EFFECT OF DIFFERENT GROWING MEDIA ON THE GROWTH AND YIELD OF VERTICALLY GROWN THAI BASIL ON ROOFTOP

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JUNE, 2022

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

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

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CERTIFICATE

This is to certify that thesis entitled, **"EFFECT OF DIFFERENT GROWING MEDIA ON THE GROWTH AND YIELD OF VERTICALLY GROWN THAI BASIL ON ROOFTOP"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **MEHNAZ HAQUE MONIKA,** Registration No**. 15-06775** 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, as has been availed of during the course of this investigation has duly been acknowledged.

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TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are due to the "Almighty Allah" Who kindly enabled the author to complete the research work and the thesis leading to Master of Science.

*The author would like to express her heartiest respect, her deep sense of gratitude and sincere, profound appreciation to her supervisor, **Prof. Dr. A Hasnat M Solaiman**, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.*

*The author would like to express her heartiest respect and profound appreciation to her Co-supervisor, **Prof. Dr. Jasim Uddain**, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.*

The author expresses her sincere respect to honorable chairman and all the teachers of Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.

Mere diction is not enough to express her profound gratitude and deepest appreciation to her father, mother, brothers, sisters, and relatives for their ever-ending prayer, encouragement, sacrifice and dedicated efforts to educate her to this level.

The Author

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ABSTRACT

An experiment was carried out on the rooftop of Dr. M. Wazed Miah Central Laboratory, Sher-e-Bangla Agricultural University, Dhaka from January 2022 to March 2022 to find out the effect of different growing media on Thai basil plants. The experiment consisted of single factor; G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded for different growth and yield parameters and significant variation was recorded for different treatment. Plant heights were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that plant height increased with the advancement of time up to 50 DAT. The highest plant height at all the growth stages was recorded (17.96, 26.79, 31.26, 35.95 and 40.81 cm) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest plant height was recorded (6.04, 8.27, 10.08, 13.48 and 16.82 cm) in G_0 (100% soil). Combination of cocopeat, vermicompost and soil media was most effective for vegetative growth as well as quantitative yield of Thai basil plants. Considering the yield performance, Thai basil showed the highest leaf yield per container (0.26 kg) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (0.23 kg) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat).

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LIST OF ABBREVIATION AND ACRONYMS

%	=	Percent
^{0}C	=	Degree Celsius
AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV%	=	Percentage of Coefficient of Variance
DAS	=	Days after Sowing
et al.	=	And others
FAO	=	Food and Agriculture Organization
g	=	Gram
kg	=	Kilogram
LSD	=	Least Significant Difference
Max	=	Maximum
Mg	=	Milligram
Min	=	Minimum
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Not Significant
PGRs	=	Plant Growth Regulators
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
wt	=	Weight

CHAPTER I

INTRODUCTION

Basil is a herb that can be either annual or perennial. All around the world, basil is cultivated as a culinary herb. Additionally, it produces essential oils that are used to flavor and scent food as well as to decorate gardens. Basil's native habitat spans from tropical regions in central Africa to Southeast Asia. It is a delicate plant that is frequently referred to as the "King of the herbs" and is used in cuisines around the globe. Over 150 species are grown around the globe. Thai basil (*Ocimum basilicum*) is a member of the Lamiaceae family of edible plants. The essential oils that give Thai basil (*Ocimum* spp.) its distinct scents are combined with non-volatile components like rosmarinic acid. (Koroch *et al.*, 2010). Thai basil produced for dried leaf and fresh markets rank second and third, respectively (Kopsell *et al.*, 2005). It is a species that is frequently used to make foods, such as pesto sauce, soft drinks, cosmetics, fragrances, and other household goods. It is also evident that basil is grown for commercial purposes in greenhouses, fields, and soilless systems (Craker *et al.*, 2003). Different accessions of holy basil could be expected to produce essential oils with varying chemical compositions, similar to many other aromatic plants of the same species (Putievsky *et al.*, 1999). Herbs are important food sources and for maintaining good health, according to research reports (Burkil, 1997).

Basil leaves are commonly taken from crop fields at different stages of growth and are widely used as spices, either fresh or dried, to give meals a distinctive flavor and perfume as well as for medicinal purposes. The beverage, cosmetics, and related industries occasionally place value on essential oils extracted from its leaves. Basil and peppermint are farmed primarily for their therapeutic properties, which are primarily attributable to the minerals they produce (Ogden and Ellen, 1990). However, according to Osuagwu (2008), these minerals can change depending on the crop's age and how well the plant is able to absorb nutrients. It is produced in open fields for the most part of the world. However, it is challenging to regulate the yield and quality of phenolics and essential oils in basil grown outdoors, and its phytochemical content varies greatly depending on the cultivation site, season, and cultivar (Fischer *et al.*, 2011). Currently, vertical farming systems, also referred to as plant factories, are indoor growth facilities where plants are grown in multiple layers. All climate factors can be controlled as plants are cultivated in a closed system without pesticides in a vertical farm (Sharath Kumar *et al.*, 2020).

Vertical gardening refers to the practice of transplanting flora from the roof to the walls (Bass and Baskaran, 2003). Additionally, it can be placed on apartment balconies and verandas. Additionally, a vertical garden can support a wide variety of plant species and high economic productivity (Timur and Karaca, 2013), particularly for vegetable and salad crops (Utami and Jayadi, 2011). According to Perini and Novi (2016), it also offers benefits for acoustics, aesthetics, and heat protection. So, using vertical farming as a tool for producing lettuce sustainably in urban areas is a great idea.

Cowdung increases the characteristics of the soil, which increases the efficiency of mineral fertilizers. Long-term use of cowdung improved the range of available water, bulk density, aggregate stability, and pore space (Vanlauwe *et al.*, 2001). Animal manures have many advantages over soluble fertilizers, including their gradual mineralization and the addition of organic matter to the soil that they create (Lakshmikathan, 1983). In 2004, Gupta and Tripathi discovered that the incorporation of cow dung considerably affected the organic matter, cation exchange capacity, and pH of the soil, which in turn had an impact on sugarcane productivity.

Vermicompost is a nutrient-rich mixture of vitamins, enzymes, macro and micronutrients, and growth hormones that is produced by earthworms (Bhavalkar, 1991). Vermicompost increases the surface area, provides excellent nutrient absorption and retention, and retains more nutrients for longer. It has been discovered that soil supplemented with vermicompost has a significantly higher bulk density and resists compression more readily (Lunt and Jacobson, 1994). By making the root cell membrane more permeable, promoting root growth, and boosting the number of root hairs, vermicompost improves plant nutrient uptake (Pramanik *et al.,* 2007). Additionally, it encourages better root development and nutrient absorption while enhancing the soil's nutrient status for both macro- and micronutrients. Nutrition is therefore essential to increasing plant productivity and the concentration of bioactive substances on a quantitative and qualitative basis (Shah *et al.,* 2010).

Cocopeat is a fantastic growth medium for vertical farming. Cocopeat is created from the brown and white fibers that are found in the space between a coconut's shell and its outer layer. It improves soil aeration for the optimal root development while maintaining the right amount of nutrient availability for plants. Additionally, it helps to loosen heavy soil and enhances the soil's capacity to hold onto water. Both commercial potting soil and coconut coir provide excellent surfaces for growing plants or microgreens. Grow bag soils include relatively little actual soil and a combination of coconut coir, vermicompost, biochar, etc. A suitable growing media component with acceptable pH, electrical conductivity, and other chemical characteristics is coco peat (Abad *et al.,* 2002).

Everyone is aware that biochar can be used to replace some components of regularly used substrates for containers. Biochar has gained increasing interest in recent years for its usage in agriculture. The use of biochar to substrates for containers has various benefits. (Crutchfield *et al.,* 2018) According to Dumroese *et al.* (2011), biochar on container substrates may increase water-holding capacity and decrease nutrient loss. According to Yu *et al.* (2020), different proportions of biochar combined with other substrate components produced a range of outcomes. Food security is becoming a more urgent issue in light of the effects of global warming and the growth of urban populations, particularly in light of the limited availability of resources such arable land, clean water, and fuel energy (Liaros *et al.,* 2016). Indoor vertical farming emerged as an environmentally sustainable form of plant production because of its high resource use efficiency of both land and water (Touliatos *et al.*, 2016). Therefore, the present study was undertaken with the following objectives:

1. To investigate the effect of different growing media on growth performance of Thai basil;
2. To find out the effect of different growing media on yield of Thai basil.

CHAPTER II

REVIEW OF LITERATURE

The essential herb Thai basil is used to make pesto sauce, soft drinks, cosmetics, scents, and other foods. It is cultivated for its outstanding essential oil, which has many therapeutic uses in medicine, food, herbal remedies, perfumery, aromatherapy, and flavoring agents. To help relieve the physical and emotional stresses of daily life and to increase health, lifespan, and wellness, its leaves and products should be routinely ingested. This chapter reviews some of the significant and educational works and research discoveries connected to vertical farming and growing medium on various basil or other herbs that have been conducted in our nation and elsewhere thus far, judiciously organized under several themes in a userfriendly manner.

2.1 Vertical farming

In a practice known as vertical farming, crops are tended to in layers that are vertically maintained in order to utilize the uncommon vertical area that is generally overlooked in almost every cultivation strategy. One of the many pressing issues facing the world is the growth of the population. Globally, it is estimated that 800 million hectares of land, or around 38% of the land on the earth, are set aside for soil-based farming. Additionally, according to Ellingsen and Despommier (2008), 80% of the world's arable land is currently in use. The world's population is on the cusp of explosion, and feeding this growing population is difficult (Sonawane, 2018).

In order to manage the demand-to-supply ratio and prevent falling food prices, harmful pollution, and inflation, cities will need to grow their own food, according to certain urban planners and agricultural specialists (Al-Kodmany, 2018). The vertical farming paradigm, according to Benke and Tomkins (2017), is essentially an indoor farm built on a high-rise multi-level factory design. When temperature and humidity are managed, the effects of seasonality can be mitigated or even avoided. With yearround crop production, yields that are orders of magnitude higher, and freedom from pests, droughts, and flooding, vertical farming has the potential to offer a sustainable food production paradigm. The strategy encourages energy production from compost-produced methane, a reduction in the usage of fossil fuels, ecosystem restoration, pathogen control, and water recycling (no tractors, plows, or shipping), long-term employment creation, and minimal or no pesticide requirements. Indoor farming's regulated atmosphere ensures optimal growth conditions and offers a great means of achieving economies of scale.

According to Despommier (2010) and others, any crop can theoretically be cultivated in a vertical farming greenhouse. According to Frazier (2017), the reason leafy greens are such a well-liked crop is because they have a large profit margin as opposed to any inherent limitations in crop kinds. Vertical farming has been promoted as an engineering solution to increase agricultural production productivity per area as a result of the expansion of plant culture into the vertical dimension (Eigenbrod and Gruda, 2014).

2.1.1 Productivity of vertical farming

A study on cultivar trials in an organic vertical system was carried out by Nwosisi *et al.* (2017) on the Tennessee State University's Nashville certified organic farm. In the vertical-grow system, several cultivars of lettuce, chard, kale, mustard greens, basil, and coriander were grown and successfully harvested. The plants received organic nutrients from an automated system dubbed "Drip Organics." In the stacked pots, perlite and coco fiber material were employed. It was determined that organic vertical farming had the potential to provide food security, year-round produce, and ease food transportation within urban and semi-urban areas, even though modern organic farming would continue to be a widely used food production method as evidenced by its global acceptance and steady growth.

Al-Chalabi (2015) prepared a paper with the purpose to examine the feasibility and plausibility of the vertical farming concept from 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) conducted a study to build a vertical farm and thereafter explore its economic viability. A 37-floor farm was designed and simulated in Berlin as part of a concurrent engineering study that DLR Bremen started in order to determine the cost of production and market potential of this technology. Due to stacking and several harvests, it produced roughly 3,500 tons of fruits and vegetables and 140 tons of tilapia fillets, 516 times more than was anticipated from a footprint area of 0.25 ha. The total cost of the investment was € 200 million, and it used 3.5 GWh of electricity annually and 80 million liters of water. The cost of the manufactured food per kilogram varied between €3.50 and €4.00. 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) conducted a vertical garden experiment at the Centre for Land Resources of Gadjah Mada University in Yogyakarta, Indonesia. Growing beds or raised beds were the basic building block of an intensive garden. Several of these beds were constructed using 6 levels of 64 m^2 and 4 levels of 41.72 m^2. Organic matter (manure and compost) supplied the nutrients, while treated wastewater provided the water. Then, several fruits (lemon, guava, mango, passion fruit) and vegetables (Chinese cabbage, lettuce, water spinach, and chili red) were planted. The findings indicated that plants that needed the most sunlight, such as fruit and numerous vegetables, were most suited for vertical planting. Crop harvesting and cultivation were made simpler and plants produced in vertical gardens were less susceptible to pests and illnesses. Vertical gardening boosted the aesthetic of the yard and gave the plants proper oxygenation. In general, vertical gardening produced more than conventional plantation techniques did.

2.2 Effect of different growing media

According to an experiment, the media type, MS concentration, and types of growth regulators had a qualitative and quantitative impact on the growth and volatile content of the *Ocimum basilicum* plant. The PGPR boosted the output of biomass (Montfort *et al.*, 2018). According to Befrozfar *et al.* (2013), the combination of PGPRs and humic 9 acid led to the highest essence percentage, essence yield, and plant height.

Rakocy *et al.* (2009) oversaw an experiment in which lettuce and basil seedlings were grown on various types of media. Diverse compost mixtures (fish solids to guinea grass ratios of 80:20, 60:40, and 40:60), coco-vermiculite mix with and without fertilizer (100% soil), 100% fish solids, and a 1:1 mixture of fish solids and sand are also available. On the other hand, plants of sweet basil (*Ocimum basilicum* 'Spicy globe') were cultivated in containers with comparable compost mixtures and fertilized soil (100% soil). According to the results, using compost material produced the best results.

In an experiment on basil that was produced organically, Aboutalebi *et al.* (2013) controlled for cultivar (two local cultivars) and fertilizer sources (solid organic manure, inorganic nutrient solution, and organic nutrient solution). The findings showed that there was little distinction between organic and inorganic nutrient sources. Rashmi *et al.* (2008) looked into the results of biofertilizer inoculation. With the treatment combination of *Glomus fasciculatum*, *Azoto chroccocum*, and *Aspergillus awamori*, each at 2 kg/ha, plants in *O. gratissimum* demonstrated maximum plant height, number of leaves, number of branches, biomass, major and micronutrients, and essential oil content. (Sudhakara *et al.*, 2005).

Peppermint, basil, and dill can be grown in soils contains Cd, Pb, and Cu medium and there was no probability for metal transfer into the oils. Results found that the use of aromatic plants as alternative crops for Cd, Pb, and Cu enriched soils. (Zheljazkov *et al.*, 2006).

Three further trials were examined, employing plastic containers with peat mix bases and sub-watering, in heated greenhouses. A soluble 20-20-20 fertilizer's concentration decreased growth rate (1–5 g/l), with 1 g/l being the optimal concentration. However, the sweet basil showed a strong sensitivity to fertilizer content. The best growth outcomes are produced by 1:1:2 ratios when compared to 1:1:1 and 1:0.25:1.5 ratios, per experiments utilizing varied N, P_2O_5, and K_2O ratios (Tesi *et al.*, 1995).

Cowdung

Indian basil was the subject of research by Singh *et al.* (2014) on integrated nutrition management. In comparison to other treatments, the application of 50% inorganic fertilizers (50:20:20 NPK kg ha^{-1}) plus 50% farm yard manure (10.0 Mg ha^{-1}) resulted in relatively higher fresh herb and essential oil yields. It also increased the post-harvest soil's organic carbon status, available N, P_2O_5, and K_2O by 0.16 percent, 62.4 kg ha^{-1}, 54.7 kg, and 29.3 kg, respectively. Last but not least, combining the application of 50% of each inorganic fertilizer (50:20:20 NPK kg ha^{-1}) and FYM (10.0 Mg ha^{-1}) led to increased yields of herbs and oils as well as improved soil fertility.

At the Horticulture Farm of Sher-e-Bangla Agricultural University,Dhaka, Ferdowsy (2013) conducted an experiment. Four organic manures, namely OM_0: no organic manure, OM_1: cowdung, OM_2: poultry manure, and OM_3: vermicompost, were used in the experiment, along with three spacings, namely S_1 (40 cm 20 cm), S_2 (40 cm 25 cm), and S_3 (40 cm 30 cm). A two-factorial experiment with three replications was set up using a randomized complete block design. Due to the impact of organic manure and spacing at various DATs (days after transplanting), significant variances were observed. In the case of vermicompost, OM_3 produced the highest gross yield (26.71 t/ha), while OM_0 produced the lowest (18.02 t/ha). The OM_3S_2 sample had the highest benefit-cost ratio (2.46), while the OM_0S_1 sample had the lowest (1.78).

Crop yields are increased (Bhatnagar *et al.*, 1983) and soil organic carbon and nutrient content are increased (Saha *et al.*, 2007) by incorporating crop leftovers with cowdung. Akande *et al.* (2006) reported on the effectiveness of cowdung in facilitating the release of phosphate from applied rock phosphate. According to Akande *et al.* (2006), the majority of cowdung, a type of farmyard manure, is the excrement gathered from cattle. It can be used as dry manure or applied to soils as slurry. Cow dung mixed with inorganic nitrogen (N) improved soil acidity, according to Olayinka and Ailenubhi (2001).

Vermicompost

In order to grow organic basil (*Ocimum basilicum* L.) and sweet pepper (*Capsicum annuum* L.), Sharifi *et al.* (2019) examined the availability of nutrients in three vermicompost/peat ratios with or without biochar and/or mycorrhizal fungi inoculation. Three levels of vermicompost/peat ratios (0, 15 and 30% volume basis), two levels of mycorrhizal fungi inoculant (*Glomus intraradices*), and two levels of biochar mixture (at 0 and 10% weight basis) were utilized. In comparison to control, basil uptake increased noticeably at 15 and 30% vermicompost rates, respectively, by 68 and 44%. Basil P absorption increased 2.4 times in low rate and 2.1 times in high rate vermicompost compared to control (142 and 125 vs. 60 mg P), whereas biochar treatment had no effect on the assessed nutritional parameters in basil. Mycorrhizal inoculation increased P absorption from 102 to 116 mg. The total amount of growth media P at harvest was changed in the instance of sweet pepper by the vermicompost/peat rate. The biochar treatment had an effect only on the S concentration in the sweet pepper tissue; mycorrhiza inoculation had no effect on the measures of the sweet pepper. Organic basil can be grown successfully using vermicompost/peat ratios of 15% (v/v) with mycorrhiza inoculant because they provide a balanced amount of nutrients throughout the plant's life cycle.

Sönmez *et al.* (2019) conducted a study to assess the impacts of agricultural waste composts on lettuce quality, yield, and nutrient contents. Composts used in the study were made up of various agricultural wastes, including pruning wastes (PW) and wasted mushroom composts (SMC). The effects of compost on the growth and nutrient content of lettuce were studied after the addition of five different compost medias to the pot soil (1ton ha^{-1}). The study was conducted in the spring and fall, two consecutive seasons. The findings demonstrated that compost applications resulted in more plant growth and yield than the control. For many metrics, Mix1 (80%SMC+20%PW) and Mix2 (70% SMC+30 PW) treatments typically had the greatest values. Results, thus, indicate that improved yield and quality can be obtained by using agricultural waste composts.

An experiment designed by Hewidy *et al.* (2014) to examine how basil grown in a greenhouse or an open field responds to different growing media in terms of growth and oil production. 100% loamy soil and mixtures of 20, 40, 60, and 80% peat moss were employed. In contrast, six different growth media were produced utilizing loamy soil along with 10, 20, or 30% compost or vermicompost. Plants cultivated in compost had two to three times as many shoots as control plants, and their chlorophyll content was substantially lower than that of plants grown in different peat moss medium combinations. The number of lateral stems in basil rose (up to 2-4 times) in substrate combinations with compost added. The effects of vermicompost (application and non-application), humic acid (non-application, seed treatment, and foliar application), and plant growth-promoting bacteria (inoculation and noninoculation) applied to basil were investigated. The maximum wet and dry yield, essence yield, and chlorophyll a, b, and a+ b were seen in the interaction between PGPRs and vermicompost. PGPRs and vermicompost application significantly alter practically every assessed attribute.

The maximum dry matter production (828.79 kg/ha), nutrient content NPK (3.87, 0.81, 1.86%), essential oil percentage (0.44%), and nutrient absorption (31.86, 6.67, 15.41 kg/ha) were produced by the treatment combination of 100% NPK at 60 DAP (Thakur *et al.,* 2011). Dragonhead (*Dracocephalum moldavica* L.) produced the maximum herbage and essential oil yields when applied with a 10 t/ha manure application, 5 t/ha vermicompost application, and a combined application of 10 t/ha manure and 5 t/ha vermicompost (Darzi *et al.*, 2015).

Mamta *et al.* (2012) conducted two distinct field trials to investigate the impact of vermicompost on the development and productivity of brinjal plants. Vermicompost prepared from a combination of cow manure, kitchen trash, and garden waste was used to treat brinjal plants in the field. The test crop's seed germination was significantly impacted by the various treatments. The vermicompost-treated field outperformed the control in terms of plant height, leaf count, and fruit weight, and the fruits on the vermicompost-treated plot were unharmed. According to the study, vermicompost amendments had a variety of benefits on brinjal crops, and we suggest farmers use vermicompost rather than synthetic fertilizers while cultivating brinjal crops. Vermicompost has a very wide variety of microorganisms. In the soil, earthworms continue to multiply beneficial microbes in the billions and trillions. Depending on the type of organic matter present in the soil, earthworms can change the organization of the microbial community (Jack, 2010).

By using half the required amount of fertilizer and applying vermicompost, Pritam *et al.* (2010) demonstrated that they could increase the number of leaves per plant of potatoes when compared to the control. In trials on plants grown in pots, he also found that soil amended with 30% vermicompost led to the most marigold (*Tagetes erecta* L.) blossoms, while soil treated with 40% vermicompost resulted in flowers with the largest diameter. Along with the marigold plants' growth and flowering, it was discovered that the amount of vermicompost had a significant impact on the shoot and root biomass, height, and flower diameter. The growing of significant vegetable crops including tomato (*Lycopersicum esculentus*), eggplant (*Solanumme langona*), and okra (*Abelmoschus esculentus*) using vermicompost has shown extremely good results, according to Agarwal *et al.* (2010).

According to Lazcano *et al.* (2009), the effects of vermicompost have included changes in seedling morphology, such as increased leaf area and root branching of plants. Vermicomposting leachates or water extracts, applied as substrate amendments or foliar sprays, have been shown in several studies to additionally encourage the growth of tomato plants (Tejada *et al.*, 2008) and strawberries (Singh *et al.*, 2010).

According to Hussein *et al.* (2006), compost applications and different plant densities had a particular impact on *Dracocephalum moldavica* L. (dragonhead). The highest compost concentration (39.6 t/ha) and medium separation had a favorable impact on vegetative development and caused essential oil buildup. With percentages greater than or equal to 1%, June saw the highest oil yields in *Rosmarinus officinalis* L., regardless of the growing medium or type of fertilization used in the experiment (Miguel *et al.*, 2007). In coleus, the combination use of FYM @ 15 t, vermicompost @1 t and neem cake @1 t along with bio-fertilizers @10 kg (*Azotobacter chroococum, Bacillus megetarium, Glomus bhagyaraj*) per ha produced in the tallest plant (49.96 cm), plant spread (2635.9 cm^2), leaf area

(9732.45 cm^2), total dry matter/plant (284.25 g), number of tuberous roots/plant (34.23) and dry weight of tubers roots/ha (13.49 t).

Vermicompost are finely-divided, peat like material, with high porosity, aeration, drainage, water holding capacity and microbial activity which make them excellent as soil conditioner and as plant growing media (Rakocy *et al*.,2009). Vermicompost are finely divided peat like materials with high porosity, aeration, drainage, waterholding capacities, and low C: N ratios produced from organic wastes that have been stabilized by interactions between high earthworm densities and microorganisms without passing a thermophilic stage (Dominguez, 2004).

Singh *et al.* (2008) reported that vermicompost increased the yield of strawberries by 32.7 % and also drastically reduced the incidence of physiological disorders like albinism (16.1 - 4.5 %), fruit malformations (11.5 % - 4 %), grey mould (10.4 % - 2.1 %) and diseases like Botrytis rot. By suppressing the nutrient related disorders, vermicompost use increased the yield and quality of marketable strawberry fruits up to 58.6 %. Chamani *et al.* (2008) reported that vermicompost had significant ($P>0.05$) positive effects on flower numbers, leaf growth and shoot fresh and dry weights of crops compared to both control and peat amended media.

Eudrilus eugeniae (Kinberg), a rare earthworm, was used in a field experiment by Ellingsen *et al.* (2008) to create compost made from coirpitches. This vermicompost coirpith was modified with alkaline soil from an industrial site and contrasted with coirpith composted with EM (effective microorganisms) in field plots as a growth medium for the therapeutic plant, *Andrographis paniculata* (Nees). The same compost was successfully altered with garden soil to produce significant plant growth. The current findings imply vermicompost coirpith could be useful for reclaiming soils from industrial areas for the growing of *A. paniculata* in a small nursery.

According to Saha *et al.* (2007), earthworm casts are soil conditioners with a high nutrient bioavailability for plant growth. Vermicompost may improve the nutritional value of various vegetable crops in addition to promoting plant development and productivity (Gutierrez-Miceli *et al.*, 2007). Perennial rye grass (*Lolium perenne* L.) planted in soils amended with 10 to 20% vermicompost had higher chlorophyll content than plants from unamended soils, according to a study by Cheng *et al.*

(2007). The cultivation system into which vermicompost is incorporated, as well as the vermicompost's physical, chemical, and biological characteristics, which vary greatly depending on the original feedstock, the earthworm species used, the production process, a variety of other factors, may all affect how variable its effects are the age of vermicompost (Rodda *et al.*, 2006).

According to Miguel *et al.* (2007), the countless microorganisms that are present and actively growing in the soil are capable of giving crops all the nutrients they require when they need them. Only when there are 108 microbes per cubic centimeter of soil does the soil become alive. For life and growth, these microbial populations require a sufficient amount of organic manures as food. Vermicompost, for instance, an organic source of plant nutrients, has been shown by Nagavallemma *et al.* (2006) to have a larger percentage of nutrients required for plant growth in readily available forms.

Sudhakara (2005) conducted a study and found that application of vermicompost and poultry manure subsequently increase yield attributing characters and yield of broccoli. Vermicompost has been found to have positive effects on some aromatic and medicinal plants (Akande *et al.*, 2006).

Tomato (*L. esculentum* L.) yield has also been shown to be greatly increased by the application of vermicompost at a rate of 5 t ha^{-1}. Vermicompost has also been demonstrated to promote plant flowering, boosting both the quantity and biomass of the flowers that are generated (Abiram *et al.*, 2010) and fruit yield (Singh *et al*., 2014). According to Atiyeh *et al.* (2000), microflora linked with vermicomposting may promote plant growth by causing hormone-like activity on the creation of metabolites.

According to Atiyeh *et al.* (2000), agro-climatic parameters of the growing environment have an impact on the rates of vermicompost added to the soil, which in turn have an impact on plant growth and development. Vermicompost has beneficial effects, such as stimulating the germination of seeds in a variety of plant species, such as tomato plants (Zheljazkov *et al.*, 2006) and petunias (Agarwal *et al.*, 2010). According to an experiment by Abbey *et al*. (2012), tomato plants with vermicompost applied at a rate of 25% had stems that were 11 mm longer and 40 mm wider than the control plants.

Cocopeat

Sweet basil is grown in great amounts by pot culture, as demonstrated by Baeck *et al.* (2001), and the optimal substrate and nutrient solution concentration have been studied. Cocopeat exhibited better growth, however peat moss had a negative effect. The most essential oils were found in sweet basil that was grown on a substrate that had a 1:1 mixture of cocopeat and perlite. Additionally, for better growth and a higher essential oil content, it was suggested that sweet basil be grown with a one-fold concentration of herb nutrient solution in substrate mixed with cocopeat and perlite (1:1, v: v).

Biochar

In an experiment, Yu *et al.* (2019) used biochar made from sugarcane bagasse and mixed hardwood to grow basil and tomato seedlings in containers. PM, P, 70% PM: 30% P, and a commercial propagation mix are all components of mixed hardwood biochar (HB) mixes. A combination of sugarcane bagasse biochar (SBB) has 10%, 30%, 50%, or 70% SBB, 30% perlite (P), and the rest is peat moss (PM). The fresh weight, dry weight, and growth index (GI) of tomato and basil seedlings grown in all of the biochar mixes (apart from 50% HB) were lower than those of a commercial propagation mix. Furthermore, 70% HB for the production of tomato and basil seedlings could be increased with PM without having a negative impact on plant biomass.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used and followed for conducting the experiment presented under the following headings:

3.1 Description of the experimental site

3.1.1 Location

The experiment was conducted on the rooftop of Dr. M. Wazed Mia central laboratory, Sher-e-Bangla Agricultural University, Dhaka, during the period from January 2022 to March 2022. Location of the site was 23°74/N latitude and 90°35/E longitude and at an elevation of 8.2 m from sea level. The map showing the location of experimental site and soil properties under the study in Appendix I and II.

3.1.2 Climate and weather

The experimental site is located in subtropical region where climate is characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during rest of the month (Rabi season). The maximum and minimum temperature, humidity rainfall and soil temperature during the study period are collected from the Sher-e-Bangla Mini weather station (Appendix III).

3.2 Experimental details

3.2.1. Planting materials

The seed of Thai basil were collected from the Siddik bazar, Gulistan, Dhaka, during November, 2021. Then those seed were planted separately in seed beds to grow outdoor for the experiment. Normal intercultural operations were done in those beds.

Then seedlings from different basil plants were collected as per needed.

3.2.2 Vertical structure

The vertical structure for the study was constructed of three stairs like structure with 0.3 cm thickness of steel frame and 0.5 cm thickness of PVC board. Each stair has an area of 35 cm × 35 cm. Each stair lies at a height of 30 cm above the other one. Every stair like steel structure were built to accommodate three growing containers and a total of nine structures were used in this experiment.

3.2.3 Treatments of the experiment

This experiment was conducted to find out the influence of different growing media on the growth and yield of Thai basil plants. The treatments of this experiment were as follows:

Treatment:

1. G_0 = 100 % soil
2. G_1 = 80 % soil + 20 % cowdung
3. G_2 = 60 % soil + 40 % cowdung
4. G_3 = 80 % soil + 20 % vermicompost
5. G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat
6. G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat
7. G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat
8. G_7 = 80 % soil + 10 % vermicompost + 10 % biochar
9. G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar

3.2.4 Collection of cowdung, vermicompost, cocopeat, biochar and soil

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

3.2.5 Nutrient content of cowdung, vermicompost, cocopeat, biochar and soil

The composition of cowdung, vermicompost, cocopeat, field used biochar and soil is shown as tabular form in table 1.

Table 1. Composition of cowdung, vermicompost, cocopeat, biochar and soil

Media	Nutrients			Source
	N (%)	P (%)	K (%)	
Cowdung	0.4-3	0.4-0.8	0.8-1.2	Adegunloye *et al.*, 2007
Vermicompost	2.50-3	1.8-2.9	1.4-2	Nagavallemma *et al.*, 2006
Cocopeat	0.41	0.81	1.32	ACI fertilizer, 2016
Biochar	1.30	0.85	1.00	ACI fertilizer, 2016
Soil	0.03-0.05	0.2-0.3	0.5-1	SRDI, 2013

3.2.6 Design and layout of the experiment

The single-factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The vertical structure for the experiment was constructed of three stairs like structure with 0.3 cm thickness of steel frame and 0.5 cm thickness of PVC board. Each growing containers has an area of 35cm × 35 cm. One stair lies at a height of 30 cm above the other. Each vertical structure contained three growing containers. The measurement of growing container was 35×35×30cm (Figure 1).

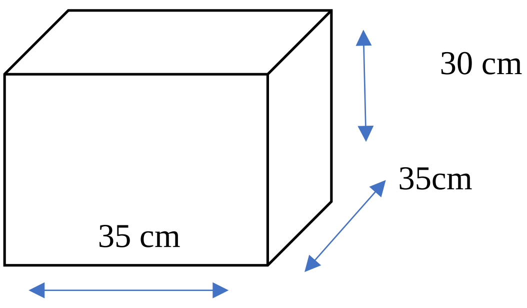

Figure 1. Growing container measurement

3.2.7 Preparation of experimental growing media

Different growing media were used for rooftop vertical farming. The media made with cowdung, vermicompost, cocopeat, biochar and soil combination were used. This growing media mixture has increased water holding capacity, reduced risk of pest and disease, good aeration etc. in rooftop condition. The following combinations of media were prepared and are filled in growing containers for comparing their performance.

Table 2. Different treatments of growing media used for the study

Compositions	Kg/container	Growing containers
100 % soil	10 kg soil	3
80 % soil + 20 % cowdung	8 kg soil + 2 kg cowdung	3
60 % soil + 40 % cowdung	6 kg soil + 4 kg cowdung	3
80 % soil + 20 % vermicompost	8 kg soil + 2 kg vermicompost	3
60 % soil + 20 % vermicompost + 20 % cocopeat	6 kg soil + 2 kg vermicompost + 2 kg cocopeat	3
50 % soil + 30 % vermicompost + 20 % cocopeat	5 kg soil + 3 kg vermicompost + 2 kg cocopeat	3
50 % soil + 40 % vermicompost + 10 % cocopeat	5 kg soil + 4 kg vermicompost + 1 kg cocopeat	3
80 % soil + 10 % vermicompost + 10 % biochar	8 kg soil + 1 kg vermicompost + 1 kg biochar	3
70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar	7 kg soil + 1 kg vermicompost + 1 kg coopeat + 1 kg biochar	3

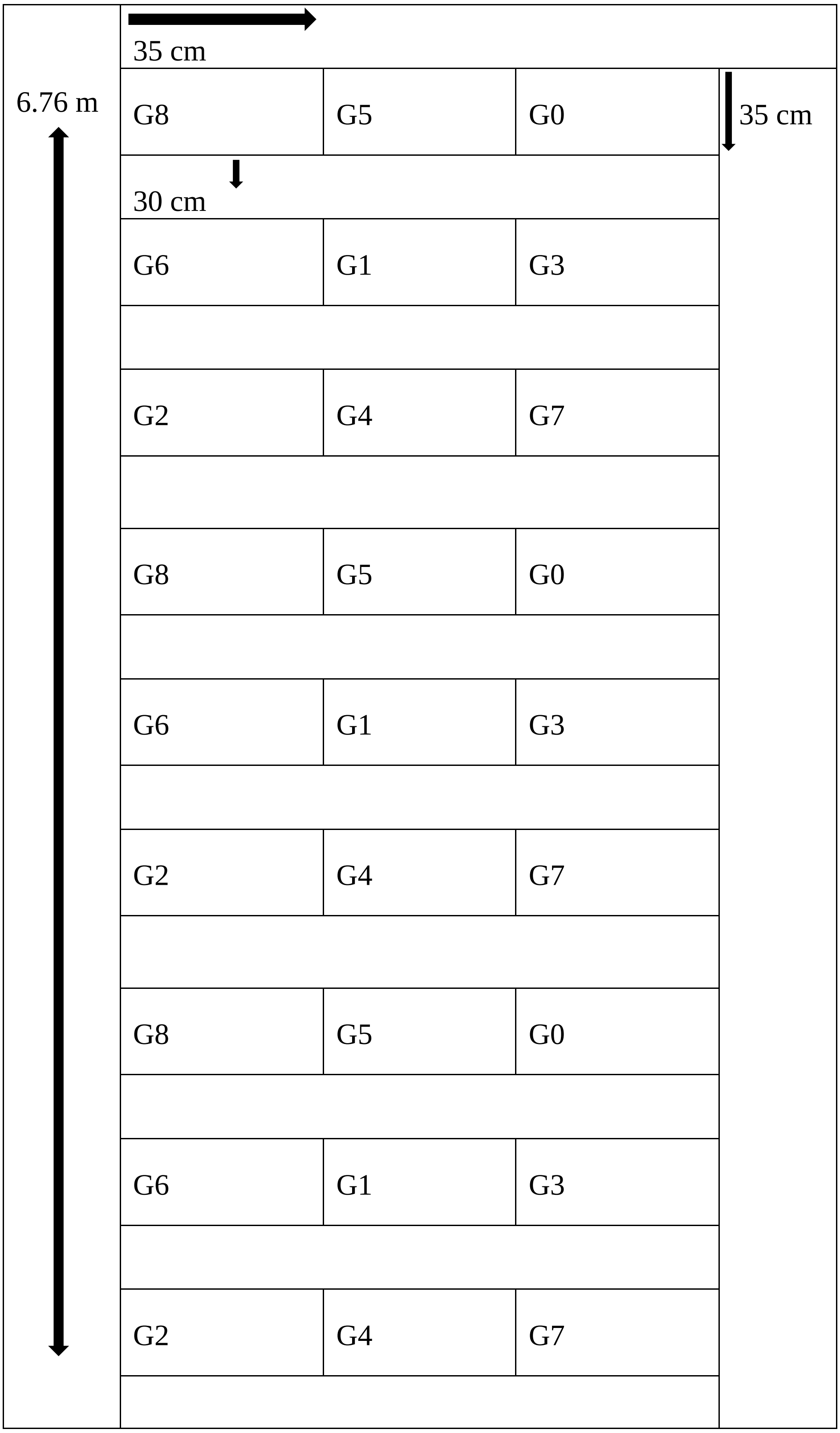

Figure 2. Layout of the experiment

Container size = 35cm ×35cm ×30cm

Spacing between vertical structure = 30 cm

Spacing between replications = 30 cm

Treatments:

1. G_0 = 100 % soil
2. G_1 = 80 % soil + 20 % cowdung
3. G_2 = 60 % soil + 40 % cowdung
4. G_3 = 80 % soil + 20 % vermicompost
5. G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat
6. G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat
7. G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat
8. G_7 = 80 % soil + 10 % vermicompost + 10 % biochar
9. G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar

3.3 Growing of crops

3.3.1 Planting of the seedlings

The stem seedlings were planted on the 10th February, 2022. The seedlings of Thai basil were about 9.0 cm long and about 3.0 cm was kept below the soil.

3.3.2 Intercultural operation

After transplanting weeding, plant protection etc. were accomplished for better growth and development of the Thai basil.

3.3.2.1 Irrigation system

Light watering was provided with water cane immediately after sowing seeds and this technique of irrigation was used as every day at early morning and sometimes also in evening throughout the growing period. Plants were irrigated once in every day. Since the growing media were with high water holding capacity and transpiration is comparatively less small quantity of water is needed.

3.3.2.2 Weeding

The weeding was done every at 15 days interval after transplanting to keep the growing containers free from weeds.

3.3.2.3 Plant protection measures

No disease or insect pests were noted in the rooftop conditions. So, there was no need to control those.

3.3.3 Harvesting

The harvesting was done at 50 days after transplanting (DAT) by uprooting the plants.

3.4 Data collection

For analysing the growth of the Thai basil plants under different treatments total 135 plants were arranged in the experiment. Observations such as plant height and number of leaves, leaf length, leaf breadth were made after every 10 days and the overall growth was assessed over a period of 50 days. The collected data were tabulated and compared separately for each trial. The heights of the selected plants were measured from the surface of the rooting media to the tip of the plant. Numbers of leaves selected plants of each growing containers were counted at an interval of 10 days. Weight of fresh plant, dry weight of plant of Thai basil were measured after harvest.

3.4.1 Plant height

Plant height was measured from all plants from individual container (5 plants) by using meter scale in centimetre from the ground level to the tip of the longest branch at 10 days interval starting from first days after transplanting (DAT) and continued up to 50 DAT i.e. at harvest and their mean value was calculated and expressed in cm.

3.4.2 Number of branch per plant

Number of branch per plant was counted from plants at 10 days interval starting from first days after transplanting (DAT) and continued up to 50 DAT.

3.4.3 Leaf length

Leaf length was measured by centimetre scale. Mature leaf was measured at 10 days interval expressed in cm. Three mature leaves from each plant were measured and then average it after that mean was calculated.

3.4.4 Leaf breadth

Leaf breadth was measured by centimetre scale. Mature leaf was measured at 10 days interval and expressed in centimetres. Three mature leaves from each plant were measured and then average it after that mean was calculated.

3.4.5 Leaf area

Leaf area was measured by centimetre scale. Mature leaf area was measured at 10 days interval and expressed in centimetres. Leaf area of five selected plants per plot were measured in centimeter^2 (cm^2) by multiplying the leaf length with the leaf breadth of each leaf.

Leaf area (cm^2) = Leaf length (cm) × Leaf breadth (cm)

3.4.6 Number of leaves per plant

Number of leaves per plant was counted from plants at 10 days interval starting from 10 days after transplanting (DAT) and continued up to 50 DAT and their mean value was calculated.

3.4.7 Root length

The length of root was measured using a meter scale and was expressed in centimetre (cm).

3.4.8 Shoot length

The length of Shoot was measured using a meter scale and was expressed in centimetre (cm).

3.4.9 Root shoot ratio

The length of root and shoot was measured using a meter scale and Ratio of root to shoot length was measured.

3.4.10 Total weight of plant

All fresh weight of selected plant was measured. Then these were placed on the digital balance for the calculation of weights. At harvest, fresh weight of five plants per plot was weighed by balance and their mean value was calculated as total plant weight was expressed in gram (g).

3.4.11 Fresh weight of leaf

All fresh weight of leaf of selected plant were collected. At harvest, fresh weight of leaf of five plants per container was weighed by balance and their mean value was calculated as plant fresh weight of leaf was expressed in gram (g).

3.4.12 Dry weight of leaf

Leaf from selected plant were collected and kept for drying as a natural condition and after sun drying; Sundry weight of leaves was measured from each treatment and then weighted which expressed as gram (g). 10 leaves of selected plants were cut down and oven dried at temperature of 60°C for 72 hours and was weighed in gram by an electrical balance.

3.4.13 Fresh weight of root

All fresh weight of root of selected plant were collected. At harvest, fresh weight of root of five plants per container was weighed by balance and their mean value was calculated as plant fresh weight of root was expressed in gram (g).

3.4.14 Dry weight of root

Root from selected plant were collected and kept for drying as a natural condition and after sun drying; Sundry weight of root was measured from each treatment and then weighted which expressed as gram (g). Roots from selected plants were cut down and oven dried at temperature of 60°C for 72 hours and was weighed in gram by an electrical balance.

3.4.15 Fresh weight of shoot

All fresh weight of shoot of selected plant were collected. At harvest, fresh weight of shoot of five plants per container was weighed by balance and their mean value was calculated as plant fresh weight of shoot was expressed in gram (g).

3.4.16 Dry weight of shoot

Shoot from selected plant were collected and kept for drying as a natural condition and after sun drying; Sundry weight of shoot was measured from each treatment and then weighted which expressed as gram (g). Shoots from selected plants were cut down and oven dried at temperature of 60°C for 72 hours and was weighed in gram by an electrical balance.

3.4.17 Yield per container

The weight of leaf of 5 plants was counted. The fresh leaf weight of each container was taken separately with electric balance.

3.5 Statistical analysis

The recorded data on different parameters were statistically analysed by using Statistix-10 software to find out the significance of variation resulting from the experimental treatments. The mean values for all the treatments were accomplished by LSD. The significance of difference between pair of means was tested at 5% and 1% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the Improvement of plant growth, nutrient and energy use efficiency of vertically grown Thai basil under different growing media in rooftop garden. Data on different growth, yield contributing parameters, yield and quality parameters of Thai basil were recorded. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

Significant variation was found for plant height of vertically grown Thai basil at different growth stages as influenced by different growing media (Appendix IV). Plant heights were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that plant height increased with the advancement of time up to 50 DAT. The highest plant height at all the growth stages was recorded (17.96, 26.79, 31.26, 35.95 and 40.81 cm) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest plant height was recorded (6.04, 8.27, 10.08, 13.48 and 16.82 cm) in G_0 (100% soil) (Table 3). This finding was also supported by Monfort *et al.* (2018) who demonstrated that the relatively highest values of plant height were recorded for plots fertilized with the highest doses of vermicompost and NPK fertilizers. Effective dose of vermicompost tea hasten the plant growth by secreting important trace elements, antioxidants, bioactive compounds and exopolysaccharides (Crutchfield *et al.,* 2018). Nwosisi *et al.* (2017) reported the balance of nutrients received by plants is critical in supporting plant growth. Excess nutrients can be toxic to plant tissues, whereas a nutrient deficiency can result in stunted growth.

Table 3. Effect of different growing media on the plant height of vertically grown Thai basil at different days after transplanting (DAT)

Treatments	Plant height (cm) at				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
G_0	6.04 e	8.27 g	10.08 f	13.48 h	16.82 g
G_1	8.58 de	11.84 ef	16.63 e	20.92 f	24.59 e
G_2	14.73 ab	21.81 bc	26.87 bc	30.65 c	35.26 b
G_3	10.62 cd	14.24 e	18.98 e	23.62 e	27.19 d
G_4	14.11 abc	20.97 cd	25.74 cd	29.41 c	33.18 c
G_5	16.69 ab	24.21 ab	29.32 ab	33.91 b	37.00 b
G_6	17.96 a	26.79 a	31.26 a	35.95 a	40.81 a
G_7	7.54 de	10.47 fg	12.55 f	15.31 g	19.95 f
G_8	13.24 bc	18.84 d	23.39 d	27.27 d	32.52 c
LSD (0.05)	3.88	2.76	2.78	1.30	2.04
CV (%)	8.46	9.14	7.43	2.92	3.97

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

4.1.2 Branch number

Significant variation was found for branch number of vertically grown Thai basil at different growth stages as influenced by different growing media (Appendix V). Branch number were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that branch number increased with the advancement of time up to 50 DAT.

The highest branch number at all the growth stages was recorded (6.51, 8.35, 10.56, 13.38 and 15.77) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) and statistically similar with G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest branch number was recorded (4.15, 5.46, 6.96, 7.68 and 8.41) in G_0 (100% soil) (Table 4).

Table 4. Effect of different growing media on the branch number of vertically grown Thai basil at different days after transplanting (DAT)

Treatments	**Branch number at**				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
G_0	4.15 g	5.46 h	6.96 g	7.68 i	8.41 f
G_1	4.69 f	6.51 f	8.47 e	10.29 g	12.22 d
G_2	5.93 bc	7.9 b	9.92 b	12.02 c	14.31 b
G_3	5.1 e	6.82 e	8.93 d	10.91 f	12.72 d
G_4	5.75 c	7.43 c	9.49 c	11.83 d	13.97 bc
G_5	6.12 b	8.09 b	10.12 b	13.08 b	15.29 a
G_6	6.51 a	8.35 a	10.56 a	13.38 a	15.77 a
G_7	4.47 f	5.92 g	7.74 f	9.17 h	11.08 e
G_8	5.42 d	7.18 d	9.13 cd	11.24 e	13.54 c
LSD (0.05)	0.23	0.24	0.41	0.17	0.5
CV (%)	2.57	1.96	2.59	2.87	2.22

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 1% biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

4.1.3 Leaf length

Significant variation was found for leaf length of vertically grown Thai basil at different growth stages as influenced by different growing media (Appendix VI). Leaf length were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that leaf length increased with the advancement of time up to 50 DAT. The highest leaf length at all the growth stages was recorded (4.72, 5.65, 6.42, 6.80 and 7.38 cm) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) which is statistically similar with G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat) treatment. In contrast, the lowest leaf length was recorded (2.25, 2.95, 3.25, 3.54 and 3.92 cm) in G_0 (100% soil) (Table 5).

Table 5. Effect of different growing media on the leaf length of vertically grown Thai basil at different days after transplanting (DAT)

Treatments	Leaf length (cm) at				
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
G_0	2.25 f	2.95 g	3.25 f	3.54 h	3.92 h
G_1	2.62 e	3.59 ef	4.33 e	4.54 f	4.92 g
G_2	3.65 b	4.82 b	5.78 b	6.10 c	6.57 c
G_3	2.94 d	3.90 de	4.92 d	5.13 e	5.51 f
G_4	3.21 c	4.36 c	5.44 c	5.92 c	6.28 d
G_5	3.82 b	5.01 b	6.17 ab	6.57 b	7.08 b
G_6	4.72 a	5.65 a	6.42 a	6.80 a	7.38 a
G_7	2.42 ef	3.27 fg	4.07 e	4.33 g	4.77 g
G_8	3.04 cd	4.01 cd	5.12 d	5.62 d	5.96 e
LSD (0.05)	0.27	0.41	0.27	0.18	0.27
CV (%)	4.84	5.68	3.09	1.95	2.68

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20

% cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

4.1.4 Leaf breadth

Significant variation was found for leaf breadth of vertically grown Thai basil at different growth stages as influenced by different growing media (Appendix VII). Leaf breadth were measured at 10, 20, 30, 40 and 50 DAT. It is observed that leaf breadth increased with advancement of time up to 50 DAT. The highest leaf breadth at all growth stages was recorded (2.22, 2.43, 2.79, 3.02 and 3.39 cm) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest leaf breadth was recorded (1.09, 1.22, 1.39, 1.53 and 1.64 cm) in G_0 (100% soil) (Table 6).

Table 6. Effect of different growing media on the leaf breadth of vertically grown Thai basil at different days after transplanting (DAT)

Treatments	**Leaf breadth (cm) at**				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
G_0	1.09 f	1.22 g	1.39 h	1.53 h	1.64 g
G_1	1.32 de	1.42 ef	1.59 g	1.73 g	1.94 f
G_2	1.81 b	2.01 b	2.28 c	2.51 c	2.76 c
G_3	1.40 cd	1.53 de	1.76 f	1.90 f	2.01 f
G_4	1.57 c	1.81 c	2.09 d	2.35 d	2.58 d
G_5	2.05 a	2.14 b	2.47 b	2.71 b	3.04 b
G_6	2.22 a	2.43 a	2.79 a	3.02 a	3.39 a
G_7	1.17 ef	1.35 fg	1.51 g	1.62 gh	1.71 g
G_8	1.48 cd	1.65 d	1.93 e	2.13 e	2.29 e
LSD (0.05)	0.18	0.15	0.10	0.11	0.13
CV (%)	6.76	4.86	2.89	3.19	3.28

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

4.1.5 Leaf area

Significant variation was found for leaf area of vertically grown Thai basil at different growth stages as influenced by different growing media (Appendix IX). Leaf area were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that leaf area increased with the advancement of time up to 50 DAT. The highest leaf area at all the growth stages was recorded (10.47, 13.77, 17.91, 20.53 and 25.03 cm^2) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest leaf area was recorded (2.45, 3.61, 4.53, 5.43 and 6.43 cm^2) in G_0 (100% soil) (Table 7). The data analysis of growing stage tabulated that the leaf area was constantly increased as the elapsed, but with significant changes. Crutchfield *et al.* (2018) stated that good compost could be fostering the nutrients to the plants that enhanced biomass production and overall growth performance. In agreement with this result, Darzi *et al.,* (2015) stated that vermicompost tea produced significant improvements in leaf area in the vegetable crop.

Table 7. Effect of different growing media on the leaf area of vertically grown Thai basil at different days after transplanting (DAT)

Treatments	Leaf area (cm^2)at				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
G_0	2.45 f	3.61 g	4.53 h	5.43 h	6.43 i
G_1	5.03 d	5.10 ef	6.89 g	7.85 g	9.54 g
G_2	6.61 c	9.71 b	13.17 c	15.31 c	18.14 c
G_3	4.12 e	5.97 de	8.67 f	9.57 f	11.07 f
G_4	5.03 d	7.91 c	11.36 d	13.91 d	16.22 d
G_5	7.84 b	10.76 b	15.26 b	17.81 b	21.55 b
G_6	10.47 a	13.77 a	17.91 a	20.53 a	25.03 a
G_7	2.62 f	4.41 fg	6.15 g	7.01 g	8.17 h
G_8	4.50 de	6.59 d	9.86 e	11.68 e	13.65 e
LSD (0.05)	0.71	1.30	0.77	0.90	1.04
CV (%)	7.70	9.98	4.24	4.27	4.17

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

4.1.6 Leaf number

Significant variation was found for leaf number of vertically grown Thai basil at different growth stages as influenced by different growing media (Appendix VIII). Leaf number were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that leaf number increased with the advancement of time up to 50 DAT. The highest leaf number at all the growth stages was recorded (29.94, 54.76, 76.42, 97.92 and 123.28) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat followed) G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest leaf number was recorded (11.65, 17.48, 25.28, 36.12 and 49.18) in G_0 (100% soil) (Table 8). According to Sharifi *et al.* (2019), the increase in leaves number and size was depend on the supplied nutrition. The nutrient absorption capacity of the plant enhanced root development and increased translocation of carbohydrates from source to the growing points. With good nutrients and conditions, plant was progressing from earlier to the later stage by cell division and enlargement with the increasing of growing stage (Monfort, 2018). Moreover, this finding was supported by Singh *et al.* (2014) who reported increases in leaf number with increasing doses of organic and inorganic fertilizers applied.

Table 8. Effect of different growing media on the leaf number of vertically grown Thai basil at different days after transplanting (DAT)

Treatments	Leaf number at				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
G_0	11.65 f	17.48 e	25.28 h	36.12 h	49.18 h
G_1	13.83 ef	24.17 d	41.83 f	54.17 f	72.06 f
G_2	23.29 bc	42.84 b	60.46 bc	79.12 c	97.69 bc
G_3	15.18 e	33.57 c	46.54 ef	63.08 e	84.00 e
G_4	20.64 cd	36.19 c	55.12 cd	72.57 d	94.18 cd
G_5	25.51 b	47.65 b	65.23 b	85.26 b	101.51 b
G_6	29.94 a	54.76 a	76.42 a	97.92 a	123.28 a
G_7	12.14 ef	20.22 de	30.92 g	41.83 g	57.64 g
G_8	18.73 d	33.57 c	51.72 de	67.75 de	88.15 de
LSD (0.05)	3.11	4.94	5.50	4.93	6.62
CV (%)	9.47	8.27	6.31	4.28	4.48

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost

+ 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

4.1.7 Root length

Root length of Thai basil significantly differed among the different growing media (Appendix X). From result it is observed that the highest root length of plant (25.65 cm) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) which is statistically similar to (25.65 cm) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest root length of plant (14.57 cm) was recorded from G_0 (100% soil) (Table 9).

4.1.8 Shoot length

Shoot length of Thai basil significantly differed among the different growing media (Appendix X). From result it is observed that the highest shoot length of plant (31.47 cm) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (29.01 cm) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest shoot length of plant (13.20 cm) was recorded from G_0 (100% soil) (Table 9).

4.1.9 Root-shoot ratio

Root-shoot ratio of Thai basil significantly differed among the different growing media (Appendix X). In Table 9, it is observed that the highest root- shoot ratio of plant (1.11) was recorded from G_0 (100% soil) followed by (1.07) from G_7 (80 % soil + 10 % vermicompost + 10 % biochar). In contrast, the lowest root- shoot ratio of plant (0.82) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) (Figure 3).

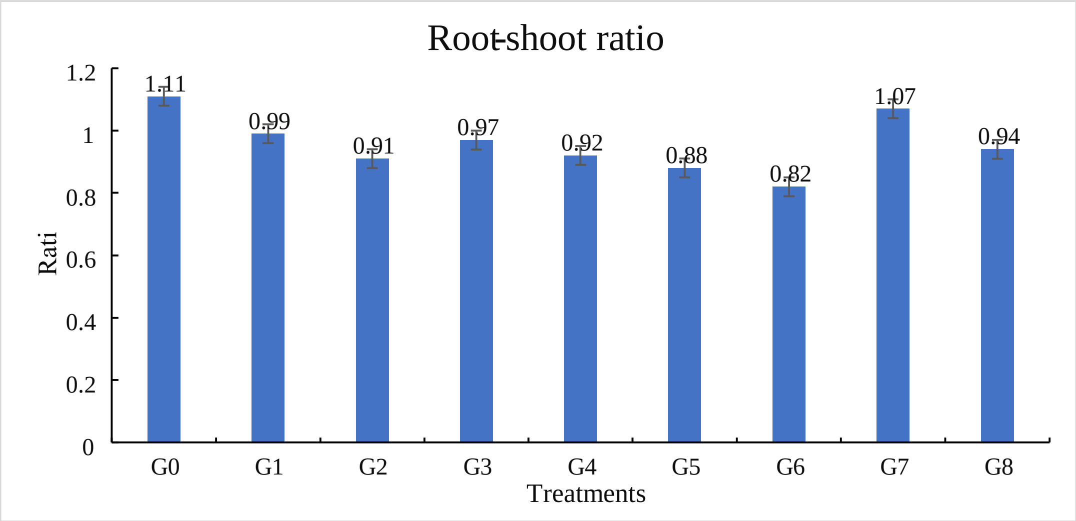

Figure 3. Effect of different growing media on root-shoot ratio of vertically grown Thai basil

Table 9. Effect of different growing media on root length, shoot length and root-shoot ratio of vertically grown Thai basil

Treatments	Root length (cm)	Shoot length (cm)	Root-shoot ratio
G_0	14.57 c	13.20 f	1.11 a
G_1	18.62 b	18.87 de	0.99 abc
G_2	24.53 ab	27.03 bc	0.91 cd
G_3	19.39 b	19.99 d	0.97 bc
G_4	24.05 ab	26.13 bc	0.92 cd
G_5	25.65 a	29.01 ab	0.88 cd
G_6	25.65 a	31.47 a	0.82 d
G_7	17.67 b	16.65 e	1.07 ab
G_8	22.72 ab	24.25 c	0.94 cd
LSD (0.05)	2.97	2.94	0.12
CV (%)	8.01	7.41	7.45

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 %

soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

4.1.10 Total weight of plant

Total fresh weight of plant of Thai basil significantly differed among the different growing media (Appendix X). From result it is observed that the highest total fresh weight of plant (139.83 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by 131.27 g from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total fresh weight of plant (87.67 g) was recorded from G_0 (100% soil) (Table 10).

4.1.11 Leaf fresh weight

Total leaf fresh weight of plant of Thai basil significantly differed among the different growing media (Appendix XI). From result it is observed that the highest total leaf fresh weight of plant (45.56 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (43.86 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total leaf fresh weight of plant (24.49 g) was recorded from G_0 (100% soil) (Table 10).

4.1.12 Leaf dry weight

Total leaf dry weight of plant of Thai basil significantly differed among the different growing media (Appendix XI). From result it is observed that the highest total leaf dry weight of plant (11.52 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) which is statistically similar with (11.05 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat) treatment. In contrast, the lowest total leaf dry weight of plant (6.15 g) was recorded from G_0 (100% soil) (Table 10).

Table 10. Effect of different growing media on total weight of plant and leaf fresh and dry weight of vertically grown Thai basil

Treatments	Total weight of plant (g)	Leaf fresh weight (g)	Leaf dry weight (g)
G_0	87.67 g	24.49 g	6.15 g
G_1	93.23 f	30.33 f	7.69 f
G_2	117.40 c	39.04 b	10.23 bc
G_3	98.87 e	32.70 e	8.16 ef
G_1	109.63 d	36.75 c	9.66 cd
G_5	131.27 b	43.86 a	11.05 ab
G_6	139.83 a	45.56 a	11.52 a
G_7	90.70 f	26.28 g	6.66 g
G_8	101.57 e	34.86 d	8.97 de
LSD (0.05)	2.81	1.82	0.98
CV (%)	1.51	3.02	6.36

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost

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4.1.13 Shoot fresh weight

Total shoot fresh weight of plant of Thai basil significantly differed among the different growing media (Appendix XI). From result it is observed that the highest total shoot fresh weight of plant (93.19 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (87.52 g) from G5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total shoot fresh weight of plant (58.44 g) was recorded from G_0 (100% soil) (Table 11).

4.1.14 Root fresh weight

Total root fresh weight of plant of Thai basil significantly differed among the different growing media (Appendix XI). From result it is observed that the highest total root fresh weight of plant (21.24 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (20.13 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total root fresh weight of plant (13.14 g) was recorded from G_0 (100% soil) (Table 11).

4.1.15 Root dry weight

Total root dry weight of plant (g) of Thai basil significantly differed among the different growing media (Appendix XI). From result it is observed that the highest total root dry weight of plant (5.58 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (5.12 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total root dry weight of plant (2.93 g) was recorded from G_0 (100% soil) (Table 11).

Table 11. Effect of different growing media on shoot and root fresh and dry weight of vertically grown Thai basil

Treatments	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)
G_0	58.44 i	15.79 h	13.14 h	2.93 g
G_1	62.19 h	16.81 g	15.33 f	3.83 ef
G_2	78.85 c	21.31 c	19.52 b	4.65 bc
G_3	65.91 g	17.78 f	16.20 e	3.94 de
G_4	73.09 d	19.75 d	18.21 c	4.51 c
G_5	87.52 b	23.65 b	20.13 b	5.12 ab
G_6	93.19 a	25.19 a	21.24 a	5.58 a
G_7	60.88 e	16.45 g	14.32 g	3.42 fg
G_8	67.71 f	18.30 e	17.37 d	4.39 cd
LSD (0.05)	1.70	0.47	0.79	0.51
CV (%)	1.36	1.38	2.64	6.92

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

4.2 Yield per container

Yield per container of Thai basil (only leaf as consumable plant parts) significantly differed among the different growing media (Appendix XII). From result it is observed that the highest leaf yield per container (0.26 kg) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (0.23 kg) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest leaf yield per container (0.11 kg) was recorded from G_0 (100% soil) (Table 12). Vermicompost has also been shown to stimulate plant flowering, increasing the number and biomass of the flowers produced (Abiram *et al.*, 2010), as well as increasing fruit yield (Singh *et al.*, 2014). Abbey *et al.* (2012) argued that growth promotion of plants may be due to micro flora associated with vermicomposting that induce hormone-like activity on the production of metabolites.

Table 12. Effect of different growing media on yield of vertically grown Thai basil

Treatments	Yield per container (kg)
G_0	0.11 e
G_1	0.15 cd
G_2	0.20 b
G_3	0.17 bc
G_4	0.19 b
G_5	0.23 a
G_6	0.26 a
G_7	0.13 de
G_8	0.18 bc
LSD (0.05)	0.03
CV (%)	10.21

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

[G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out in the rooftop structure of Dr. M. Wazed Mia Central Laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from January 2022 to March 2022 to find out the effect of different growing media on Thai basil varieties in rooftop vertical farm. The experiment consisted of single factor; G_0 = 100 % soil, G_1 = 80 % soil + 20 % cowdung, G_2 = 60 % soil + 40 % cowdung, G_3 = 80 % soil + 20 % vermicompost, G_4 = 60 % soil + 20 % vermicompost + 20 % cocopeat, G_5 = 50 % soil + 30 % vermicompost + 20 % cocopeat, G_6 = 50 % soil + 40 % vermicompost + 10 % cocopeat, G_7 = 80 % soil + 10 % vermicompost + 10 % biochar and G_8 = 70 % soil + 10 % vermicompost + 10 % cocopeat + 10 % biochar. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data were recorded for different growth and yield parameters and significant variation was recorded for different treatment. The collected data were statistically analysed for evaluation of the treatment effect.

Significant variation was found for plant height of vertically grown Thai basil at different growth stages as influenced by different growing media. Plant heights were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that plant height increased with the advancement of time up to 50 DAT. The highest plant height at all the growth stages was recorded (17.96, 26.79, 31.26, 35.95 and 40.81 cm) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest plant height was recorded (6.04, 8.27, 10.08, 13.48 and 16.82 cm) in G_0 (100% soil).

Branch number were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that branch number increased with the advancement of time up to 50 DAT. The highest branch number at all the growth stages was recorded (46.51, 8.35, 10.56, 13.38 and 15.77) in G_6 (50 % soil + 40 % vermicompost + 10 %

cocopeat) and statistically similar with G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest branch number was recorded (4.15, 5.46, 6.96, 7.68 and 8.41) in G_0 (100% soil).

Leaf length were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that leaf length increased with the advancement of time up to 50 DAT. The highest leaf length at all the growth stages was recorded (4.72, 5.65, 6.42, 6.80 and 7.38 cm) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) which is statistically similar with G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat) treatment. In contrast, the lowest leaf length was recorded (2.25, 2.95, 3.25, 3.54 and 3.92 cm) in G_0 (100% soil).

Leaf breadth were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that leaf breadth increased with the advancement of time up to 50 DAT. The highest leaf breadth at all the growth stages was recorded (2.22, 2.43, 2.79, 3.02 and 3.39 cm) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest leaf breadth was recorded (1.09, 1.22, 1.39, 1.53 and 1.64 cm) in G_0 (100% soil).

Leaf area were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that leaf area increased with the advancement of time up to 50 DAT. The highest leaf area at all the growth stages was recorded (10.47, 13.77, 17.91, 20.53 and 25.03 cm^2) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest leaf area was recorded (2.45, 3.61, 4.53, 5.43 and 6.43 cm^2) in G_0 (100% soil).

Leaf number were measured at 10, 20, 30, 40 and 50 DAT. From the table it is observed that leaf number increased with the advancement of time up to 50 DAT. The highest leaf number at all the growth stages was recorded (29.94, 54.76, 76.42, 97.92 and 123.28) in G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat followed) G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest leaf number was recorded (11.65, 17.48, 25.28, 36.12 and 49.18) in G_0 (100% soil). From result it is observed that the highest root length of plant (25.65

cm) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) which is statistically similar to (25.65 cm) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest root length of plant (14.57 cm) was recorded from G0 (100% soil).

Shoot length (cm) of Thai basil significantly differed among the different growing media (Table 7). From result it is observed that the highest shoot length of plant (31.47 cm) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (29.01 cm) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest shoot length of plant (13.20 cm) was recorded from G_0 (100% soil). Root-shoot ratio (cm) of Thai basil significantly differed among the different growing media (Table 7). From result it is observed that the highest root- shoot ratio of plant (1.11) was recorded from G_0 (100% soil) followed by (1.07) from G_7 (80 % soil + 10 % vermicompost + 10 % biochar). In contrast, the lowest root- shoot ratio of plant (0.82) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat). From result it is observed that the highest total fresh weight of plant (139.83 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by 131.27 g from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total fresh weight of plant (87.67 g) was recorded from G_0 (100% soil).

From result it was observed that the highest total leaf fresh weight of plant (45.56 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (43.86 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total leaf fresh weight of plant (24.49 g) was recorded from G_0 (100% soil).

From result it was observed that the highest total leaf dry weight of plant (11.52 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) which is statistically similar with (11.05 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat) treatment. In contrast, the lowest total leaf dry weight of plant (6.15 g) was recorded from G_0 (100% soil).

From result it was observed that the highest total shoot fresh weight of plant (93.19 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (87.52 g) from G5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total shoot fresh weight of plant (58.44 g) was recorded from G_0 (100% soil). From result it is observed that the highest total shoot dry weight of plant (25.19 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (23.65 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total shoot dry weight of plant (15.79 g) was recorded from G_0 (100% soil).

From result it was observed that the highest total root fresh weight of plant (21.24 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (20.13 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total root fresh weight of plant (13.14 g) was recorded from G_0 (100% soil). From result it is observed that the highest total root dry weight of plant (5.58 g) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (5.12 g) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest total root dry weight of plant (2.93 g) was recorded from G_0 (100% soil).

From result it was observed that the highest leaf yield per container (0.26 kg) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (0.23 kg) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat). In contrast, the lowest leaf yield per container (0.11 k g) was recorded from G_0 (100% soil).

Conclusion

Considering the above-mentioned findings, it may be concluded that in rooftop condition, combination of cocopeat, vermicompost and soil media was most effective for vegetative growth as well as quantitative yield Thai basil plants. Considering the yield performance, Thai basil showed the highest leaf yield per container (0.26 kg) was recorded from G_6 (50 % soil + 40 % vermicompost + 10 % cocopeat) followed by (0.23 kg) from G_5 (50 % soil + 30 % vermicompost + 20 % cocopeat).

Scope for the further studies includes the following.

1. Studies using different plants and cultivation techniques such as hydroponics, aquaponics, aeroponics etc.
2. Studies using different growing media and longer period of study could be explored before drawing valid conclusion.
3. Studies on automation of irrigation and lighting system.

Recommendations

Considering the findings of the present experiment, further studies in the following areas may be suggested

1. More research should be done through soil + vermicompost + cocopeat and other species of basil before the large-scale vertical farming in rooftop.
2. Chemical analysis of leaves may be considered which is suggested for further experiment.
3. The study might be conducted at the same Agro-Ecological Condition for the conformation of the result.
4. Further study should be needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment

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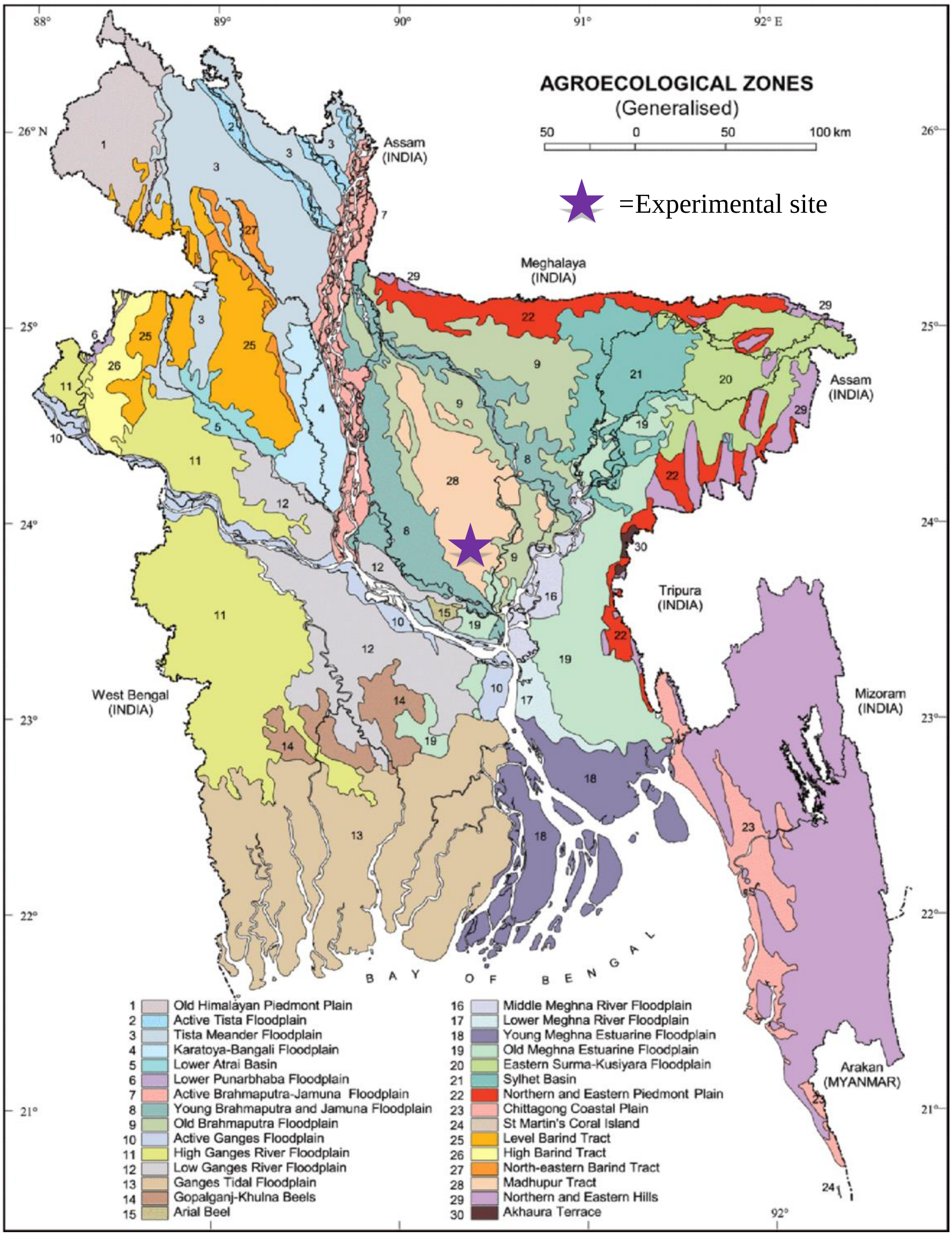
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of experimental site

A. Morphological characteristics of the experimental site

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Horticulture research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly levelled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	Value
pH	5.9
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 III. Monthly meteorological information during the period from January to April, 2022

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2022	January	25.2	12.8	69	00
	February	27.3	16.9	66	39
	March	31.7	19.2	57	23
	April	33.50	25.90	64.50	119

Source: Meterological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance on the plant height of vertically grown Thai basil

Source of variation	D.F.	Mean square of plant height (cm) at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replications	2	8.523	0.324	0.855	5.961	3.881
Treatments (G)	8	52.384**	127.844**	167.706**	186.595**	195.400**
Error	16	5.046	2.554	2.587	0.561	1.390

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix V. Analysis of variance on the branch number of vertically grown Thai basil

Source of variation	D.F.	Mean square of branch number at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replications	2	0.009	0.009	0.034	0.019	0.039
Treatments (G)	8	1.818**	2.285**	3.208**	3.577**	3.914**
Error	16	0.024	0.056	0.024	0.011	0.024

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VI. Analysis of variance on the leaf length of vertically grown Thai basil

Source of variation	D.F.	Mean square of Leaf length (cm) at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replications	2	0.010	0.012	0.001	0.007	0.002
Treatments (G)	8	0.450**	0.484**	0.663**	0.802**	1.114**
Error	16	0.011	0.007	0.003	0.005	0.006

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VII. Analysis of variance on the leaf breadth of vertically grown Thai basil

Source of variation	D.F.	Mean square of Leaf breadth (cm) at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replications	2	0.039	0.056	0.008	0.089	0.164
Treatments (G)	8	1.932**	2.927**	4.058**	9.978**	15.472**
Error	16	0.019	0.019	0.055	0.009	0.084

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VIII. Analysis of variance on the leaf number of vertically grown Thai basil

Source of variation	D.F.	Mean square of Leaf number at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replications	2	0.121	1.337	11.238	4.770	30.140
Treatments (G)	8	122.113**	471.736**	795.333**	1211.810**	1572.200**
Error	16	3.234	8.139	10.107	8.100	14.610

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IX. Analysis of variance on the leaf area of vertically grown Thai basil

Source of variation	D.F.	Mean square of Leaf area(cm^2) at				
		10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
Replications	2	0.309	0.315	0.167	0.517	0.279
Treatments (G)	8	19.575**	33.228**	58.795**	79.551**	119.684**
Error	16	0.173	0.567	0.196	0.268	0.362

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix X. Analysis of variance Total weight of plant, Root length, Shoot length and Root-shoot ratio of vertically grown Thai basil

Source of variation	D.F.	Mean square of			
		Total weight of plant (g)	**Root length (cm)**	**Shoot length (cm)**	**Root-shoot ratio**
Replications	2	1.160	0.149	0.063	0.002
Treatments (G)	8	1012.860**	47.628**	111.698**	0.025**
Error	16	2.640	2.948	2.891	0.005

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix XI. Analysis of variance on fresh and dry weight of vertically grown Thai basil

Source of variation	D.F.	Mean square of					
		Leaf fresh weight (g)	**Leaf dry weight (g)**	**Shoot fresh weight (g)**	**Shoot dry weight (g)**	**Root fresh weight (g)**	**Root dry weight (g)**
Replications	2	12.962	2.214	0.145	0.014	1.279	1.390
Treatments (G)	8	158.641**	10.666**	448.926**	32.840**	22.697**	2.056**
Error	16	1.109	0.321	0.962	0.072	0.209	0.087

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix XII. Analysis of variance on yield of vertically grown Thai basil

Source of variation	D.F.	Mean square of
		Leaf yield per container (kg)
Replications	2	7.000
Treatments (G)	8	6.717**
Error	16	3.333

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

PLATES

Plate 1. Seed bed preparation and seed sowing.

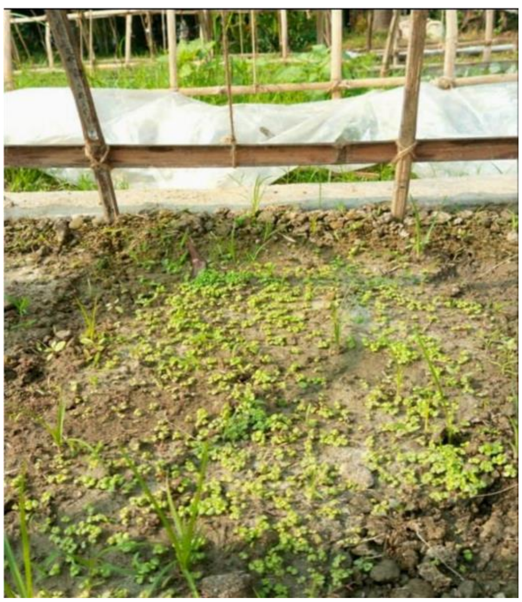


Plate 2. Seed germination

Plate 3. Media preparation

Plate 4. Data collection.