G_2, G_4, G_5 and G_6 were displayed statistically identical results. Highest plant height (19.96 cm) was obtained from G_2. Second highest plant height (19.63 cm) was showed by G_1 followed by G_6 (19.58 cm). Lowest (11.97 cm) was found in G_8.

Plant height at harvesting time (70 DAT) was expressed various results influenced by different growing media of BARI Chive-1. Longest plant (21.43 cm) was observed in G_2 (50% soil + 25% vermicompost + 25% cowdung) treatment followed by G_6 treatment (20.67cm) and shortest chive plant was found in G_8 (50% Soil + 30% Vermicompost + 10%Biochar + 10% Kitchen compost) treatment followed by G_7 (50% Soil + 25% Vermicompost + 25% Biochar) (16.78 cm). **Jaafar *et al.*, (2012)** and **Saha & Chakraborty (2019)** found same result on chive.

Table 2. Effect of different organic growing media on plant height (cm) of BARI Chive-1 at different days after transplanting (DAT).

Treatments	**Plant height (cm)**			
	30 DAT	**45 DAT**	**60 DAT**	**70 DAT**
G_0	8.85 d	12.51 d	16.22 c	19.87 ab
G_1	14.78 bc	17.06 b	19.63 a	20.03 ab
G_2	**19.00 a**	**19.24 a**	**19.96 a**	**21.43 a**
G_3	16.68 b	17.95 ab	18.00 b	18.87 b
G_4	15.70 b	17.24 b	19.00 ab	19.78 ab
G_5	16.24 b	16.85 b	18.89 ab	20.60 ab
G_6	16.53 b	18.21 ab	19.58 a	20.67 ab
G_7	13.57 c	14.67 c	15.68 c	16.78 c
G_8	9.84 d	10.96 d	11.97 d	13.08 d
CV (%)	7.82	5.93	5.31	5.86
LSD (0.05)	1.97	1.65	1.62	1.94

Letters denote differences.

G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

Rekha *et al.*, (2018) reported that, 50% vermicompost amended soil increased shoot and plant length of *C. annum*. Organic fertilizer contains a consortium of macro and micro nutrients which are desired for plant growth. The NPK content of vermicompost-cowdung amended soil was found to be enhanced when compared to the other amended soil. The soil amended with vermicompost provides much nutrients, which are not always available in chemically treated soil **(Ansari and Ismail 2008)**. This increased nutrient uptake by plants may have contributed to maximum growth of plant. Elsewhere **Gravel *et al.*, (2013)** indicated that the mixture of potting soil with biochar had no indicative effect on shoot growth of sweet pepper, geranium, and basil.

4.2 Leaf length

Leaf length of Different days after transplanting (30 DAT, 45 DAT, 60 DAT and 70 DAT) were discussed in this section. The results showed significant difference on leaf length at various DAT influenced by different growing media (Figure 4).

At 30 DAT, the maximum leaf length (11.07 cm) was recorded from G_6 (50% Soil +25% kitchen compost + 25% cocopeat) and lowest (6.84 cm) was found from G_0 (100% soil). But G_1, G_2, G_3, G_4 and G_6 treatments were showed statistically similar results.

At 45 DAT, the highest leaf length (11.85 cm) was also found in G_6 (50% Soil +25% kitchen compost + 25% cocopeat) and lowest (7.30 cm) was found in G_0 (100% soil) followed by G_8 (50% soil + 30% vermicompost + 10% biochar +10% kitchen compost). And G_1, G_2, G_3, G_4 and G_6 treatments were exhibited statistically similar results.

G_1 (50% soil + 50% vermicompost) was displayed highest leaf length (15.15 cm) at 60 DAT followed by G_2 (50% soil + 25% vermicompost +25% cowdung) (14.08 cm). Lowest leaf length (9.54 cm) revealed by G_8 (50% soil + 30% vermicompost + 10% biochar +10% kitchen compost). G_1, G_2 and G_6 treatments were showed statistically identical results.

In this study leaf length of BARI Chive-1 demonstrated statistically same result in G_1, G_2 and G_6 treatments at 70 DAT. Highest leaf length (16.53 cm) at 70 DAT was exhibited by G_1 (50% soil + 50% vermicompost) followed by G_2 and G_6. Lowest leaf length (10.21 cm) was displayed by G_8 (50% soil + 30% vermicompost + 10% biochar +10% kitchen compost). Jaafar *et al.*, (2012) investigated the effect of kitchen waste compost and coco-peat on the growth and yield of organic chives. The results showed that the use of kitchen waste compost and coco-peat significantly increased plant height, leaf number, leaf area, and fresh and dry weight of the chives.

Table 3. Effect of different organic growing media on leaf length of BARI Chive-1 at different days after transplanting (DAT).

Treatments	**Leaf length (cm)**			
	30 DAT	**45 DAT**	**60 DAT**	**70 DAT**
G_0	6.84 b	7.30 d	10.25 de	11.33 cd
G_1	**11.14 a**	11.2 a	**15.15 a**	**16.53 a**
G_2	9.77 a	10.80 ab	14.083 ab	16.22 a
G_3	9.85 a	10.97 a	11.65 cde	11.99 cd
G_4	10.16 a	10.79 ab	10.84 de	11.87cd
G_5	7.89 b	9.80 b	12.21 bcd	13.23 bc
G_6	11.07 a	**11.85 a**	13.57 abc	14.60 ab
G_7	8.1 b	8.58 c	10.61 de	11.65 cd
G_8	7.09 b	7.39 d	9.54 e	10.21 d
CV (%)	9.51	6.22	10.61	9.24
LSD (0.05)	1.49	1.06	2.20	2.09

Letters denote differences.
G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

4.3 Leaf number:

Significant variation due to growth medias on number of leaves per plant was observed at different days after transplanting (Figure 5).

The highest leaf number per plant at 30 DAT was produced by G_4 (3.28) followed by G_3 and G_2. The least number of leaves per plant were recorded for G_8 (1.14).

At 45 DAT, maximum leaf number per plant were recorded in G_6 (5.02) followed by G_4 (4.99) and minimum leaf number per plant were observed in G_8 (2.00). G_1, G_2, G_3, G_4 and G_6 were exhibited statistically similar result.

G_6 treatment also gave highest leaf number per plant at 60DAT (6.27). G_2 showed second highest leaf number per plant (6.07) and G_2, G_3, G_5 and G_6 were reveled statistically similar result. The lowest leaf number per plant was showed by G_8 (3.57).

The most leaf number per plant (6.70) of chive was showed by G_6 when leaf were harvested (at 70 DAT) followed by G_3 (6.36) and G_2, G_3, G_5 and G_6 were statistically similar. And the lowest leaf number per plant was showed by G_8 (3.95).

It is well established that the addition of organic fertilizers increased the organic matter contents of the soil and availability of other plant nutrients (Brar *et al.*, 2004). For this reason, the number of branches plant $^{-1}$ was significantly increased due to the application of different levels of organic media.

Table 4. Effect of different organic growing media on leaf number per plant of BARI Chive-1 at different days after transplanting (DAT).

Treatments	**Leaf number per plant**			
	30 DAT	**45 DAT**	**60 DAT**	**70 DAT**
G_0	1.83 c	3.38 c	5.38 cd	5.45 de
G_1	2.69 b	4.73 ab	6.07 ab	6.24 bc
G_2	2.80 ab	4.47 ab	5.99 ab	6.36 ab
G_3	3.07 ab	4.48 ab	4.86 e	4.93 f
G_4	**3.28 a**	**4.99 a**	5.69 bc	5.83 cd
G_5	2.56 b	4.30 b	5.92 ab	6.31 ab
G_6	2.71 b	5.02 a	**6.27 a**	**6.70 a**
G_7	1.88 c	3.40 c	4.98 de	5.12 ef
G_8	1.14 d	2.00 d	3.57 f	3.95 g
CV (%)	12.51	8.93	4.54	4.65
LSD (0.05)	0.53	0.63	0.43	0.46

Letters denote differences.

G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

4.4 Fresh weight (g) per plant with root:

Significant differences were noticed in this study on fresh weight (g) per plant with root which were influenced by different growing media **(Figure 6).**

Maximum fresh weight (g) per plant with root (5.58g) was found in G_2 treatment and minimum fresh weight (g) per plant with root (1.79 g) was discovered by G_8 treatment. But G_2 and G_6 treatments showed statistically similar result.

4.5 Dry weight (g) per plant with root:

Growing media influenced dry weight (g) per plant with root significantly. **(Figure 6).**

Highest dry weight (g) per plant (0.69 g) with root was revealed by G_2 and G_6, G_2 and G_3 showed the similar result (0.68 g and 0.66g) statistically (Appendix XIV). Other hand lowest dry weight (g) per plant (0.23 g) with root was found in G_8 treatment. **Kundu and Gope (2017)** showed that the use of vermicompost and coco-peat increased fresh and dry weight of the chives. The use of coco-peat and vermicompost also increased the quality of the chives by increasing the content of ascorbic acid and total phenols **(Khan *et al.*, 2017).**

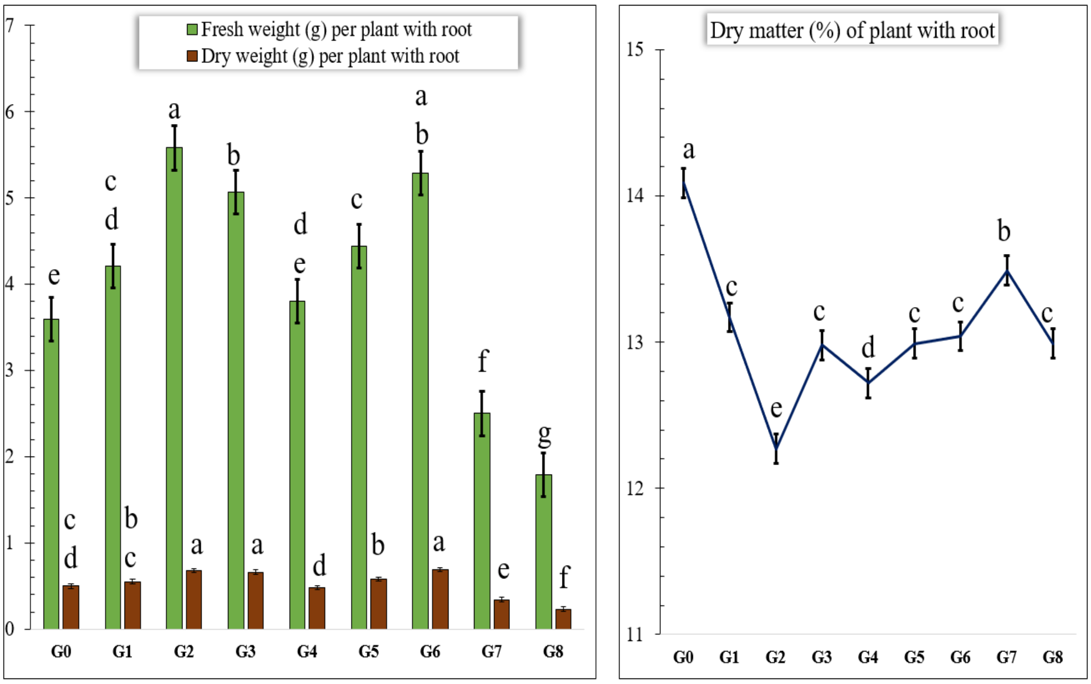


Figure 6. Effect of different organic growing media on fresh weight (g) per plant with root, dry weight (g) per plant with root and dry matter (%) of plant with root of BARI Chive-1. Letters denote differences. Vertical bars indicate standard error of means.

G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

4.6 Dry matter (%) of plant with root:

Highest dry matter (14.09%) content of plant with root was found in G_0 where only soil was used for growing chive. And lowest dry matter (12.27%) of plant with root was found in G_2. All the treatments affected significantly on dry matter content of plant with root. **(Figure 6).**

4.7 Fresh weight (g) per plant without root:

There was distinct difference on fresh weight per plant without root which were influenced by different growing media (Table:2).

Maximum fresh weight per plant without root (5.1g) was found in G_2 treatment and minimum fresh weight per plant without root (1.59 g) was discovered by G_8 treatment. But G_2 and G_6 treatments showed statistically similar result.

Table 2. Effect of different organic growing media on fresh weight (g) per plant without root, dry weight (g) per plant without root and dry matter (%) of plant with root of BARI Chive-1.

Treatments	Fresh weight (g) per plant without root	Dry weight (g) per plant without root	Dry matter (%) of plant without root
G_0	3.18 e	0.39 cd	**12.21 a**
G_1	3.77 cd	0.43 bc	11.44 b
G_2	**5.1 a**	**0.55 a**	10.77 c
G_3	4.61 b	**0.53 a**	11.46 b
G_4	3.39 de	0.37 d	10.87 c
G_5	4.02 c	0.46 b	11.39b
G_6	**4.81 ab**	**0.55 a**	11.49 b
G_7	2.22 f	0.26 e	11.54 b
G_8	1.59 g	0.18 f	11.02 c
CV (%)	6.16	6.18	1.41
LSD (0.05)	0.387	0.044	0.277
Level of significant	**	**	**

Foot note: G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

Letters denote differences at 0.05 level of probability. ** Significant at 1% level of probability

4.8 Dry weight (g) per plant without root:

In this trial growing media influenced dry weight (g) per plant without root significantly. (Table:2)

G_2, G_3 and G_6 were exhibited statistically highest dry weight (g) per plant without root (0.55g, 0.53g and 0.55g). Lowest dry weight (g) per plant without root (0.18 g) was found in G_8 treatment.

Tanimu *et al.*, (2007) confirmed similar result in case of Maize. **El-Dewiny *et al.*, (2006)** showed that dry weight of radish and spinach plants increased with application of sewage sludge.

4.9 Dry matter (%) of plant without root:

100% soil (G_0) exhibited highest dry matter percentage (12.21) followed by G_7 (11.54). Lowest dry matter percentage (10.77) was recorded by G_2 treatment. Different growing media were responded significantly on dry matter content of plant without root. (Table:2).

4.10 Fibrous root number per plant:

The result showed significant difference on fibrous root number influenced by different growing media **(Figure 7).** Highest fibrous root number (9.42) per plant were obtained from G_4 where mixture of 75% soil and 25% cowdung was used as growing media. Lowest fibrous root number (6.88) per plant was observed by G_0 (Appendix XIV).

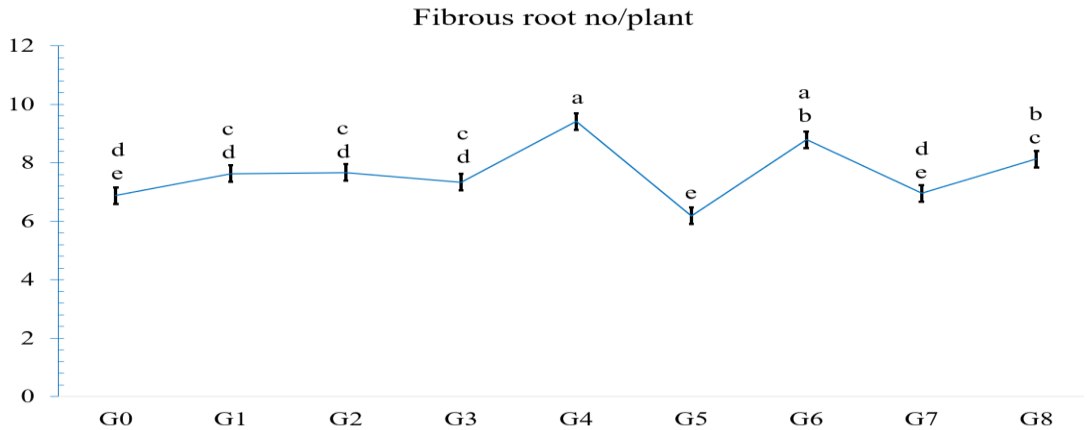


Figure 7. Effect of different organic growing media on fibrous root number per plant of BARI Chive-1.

Letters denote differences. Vertical bars indicate standard error of means.

G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco

(50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

4.11 Fresh weight of flat stem per plant (g):

Flat stem of chive is one of the edible parts. Different growing media were significantly influenced fresh weight of flat stem of chive (Table 3). In this study maximum fresh weight of flat stem per plant (1.28 g) found in G_2 treatment where soil, vermicompost and cowdung mixture was used as growing media. G_2 and G_6 treatment were showed similar result by statistical analysis. Minimum fresh weight of flat stem per plant (0.41 g) was found in G_8 treatment.

Table 3. Effect of different organic growing media on fresh weight (g) of flat stem per plant, dry weight (g) of flat stem per plant and dry matter (%) of flat stem per plant of BARI Chive-1.

Treatments	**Fresh weight of flat stem per plant (g)**	**Dry weight of flat stem per plant (g)**	**Dry matter (%) of flat stem**
G_0	0.81 e	0.14 c	**17.68 a**
G_1	0.95 cd	0.16 bc	16.46 bc
G_2	**1.28 a**	**0.21 a**	16.22 c
G_3	1.17 b	**0.19 a**	16.50 bc
G_4	0.86 de	0.13 c	16.24 c
G_5	1.02 c	0.17 b	16.32 bc
G_6	**1.20 ab**	**0.20 a**	16.66 b
G_7	0.57 f	0.09 d	16.69 b
G_8	0.41 g	0.07 e	16.54 bc
CV (%)	6.115	6.565	1.38
LSD (0.05)	0.097	0.0172	0.396
Level of significant	**	**	**

Foot note: G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

Letters denote differences at 0.05 level of probability.

** Significant at 1% level of probability

4.12 Dry weight of flat stem per plant (g):

Dry weight of flat stem per plant (g) remained highest in G_2, G_3 and G_6 statistically (0.21 g, 0.19g and 0.20 g). And the lowest dry weight of flat stem per plant (g) was exhibited in G_8 treatment (0.07 g) (Table 3).

4.13 Dry matter (%) of flat stem:

Different organic matter responded significantly on dry matter of flat stem but only soil based growing media had high dry matter percentage. The results showed that G_0 treatment had high dry matter percentage (17.68) and G_2 treatment had low dry matter percentage (16.22) (Table 3).

4.14 Fresh weight of leaves per plant (g):

Leaves are another edible part of chive. Fresh weight of leaves per plant (g) significantly varied by different organic growing media. Highest fresh weight of leaves per plant (3.82 g) was observed in G_2 treatment where 25% vermicompost and 25% cowdung were added with 50% soil. Lowest fresh weight of leaves per plant (1.18 g) was found in G_8 **(Figure 8)** (Appendix XIV)**.** The fresh weight of leaves varied with levels and types of organic amendment irrespective of soils used. Similar result was reported by **Uka *et al.* (2013)** for the fresh weight of okra.

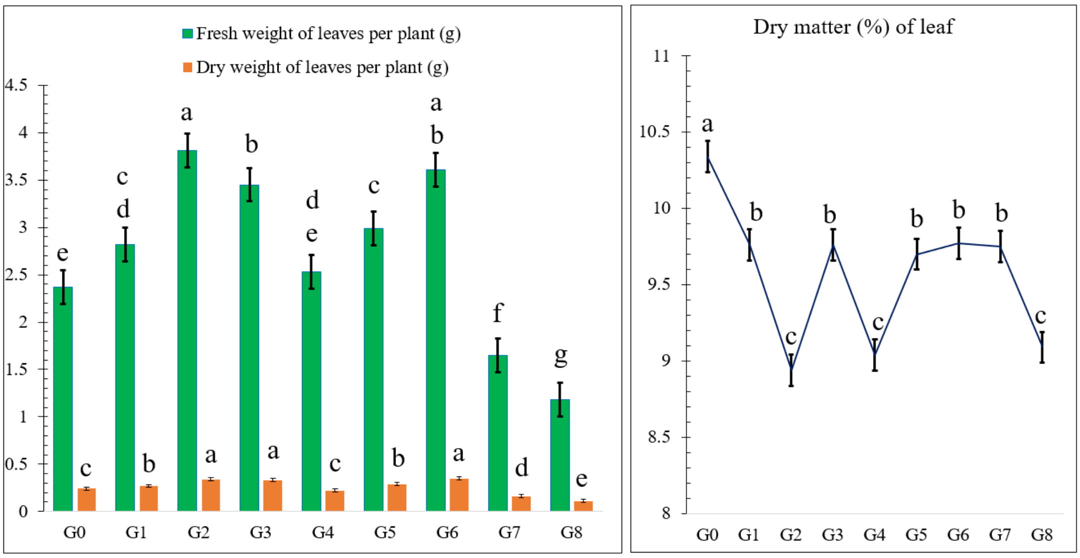


Figure 8. Effect of different organic growing media on fresh weight (g) of leaves per plant, dry weight (g) of leaves per plant and dry matter (%) of leaf of BARI Chive-1. Letters denote differences. Vertical bars indicate standard error of means.

G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco

(50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

4.15 Dry weight of leaves per plant (g):

G_2, G_3 and G_6 were showed statistically similar dry weight of leaves per plant (0.34 g, 0.33 g and 0.35 g) and they were mentioned as highest. Lowest dry weight of leaves per plant (0.11 g) was showed by G_8 **(Figure 8).**

4.16 Dry matter (%) of leaf:

Organic media may increase water content of leaf and thus dry matter percentage decreased in organic matter treated media in this study and they react significantly on dry matter percentage of leaf. Highest dry matter of leaf (10.34%) was observed by G_0 and lowest (9.04%) was observed by G_4 **(Figure 8)** (Appendix XIV)**.**

4.17 Fresh weight of root per plant (g):

Fresh root weight was significantly affected by different organic growing media. Maximum root weight per plant (0.49 g) was observed by G_2 treatment and lowest (0.20 g) was found in G_8 (Table 4).

Table 4. Effect of different organic growing media on fresh weight (g) of root per plant, dry weight (g) of root per plant and dry matter (%) of root per plant of BARI Chive-1.

Treatments	**Fresh weight of root per plant (g)**	**Dry weight of root per plant (g)**	**Dry matter (%) of root**
G_0	0.40 d	0.12 d	28.92 a
G_1	0.44 bcd	0.12 bcd	27.86 d
G_2	0.49 a	0.13 ab	27.53 e
G_3	0.46 abc	0.13 abc	28.37 bc
G_4	0.41 d	0.11 d	28.14 cd
G_5	0.42 cd	0.12 cd	28.32 c
G_6	0.48 ab	0.14 a	28.65 ab
G_7	0.28 e	0.08 e	28.82 a
G_8	0.20 f	0.06 f	28.34 bc
CV (%)	6.22	6.27	0.67
LSD (0.05)	0.042	0.012	0.32
Level of significant	**	**	**

Foot note: G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

Letters denote differences at 0.05 level of probability.
** Significant at 1% level of probability

4.18 Dry weight of root per plant (g):

G_2, G_3 and G_6 were exhibited similarly highest dry weigh of root per plant (g) by statistical analysis (0.13 g, 0.13 g and 0.14 g). Lowest dry weight of root per plant (g) was showed by G_8 (Table 4).

4.19 Dry matter (%) of root:

G_0, G_6 and G_7 treatments are showed statistically similar highest dry matter percentage of root (28.92, 28.65 and 28.82). Lowest dry matter content of root showed by G_2 (27.53%) (Table 4).

4.20 Yield (g) per pipe:

Every treatment is set in a vertically established pipe (0.79 m × 0.10 m) and all nine treatments are replicated 3 times in this study. Here, all the treatments were affected significantly on the yield (g) per pipe. Maximum yield per pipe (71g) was found in G_2 treatment and minimum (22g) was found in G_8 treatment. (Figure 9)

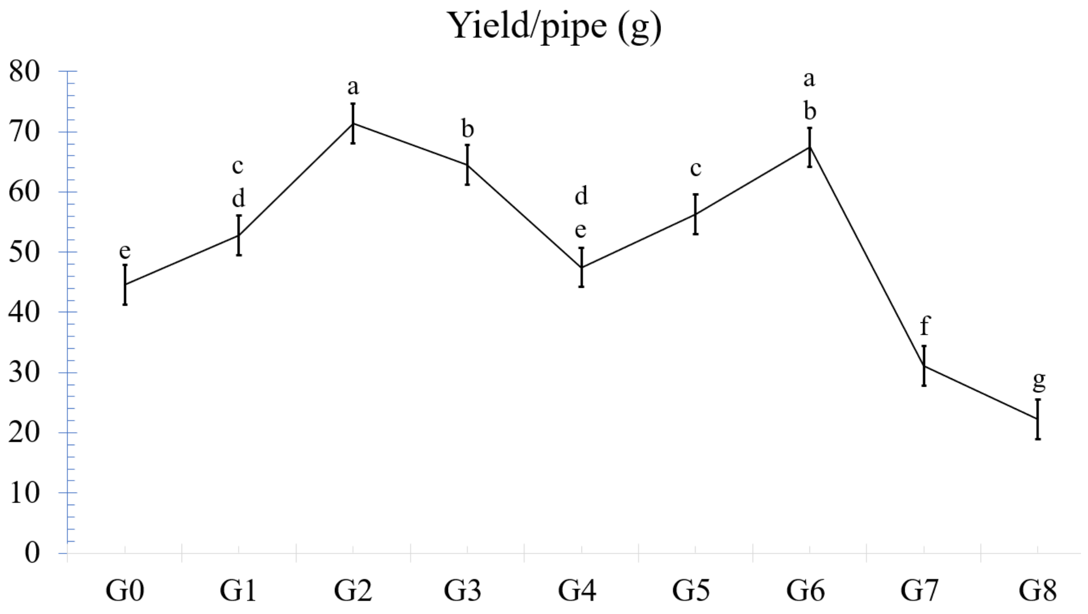


Figure 9. Effect of different organic growing media on yield/pipe (g) of BARI Chive-1. Letters denote differences. Vertical bars indicate standard error of means.

G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

4.21 Yield (t/ha):

Yield (g) per pipe was converted to yield (t) per vertical structure area first then it was converted to yield per ha and yield (t/ha) of chive highly affected by different growing media. The highest yield (5.13 t/ha) was observed by G_2 treatment where 50% soil, 25% vermicompost and 25 % cowdung were mixed and used for growing. Second highest yield of BARI Chive-1 (4.88 t/ha) was obtained from that media which was mixed with 50% soil, 25% kitchen compost and 25% cocopeat (G_6) (Figure 10) (Appendix XIV). The finding of the present study was homologous as the findings reported by **Zaman *et al.*, (2015)** using vermicompost as organic additives. **Mehedi *et al.*, (2012)** also described the highest yield of carrot applying cowdung @ 15 t ha^{-1}. Soil, vermicompost, biochar and kitchen compost (G_8) mixed growing media represent lowest yield (1.6 t/ha).

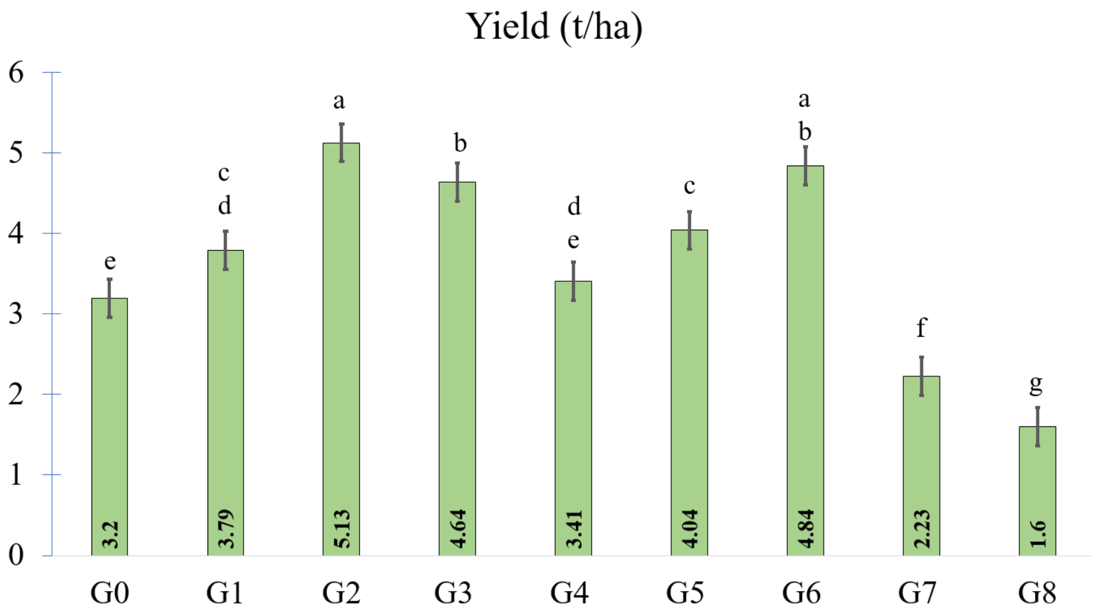


Figure 10. Effect of different organic growing media on yield (t/ha) of BARI Chive-1. Letters denote differences. Vertical bars indicate standard error of means.

G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

Saha & Chakraborty (2019) showed that the use of coco-peat and vermicompost significantly increased plant height, leaf number, leaf area, and fresh and dry weight of the chives. The combination of coco-peat and vermicompost also increased the yield of the chives. (**Khan *et al.*, 2017**). The application of biochar did not show any positive effect on the productive response of BARI Chive-1. **Gravel *et al.*, (2013)** reported that the mixture of potting soil with biochar had no significant effect on shoot growth of sweet pepper, geranium, and basil; while increased coriander shoot weight and decreased the weight of lettuce plants. **Atkinson *et al*., (2010)** observed that the usually high C/N ratios of biochar could lead to a higher N immobilization and eventually to N deficiencies in plants and it affects the plant growth and yield directly.

CHAPTER V

SUMMARY AND CONCLUSION

Chapter V

SUMMARY AND CONCLUSION

The experiment was conducted on rooftop of Dr. MA Wazed Miah Research Centre building at the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to evaluate the influence of organic growing media on growth, yield and quality performance of BARI Chive-1 variety in vertical garden during January to March of the year 2022. The experiment was laid out in a randomized complete block design (RCBD) having twenty-seven experimental units (9 treatments with 3 replications). The nine treatments were G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cowdung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Cocopeat (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10).

Different growth and yield parameters were measured and recorded followed by statistical comparison of data.

Plant height was recorded at 30, 45, 60 and 70 days after transplanting (DAT)of BARI Chive-1. At 30 DAT, the maximum plant height (19.00 cm) was recorded from G_2 (50% Soil + 25% Vermicompost+ 25% cowdung) followed by G_3 (50% soil + 50% cowdung) and lowest (8.85 cm) was found from G_0 (100% soil). At 45 DAT, the highest plant height (19.24 cm) was also found in G_2 (50% Soil + 25% Vermicompost+ 25% cowdung) followed by G_6 (50% soil+ 25% kitchen compost+ 25% cocopeat) but lowest (10.96 cm) was found in G_8 and G_2, G_3 and G_6 treatments were exhibited statistically similar results. At 60 DAT, G_1, G_2, G_4, G_5 and G_6 were displayed statistically identical results. Highest plant height (19.96 cm) was obtained from G_2. Second highest plant height (19.63 cm) was showed by G_1 followed by G_6 (19.58 cm). Lowest (11.97 cm) was found in G_8. At harvesting time (70 DAT) longest plant (21.43 cm) was observed in G_2 (50% soil + 25% vermicompost + 25% cowdung) treatment followed by G_6 treatment (20.67cm) and shortest chive plant was found in G_8 (50% Soil + 30% Vermicompost + 10%Biochar + 10% Kitchen compost) treatment followed by G_7 (50% Soil + 25% Vermicompost + 25% Biochar) (16.78 cm).

Leaf length of Different days after transplanting (30 DAT, 45 DAT, 60 DAT and 70 DAT) were calculated. At 30 DAT, the maximum leaf length (11.07 cm) was recorded from G_6 (50% Soil +25% kitchen compost + 25% cocopeat) and lowest (6.84 cm) was found from G_0 (100% soil). But G_1, G_2, G_3, G_4 and G_6 treatments were showed statistically similar results. At 45 DAT, the highest leaf length (11.85 cm) was also found in G_6 (50% Soil +25% kitchen compost + 25% cocopeat) and lowest (7.30 cm) was found in G_0 (100% soil) followed by G_8 (50% soil + 30% vermicompost + 10% biochar +10% kitchen compost). And G_1, G_2, G_3, G_4 and G_6 treatments were exhibited statistically similar results. G_1 (50% soil + 50% vermicompost) was displayed highest leaf length (15.15 cm) at 60 DAT followed by G_2 (50% soil + 25% vermicompost +25% cowdung) (14.08 cm). Lowest leaf length (9.54 cm) revealed by G_8 (50% soil + 30% vermicompost + 10% biochar +10% kitchen compost). G_1, G_2 and G_6 treatments were showed statistically identical results. Leaf length of BARI Chive-1 demonstrated statistically same result in G_1, G_2 and G_6 treatments at 70 DAT. Highest leaf length (16.53 cm) at 70 DAT was exhibited by G_1 (50% soil + 50% vermicompost) followed by G_2 and G_6. Lowest leaf length (10.21 cm) was displayed by G_8 (50% soil + 30% vermicompost + 10% biochar +10% kitchen compost).

The highest leaf number per plant at 30 DAT was produced by G_4 (3.28) followed by G_3 and G_2. The least number of leaves per plant were recorded for G_8 (1.14). At 45 DAT, maximum leaf number per plant were recorded in G_6 (5.02) followed by G_4 (4.99) and minimum leaf number per plant were observed in G_8 (2.00). G_1, G_2, G_3, G_4 and G_6 were exhibited statistically similar result.

G_6 treatment also gave highest leaf number per plant at 60DAT (6.27). G_2 showed second highest leaf number per plant (6.07) and G_2, G_3, G_5 and G_6 were reveled statistically similar result. The lowest leaf number per plant was showed by G_8 (3.57). The most leaf number per plant (6.70) of chive was showed by G_6 when leaf were harvested (at 70 DAT) followed by G_3 (6.36) and G_2, G_3, G_5 and G_6 were statistically similar. And the lowest leaf number per plant was showed by G_8 (3.95).

Maximum fresh weight (g) per plant with root (5.58g) was found in G_2 treatment and minimum fresh weight (g) per plant with root (1.79 g) was discovered by G_8 treatment. But G_2 and G_6 treatments showed statistically similar result.

Highest dry weight (g) per plant (0.69 g) with root was revealed by G_2 and G_6, G_2 and G_3 showed the similar result (0.68 g and 0.66g) statistically. Other hand lowest dry weight (g) per plant (0.23 g) with root was found in G_8 treatment.

Highest dry matter (14.09%) content of plant with root was found in G_0 where only soil was used for growing chive. And lowest dry matter (12.27%) of plant with root was found in G_2.

Maximum fresh weight per plant without root (5.1g) was found in G_2 treatment and minimum fresh weight per plant without root (1.59 g) was discovered by G_8 treatment. But G_2 and G_6 treatments showed statistically similar result.

$G_{2,}$ G_3 and G_6 were exhibited statistically highest dry weight (g) per plant without root (0.55g, 0.53g and 0.55g). Lowest dry weight (g) per plant without root (0.18 g) was found in G_8 treatment.

100% soil (G_0) exhibited highest dry matter percentage (12.21) followed by G_7 (11.54). Lowest dry matter percentage (10.77) was recorded by G_2 treatment.

Highest fibrous root number (9.42) per plant were obtained from G_4 where mixture of 25% soil and 75% cowdung was used as growing media. Lowest fibrous root number (6.88) per plant was observed by G_0.

In this study maximum fresh weight of flat stem per plant (1.28 g) found in G_2 treatment where soil, vermicompost and cowdung mixture was used as growing media. G_2 and G_6 treatment were showed similar result by statistical analysis. Minimum fresh weight of flat stem per plant (0.41 g) was found in G_8 treatment.

Dry weight of flat stem per plant (g) remained highest in G_2, G_3 and G_6 statistically (0.21 g, 0.19g and 0.20 g). And the lowest dry weight of flat stem per plant (g) was exhibited in G_8 treatment (0.07 g).

The results showed that G_0 treatment had high dry matter percentage (17.68) and G_2 treatment had low dry matter percentage (16.22).

Highest fresh weight of leaves per plant (3.82 g) was observed in G_2 treatment where 25% vermicompost and 25% cowdung were added with 50% soil. Lowest fresh weight of leaves per plant (1.18 g) was found in G_8.

G_2, G_3 and G_6 were showed statistically similar dry weight of leaves per plant (0.34 g, 0.33 g and 0.35 g) and they were mentioned as highest. Lowest dry weight of leaves per plant (0.11 g) was showed by G_8.

Highest dry matter of leaf (10.34%) was observed by G_0 and lowest (9.04%) was observed by G_4.

Maximum fibrous root weight per plant (0.49 g) was observed by G_2 treatment and lowest (0.20 g) was found in G_8.

G_2, G_3 and G_6 were exhibited similarly highest dry weigh of root per plant (g) by statistical analysis (0.13 g, 0.13 g and 0.14 g). Lowest dry weight of root per plant (g) was showed by G_8.

G_0, G_6 and G_7 treatments are showed statistically similar highest dry matter percentage of root (28.92, 28.65 and 28.82). Lowest dry matter content of root showed by G_2 (27.53%).

Maximum yield per pipe (71g) was found in G_2 treatment and minimum (22g) was found in G_8 treatment.

Highest yield (5.13 t/ha) was observed by G_2 treatment where 50% soil, 25% vermicompost and 25 % cowdung were mixed and used for growing. Second highest yield of BARI Chive-1 (4.88 t/ha) was obtained from that media which was mixed with soil, kitchen compost and cocopeat (G_6). Soil, vermicompost, biochar and kitchen compost (G_8) mixed growing media represent lowest yield (1.6 t/ha).

So, it is concluded that to ensure food security and quality food vertical gardening may be a popular choice for urban gardener. BARI Chive-1 is an excellent variety to alternative of onion and garlic. For organic safe cultivation, 50% soil+ 25% vermicompost + 25 % cowdung mixture and 50% Soil + 25% Kitchen compost + 25 % Cocopeat mixture were showed very good result in vertical garden for BARI chive-1 production in this study. But further study is needed for confirmed these findings and also more organic media should be added in future study. Since BARI Chive-1 is a year-round variety, so future study should be designed for year-round production.

REFERENCES

REFERENCES

Abdani, D.B. (2020). Inorganic Fertilizers (Ground and Foliar Application) and Organic Fertilizer: Their Effects on the Growth and Yield of Pechay (*Brassica napus* L. subsp. chinensis var. Black Behi). *Int. J. Res. Studies in Agric. Sci.* (IJRSAS), 6(5): 38-55. DOI: http://dx.doi.org/10.20431/2454- 6224.0606005

Allium tuberosum. (2023, April 23). In *Wikipedia*. https://en.wikipedia.org/wiki/ Allium_tuberosum

Alam, M.J., Kaneko, S. and Rahman, M. M. (2015). The Decreasing Trend of Agricultural Land in Bangladesh: Myth and Facts. *The Jahangir Nagar economic review.* 26: 85-97.

Al-Chalabi, M. (2015). Vertical farming: Skyscraper sustainability. *Sustainable Cities and Society*, **18:**74-77.

Akanda, R.I. (2019). Chives, alternative to onions and garlic. *Dhaka Tribune*. November 18th2019. https:// archive.dhakatribune.com/bangladesh/nation/ 2019/11/19/chives-alternative-to-onions-and-garlic

Ansari, A.A, Ismail, S.A. 2008. Relamation of sodic soils through vermitechnology. *Pakistan J. Agric. Res.* 21:92–97

Antoniadis, A., Tsafaras, D., and Tzortzakis, N. (2018). Potential of organic substrates on *Escherichia coli* in fresh-cut lettuce during storage. *Food Control*, 84, 168-173.

Aslanpour, M., Shoor, M., Ghalekahi, B., Sharifi, A. and Kharazi, M. (2019). Effect of Light Variables Treatments on Growth and Flowering of Saintpaulia (*Saintpaulia Ionantha Wendi*). *Int. Transaction J Eng. Management, & Applied Sci. Tech.* 10(5): 597-606.

Atkinson, C.J., Fitzgerald, J.D. and Hipps, N.A. (2010) Potential mechanisms for achieving agriculture benefits from biochar application to temperate soils: A review. *Plant Soil*. 337, 11–18.

Banerjee, C., and Adenaeuer, L. (2014). Up, Up and Away! The Economics of Vertical Farming. *J. Agric. Studies*. **2**(1): 40-60.

BBS (Bangladesh Bureau of Statistics), (2021). Agricultural Census of Bangladesh. Dhaka: *Ministry of Planning*.

Borrelli, K., Milesi, L., and Mozzato, D. (2021). Growth and productivity of chives (*Allium schoenoprasum* L.) in a vertical garden system using compost. *Scientia Horticulturae*, 279, 109915.

Bustamante, M. A., Paredes, C., Marhuenda-Egea, F. C., Pérez-Espinosa, A., Bernal, M. P., and Moral, R. (2008). Co-composting of distillery wastes with animal manures: Carbon and nitrogen transformations in the evaluation of compost stability. *Chemosphere*, 72(4), 551-557. doi: 10.1016/j.chemosphere.2008.03.003

Byrne, J., Sipe, N., and Searle, G. (2019). Urban agriculture as a land use planning strategy: A case study of Melbourne. *Landscape and Urban Planning*. 191, 103-618.

Ciavatta, C., Govi, M., Antisari, L. V., and Sequi, P. (2015). Peat-based and peat-free growing media: influence on growth and quality of marigold (*Tagetes erecta* L.) plants. *J. of Env. Sci. and Health*, Part B, 50(9), 658-666.

Cig, A. (2019). Effects of Different Growing Media on Plant Growth and Nutrient Contents of Petunia (*Petunia hybrida*). *Int. J. Secondary Metabolite*. 6(4): 302-309.

Debono, R., Raimondo, S., and Martin, S. (2021). Year-round food production in urban areas using vertical hydroponic systems. *Acta Horticulturae*, 1302, 325-332.

El-Dewiny, C.Y., Moursy, K.S. and El-Aila, H.I. (2006). Effect of organic matter on the release and availability of phosphorus and their effects on spinach and radish plants. *Res. J. Agric. Biol. Sci.* 2: 103–108.

Gao, Q., Li, X.-B., Sun, J., Xia, E.-D., Tang, F., Cao, H.Q. and Xun, H. (2018) Isolation and identification of new chemical constituents from Chinese chive (*Allium tuberosum*) and toxicological evaluation of raw and cooked Chinese chive. *Food Chem. Toxicol.* 112, 400–411.

Gravel, V., Dorais, M. and Menard, C. (2013) Organic potted plants amended with biochar: Its effect on growth and Pythium colonization. Can. *J. Plant Sci.* 93, 1217-1227.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research. *2nd edn. International Rice Research Institute. Los Banos, Philippines*. 207–215.

Gül, A., Eroğul, D., Öztan, F. and Tepecik, M. (2007). Effect of growing media on plant growth and nutrient status of crisp-head lettuce. *Acta Hortic*. 729: 367-371.

Hashimoto, S., Mitazawa, M. and Kameoka, H. (1983) Volatile flavor components of chive (*Allium schoenoprasum* L.). *J. of Food Sci.* 48(6): p. 1858-1859.

Ibanez, I., Artigas, V., Font, G., and Gomez-Catalan, J. (2021). Impact of growing media on the persistence and internalization of Salmonella and Listeria monocytogenes in lettuce. *Food Microbiology.* 94, 103-655.

Imahori, Y., Suzuki, Y., Uemura, K., Kishioka, I., Fujiwara, H., Ueda, Y. and Chachin, K. (2004). Physiological and quality responses of Chinese chive leaves to low oxygen atmosphere. *Postharvest Biol. Technol.* 31, 295–303.

Islam, R., Solaiman, A.H.M, Kabir M.H., Arefin, S.M.A., Azad, M.O.K., Siddiqee, M.H., Alsanius, B.W. and Naznin, M.T. (2021). Evaluation of Lettuce Growth, Yield, and Economic Viability Grown Vertically on Unutilized Building Wall in Dhaka City. *Front. Sustain. Cities.* 3:5,82431. doi: 10.3389/frsc.2021.582431

Islam, R., Islam, M. N., and Khandaker, M. M. (2019). Assessment of nutrients and heavy metals in food waste and its compost. *J. of Environ. Sci. and Natural Resources*, 12(2), 79-83. doi: 10.3329/jesnr.v12i2.43041

Islam, M. S., and Hossain, M. M. (2018). Effects of coir and peat moss on growth and yield of garlic chives (*Allium tuberosum* Rottler ex Spreng). *J. of Agric. and Environ. Sci.*, 7(3), 57-60.

Islam, M. S., Sultana, S., Hanafi, M. M., and Rafii, M. Y. (2016). Soil fertility management for sustainable crop production in Bangladesh: A review. *Agronomy.* 6(1), 6. doi: 10.3390/agronomy6010006

Jaafar, H. Z. E., Ibrahim, M. H., Karimi, E., and Jahromi, M. F. (2012). Growth and yield of organic chives (*Allium schoenoprasum*) as affected by kitchen waste compost and coco-peat. *African J. of Biotechnology*, 11(31), 7948-7956.

Khan, S. M., Iftikhar, S., Ahmad, S., and Ullah, M. (2017). Effect of coco-peat and vermicompost on growth, yield and quality of chives (*Allium fistulosum* L.). *Pakistan J. of Agric. Sci.*, 54(2), 359-364.

Khan, T.F., Salma, M.U. and Hossain, S.A. (2018) Impacts of Different Sources of Biochar on Plant Growth Characteristics. *American J. of Plant Sciences.* 9,1922-1934. https://doi.org/10.4236/ ajps.2018.99139

Kim, S., Lee, J., and Cho, Y. (2020). Effects of compost on growth and yield of garlic chives (*Allium tuberosum* Rottler ex Spreng) in a vertical farm. *International Journal of Vertical Farming.* 5(2), 43-47.

Kim, J., and Lee, J. (2022). Effects of coir and peat moss on growth and yield of garlic chives (*Allium tuberosum* Rottler ex Spreng) in a vertical farm. *Journal of Vertical Farming*. 12(2), 23-26.

Kumar, A., Singh, G., and Singh, Y. P. (2019). Effect of growing media on growth and yield of chives (*Allium schoenoprasum*) in vertical farming. *International Journal of Chemical Studies*. 7(4), 3694-3696.

Kundu, A., and Gope, G. (2017). Effect of vermicompost and coco-peat on growth and yield of onion chives (*Allium fistulosum* L.). *Indian J. of Agric. Res.* 51(4), 360-365.

Lehmann, J., and Joseph, S. (2015). Biochar for Environmental Management: Science, Technology and Implementation. *Routledge*.(2nd ed.).

Li, X., Wang, Y. and Liu, Y. (2017). Effects of vermicompost on growth and yield of garlic chives (*Allium tuberosum* Rottler ex Spreng). *J. of Applied Hort.* 19(1), 13-16.

Li, Y. and Chen, L. (2019). Effects of compost on growth and yield of garlic chives (*Allium tuberosum* Rottler ex Spreng). *International J. of Agric. and Bio.* 21(3), 425-430

Massiot, G. Saponin. (1995) In Chemistry and Pharmacology of Natural Products Series. Hostettmann, K. and Marston, A. (Eds.). *University Press: Cambridge, UK.* Volume 548, p. £85. ISBN 0-521-32970-1.

Mehedi, T.A., Siddique, M.A. and Shahid, S.B. (2012). Effect of urea and cow dung on growth and yield of carrot. *J. Bangladesh Agril. Univ.* 10: 9–13.

Moon, G.S., Ryu, B.M. and Lee, M.J. (2003) Components and antioxidative activities of buchu (Chinese chives) harvested at different times. *Korean J. Food Sci. Technol*. 35: 493–498.

Nwosisi, S., Nandwani, D. and Chowdhury, S. (2017). Organic vertical Gardening for Urban Communities. *Acta Hort.,* 1189**:** 399-402.

Ortiz-Ribbing, L. M., Hodges, A. W., and Suter, G. W. (2020). Vertical farms and greenhouse technologies: Opportunities for sustainable food production in urban areas. *J. of Cleaner Prod.* 263:121497.

Puja B. S. Ariina M.M.S., Singh T.S. and Roveni D. (2022). Effect of organic compost and PSB on growth and yield of chives (*Allium tuberosum* L.). *The Pharma Innovation Journal*. 11(8): 1319-1322.

Ramos-Gonzalez R., Orozco-Almanza M.S., Monroy-Ata A., Rojas-Cortés M. and De J. (2019). Cultivation of three aromatic species in a vertical garden with two organic fertilizers. *Agroproductividad.* 12(3),41–46.DOI: 10.32854/agrop.v0i0.1151

Ramesh, M., Palaniradja, K. and Alavudeen, A. (2016). Coconut coir fiber and its composites: a review. *Journal of Reinforced Plastics and Composites*. 35(9), 697-706. doi: 10.1177/0731684416653417

Rekha, G.S., Kaleena, P.K., Elumalai, D., Srikumara, M.P. and Maheshwari, V.N. (2018). Effects of vermicompost and plant growth enhancers on the exo-morphological features of *Capsicum annum* (Linn.) Hepper. *Int J Recycl Org Waste Agricult.* **7**, 83–88. https://doi.org/10.1007/s40093-017-0191-5

Riaz, A., Muhammad, R. and Younis, A. (2008). Effects of different growing media on growth and flowering of *Zinnia elegans* cv. blue point. *Pak. J. Bot*. 40(4): 1579-1585.

Sardoei, A.S. and Shahdadneghad, M. (2015). Effect of different growing media on the growth and development of Zinnia (*Zinnia elegans*) under the agroclimatic condition of jiroft. *Res. J. of Environ. Sci.* 9: 302-306.

Sagolsem, P.B., Ariina, M.S., Singh, T.S. and Roveni D. (2022). Effect of organic compost and PSB on growth and yield of chives (*Allium tuberosum* L.). *The Pharma Innovation J.* 11(8):1319-1322

Saha, S. and Chakraborty, D. (2019). Impact of coco-peat and vermicompost on growth and yield of chive (*Allium fistulosum* L.). *International Journal of Current Microbiology and Applied Sciences*. 8(1), 1072-1079.

Shah, M. A. and Uddin, M. N. (2017). Effect of peat moss and lime on growth and yield of garlic chives (*Allium tuberosum* Rottler ex Spreng). *Bangladesh Journal of Agricultural Researc*. 42(2), 191-196.

Siddique, M. M. A. (2017). Effect of organic farming on growth, yield and quality of lettuce and on soil properties. M.S. thesis, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh

Singh, R. P. and Sharma, R. R. (2012). Cow dung as an effective feedstock for vermicomposting: A comparative study with water hyacinth and cowpea wastes. *Environmental Science and Pollution Research*. 19(8), 3194-3201. doi: 10.1007/s11356-012-0906-4

Sinha, Rajiv, Herat, Sunil, Valani, Dalsukhbhai, Chauhan and Krunalkumar (2009). Earthworms Vermicompost: A Powerful Crop Nutrient over the Conventional Compost & Protective Soil Conditioner against the Destructive Chemical Fertilizers for Food Safety and Security. Am-Euras. J. Agric. & Environ. Sci., 5 (S): 01-55. http://hdl.handle.net/10072/30336

Souza, T. G., Neto, J. D. A., Cabral, G. R. and Costa, L. L. (2019). Sustainability indicators of organic and conventional lettuce production using peat and coconut coir substrates. *Horticultura Brasileira*, 37(2), 143-150.

Tanimu, J., Uyovbisere, E.O., Lyocks, S.W.J. and Tanimu, Y. (2007). Effects of Cow Dung on the Growth and Development of Maize Crop. *Greener J. Agric. Sci*. 3(5): 371–383

The United Nations (2017). World Population Prospects. The 2017 Revision. New York, NY: United Nations. Available online at: https://www.un.org/ development/desa/publications/world-population-prospects-the-2017 revision. html

Utami, S. N. H. and Jayadi, R. (2011). Vertical gardening for vegetables. In International Symp. on Sustainable Vegetable Production: Southeast Asia. 958: 195-202.

Uka, U.N., Chukwuka, K.S. and Iwuagwu, M. (2013). Relative effect of organic and inorganic fertilizers on the growth of okra (*Abelmoschus esculentus* L.) *Moeuch. J Agric. Sci*. 58: 159–166.

Waseem, K., Hameed, A., Jilani, M.S., Kiran, M., Mamoon-Ur Rasheed, Ghazanfarullah, J. S. and Jilani, T.A. (2013). Effect of different growing media on the growth and Flowering of stock (*Matthiola incana*) under the agroclimatic condition of dera ismail khan. Pak. *J. Agri. Sci.* 50(3): 523-527.

Xiangwei, Y., Jiang, H., Zhao, M., Suo, F., Zhang, C., Zheng, H., Sun, K., Zhang, G., Li, F. and Li, Y. (2020). Biochar reduced Chinese chive (*Allium tuberosum*) uptake and dissipation of thiamethoxam in an agricultural soil. ***J.** of Hazardous Materials**.*** 390. https://doi.org/10.1016/j.jhazmat.2019.121749.

Yang, Y., Liu, Y. and Zhang, J. (2021). Effects of vermicompost on growth and yield of garlic chives (*Allium tuberosum* Rottler ex Spreng) in a vertical farm. *Vertical Farming.* 11(1), 17-20.

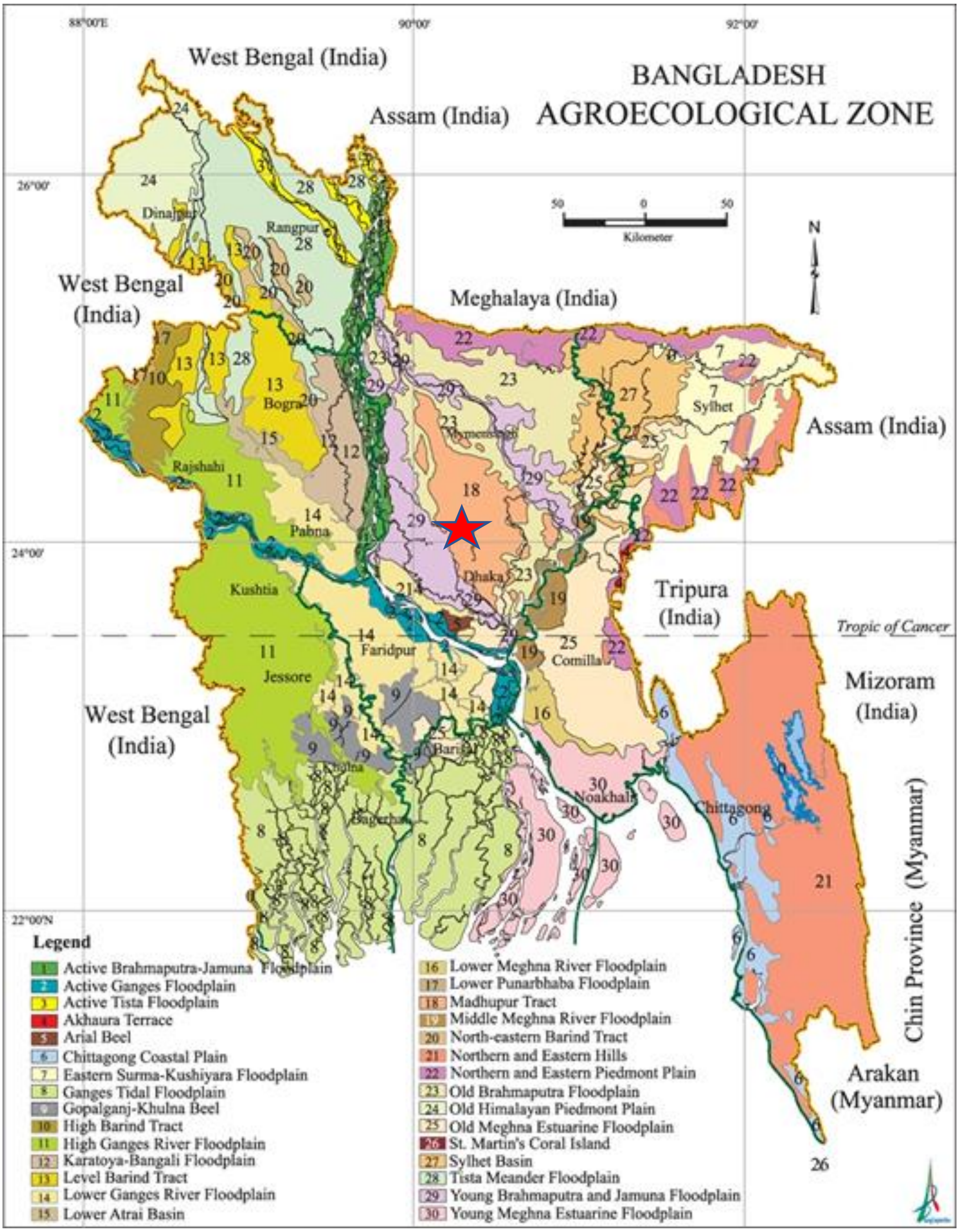
Zaman, M.M., Chowdhury, M.A.H., Islam, M.R. and Uddin, M.R. (2015). Effects of vermicompost on growth and leaf biomass yield of stevia and post-harvest fertility status of soil. *J. Bangladesh Agril. Univ*. 13(2): 169–174.

Zhang, W.N., Zhang, H.L., Lu, C.Q., Luo, J.P. and Zha, X.Q. (2016) A new kinetic model of ultrasound-assisted extraction of polysaccharides from Chinese chive. *Food Chem*. 212: 274–281.

APPENDICES

APPENDICES

Appendix I: Map showing the experimental site



★ Experimental site

Appendix II: Morphological characteristics of the experimental site

Morphology	**Characteristics**
Location	SAU farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ-28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Appendix III: The initial physical and chemical characteristics of soil of the experimental soil

Physical characteristics	
Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	Value
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Appendix IV. Monthly Weather Report during the experimental period, January to March, 2022

Months	Temperature (˚c)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
January	21.9	13.5	72	00
February	23.5	13.4	67	00
March	31.7	19.2	77	06

Source: Bangladesh Meteorological Department (Climate and weather division), Agargaon, Dhaka-1207.

Appendix V. Analysis of variance of plant height (cm) of BARI Chive-1 at different days after transplanting (DAT) influenced by different organic growing media

Source	DF	Mean square			
		30DAT	45DAT	60DAT	70DAT
Replication	2	50.80	44.28	33.63	43.59
Treatments	8	33.01*	23.20*	20.51*	20.11*
Error	16	1.30	0.91	0.88	1.25
CV		7.82	5.93	5.31	5.89

*: Significant at 0.05 level of significance

Appendix VI. Analysis of variance of leaf length (cm) of BARI Chive-1 at different days after transplanting (DAT) influenced by different organic growing media

Source	DF	Mean square			
		30DAT	45DAT	60DAT	70DAT
Replication	2	20.10	21.49	48.63	43.19
Treatments	8	8.17*	8.61*	11.06*	15.03*
Error	16	0.75	0.38	1.61	1.46
CV		9.51	6.21	10.60	9.24

*: Significant at 0.05 level of significance

Appendix VII. Analysis of variance of leaf number per plant of BARI Chive-1 at different days after transplanting (DAT) influenced by different organic growing media

Source	DF	Mean square			
		30DAT	45DAT	60DAT	70DAT
Replication	2	1.67	2.39	2.51	2.47
Treatments	8	1.41*	2.91*	2.15*	2.30*
Error	16	0.09	0.13	0.06	0.06
CV		12.51	8.93	4.54	4.65

*: Significant at 0.05 level of significance

Appendix VIII. Analysis of variance of fresh weight (g) per plant with root, dry weight (g) per plant with root and dry matter (%) of plant with root of BARI Chive-1 influenced by different organic growing media

Source	DF	Mean square		
		fresh weight (g) per plant with root	dry weight (g) per plant with root	dry matter (%) of plant with root
Replication	2	2.92	0.04	0.31
Treatments	8	4.80*	0.08*	0.52*
Error	16	0.06	0.001	0.02
CV		6.14	6.14	1.11

*: Significant at 0.05 level of significance

Appendix IX. Analysis of variance of fresh weight (g) per plant without root, dry weight (g) per plant without root and dry matter (%) of plant without root of BARI Chive-1 influenced by different organic growing media

Source	DF	Mean square		
		fresh weight (g) per plant without root	dry weight (g) per plant without root	dry matter (%) of plant without root
Replication	2	2.36	0.039	0.41
Treatments	8	4.16*	0.07*	0.55*
Error	16	0.05	0.001	0.02
CV		6.15	6.16	1.38

*: Significant at 0.05 level of significance

Appendix X. Analysis of variance of fresh weight (g) of flat stem per plant, dry weight (g) of flat stem per plant and dry matter (%) of flat stem per plant of BARI Chive-1 influenced by different organic growing media

Source	DF	Mean square		
		fresh weight (g) of flat stem per plant	dry weight (g) flat stem per plant	dry matter (%) flat stem per plant
Replication	2	0.15	0.004	0.003
Treatments	8	0.25*	0.007*	0.58*
Error	16	0.003	0.00009	0.05
CV		6.11	6.57	1.38

*: Significant at 0.05 level of significance

Appendix XI. Analysis of variance of fresh weight (g) of leaves per plant, dry weight (g) of leaves per plant and dry matter (%) of leaf of BARI Chive-1 influenced by different organic growing media

Source	DF	Mean square		
		fresh weight (g) of leaves per plant	dry weight (g) of leaves per plant	dry matter (%) of leaf per plant
Replication	2	1.31	0.007	0.73
Treatments	8	2.35*	0.02*	0.62*
Error	16	0.02	0.0002	0.05
CV		6.17	6.21	2.37

*: Significant at 0.05 level of significance

Appendix XII. Analysis of variance of fresh weight (g) of root per plant, dry weight (g) of root per plant and dry matter (%) of root per plant of BARI Chive-1 influenced by different organic growing media

Source	DF	Mean square		
		fresh weight (g) of root per plant	dry weight (g) of root per plant	dry matter (%) of root per plant
Replication	2	0.029	2.436e-03	0.008
Treatments	8	0.026*	2.057e-03*	0.589*
Error	16	0.0006	4.976e-05	0.036
CV		6.22	6.26	0.67

*: Significant at 0.05 level of significance

Appendix XIII. Analysis of variance of fibrous root no. per plant, yield/pipe (g) and Yield (t/ha) of BARI Chive-1 influenced by different organic growing media

Source	DF	Mean square		
		Fibrous root no	Yield/pipe (g)	Yield (t/ha)
Replication	2	14.11	464.29	2.39
Treatments	8	2.98*	815.47*	4.21*
Error	16	0.25	9.81	0.05
CV		6.59	6.15	6.15

*: Significant at 0.05 level of significanc

Appendix XIV. Effect of different organic growing media on fresh weight (g) per plant with root, dry weight (g) per plant with root, dry matter (%) of plant with root, fibrous root number per plant, fresh weight (g) of leaves per plant, dry weight (g) of leaves per plant, dry matter (%) of leaf and yield (t/ha) of BARI Chive-1.

Treatments	Fresh weight/plant (with root)	Dry weight/plant (g) (with root)	Dry matter (%) of Plant (with root)	Fibrous root no.	Fresh weight of leaves/ plant (g)	Dry weight of leaves/ plant (g)	Dry matter (%) of leaf	Yield (t/ha)
G_0	3.59 e	0.50 cd	**14.09 a**	6.88 bc	2.37 e	0.24 c	10.34 a	5.57 e
G_1	4.21 cd	0.55 bc	13.17 c	7.63 abc	2.82 cd	0.27 b	9.76 b	6.59 cd
G_2	5.58 a	**0.68 a**	12.27 e	7.67 abc	3.81 a	0.34 a	8.93 c	8.92 a
G_3	5.067 b	0.66 a	12.98 c	7.34 abc	3.45 b	0.33 a	9.76 b	8.07 b
G_4	3.98 de	0.48 d	12.72 d	9.42 a	2.53 de	0.22 c	9.04 c	5.93 de
G_5	4.44 c	0.58 b	12.99 c	6.19 c	2.99 c	0.29 b	9.70 b	7.04 c
G_6	5.29 ab	**0.69 a**	13.04 c	8.79 ab	3.61 ab	0.35 a	9.77 b	8.43 ab
G_7	2.50 f	0.34 e	13.49 b	6.96 bc	1.65 f	0.16 d	9.75 b	3.89 f
G_8	1.79 g	0.23 f	12.99 c	8.00 abc	1.18 g	0.11 e	9.09 c	2.78 g
CV (%)	6.13	6.169	1.12	17.37	6.173	6.218	2.37	6.15
LSD (0.05)	0.43	0.0559	0.25	2.30	0.29	0.0278	0.39	0.68

Letters denote differences. Vertical bars indicate standard error of means.

G_0: soil (100%), G_1:Soil + Vermicompost (50:50), G_2 : soil+ vermicompost + cowdung (50:25:25), G_3: Soil+ Cow-dung (50:50), G_4: Soil+ Cowdung (75:25), G_5: Soil+ Cowdung+ Kitchen compost (50:25:25), G_6: Soil + Kitchen compost + Coco (50:25:25), G_7: Soil + Vermicompost + Biochar (50:25:25) and G_8: Soil + Vermicompost + Biochar + Kitchen compost (50:30:10:10)

Appendix XV. Some pictorial presentation of experiment

Plate 1: Preparation of growing media and growing device for BARI Chive-1 planting

Plate 2: Planting the sucker of BARI Chive -1

Plate 3. Irrigation and weeding practices

Plate 4. Data collection

Plate 5. Experimental site investigation by honorable supervisor.

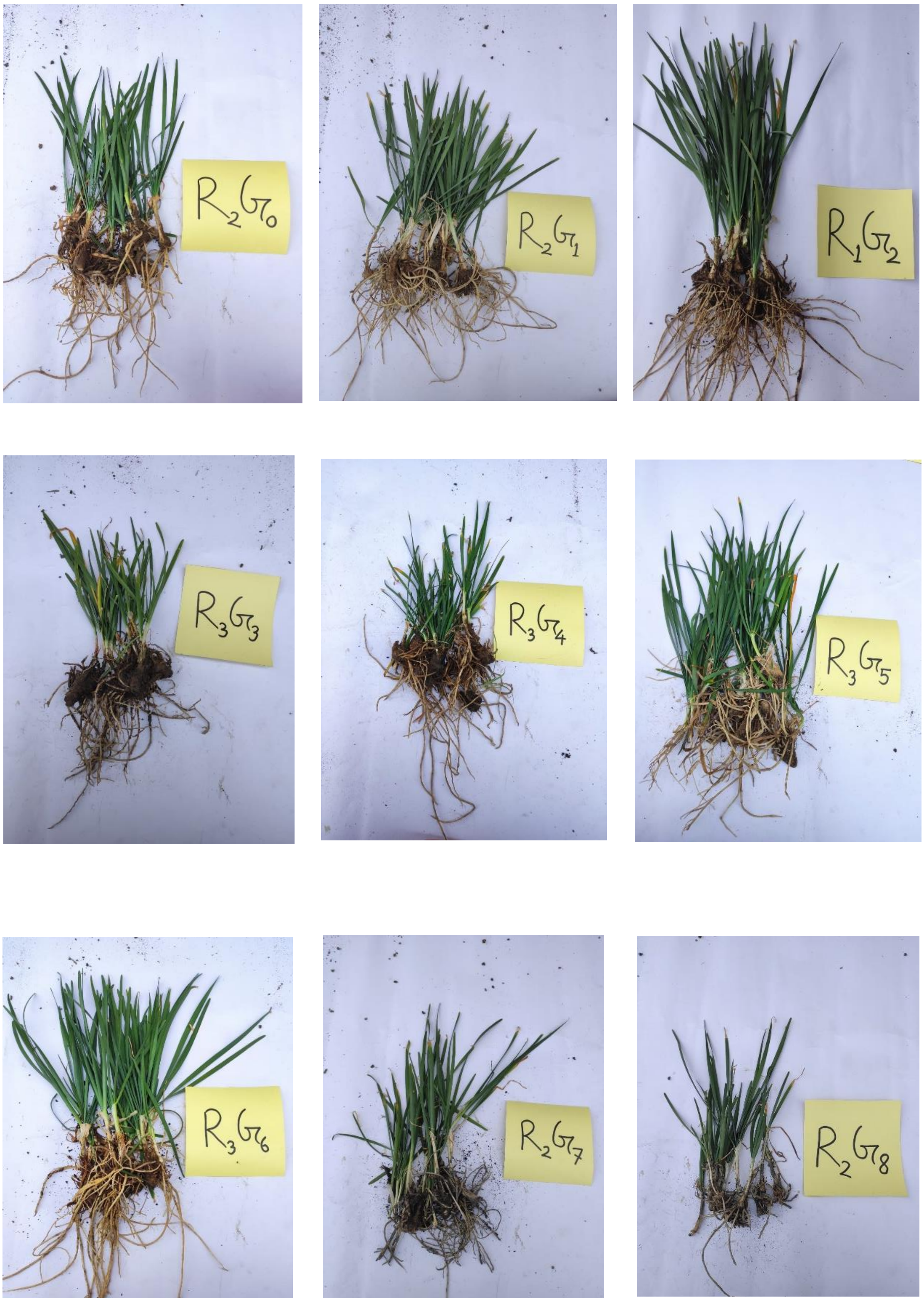


Plate 6. Pictorial view of different growing media effect on BARI Chive-1 at harvest

Plate 7. Different parts of BARI Chive -1. A: Full plant, B: Leaves, C: Flat stem and D: Fibrous Root