EFFECT OF DIFFERENT GROWING MEDIA ON BASIL VARIETIES IN SIMULATED INDOOR VERTICAL FARM

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CERTIFICATE

This is to certify that the thesis entitled **'EFFECT OF DIFFERENT GROWING MEDIA ON BASIL VARIETIES IN SIMULATED INDOOR VERTICAL FARM'** 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 results of a piece of bona fide research work carried out by **TUNAJJINA KAWSAR**, Registration No. **14-05920** 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, 2021
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Dedicated
to my beloved
Parents

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The Authoress

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ABSTRACT

The present experiment was conducted in the indoor farm of Dr. M. Wazed Mia Central Laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2020 to April 2021 to evaluate the effect of growing media on basil varieties in simulated indoor vertical farm. The experiment consisted of two factors; Factor A: Growing media (3 levels) as- M_1- cocopeat (20%) + vermicompost (70%) + soil (10%), M_2- vermicompost (90%) + soil (10%), M_3- biochar (10%) + vermicompost (80%) + soil (10%) and Factor B: Variety (2 levels) as- V_1- Italian sweet basil and V_2- Holy basil. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Different growing media and varieties significantly influenced on different growth, yield parameter and nutrients of basil. In case of growing media, the highest plant height (39.08 cm), the number of leaves/plant (86.67), the length of leaf (9.37 cm), leaf breadth (5.33 cm), fresh weight (147.83 g) and dry weight (69.62 g), oil content (1.23%) were found from M_1 and those were minimum in M_3. Considering the varieties, V_2 produced the highest plant (33.26 cm), leaf number (68.11), fresh weight (127.76 g) and dry weight (54.57 g). Moreover, the highest length of leaf (9.92 cm), leaf breadth (5.72 cm), essential oil content (1.17%) were from V_1. Regarding the combined effect, the highest plant height (43.60 cm), leaf number (100.33), fresh weight (159.49 g) and dry weight (74.78 g) were observed from M_1V_2 and the lowest plant height (16.27 cm), fresh weight (90.09 g) and dry weight (23.46 g) were observed from M_3V_1. However, M_1 gave highest results in P (1.11%), K (1.93%), Na (0.68%) and S (0.67%) and M_3 gave the lowest results. In variety, P (0.92%) and S (0.63%) content were highest in V_1, lowest in V_2. Furthermore, K (1.62%) and Na (0.63%) content were highest in V_2, lowest in V_1. In combination, the maximum P (1.3%), and S (0.71%) content in basil were found in M_1V_1; minimum P in M_3V_2 and S in M_3V_2. On the contrary, Maximum K (2.2%) and Na (0.76%) were found in M_1V_2, minimum in M_3V_1. The results showed that the use of vermicompost with cocopeat increased the growth, oil and nutrients in both basils.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACRONYM	ABBREVIATION
CV	Coefficient of Variance
Cm	Centimeter
DAT	Days After Transplanting
et al	and others
G	Gram (s)
Hortc.	Horticulture
i.e.	*id est* (L), that is
J.	Journal
Kg	Kilogram
K	Potassium
LED	Light Emitting Diode
LSD	Least Significant Difference
ml	milliliter
Na	Sodium
PPFD	Photosynthetic Photon Flux Density
P	Phosphorus
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
$t\ ha^{-1}$	Ton per hectare
RCBD	Randomized Completely Block Design
%	Percentage
@	At the rate

CHAPTER I

INTRODUCTION

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INTRODUCTION

Basil is an annual, or sometimes perennial, herb used for its leaves. Basil is cultivated worldwide as a culinary herb, it is also a source of essential oil for use in foods, flavors and fragrances as well as garden ornamental. Basil is native to tropical regions from central Africa to Southeast Asia. It is a tender plant, and is used in cuisines worldwide often referred to as the "King of the herbs". More than 150 species are cultivated in the world. Italian sweet basil (*Ocimum basilicum*) and Holy basil (*Ocimum tenuiflorum*) belongs to culinary herb of the family Lamiaceae. Holy basil is popularly known as "Tulsi" in Bangladesh. In recent years basil (*Ocimum basilicum* L.) production has increased due to its high value, popularity and demand. Bangladesh is rich in medicinal plant (Ghani, 2002) & there are about 5000 species of plant in Bangladesh (ICUN, 2003). Basil (*Ocimum* spp.) species, which have been used for centuries as spices and medicinal plants, contain essential oils, responsible for characteristic aromas, and other non-volatile components, such as rosmarinic acid (Koroch *et al*., 2010). Basil produced for dried leaf and fresh markets rank second and third, respectively (Kopsell *et al*., 2005). It is widely used species in cosmetics, perfumery and in the preparation of foods, including pesto sauce and soft drinks.

It is also evident that, basil is commercially produced in the field, greenhouse and soilless system (Craker *et al*., 2003). Similar to many other aromatic plants of the same species, different accessions of holy basil could be expected to produce essential oils with differences in chemical composition (Putievsky *et al*., 1999). Herbs are plants valued for their medicinal and aromatic properties. Research reports have shown that herbs play vital roles as source of food and maintenance of good health (Burkil, 1997).

The leaves of basil are often harvested from crop field at different stages of pant growth and used extensively, either fresh or dried as spice to add distinctive aroma and flavor to food and as medicine, sometimes essential oils extracted from their leaves are important in beverage, cosmetics and allied industries. The minerals obtained from basil and peppermint contributes to their medicinal importance which is a potent goal for which they are planted (Ogden and Ellen, 1990). These minerals, however, are reported to vary with crop age and nutrient uptake of the plant among other factors (Osuagwu, 2008). Most of its production are in open fields in all over the world. However, the yield and quality of essential oils and phenolics of basil grown outdoors is hard to control and its phytochemical concentration varies widely with cultivation location, season, and cultivar (Fischer *et al*., 2011; Hassanpouraghdam *et al*., 2010).

Currently, vertical farming systems, also called plant factories, are indoor growth facilities with plants grown in multiple layers. In a vertical farm, plants are grown in a closed system without the use of pesticides and all climate factors can be controlled (SharathKumar *et al*., 2020). Light is the primary source of energy for plants and the dominant light source in a vertical farm is light emitting diodes (LEDs) which makes a vertical farm efficient and allows for year-round production. LEDs are energy efficient; they have a low heat emission, the light intensity can be adjusted and light spectra can be modulated (Kusuma *et al*., 2020). Leafy vegetables and herbs are often the crops of choice in vertical farms due to fast growth, low plant height, and high retail price (Touliatos *et al*., 2016). Vertical farming is a new form of agriculture that are not dependent on cultivable land and that can be established also in the city environment are gaining increasing popularity. Vertical Farms with Artificial Lighting (VFALs), are closed plant production systems where environmental factors (e.g., temperature, humidity, light, and CO_2 concentration) are controlled, minimizing the interactions with the external climate.

We know, vermicompost is produced by using worms to digest and thus break down organic matter, such as sewage sludge animal waste and crop residues. Vermicompost is finely textured and rich in nutrients and it has good water-holding capacity because of its high organic matter content. Beneficial effects have been shown in a lot of studies in which vermicompost was used in containers with other substrates (Atiyeh *et al*., 2000). It also promotes better root growth and nutrient absorption and improves nutrient status of soil, both macro-nutrients and micro-nutrients. So, nutrition is vital that increases plant productivity and the concentration of bioactive compounds both quantitatively and qualitatively (Shah *et al.*, 2010).

It is known to everyone that, biochar, attracting increasing interests in recent years for its use in agriculture, can be used to replace some components of commonly used container substrates. The incorporation of biochar in container substrates has many benefits. Biochar in container substrates could increase water-holding capacity (Dumroese *et al*., 2011) and reduce nutrient leaching. (Crutchfield *et al*., 2018). Different percentages of biochar mixed with other substrates components also led to diverse results (Yu *et al*., 2020).

In addition, cocopeat is an excellent growing medium for vertical farming. Cocopeat is a renewable material made from the brown and white fibers found between the shell and the outer coating of a coconut. It improves aeration in the soil for optimal root growth while maintaining the ideal nutrient availability for plants. It also helps in loosening the heavy soil and enhances the water retention capacity. Commercial potting mixes and coconut coir both make excellent substrates for growing either plants or microgreens. Grow bag soils contain very less amount of soil, also are a mix of coconut coir, vermicompost and biochar etc. Cocopeat is considered as a good growing media component with acceptable pH, electrical conductivity and other chemical attributes. (Abad *et al*.,2002).

In consideration of global climate change and increasing urban populations, food security is an increasingly pressing matter, especially considering limited resources such as arable land, clean water, and fuel energy (Dunwoody, 2014; 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 (Despommier, 2013; Kozai, 2013; Kozai *et al*., 2015; Touliatos *et al*., 2016). However, this research examined the comparative advantages of selected growing media for different basil growth using the white LED on in an indoor vertical farm.

OBJECTIVES:

This study has been taken under consideration to achieve the following objectives:

1. To evaluate the impact of growing media on growth of basil in a vertical farm using white LED light.
2. To investigate the effect of growing media on nutrients contents of basil varieties.
3. To find out the effect of different growing media on oil contents of basil varieties.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Basil is an important medicinal herb used in cosmetics, perfumery and in the preparation of foods, including pesto sauce and soft drinks. It is cultivated for their extraordinary essential oil which displays many therapeutic usages such as in medicinal application, culinary, herbs, perfume for herbal toiletries, aromatherapy treatment and as flavoring agents. Daily consumption of its leaves and its products is considered to prevent diseases, promote health, longevity, wellbeing and helps to reduce the physical and mental stresses of daily life. Some of the important and informative works and research findings related to vertical farming and growing media on different basil or other herbs so far done at our country and abroad have been reviewed in this chapter selectively under diverse headings as the users' friendly manner.

2.1 Vertical farming

The Vertical Farming is husbandry of crops, planted in vertically managed layers so as to harness the unaccustomed vertical area which is otherwise left unconsidered in almost every cultivation practice. As the list of the major issues in world is long, the population explosion is one among those major issues. It is estimated that there is approximately 800 million hectares of land that is designated to soil-based farming globally, which constitutes about 38% of the total global land area. Moreover, about 80% of the total arable land is currently being utilized across the globe (Ellingsen & Despommier, 2008).

The whole world is on the verge of population explosion and it is a challenge to feed this ever-increasing population (Sonawane, 2018).

Some urban planners and agricultural leaders have argued that cities will need to produce food internally to manage the ratio of demand and supply to avoid falling food prices, harmful pollution and inflation (Al-Kodmany, 2018).

As per Benkea and Tomkins (2017), The vertical farming model is essentially an indoor farm based on a high-rise multi-level factory design. Classic features include innovative use of recycled water accelerated by rainwater or water from a desalination plant, automatic air-temperature and humidity control, using solar panel for lighting and heating, and tunable 24-hour LED illumination. The LED equipment can be ran throughout a growing season to emit a programmed spectrum of light that is optimal for photosynthesis for different types of crops. When together with regulation of temperature and humidity, the effects of seasonality can be minimized or eliminated. The potential benefits of vertical farming include a sustainable food-production model with all-year-round crop production, higher yields by an order of magnitude, and freedom from droughts, floods, and pests. The proposal is compatible with water recycling, ecosystem restoration, reduction of pathogens, energy production by methane generation from compost, reduced use of fossil fuels (no tractors, plows, or shipping), generation of new jobs for many years, and low or no requirement for pesticides.

The controlled environment of indoor farming guarantees an optimized growing condition and provided a perfect way to reach economy-of scale production. Despommier (2010) and others claims that, in principle, any crop can be grown in a vertical farming greenhouse. Frazier (2017) reported that a reason for leafy greens being very popular as a crop is that they provide a premium profit margin, rather than any inherent limitations in crop types.

Vertical farming has been proposed as an engineering solution to increase productivity per area by extending plant cultivation into the vertical dimension, thus enhancing land use efficiency for crop production (Eigenbrod and Gruda, 2014).

2.2 Effect of different growing media

Baeck *et al*. (2001) studied on optimum substrate and concentration of nutrient solution for mass production of sweet basil by pot culture. Better growth visible in cocopeat, but peat moss gave an unpropitious effect. Sweet basil grown in substrate mixed with cocopeat and perlite (1:1, v: v) was highest in essential oil content. Moreover, one-fold concentration of herb nutrient solution in substrate mixed with cocopeat and perlite (1:1, v: v) was advocated for better growth and higher essential oil content of sweet basil.

Singh *et al.* (2014) conducted to study integrated nutrient management in Indian basil. Application of 50% inorganic fertilizers (50:20:20 NPK kg ha^{-1}) + 50% farm yard manure (10.0 Mg ha^{-1}) showed relatively higher fresh herb and essential oil yields over other treatments and also increased the organic carbon status, available N, P_2O_5 and K_2O by 0.16%, 62.4, 54.7 and 29.3 kg ha^{-1} in the post-harvest soil from their initial values, respectively. Lastly, the combined application of 50% each of inorganic fertilizers (50:20:20 NPK kg ha^{-1}) and FYM (10.0 Mg ha^{-1}) showed higher herb, oil yields and improved the soil fertility.

Sharifi *et al.* (2019) investigated nutrient availability in three vermicompost/peat ratios with or without biochar and/or mycorrhizal fungi inoculation for producing organic basil (*Ocimum basilicum* L.) and sweet pepper (*Capsicum annuum* L.). Mixture of biochar at two levels (0 and 10% weight basis), three levels of vermicompost/peat ratios (0, 15 and 30% volume basis) and mycorrhizal fungi inoculant (*Glomus intraradices*) at two levels (with and without application) were used. Basil S uptake significantly increased by 68 and 44% in 15 and 30% vermicompost rates compared with control, respectively. Basil P uptake raised 2.4-fold in low rate and 2.1-fold in high rate of vermicompost compared with control (142 and 125 vs. 60 mg P) and the measured nutrient parameters in basil were not affected by biochar treatment. Mycorrhizal inoculation increased P uptake from 102 to 116 mg. Total growing media P at harvest was affected by vermicompost/peat rate in case of sweet pepper. Biochar treatment only affected sweet pepper tissue S concentration and Mycorrhiza inoculation did not affect measured parameters in sweet pepper. 15% (v/v) vermicompost/peat ratios with mycorrhiza inoculant was acceptable for growing organic basil and contain a balanced nutrient level during basil life cycle.

Yu *et al*. (2019) conducted an experiment on potted basil and tomato seedling production using mixed hardwood and Sugarcane bagasse biochar. Sugarcane bagasse biochar (SBB) mixes contain (10%, 30%, 50%, and 70% SBB with 30% perlite (P) and the rest being peat moss (PM); by vol), mixed hardwood biochar (HB) mixes (10%, 30%, 50%, 70% and 100% HB with PM; by vol.), PM, P, 70% PM : 30% P, and a commercial propagation mix. Both tomato and basil seedlings grown in all of the biochar mixes (except 50% HB) showed lower fresh weight, dry weight and growth index (GI) compared to a commercial propagation mix. Moreover, 70% HB could be ameliorated with PM for tomato and basil seedling production without negative effects on plant biomass.

Hewidy *et al*. (2014) organized an experiment to study the effect of growing media on growth and oil production of basil in greenhouse or in open field. 20, 40, 60 and 80% blends in volume of peat moss and 100% loamy soil was used. On the other hand, 6 growing media were prepared consist of 10, 20 or 30% of compost or vermicompost with loamy soil. Plants grown in compost showed 2-3 times greater shoot number and Different peat-moss media mixture and control showed notable reduction in chlorophyll content. When compost added into substrate mixtures the number of lateral stems increased (up to 2-4 times) in basil.

Research on plant growth promoting bacteria (inoculation and non-inoculation), vermicompost (application and non-application), humic acid (non application, seed treated and foliar application) applied on basil to see the on growth and essence of basil. PGPRs and application of vermicompost significantly affects almost the measured trait as well as the highest wet and dry yield, essence yield and chlorophyll a, b and a+ b was observed in the interaction between PGPRs and vermicompost. The combination of PGPRs and humic acid directed to the highest essence percentage, essence yield and plant height (Befrozfar *et al.*, 2013).

Rakocy *et al*. (2009) regulated an experiment in which used different media types for seedling production of lettuce and basil. Different compost mix (80:20, 60:40, 40:60 mixes in volume of fish solid to guinea grass), coco-vermiculite mix with and without fertilization (control), 100% fish solids and a 1:1 mix of fish solids and sand. On the other hand, sweet basil plants (*Ocimum basilicum* 'Spicy globe') grown in pots with the similar types of compost mixes and fertilized soil (control). Results suggested that the use of compost media was given the best result.

An investigation on three subsequent experiments were carried out in heated greenhouses in plastic containers that contain peat mix substrate and irrigated by sub irrigation. The increasing concentration of a 20–20–20 soluble fertilizer (1–5 g/l) decreased the rate of growth, the optimum concentration resulting 1 g/l. however, the sweet basil had very sensitive to high fertilizer concentration. The application of different ratios of N, P_2O_5, K_2O has stated that 1:1:2 ratio give the best growth result in comparison with 1:1:1 and 1:0.25:1.5 ratios. (Tesi *et al.*, 1995).

Aboutaleb *et al*. (2013) were designed an experiment with two factors, cultivar (two local cultivars) and nutrient sources (inorganic nutrient solution, solid organic manure and organic nutrient solution) on organically grown basil. Result founded that there was no remarkable difference between inorganic nutrient sources and organic nutrient solution.

Rashmi *et al*. (2008) investigated the effects of inoculation of biofertilizers. In *O. gratissimum*, plants showed maximum plant height, number of leaves, number of branches, biomass, major and micronutrients and essential oil content with the treatment combination of *Glomus fasciculatum*, *Azotochroccocum*, *Aspergillus awamori* each @ 2 kg/ha.

Hussein *et al*. (2006) reported that various plant densities and compost applications had a special influence on *Dracocephalum moldavica* L. (dragonhead). Maximum level of compost (39.6t/ha) and medium distance had a positive effect on vegetative growth and induced essential oil accumulation.

In *Rosmarinus officinalis* L. The highest oil yields were observed in June with percentages greater or equal to 1%, independent on the growing media or fertilization type 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). (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).

In *Ocimum basilicum* plant, an experiment was suggested that media type, MS concentration and the growth regulator types influenced the growth and volatile composition qualitative and quantitatively. The PGR increased biomass production. (Monfort *et al*., 2018).

In sweet basil, 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 uptake (31.86, 6.67, 15.41 kg/ha) were enlisted in treatment combination of 100% NPK at 60 DAP (Thakur *et al*., 2011).

The highest herbage and essential oil yields of dragonhead (*Dracocephalum moldavica* L.) were obtained by using 10 t/ha manure application and 5 t/ha vermicompost and integrated application of 10 t/ha manure and 5 t/ha vermicompost. (Darzi *et al*., 2015).

2.3 Effect of LED light on plants in indoor vertical farming

Hammock (2018) reported that at B : R LED ratios in supplemental lighting of 40:60 ratio showed in higher limonene and linalool compared with basil grown under HPS lighting.

Frąszczak *et al*. (2015) conducted a study on chemical composition of lemon balm and Basil under fluorescent lamps (FL) and LED modules (LEDs). Basil and lemon balm herbage had higher content of macro and micronutrients under LEDs. But under fluorescent light, the content of essential oils was greater in basil herbage and vitamin C was significantly (26%) higher in the plants.

Samuoliene *et al.* (2009) exposed that lettuce, marjoram and green onion to red light for three days and they observed a considerable decrease in the content of nitrates.

Yorio *et al*. (2001) reported that there was higher dry matter weight accumulation in lettuce grown under red light supplemented with blue light than in lettuce grown under red light alone.

Sabzalian *et al*. (2014) detected performance of vegetables, flowers, and medicinal plants under the treatment of 100 % red, 100 % blue, 70 % red plus 30 % blue, or 100 % white LED. Essential oil of Mentha increased up to four times with 70/30 % red-blue lighting and it also led to a better growth of lentil and basil.

Amaki *et al*. (2011) reported that top fresh weight, total leaf weight and total leaf increased in green monochromatic light. Moreover, the total leaf weight and total leaf area of lateral shoots and essential oil showed the highest under blue light. Although, the essential oil contents under blue light were 1.2-4.4 times higher than white light.

Due to the high LED lighting efficiency, greater LUE and EUE, the white LED light quality with R:B ratio of 1.5 is preferable for pepper seedling production. (Liu *et al.*, 2019).

The combination of blue or red LED light sources in vitro propagation of *R. glutinosa* can be a correct way to improve the medicinal values of the plant. (Manivannan, 2015).

Yusof *et al*. (2016) referred that the daylight compact fluorescent light (CFL), blue and red LED (475 nm and 650 nm) had influenced on *Typhonium flagelliforme*. Whereas, the blue light increased the height of the plant and retained the most water in the leaves. Moreover, the red LED emits more carbon dioxide and enhanced chlorophyll in the leaves.

Nicole *et al*. (2019) observed that light quality affects shelf life of baby leaf spinach and rocket. High blue content (35%) was best and the least one was high far red (25%). Light quality also changed the taste of vegetables.

Piovene *et al.* (2015) showed that LED lighting qualify to improve antioxidant compounds and decrease nitrates content in basil leaves. Red: blue ratio of 0.7 was important for proper plant development which upgrade nutraceutical properties in both sweet basil and strawberry crops.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out to assess the 'Effect of Different Growing media on basil varieties in simulated indoor vertical farm'. The materials and methods i.e. experimental period, location, climate condition and soil of experimental site, planting materials, design of the experiment, data collection and data analysis procedure that were used for conducting the experiment are presented in this chapter under the following headings and sub-headings-

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from November 2020 to April 2021.

3.1.2 Experimental location

The present study was conducted in indoor structure of Dr. M. Wazed Mia Central Laboratory, Sher-e-Bangla Agricultural University, Dhaka.

3.1.3 Indoor growing condition

A shaded room was selected and required condition of light was supplemented with white LED, so that light intensity sufficient for plant growth was available. The temperature of the experimental site was average 20 ºC to 22 ºC during the experimental period and a relative air humidity of 70-72% were maintained. The temperature was maintained with air condition. PPFD was measured and regulated at the crop level using a photometer – radiometer. PPFD was supplemented with 150 μmol m^{-2} s^{-1} by lighting.

3.1.4 Vertical structure

The vertical structure for the project was of three arrays fabricated with 30 mm MS angle/plyboard and mild steel sheet of 1.5 mm thickness or 6mm MDF board. Each array has an area of 60x60 cm. One array lies at a height of 65 cm above the other. Three arrays were used for the cultivation and top layer was constructed with an aim to install a small water tank to support irrigation. Total height of setup from ground was 7.5 ft.

3.2 Experimental details

3.2.1 Plantings materials

The seed of Italian sweet basil and holy basil were collected from the Sobuj Bangla Nursery, Agargaon, Dhaka, during October, 2020. 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 Factors of the experiment

This was a 2-factor experiment of which the factors were as follows:

Factor A: Growing media (3 levels)

M_1- Cocopeat (20%) + Vermicompost (70%) + Soil (10%)

M_2- Vermicompost (90%) + Soil (10%)

M_3- Biochar (10%) + Vermicompost (80%) + Soil (10%)

Factor B: Variety (2 levels)

V_1- Italian sweet basil

V_2- Holy basil

3.2.3 Experimental treatments

This two-factor experiment was designed with (3 × 2) treatments i.e. 6 treatment combinations. So, the 6 are presented- M_1V_1, M_1V_2, M_2V_1, M_2V_2, M_3V_1, M_3V_2. Total 9 growing bags with 18 plants were used to conduct the experiment.

3.2.4 Collection of biochar, cocopeat, vermicompost and soil

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

3.2.5 Nutrient content of vermicompost, cocopeat and biochar

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

Table 1. Composition of vermicompost and bio-fertilizer

Media	Nutrients		
	N (%)	P (%)	K (%)
Vermicompost	1.5-2.0	0.9-1.7	1.5-2.4
Cocopeat	0.41	0.81	1.32
Biochar	1.30	0.85	1.00

Source: ACI fertilizer, 2016

3.2.6 Design and layout of the experiment

The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The vertical structure for the experiment was of three arrays fabricated with 30 mm MS angle/plyboard and mild steel sheet of 1.5 mm thickness or 6mm MDF board. Each array has an area of 60x60 cm. One array lies at a height of 65 cm above the other. Each array contained 3 grow bags and each bag contained two variety of basil. The measurement of grow bag was 20x12x6 inch (plate 1). The layout of the experiment is shown in plate 2.

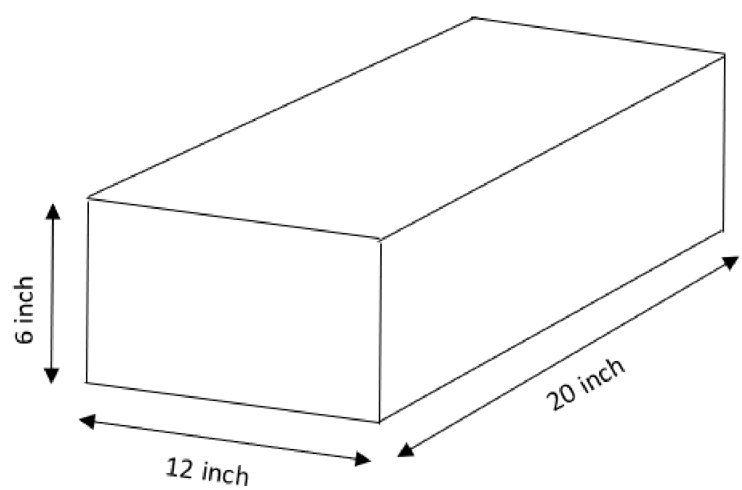


Plate 1: Grow bag measurement

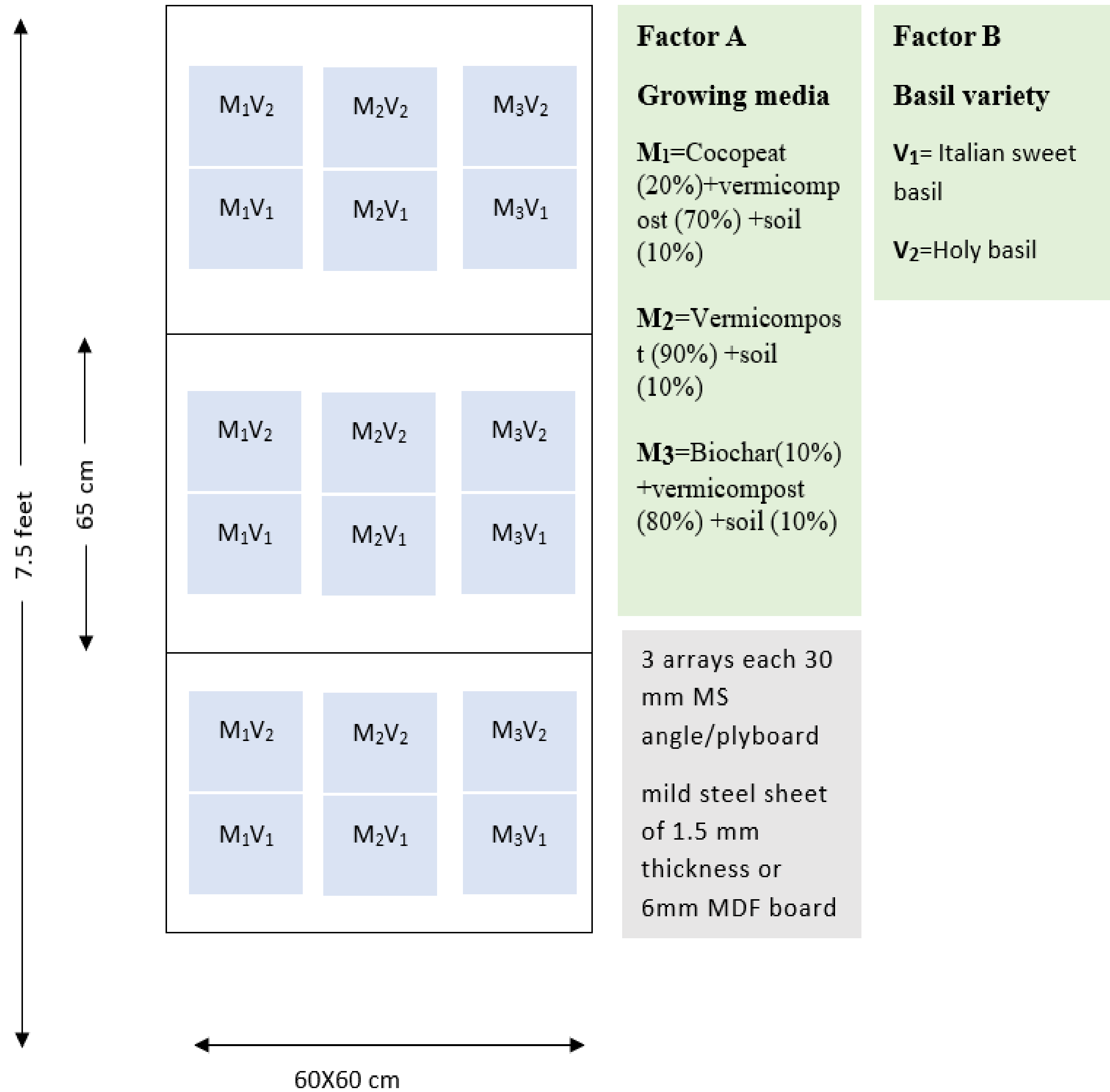


Plate 2: Layout of indoor experiment

3.2.7 Preparation of experimental growing media

Different growing media were used for indoor vertical farming. The media made with 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 indoor condition. Growing media preparation is shown in plate 3. The following combinations of media were prepared and are filled in growing bags for comparing their performance.

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

Compositions	Bags no.	Kg/bags
Cocopeat (20%) + vermicompost (70%) + soil (10%)	3	3 kg cocopeat,10.5 kg vermi,1.5 kg soil
Vermicompost (90%) + soil (10%)	3	15 kg vermi,1.5 kg soil
Biochar (10%) + vermicompost (80%) + soil (10%)	3	1.5 kg biochar, 12 kg vermi, 1.5 kg soil

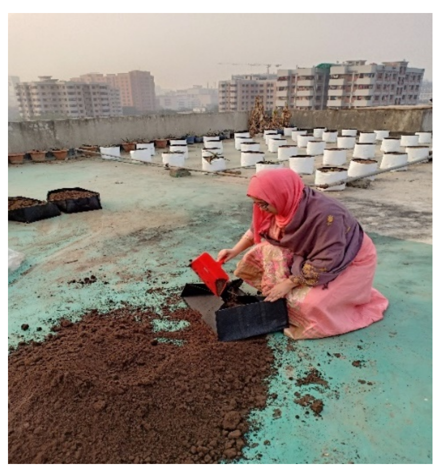


Plate 3: Growing media preparation

3.3 Growing of crops

3.3.1 Planting of the seedlings

The stem seedlings were planted on the 15th December, 2020. The seedlings of Italian sweet basil were about 5.5 cm long and about 3.5 cm was kept below the soil and holy basil were about 6 cm long and about 4 cm was kept below the soil.

3.2.2 Intercultural operation

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

3.3.2.1 Irrigation system

Irrigation was done using drip method. Laterals of 4/7 mm size and online drippers of 2 liters per hour capacity were used. For this type of cultivation practice drip irrigation is more suitable. Plants were irrigated once in two days for about 10 minutes. Since the growing media are of with high water holding capacity and transpiration is comparatively less small quantity of water is needed.

Plate 4: Drip irrigation

3.3.2.2 Weeding

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

3.3.2.3 Plant protection measures

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

3.4 Harvesting

The harvesting was done at 50 days after transplanting (DAT) by cutting the plants with a scissor.

3.5 Data collection

For analyzing the growth of the 2 different basil varieties plants under different treatments total A 18 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 array were counted at an interval of 10 days. Weight of fresh herbage, dry weight of herbage and oil yield of two variety basils and nutrients content were measured after harvest.

Plate 5: Data collection

3.5.1 Plant height (cm)

Plant height was measured from all 18 plants by using meter scale in centimeter 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.

3.5.2 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.

3.5.3 Leaf length (cm)

Leaf length was measured by centimeter 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.

3.5.4 Leaf breadth (cm)

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

3.5.5 Fresh weight of individual plant (g)

Fresh weight of individual plant was recorded from selected plants in grams (g) with a balance at final harvest.

3.5.6 Dry weight of individual plant (g)

At first selected plants were collected. Then cut into pieces and was dried under sunshine for 3 days and dried in the oven for 7 days. The final individual dry weight of the sample was taken and expressed in gram.

3.5.7 Essential oil yield

Essential oil of basil was extracted by hydro distillation method in laboratory (FAB LAB, SAU) by hydro distiller from dry herb of basil. Oil was extracted from 20 g dry herb from each different bag and measured by measuring cylinder in ml.

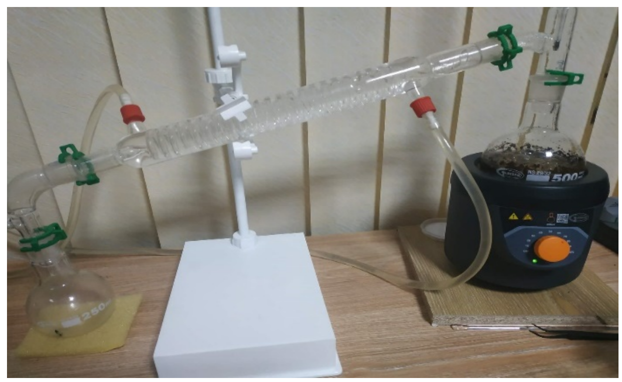
3.5.7.1 Methodology of hydro distillation

In hydro distillation plant material was soaked in water and heated until it boils. The resulting steam from boiling water carried the volatile oils with it. Cooling and condensation subsequently separate the oil from the water. Water, and the steam passes through the plant material. The leaves were carefully distributed on the grill to allow for even steaming and thorough extraction.

3.5.7.2 Distillation procedure

At first, 20 g dry herb of basil was taken in the 500 ml flask and it was filled two third parts with water. Afterwards, the flask was seated on heating mantel. It needed to adjust the temperature at 100-120°C (boiling point of water). At 70% temperature was measured by thermometer. The total process was continued for 2-3 hours. The mixer of oil and water were collected in Florentine flask. Lastly, the essential oil was separated easily by separator where the oil is floating on the water to drop out from separator. Distillation is showing in plate 6.

Boiling Basil leaf



Basil oil separation

Plate 6: Procedure of hydro distillation of basil

3.5.8 Oil content of basil

Oil content of basil was recorded by converting the percentage of oil yield and was expressed in %.

3.5.9 Chemical analysis of basil plant

3.5.9.1 Preparation of plant extract for P, K, Na and S determination

The samples were dried in an oven at 70^0C to obtain constant weight and finely ground via a grinding machine. Then the ground samples were passed through a 20-mesh sieve and stored into paper bags. With the help of electrical balance ,1 g oven-dried samples of basil plants were measured.

3.5.9.2 Digestion of plant sample

1 g dried samples were taken in conical flask and about 20 ml of di-acid mixture (nitric acid : perchloric acid=2:1) was taken in a conical flask. Kept stand for 20 minutes and then transferred to a digestion block. After that continued heating at 100^0C. Heating was stopped when the dense white fumes occurred. The contents of flask were boiled until the solution became clear and colorless. After cooling room temperature, the contents filtered through Whatman No. 40 filter paper into a 100 ml volumetric flask and the volume was made up to the mark with distilled water. The contents were then stored at room temperature with clearly marked containers. Content of P, S was determined by spectrophotometer and content of K, Na was determined by flame emission spectrophotometer.

3.5.9.3 Determination of phosphorus

The amount of phosphorus (P) was estimated from the plant extract by ascorbic acid blue color method with the help of a spectrophotometer at 660 nm. 12 g ammonium molybdate $(NH_4)_6Mo_70_{24}.4H_20)$ and 0.2908 g antimony potassium tartrate $K_2Sb_2(C_4H_20_6)_2.3H_20$ were mixed together and volume was made up to 2000 ml with distilled water used as reagents. About 20 ml of the extract was pipetted out in a 100 ml volumetric flask. About 20 ml color developing reagent was added slowly. About 20 ml of the standard P solutions (100 ppm) was pipetted to a 1 L volumetric flask and volume was made up to the mark by distilled water. This solution contained 2 ppm. About 20 ml color developing reagent was added to each flask, mixed and volume was made with distilled water. These solutions gave 0, 0.1, 0.2, 0.3, 0.4 and 0.5 ppm of P solution respectively. A standard curve was prepared from the spectrophotometer reading and concentrations of plant samples were calculated from the curve.

3.5.9.4 Determination of potassium

The amount of potassium (K) in the plant extract was determined with the help of a flame emission spectrophotometer. Primary potassium standard solution (1000 ppm) was made with potassium chloride and distilled water. Then secondary potassium solution (100 ppm and 10 ppm) was prepared. A series of standard solution containing 1 ppm, 2 ppm, 3 ppm, 4 ppm, 5 ppm and 6 ppm were prepared. Then, the reading (% emission) were taken from flame emission spectrophotometer and a standard curve was prepared from the reading taken. Plant samples were taken in volumetric flask and volume was made up to the mark by distilled water. Then the samples reading was taken and concentrations were calculated from the standard curve.

3.5.9.5 Determination of sodium

The amount of sodium (Na) in the plant extract was determined with the help of a flame emission spectrophotometer. Primary sodium standard solution (1000 ppm) was made with sodium chloride and distilled water. Then secondary potassium solution (100 ppm and 10 ppm) was prepared. A series of standard solution containing 1 ppm, 2 ppm, 3 ppm, 4 ppm, 5 ppm and 6 ppm were prepared. Then, the reading (% emission) were taken from flame emission spectrophotometer and a standard curve was prepared from the reading taken. Plant samples were taken in volumetric flask and volume was made up to the mark by distilled water Then the samples reading was taken and concentrations were calculated from the standard curve.

3.5.9.6 Determination of sulphur

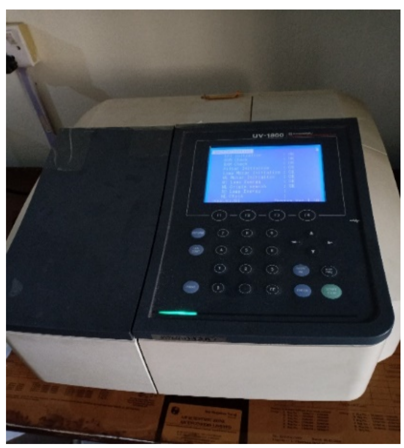
The amount of sulphur (S) was estimated from the plant extract with the help of a spectrophotometer at 420 nm. About 20 ml of the extract was pipetted out in a 100 ml volumetric flask. This solution contained 2 ppm. Added proper amount of materials and let the sample for proper mixing. These solutions gave 0, 0.1, 0.2, 0.3, 0.4 and 0.5 ppm of S solution respectively. A standard curve was prepared from the spectrophotometer reading and concentrations of plant samples were calculated from the curve.

Plant Sample (weighing)

Digestion of samples (Filter)

Adding distilled water

Phosphorus samples



Spectrophotometer (P and S)

Flame emission spectrophotometer (K and Na)

Plate 7: Procedure of P, K, Na and S nutrients analysis of basil

3.6 Statistical analysis

The recorded data on different parameters were statistically analyzed by using Statistix10 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

CHAPTER IV

RESULTS AND DISCUSSION

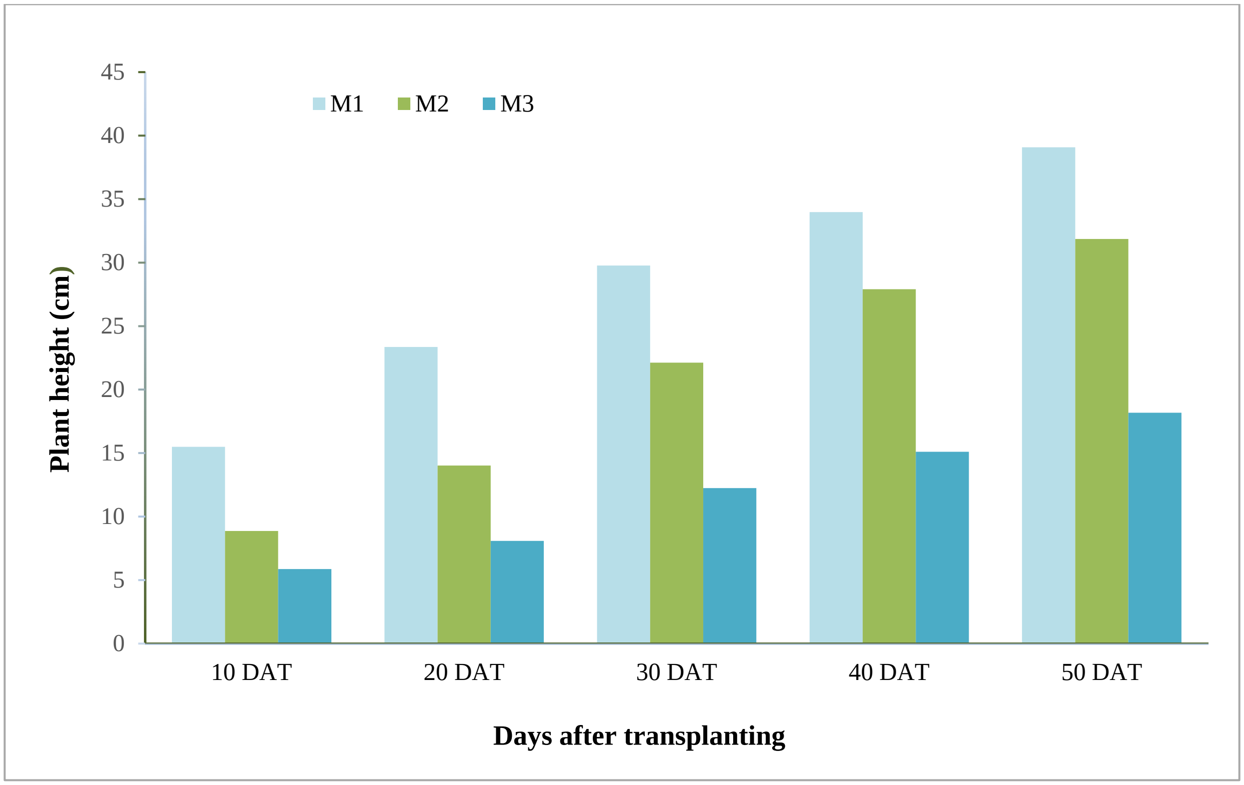
This chapter represents the results and discussion of the present study. The experiment was carried out to assess the effect of growing media and variety on growth, yield and essential oil content, nutrient content of basil. The analysis of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendices I-VI. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height (cm)

Plant height of basil at 10, 20, 30, 40, 50 DAT (Days after transplanting) showed statistically significant differences due to different growing media (Figure 1 and Appendix VII). At 10, 20, 30, 40 and 50 DAT the tallest plant (15.50, 23.35, 29.76, 33.98 and 39.08 cm, respectively) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was closely followed (8.86, 14.02, 22.12, 27.90 and 31.86 cm, respectively) by M_2 (vermicompost (90%) + soil (10%)), whereas the shortest plant (5.86, 8.08, 12.25, 15.10 and 18.18 cm, respectively) was found from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)). Data revealed that different growing media produced different height of plant. Although plant height is a genetical character but the management practices and growing media also influence plant height. Abbey et al. (2012) reported that plant height and fresh weight for VC 2:1 were greater than those for plants from all other media.

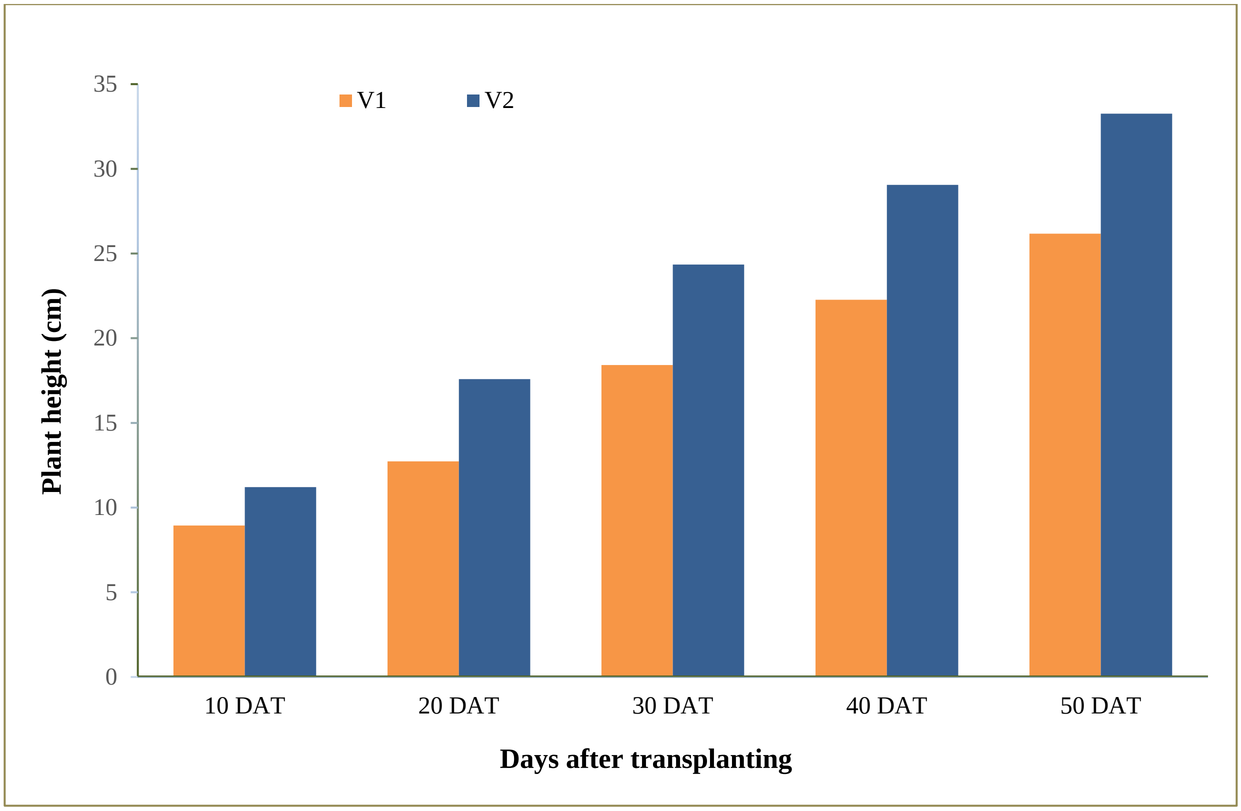
In terms of plant height of basil at 10, 20, 30, 40, 50 DAT showed statistically significant differences due to different variety (Figure 2 and Appendix VII). At 10, 20, 30, 40, 50 DAT the tallest plant (11.21, 17.58, 24.34, 29.05 and 33.26 cm, respectively) was recorded from V_2 (Holy basil) which was statistically different (14.30, 17.95, 21.83 and 19.20 cm, respectively), while the shortest plant (8.94, 12.72, 18.41, 22.27 and 26.17 cm, respectively) was recorded from V_1 (Italian sweet basil).

Combined effect of different growing media and variety showed statistically significant variation in terms of plant height of basil at 10, 20, 30, 40, 50 DAT (Table 3). At 10, 20, 30, 40, 50 DAT, the tallest plant (18.33, 28.41, 34.40, 39.03 and 43.60 cm, respectively) was observed from M_1V_2 and the shortest plant (5.50, 6.70, 10.67, 13.37 and 16.27 cm, respectively) was observed M_3V_1.



Here, $\mathbf{M_1}$- cocopeat (20%) + vermicompost (70%) + soil (10%), $\mathbf{M_2}$- vermicompost (90%) + soil (10%), $\mathbf{M_3}$- biochar (10%) + vermicompost (80%) + soil (10%)

Figure 1: Effect of growing media on plant height of basil



Here, **V_1**- Italian sweet basil, **V_2**- Holy basil

Figure 2: Effect of variety on plant height of basil

Table 3. Combined effect of growing media and variety on plant height at different days after transplanting (DAT) of basil

Treatments	Plant height at different days after transplanting (DAT) of basil				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
M_1V_1	12.67 b	18.30 b	25.13 b	28.93 b	34.57 b
M_1V_2	18.33 a	28.41 a	34.40 a	39.03 a	43.60 a
M_2V_1	8.67 cd	13.18 c	19.44 c	24.50 c	27.67 c
M_2V_2	9.07 c	14.86 c	24.80 b	31.30 b	36.07 b
M_3V_1	5.50 e	6.70 d	10.67 d	13.37 d	16.27 e
M_3V_2	6.23 de	9.47 d	13.83 d	16.83 d	20.10 d
LSD (0.05)	1.14	1.30	1.48	1.56	1.43
CV %	2.54	2.90	3.03	3.47	3.18

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%)

M_2- vermicompost (90%) + soil (10%)

M_3- biochar (10%) +vermicompost (80%) + soil (10%)

V_1- Italian sweet basil

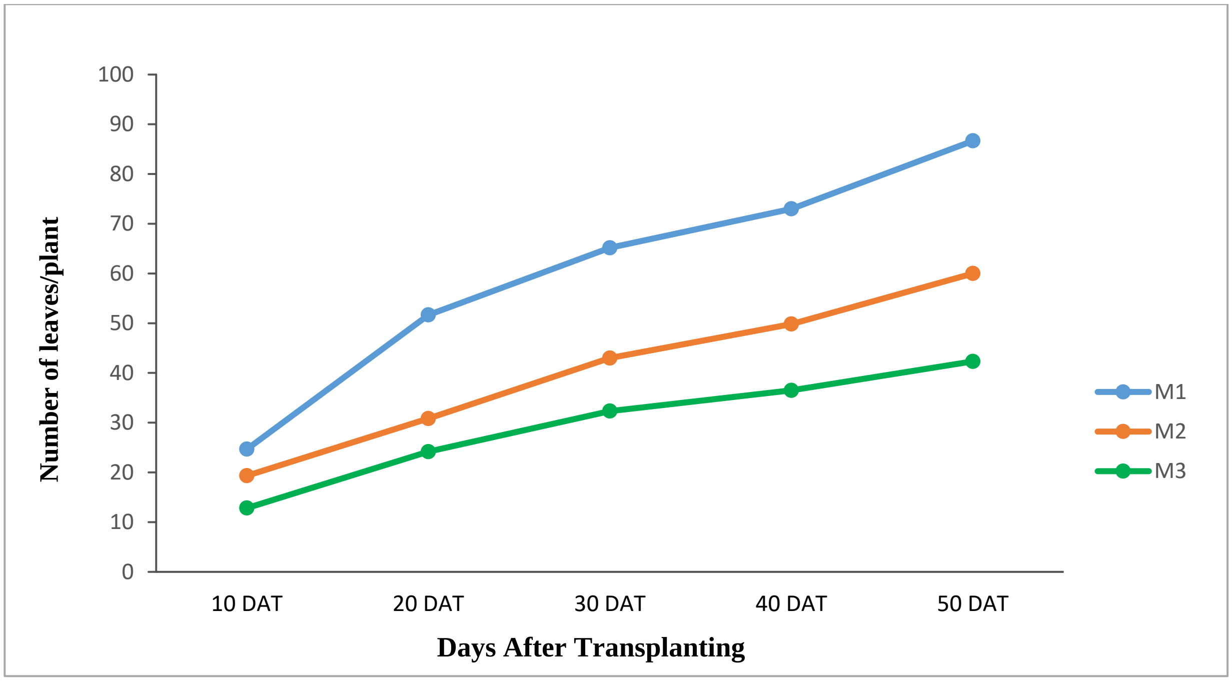
V_2- Holy basil

4.2 Number of leaves/plant

Number of leaves/plant of basil at 10, 20, 30, 40, 50 DAT (Days after transplanting) showed statistically significant differences due to different growing media (Figure 3 and Appendix VIII). At 10, 20, 30, 40, 50 DAT the highest number of leaves/plant (24.67, 51.67, 65.16, 73.00 and 86.67, respectively) was recorded from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)), whereas the lowest number of leaves/plant (12.83, 24.17, 32.33, 36.50 and 42.33, respectively) was found from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)).

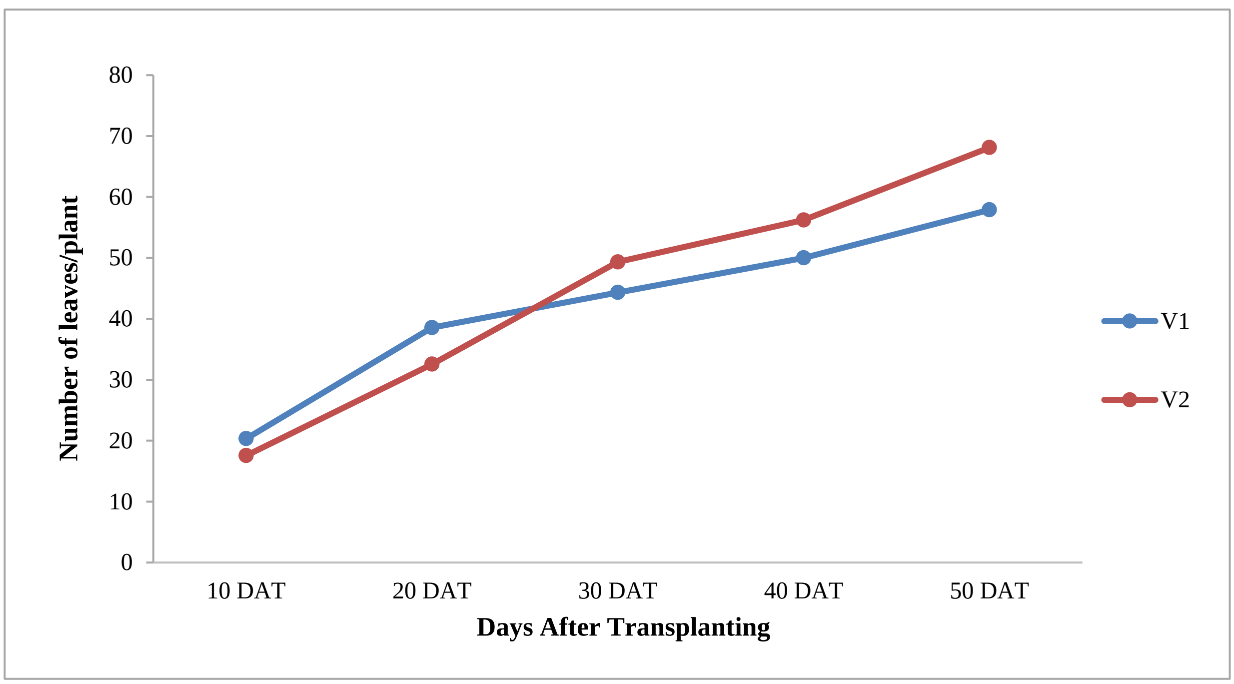
In terms of number of leaves/plant of basil at 10, 20, 30, 40, 50 DAT showed statistically significant differences due to different variety (Figure 4 and Appendix VIII). At 10, 20, 30, 40, 50 DAT the highest number of leaves/plant (17.56, 32.56, 49.33, 56.22 and 68.11, respectively) was recorded from V_2 (Holy basil) and the lowest number of leaves/plant (20.33, 38.56, 44.33, 50.00 and 57.89, respectively) was found from V_1 (Italian sweet basil).

Combined effect of different growing media and variety showed statistically significant variation in terms of number of leaves/plant of basil at 10, 20, 30, 40, 50 DAT (table 4). At 10, 20, 30, 40, 50 DAT the highest number of leaves/plant (23.00, 52.67, 71.67, 80.33 and 100.33, respectively) was found from M_1V_2 treatment combination. Meanwhile, the lowest number of leaves/plant (14.00, 20.00, 32.00, 35.67 and 41.00, respectively) was recorded from M_3V_2 treatment combination.



Here, **M_1**- cocopeat (20%) + vermicompost (70%) + soil (10%), **M_2**- vermicompost (90%) + soil (10%), **M_3**- biochar (10%) + vermicompost (80%) + soil (10%)

Figure 3: Effect of growing media on number of leaves/plant of basil



Here, **V_1-** Italian sweet basil, **V_2-** Holy basil

Figure 4: Effect of variety on number of leaves/plant of basil

Table 4. Combined effect of growing media and variety number of leaves/plant at different days after transplanting (DAT) of basil

Treatments	Number of leaves/plant at different days after transplanting (DAT) of basil				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
M_1V_1	26.33 a	50.67 a	58.67 b	65.66 b	73.00 b
M_1V_2	23.00 a	52.67 a	71.67 a	80.33 a	100.33 a
M_2V_1	23.00 a	36.67 b	41.67 c	47.00 c	57.00 c
M_2V_2	15.67 b	25.00 d	44.33 c	52.67 c	63.00 bc
M_3V_1	11.67 b	28.33 c	32.67 d	37.33 d	43.67 d
M_3V_2	14.00 b	20.00 cd	32.00 d	35.67 d	41.00 d
LSD (0.05)	2.11	3.40	3.13	3.09	5.88
CV %	4.72	7.59	6.98	6.90	13.11

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

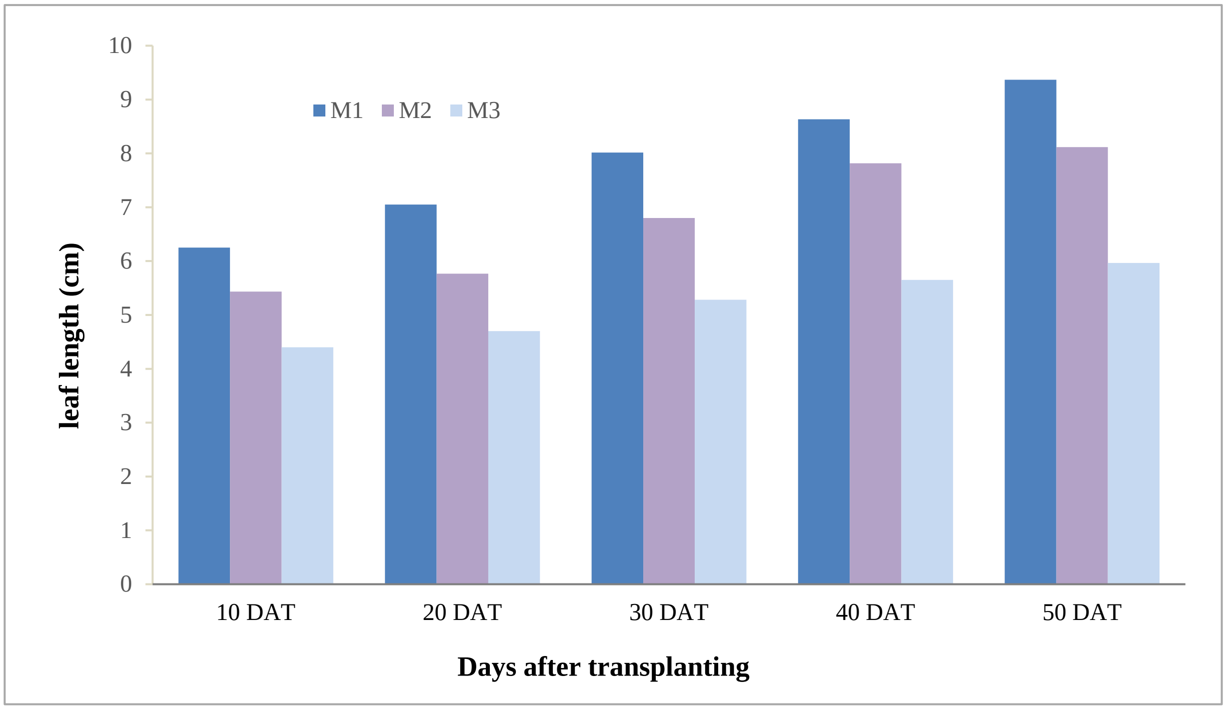
M_3- biochar (10%) + vermicompost (80%) + soil (10%)

4.3 Leaf length (cm)

Statistically significant variation was observed due to different growing media in terms of leaf length of basil at 10, 20, 30, 40 and 50 DAT (Figure 5 and Appendix IX). At 10, 20, 30, 40 and 50 DAT, the longest leaf (6.25, 7.05, 8.02, 8.63 and 9.37 cm, respectively) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was closely followed (5.43, 5.77, 6.80, 7.82 and 8.12 cm, respectively) by M_2, while the shortest leaf (4.40, 4.70, 5.28, 5.65 and 5.97 cm, respectively) was recorded from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)).

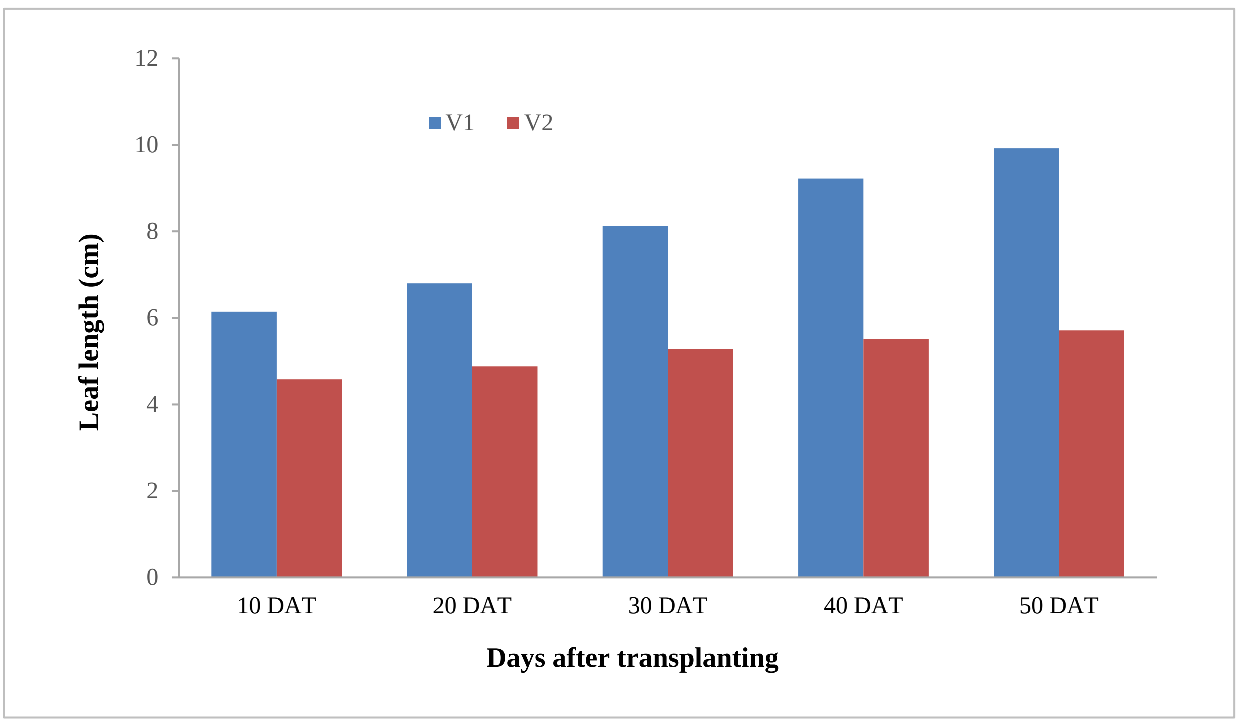
Leaf length of basil 10, 20, 30, 40 and 50 DAT showed statistically significant differences due to different variety (Figure 6 and Appendix IX). At 10, 20, 30, 40 and 50 DAT, the longest leaf (6.14, 6.80, 8.12, 9.22 and 9.92 cm, respectively) was found from V_1 (Italian sweet basil) while the shortest leaf (4.58, 4.88, 5.28, 5.51 and 5.71 cm, respectively) was recorded from V_2 (Holy basil).

Combined effect of different growing media and variety showed statistically significant variation in terms of leaf length of basil at 10, 20, 30, 40, 50 DAT (table 5). The longest leaf (6.77, 8.00, 9.57, 10.57 and 11.70 cm, respectively) was found from M_1V_1 treatment combination and the shortest leaf (4.07, 4.17, 4.30, 4.46 and 4.63 cm, respectively) was recorded from M_3V_2 treatment combination.



Here, **M1**- cocopeat (20%) + vermicompost (70%) + soil (10%), **M2**- vermicompost (90%) + soil (10%), **M3**- biochar (10%) +vermicompost (80%) + soil (10%)

Figure 5: Effect of growing media on leaf length(cm) of basil



Here, **V_1**- Italian sweet basil, **V_2**- Holy basil

Figure 6: Effect of variety on leaf length(cm) of basil

Table 5. Combined effect of growing media and variety on leaf length at different days after transplanting (DAT) of basil

Treatments	Leaf length at different days after transplanting (DAT) of basil				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
M_1V_1	6.77 a	8.00 a	9.57 a	10.57 a	11.70 a
M_1V_2	5.73 b	6.10 c	6.47 c	6.70 b	7.03 b
M_2V_1	6.93 a	7.17 b	8.53 b	10.27 a	10.77 a
M_2V_2	3.93 d	4.37 e	5.07 d	5.36 c	5.47 c
M_3V_1	4.73 c	5.23 d	6.27 c	6.83 b	7.30 b
M_3V_2	4.07 d	4.17 e	4.30 e	4.46 c	4.63 c
LSD (0.05)	0.27	0.25	0.28	0.32	0.46
CV %	0.60	0.56	0.63	0.71	1.03

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

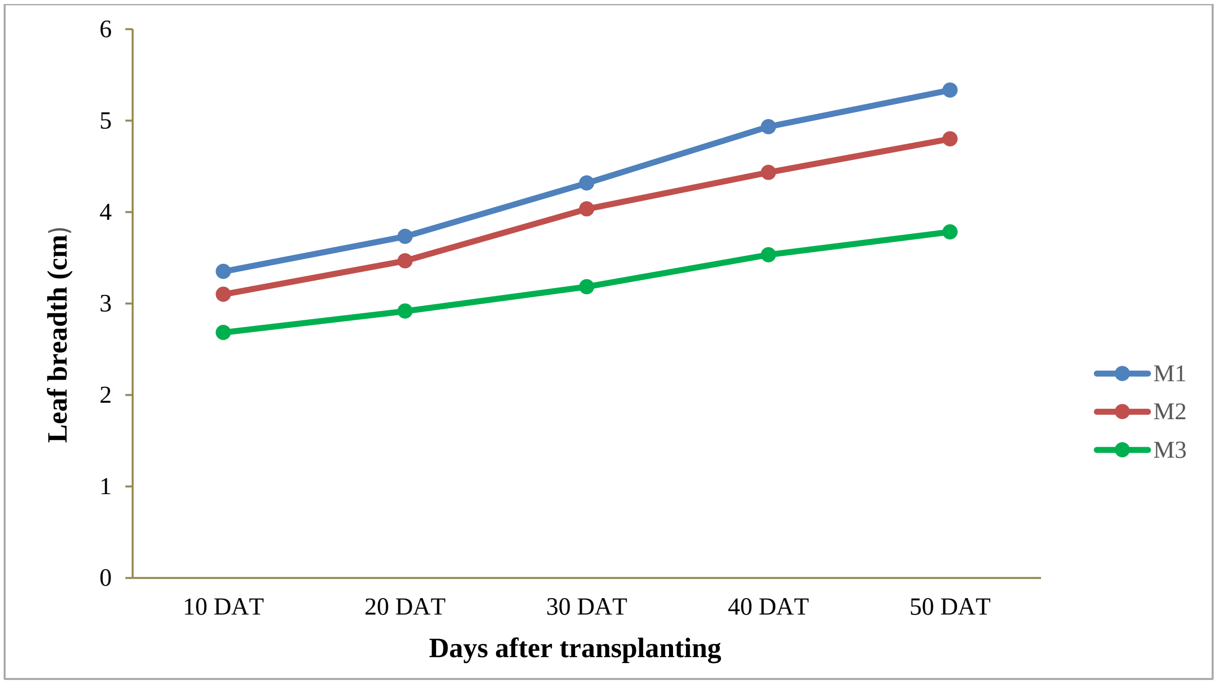
M_3- biochar (10%) + vermicompost (80%) + soil (10%)

4.4 Leaf breadth (cm)

Leaf breadth of basil at 10, 20, 30, 40, 50 DAT (Days after transplanting) showed statistically significant differences due to different growing media (Figure 7 and Appendix X). At 10, 20, 30, 40, 50 DAT the highest leaf breadth (3.35, 3.73, 4.32, 4.93 and 5.33 cm, respectively) was recorded from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)), whereas the lowest number of leaf breadth (2.68, 2.92, 3.18, 3.53 and 3.78, cm respectively) was found from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)).

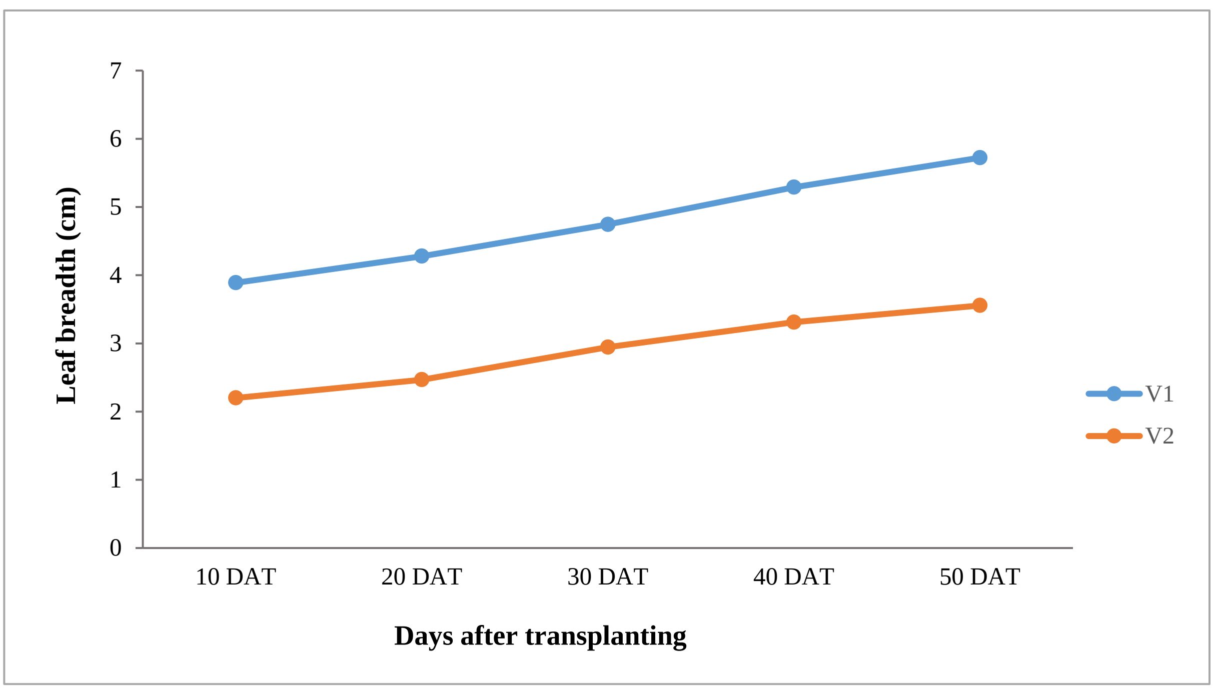
In terms of leaf breadth of basil at 10, 20, 30, 40 and 50 DAT showed statistically significant differences due to different variety (Figure 8 and Appendix X). At 10, 20, 30, 40, 50 DAT the highest leaf breadth (3.89, 4.28, 4.74, 5.29 and 5.72 cm, respectively) was recorded from V_1 (Italian sweet basil) and the lowest leaf breadth (2.20, 2.47, 2.94, 3.31 and 3.56 cm, respectively) was found from V_2 (Holy basil).

Combined effect of different growing media and variety showed statistically significant variation in terms of leaf breadth of basil at 10, 20, 30, 40, 50 DAT (table 6). At 10, 20, 30, 40, 50 DAT the highest leaf breadth (4.40, 4.80, 5.47, 6.17 and 6.67 cm, respectively) was found from M_1V_1 treatment combination. Meanwhile, the lowest leaf breadth (2.30, 2.23, 2.46, 2.66 and 2.86 cm, respectively) was recorded from M_3V_2 treatment combination.



Here, **M₁**- cocopeat (20%) + vermicompost (70%) + soil (10%), **M₂**- vermicompost (90%) + soil (10%), **M₃**- biochar (10%) + vermicompost (80%) + soil (10%)

Figure 7: Effect of growing media on leaf breadth (cm) of basil



Here, **V_1**- Italian sweet basil, **V_2**- Holy basil

Figure 8: Effect of variety on leaf breadth (cm) of basil

Table 6. Combined effect of growing media and variety on leaf breadth at different days after transplanting (DAT) of basil

Treatments	Leaf breadth at different days after transplanting (DAT) of basil				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
M_1V_1	4.40 a	4.80 a	5.47 a	6.17 a	6.67 a
M_1V_2	2.30 d	2.67 d	3.17 d	3.70 d	4.00 d
M_2V_1	3.90 b	4.43 a	4.87 b	5.30 b	5.80 b
M_2V_2	2.3 d	2.50 cd	3.20 d	3.57 d	3.80 d
M_3V_1	3.37 c	3.60 b	3.90 c	4.40 c	4.70 c
M_3V_2	2.30 d	2.23 d	2.46 e	2.66 e	2.86 e
LSD (0.05)	0.18	0.19	0.22	0.19	0.19
CV %	0.40	0.43	0.50	0.41	0.43

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

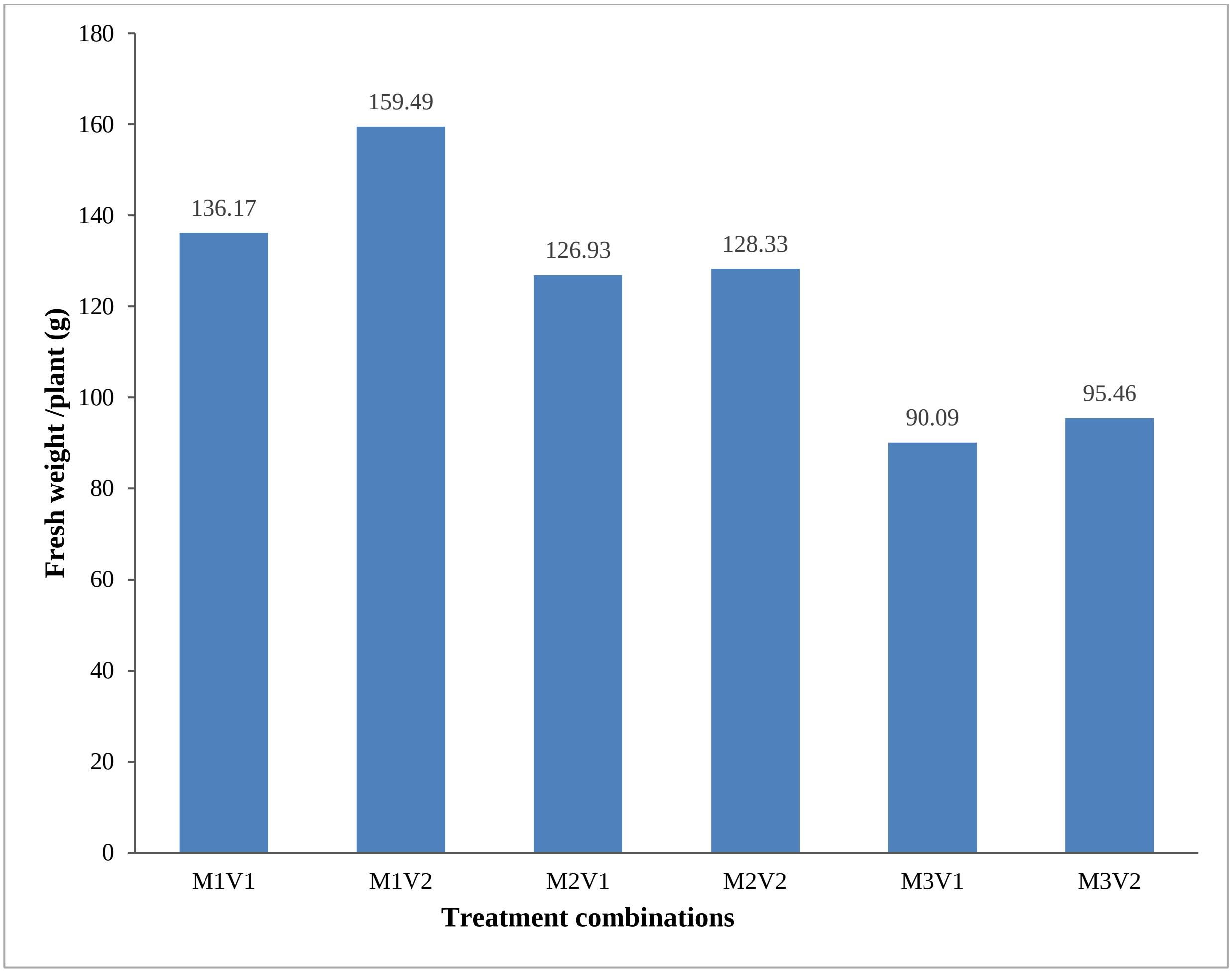
M_3- biochar (10%) + vermicompost (80%) + soil (10%)

4.5 Fresh weight of individual plant (g)

Weight of individual plant of basil showed significant differences with different growing media (Table 7). The highest weight of individual plant (147.83 g) was recorded from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was followed by (127.63 g) M_2 (vermicompost (90%) + soil (10%)), while the lowest weight (92.77 g) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)).

Significant variation was recorded for weight of individual plant of basil showed due to different variety (Table 7). The highest weight of individual plant (127.76 g) was recorded from V_2 (Holy basil), whereas the lowest weight (117.73 g) was found from V_1 (Italian sweet basil).

Combined effect of different growing media and variety showed statistically significant differences in terms of weight of individual plant of basil (Figure 9 and Appendix XI). The highest weight of individual plant (159.49 g) was observed from M_1V_2 and the lowest weight (90.09 g) was found from M_3V_1 treatment combination.



Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

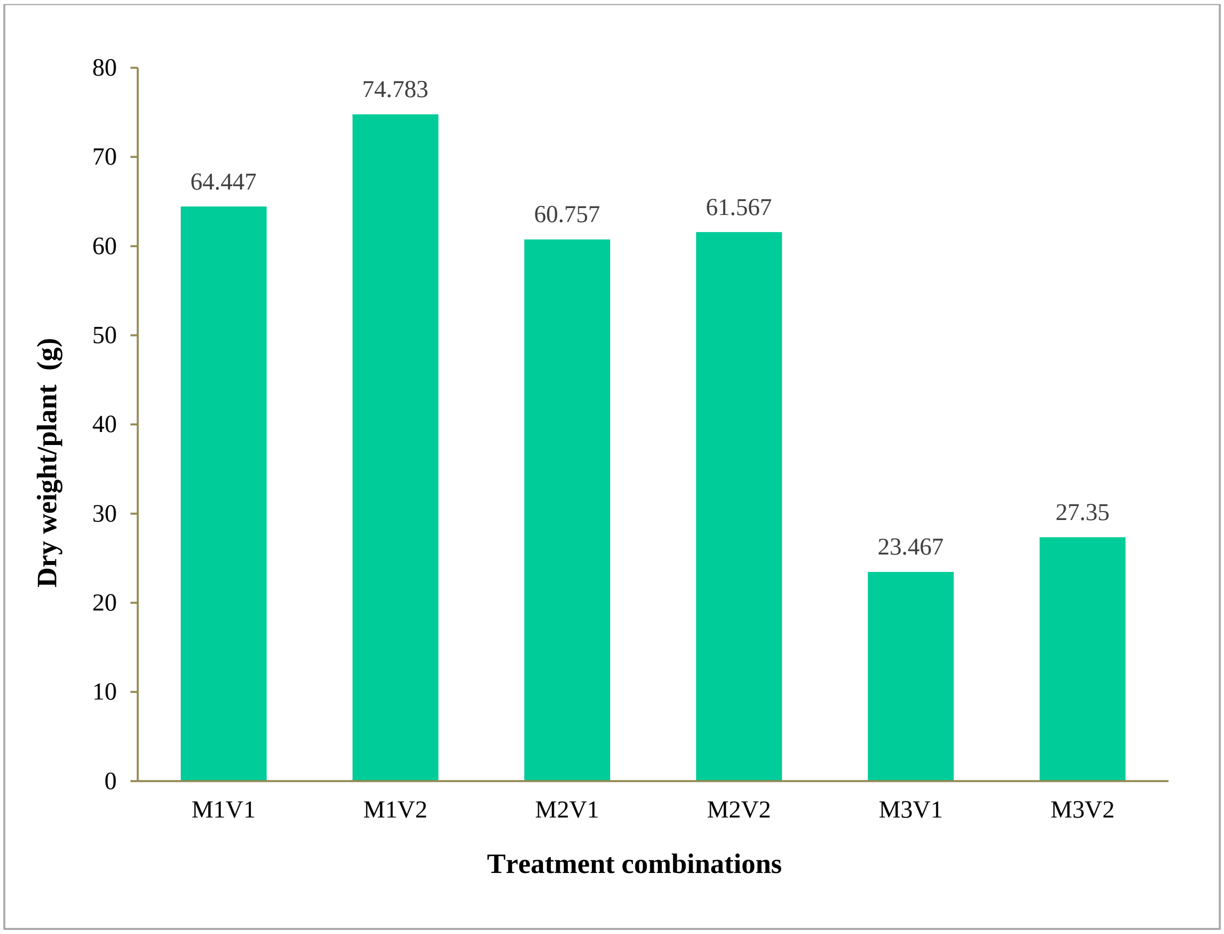
Figure 9: Combined effect of growing media and variety on fresh weight/plant of basil

4.6 Dry weight of individual plant (g)

Dry weight of individual plant of basil showed significant differences in response to different growing media (Table 7). The highest dry weight of individual plant (69.62 g) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was followed by M_2 (61.62 g), while the lowest dry weight of individual plant (25.41 g) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)).

Significant variation was recorded for dry weight of individual plant of basil showed due to different variety (Table 7). The highest dry weight of individual plant (54.57 g) was recorded from V_2 (Holy basil), whereas the lowest dry weight was (49.56 g) found from V_1 (Italian sweet basil).

Combined effect of different growing media and variety showed statistically significant differences in terms of dry weight of individual plant of basil (Figure 10 and Appendix XI). The highest dry weight of individual plant (74.78 g) was observed from M_1V_2 and the lowest dry weight (23.46 g) was found from M_3V_1 treatment combination.



Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

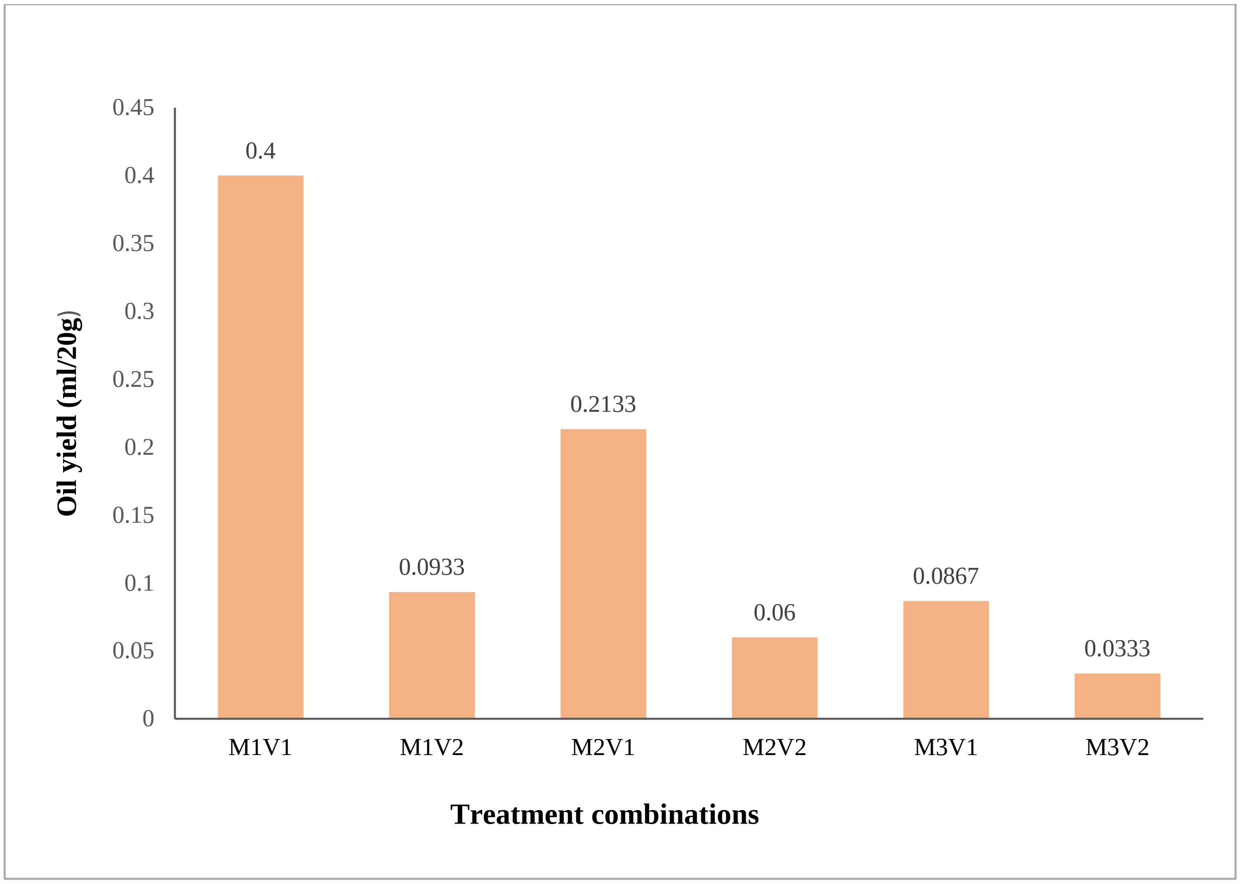
Figure 10: Combined effect of growing media and variety on dry weight (g)/plant of basil

4.7 Essential oil yield (ml)

Essential oil yield (ml)/20 g of dry basil varied significantly due to different growing media (Table 7). The highest oil yield (ml)/20 g of dry basil (0.25 ml) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was followed by M_2 (0.14 ml), while the lowest oil yield (0.06 ml) was observed from M_3 (vermicompost (80%) + biochar (10%) + soil (10%)).

Significant variation was recorded for oil yield (ml)/20 g of dry basil showed due to different variety (Table 7). The highest oil yield (ml)/20 g of dry basil (0.23 ml) was recorded from V_1 (Italian sweet basil), whereas the lowest oil yield (0.31 ml) was found from V_2 (Holy basil).

Combined effect of different growing media and variety showed statistically significant differences in terms of oil yield (ml)/20 g of dry basil (Figure 11 and Appendix XI). The highest oil yield (ml)/20 g of dry basil (0.4 ml) was observed from M_1V_1 and the oil yield (ml)/20 g of dry basil (0.03 ml) was found from M_3V_2 treatment combination.



Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

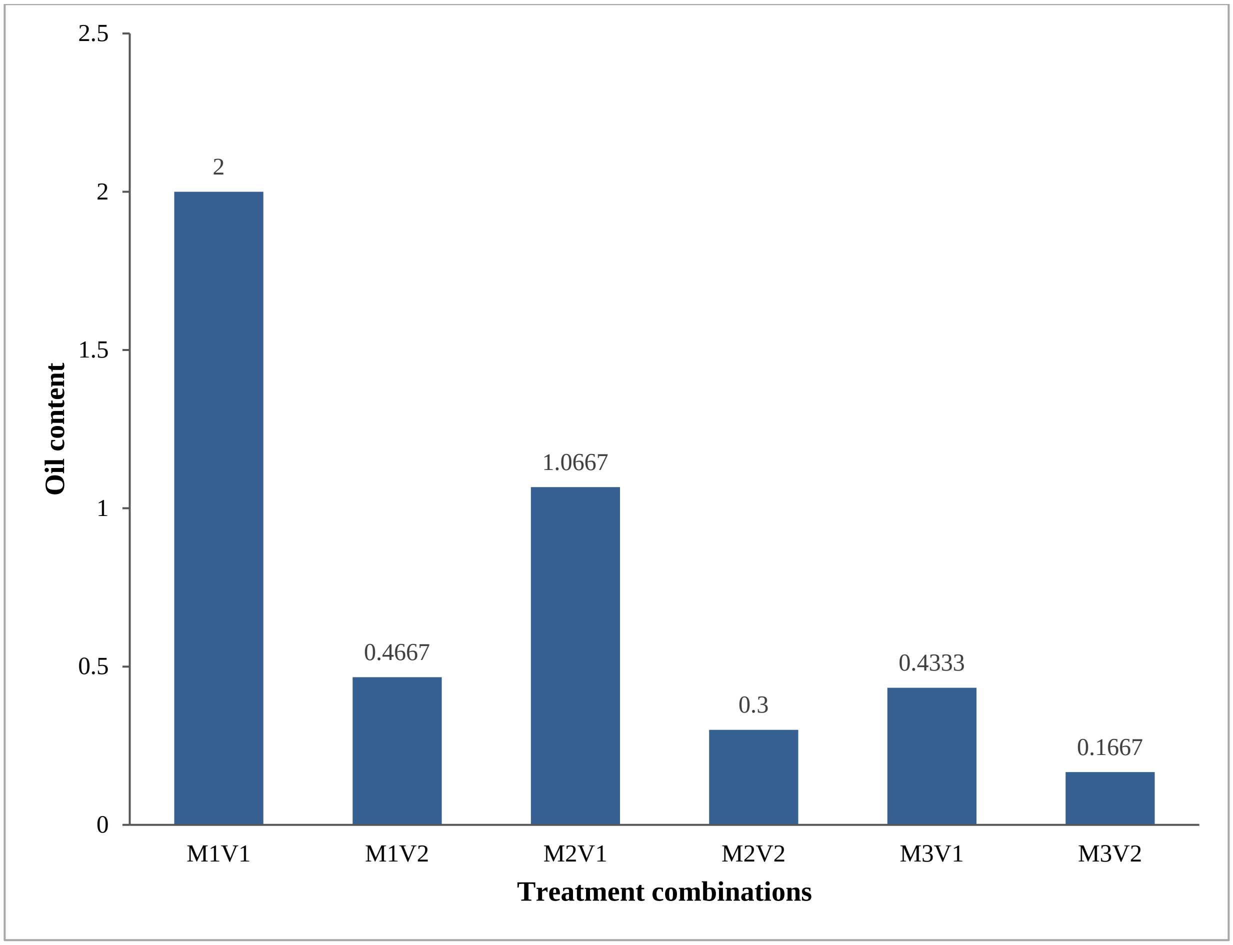
Figure 11: Combined effect of growing media and variety on oil yield (ml)/20 g of dry basil

4.8 Essential Oil content

Essential Oil content of basil showed significant differences in response to different growing media (Table 7). The highest oil content (1.23%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was followed by (0.68%) M_2, while the lowest oil content (0.30%) was observed from M_3 (vermicompost (80%) + biochar (10%) + soil (10%)).

Significant variation was recorded for essential oil content of basil showed due to different variety (Table 7). The highest essential oil content of dry basil (1.17%) as recorded from V_1 (Italian sweet basil), whereas the lowest oil yield (0.31%) was found from V_2 (Holy basil).

Combined effect of different growing media and variety showed statistically significant differences in terms of essential oil content of basil (Figure 12 and Appendix XI). The highest essential oil content of basil (2.00%) was observed from M_1V_1 and the lowest oil yield (0.17%) was observed from M_3V_2 treatment combination.



Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

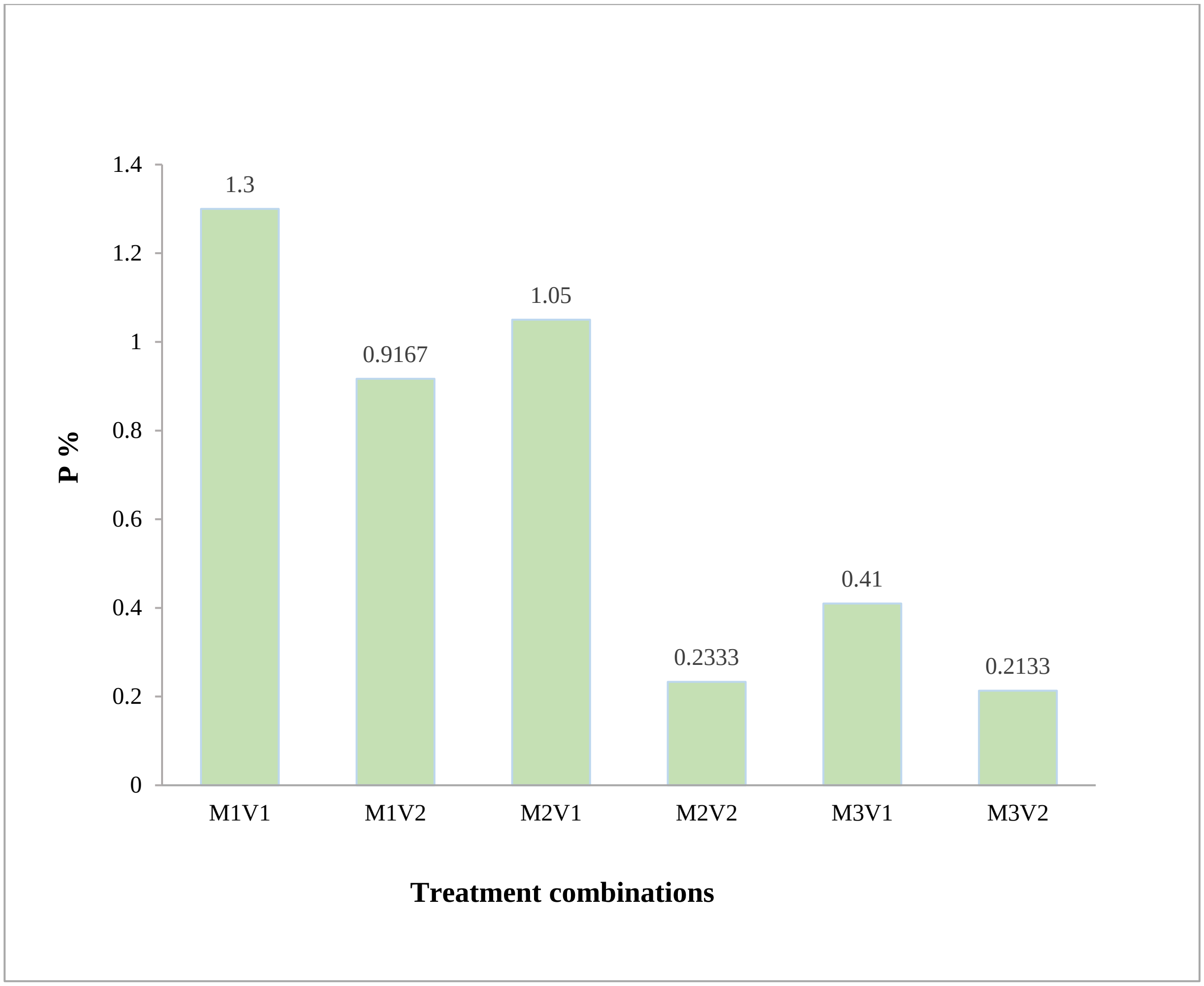
Figure 12: Combined effect of growing media and variety on essential oil content of dry basil

4.7 Phosphorus content

Phosphorus content of basil showed significant differences in response to different growing media (Table 8). The highest P content (1.11%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was followed by (0.31%) M_2, while the lowest P content (0.64%) was observed from M_3 (vermicompost (80%) + biochar (10%) + soil (10%)). Abiram *et al.* (2010) indicated that vermicompost, when added to coir dust, improves the physical property and nutrient content of the medium.

Significant variation was recorded for P content of basil showed due to different variety (Table 8). The highest P content of basil (0.92%) as recorded from V_1 (Italian sweet basil), whereas the lowest P yield (0.45%) was found from V_2 (Holy basil).

Combined effect of different growing media and variety showed statistically significant differences in terms of P content of basil (Figure 13 and Appendix XII). The highest P content of basil (1.3%) was observed from M_1V_1 and the lowest P yield (0.21%) was observed from M_3V_2 treatment combination.



Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

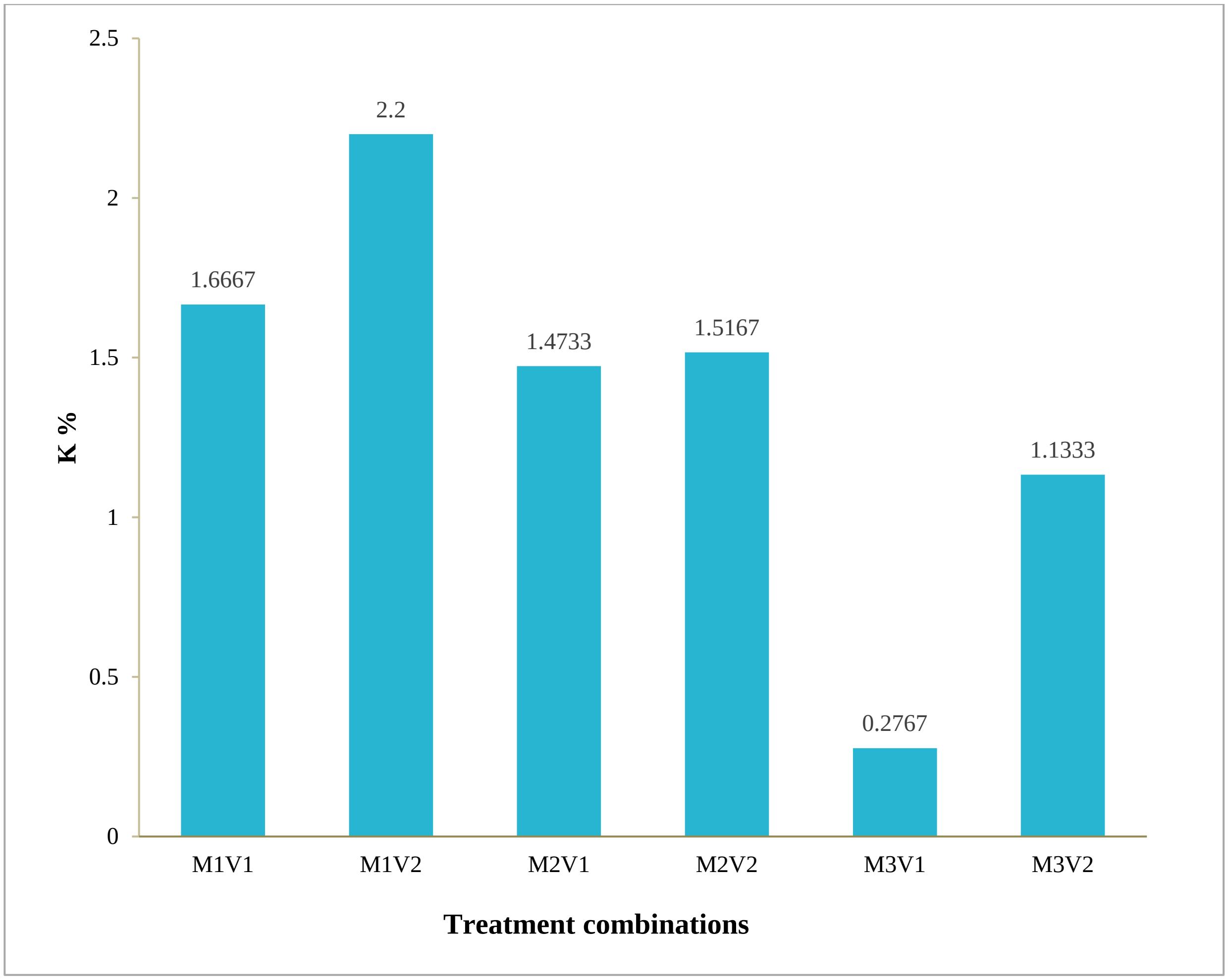
Figure 13: Combined effect of growing media and variety on phosphorus content of basil

4.10 Potassium content

Potassium content of basil showed significant differences in response to different growing media (Table 8). The highest K content (1.93%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was followed by (0.70%) M_2, while the lowest K content (1.49%) was observed from M_3 (biochar (10%) + vermicompost (80 %) + soil (10%)).

Significant variation was recorded for K content of basil showed due to different variety (Table 8). The highest K content of basil (1.62%) as recorded from V_2 (Holy basil), whereas the lowest K yield (1.13%) was found from V_1 (Italian sweet basil).

Combined effect of different growing media and variety showed statistically significant differences in terms of K content of basil (Figure 14 and Appendix XII). The highest K content of basil (2.2%) was observed from M_1V_2 and the lowest K yield (0.27%) was observed from M_3V_1 treatment combination.



Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

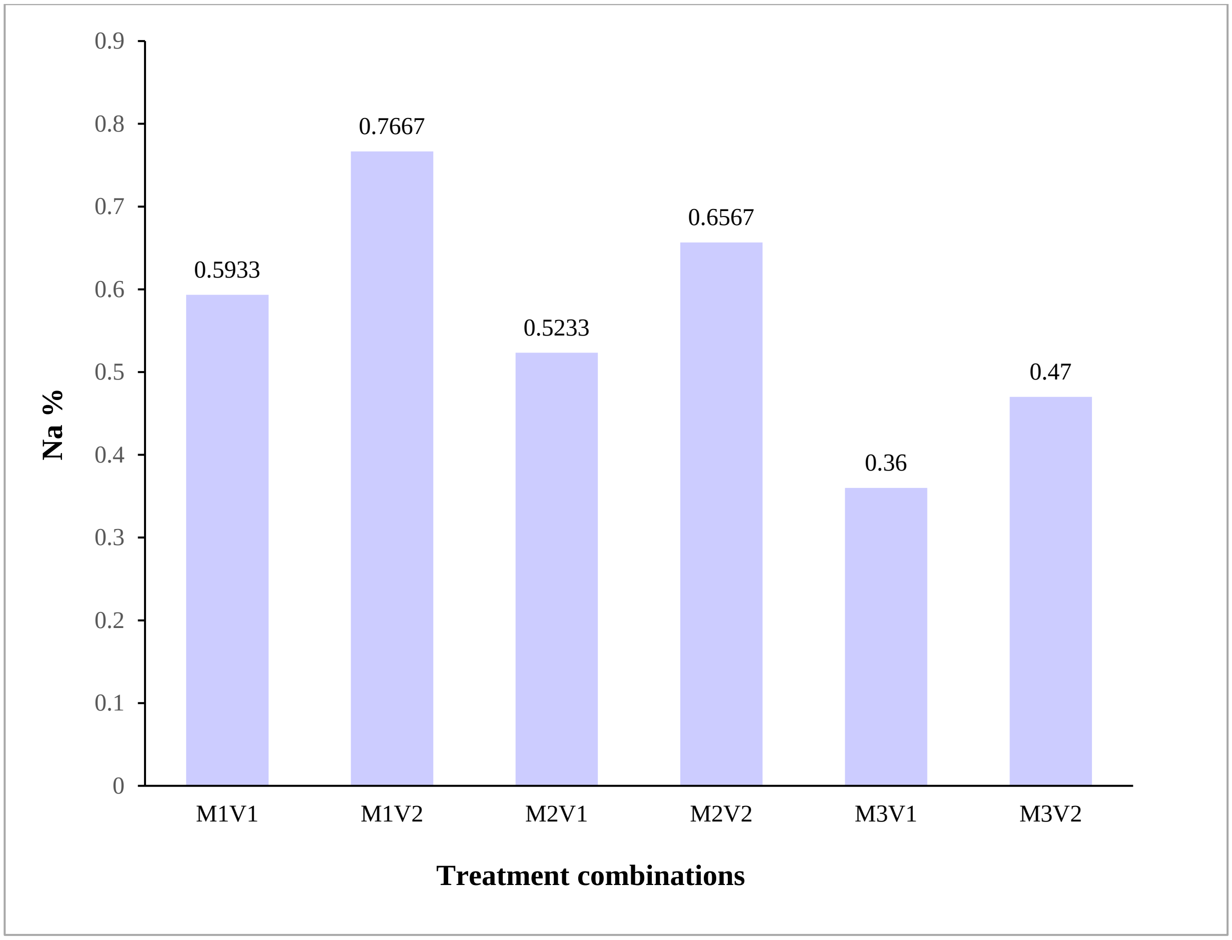
Figure 14: Combined effect of growing media and variety on potassium content of basil

4.11 Sodium content

Sodium content of basil showed significant differences in response to different growing media (Table 8). The highest Na content (0.68%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was followed by (0.59%) M_2, while the lowest Na content (0.41%) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)).

Significant variation was recorded for Na content of basil showed due to different variety (Table 8). The highest Na content of basil (0.63%) as recorded from V_2 (Holy basil), whereas the lowest Na yield (0.49%) was found from V_1 (Italian sweet basil).

Combined effect of different growing media and variety showed statistically significant differences in terms of Na content of basil (Figure 15 and Appendix XII). The highest Na content of basil (0.76%) was observed from M_1V_2 and the lowest Na yield (0.36%) was observed from M_3V_1 treatment combination.



Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

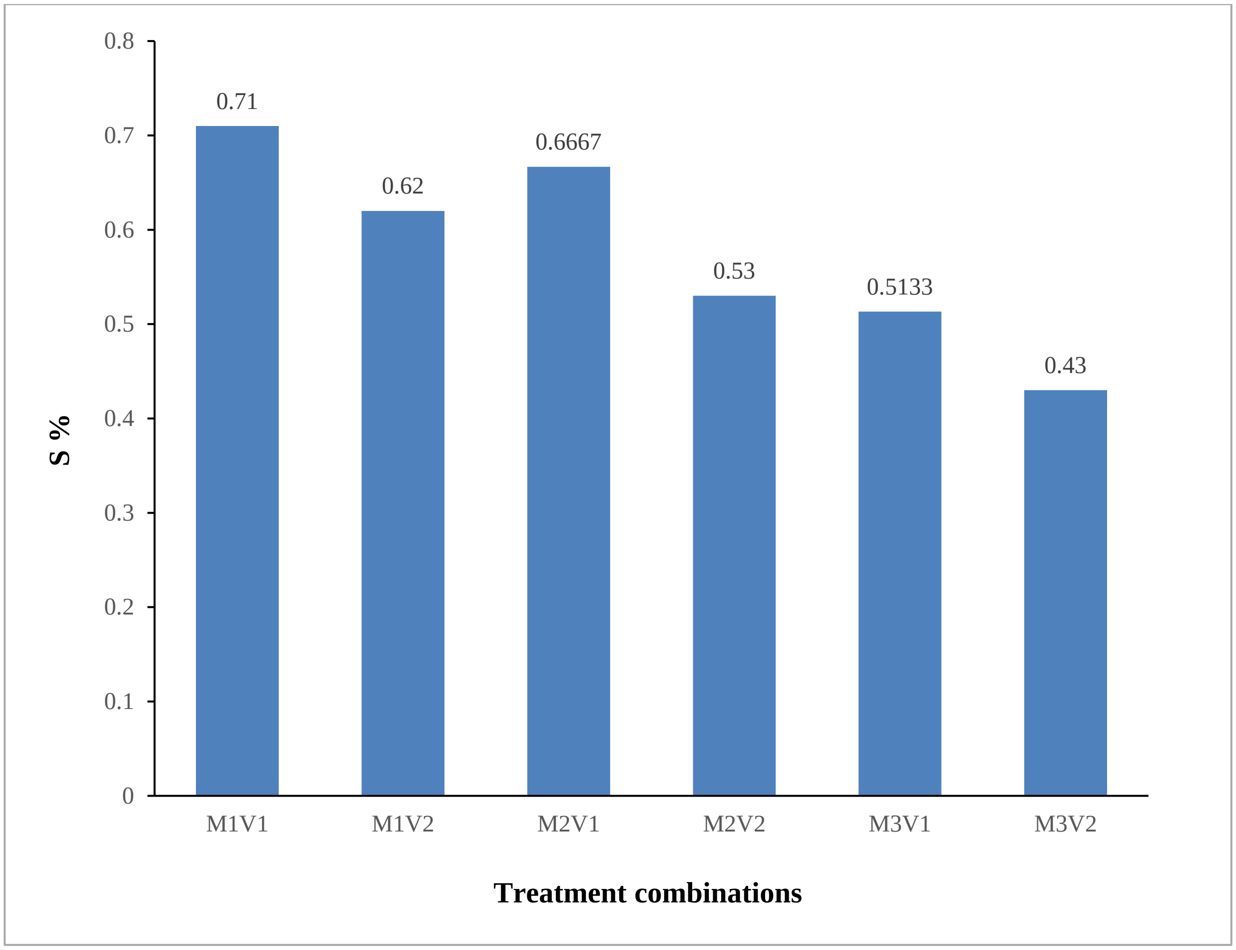
Figure 15: Combined effect of growing media and variety on sodium content of basil

4.12 Sulphur content

Sulphur content of basil showed significant differences in response to different growing media (Table 8). The highest S content (0.67%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) which was followed by (0.59 %) M_2, while the lowest S content (0.47%) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)).

Significant variation was recorded for Na content of basil showed due to different variety (Table 8). The highest Na content of basil (0.63%) as recorded from V_2 (Holy basil), whereas the lowest Na yield (0.49%) was found from V_1 (Italian sweet basil).

Combined effect of different growing media and variety showed statistically significant differences in terms of S content of basil (Figure 16 and Appendix XII). The highest S content of basil (0.71%) was observed from M_1V_1 and the lowest S yield (0.43%) was observed from M_3V_2 treatment combination.



Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

Figure 16: Combined effect of growing media and variety on sulphur content of basil

Table 7. Effect of different growing media and variety on yield and yield contributing characters of basil

Treatments	Wt. of individual plant (g)	Dry weight/plant (g)	Oil yield (ml/20 g)	Oil content (%)
Different Growing media				
M_1	147.83	69.62	0.25	1.23
M_2	127.63	61.16	0.14	0.68
M_3	92.77	25.41	0.06	0.30
LSD (0.05)	3.89	1.61	0.012	0.06
Level of Significance	0.05	0.05	0.05	0.05
CV (%)	8.68	3.58	0.03	0.13
Different variety				
V_1	117.73	49.56	0.23	1.17
V_2	127.76	54.57	0.06	0.31
LSD (0.05)	3.18	1.31	9.37	0.05
Level of Significance	0.05	0.05	0.05	0.05
CV (%)	7.08	2.93	0.02	0.11

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%)　　V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%)　　V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

Table 8. Effect of different growing media and variety on nutrients content of basil

Treatments	P %	K %	Na %	S %
Different Growing media				
M_1	1.11	1.93	0.68	0.67
M_2	0.64	1.49	0.59	0.59
M_3	0.31	0.70	0.41	0.47
LSD (0.05)	0.03	0.04	0.01	0.01
Level of Significance	0.05	0.05	0.05	0.05
CV (%)	0.07	0.08	0.02	0.02
Different variety				
V_1	0.92	1.13	0.49	0.63
V_2	0.45	1.62	0.63	0.53
LSD (0.05)	0.02	0.04	0.09	0.01
Level of Significance	0.05	0.05	0.05	0.05
CV (%)	0.06	0.08	0.02	0.02

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

CHAPTER V

SUMMARY AND CONCLUSION

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The experiment was carried out in the indoor structure of Dr. M. Wazed Mia Central Laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2020 to April 2021 to find out the effect of different growth media on basil varieties in simulated indoor vertical farm. The experiment consisted of two factors; **Factor A**: Growing media 3 levels as- **M_1-**cocopeat (20%) + vermicompost (70%) + soil (10%), **M_2-**vermicompost (90%) + soil (10%), **M_3-**biochar (10%) + vermicompost (80%) + soil (10%) and **Factor B:** Variety (2 levels) as- **V_1-**Italian sweet basil and **V_2-**Holy basil. The two factors 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 analyzed for evaluation of the treatment effect.

Significant variations were observed due to plant height of basil at 10, 20, 30, 40 and 50 DAT the tallest plant (15.50, 23.35, 29.76, 33.98 and 39.08 cm, respectively) was recorded from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) and the shortest plant (5.86, 8.08, 12.25, 15.10 and 18.18 cm, respectively) was found from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); the highest number of leaves/plant (24.67, 51.67, 65.16, 73.00 and 86.67, respectively) was recorded from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)), whereas the lowest number of leaves/plant (12.83, 24.17, 32.33, 36.50 and 42.33 respectively) was found from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); the longest leaf (6.25, 7.05, 8.02, 8.63 and 9.37 cm, respectively) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) , while the shortest leaf (4.40, 4.70, 5.28, 5.65 and 5.97 cm, respectively) was recorded from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); the highest leaf breadth (3.35, 3.73, 4.32, 4.93 and 5.33 cm, respectively) was recorded from M_1 (cocopeat (20%) + vermicompost (70%) +

soil (10%)), whereas the lowest number of leaf breadth (2.68, 2.92, 3.18, 3.53 and 3.78, cm respectively) was found from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); The highest fresh weight of individual plant (147.83 g) was recorded from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)), while the lowest fresh weight (92.77 g) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); The highest dry weight of individual plant (69.62 g) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)), while the lowest dry weight of individual plant (25.41 g) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); The highest oil yield (ml)/20 g of dry basil (0.25 ml) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)), while the lowest oil yield (0.06 ml) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); The highest oil content (1.23%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)), while the lowest oil content (0.30%) was found from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); The highest P content (1.11%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) and the lowest P content (0.64%) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); The highest K content (1.93%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)), while the lowest K content (1.49%) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); The highest Na content (0.68%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)) and the lowest Na content (0.41%) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)); The highest S content (0.67%) was found from M_1 (cocopeat (20%) + vermicompost (70%) + soil (10%)),while the lowest S content (0.47%) was observed from M_3 (biochar (10%) + vermicompost (80%) + soil (10%)).

In terms of plant height of basil at 10, 20, 30, 40 and 50 DAT the tallest plant the tallest plant (11.21, 17.58, 24.34, 29.05 and 33.26 cm, respectively) was recorded from V_2 (Holy basil), while the shortest plant (8.94, 12.72, 18.41, 22.27 and 26.17 cm, respectively) recorded from V_1 (Italian sweet basil); the highest number of leaves/plant (17.56, 32.56, 49.33, 56.22 and 68.11, respectively) was recorded from V_2 (holy basil) and the lowest number of leaves/plant (20.33, 38.56, 44.33, 50.00 and 57.89, respectively) was found from V_1 (Italian sweet basil); the longest leaf (6.14, 6.80, 8.12, 9.22 and 9.92 cm, respectively) was found from V_1 (Italian sweet basil) while the shortest leaf (4.58, 4.88, 5.28, 5.51 and 5.71 cm, respectively) was recorded from V_2 (Holy basil); the highest leaf breadth (3.89, 4.28, 4.74, 5.29 and 5.72 cm, respectively) was recorded from V_1 (Italian sweet basil) and the lowest leaf breadth (2.20, 2.47, 2.94, 3.31 and 3.56 cm, respectively) was found from V_2 (Holy basil); The highest fresh weight of individual plant (127.76 g) was recorded from V_2 (Holy basil), whereas the lowest fresh weight (117.73 g) was found from V_1 (Italian sweet basil); The highest dry weight of individual plant (54.57 g) was recorded from V_2 (Holy basil), whereas the lowest dry weight was (49.56 g) found from V_1 (Italian sweet basil) ; The highest oil yield (ml)/20 g of dry basil (0.23 ml) as recorded from V_1 (Italian sweet basil), whereas the lowest oil yield (0.31 ml) was found from V_2 (Holy basil); The highest essential oil content of dry basil (1.17%) as recorded from V_1 (Italian sweet basil), whereas the lowest oil yield (0.31%) was found from V_2 (Holy basil); The highest P content of basil (0.92%) as recorded from V_1 (Italian sweet basil), whereas the lowest P yield (0.45%) was found from V_2 (Holy basil); The highest K content of basil (1.62%) as recorded from V_2 (Holy basil), whereas the lowest K yield (1.13%) was found from V_1 (Italian sweet basil); The highest Na content of basil (0.63%) as recorded from V_2 (Holy basil), while the lowest Na yield (0.49%) was found from V_1 (Italian sweet basil); The highest S content of basil (0.63%) as recorded from V_1 (Italian sweet basil), whereas the lowest S yield (0.53%) was found from V_2 (Holy basil).

Combined effect of different growing media and variety showed statistically significant variation in terms of plant height of basil at 10, 20, 30, 40, 50 DAT. the tallest plant (18.33, 28.41, 34.40, 39.03 and 43.60 cm, respectively) was observed from M_1V_2 and the shortest plant (5.50, 6.70, 10.67, 13.37 and 16.27 cm, respectively) was observed M_3V_1; the highest number of leaves/plant (23.00, 52.67, 71.67, 80.33 and 100.33, respectively) was found from M_1V_2 treatment. Meanwhile, the lowest number of leaves/plant (14.00, 20.00, 32.00, 35.67 and 41.00, respectively) was recorded from M_3V_2 treatment; the longest leaf (6.77, 8.00, 9.57, 10.57 and 11.70 cm, respectively) was found from M_1V_1 treatment combination and the shortest leaf (4.07, 4.17, 4.30, 4.46 and 4.63 cm, respectively) was recorded from M_3V_2; the highest leaf breadth (4.40, 4.80, 5.47, 6.17 and 6.67 cm, respectively) was found from M_1V_1 treatment. Meanwhile, the lowest leaf breadth (2.30, 2.23, 2.46, 2.66 and 2.86 cm, respectively) was recorded from M_3V_2 treatment; The highest fresh weight of individual plant (159.49 g) was observed from M_1V_2 and the lowest fresh weight (90.09 g) was found from M_3V_1 treatment combination; The highest dry weight of individual plant (74.78 g) was observed from M_1V_2 and the lowest dry weight (23.46 g) was found from M_3V_1 treatment combination; The highest oil yield (ml)/20 g of dry basil (0.4 ml) was observed from M_1V_1 and the oil yield (ml)/20 g of dry basil (0.03 ml) was found from M_3V_2 treatment combination; The highest essential oil content of basil (2.00%) was observed from M_1V_1 and the lowest oil yield (0.17%) was observed from M_3V_2 treatment combination. The highest P content of basil (1.3%) was observed from M_1V_1 and the lowest P yield (0.21%) was observed from M_3V_2 treatment combination; The highest K content of basil (2.2%) was observed from M_1V_2 and the lowest K yield (0.27%) was observed from M_3V_1 treatment combination; The highest Na content of basil (0.76%) was observed from M_1V_2 and the lowest Na yield (0.36%) was observed from M_3V_1 treatment combination; The highest S content of basil (0.71%) was observed from M_1V_2 and the lowest S yield (0.43%) was observed from M_3V_2 treatment combination.

Conclusion

Considering the above-mentioned findings, it can be concluded that in indoor condition, combination of cocopeat, vermicompost and soil media was most effective for vegetative growth as well as quantitative yield of its essential oil and nutrients on both basils varieties. Italian sweet basil leaf was produced more essential oil than holy basil. On the other hand, holy basil had shown higher yield. Cocopeat, vermicompost and soil combination had best performance over other growing media in case of P, K, Na, S nutrients uptakes. Considering the variety, Italian sweet basil showed highest result in P and S uptake. However, K and Na content were highest in holy basil. Scope for the further studies includes the following.

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

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APPENDICES

APPENDICES

Appendix I. Analysis of variance of the data on plant height of basil at different days after transplanting (DAT) as influenced by different growing media and variety

Source of Variance	Degree of Freedom	Mean Square				
		Plant Height (cm) at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replication	2	7.33	9.26	19.07	25.30	31.02
Growing media(A)	2	145.80**	355.59**	462.72**	557.43**	676.12**
variety (B)	1	23.12**	106.05**	158.30**	207.40**	226.14**
Interaction (AxB)	2	13.05**	31.51**	14.32*	16.50*	12.07*
Error	10	1.95	2.54	3.30	3.64	3.05

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

Appendix II. Analysis of variance of the data on number of leaves/plant of basil at different days after transplanting (DAT) as influenced by different growing media and variety

Source of Variance	Degree of Freedom	Mean Square				
		Number of leaves/plant at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replication	2	5.39	19.39	27.17	32.72	140.67
Growing media(A)	2	210.72**	1234.72**	1683.17**	2046.72**	2988.67**
variety (B)	1	34.72*	162.00**	112.50*	174.22**	470.22**
Interaction (AxB)	2	35.39*	76.17*	76.17*	100.39**	357.56**
Error	10	6.72	17.39	14.70	14.39	52.00

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

Appendix III. Analysis of variance of the data on leaf length of basil at different days after transplanting (DAT) as influenced by different growing media and variety

Source of Variance	Degree of Freedom	Mean Square				
		Leaf length (cm) at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replication	2	0.03	0.07	0.10	0.16	0.32
Growing media(A)	2	5.16**	8.30**	11.25**	14.26**	17.74**
variety (B)	1	11.05**	16.63**	36.41**	61.98**	79.80**
Interaction (AxB)	2	2.36**	1.13**	0.92**	2.43**	2.83**
Error	10	0.11	0.09	0.12	0.15	0.32

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

Appendix IV. Analysis of variance of the data on leaf breadth of basil at different days after transplanting (DAT) as influenced by different growing media and variety

Source of Variance	Degree of Freedom	Mean Square				
		Leaf breadth (cm) at				
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Replication	2	0.0156	0.0172	0.0072	0.0317	0.0072
Growing media(A)	2	0.68**	1.04**	2.09**	3.02**	3.72**
variety (B)	1	12.84**	14.76**	14.58**	17.60**	21.13**
Interaction (AxB)	2	0.21*	0.24*	0.30*	0.27*	0.29*
Error	10	0.05	0.06	0.07	0.05	0.06

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

Appendix V. Analysis of variance of the data on yield contributing characters and oil of basil as influenced by different growing media and variety

Source of Variance	Degree of Freedom	Mean Square			
		Fresh wt. of individual plant(g)	Dry wt. of individual plant(g)	Oil yield(ml/20g)	Oil content (%)
Replication	2	114.28	18.50	0.00096	0.02
Growing media(A)	2	4653.96**	3303.99**	0.05**	1.32**
variety (B)	1	452.90**	112.95**	0.13**	3.29**
Interaction (AxB)	2	204.75*	35.46*	0.02**	0.61**
Error	10	45.53	7.76	0.00040	0.01

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

Appendix VI. Analysis of variance of the data on nutrient of basil as influenced by different growing media and variety

Source of Variance	Degree of Freedom	Mean Square			
		P %	K %	Na %	S %
Replication	2	0.00382	0.00629	0.00012	0.00005
Growing media(A)	2	0.96136**	2.32504**	0.10895**	0.05787**
variety (B)	1	0.97534**	1.02722**	0.08681**	0.04805**
Interaction (AxB)	2	0.15176**	0.25154**	0.00154*	0.00127*
Error	10	0.00294	0.00638	0.00036	0.00026

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

Appendix VII. Effect of growing media and variety on plant height of at different days after transplanting (DAT) of basil

Treatments	Plant height at different DAT				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
Different Growing media					
M_1	15.50 a	23.35 a	29.76 a	33.98 a	39.08 a
M_2	8.86 b	14.02 b	22.12 b	27.90 b	31.86 b
M_3	5.86 c	8.08 c	12.25 c	15.10 c	18.18 c
LSD (0.05)	0.80	0.92	1.05	1.10	1.01
Level of Significance	0.05	0.05	0.05	0.05	0.05
CV (%)	1.79	2.05	2.34	2.34	2.25
Different Variety					
V_1	8.94 b	12.72 b	18.41 b	22.27 b	26.17 b
V_2	11.21 a	17.58 a	24.34 a	29.05 a	33.26 a
LSD (0.05)	0.66	0.75	0.86	0.89	0.82
Level of Significance	0.05	0.05	0.05	0.05	0.05
CV (%)	1.47	1.67	1.91	2.00	1.83

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%)
M_2- vermicompost (90%) + soil (10%)
M_3- biochar (10%) + vermicompost (80%) + soil (10%)

V_1- Italian sweet basil
V_2- Holy basil

Appendix VIII. Effect of growing media and variety on number of leaves/plant at different days after transplanting (DAT) of basil

Treatments	Number of leaves/plant at different DAT				
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Different Growing media					
M_1	24.67 a	51.67 a	65.16 a	73.00 a	86.67 a
M_2	19.33 b	30.83 b	43.00 b	49.83 b	60.00 b
M_3	12.83 c	24.17 c	32.33 c	36.50 c	42.33 c
LSD (0.05)	1.49	2.41	2.21	2.19	4.16
Level of Significance	0.05	0.05	0.05	0.05	0.05
CV (%)	3.34	5.36	4.93	4.88	9.28
Different Variety					
V_1	20.33 a	38.56 a	44.33 b	50.00 b	57.89 b
V_2	17.56 b	32.56 b	49.33 a	56.22 a	68.11 a
LSD (0.05)	1.22	1.97	1.81	1.78	3.39
Level of Significance	0.05	0.05	0.05	0.05	0.05
CV (%)	2.72	4.3800	4.03	3.98	7.57

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%)
M_2- vermicompost (90%) + soil (10%)
M_3- biochar (10%) + vermicompost (80%) + soil (10%)

V_1- Italian sweet basil
V_2- Holy basil

Appendix IX. Effect of growing media and variety on leaf length at different days after transplanting (DAT) of basil

Treatments	Leaf length at different DAT				
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Different Growing media					
M_1	6.25 a	7.05 a	8.02 a	8.63 a	9.37 a
M_2	5.43 b	5.77 b	6.80 b	7.82 b	8.12 b
M_3	4.40 c	4.70 c	5.28 c	5.65 c	5.97 c
LSD (0.05)	0.19	0.18	0.20	0.23	0.33
Level of Significance	0.05	0.05	0.05	0.05	0.05
CV (%)	0.42	0.39	0.45	0.50	0.73
Different Variety					
V_1	6.14 a	6.80 a	8.12 a	9.22 a	9.92 a
V_2	4.58 b	4.88 b	5.28 b	5.51 b	5.71 b
LSD (0.05)	0.15	0.14	0.16	0.18	0.27
Level of Significance	0.05	0.05	0.05	0.05	0.05
CV (%)	0.34	0.32	0.36	0.41	0.59

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%)

M_2- vermicompost (90%) + soil (10%)

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

V_1- Italian sweet basil

V_2- Holy basil

Appendix X. Effect of growing media and variety on leaf breadth at different days after transplanting (DAT) of basil

Treatments	Leaf breadth at different DAT				
	10 DAT	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**
Different Growing media					
M_1	3.35 a	3.73 a	4.32 a	4.93 a	5.33 a
M_2	3.10 b	3.47 b	4.03 b	4.43 b	4.80 b
M_3	2.68 c	2.92 c	3.18 c	3.53 c	3.78 c
LSD (0.05)	0.13	0.14	0.16	0.13	0.14
Level of Significance	0.05	0.05	0.05	0.05	0.05
CV (%)	0.28	0.31	0.35	0.29	0.30
Different Variety					
V_1	3.89 a	4.28 a	4.74 a	5.29 a	5.72 a
V_2	2.20 b	2.47 b	2.94 b	3.31 b	3.56 b
LSD (0.05)	0.10	0.11	0.13	0.11	0.11
Level of Significance	0.05	0.05	0.05	0.05	0.05
CV (%)	0.23	0.25	0.28	0.24	0.25

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

Appendix XI. Combined effect of growing media and variety on yield and yield contributing characters of basil

Treatments	Fresh wt. of individual plant(g)	Dry wt. of individual plant(g)	Oil yield(ml/20g)	Oil content (%)
M_1V_1	136.17 b	64.447 b	0.4000 a	2.0000 a
M_1V_2	159.49 a	74.783 a	0.2133 b	1.0667 b
M_2V_1	126.93 b	60.757 b	0.0933 c	0.4667 c
M_2V_2	128.33 b	61.567 b	0.0867 c	0.4333 c
M_3V_1	90.09 c	23.467 c	0.0600 cd	0.3000 cd
M_3V_2	95.46 c	27.350 c	0.0333 d	0.1667 d
LSD (0.05)	5.5091	2.2742	0.0162	0.0812
CV %	12.275	5.0672	0.0362	0.1809

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)

Appendix XII. Combined effect of growing media and variety on nutrients content of basil

Treatments	Phosphorus %	Potassium %	Sodium %	Sulphur %
M_1V_1	1.30 a	1.67 b	0.59 c	0.71 a
M_1V_2	0.91 c	2.20 a	0.77 a	0.62 c
M_2V_1	1.05 b	1.47 c	0.52 d	0.67 b
M_2V_2	0.23 e	1.52 c	0.66 b	0.53 d
M_3V_1	0.41 d	0.28 e	0.36 f	0.51 d
M_3V_2	0.21 e	1.13 d	0.47 e	0.43 e
LSD (0.05)	0.04	0.07	0.02	0.01
CV %	0.10	0.15	0.03	0.03

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

Here,

M_1- cocopeat (20%) + vermicompost (70%) + soil (10%) V_1- Italian sweet basil

M_2- vermicompost (90%) + soil (10%) V_2- Holy basil

M_3- biochar (10%) + vermicompost (80%) + soil (10%)