INFLUENCE OF ORGANIC MANURES ON GROWTH AND YIELD OF MINT, CHILLI AND INDIAN SPINACH USING GEOTEX VERTICAL FARMING TECHNOLOGY

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CERTIFICATE

This is to certify that the thesis entitled ***"Influence of organic manures on growth and yield of mint, chilli and indian spinach using geotex vertical farming technology"*** *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****, embodies the result of a piece of bona fide research work carried out by* ***ANZUMAN RAHMAN NITU,*** *Registration number:* ***14-05935,*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was carried out at the "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during December 2019 to May 2020 to study the effect of different organic manures on growth and yield of horticultural crops like mint, chilli and indian spinach. (7x4) sq feet vertical structure was used. Each pocket contains 4 kg growing media. Long lasting and eco friendly geo textile cloth was used to make pocket for crop plantation. Those pockets were attached with vertical structure. The experiment consisted of one factor and these are T_1:Control; T_2:2 kg vermicompost and 2 kg soil per pocket; T_3:1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket and T_4:2 kg kitchen compost and 2 kg soil per pocket. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on growth, yield components and yield of mint, chilli and indian spinach and significant variation was observed for most of the studied characters. In case of mint the highest production from individual plant was recorded from T_3 (1.5 kg Vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was 151.40 g per plant. The lowest production from individual plant was recorded from T_1 (control) which was 80.00 g per plant. In case of chilli results revealed that the highest fruit production (88.43 g) was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was significantly different from others treatments. On the other hand the lowest fruit production (24 g) was obtained from T_1 (control) which was statistically similar to T_4 (2 kg kitchen compost and 2 kg soil per pocket) and the yield was 29.67 g. In case of indian spinach the highest production from individual plant was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was 290.66 g. The lowest production from individual plant was recorded from T_1 (control) which was 71.33 g.

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LIST OF ACRONYMS

Acronym		Full meaning
AEZ	=	Agro-Ecological Zone
%	=	Percent
^{0}C	=	Degree Celsius
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	And others
FAO	=	Food and Agriculture Organization
g	=	Gram (g)
ha^{-1}	=	Per hectare
kg	=	Kilogram
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
t	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

CHAPTER I
INTRODUCTION

CHAPTER I

INTRODUCTION

Roofs with vegetated surface or any vertical structure provide ecosystem service in urban areas including better regulation of temperature. Rooftop farms can help reduce local temperatures (Wong *et al.*,2007) and when implemented on a city wide scale, could result in significant cooling of the urban environment (Base *et al*.,2003). A garden or rooftop farm is a place where people can come together for mutual benefit and often providing a common social and cultural identity for city residents. Although green roofs are initially more expensive to construct, it can be more economical over the life span of roof because of the energy saved and longevity of roof membranes. Vertical structure are challenging for plant growth and survival. But it will save area and provide food security which is the crying need for present Bangladesh. Urban agriculture is used to supplement inadequate household incomes. Besides, the use of organic manure like vermicompost and coco fiber will reduce fertilizer cost and health risk. Biofertilizers and organic manure ensures higher productivity, minimize expenditure of costly fertilizer inputs, improves the efficiency of added fertilizer and provides good soil health. Vermicompost contains an average of 1.5%-2.2% N, 1.8%-2,2% P, 1.0%-1.5% K. Long term application of organic manures (Tiwari *et al.,*2002) and biofertilizers (Bhunia *et al.*,2006; Kumar *et al.*,2009) were reported to improve soil organic carbon, available N, P and K. Household waste can also be used after decomposition. Organic fertilizers influence both yield and plant micronutrient contents and thus help sustain crop productivity (Mottaghian *et al.*,2008). This research will contribute to establish vertical roof top garden, provide family nutrition and mitigate global warming challenge in the long run.

Peppermint *(Mentha piperita* L.) is a perennial herb, popularly known as “Mint” in Bangladesh belongs to Labiatae family. It is an important oil bearing herb which is native to Mediterranean countries and the World most valuable flavoring agent. Peppermint is grown for commercial production of peppermint essential oil, for production of peppermint dry leaves, or for the fresh herb market. Peppermint essential oil is a major aromatic agent used extensively in chewing gum, toothpaste, mouth washes, confectionary and aromatherapy products. Peppermint is one of the most popular in traditional medicine as herbal tea, essential oil and menthol which are used as pharmaceuticals and oral preparation (Edris *et al.*,2003). Tea is prepared by using the mint leaves in a dry or fresh form. Its leaves can be used either in raw form or it can be cooked and it also contains the essential oil. This herb also used to season salad and other cooked food. Mint is usually taken after a meal for its credibility to reduce indigestion and colonic spasms by decreasing the gastro cholic refluxes. Its pleasant taste makes it an excellent gastric stimulant.

Chilli (*Capsicum frutescens*) is an important spice in Bangladesh. It belongs to the family Solanaceae. Chilli is a native crop of Central America and West Indies but spread quickly throughout the Tropical countries. Chilli is a favorite spice in Indian sub-continent. It is virtually an indispensible item in the kitchen for every day cooking. Red chilli fruit contains 15.9% protein, 31.6% carbohydrate, 50 mg/100g vitamin-C and small quantities of vitamin A, B and E. It is an impotent cash crop in Bangladesh. It is also a cash crop of the country. Conventional farm systems leading to qualitative deterioration of soil as well as agricultural yield. However, a growing awareness of the adverse impacts of inorganic fertilizers on crop production as well as increasing environmental and ecological concerns has stimulated greater interest in the utilization of organic amendments for crop production. Organic manures act not only as a source of nutrients and organic matter, but also increase microbial diversity and activity in soil, which influence soil structure and nutrients turnover, in addition to improvement in other physical, chemical and biological properties of the soil (Albiach *et al.*,2000). Thus organic amendments/manures are environmentally benign and help in maintaining soil fertility as well as agricultural productivity. It is also called the life of soil and plays an important role for sustainable soil fertility and crop productivity. It plays an important role physical, chemical and biological property of the soils and ultimately enhances the crop productivity. The greatest benefit from cycling and recycling of organic matter in soils is the overall improvement in soil environment as well as supplying nutrients especially N, P, K and S. It also improves the soil physical and chemical properties like porosity water-holding capacity. It has been widely used for increasing crop production. Among various organic products, vermicompost has been recognized as potential soil amendment. Vermicompost is a product of non thermophilic biodegradation of organic material by combined action of earthworms and associated microbes. It is a highly fertile, finely divided peat-like material with high porosity, aeration, water- holding capacity and low C:N ratios. So, vermicompost is very essential for the growth and yield of chilli.

Indian spinach (*Basella alba* L.) commonly known as poi, belongs to the family Basellaceae. It is a popular summer leafy vegetable widely cultivated in Bangladesh, India, in Tropical

Asia and Africa. Indian spinach is a fleshy annual or biennial, twining much branched herb with alternate leaves. Leaves are broadly ovate and pointed at the apex. Flowers are white or pink, small sessile in cluster on elongated thickened peduncles in an open branched inflorescence. Fruit is enclosed in fleshy perianth. There are mainly two distinct types, *Basella alba* and *Basella rubra*, one with green petioles and stems and the other with reddish leaves, petioles and stems. Both the green and red leaved cultivars are consumed as vegetables but green-leaved cultivars are commercially cultivated. The fresh tender leaves and stems are consumed as leafy vegetable after cooking. As half of the water soluble substance may be lost by boiling in water, it is preferable to cook the leaves in soups and stews. Indian spinach is popular for its delicate, crispy, texture and slightly sweeter taste in fresh condition. The nutritive value of Indian spinach is very high with a good content of minerals and a moderate storage of vitamins to the human diet plus substantial amount of fibre and water. The plant is reported to contain moisture -93%, protein -1.2%, iron - 1.4%, calcium - 0.15%, vitamin A - 3250 IU/l00g. In addition to these, *Basella alba* contains 16g fluoride/100g and nitrate content is 764 ppm on dry weight basis. There was no loss of nitrate even after 48hrs of cold storage. Moreover, it is sedative, diuretic and expectorant. The coloring matter present in the red cultivar is reported to have been used in China as a dye. The ripe fruits also contain a deep violet coloring matter which is also used for coloring food. On account of the presence of mucilage substances in the leaves and stems, it is used as poultice. The juice of leaves is prescribed in cases of constipation, particularly for children and pregnant woman. The crop grows in well sandy loam soil provided it is wall drained and well aerated. Adequate moisture and partial shade result in better growth of the plant and formation of bigger succulent leaves. Cultivation of the crop should be avoided in regions affected by frost. The crop is usually grown during warm and moist seasons. Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh. The cultivation of *Basella alba* requires proper supply of plant nutrient. This requirement can be provided by applying inorganic fertilizer or organic manure or both. Only organic manure application can replace the requirement of inorganic fertilizer. Organic manure improves soil structure and water holding capacity. Moreover, it facilitates aeration in soil. Recently, organic farming is appreciated by vegetable consumers as it enhances quality of the produce. Nowadays people are willing to get the vegetable without the inorganic fertilizer, because they are suffering from serious diseases which are due to the bad effect of inorganic fertilizer. A number of agronomic practices have been found to affect the yield of vegetable crops. Sowing time had a marked effect on growth and development of crops. Effect of sowing time on growth and development has significant influence in Indian spinach. Earlier sowing provides more time for the growth and development of plant which is favorable for higher yield.

Objectives of the research work:

- To find out the suitable organic manures on the growth and yield of mint, chilli, indian spinach

CHAPTER II
REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

The organic production of different mint species and related crops was studied by various authors. The valued conclusions of those assessments are appraised critically and highlighted in this chapter selectively under diverse headings as the users' friendly manner.

2.1 Concept of Organic farming

Organic farming is not merely a non-chemical agriculture; instead, it is a system of farming based on integrated relationships. So, the relationship among soil, water, plants and soil micro flora should be known and then the overall association of both the plant and the animal kingdoms could be established of which human being are at the apex who can bring the integrated system in agriculture. The totality of these liaisons is the backbone of organic farming.

The uses of organic manures to meet the nutrient requirements of crops would be inevitable in the years to come for sustainable agriculture. Organic manures generally improve the physical, chemical and biological properties of soils beside conserving and improving the moisture holding capacity. Organic manures provide nutrients and are considered as one of the vital keys to increase biomass production, especially for the quality of essential oils in medicinal plants and spices, as well as being safer for the humans and animals health and the environment, providing benefits in the form of improvement in soil physical, chemical and biological 6 properties (Priyadarshani *et al.*,2013; Rosal *et al.*,2011; Al-Fraihat *et al.*,2011; Brant *et al.*,2010 and Correa *et al.*,2010). According to the USDA (2012), the organic farming is a production system which avoids or largely excludes the uses of synthetic fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent possible, organic farming systems rely on crop rotations, crop residues, animal manures, legumes, green manures, off farm organic wastes and the means of biological pest control strategies. This is to maintain the soil productivity and the good condition of the field to get plant nutrients and control insects, weeds and other pests too. An additional benefit of using organic compost to provide nutrients for plant growth is that those provide an alternative measure to manage and dispose farm residues. The growing demand for food produced without the uses of pesticides as well as the pollution free environment is a global issue. In general, consumers are increasingly purchasing organic products including herbal and medicinal plants (Naguib, 2011), which have a growing global market as those are a source of biologically active natural products. The principal elements considered while practicing organic farming are: a) creating a healthy crop field, b) making nutrient and energy flows in the soil ecosystem, c) keeping the life in the cycle, and d) sustainable yield.

2.2 Concept of vertical farming

Vertical farming is the act of producing food on vertically slanted surfaces. Rather than cultivating vegetables and other foods on a solitary level, such as in a field or a nursery, this technique produces food sources in vertically stacked layers normally integrated into different structures like a high rise/skyscraper, dispatching compartment or repurposed warehouse. Despite the fact that the idea appears to be new rather it could be seen as an expansion of greenhouse advancements (Anonymous, 2015).

2.3 Effect of Organic manure on yield and yield contributing characters of *Mentha*

Suresh *et al.,* (2018) Studied on the organic nutrition for the growth and yield of the Japanese mint and pointed out that the application of vermicompost @ 2.5 t /ha + humic acid 0.2% + panchagavya 3% resulted in improving the growth characteristics like plant height, plant spread, number of lateral branches, number of leaves and leaf area, the herbage yield and dry matter production as well.

Arafa *et al.,* (2017) studied the effect of some organic manures and bio-fertilizers on *Mentha* plant which suggested that bio-fertilizers produced higher fresh herb in terms of g/plant and ton/ha. The maximum total fresh yield g/plant for two cuts was gained from FYM + N (298.6 and 309.6) g/plant in both seasons. The treatment of FYM + N recorded the tallest plants; the highest mean value was (70.3 and 69.0 cm) in both seasons respectively. The highest branches number/plant was (19.8 and 20.8) in both seasons respectively from FYM + N.

Hussein *et al.,* (2015) conducted a study on the effects of foliar organic fertilization on the growth, yield and oil contents of *M. piperita var. citrate* in Malaysia. The results showed that there was significantly clear positive trend in increasing growth traits by spraying humic acid. The interaction effect was significant in both cuts, the highest values of plants, herbage fresh and dry weights (g/plant) were obtained from the treatment sprayed with humic acid @ 5g/ L + amino spot at 1.5 ml followed by the treatment sprayed with 2.5 g/ L humic acid + 1.5 ml/ L amino spot at the two cuts.

Mahmoodabad *et al.,* (2014) investigated the changes in the yield and the growth of green mint under foliar application of urea and soil application of vermicompost showed the highest

(295g) and the lowest (217.33 g) plant dry weights, respectively in the application of vermicompost @ 10 t/ha over the control treatment.

Olfati *et al.*,(2014) conducted an experiment on mint and reported that vermicompost had the highest essential oil yield (24.21 ml/m), the highest number of lateral branches (18), fresh (10.51 g) and dry weight (4.64 g) of plant, fresh (2,102.9 kg/ha) and dry (928.67 kg/ha) yield, leaf area index (0.17) and the highest oil per plant (0.24 ml/plant) and oil yield (18.49 ml/m).

Rahman *et al*., (2014) stated that in case of production of Pudina, cowdung, poultry manure and cowdung+ NPK fertilizer produced statistically identical yield. Cowdung and poultry manure showed its superiority on plant height, Leaf length,1000-fresh leaf yield and fresh yield of Tulsi and Pudina (Mint) medicinal plant to the control cowdung treatment gave the highest no. of branch/plant as the value 15.33 no. of branch/plant. The maximum leaf number (150.00) was appeared in cowdung treatment. Research on the quality yield of the herbal mint (*M. piperata* L) under the influence of mineral and organic fertilization in Germany showed that the yield of the mint herbage was positively influenced by the increasing nitrogen rates up to 120 kg/ ha, which was the highest production rate. It was worth noting that the use of foliar fertilization on peppermint herbage achieved a production of 18,666 kg /ha (Valeriu and Ovidiu, 2011).

An investigation with the roots of Asparagus racemosus grown under organic manures-cowdung, compost and vermicompost without using mineral or chemical fertilizer showed that the total phenol and total flavonoid content was highest in the plants from vermicompost treated soil. The antioxidant activity was highest in the plants from compost treated soil (Saikia and Upadhyaya, 2011).

An Iranian investigation revealed that inoculation of *Ocimum basilicum* roots with plant growth-promoting rhizobacteria (PGPR) improved growth and accumulation of essential oils. Treatments were *Pseudomonas putida* strain 41, *Azotobacter chroococcum* strain 5 and *Azosprillum lipoferum*. In comparison to the control treatment, all factors were increased by PGPR treatments. The maximum root fresh weight (3.96 g/plant), N content (4.72%) and essential oil yield (0.82%) were observed in the *Pseudomonas* + *Azotobacter* + *Azosprillum* treatment. All 9 factors were higher in the *Pseudomonas* + *Azotobacter* + *Azosprillum*and *Azotobacter* + *Azosprillum* treatments (Ordookhani *et al.,* 2011).

Kumar and Sood (2010) conducted an experiment on this crop with three organic fertilizers: FYM (10 t/ha), vermicompost (10 t/ha) and *Azotobacter* (10 kg/ha); and one standard dose of

NPK (120:50:40 kg/ha). The use of vermicompost resulted in enhanced plant height, yield, oil content and oil yield of 39.48 cm, 190.11 q/ha, 0.34% and 57.29 kg/ha. An experiment with application of saline water in addition to bio and organic fertilization on geranium plant revealed that peanut compost slightly increased plant fresh and dry weights. The oil percentage decreased at high salinity level of 6000 ppm but at 3000 ppm the oil percentage reached 0.4 when treated with (half dose of compost+Bio) and 0.6% when plants were supplied with full dose of peanut compost compared to the control (Leithy *et al.,* 2009).

An investigation with marjoram (*Majorana hortensis* L.) indicated that the use of combined treatment of bio-fertilizers gave better results for all studied traits. The oil percentage and yield per plant for three cuttings was almost twofold higher on fresh weight basis as a result of aqueous extracts of compost at low level + bio-fertilizers compared with control. The chemical composition of marjoram essential oil did not change due to the fertilization type or level (Gharib *et al.,* 2008). In an Iranian experiment, the effects of different levels of vermicompost and irrigation were evaluated on morphological characteristics and essential oil content of "Goral" an improved German chamomile. The results indicated that the vermicompost application improved plant height, early flowering; flowers dry weight, anthodia height and diameter significantly. The highest essential oil yield detected in 10% vermicompost and irrigation 4 mm per two weeks. This experiment 10 revealed that 15% vermicompost plus 2 mm irrigation per two weeks was the best treatment to produce the flower yield in Goral cultivar of German chamomile in organic system (Azizi *et al.,* 2008).

In a study, vermicompostedcoirpith and coirpith composted with microorganisms were used as a growth medium for growing the medicinal plant. The results indicated that vermicompost could be helpful for the reclamation of soils from industrial sites in a small scale nursery (Vijaya *et al.,* 2008).

El-Sherbeny *et al.,*(2005) stated that by increasing levels of compost fertilizer to *Sideritis montana* L., vegetative growth and major components of essential oils also increased. Poultry manure application significantly increased the herbage, essential oil content and dry matter yield in Java citronella plants (Adholeya and Prakash, 2004). The percentage of essential oil, fresh and dry matter of marjoram plants positively responded to increased levels of composted manure compared with chemical fertilizer (Edris *et al.,* 2003).

Ram *et al., (*2001) conducted a field experiment with peppermint (*Menthapiperita* L.) in a sandy loam soil at Lucknow, India where suggested to get sustainable production of peppermint, application of Vermicompost 9 t/ha along with 112.5 kg N/ha through synthetic fertilizer is recommended for light textured sandy loam soils as it produced maximum essential oil (94.3 kg/ha), increased the herb and essential oil yields by 104 and 89%.

Chand *et al.,* (2001) recorded the highest herbage yield (28.81 and 24.71 t/ha) and oil yield (216.0 and 222.4 t/ha) in mint with the combined uses of FYM (6.7 t/ha) and NPK (133:40:40 kg/ha).

Singh et *al.,* (1988) noted that the uses of FYM @ 40 t /ha increased the oil yield (75.4 l/ha) with higher net returns ha-1 (Rs. 34322/ha) in *M. arvensis.*

2.4 Effect of Organic manure on yield and yield contributing characters of Chilli

Ishtiyaq *et al.,* (2015) conducted to investigate the effect of different rates (2, 4 and 6 t/ha) of vermicompost on germination, growth and yield of *Solanumm elongena* under field conditions. The data revealed that different rates of vermicompost produced varied and significant effect. Maximum value was recorded at 6 t/ha, followed by 4 t/ha and the least at 2 t/ha. The dose of 6 t/ha significantly (P\0.05) increased germination (22.56 ± 2.5 %), number of fruits per plant (3.55 ± 0.07) mean fruit weight (73± 5.0 g), yield per plant (1.48 ± 0.05 kg) and marketable fruits (28.66 ± 3.0 %) when compared with the control.

Reshid *et al.,* (2014) conducted that a plastic pot set-up with soil was used to determine the effects and efficiency level of vermicompost on the growth and yields of tomatoes (*Solanum lycopersicum* L.). The study was conducted through effect of increasing concentration of vermicompost (control, 10%, 20%, 30% and 40%w/w) in target plant growth. The present study was carried out on the basis of Randomized Complete Block Design (RCBD) with 5 treatments and 3 replications. The obtained results from the present research indicated that applied vermicompost especially; at 20% level had significantly improving effects on better growth and development of vermicompost treated tomatoes as they had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields. Generally, the addition of vermicompost led to improve the yield of tomato cultivars as compared to control. Hence, it could be suggested that treated plants, with this vermicompost increased the growth, yield and the above chemical compositions and pH of the soil.

Kattimani and Shashidhara (2006) conducted that a field experiment was conducted during kharif 2002, in Dharwad, Karnataka, India, to study the response of chilli genotypes to integrated nutrient management. The experiment was laid out in a split plot design with three genotypes in main plot and five fertilizer combinations in sub- plots. Application of FYM at 10 t/ha along with 100% recommended dose of fertilizer resulted in higher fruit yield.

Ananthi *et al.*, (2004) conducted that field experiments were carried out with chilli (*C. annuum*), Coimbatore, Tamil Nadu, India. The treatments included 2 sources (MOP) and sulfate of potash (SOP)) and 5 levels (0, 30, 45, 60 and 75 kg/ha) of K, with application of farmyard manure (FYM). Application of farmyard manure increased chilli production.

Hangarge *et al.*, (2004) conducted that a field experiment was conducted to study the influence of vermicompost and other organics on the fertility and productivity of soil under chilli-spinach cropping system in Maharashtra, India. The application of vermicompost at 5 t ha-1 + organic booster at 1 litre m-2, and soil conditioner (Tera care) at 2.5 t ha-1 + organic booster enhanced the availability of N, P, K and organic C content in soil. The recommended rates of NPK and organic sources each alone did not have any significant effect. The combined effect of organic + organic sources proved to be better than either organic alone or combination of organic + inorganic fertilizer.

Subhasmita*et al.*, (2004) conducted that the effects of vermicompost based on karanj, niger, mahua, Indian mustard, groundnut or neem oilseed cake, and NPK (120:80:60 kg/ha) as control. Leaf damage varied from 20.0 to 53.3%, whereas fruit yield per plant ranged from 9.7 to 21.3%. The vermicompost based on mahua oilseed cake resulted in the lowest percentage of leaf damage (16.7%), whereas the vermicompost based on groundnut oilseed cake recorded the highest fruit yield (21.3 g per plant).

Yadav and Vijayakumari (2004) was conducted that a pot culture experiment at Avinashilingam University, Coimbatore, Tamil Nadu, India, to assess the effect of vermicomposted vegetable waste, alone and in combination with different organic manures and chemical fertilizer, on the biochemical characters of chilli (*Capsicum annuum*). The protein content was higher in vermicompost treatment on 60 and 90 days after sowing (113.37 and 79.69 mg/g, respectively), whereas it was higher in vermicompost+farmyard manure (FYM) treatment on 30 (35.73 mg/g) days after sowing. The carbohydrate content was higher in vermicompost+FYM treatment on 30 and 90 (4.67 and 6.46 mg/g, respectively) days after sowing, while on 60 days after sowing, it was higher in the vermicompost treatment (15.34 m/g). Chlorophyll a (0.23 mg/g), chlorophyll b (0.38 mg/g) and total chlorophyll (0.62 mg/g) were higher in vermicompost+neem cake treatment on 30 days after sowing. On 60 days after sowing, higher chlorophyll b (2.61 mg/g) and total chlorophyll

(3.62 mg/g) contents were observed in the treatment containing vermicompost alone. On 90 days after sowing, chlorophyll a (1.01 mg/g) and total chlorophyll (1.92 mg/g) content was higher in vermicompost alone, and chlorophyll b (1.07 mg/g) in the vermicompost+FYM treatment.

Hiranmai and Vijayakumari (2003) conducted that a pot culture experiment was undertaken to evaluate the effect of vermicompost applied singly and in combination with different organic manures (farmyard manure (FYM), composted coir pith, composted press mud, composted sugarcane trash, biofertilizer, green manure, and neem cake) and inorganic fertilizers on the biometric and yield parameters of chilli (*Capsicum annum*). The biometric parameters varied significantly among the treatments. Vermicompost alone and admixed with FYM, green manure, neem cake and NPK fertilizers were effective in improving various biometric parameters. Better yield parameters were observed in the vermicompost treatment.

Maheswari *et al.*, (2003) conducted that an experiment was conducted in Annamalai, Tamil Nadu, India to study the nutrient uptake pattern in chilli through the foliar application of organic nutrients. Application of vermin wash at 1:5 dilution with complete dose of RDF resulted in higher P uptake (7.74 kg/ha). The individual effect of amino acid improved the micronutrients, Fe, Zn, Mn and Cu (0.23, 0.04, 0.22 and 0.09 kg/ha). Fe and Zn (0.23 and 0.04 kg/ha) uptake was influenced by humic acid application.

Hangarge *et al.*, (2001) conducted to a field experiment was conducted in Maharashtra, India, to determine the response of chilli (*Capsicum annum*) to integrated nutrient supply system. The treatments were control (recommended rate of NPK, T1), and vermicompost at 5 t/ha or soil conditioner (Tera care) at 2.5 t/ha combined with 25 and 50% NPK, organic booster at 1 litre/m2 and cow dung urine slurry. Results revealed that soil conditioner+organic booster was the most effective in increasing the height, stem girth, number of branches, number of fruits and green chilli yield, followed by the treatment with vermicompost+organic booster. The application of vermicompost or soil conditioner in combination with chemical and organic fertilizers significantly increased growth and yield attributes of chilli compared to organic and chemical fertilizers alone.

Sharu and Meerabai (2001) conducted that field experiment was conducted in Vellayani, Kerala, India, during 1999/2000 to study the effect of poultry manure, vermicompost, and neem cake, singly (100%) or in combination (25, 50, or 75%) with inorganic N (25, 50, or 75%), on chilli yield and quality. The highest fruit yield (9.66 t/ha) was obtained with 50%

poultry manure+50% inorganic N. The best keeping quality and highest ascorbic acid content was recorded for 100% poultry manure, 50% inorganic N+50% poultry manure, 25% inorganic N+75% poultry manure, 25% inorganic N+75% vermicompost, 100% vermicompost, 25% inorganic N+75% neem cake, and 100% neem cake. Poultry manure was superior among the organic fertilizers, and a 1:1 ratio of inorganic to organic fertilizer was best for increasing chilli yield and quality.

Fugro (2000) conducted that the field experiments were conducted in the Konkan region of Maharashtra, India, to test the efficacy of several organic manures and organic pesticides, alone and in combination with inorganic fertilizers and chemical pesticides, for the control of leaf curl [pepper leaf curl virus] and die-back (caused by *Colletotrichum capsici*) diseases of chilli (*Capsicum annum*). The organic manures tested included farmyard manure (FYM), organic manure, organic manure - cellrich, neem cake and vermicompost. The treatment comprising organic manure in combination with NPK superimposed with alternate sprays of organic and chemical pesticides produced the maximum yield of green chilli (166 q/ha). The lowest incidence of leaf curl (2.12%) and die-back (4.03%) was also observed in the same treatment. These results suggest that in lateritic soils like the Konkan region, it is not possible to maximize the crop yield merely with the use of organic manures and organic pesticides. However, the appropriate combination of both organic and inorganic fertilizers and pesticides is needed to maximize the crop yield and manage chilli diseases to a satisfactory level.

Elias *et al.*, (1997) recommended a dose of 206 kg urea, 141 kg TSP, 159 kg MP and 15 t cowdung/ha was used by chilli cultivation. However, their recommendation appeared to be erratic when the dose per square meter of bed was considered. The dose recommended for a square meter of bed did not agree with the recommended dose per hectare. Perhaps the authors did not consider that the effective bed are in one hectare of land would be 6350 sq.m.

Ahmed *et al.*, (1993) reported that organic residues such as cowdung @ 20 t/ha in compaction with other fertilizer played an important role in respect of growth and fruit yield of chilli.

Shaheed (1997) conducted an experiment to investigate the effect of organic manures on yield and quality of rafted chilli. He reported that mustard oil cake (1500 g/plot) as an alternative of cowdung and poultry dropping played an important role in increasing the yield of grafted chilli.

Youssef *et al.,* (2001) carried out an experiment to study the effect of different fertilizers, i.e. mineral (ammonium nitrate and potassium sulphate) and organic manure (cowdung) alone or in combination, on the quantity and quality of chilli under clear polythene low tunnels. Treatment with 100% organic manure alone combination with ammonium nitrate resulted in taller plants than other treatments. However, fruit dimensions were the highest with organic manure alone.

Shashidhare *et al.,* (1998) studied the effects of organic and inorganic fertilizers on growth and yield of chilli [*Capsicum sp*.] at the Chilli Research Centre at Karataka in India. Treatment comprised organic sources like FYM (5 t/ha) in combination with 0, 50% or 100% of the recommended dose of fertilizer. Organic sources had no significant influence on fruit yield Application of 100% RDF together with organic fertilizer increased yield (mean 693 kg/ha) significantly over 50% and 0% RDF (558 and 506 kg/ha, respectively).

Nitta *et al.,* (1989) conducted an experiment on the effect of application of crop residues and FYM on the root development, plant growth and yield of chilli and some soil properties for seven years. It was found that the yield increase with crop residues was smaller than that with FYM (cowdung). Application of both FYM and crop residues increased yields as much as FYM alone.

2.5 Effect of Organic manure on yield and yield contributing characters of Indian Spinach

Vidigal *et al.,* (1997) mentioned that dried pig manure gave the highest yields in Indian spinach at 65 days after sowing (54.4 t/ha), an increase of 33.3% above those supplied with NPK, with similar results in a succeeding crop planted on the same ground in late September (a 39.4% increase over NPK). Napier grass + coffee straw + pig slurry was the best mixture, increasing yields 10.8% and 17.6% above those produced by NPK in 1st and 2nd crops, respectively.

CHAPTER III
MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2019 to May 2020. 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 experimental site:

3.1.1 Experimental location

The present study was conducted at the Horticulture Research farm of Sher-eBangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The GPS of experimental site was at 24°09′ N latitude and 90°34′ E longitudes with an elevation of 8.4 meter from sea level which has been shown in the Appendix I.

3.1.2 Climatic condition

The climate of the experimental site was subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). Rabi season is characterized by plenty of sunshine. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1212 and presented in Appendix II.

3.1.3 Soil

The soil of the belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the study. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of sandy loam with pH and organic matter capacity 5.9 and 0.78%, respectively and the soil composed of 26% sand, 43% silt, 31% clay. Details descriptions of the characteristics of soil are presented in Appendix III.

3.2 Experimental Details

3.2.1 Planting Materials:

Mint: The stem cuttings of Mint were collected from the rooftop of FABLAB, SAU and then separately planted in the experimental pocket which was 48 inch x 7inch in size.

Chilli: Seeds were collected from BARI. BARI morich-1 variety was selected. It's a dwarf variety so that it can grow easily in vertical structure.

Indian Spinach: Seeds were collected from BARI. BARI puishak-2 variety was selected which stem color is green.

3.2.2 Vertical Structure & pocket preparation:

(7×4) sq. ft. vertical wooden frame was made. Polythene sheet was used to protect it from rain. Long lasting and eco-friendly geo textile cloth was used to make the pockets for crop plantation. Those pockets were attached with the vertical structure.

3.2.3 Factor of the experiment:

T_1= Control

T_2= 2 kg vermicompost and 2 kg soil per pocket

T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket

T_4= 2 kg kitchen compost and 2 kg soil per pocket

3.2.4 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. (7×4) sq. ft. vertical structure was used. Each pocket contains 4kg growing media. The layout of the experiment is shown here.

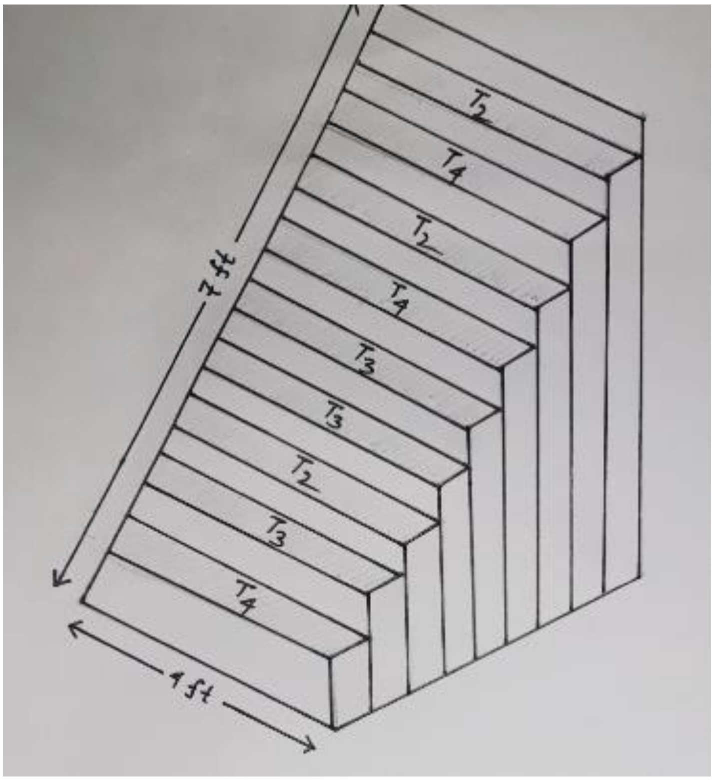

Plate1. Layout of experimental plot

Where,

T_1= Control

T_2= 2 kg vermicompost and 2 kg soil per pocket

T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket

T_4= 2 g kitchen compost and 2 kg soil per pocket

3.2.5 Soil preparation

The selected soil of the experimental plot was opened in the sun for one week. All weeds, stubbles and residues were eliminated. Finally, a good tilth was achieved for crop plantation in control condition.

Besides well prepared soil was taken to mix with manures for each pocket in following manners:

Control

2 kg vermicompost + 2 kg soil

1.5 kg vermicompost + 0.5kg coco fibre + 2 kg soil

2 kg kitchen compost + 2 kg soil

3.2.6 Nutrient Composition

Vermicompost contains 1.5% - 2% N, 0.9%-1.7% P, 1.5%-2.4% K (Source: ACI Fertilizer, 2016)

Coco fibre contains 0.41% N, 0.81% P, 1.32% K (Source:http:www.researchgate.net)

Anumar kitchen compost contains organic carbon 8.6%, C:N=6.8:1, P=0.5%, K=0.56% (Source: Soil Resource Development Institute (SRDI), Farmgate, Dhaka)

3.3 Growing of crops

3.3.1 Planting of the stem cuttings of mint

The stem cuttings were planted on 19 January, 2020.

3.3.2 Seed sowing of chilli and Indian spinach and growing seedlings

Pre-soaked seeds were sown on the well prepared seed bed on 3 December, 2019. Light irrigation was given after that. Germination starts at 10 December, 2019. Healthy seedlings were transplanted at evening on 20 January, 2020. Light irrigation was given after transplanting.

3.3.3 Intercultural operation

After transplanting, various intercultural operations such as irrigation, weeding, plant protection etc. were accomplished for better growth and development of the crops.

3.3.3.1 Irrigation

The plants were watered immediately after planting. Irrigation was also done almost daily in the evening with a watering cane as needed.

3.3.3.2 Weeding

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

3.3.3.3 Plant protection measures

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

3.3.3.4 Harvesting

The first harvesting of mint and Indian spinach was done almost at 60 days after transplanting (DAT) on 16March, 2020 by cutting the shoots and at the ground level with a pair of scissors.

3.4 Data collection

Three plants were randomly selected from each harvesting plants which was recorded. Data were collected in respect of yield attributes and yields as affected by organic manure. Data on plant height, number of branches/plant, number of leaves/plant, leaf area, number of stolon/plant of mint and Indian spinach were collected at 20, 50 and 75 days after transplanting (DAT). Weight of fresh herbage of mint and Indian spinach and yield of chilli were measured after harvest.

3.4.1 Plant height (cm)

Plant height was measured from three randomly selected plants by using meter scale in centimeter from the ground level to the tip of the longest branch at 25 days after transplanting (DAT) and continued up to 75 DAT and their mean value was calculated.

3.4.2 Number of branches per plant

Number of branches per plant was counted from three randomly selected plants at 25 days interval starting from 25 days after transplanting (DAT) and continued up to 75 DAT and at harvest and their average value was calculated.

3.4.3 Number of leaves per plant

Number of leaves per plant was counted from three randomly selected plants at 25 days interval starting from 25 days after transplanting (DAT) and continued up to 75 DAT and their mean value was calculated.

3.4.4 Leaf length and leaf breadth

Leaf length and breadth were measured from three randomly selected plants and each time from same plant of same leaf in centimeter and then average was calculated. Data were collected at 25, 50, 75 DAT and their mean value was calculated and recorded.

3.4.5 Stolon number/plant

Number of stolon per plant was counted at 25 DAT and data were collected at 25, 50, 75DAT and at harvest and their mean value was calculated and recorded.

3.4.6 Canopy size (cm):

Canopy size of individual plant was counted at 25 DAT and data were collected at 25, 50, 75 DAT and at harvest and their mean value was calculated and recorded.

3.4.7 Weight of fresh herbage

Weight of individual plant was recorded from three randomly selected plants in grams (g) with a beam balance at final harvest.

3.4.8 Date of first flowering

Date of first flowering of chilli was recorded on every treatment.

3.4.9 Fruit of chilli/plant

Weight of fruit per plant was counted at 25 DAT and data were collected at 25, 50, 75 DAT and at harvest and their mean value was calculated and recorded.

3.4.10 Yield/plot

Yield of mint, chilli fruit and Indian spinach per plant was recorded.

3.5 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 Least Significant Difference (LSD) test. The significance of difference between pair of means was tested at 5% and 1% level of probability (Gomez and Gomez, 1984).

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 vertical farming with the help of different organic fertilizers in some horticultural crops like chilli, Indian spinach and mint. The analysis of variance (ANOVA) of the data on different growth and yield parameters are presented. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings:

4.1 Mint

4.1.1 Plant height (cm) of mint

Plant height of mint at 25, 50, 75 DAT (Days after transplanting) showed statistically significant differences due to use of different organic fertilizers (Appendix XI). At different days of transplanting (DAT) the tallest plant (13.23 cm, 16.67 cm and 15.00 cm at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the shortest plant (4.00 cm, 5.47 cm and 5.33 cm at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). Plant height of mint varied significantly due to use of different organic manures.

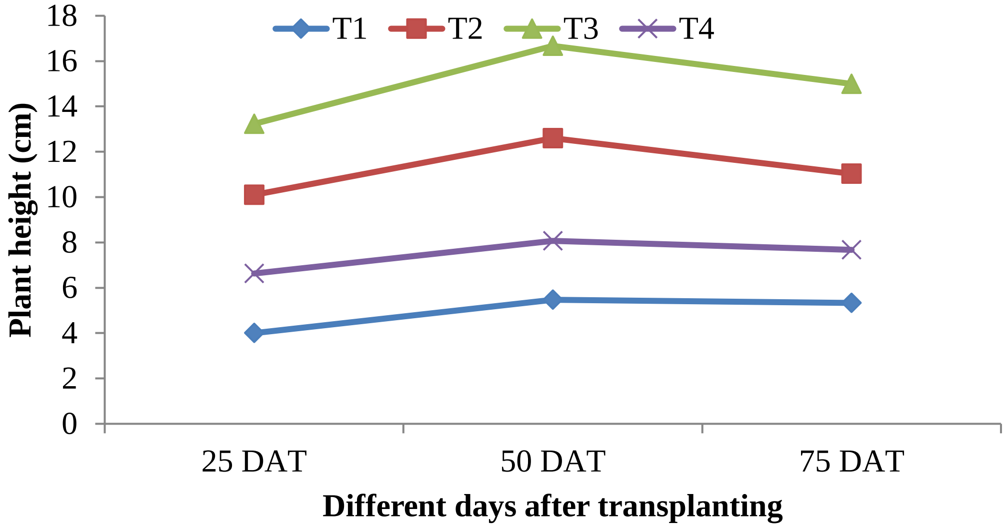

Fig.1. Effect of different organic manures on plant height of mint

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.1.2 Number of leaves/plant (mint)

Statistically significant variation was found for number of leaves per plant due to use of different organic manures (Appendix XII). At different days of transplanting (DAT) the maximum no. of leaves per plant (151.33, 296.00 and 221.33 at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the minimum no. of leaves per plant (54.67, 157.00 and 96.67 at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). No. of leaves per plant varied significantly due to use of different organic manures.

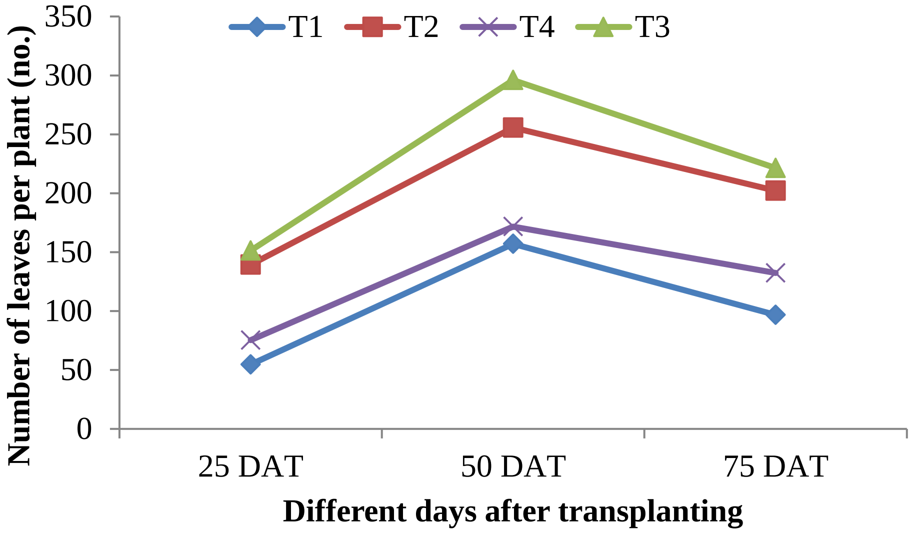

Fig.2. Effect of different organic manures on leaf number of mint

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4. 1. 3. Canopy size (cm) of mint

Statistically significant variation was found for canopy per plant due to use of different organic manures (Appendix XIII). At different days of transplanting (DAT) the maximum canopy size (15.03 cm, 16.13 cm and 15.07 cm at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the minimum canopy size 6.57cm, 11cm, 9.67cm at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). No of leaves per plant varied significantly due to use of different organic manures.

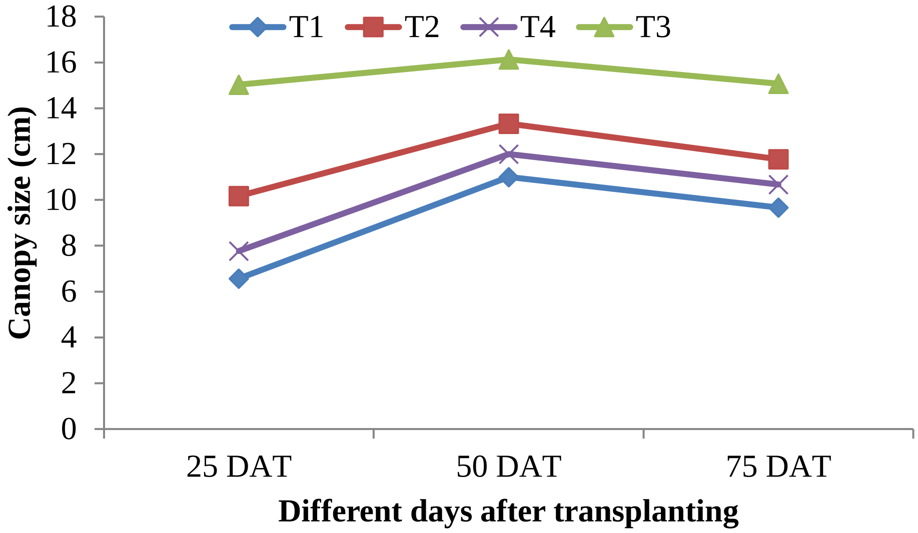

Fig.3. Effect of different organic manures on canopy size (cm) of mint

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.1.4 Branch/stolon number of mint per plant

Nitrogen is an element essential to plants and elements such as carbon, oxygen, hydrogen and sulfur combine even more valuable materials such as amino acids, nucleic acids, alkaloids and bases are produced. Chlorophyll as a place for light absorption and synthesis related to this element for plant growth and development is vital. If the nitrogen available to plants than the limit may cause disturbances in the vital processes of plants that may be in different forms such as high growth, reduces, delay or even stop the growth may increase the incidence. The possible reason for the acceleration of these growth parameters might be due to influence of nitrogen. Moreover, nitrogen is an important component of amino acids and coenzymes which are of considerable biological importance. The positive effect of the added manure was attributed to the 27 beneficial effects of manure on soil structure (Willium and Cooke, 1967; Malik) increasing in permeability and diffusivity of water and root penetration and their complex properties which improve soil fertility status. So, vermicompost and bio-fertilizer gave higher yields over the control ones (Appendix XIV). The highest branch no. /plant (24.67, 49.67, 42.33 were form 25, 50, 75 DAT respectively) was recorded from T_3 (1.5kg vermicompost, 0.5 kg coco fibre and 2kg soil per pocket) whereas the lowest branch no. /plant (6.67, 17.00 and 12.67 at 25, 50, 75 DAT respectively) was found from T_1 (control).

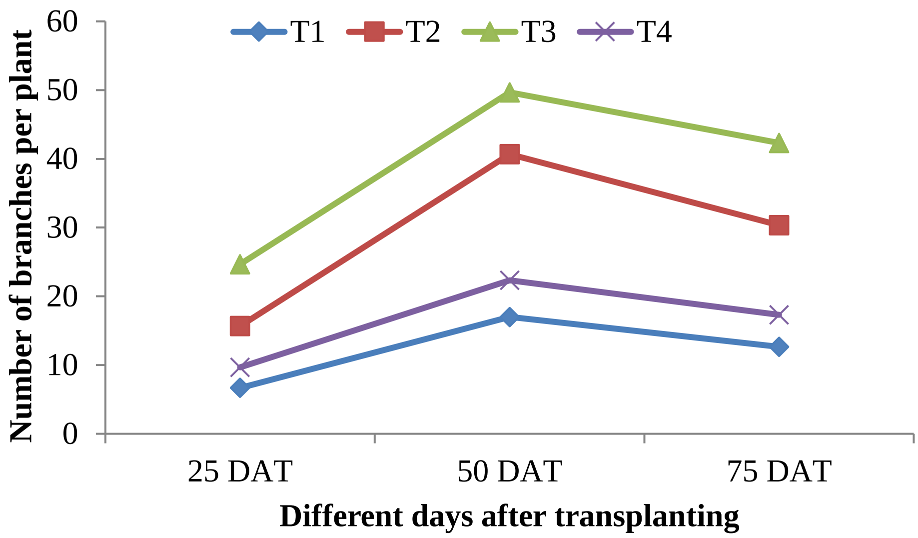

Fig.4. Effect of different organic manures on branch number of mint

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.1.5 Yield contributing parameters of mint

4.1.5.1 Leaf length (cm) of mint

Leaf length of mint showed significant differences with Different organic manures (Appendix XV). The highest leaf length was obtained fromT_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (2.60 cm, 3.17 cm, 2.80 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf length was obtained fromT_1 (control) which were (1.47cm, 2.10cm and 1.87cm at 25, 50, 75 DAT respectively) and it was statistically similar with the T_4 (2 kg Kitchen compost and 2 kg soil per pocket).

Table 1.Effect of different organic manures on leaf length (cm) of mint

Treatments	Length of leaves per plant (cm) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	1.47 c	2.10 c	1.87 c
T_2	2.17 ab	2.60 b	2.30 b
T_3	2.60 a	3.17 a	2.80 a
T_4	2.07 b	2.47 bc	2.20 bc
$LSD_{0.05}$	0.49	0.37	0.36
CV%	11.87	7.18	8.07

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.1.5.2 Leaf breadth (cm) of mint

Leaf breadth of mint showed significant differences with Different organic manures (Appendix XVI). The highest leaf breadth was obtained fromT_3 (1.5kg vermicompost, 0.5 kg coco fibre and 2kg soil per pocket) which was (1.87 cm, 2.37 cm, 2.02 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf breadth was obtained fromT_1 (control) which were (1.13 cm, 1.48 cm and 1.17 cm at 25, 50, 75 DAT respectively) and it was statistically similar with the T_4 (2kg Kitchen compost and 2kg soil per pocket).

Table 2.Effect of different organic manures on leaf breadth (cm) of mint

Treatments	Breadth of leaves per plant (cm) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	1.13 c	1.48 c	1.17 c
T_2	1.43 b	2.07 b	1.73 b
T_3	1.87 a	2.37 a	2.02 a
T_4	1.23 bc	1.60 c	1.38 c
$LSD_{0.05}$	0.20	0.29	0.23
CV%	7.13	7.63	7.41

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.1.5.3 Total yield (g) per plant

Weight of individual plant of mint showed significant differences with different organic manures (Appendix XVII). The highest fresh yield of individual plant was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was 151.40 g. The lowest weight of individual plant was recorded from T_1 (control) which was 80.00 g. Sharma (2012) reported that a climate with adequate and regular rainfall and good sunshine during its growing period ensures a good yield of mint. Significant variation was recorded for weight of individual plant of mint showed due to different organic manure. Mahmoodabad *et al.,* (2014) reported that organic manure showed the highest plant weights over the control treatment. Application of organic nutrients induced better utilization of water and nutrients for plant growth and development and also improved photosynthetic efficiency of individual plants, thereby resulting in increased yields. Scavroni *et al.,* (2005) also reported that oil production in mint plants increased when plants were grown with biosolid. Biofertilizers gave better results for all studied traits as the oil percentage and yield per plant which was also supported by Gharib *et al.,* (2008). Bio-fertilizer is supplied the major nutrients as N, P and K to the plant on long term basis which enhanced plant height, leaf number and leaf area/plant, fresh and dry weight (g) as well as oil yield and essential oil content which was also supported by Arafa *et al.*, (2017) ; Ordookhani *et al.*, (2011); Kumar and Sood, (2010).

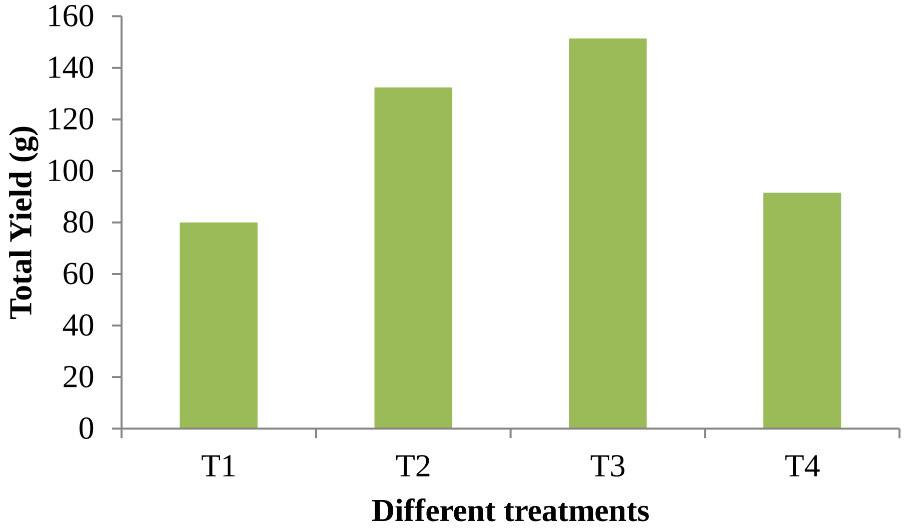

Fig.5. Effect of different organic manures on yield of mint

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

Table 3.Effect of different organic manures onyield of mint

Treatments	First yield per plant (g)	Second yield per plant (g)
T_1	41.67 d	38.33 d
T_2	64.83 b	67.57 b
T_3	75.33 a	76.07 a
T_4	46.87 c	44.66 c
$LSD_{0.05}$	5.12	5.07
CV%	4.48	4.47

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.2. Chilli

4.2.1. Plant height (cm) of chilli

Plant height of chilli was significantly influenced by different organic manures (Appendix IV). Vermicompost application showed significant effect on plant height of chilli at different days after transplanting (DAT). Mamta *et al.*, (2012) observed the similar result. They reported that plant height were higher in the vermicompost treated field as compared to control. Ali *et al.*, (2011) observed that the plant height of chilli in the vermicompost used filed were higher than the control. At different days of transplanting (DAT) the tallest plant (16.20 cm, 41.73 cm and 48.50 cm) were recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the shortest plant (7.03 cm, 10.33 cm and 15.67 cm at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). Plant height of mint varied significantly due to use of different organic manures.

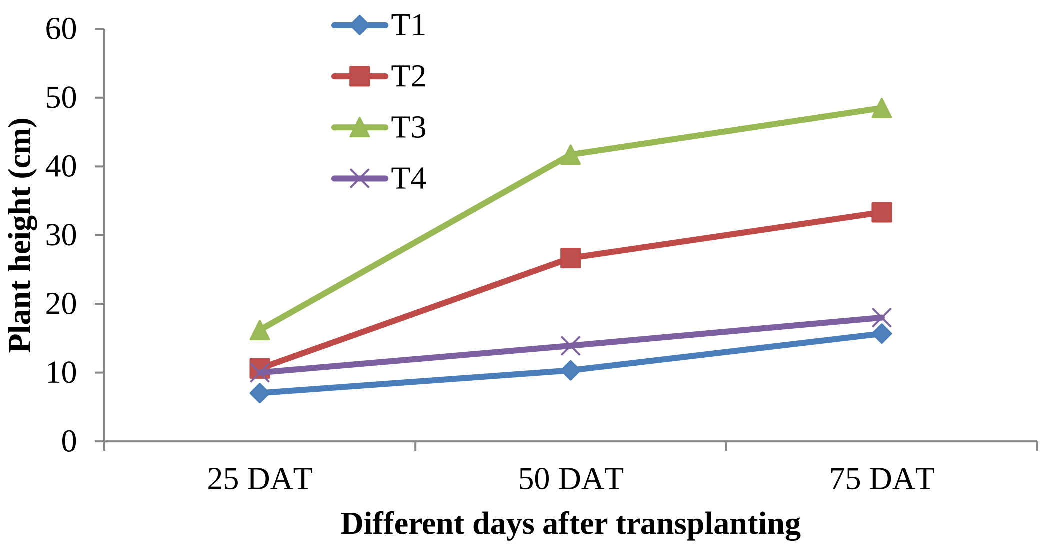

Fig.6. Effect of different organic manures on plant height of chilli

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.2.2 No. of leaves of chilli per plant

Different organic manure application showed significant effect on number of leaves per plant of chilli at different days after transplanting (DAT) (Appendix V). Statistically significant variation was found for number of leaves per chilli plant due to use of different organic manures (Appendix V). At different days of transplanting (DAT) the maximum no of leaves per plant (35.00, 69.00, 91.67 at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the minimum no of leaves per plant (10.00, 21.33, 33.67 at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). No of leaves per plant varied significantly due to use of different organic manures.

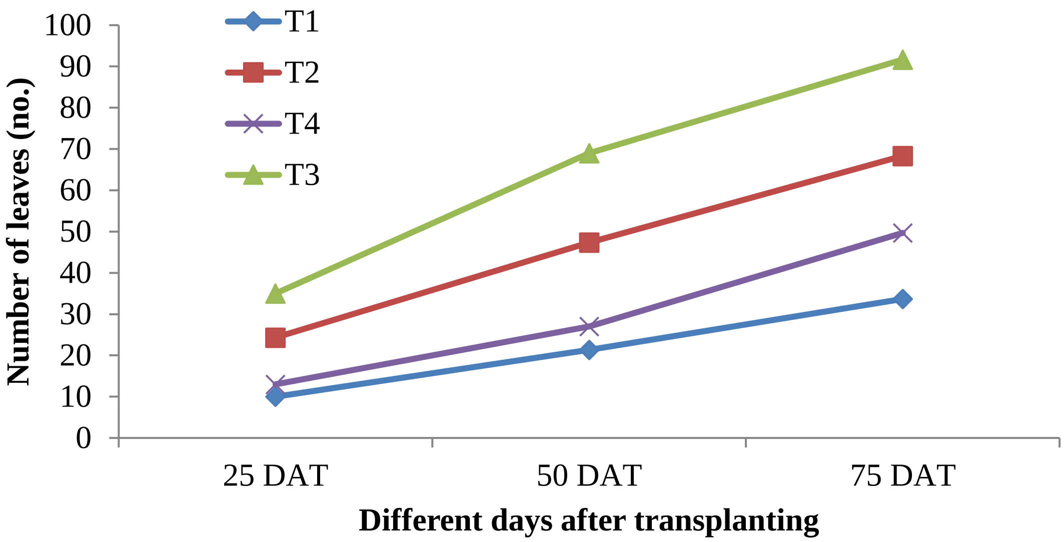

Fig.7. Effect of different organic manures on number of leaves of chilli

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.2.3 Leaf length (cm) of chilli

Leaf length of chilli showed significant differences with Different organic manures (Appendix VIII). The highest leaf length was obtained fromT_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (8.70 cm, 12.07 cm, 14.17 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf length was obtained fromT_1 (control) which were (5 cm, 6 cm and 7 cm at 25, 50, 75 DAT respectively) and it was statistically similar with the T_4 (2 kg Kitchen compost and 2 kg soil per pocket).

Table 4. Effect of different organic manures on leaf length of chilli

Treatments	Length of leaves per plant (cm) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	5.00 c	6.00 c	7.00 c
T_2	7.67 ab	9.00 b	10.10 b
T_3	8.70 a	12.07 a	14.17 a
T_4	6.00 bc	7.67 bc	8.67 bc
$LSD_{0.05}$	1.74	2.30	2.41
CV%	12.76	13.26	12.07

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.2.4 Leaves breadth (cm) of chilli

Leaf breadth of chilli showed significant differences with Different organic manures (Appendix IX). The highest leaf breadth was obtained fromT_3 (1.5 kg Vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (2.80 cm, 2.87 cm, 2.90 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf breadth was obtained fromT_1 (control) which were (1.50 cm, 1.53 cm and 1.57 cm at 25, 50, 75 DAT respectively) and it was statistically similar with the T_4 (2 kg Kitchen compost and 2 kg soil per pocket).

Table5. Effect of different organic manures on leaf breadth of chilli

Treatments	Breadth of leaves per plant (cm) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	1.50 d	1.53 d	1.57 d
T_2	2.20 b	2.27 b	2.33 b
T_3	2.80 a	2.87 a	2.90 a
T_4	1.80 c	1.93 c	1.97 c
$LSD_{0.05}$	0.28	0.20	0.24
CV%	6.82	4.72	5.54

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.2.5. Branch number of chilli

Branch number of chilli showed significant differences with different organic manures (Appendix VII). The highest branch number of chilli was obtained from T_3 (1.5kg vermicompost, 0.5 kg coco fibre and 2kg soil per pocket) which was (6.00, 10.33 and 14.67 at 25, 50, 75 DAT respectively). On the other hand the lowest branch number of chilli was obtained fromT_1 (Control) which were (0, 2, 6.33 at 25, 50, 75 DAT respectively).

Table6. Effect of different organic manures on branch number of chilli

Treatments	Number of branches per plant (no.) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	0.00 d	2.00 c	6.33 d
T_2	2.33 b	6.33 b	10.33 b
T_3	6.00 a	10.33 a	14.67 a
T_4	1.67 c	3.00 c	8.00 c
$LSD_{0.05}$	0.56	1.21	1.49
CV%	11.23	11.17	7.58

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.2.6. Canopy size (cm) of chilli

Lallaw *et al.*, (2012) found that the canopy size was increase when increase the organic manure levels (Appendix VI). Kulkarni *et al.*, (2002) suggested that the vermicompost @ 5 t/ha used the chilli cultivation field then all the growth parameter including canopy size was maximum. The largest canopy size (33.17cm) was recorded from T_3 (1.5kg vermicompost, 0.5 kg cocofibre and 2kg soil per pocket. In comparison, the smallest canopy size (14.07cm) was observed in control.

Table7. Effect of different organic manures on canopy size (cm) of chilli

Treatments	Canopy size per plant (cm) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	6.00 d	10.67 c	14.07 c
T_2	12.33 b	20.00 b	24.00 b
T_3	17.00 a	27.00 a	33.17 a
T_4	10.00 c	14.00 c	18.33 c
$LSD_{0.05}$	2.13	3.60	5.62
CV%	9.42	10.06	12.57

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.2.7 Yield contributing characters of chilli

Yield contributing characters were affected significantly with the use of different organic manures (Appendix X).

4.2.7.1 Days to first flowering

Days to first flowering of chilli showed statistically significant variation due to different organic manures. The maximum days of first flowering (43) was obtained from T_1 (control) which was significantly different form all other treatments. On the other hand, the minimum days to first flowering was 31 and it was found from T_3 (1.5kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was significantly different from others treatment. Kulkarni *et al.,* (2002) said that soil conditioner organic booster was the most effective in decreasing the days to flower initiation followed by the treatment with vermicompost & organic booster.

4.2.7.2 Single Fruit weight of chilli (g)

Non-significant influence was observed among the in case of single fruit weight of chilli. However the maximum fruit weight (3 g) was obtained from T_3 (1.5 kg Vermicompost, 0.5 kg coco fibre and 2kg soil per pocket) which was statistically similar to T_2 (2 kg

Vermicompost and 2 kg soil per pocket) and in this case single fruit weight was 2.87 g. On the other hand the minimum fruit weight (1.91 g) was obtained from T_1 (Control).

4.2.7.3 Fruit length (cm)

Variation in fruit length of chilli was statistically significant due to different treatment. The maximum fruit length (8.10cm) was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was significantly different from others treatments. The minimum fruit length (3.23 cm) was obtained from T_1 (control).

4.2.7.4 Fruits weight per plant (g)

Fruit weight of chilli per plant under present study was significantly influenced by different organic manures. Results revealed that the highest fruit yield (88.43 g) was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was significantly different from others treatments. On the other hand the lowest fruit yield (24 g) was obtained from T_1 (control) which was statistically similar to T_4 (2 kg kitchen compost and 2 kg soil per pocket) and the yield was 29.67g. Ishtiyaq *et al.* (2015) said that the vermicompost dose of 6 t/ha significantly increased average fruit weight when compared with the control. This study suggests that macrophyte-based vermicompost as a potential source of plant nutrients for sustainable crop production. Ahmed *et al.,* (1993) reported that organic residues in compaction with other fertilizer played an important role in respect of number of fruits per plant of chilli.

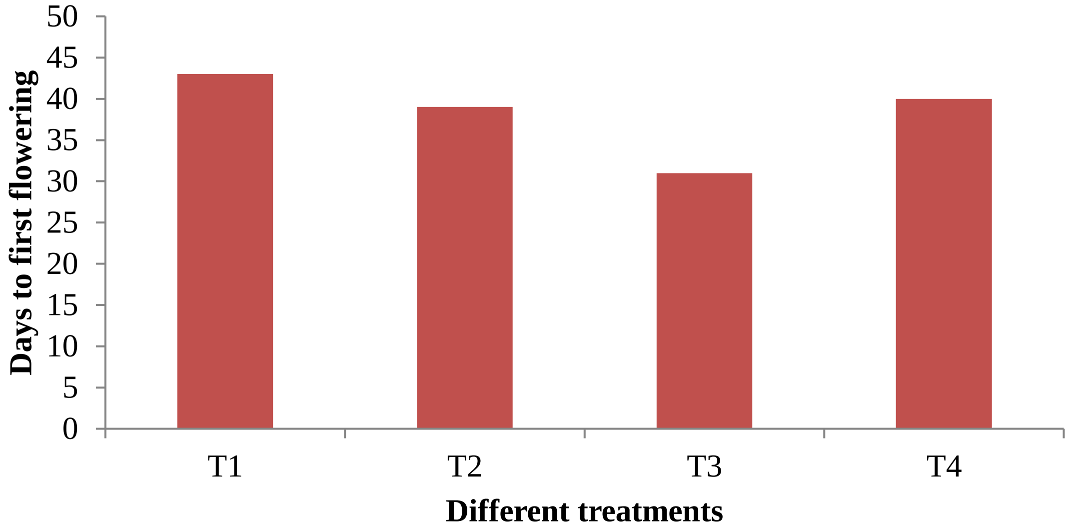

Fig.8. Effect of different organic manures on flowering of chilli

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

Table8. Effect of different organic manures on yield contributing characters and yield of chilli

Treatments	First flowering (days)	Single fruit weight (g)	Fruit length (cm)
T_1	43.00 a	1.91 b	3.23 c
T_2	39.00 b	2.87 a	5.90 b
T_3	31.00 c	3.00 a	8.10 a
T_4	40.00 ab	2.00 b	3.67 c
$LSD_{0.05}$	3.61	0.29	1.02
CV%	4.73	6.01	9.74

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

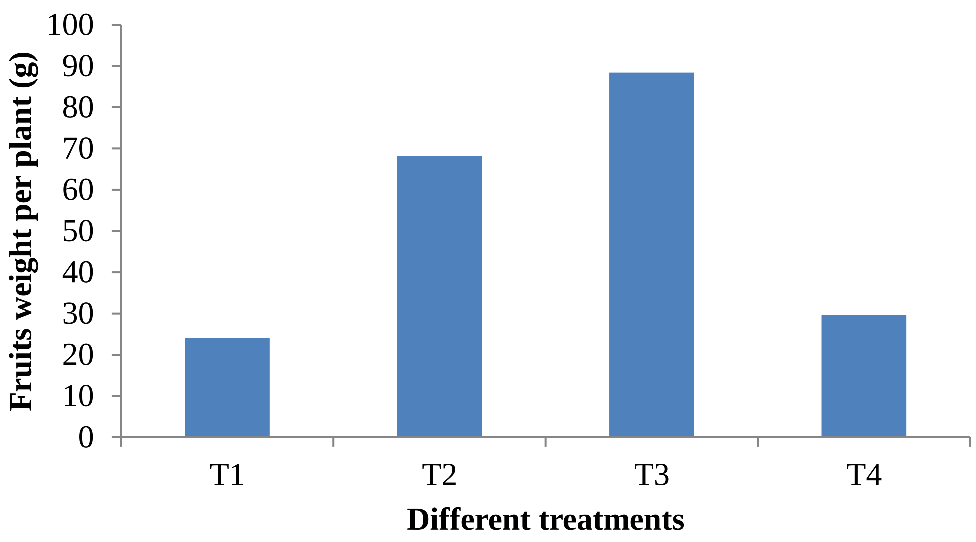

Fig.9. Effect of different organic manures on fruits weight per plant of chilli

Where,

T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.3. Indian spinach

4.3.1 Plant height of indian spinach

Plant height of Indian spinach at 25, 50, 75 DAT (Days after transplanting) showed statistically significant differences due to use of different organic fertilizers (Appendix XI). At different days of transplanting (DAT) the tallest plant (14.33 cm, 46.67 cm and 31.50 cm at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the shortest plant (6.17 cm, 18.50 cm, 12.43 cm at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). Plant height of Indian spinach varied significantly due to use of different organic manures.

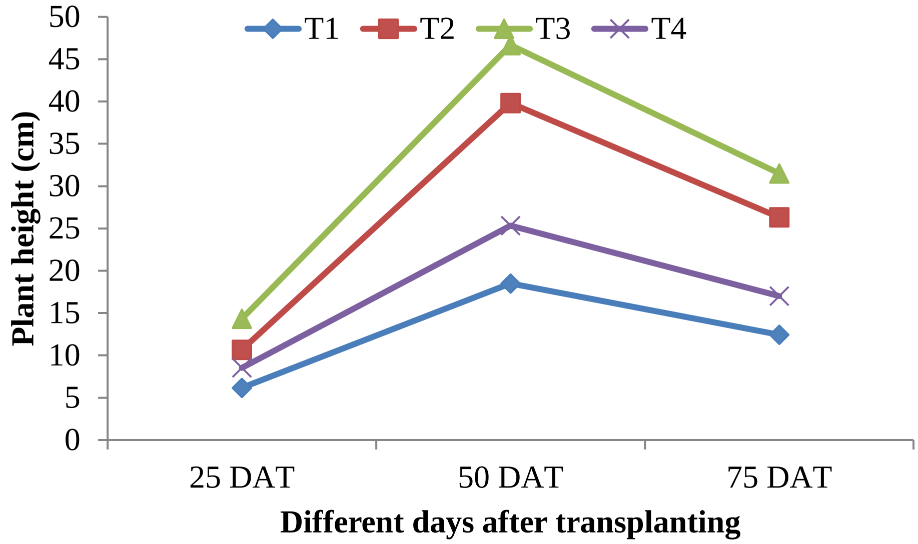

Fig.10. Effect of different organic manures on plant height of indian spinach

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.3.2 Number of leaves of indian spinach per plant

Statistically significant variation was found for number of leaves per plant due to use of different organic manures (Appendix XIV). At different days of transplanting (DAT) the maximum no of leaves per plant (13.67, 34.00 and 26.67 at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the minimum no of leaves per plant (5.67, 14.67 and 9.00 at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). No of leaves per plant varied significantly due to use of different organic manures.

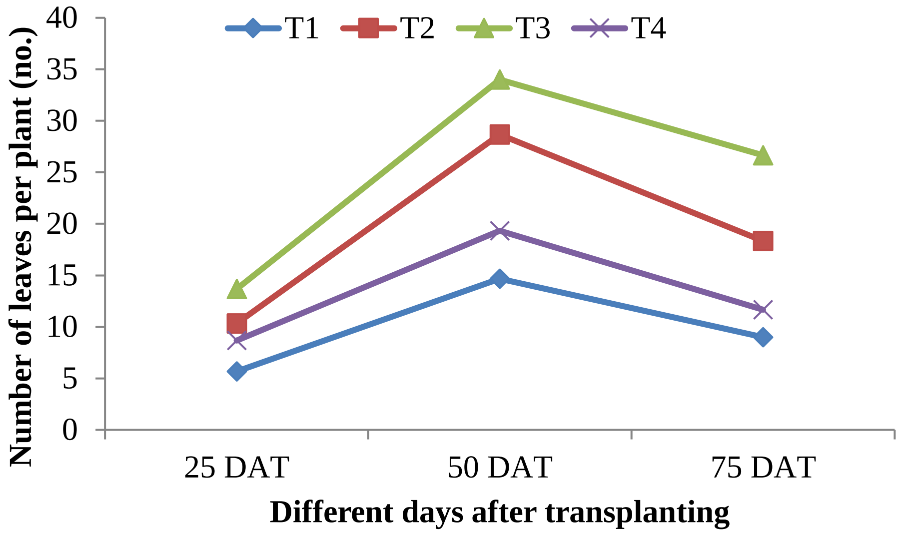

Fig.11. Effect of different organic manures on leaf number of indian spinach

Where,

T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.3.3 Canopy size of indian spinach (cm)

The largest canopy size (19.83 cm, 24.23 cm and 23.07 cm at 25, 50, 75 DAT respectively) was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was statistically significant from the other treatments (Appendix XX). In comparison, the smallest canopy size (7.37 cm, 9.87 cm and 8.13 cm at 25, 50, 75 DAT respectively) was observed in control.

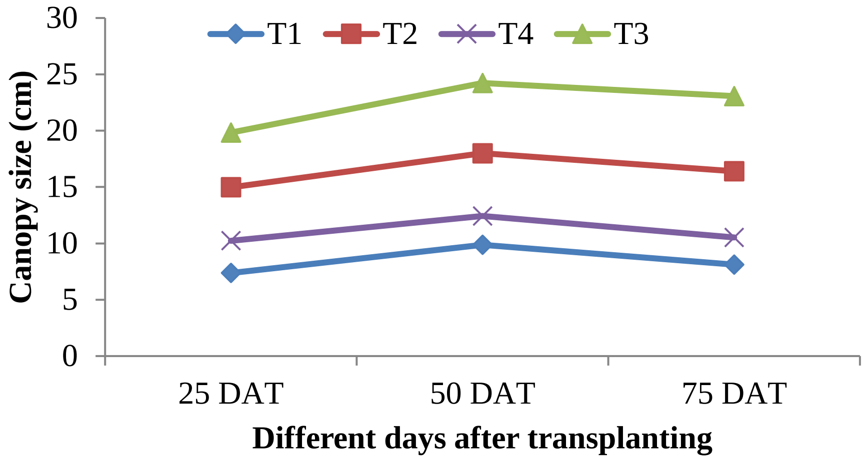

Fig.12. Effect of different organic manures on canopy size (cm) of indian spinach

Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.3.4 Yield contributing characters of indian spinach

4.3.4.1 Leaves length (cm) of indian spinach

Leaf length of Indian spinach showed significant differences with Different organic manures (Appendix XXII). The highest leaf length was obtained fromT_3 (1.5 kg Vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (12.33 cm, 13.50 cm, 10.97 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf length was obtained fromT_1 (control) which were (5.77 cm, 6.57 cm and 5.33 cm at 25, 50, 75 DAT respectively).

Table 9.Effect of different organic manures on leaf length (cm) of indian spinach

Treatments	Length of leaves per plant (cm) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	5.77 d	6.57 d	5.33 d
T_2	10.60 b	11.70 b	9.67 b
T_3	12.33 a	13.50 a	10.97 a
T_4	7.43 c	8.37 c	7.33 c
$LSD_{0.05}$	1.51	1.78	1.29
CV%	8.36	8.87	7.80

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.3.4.2 Leaves breadth (cm) of indian spinach

Leaf breadth of Indian spinach showed significant differences with different organic manures (Appendix XXIII). The highest leaf breadth was obtained fromT_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (9.13 cm, 11.27 cm, 10.00 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf breadth was obtained fromT_1 (Control) which were (2.43 cm, 3.20 cm and 2.22 cm at 25, 50, 75 DAT respectively).

Table 10.Effect of different organic manures on leaf breadth (cm) of indian spinach

Treatments	Breadth of leaves per plant (cm) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	2.43 d	3.20 d	2.22 d
T_2	6.20 b	7.47 b	6.53 b
T_3	9.13 a	11.27 a	10.00 a
T_4	4.77 c	6.03 c	5.12 c
$LSD_{0.05}$	0.83	1.29	1.22
CV%	7.37	9.25	10.22

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.3.4.3 Branch number of indian spinach

Branch number of Indian spinach showed significant differences with Different organic manures (Appendix XXI). The highest branch number was obtained fromT_3 (1.5kg vermicompost, 0.5 kg coco fibre and 2kg soil per pocket) which was (3.67, 5.00, 4.33 at 25, 50, 75 DAT respectively). On the other hand the lowest branch number was obtained from T_1 (control) which were (0.67, 1.33 and 1.00 at 25, 50, 75 DAT respectively).

Table 11.Effect of different organic manures on branch number of indian spinach

Treatments	Number of branches per plant (no.) at different days after transplanting		
	25 DAT	50 DAT	75 DAT
T_1	0.67 d	1.33 d	1.00 c
T_2	2.33 b	3.67 b	2.67 b
T_3	3.67 a	5.00 a	4.33 a
T_4	1.33 c	2.67 c	1.33 c
$LSD_{0.05}$	0.37	0.48	0.39
CV%	9.48	7.66	8.39

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

4.3.4.4 Total yield (g) of indian spinach

Total yield of Indian spinach showed significant differences with different organic manures (Appendix XXIV). The highest weight of individual plant was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2kg soil per pocket) which was 290.66 g. The lowest weight of individual plant was recorded from T_1 (control) which was 71.33 g. Sharma (2012) reported that a climate with adequate and regular rainfall and good sunshine during its growing period ensures a good yield of indian spinach. Significant variation was recorded for weight of individual plant of Indian spinach showed due to different organic manure. Mahmoodabad *et al.*, (2014) reported that organic manure showed the highest plant weights over the control treatment.

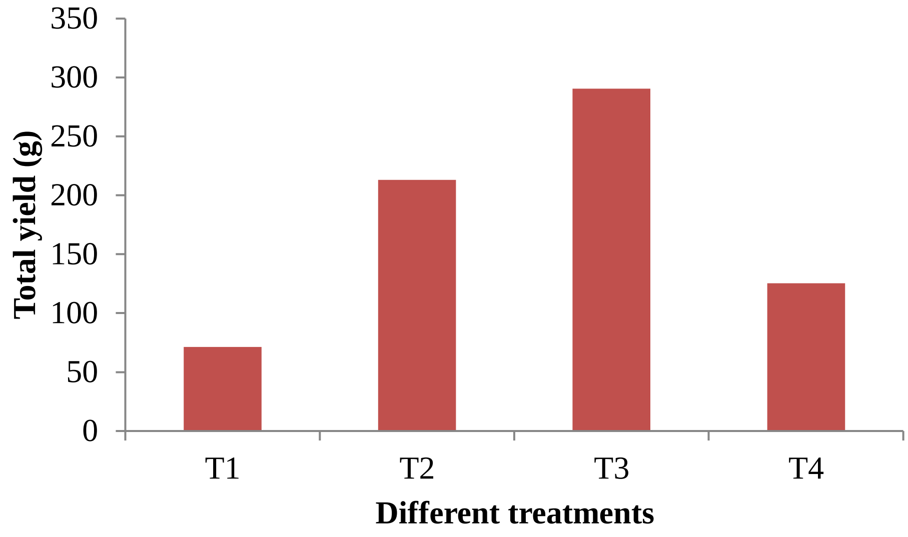

Fig.13. Effect of different organic manures on yield indian spinach

Where,

T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

Table12. Effect of different organic manures on yield Indian spinach

Treatments	First yield per plant (g)	Second yield per plant (g)
T_1	36.00 d	35.33 d
T_2	113.00 b	100.00 b
T_3	154.33 a	136.33 a
T_4	64.00 c	61.33 c
$LSD_{0.05}$	21.64	16.26
CV%	11.80	9.78

In a column means having similar letter(s) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability
Where,
T_1= Control
T_2= 2 kg vermicompost and 2 kg soil per pocket
T_3= 1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket
T_4= 2 kg kitchen compost and 2 kg soil per pocket

CHAPTER V
SUMMARY AND CONCLUSION

CHAPTER V

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In case of mint at 25, 50, 75 DAT (Days after transplanting) the tallest plant (13.23 cm, 16.67 cm and 15.00 cm) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the shortest plant (4.00 cm, 5.47 cm and 5.33 cm at 25, 50, 75 DAT respectively) was recorded form T_1 (control). At different days of transplanting (DAT) the maximum no of leaves per plant (151.33, 296.00 and 221.33 at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the minimum no of leaves per plant (54.67, 157.00 and 96.67 at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). The maximum canopy size (15.03 cm, 16.13 cm and 15.07 cm at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the minimum canopy size 6.57 cm, 11cm, 9.67 cm at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). The highest branch no./plant (24.67, 49.67, 42.33 were form 25, 50, 75 DAT respectively) was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) whereas the lowest branch no./plant (6.67, 17.00 and 12.67 at 25, 50, 75 DAT respectively) was found from T_1 (control). The highest leaf length was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (2.60 cm, 3.17 cm, 2.80 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf length was obtained from T_1 (Control) which were (1.47 cm, 2.10 cm and 1.87 cm at 25, 50, 75 DAT respectively) and it was statistically similar with the T_4 (2 kg kitchen compost and 2 kg soil per pocket). The highest leaf breadth was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (1.87 cm, 2.37 cm, 2.02 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf breadth was obtained from T_1 (control) which were (1.13 cm, 1.48 cm and 1.17 cm at 25, 50, 75 DAT respectively) and it was statistically similar with the T_4 (2 kg kitchen compost and 2 kg soil per pocket). The highest weight of individual plant was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was 151.40 g. The lowest weight of individual plant was recorded from T_1 (control) which was 80.00 g.

In case of chilli at 25, 50, 75 DAT respectively the tallest plant (16.20 cm, 41.73 cm and 48.50 cm) were recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the shortest plant (7.03 c m, 10.33 cm and 15.67 cm at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). The maximum no. of leaves per plant (35.00, 69.00, 91.67 at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the minimum no. of leaves per plant (10.00, 21.33, 33.67 at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). The highest leaf length was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (8.70 cm, 12.07 cm, 14.17 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf length was obtained from T_1 (control) which were (5 cm, 6 cm and 7 cm at 25, 50, 75 DAT respectively) and it was statistically similar with the T_4 (2 kg kitchen compost and 2 kg soil per pocket). The highest leaf breadth was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (2.80 cm, 2.87 cm, 2.90 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf breadth was obtained from T_1 (control) which were (1.50cm, 1.53cm and 1.57cm at 25, 50, 75 DAT respectively) and it was statistically similar with the T_4 (2 kg Kitchen compost and 2 kg soil per pocket). The largest canopy size (33.17 cm) was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket). In comparison, the smallest canopy size (14.07 cm) was observed in control. The maximum days of first flowering (43) was obtained from T_1 (control) which was significantly different form all other treatments. On the other hand, the minimum days to first flowering was 31 and it was found from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was significantly different from others treatment. Non-significant influence was observed among the in case of single fruit weight of chilli. However the maximum fruit weight (3 g) was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was statistically similar to T_2 (2 kg vermicompost and 2 kg soil per pocket) and in this case single fruit weight was 2.87 g. On the other hand the minimum fruit weight (1.91 g) was obtained from T_1 (control). The maximum fruit length (8.10 cm) was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was significantly different from others treatments. The minimum fruit length (3.23 cm) was obtained from T_1 (control). Results revealed that the highest fruit yield (88.43 g) was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was significantly different from others treatments. On the other hand the lowest fruit yield (24 g) was obtained from T_1 (control) which was statistically similar to T_4 (2 kg kitchen compost and 2 kg soil per pocket) and the yield was 29.67 g.

In case of Indian Spinach, the tallest plant (14.33 cm, 46.67 cm and 31.50 cm at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the shortest plant (6.17 cm, 18.50 cm, 12.43 cm at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). The maximum no of leaves per plant (13.67, 34.00 and 26.67 at 25, 50, 75 DAT respectively) was recorded form T_3 (1.5 kg vermicompost + 0.5 kg coco fibre + 2 kg soil per pocket). On the other hand the minimum no of leaves per plant (5.67, 14.67 and 9.00 at 25, 50, 75 DAT respectively) was recorded form control T_1 (control). The largest canopy size (19.83 cm, 24.23 cm and 23.07 cm at 25, 50, 75 DAT respectively) was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was statistically significant from the other treatments. In comparison, the smallest canopy size (7.37 cm, 9.87 cm and 8.13 cm at 25, 50, 75 DAT respectively) was observed in control. The highest leaf length was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (12.33 cm, 13.50 cm, 10.97 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf length was obtained from T_1 (control) which were (5.77 cm, 6.57 cm and 5.33 cm at 25, 50, 75 DAT respectively). The highest leaf breadth was obtained from T_3 (1.5 kg Vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (9.13 cm, 11.27 cm, 10.00 cm at 25, 50, 75 DAT respectively). On the other hand the lowest leaf breadth was obtained from T_1 (Control) which were (2.43 cm, 3.20 cm and 2.22 cm at 25, 50, 75 DAT respectively). The highest branch number was obtained from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was (3.67, 5.00, 4.33 at 25, 50, 75 DAT respectively). On the other hand the lowest branch number was obtained from T_1 (control) which were (0.67, 1.33, 1.00 at 25, 50, 75 DAT respectively). The highest weight of individual plant was recorded from T_3 (1.5 kg vermicompost, 0.5 kg coco fibre and 2 kg soil per pocket) which was 290.66 g. The lowest weight of individual plant was recorded from T_1 (control) which was 71.33 g.

CHAPTER VI
REFERENCES

REFERENCES

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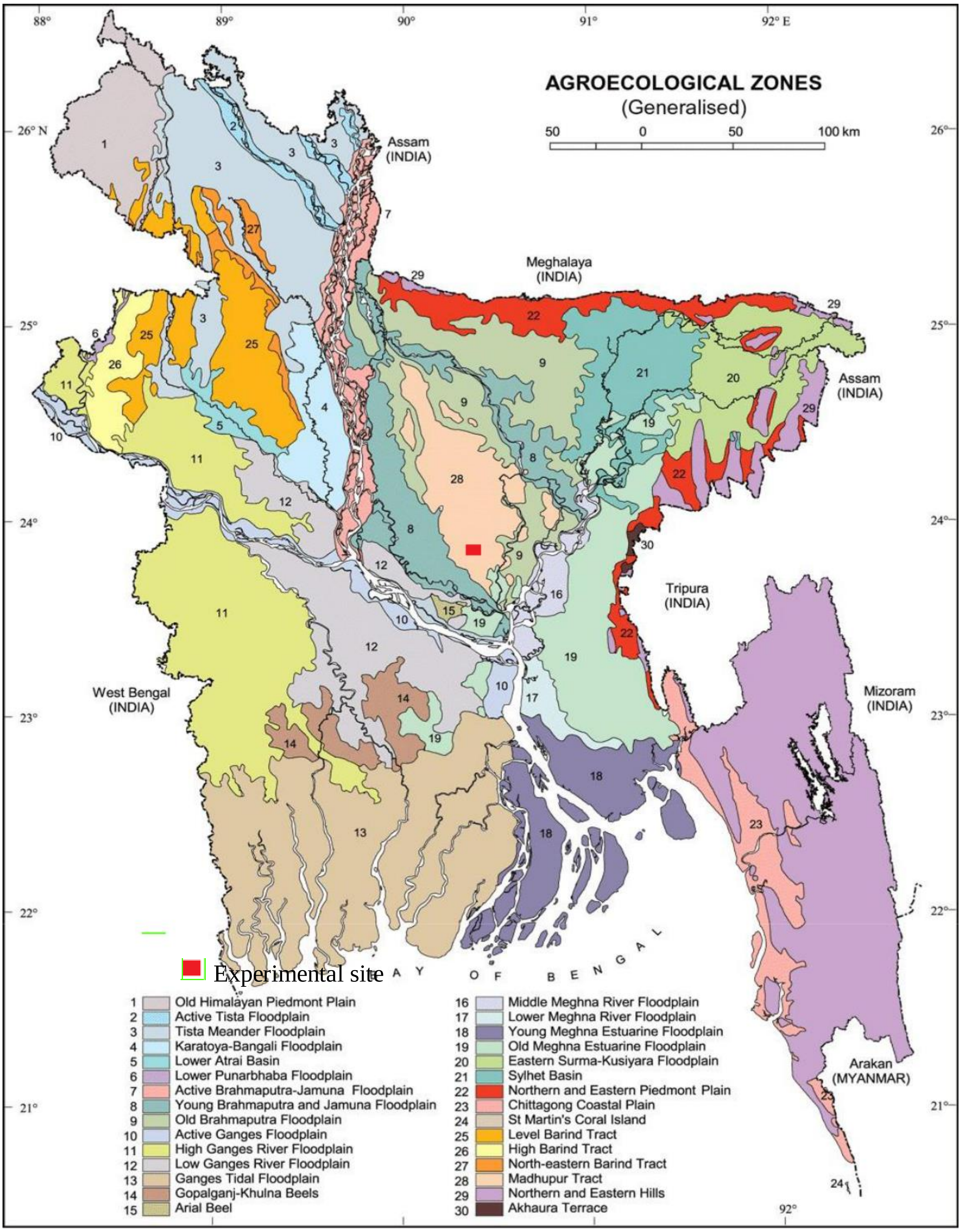
APPENDICES

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



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

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

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

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

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

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

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Mean square values of plant height at different days after transplanting of chilli plant growing under the experiment

Sources of variations	Degrees of freedom	Mean square of plant height at		
		25 DAT	50 DAT	75 DAT
Replication	2	0.491	9.976	14.498
Treatment	3	43.927**	607.536**	697.743**
Error	6	1.011	3.728	4.520

** significant at 1% level of significance

Appendix V. Mean square values of number of leaves per plant at different days after transplanting of chilli growing under the experiment

Sources of variations	Degrees of freedom	Mean square of number of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	9.021	2.740	64.770
Treatment	3	391.417**	1406.780**	1869.670**
Error	6	1.521	8.260	10.02

** significant at 1% level of significance

Appendix VI. Mean square values of canopy size per plant at different days after transplanting in chilli growing during experimentation

Sources of variations	Degrees of freedom	Mean square of canopy size at		
		25 DAT	50 DAT	75 DAT
Replication	2	1.106	0.583	2.066
Treatment	3	63.333**	154.750**	204.463**
Error	6	1.139	3.250	7.921

** significant at 1% level of significance

Appendix VII. Mean square values of number of branches per plant at different days after transplanting in chilli growing during experimentation

Sources of variations	Degrees of freedom	Mean square of number of branches per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	0.070	0.380	0.333
Treatment	3	19.222**	42.528**	39.222**
Error	6	0.078	0.366	0.555

** significant at 1% level of significance

Appendix VIII. Mean square values of length of leaves per plant at different days after transplanting in chilli growing during experimentation

Sources of variations	Degrees of freedom	Mean square of length of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	2.678	0.747	1.455
Treatment	3	8.234**	19.781**	28.148**
Error	6	0.762	1.326	1.452

** significant at 1% level of significance

Appendix IX. Mean square values of breadth of leaves per plant at different days after transplanting in chilli growing during experimentation

Sources of variations	Degrees of freedom	Mean square of breadth of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	0.010	0.003	0.016
Treatment	3	0.947**	0.954**	0.963**
Error	6	0.020	0.010	0.015

** significant at 1% level of significance

Appendix X. Mean square values of yield contributing characters in chilli growing during experimentation

Sources of variations	Degrees of freedom	Mean square of			
		First flowering	Single fruit weight	Fruit length	Fruits weight per plant
Replication	2	30.438	0.025	0.520	25.850
Treatment	3	78.750**	0.974**	15.116**	2872.330**
Error	6	3.271	0.022	0.258	17.720

** significant at 1% level of significance

Appendix XI. Mean square values of plant height at different days after transplanting of mint plant growing under the experiment

Sources of variations	Degrees of freedom	Mean square of plant height at		
		25 DAT	50 DAT	75 DAT
Replication	2	1.501	0.827	1.003
Treatment	3	48.699**	73.533**	53.056**
Error	6	0.798	1.187	1.258

** significant at 1% level of significance

Appendix XII. Mean square values of number of leaves per plant at different days after transplanting in mint growing under the experiment

Sources of variations	Degrees of freedom	Mean square of number of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	14.580	130.100	250.600
Treatment	3	6739.000**	13353.200**	10264.300**
Error	6	34.250	109.500	58.800

** significant at 1% level of significance

Appendix XIII. Mean square values of canopy size per plant at different days after transplanting in mint growing during experimentation

Sources of variations	Degrees of freedom	Mean square of canopy size at		
		25 DAT	50 DAT	75 DAT
Replication	2	2.831	3.590	2.106
Treatment	3	42.083**	14.873**	16.507**
Error	6	0.927	1.078	0.996

** significant at 1% level of significance

Appendix XIV. Mean square values of number of branches per plant at different days after transplanting in mint growing during experimentation

Sources of variations	Degrees of freedom	Mean square of number of branches per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	1.396	15.771	0.646
Treatment	3	189.000**	704.972**	538.000**
Error	6	1.563	3.993	2.979

** significant at 1% level of significance

Appendix XV. Mean square values of length of leaves per plant at different days after transplanting in mint growing during experimentation

Sources of variations	Degrees of freedom	Mean square of length of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	0.016	0.083	0.081
Treatment	3	0.654**	0.588**	0.448**
Error	6	0.061	0.034	0.034

** significant at 1% level of significance

Appendix XVI. Mean square values of breadth of leaves per plant at different days after transplanting in mint growing during experimentation

Sources of variations	Degrees of freedom	Mean square of breadth of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	0.020	0.013	0.018
Treatment	3	0.317**	0.507**	0.424**
Error	6	0.010	0.021	0.014

** significant at 1% level of significance

Appendix XVII. Mean square values of yield in mint growing during experimentation

Sources of variations	Degrees of freedom	Mean square of		
		First yield	Second yield	Total yield
Replication	2	60.543	34.855	101.400
Treatment	3	735.145**	975.410**	3397.960**
Error	6	6.570	6.429	32.390

** significant at 1% level of significance

Appendix XVIII. Mean square values of plant height at different days after transplanting of Indian spinach plant growing under the experiment

Sources of variations	Degrees of freedom	Mean square of plant height at		
		25 DAT	50 DAT	75 DAT
Replication	2	13.141	56.250	5.063
Treatment	3	36.033**	501.755**	225.447**
Error	6	0.274	2.917	4.729

** significant at 1% level of significance

Appendix XIX. Mean square values of number of leaves per plant at different days after transplanting in Indian spinach growing under the experiment

Sources of variations	Degrees of freedom	Mean square of number of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	12.250	52.563	39.063
Treatment	3	33.407**	230.554**	186.329**
Error	6	0.917	4.562	1.729

** significant at 1% level of significance

Appendix XX. Mean square values of canopy size per plant at different days after transplanting in Indian spinach growing during experimentation

Sources of variations	Degrees of freedom	Mean square of canopy size at		
		25 DAT	50 DAT	75 DAT
Replication	2	8.680	3.751	1.003
Treatment	3	89.911**	122.056**	133.262**
Error	6	0.978	1.620	0.602

** significant at 1% level of significance

Appendix XXI. Mean square values of number of branches per plant at different days after transplanting in Indian spinach growing during experimentation

Sources of variations	Degrees of freedom	Mean square of number of branches per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	0.004	0.212	0.144
Treatment	3	5.116**	7.234**	6.884**
Error	6	0.036	0.058	0.038

** significant at 1% level of significance

Appendix XXII. Mean square values of length of leaves per plant at different days after transplanting in Indian spinach growing during experimentation

Sources of variations	Degrees of freedom	Mean square of length of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	0.811	1.011	0.698
Treatment	3	26.576**	29.591**	18.712**
Error	6	0.569	0.792	0.422

** significant at 1% level of significance

Appendix XXIII. Mean square values of breadth of leaves per plant at different days after transplanting in Indian spinach growing during experimentation

Sources of variations	Degrees of freedom	Mean square of breadth of leaves per plant at		
		25 DAT	50 DAT	75 DAT
Replication	2	0.163	0.016	0.067
Treatment	3	23.562**	33.796**	31.373**
Error	6	0.172	0.418	0.371

** significant at 1% level of significance

Appendix XXIV. Mean square values of yield of Indian spinach growing during experimentation

Sources of variations	Degrees of freedom	Mean square of		
		First yield	Second yield	Total yield
Replication	2	58.330	5.250	41.600
Treatment	3	8246.330**	5874.750**	28034.800**
Error	6	117.330	66.250	205.400

** significant at 1% level of significance

Plate 2. Different intercultural operations

Plate 3. Field visit with supervisor

Plate 4. Experimental field