INFLUENCE OF ORGANIC FERTILIZERS AND MICRONUTRIENTS ON GROWTH AND YIELD OF STRAWBERRY

MD. MOFIZUR RAHMAN

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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INFLUENCE OF ORGANIC FERTILIZERS AND MICRONUTRIENTS ON GROWTH AND YIELD OF STRAWBERRY

BY

MD. MOFIZUR RAHMAN

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Approved by

Prof. Md. Ruhul Amin
Department of Horticulture
SAU, Dhaka
Supervisor

Prof. Abul Faiz Md. Jamal Uddin (Ph.D.)
Department of Horticulture
SAU, Dhaka
Co-Supervisor

Dr. Tahmina Mostarin
Chairman
Examination Committee

Department of Horticulture

Sher-e-Bangla Agricultural University

Sher-e -Bangla Nagar, Dhaka-1207

Memo No.: Dated:

CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF ORGANIC FERTILIZERS AND MICRONUTRIENTS ON GROWTH AND YIELD OF STRAWBERRY"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by **MD. MOFIZUR RAHMAN,** Registration No. **09-03412** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2015
Dhaka, Bangladesh

Prof. Md. Ruhul Amin
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

Dedicated to

My

Beloved Parents

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INFLUENCE OF ORGANIC FERTILIZERS AND MICRONUTRIENTS ON GROWTH AND YIELD OF STRAWBERRY

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ABSTRACT

The experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2014 to March 2015. The experiment was consisted of two factors namely Factor A: Three levels of organic fertilizers as- O_0: Control (0 kg/ha), O_{ver}: Vermicompost (500 kg/ha) and O_{moc}: Mustard oil cake (1000 kg/ha); Factor B: Three levels of micronutrients as- M_0: Control (0 kg/ha), M_B: Boron (1 kg/ha), M_{Zn}: Zinc (1.5 kg/ha). All the treatmnts were applied in foliar application. The two factorial experiments were laid out in Randomized Complete Block Design with four replications. Organic fertilizers and Micronutrients influenced significantly on most of the parameters. Among organic fertilizers, maximum number of fruits (26.9/plant), fruit weight (383.7g/plant), brix (7.8%) and yield (11.0 t/ha) was found in O_{ver} whereas the minimum in $O_{0.}$ For micronutrients maximum number of fruits (26.3/plant), fruit weight (369.9g/plant), brix (7.3%) and yield (10.6 t/ha) was found in M_{Zn} while the minimum in $M_{0.}$ In combined effect, the highest yield (11.8 t/ha) was obtained from $O_{ver}M_{Zn}$ and the lowest (7.4 t/ha) in O_0M_0. The highest benefit cost ratio (2.35) was from $O_{ver}M_{Zn}$ where the lowest (1.53) in $O_0M_{0.}$ So it can be concluded that vermicompost and zinc showed the best performance for growth and yield of strawberry.

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ABBREVIATIONS AND ACRONYMS

SAU	: Sher-e-Bangla Agricultural University
SAURES	: Sher-e-Bangla Agricultural University Research
TSS	: Total Soluble Solid
SG	: SAU Germplasm
ver	: Vermicompost
moc	: Mustard oil cake
B	: Boron
Zn	: Zinc
NAA	: Naphthalene Acetic acid
IAA	: Indole -3 Acetic Acid
GA_3	: Gibbrellic Acid
pH	: Potential hydrogen
ppm	: Parts per million
DM	: Dry matter
CV.	: Cultivars
AEZ	: Agro-Ecological Zone
ANOVA	: Analysis of Variance
df	: Degrees of freedom
CV%	: Percentage of Coefficient of Variation
FAO	: Food and Agriculture Organization of United Nations
EC	: Electrical Conductivity
UNDP	: United Nations Development Programme

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Strawberry (*Fragaria ananassa*) belongs to the family Rosaceae is a perennial plant which sprouts in every year. It comprises a shorten stem or crown from which leaves, runners, roots, auxiliary crowns and inflorescences of the plant arise (Darnell *et al*., 2003 and Bowling, 2000). Leaves are trifoliate where flowers and fruits are produced on a stalk that emerges from an auxiliary bud. Flowers are white in color which eventually develops into small, conical shaped and light green immature fruits. They are not classified as berries. They usually turn into red on maturity along berry featuring red pulp with tiny and yellow color seeds piercing through its surface from inside. It is native to most of the Northern hemisphere including Europe and Britain. It is cultivated throughout the world specially USA, Spain, Mexico, Russia, Egypt, Germany, Poland, Japan and China.

It is an important high value horticultural crop and one of the most delicious fruits in the world. It is widely appreciated for its bright red color, juicy texture, sweetness, higher percentage of phenolics, flavonoids, aroma and vitamin contents (Hakkinen and Torronen, 2000; Hancock, 1999). It is usually eaten as raw or used to making ice-creams, jams, jellies, pickles, chocolates, biscuits, cakes and milkshakes. It is used in pharmaceuticals for its medicinal value and also in cosmetic industries. It is a rich source of vitamin C and contains numerous important dietary components (Riyaphan *et al*., 2005). It has potential health benefits against cancer, aging, inflammation and neurological diseases. Besides, it contains good amount of minerals like potassium, manganese, fluorine, copper, iron and iodine. It is a new fruit crop and commercial production is possible in climatic range including Sub-tropical country like Bangladesh (Barneyl, 1999). It is very popular fruit throughout the globe as well as in our country for its attractive color and flavour. Due to these advantages it is becoming more popular, although most of the farmers are not well known regarding the technology.

Organic fertilizer is an excellent source of nutrients and it could maintain high microbial population activities. Fruits harvested from plant receiving organic fertilizers were compact, lower acidity, attractive color and fruit yield with better quality (Singh *et al*., 2010; Islam, 2003). Vermicompost has high levels of available NPK and micronutrients, microbial and enzyme activities and growth regulators (Parthasarthi and Ranganathan, 1999; Chaoui *et.al*., 2003). It is ecofriendly and improved indexes of yield like fruit length, number of fruit and fruit weight (Atefe *et al.,* 2012; Daniel and Jader, 2012). It improves soil structures, moisture, nutrient retention, aeration, water holding capacity and infiltration. Mustard oil cake has unique properties that make it a favorable fertilizer and even herbicide source. Growers can get both fertilizer and pesticide benefits from mustard meals. It has been shown to control weeds, insect pests, nematodes and pathogens (Boydston *et al.,* 2007; Mazzola *et al.,* 2007; Rice *et al.,* 2007; Vaughn *et al.,* 2006; Norsworthy and Meehan, 2005; Chung *et al.,* 2002; Elberson *et al.,* 1996, 1997; Walker, 1996; 1997).

Micronutrients are essential for normal growth and development of strawberry. They generally serve as catalysts for chemical reactions in the plant. Boron plays a vital role in the hormone movement, activated salt absorption, flowering and fruiting process, pollen germination, physiological process such as cell maturation, cell elongation, cell division, cell proliferation, sugar transport, hormone metabolism and cytokinin synthesis (Wang *et al*., 2003). Zinc is one of the most fundamental micronutrient for plant especially to fruit crops for sweetness. It stimulates the enzymes that participate in biological process for the formation of chlorophyll. It is a major component of almost 60 enzymes and it has a role in synthesis of auxin which is directly associated with improvement of weight of fruits and its deficiency caused problems related to physiological structure (Marjan *et al*., 2013; Shivanandam *et al*., 2007). It plays an important role in photosynthesis and enzymatic activation, resulting in increasing sugar and decreasing acidity (Abedy, 2001). In our country about 2.0 million hectare of agricultural lands are zinc deficient under the different Agro-ecological zone of Bangladesh.

Organically grown strawberry produced quality fruit with sweetness in taste, longer shelf life and better flavor (Reganold *et al*., 2010). Besides micronutrient has an important role on plant growth and development. Very few research have been conducted in Bangladesh on the effect of organic fertilizers and micronutrients on growth and yield of strawberry. Considering the above circumstances, this study has been undertaken with following objectives:

- To determine the effect of organic fertilizers on growth and yield of strawberry
- To determine the effect of micronutrients on growth and yield of strawberry
- To find out the best combination of organic fertilizers and micronutrients on growth and yield of strawberry

CHAPTER II
REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Strawberry (*Fragaria annanasa*) is one of the most popular fruit in the world. Though strawberry is an exotic fruit but it has an opportunity to grow commercially in Bangladesh. Now-a-days, strawberries are not only uses as fruit but also as raw materials in different industries. However, some of the important and informative works in relation to organic fertilizers and micronutrients so far been done in home and abroad are presented below:

2.1 Influence of organic Fertilizers

2.1.1 Vermicompost related

Ali *et al.* (2014) conducted an experiment to increase the growth and yield of summer tomato An experiment was carried out in the experimental field of the Olericulture Research field, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Dhaka, Bangladesh to investigate the potential of vermicompost and mustard oil cake leachate as foliar organic fertilizer with reference to the growth, yield and TSS status of BARI hybrid tomato 8 and then examined their effects on different parameters. Treatments of the experiment were: No foliar application (T); foliar application of leachate from vermicompost (T_2) and foliar application of leachate from mustard oil cake (T_3). The experimental data revealed that significant increase in growth; yield and TSS on BARI hybrid tomato-8 were observed due to foliar application of vermicompost and mustard oil cake. All parameters performed better results with the foliar application of the leachate from vermicompost which was very close the mustard oil cake. However, maximum number of fruit (30.9/plant), yield (14.3 kg/plot) and TSS (4.7%) were found from the foliar application of leachate from vermicompost which was followed by mustard oil cake (28.4 /plant, 12.7 kg/plot and 4.2% respectively) whereas minimum from control.

Sara Khalid *et al.* (2013) conducted an experiment using six different organic amendments on strawberry (*Fragaria ananassa* Duch.) cv. Chandler which included T_1 = planting media (soil + silt + farm yard manure); T_2 = planting media + 400 mg/L humic acid; T_3 = planting media + 200 g /kg leaf manure; T_4 = planting media + 200 g/kg vermicompost; T_5 = planting media + 200 g/kg plant fertilizer and T_6 = planting media + 200 g/kg bio-compost. Hence farm yard manure (FYM) and vermicompost based organic amendments enhanced vegetative growth and improved quality of strawberry fruits.

Atefe *et al.* (2012) conducted an experiment and it was found that application of vermicompost in substrate improved indexes of yield like number of inflorescences, fruit length, number of fruit, mean of fruit weight and yield.

Attarde *et al.* (2012) conducted an experiment to investigate the effect of organic and inorganic fertilizers on growth and nutrient status of *Abelmoschus esculentus* (okra plant). For the experiment, various combinations of fertilizers such as Vermicompost (VC), Chemical Fertilizer (CF) and Farmyard Manure (FYM) were applied by followings, T_1: Control, T_2: (FYM 100%), T_3: (VC 100%), T_4: (CF 100%), T_5: (VC 75% + CF 25%), T_6: (VC 75% + FYM 25%), T_7: (VC 50% + FYM 50%) and T_8: (VC 50% + CF 50%). The study indicated that that with the use of inorganic fertilizers plants physical characteristics were enhanced compared to other treatments whereas nutrient status of okra fruit was recorded maximum in treatment T_3 (VC 100%) and followed by T_6 (VC 75% + FYM 25%).

Daniel and Jader (2012) reported that use of vermicompost and its product represents a crucial ecofriendly technology that capable of recycling organic wastes to be used as fertilizers. Through its hormone-like substances vermicompost, liquid humus or worm bed leachates stimulates plant growth.

Jayakumar and Natarajan (2012) conducted an experiment and find out that vermicomposting is a non-thermophilic, boioxidative process that involves earthworms and associated microbes. Vermicompost enhances soil biodiversity by promoting beneficial microbes which in turn enhance plant growth directly by production of plant growth-regulating hormones and enzymes and indirectly by controlling plant pathogens, nematodes and other pests thereby enhancing plant health and minimizing the yield loss.

Nath and Singh (2012) used of vermiwash extracted from vermicomposts as liquid biofertilizer for growth and productivity of paddy (*Oryza sativa*), maize (*Zea mays*) and millet (*Penisetum typhoides*) crops and noticed significant effect on growth and productivity.

Vanmathi and Selvakumari (2012) conducted an experiment on *Hibiscus esculentus* and allowed to grow in the medium of vermicompost and urea to examine the effect of vermicompost and urea on the growth and yield. There were 3 treatments viz., control, vermicompost (T_1) and urea (T_2). From the study, maximum plant height (19.8cm), number of flower (21.3), number of fruit (15.0), fruit weight (10.3g), total fruit weight (185.0g) and fruit length (12.3cm) was found from the application of vermicompost on *Hibiscus esculentus*.

Amir and Ishaq (2011) reported the importance of composts as a source of humus and nutrients to increase the growth of plant. Different composts (Vermicompost and Pitcompost) and garden soil (Control) were taken for the chemical analysis firstly and then to find the effect of these composts on the growth of a vegetative crop '*Pisum sativum'*. From the chemical analysis it was found that vermicompost was rich in nutrients like potassium, nitrate, Sodium, calcium, magnesium and chloride and have the potential for improving plant growth than pit compost and garden soil (control).

Cristina and Jorge (2011) reported that vermicompost can be described as a complex mixture of earthworm faeces, humified organic matter and microorganisms that when added to the soil or plant growing media, increases germination, growth, flowering, fruit production and accelerates the development of a wide range of plant species. The enhanced plant growth may be attributed to biologically mediated mechanisms such as the supply of plant-growth regulating substances and improvements in soil biological functions.

Stimulation of plant growth may depend mainly on biological characteristics of vermicompost, plant species used and cultivation conditions

Hatamzadeh and Masouleh (2011) observed the effects of vermicompost on growth and productivity of cymbidium (*Cymbidium* sp.) plants grown in a container medium including 50% pumice, 30% charcoal, 10% vermiculite and 10% peat moss, which was basic plant growth medium substituted with 10%, 20%, 30% and 40% (by volume) vermicompost besides control consisted of container medium alone without vermicompost Greatest vegetative growth resulted from substitution of container medium with 30% and 40% vermicompost and lowest growth was in potting mixtures containing 0% vermicompost.

Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate with maximum number of leaves, height, leaf length and productivity.

Joshi and Vig (2010) reported that various growth, yield and quality parameters like mean stem diameter, plant height, yield/plant, leaf number, total plant biomass, ascorbic acid, titrable acidity, soluble solids, insoluble solids and pH were increased significantly when treated with vermicompost.

Sinha *et al.* (2010) reported that vermicompost is a very important biofertilizer produced through the artificial cultivation of worms i.e., vermiculture. Vermicompost is enriched with all beneficial soil bacteria and also contain many of the essential plant nutrients like N, P, K and micronutrients. It increases soil aeration and texture. Plant grown in vermicompost pretreated soil represents maximum increase in all morphological parameters such as root length, shoot length, number of root branches, number of stem branches, number of leaves, number of flowers, number of pods and number of root nodules in four months sampling in comparison to untreated, FYM treated and DAP treated soils in *Pisum sp.* and *Cicer sp.*

Singh *et al*. (2010) conducted an experiment to determine the effect of foliar application of vermicompost leachates on growth, yield and quality of strawberry cv. Chandler. For this, three leachates collected from vermicomposting of cow dung (FCD), vegetable waste (FVW) and mixture of cow dung and vegetable waste in 1:2 ratio (FCVW) were used at 2 ml/L at monthly interval (total five sprays) in strawberry. The results indicated that foliar application of vermicompost leachates improved leaf area (10.1–18.9%), dry matter of plant (13.9–27.2%) and fruit yield (9.8–13.9%) significantly over control (water spray only). Foliar application of FCVW reduced albinism (from 12.1 to 5.7%), fruit malformation (11.2–8.5%) and grey mould (5.1–2.6%) thus improving marketable fruit yield (26.5% higher) with firmer fruits of better quality. The foliar application of FCD and FVW also improved these parameters and resulted in to higher marketable fruit yield (12.6 and 17.8% higher, respectively) compared to control.

Theunissen *et al*. (2010) stated that vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B; chlorophyll content of the leaves and improves the nutrient content of the different plant components (roots, shoots and fruits). The high percentage of humic acids in vermicompost contributes to plant health, as it promotes the synthesis of phenolics compounds such as anthocyanins and flavonoids which may improve the plant quality and act as a deterrent to pest and diseases.

Chamani *et al.* (2008) carried out an experiment to find out the effects of vermicompost on the growth and flowering of *Petunia hybrida* 'Dream Neon Rose'. From the study it was disclosed that vermicompost had significant positive effects on flower numbers, leaf growth and shoot fresh and dry weights compared to both control and peat amended media.

Peyvast *et al.* (2008) found the effects of different amounts of vermicompost to soil on growth, yield and chemical characteristics of spinach (*Spinacia oleracea* L.) cultivar "Virofly" were investigated in an unheated greenhouse. The results indicated that an addition of vermicompost to soil can increase number of leaves significantly.

Manatad and Jaquias (2008) evaluated growth and yield performance of vegetables as influenced by the application of different rates of vermicompost. Findings of their study exposed that fruit length, diameter, weight of fruits/plant and yield was significantly enhanced by vermicompost application in watermelon, egg plant, sweet pepper and tomato.

Nourbakhsh (2007) reported that vermicompost increases the quality, fertility and mineral content of the soil structure. It enhances soil aeration, texture and jilt thereby reducing soil compaction. It also builds up water retention capacity of soil because of its high organic matter content and promotes better root growth and nutrient absorption.

Arancon *et al.* (2006a) reported that vermicompost applications increased strawberry growth and yields significantly; including increases of up to 37% in leaf areas, 37% in plant shoot biomass, 40% in numbers of flowers, 36% in numbers of plant runners and 35% in marketable fruit weights.

Arancon *et al.* (2006b) found that vermicomposts produced commercially from cattle manure, market food waste and recycled paper waste, were applied to tomatoes *(Lycopersicon esculentum),* bell peppers *(Capsicum anuum grossum),* and strawberries (*Fragaria* spp.). The marketable tomato yields in all vermicompost-treated plots were consistently greater than yields from the inorganic fertilizer-treated plots. Leaf areas, numbers of strawberry runners, numbers of flowers, shoot weights, and total marketable strawberry yields increased significantly in plots treated with vermicompost compared to those that received inorganic fertilizers.

Barik *et al.* (2006) found that vermicompost is the earthworm derived organic fertilizers that not only supplies a good amount of different nutrient elements but also contains beneficial microbes like nitrogen fixing bacteria, mycorrhizae and growth promoting substances for betterment of crops.

Hidlago *et al.* (2006) reported that the incorporation of earthworm increased plant growth, leaf growth and root length. The suitability of vermicompost amended soil for sustaining plant growth and biological activity is a function of physical properties and the chemical properties which depend on soil organic matter.

Kannan *et al.* (2006) reported that application of recommended quantities of vermicompost to different field crops has been reported to reduce the requirement of chemical fertilizers without affecting the crop yield. Application of 100% nitrogen as vermicompost registered the higher plant height and number of branches per plant of tomato and it was significantly superior over supplementation of 100% N through urea and FYM.

Chaoui *et al.* (2005) made a report that vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium (NPK) and micro nutrients, microbial and enzyme activities and growth regulators.

Govindan and Thirumurugan (2005) was found in plant height of basmati rice at maturity with the application of vermicompost and it was on par with treatment receiving azolla at the rate 1.5 ton/ha. A progressive increase in plant height and leaf area index of soybean was observed with the conjunctive use of 75% N through vermicompost and remaining 25% N through chemical fertilizer and was found at par with 100% N through vermicompost alone. Additive benefit realized from vermicompost application) might be ascribed to its higher nutrient contents and their availability to crop.

Arancon *et al.* (2004a) conducted an experiment to find out the effect of vermicompost on strawberry plant (*Fragaria×ananasa*) var. `Chandler'. Vermicomposts were applied at 4.5m^2 field plots @ 10t/ha to evaluate the effect on growth and yield of strawberry. The results indicated that vermicompost applications increased strawberry growth and yields significantly; including increases of up to 37% in leaf areas, 37% in plant shoot biomass, 40% in numbers of flowers, 36% in numbers of plant runners and 35% in marketable fruit weights.

Arancon *et al.* (2004b) conducted an experiment where vermicomposts and inorganic fertilizers were applied to tomatoes *(Lycopersicon esculentum)* and strawberries (*Fragaria* spp.). The marketable tomato yields in all vermicompost-treated plots were consistently greater than yields from the inorganic fertilizer-treated plots. Leaf areas, number of strawberry suckers, number of flowers, shoot weights and total marketable strawberry yields increased significantly in plots treated with vermicompost compared to those that received inorganic fertilizers. The improvements in plant growth and increases in fruit yields could be due partially to large increases in soil microbial biomass after vermicompost applications, leading to production of hormones or humates in the vermicompost acting as plant-growth regulators independent of nutrient supply.

Edwards *et al.* (2004) reported that vermicompost have fine particulate structure, low C: N ratio, with organic matter oxidized, stabilized and converted into humic materials. It contains nutrients transformed into plant available forms and are extremely microbially-active. Addition of low rate of substitution of vermicompost on plant growth media to field crops have consistently increases plant germination, growth, flowering, fruiting, independent of nutrient availability.

Nagavallemma *et al*. (2004) found that vermicompost provides all nutrients in readily available form and also enhances uptake of nutrients by plants. Earthworms consume various organic wastes and reduce the volume by 40–60%. Each earthworm weighs about 0.5 g to 0.6 g, eats waste equivalent to its body weight and produces cast equivalent to about 50% of the waste it consumes in a day. These worm castings have been analyzed for chemical and biological properties. The moisture content of castings ranges between 32% and 66% and the pH is around 7.0. The worm castings contain higher percentage of both macro and micronutrients than the garden compost. Soil available N increased significantly with increasing levels of vermicompost and highest N uptake was obtained at 50% of the recommended fertilizer rate plus 10t/ha vermicompost.

Gupta (2003) reported that vermicompost has been emerging as an important source in supplementing chemical fertilizers in agriculture in view of sustainable development. It is a biofertilizer enriched with all beneficial soil microbes and also contains all the essential plant nutrients like N, P and K. Vermicompost that is prepared through conventional method has standard values of total nitrogen: 1.94%, phosphorus: 0.47% and potassium: 0.70% it is also enriched with various micronutrients such as Mg (0.46%), Fe (7563 ppm), Zn (278 ppm), Mn (475 ppm), Cu (27 ppm).

Parthasarthi and Ranganathan (2002) found that vermicomposting is a bio-oxidation and stabilization process of organic material that involves the joint action of earthworms and microorganisms. The earthworms are the agents of turning, fragmentation and aeration. It also increase N_2 fixation by both nodular and free living N_2 fixing bacteria and thus enhance plant growth. Vermicompost has been proved as cheapest source of nitrogen and other essential elements for better nodulation and yield particularly in legumes. Such plants can meet their nitrogen needs through both biological nitrogen fixation (symbiosis) and native nitrogen in the soil.

Shiow and Shin-Shan (2002) reported that vermicompost significantly enhanced strawberry (*Fragaria* × *ananassa* Duch.) plant growth and fruit quality when used as a supplement. Strawberry plants grown with vermicompost had significantly higher levels of nitrogen (N) and potassium (K), but lower levels of manganese (Mn), iron (Fe), molybdenum (Mo), and nickel (Ni) in fruit of both "Allstar" and "Honeoye". Use of vermicompost also significantly increased levels of organic acids (malic and citric acid), sugars (fructose, glucose, and total sugars), soluble solids content, and titratable acidity content in both cultivars. The results indicate that the use of compost can reduce the amount of fertilizer required for optimum strawberry plant growth.

Ali and Jahan (2001) reported that vermicompost is non toxic, utilize low energy input for composting and recycled bioorganic product. Due to absence of toxic enzymes it is also ecofriendly and has beneficial effect on the biochemical activities of the soil.

Renuka and Ravishankar (2001) conducted an experiment by application of biogass slurry + FYM, vermicompost alone have provided maximum fruit size, more number of fruits per plant, while inorganic fertilizers (NPK) recorded the minimum fruit size.

Zebarth *et al.* (1999) debriefed vermicompost that continuous and adequate use with proper management can increase soil organic carbon, soil water retention, transmission, improvement in other physical properties of soil like bulk density, penetration resistance and aggregation.

Nair *et al.* (1997) compared the microorganisms associated with vermicompost with those in traditional composts. The vermicompost had much larger populations of bacteria (5.7 x 107), fungi (22.7 x 104) and actinomycetes (17.7 x 106) compared with those in conventional composts. The outstanding physicochemical and biological properties of vermicompost makes them excellent materials as additives to greenhouse container media, organic fertilizers or soil amendments for various field horticultural crops.

Johnston *et al.* (1995) found that crop yields have increased with corresponding improvements in soil quality from addition of organic matter. Significant increases in productivity using animal manures and hay residues. Their important roles in the soil and their potentially positive effect on crop yields have made organic amendments a valuable component of farm fertilization and management programs in alternative agriculture.

Giraddi (1993) reported that vermicomposting helps to increase the density of microbes and also provides the vital macro nutrients viz., N, P, K, Ca, Mg and micronutrients such as Fe, Mo, Zn, Cu etc., Apart from this, it also contains plant growth promoting substances like NAA, cytokinins, gibberellins etc. The chemical analysis of vermicompost disclosed the availability of N, P and K content at 0.8, 1.1 and 0.5% respectively.

Curry and Byrne (1992) observed that earthworm derived nitrogen could supply 30% of the total crop requirement as it is a potential source of readily available nutrients for plant growth.

Albanell *et al.* (1988) debriefed that vermicompost tended to have pH values near neutrality that may be due to the production of CO_2 and organic acids produced during microbial metabolism.

Subbaiah *et al.* (1985) stated that the reason for increased mean fruit weight and fruit yield by the application of NPK with FYM and vermicompost was attributed to solubilization effect of plant nutrients by the addition of FYM and vermicompost leading to increased uptake of NPK as reported by and similar results were also obtained by Nair and Peter (1990) in chilli.

Edwards (1983) found from the study was that moisture content was reduced progressively during vermicomposting giving final moisture contents between 45% and 60%, the ideal moisture contents for land-applied composts

Tomati *et al.* (1983) and Bhawalker (1991) reported that large beneficial microbial population and biologically active metabolites, particularly gibberellins, cytokinins, auxins and B vitamins were observed with application of vermicompost alone or in combination with organic or inorganic fertilizers, so as to get better yield and quality of diverse crops.

2.1.2 Mustard oil cake related

Rehman *et al*. (2015) observed that bio management of root knot nematode, *M.incognita* affecting mungbean using non edible seed oil cakes is an effective and ecologically safer approach as a substitute of nematicides for the pollution free and sustainable environment.

Goswami *et al*. (2006) observed that the maximum reduction in root-galling caused by M.*incognita* on tomato plants, as well as the soil population occurred in soil, treated with both fungi (*T.viride* and *P.lilacinus*) in combination with mustard cake. However, mustard oil cake alone also showed adverse effects on the root-nodulation.

Tahmid *et al*. (2002) found the effect of Azolla (*Azolla pinnata*) in combination with mustard oil cake (MOC) was studied on the galling in roots and growth of eggplants (*Solanum melongena*) inoculated with *Meloidogyn javanica*. Fresh weight and length of both shoot and root were vigorous when dry Azolla (5g) or fresh Azolla extract (10ml) in mixing with the half standard dose (1.25g) of MOC was applied. Similarly, the galling incidence was lower in the same treatment that was identified for the vigorous growth of the plant. *A. pinnata* was found as a very effective agent for the normal growth of root and shoot with half-standard dose of Mustard oil cake. Both of these agents in together created resistance to the plants and its toxic materials might suppress the nematode activity, which ultimately confirm the lower presence of galling by *M. javanica*.

Tiyagi *et al*. (2002) observed that when biocontrol agents integrated with oil cakes showed best results. The oil cakes contributing to NPK, apart from this, oil cakes having a greater benefit in the agriculture, which none of the pesticide or synthetic fertilizer can perform. They provide slow and steady nourishment and protection to host plant; create antagonistic micro flora and fauna for pathogens, including soil nematodes Oil cakes retard nitrification of the soil/urea and thereby increase N uptake by the plants oil cakes containing 2-7% of protein N applied at @ of 4-10%suppress soil nematodes and improve plant tree health.

BARC (1997) reported that mustard oil cake contains high amount of secondary and micronutrients in addition to N, P and K @ 5.1-5.2 , 1.8-1.9 and 1.1-1.3%, respectively

Hussain *et al*. (1989) reported that among the organic amendments, oil cakes have been found to be the most prospective because they do not only reduce nematode development but also stimulate plant growth and supplying plant nutrients of some sorts.

Fassuliotis (1979) reported that oil cakes are rich in fiber, protein and energy contents. They offer potential benefit when used as substrates in developing bioprocesses for the production of organic chemicals and biomolecules. Studies using them for the production of industrial enzymes have shown promising results.

2.2 Influence of micronutrients

2.2.1 Zinc related

Manjit *et al.* (2015) reported that foliar application of 0.2% $FeSO_4$ + 0.3% $ZnSO_4$ thrice at monthly interval tended to exhibit the highest plant height and spread, number of leaves per plant, average leaf area, number of flowers, fruits, marketable fruits per plant and total yield and marketable yield per plant. These plants also took the least duration to attain the age of flowering as well as harvesting.

Abdullah and Jafar (2014) reported that foliar application of micronutrients like iron, zinc and manganese significantly increased 1000-kernel weight, grain yield, oil content of seed and harvest index of *Brassica napus* L. cv. Talayeh. Changes in grain yield was primarily due to the number of pod per plant and that of oil yield was due to grain yield. In general, applying two parts per thousand of the micronutrient was the best treatment to obtain high qualitative and quantitative yield in cv. Talayeh in this region.

Etehadnejad and Aboutalebi (2014) conducted an experiment in order to evaluate the effects of foliar application of nitrogen and zinc on fruit set percent and quality of apple c.v 'Golab Kohanz' as factorial arrangement in randomized complete block design with three replications The first factor was foliar application of zinc (0, 3 and 6 g/L) and the second factor was foliar application of urea (0, 3 and 5 g/L). Based on the obtained results, the highest fruit set percent, fruit length, and fruit diameter, Zn amount in shoot and root and chlorophyll index significantly was observed in foliar application of 6 g/L Zn.

Kazemi (2014) conducted at experiment and found the effect of foliar application of iron, calcium and zinc sulfate. Here reproductive growth, yield and some qualitative characteristics of strawberry fruit were investigated. The treatments included zinc sulfate at three levels (50, 100 and 150 mg/L), iron at three levels (250, 500 and 1000mg /L), calcium at two levels (5 and 10 mM) and distilled water as a control. As result has shown iron, calcium and zinc sulfate increased dry weight, leaf area, length of roots of strawberry. Sprays of zinc sulfate at 150 mg/L iron at 1000 mg/L and calcium at 10 mM improved number of flowers, weight of primary and secondary fruit. The highest percentage of total soluble solids, titratable acidity and ascorbic acid was attained in fruits treated with zinc sulfate at 150 mg l-1 and the lowest was achieved in control. In general, spraying zinc sulfate at 150 mg /L, iron at 1000 mg/L and calcium at 10 mM concentration is recommended for increasing the strawberry yield.

Marjan *et al*. (2013) conducted an experiment and reported that nitrogen (N) and Zinc (Zn) are an essential nutrients element in horticulture crops growing and deficiency causes some problems related with physiological and morphological structure. An investigation was carried out with N and Zn in order to study its effect on the quality and quantity characteristics of Grape vine. The experimental design was a randomized complete block design with four replicates of 4 treatments. This work aimed to study influence the foliar spraying of zinc (as zinc sulphate) and Nitrogen (as Urea) on growth parameters, quality of fruit, flower characteristics. Zinc sulphate (Zn) at concentrations of 0.0 and 1.5g/l and Urea (N) at concentrations of 0.0 and 5 g/l ppm were applied alone and in combinations twice as foliar spray, where the first was after 45 days and the second was after 60 days of planting. Result shown application of this nutrition was caused improved vegetative and sexual growth. On treatment of $N_2 \times Zn_2$ had highest effects on increasing of fruit set. The results indicate that the applied Zn mass concentration efficiency index is different from the improve quality of fruit.

Naga Sivaiah *et al.* (2013) conducted a field experiment during rabi-2010 to find out the response of foliar application of micronutrients on vegetative and reproductive growth attributes, in two varieties of tomato viz. Utkal Kumari and Utkal Raja. The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese, mixture of all and control and the experiment was laid out in RBD with three replications. All the Micronutrients except manganese at 50ppm were applied at 100 ppm in three sprays at an interval of ten days starting from 30 days after transplanting. All the treatments resulted in improvement of plant growth characteristics viz. plant height, number of primary branches, compound leaves, tender and mature fruits per plant in both the varieties out of which application of micronutrients mixture showed the maximum effect. In tomato cv. Utkal Kumari, maximum growth rate (85.7 %) was observed with application of zinc, followed by application of micronutrients mixture (78.2 %) and boron (77.5 %).

Vikash *et al.* (2013) conducted an experiment at Horticultural Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar (U.K.), India, during two consecutive years 2010 and 2011 on 7 years old peach trees cv. Sharbati. The experiment was designed in RBD to study the effect of foliar spraying of boron, zinc and iron and its combination on fruit growth pattern and yield attributing characters of the low-chill peach. Boric acid (0.1%), zinc sulphate (0.5%) and ferrous sulphate (0.5%) were used as a source of boron, zinc and iron, respectively. All the trees fertilized with recommended dose of NPK (300:500:300 as N, P_2O_5 and K_2O).The spraying was done twice; during last week of February at after petal fall stage and again at 15 days after the first spraying during both years in three replication. Result proved that foliar spraying of peach trees with0.1% H_3BO_3+ 0.5 % $ZnSO_4$, $7H_2O$+ 0.5 % $FeSO_4$, $7H_2O$ was the promising treatment for improvement of fruit growth, fruit length, fruit diameter, fruit volume, firmness and fruit yield. This treatment was also found best for maximum fruit retention, average fruit weight as well as the fruit yield.

Aliraza gurmani *et al.* (2012) conducted a pot experiment in greenhouse, effect of soil applied Zinc (@ 0, 5, 10 & 15 mg/kg) on the growth, yield and biochemical attributes was studied of two tomato cultivars; VCT^{-1} and Riogrande. Zinc application increased the plant growth and fruit yield in both cultivars. Maximum plant growth and fruit yield in both cultivars were achieved by the Zn application at 10 mg/kg soil. Application of Zn 5 mg/kg had lower dry matter production as well as fruit yield when compared with Zn 10 and 15 mg/kg. The percent increase of fruit yield at 5 mg Zn/kg was 14 and 30%, in VCT^{-1} and Riogrande, respectively. In the same cultivars, Zn application @ 10 mg Zn/kg caused the fruit yield by 39 and 54%, while 15 mg

Zn/kg enhanced by 34 and 48%, respectively. Zinc concentration in leaf, fruit and root increased with the increasing level of Zn. Zinc application at 10 and 15 mg/kg significantly increased chlorophyll, sugar, soluble protein and superoxide dismutase and catalyses activity in leaf of both cultivars. The results of this study suggest that soil application of 10 mg Zn/kg soil have a positive effect on yield, biochemical attributes and enzymatic activities of both the tomato cultivars.

Nawaz *et al.* (2012) conducted an experiment "interactive effects of nitrogen (N), phosphorus (P) and zinc (Zn) on growth and yield of tomato" was carried out at North Mingora Agriculture Research Station, Pakistan. The experiment was laid out by three factors factorial in a randomized complete block design (RCBD) and all treatments were replicated three times. Four levels of nitrogen (0, 100, 150 and 200 kg/ha), four levels of phosphorus (0, 60, 80 and 100 kg/ ha) and three levels of zinc (0, 5 and 10 ppm) were applied. The results pertaining to various growth and yield parameters showed that early flowerings were observed when plots received phosphorus at 100 kg/ha and zinc at 10 ppm without nitrogen.

Nasiri *et.al.* (2010) evaluated the effects of foliar application of micronutrients (iron and zinc) on yield and essential oil of chamomile, two field experiments were carried out in 2008 and 2009 at the Research Station of Faculty of Agriculture, University of Tabriz, Iran. Both experiments were arranged as factorial on the basis of randomized complete block design (RCBD) with four replications. Treatments were foliar application of micronutrients (Fe, Zn and Fe + Zn through ferrous sulphate and zinc sulphate at the concentration of 0.35%).The results showed that flower yield, essential oil percentage, and essential oil yield increased by foliar application of Fe and Zn compared with control.

Abdollahi *et al*. (2012) conducted an experiment and found that paclobutrazol combined with zinc sulfate ($ZnSO_4$) at concentrations of 100 mg/l PP333×$ZnSO_4$ had positive effects on reproductive growth including inflorescence number and yield. Zink sulphate at concentration of 100 mg/l with no PP333 and H_3BO_3 application increased yield, inflorescence and fruit number as compared with other treatments.

Narimani *et al.* (2010) reported that zinc is an important micronutrient that is closely involved in the metabolism of RNA and ribosomal content in plant cells also it leads to stimulate carbohydrates, proteins and the DNA formation. It is required for the synthesis of tryptophan, a precursor of IAA which acts as a growth promoting substance.

Sing *et al*. (2010) found that the application of Zn as foliar spray not only increased the number of leaves but also reduced the leaf drop and hastened the flowering in papaya plant. Foliar sprays of zinc reduced the days to first flowering and berry maturing which might be due to the fact that zinc is involved in the biosynthesis of plant hormone IAA and plays a vital role in nucleic acid and protein synthesis.

Dutta and Banik (2007) conducted an experiment to determine the effect of foliar feeding of nutrients and plant growth regulators on physico-chemical quality of guava cv. Sardar grown in red and lateritic tract of West Bengal. Nutrients and plant growth regulators were administered three times. viz. before flowering, followed by second and third at fruit setting and three weeks after fruit setting. Experimental results revealed that foliar feeding of nutrients and plant growth regulators significantly increased the fruit length, diameter, individual fruit weight and ultimately crop yield. Maximum (6.24 cm) length of fruit was obtained with treatment urea + K_2SO_4 + Zinc + NAA followed by urea + K_2SO_4 + Zinc. This treatment also found effective in maximizing individual fruit weight and crop yield.

Shivanandam *et al*. (2007) found that zinc has been identified as component of almost 60 enzymes and it has a role in synthesis of growth promoter hormone (auxin) which is directly associated with improvement of Fresh weight of fruits.

Chaturvedi *et al*. (2005) conducted an experiment and showed that application of zinc sulphate at 0.4 per cent and ferrous sulphate at 0.2 per cent in strawberry increased the number of leaves (29.93 and 23.24), flowers (2.22 and

3.33), fruit set (2.6 and 2.8), fruits (16.10 and 16.88) and fruit yield (133.82 and 140.47g) per plant; plant height (18.85 and 18.28 cm) and ascorbic acid content (66.1 and 65.94 mg). Increase in fruit weight (8.12 and 7.98g) and acidity (0.97 and 0.96%), TSS content (9.42 and 9.33° Brix) of fruits were also found with 0.2 per cent of ferrous sulphate and 0.4 per cent of zinc sulphate. The number of runners also increased with the 0.4 per cent zinc sulphate. Higher concentration of zinc sulphate resulted in enhanced shelf life of fruits (2.95 days) at ambient temperature. On the other hand, higher concentration of ferrous sulphate had toxic effect on the plant and retarded the growth, yield and quality attributes.

Havlin *et al.* (2005) reported that the micronutrient zinc helps in building the chlorophyll through its direct impact in the composition of amino acids and carbohydrates and energy compounds used in the construction chlorophyll. As well as, it's importance in building the necessary RNA in protein synthesis and stimulates the enzymes that participate in biological processes for the formation of chlorophyll.

Nazarpur (2005) conducted an experiment to improve vegetative growth, yield and fruit quality of strawberry (*Fragaria* × *ananassa* Duch. cv. Camarosa) using different concentrations of zinc sulfate ($ZnSO_4$) and pacloboyrazol (PBZ). Plants were treated with four levels of $ZnSO_4$ (0, 50, 100 and 150 mg/L) and four levels of PBZ (0, 30, 60 and 90 mg /L). Signification difference was seen among the four levels of $ZnSO_4$ and four levels of PBZ on the growth, yield and quality of strawberry. The results showed that the foliar application of $ZnSO_4$ prior to flowering stage was recommended to increase fruit quality and yield of strawberry. Maximum and minimum fruit weight (9.50 and 8.20 g) was observed in treatments of 90 mg /L PBZ along with 150 mg/L $ZnSO_4$ and control respectively. All yield and fruit quality traits in plants treated with different concentrations of PBZ and $ZnSO_4$ had higher value than those of the control plants.

Marschneret *et al.* (1995) stated that zinc is an essential element for plant that act as a metal component of various enzymes, a functional structural, regulatory cofactor protein synthesis, photosynthesis, synthesis of auxin, cell division, maintenance of membrane structure, function, and sexual fertilization.

Bowler *et al*. (1994) reported that zinc is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory factor of a large number of enzymes

Cakmak *et al*. (1989) reported that the young strawberry plants have been established through the runner system to produce new roots and leaves need energy to be controlled carefully in terms of flowers and fruits, in this case the foliar application of zinc on the leaves during the roots formation is useful. Zinc is essential for normal plant growth and development as carbohydrates, protein metabolism and sexual fertilization depend on zinc.

2.2.2 Boron related

Somaye Rafeii and Zahra Pakkish (2014) conducted an experiment to investigate the impact of spraying boric acid on vegetative and reproductive growth of 'Camarosa' strawberry (*Fragaria* × *ananassa* Duch.). The strawberry plants were sprayed with Boric acid at 0 (control), 50 and 100 mg/L at 30 days after planting. In general, results indicated that spraying plants with boric acid had a significant effect on yield, fruit weight, chlorophyll and leaf area.

Santosh Kumari (2012) conducted an experiment to assess the effects of micronutrients viz boron, zinc, molybdenum, copper, iron, manganese, mixture of all and multiplex through foliar application on quality of fruit and seed in tomato. Three sprays of each at 100 ppm were applied at 10 days interval starting from 30 days after transplanting. Germination percentage, seedling length, speed of germination, vitamin C, total soluble solids and lycopene content showed significant variations. Foliar application of boron was found to be the best treatment for enhancing germination percentage whereas multiplex treatment was best for increasing seedling length. Total soluble solids, vitamin C and lycopene content in the fruit were enhanced by the application of copper, zinc and multiplex respectively.

Firoz *et al*. (2008) conducted an experiment to find out the response of three broccoli varieties to different levels of boron in the Chittagong hilly region. The experiment was conducted at the Hill Agricultural Research Station (HARS), Khagrachari during September 2002 to March 2003. The trial was made in randomized complete block design with three replications. The treatment consisted of three broccoli varieties, viz., Green Commet, Green King and Green Harmony with three levels of boron viz., Control (0 kg/ha), l.0 kg/ha and 2.0 kg/ha. Data on different parameters were recorded from randomly selected five plants in each plot and analyzed statistically. The parameters under study included plant height, outer leaves/plant, curd weight/plant, side curd weight/plant and curd yield. There was a significant and positive effect of boron application on the yield of the crop and 1 .0 kg B/ha was found to be an optimum rate. The 1 .0 kg B/ha rate produced the highest yield (512.3g/plant) followed by 2.0 kg B/ha showing 508.5 g/plant and the B control did the lowest (445.4g/plant).

Basavarajeshwari *et al.* (2008) conducted a field experiment to study the effect of foliar application of micronutrients on growth and yield of tomato (Megha) during 2005-06 and 2006-07 at the All India Co-ordinated Vegetable Improvement Project (AICVIP) in the University of Agricultural Sciences, Dharwad. The results based on two years mean revealed that out of nine different treatments, the application of boric acid @ of 100ppm resulted in maximum number of primary branches (18.30), yield per plant (2.07kg) and fruit yield (30.50 t/ha).

Tsipouridis *et al*. (2005) and Sotomayor *et al*. (2010) observed that increasing fruit yield due to boron spray may be attributed to their effect an increasing fruit set. Also, boron increases chlorophyll content, and leaf area, follow it increase reproductive growth.

Abd-Elmotty and Fawzy (2005) found that boron is involved in processes such as protein synthesis, transport of sugars and carbohydrate metabolism.

Wang *et al.* (2003) reported that boron has effect on many functions of the plant such as hormone movement, activate salt absorption, flowering and fruiting process and pollen germination specially its influences on the directionality of pollen tube growth. Boron seems to play an important role in achieving satisfactory fruit set.

Ahmed *et al*. (2002) found that foliar applied with boron is rapidly absorbed by the flowers, consequently help flower to have enough B to carry them through flowering and fruit set. Also, boron increases flower production and retention, pollen tube germination and elongation and fruit development.

Peres and Reyes (1983) reported that boron requirement is much higher for reproductive growth than for vegetative growth and increases flower production and retention, pollen tube elongation and germination, and seed and fruit development. The application of boron as foliar spray also enhanced the fruit set in papaya.

CHAPTER III
MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter includes the information regarding methodology that was used in execution of the experiment. It contains a short description of location of the experimental site, climatic condition, materials used for the experiment, treatments of the experiment, data collection procedure and statistical analysis etc.

3.1 Experimental sites

The experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period from October 2014 to March 2015. Location of the site is $23^0 74'$ N latitude and $90^0 35'$ E longitudes with an elevation of 8 meter from sea level (UNDP - FAO, 1988) in Agro-Ecological Zones of Madhupur Tract (AEZ No. 28) (Appendix I).

3.2 Climatic conditions

Experimental site was located in the subtropical monsoon climatic zone, set aparted by heavy rainfall during the months from May to September (Kharif season) and scantly of rainfall during the rest of the year (Rabi season). Plenty of sunshine and moderately low temperature prevails during October to March (Rabi season), which is suitable for strawberry growing in Bangladesh. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix II.

3.3 Experimental Materials

Plantlets of the strawberry cultivar (Festival) have been collected from the tissue culture laboratory, BRAC. On the other hand, all of the organic fertilizers viz. vermicompost and mustard oil cake; micronutrients viz. boron (H_3BO_3) and zinc ($ZnSO_4$) have been collected from Krishibid Upokoron Nursery, Agargaon, Dhaka-1207, and Bangladesh.

3.4 Production Methodology

3.4.1 Preparation of the plot

The experiment was conducted at the experimental field in Horticulture farm of Sher-e-Bangla Agricultural University. The selected plot of the experiment was opened in the 1st week of December 2014 with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved. The soil was treated with insecticides (Cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.4.2 Application of manure and fertilizers

Manures and fertilizers were applied to the experimental plot considering the recommended fertilizer doses of strawberry.

Table 1. Dose and fertilizer application method of strawberry in field

Fertilizers & Manures	Dose/ha	Application (%)			
		Basal	15 DAT	25 DAT	35 DAT
Cowdung	10 tonnes	100	---	---	---
Urea	200 kg	--	33.33	33.33	33.33
TSP	200 kg	100	--	--	--
MoP	220 kg	50	16.66	16.66	16.66
Zypsum	150 kg	100	---	---	---

Source: Bangladesh Agricultural Research Institute

The total amount of cowdung, TSP, Zypsum and half of MoP was applied as basal dose at the time of land preparation. On the other hand the total amount of urea and half of MoP was applied at three equal installments at 15, 25 and 35 days after transplanting.

3.4.3 Design of the experiment

First of all the entire experimental plot were divided into four blocks, each of which were then divided into 9 unit plots. The experimental design was Randomized Complete Block Design (RCBD). There were 9 treatments and 4 replications of this experiment. The size of the unit plot was 1.5m× 1m and number of replication was 4. Two adjacent unit plots were separated by 0.75m. The plantlets were planted maintaining plant to plant and row to row distance 40cm and 30 cm respectively.

3.4.4 Preparation of vermicompost leachates

Leachate was prepared by the mixing vermicompost with tap water at a ratio of 1: 2 (v/v), and stored this mixture at room temperature for about 24 h. Solution was freshly prepared and filtered by a paper filter (Whatman No. 2) before each application with a hand sprayer (Johann G. Zaller , 2006) (Plate 3a).

3.4.5 Preparation of mustard oil cake leachates

Leachate was prepared by the mixing mustard oil cake with tap water at a ratio of 1: 2 (v/v), and stored this mixture at room temperature for about 24 h. Solution was freshly prepared and filtered by a paper filter (Whatman No. 2) before each application with a hand sprayer (Johann G. Zaller, 2006) (Plate 3a).

3.4.6 Transplanting of plantlets

288 plantlets of strawberry plants were settled up for transplanting in the field. Plantlets were transplanted in such a way that crown does not go much under soil or does not remain in shallow condition. Plantlets were planted in plot on 18th December 2014.

3.4.7 Tagging of plants

Plants were tagged on 23rd December 2014 using card and bamboo sticks.

3.4.8 Treatments of the experiment

Factor- A: Organic fertilizers (O)

Leachates from organic fertilizers employed on experiment are given below

Control (O_0)

Vermicompost (O_{ver}) = (500kg/ha) = (75g/plot)

Mustard Oil Cake (O_{moc}) = (1000kg/ha) = (150g/plot)

Factor- B: Micronutrients (M)

Micronutrients employed on experiment are given below

Control (M_0)

Boron (M_B) (1 kg/ha) = (150mg/L)

Zinc (M_{Zn}) (1.5 kg/ha) = (225mg/L)

Factor- B / Factor- A	Control (M_0)	Boron (M_B)	Zinc (M_{Zn})
Control (O_0)	O_0M_0	O_0M_B	O_0M_{Zn}
Vermicompost (O_{ver})	$O_{ver}M_0$	$O_{ver}M_B$	$O_{ver}M_{Zn}$
Mustard Oil cake (O_{moc})	$O_{moc}M_0$	$O_{moc}M_B$	$O_{moc}M_{Zn}$

3.4.9 Application of the treatments

Leachate from organic fertilizers viz. vermicompost (75g/plot) and mustard oil cake (150g/plot) was applied twice at afternoon as foliar application with a hand sprayer at 10 and 20 DAT. On the other hand micronutrients viz. boron (150mg/L) and zinc (225mg/L) was applied per plot as foliar application at the same process. Spraying of a similar amount of tap water was served as a control treatment (Plate 3b).

3.4.10 Intercultural operations

Weeding:

Weeding was performed in all plots as and when required to keep the plant free from weeds.

Watering:

Frequency of watering depended upon soil moisture status by observing visually. However, avoided water logging as it is detrimental to plants.

Disease and pest management:

Diseases and pests is a major limiting factor to strawberry production. Experimental strawberry plants were treated with Malathion 250 EC and Cupravit 50 WP to prevent unwanted disease problems @0.5 ml/L and 2 g/L. On the other hand, leaf feeder is one of the important pests during growing stage. Leaf feeder was controlled by Pyrithrum @ 1.5 ml/L. Those fungicides and pesticide were sprayed two times, first at vegetative growing stage and next to early flowering stage to manage pests and diseases.

Fruit management:

In order to protect the fruits from being birds, the plots were covered with netting throughout the time of strawberry ripening (Plate 3c). Besides, dry straw was used to protect the fruit from being rotten due to soil contact (Plate 3e).

Harvesting of fruits:

Harvesting of fruits was done after the fruits reached at maturity stage. Mature fruits were harvested when fruits turned to red in color with waxy layer on surface of fruits. Fruits were harvested from first week of February 2015 to last week of March 2015.

3.4.11 Parameters

Data were collected from each plot. Data were collected under the following heading:

- Plant height (cm)
- Number of leaves/plant
- Number of runners/plant
- Leaf area (cm^2)
- Days to flowering
- Days to fruit setting
- Days to fruit harvesting
- Number of flower buds/plant
- Number of flowers/plant
- Number of fruits /plant
- Fruit length (cm)
- Fruit diameter (mm)
- Single fruit weight (g)
- Total fruit weight (g/plant)
- Yield (t/ha)
- Brix (%)

3.5. Data collection

3.5.1 Measurement of plant height

Plant height of each plant was measured in cm by using meter scale and mean was calculated (Plate 4a).

3.5.2 Number of runners and leaves

Number of runners and leaves per plant were recorded by counting all runners and leaves from each plant and mean was calculated. After 40 days of transplanting number of runners was not counted and all of runners including newly emerged were removed for better yield and quality fruits.

3.5.3 Leaf area measurement

Leaf area was measured by destructive method using CL-202 Leaf Area Meter, USA) (Plate 4b). Mature leaf (from 4th node) were measured at different days after transplanting and expressed in cm^2. Five mature leaves from each plant were measured and then average it after that mean was calculated (Plate 4b).

3.5.4 Days to flowering, fruit setting and harvesting

Days to flowering, fruiting and harvesting were counted by visual observation from the date of strawberry plantlets transplanting.

3.5.5 Measurement of fruit weights

Total fruit weight of each plot was obtained by addition of weight of the total fruit number and average fruit weight was obtained from division of the total fruit weight by total number of fruit. Fruit weight was measured by Electronic Precision Balance in gram (Plate 4c).

3.5.6 Measurement of fruit length and Diameter

Fruit length and diameter were measured using Digital Caliper -515 (DC-515) in millimeter (mm). Mean was calculated each treatment (Plate 4d).

3.5.7 Measurement of Brix percentage

Brix percentages were measured by Portable Refractometer, ERMA, Japan (Plate 4f). Every single fruit was blend and juice was collected to measure brix percentage. Mean was calculated for each treatment. Brix percentage of fruits was measured at room temperature.

3.5.8 Statistical analysis

Collected data were statistically analyzed using MSTAT-C computer package programmed. Mean for every treatments were calculated and analysis of variance for each one of characters was performed by F–test (Variance Ratio). Difference between treatments was assessed by Least Significant Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

3.5.9 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of different organic fertilizers and micronutrients. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 7% in simple rate. The market price of strawberry was considered for estimating the cost and return. Analyses were done according to the procedure of (Alam *et al*., 1989). The benefit cost ratio (BCR) was calculated as follows:

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

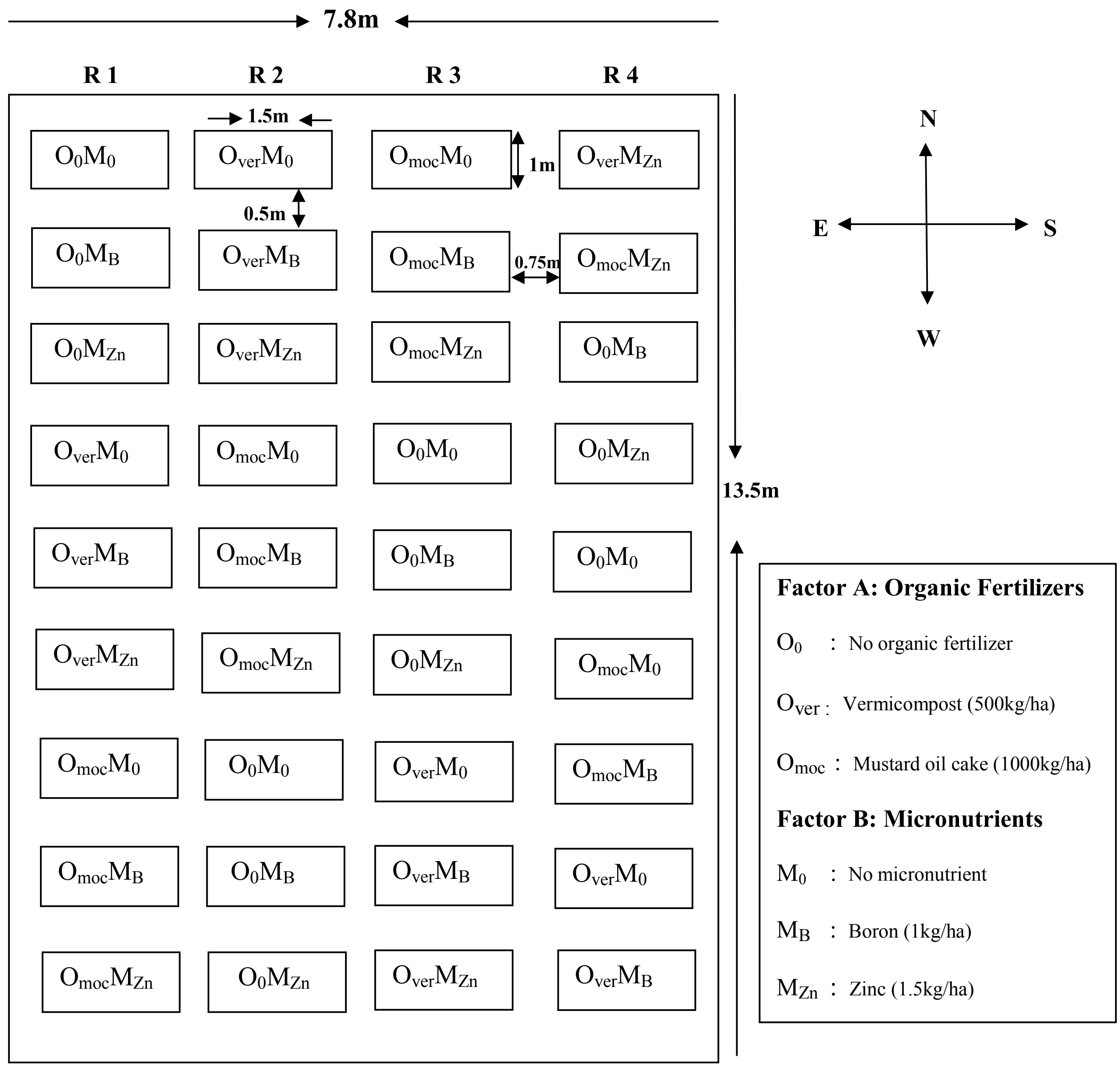


Fig.1. Layout of the research work

Plate 1: Experimental field

a

b

c

d

e

f

Plate 2: **a.** Strawberry plant; **b.** Strawberry flower; **c.** Starting to fruit sett; **d.** Strawberry fruit (green);**e.** Fruit starting to color formation **f.** Strawberry fruit (ripen)

a

b

c

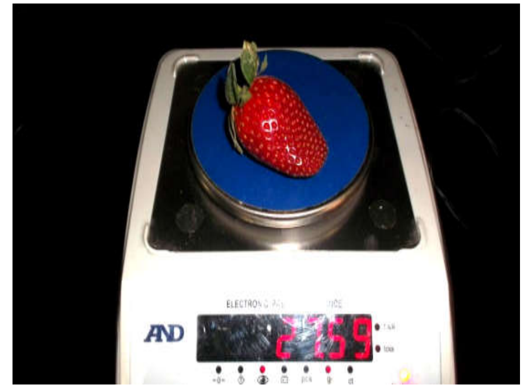
d

e

Plate 3: a. Preparation of mustard oil cake & vermicompost extract; **b**. Foliar spraying using hand sprayer; **c**. Netting for protection of ripen fruit from bird attack; **d**. Rotten fruits due to soil contact; **e.** Using straw for protection of fruits from being rotten

a

b



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e

f

Plate 4 : **a.** Measurement of plant height using meter scale in cm; **b.** Measurement of leaf area using CL-202 leaf area meter in cm^2 **c.** Measurement of fruit weight using electronic precision balance in gm; **d**. Fruit length (cm) &diameter (mm) measurement using digital caliper -515 (DC- 515); **e.** Taking fruit portion for measuring brix; **f.** Measurement of percentage of brix using portable Refractometer.

CHAPTER IV
RESULTS AND DISCUSSIONS

CHAPTER IV

RESULT AND DISCUSSION

Strawberry is a most delicious and sweet flavored fruit in the world. It is becoming popular due to its bright red color and aroma. It has huge importance on food processing industries as well as in medicinal value. Besides, the incomes per unit area are higher in its cultivation. In order to promote the strawberry production, an experiment was conducted to find out the influence of organic fertilizers and micronutrients on growth and yield of strawberry. A summary of the analysis of variances in respect of all the parameters have been shown on appendices. The recorded data have been expressed in table or graph and possible interpretations are given in this section. Results and discussions are presented under the following heads:

4.1 Plant Height

Plant height of strawberry statistically showed significant differences for the application of organic fertilizers at 30, 40, 50 and 60 DAT (Appendix III). There was a gradual thriving affinity of plant height with different days after transplanting (Figure 2). Highest plant height (19.6cm) was recorded from vermicompost (O_{ver}) treated plant that was followed (17.3cm) by mustard oil cake (O_{moc}) whereas smallest (15.3cm) in O_0 (control) at 60 DAT (Figure 2). Vermicompost generated highest plant height due to the improvement of vegetative growth of strawberry plant through better uptake of minerals and microelements. Besides, its biological characteristics and hormone like substances also stimulated plant growth. Sara Khalid *et al.* (2013) reported that vermicompost based organic amendments enhanced vegetative growth of strawberry plant. Daniel and Jader (2012) observed that vermicompost leachates have hormone like substances that stimulate plant growth. Similar findings were also found from (Hidlago *et al.,* 2006; Parthasarthi and Ranganathan, 2002).

Micronutrients showed significant variation on plant height of strawberry at 30, 40, 50 and 60 DAT (Appendix III). Plant height of strawberry showed a gradual increasing trend with different days after transplanting (Figure 3). Highest plant height (18.9cm) was recorded from zinc (M_{Zn}) treated plant that was followed (17.5cm) by boron (M_B) whereas smallest (16.2cm) in M_0 (control) at 60 DAT (Figure 3). Zinc improved plant growth as it act as a growth promoting substances. It helps in stimulation of carbohydrates and proteins; various metabolic processes; its deficiency inhibit growth and development of plant (Narimani *et al*., 2010, Cakmak *et al.,* 1999; Bowler *et al.,* 1994).

Combined effect of organic fertilizers and micronutrients also showed significant variation on plant height of strawberry (Appendix III). Tallest plant (21.9cm) was found under the $O_{ver}M_{Zn}$ treatment and shortest (14.0cm) from O_0M_0 (Table 2). The study implies that vermicompost treated with zinc showed the best combination in respect of plant height.

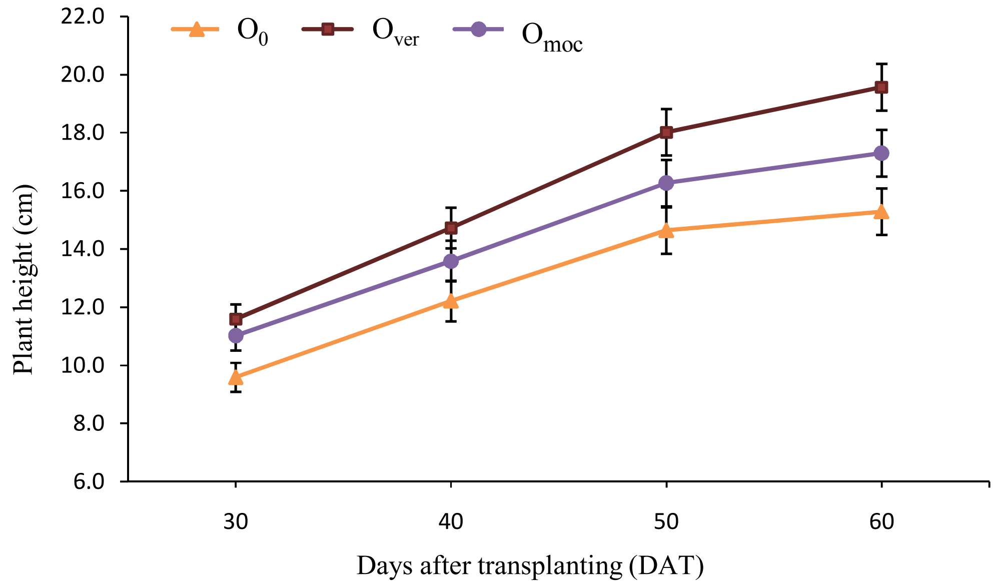

Figure 2. Influence of organic fertilizers on plant height of strawberry at different days after transplanting. (O_0 : Control; O_{ver} : Vermicompost; O_{moc} :Mustard Oil Cake), Vertical error bar showing $LSD_{0.05}$ value 0.5, 0.7, 0.8 and 0.8 at 30, 40, 50 and 60 DAT respectively.

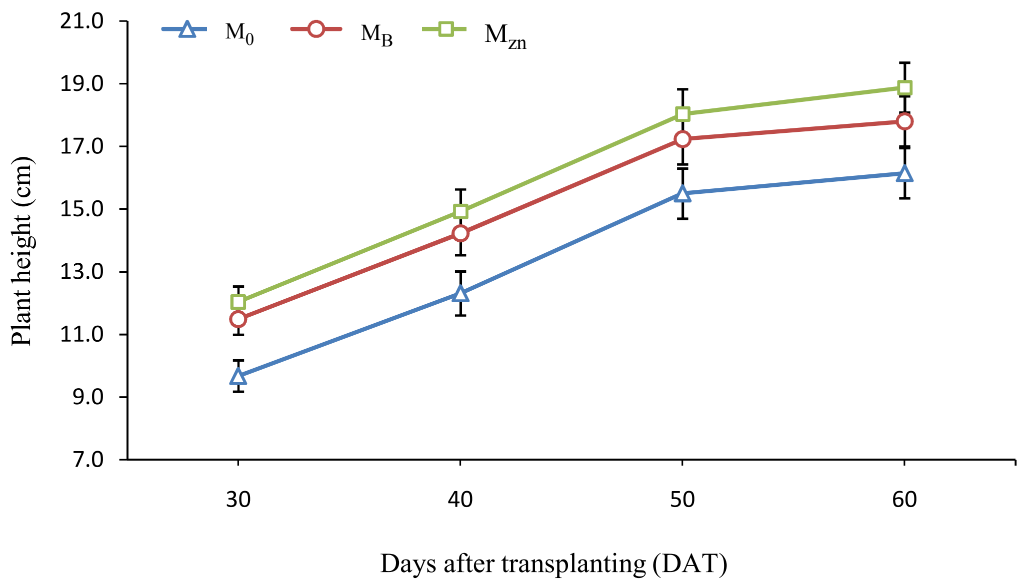

Figure 3. Influence of micronutrients on plant height of strawberry at different days after transplanting. (M_0: Control; M_B: Boron; M_{Zn}: Zinc), Vertical error bar showing $LSD_{0.05}$ value 0.5, 0.7, 0.8 and 0.8 at 30, 40, 50 and 60 DAT respectively.

Table 2. Combined effect of organic fertilizers and micronutrients on plant height of strawberry at different days after transplanting

Treatments	Plant height (cm)			
	30 DAT	40 DAT	50 DAT	60 DAT
O_0M_0	8.0 d	10.6 d	13.3 f	14.0 f
O_0M_B	10.3 c	12.8 c	14.8 e	15.4 e
O_0M_{Zn}	10.5 c	13.2 c	15.8 de	16.5 de
$O_{ver}M_0$	10.7 c	13.3 c	17.2 bc	17.9 bc
$O_{ver}M_B$	11.0 bc	14.7 b	18.2 b	18.9 b
$O_{ver}M_{Zn}$	13.1 a	16.2 a	21.3 a	21.9 a
$O_{moc}M_0$	10.3 c	13.0 c	16.0 cde	16.6 cde
$O_{moc}M_B$	11.1 bc	13.7 bc	15.7 de	16.3 de
$O_{moc}M_{Zn}$	11.7 b	14.0 bc	16.6 cd	17.3 cd
$LSD_{0.05}$	0.9	1.3	1.4	1.4
CV%	6.0	6.4	5.8	5.6

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

O_0: Control

O_{ver}: Vermicompost

O_{moc}: Mustard oil cake

M_0: Control

M_B: Boron

M_{Zn}: Zinc

4.2 Number of leaves

Leaves number of strawberry statistically visualized significant variation among different organic fertilizers application at 30, 40, 50 and 60 DAT (Appendix IV). There was a gradual rising trend of leaf number at different days after transplanting (Figure 4). Maximum leaf number (19.9) was counted in vermicompost (O_{ver}) treated plants that was followed (17.8) by mustard oil cake (O_{moc}) where minimum (15.2) in control (O_0) at 60 DAT (Figure 4). Vermicompost contains nutrient in readily available form which accelerate plant growth, hence number of leaves increased. Vermicompost provided all essential plant nutrients in readily available form like nitrogen could supply 30% of the entire crop requirement for plant growth and increased number of leaves (Tharmaraj *et al.*, 2011; Joshi and Vig, 2010; Nagavallemma *et al.*, 2004; Curry and Byrne, 1992).

Micronutrients displayed statistically significant inequality on leaves number of strawberry at 30, 40, 50 and 60 DAT (Appendix IV). Figure 5 represented a gradual growing trend of leaf number at different days after transplanting. Maximum leaf number (19.2) was counted in zinc (M_{Zn}) treated plants that was followed (17.6) by boron (M_B) whereas minimum (15.2) in control (M_0) at 60 DAT (Figure 5). Zinc plays vital role in improving vegetative growth of the plant as it acts as a growth promoting substances which increased number of leaves. Application of Zn as foliar spraying not only increased the number of leaves but also reduced the leaf drop in papaya plant (Sing *et al.,* 2010). Similar findings in relation to number of leaves were also found from (Chaturvedi *et. al.,* 2005).

Interaction effect of organic fertilizers and micronutrients in relation to number of leaves also showed significant variation (Appendix IV). Maximum number of leaf (23.1) found from $O_{ver}M_{Zn}$ treatment whereas minimum number (13.4) in O_0M_0 (Table 3). The study indicates that vermicompost along with zinc showed the best interaction in terms of leaf number.

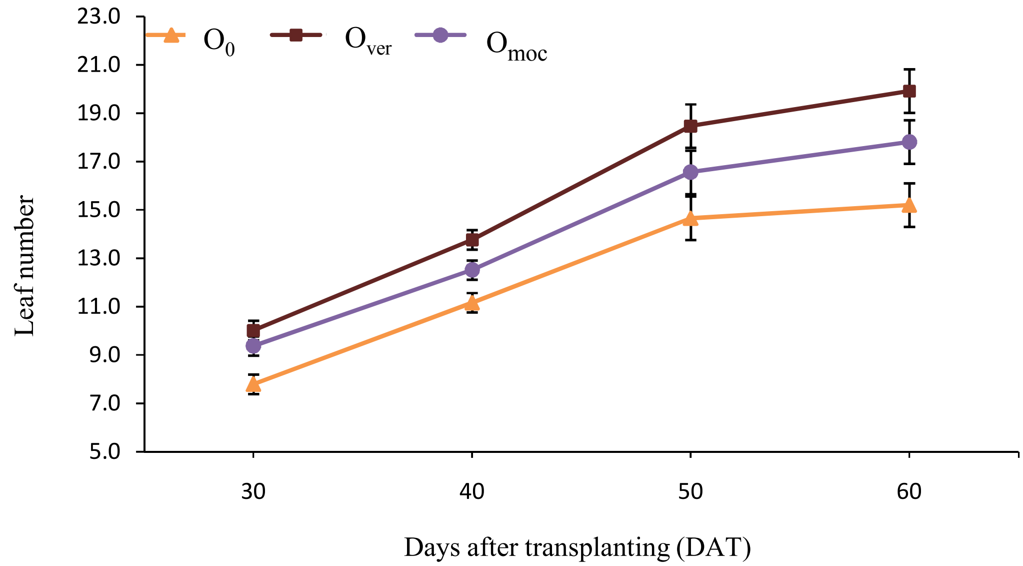

Figure 4. Influence of organic fertilizers on leaf number of strawberry at different days after transplanting. (O_0 : Control; O_{ver} : Vermicompost; O_{moc} :Mustard Oil Cake), Vertical error bar showing $LSD_{0.05}$ value 0.4, 0.4, 0.9 and 0.9 at 30, 40, 50 and 60 DAT respectively.

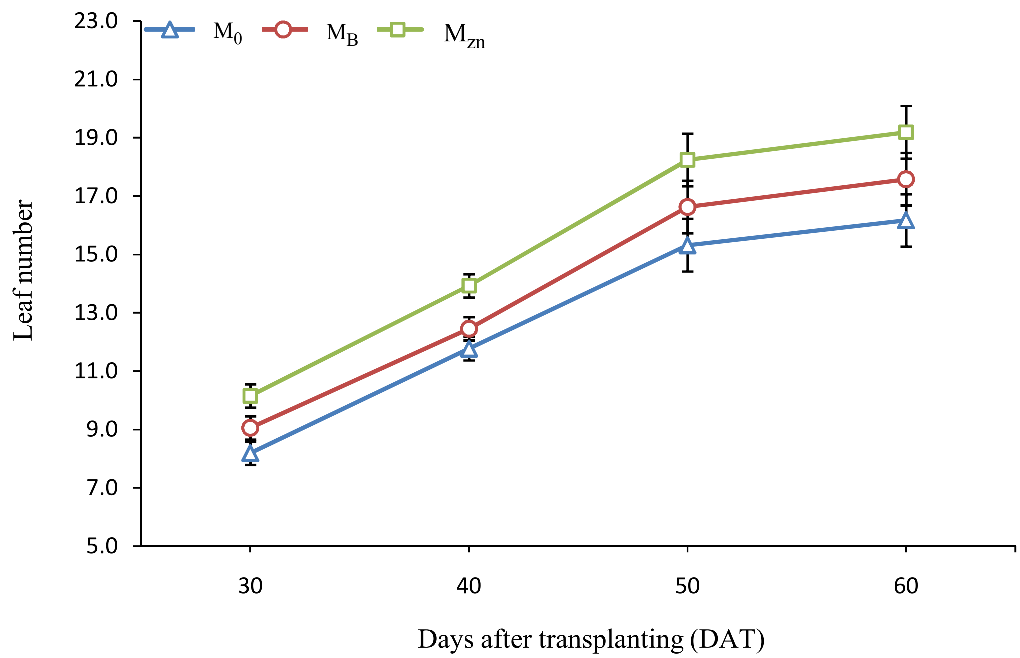

Figure 5. Influence of micronutrients on leaf number of strawberry at different days after transplanting. (M_0: Control; M_B: Boron; M_{Zn}: Zinc), Vertical error bar showing $LSD_{0.05}$ value 0.4, 0.4, 0.9 and 0.9 at 30, 40, 50 and 60 DAT respectively.

Table 3. Combined effect of organic fertilizers and micronutrients on number of leaves of strawberry at different days after transplanting

Treatments	Number of leaves							
	30 DAT		40 DAT		50 DAT		60 DAT	
O_0M_0	6.5	f	10.2	e	12.5	f	13.4	f
O_0M_B	7.9	e	12.2	b	15.6	de	16.5	de
O_0M_{Zn}	9.0	cd	13.4	bc	14.8	e	15.7	e
$O_{ver}M_0$	8.7	d	13.8	c	17.3	bc	18.3	bc
$O_{ver}M_B$	9.8	b	15.7	b	17.5	b	18.4	b
$O_{ver}M_{Zn}$	11.6	a	16.4	a	22.1	a	23.1	a
$O_{moc}M_0$	9.4	bcd	12.7	cd	15.9	cde	16.9	cde
$O_{moc}M_B$	9.5	bc	14.2	bc	16.8	bcd	17.8	bcd
$O_{moc}M_{Zn}$	9.9	b	12.7	b	17.8	b	18.8	b
$LSD_{0.05}$	0.6		0.7		1.5		1.5	
CV%	4.7		3.6		6.3		5.9	

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

O_0: Control — M_0: Control

O_{ver}: Vermicompost — M_B: Boron

O_{moc}: Mustard oil cake — M_{Zn}: Zinc

4.3 Leaf area

Leaf area of strawberry plant statistically showed significant variation among control, vermicompost and mustard oil cake at 30, 40, 50 and 60 DAT (Appendix V). It pretended a continual increasing trend among the organic fertilizers at different days after transplanting (Figure 6) Maximum leaf area (61.6cm^2) was found in vermicompost (O_{ver}) treated plant that was followed (54.6cm^2) by mustard oil cake (O_{moc}) where minimum (53.7cm^2) in control (O_0) at mature stage (Figure 6). Physico-chemical properties of soil, enzymatic activity and microbial population are enhanced due to the application of vermicompost and promoted leaf area. Leaf area of strawberry plant improved due to the foliar application of vermicompost leachate (Singh *et al.*, 2010; Aracon *et al.*, 2006a and 2006b; Kannan *et al.,* 2006).

Micronutrients statistically asserted significant differences on leaf area of strawberry at 30, 40, 50 and 60 DAT (Appendix V). There was a gradual progressive affinity of leaf area among micronutrients at different days after transplanting (Figure 7). Maximum leaf area (62.4cm^2) was observed in zinc (M_{Zn}) treated plant that was followed (55.6cm^2) by boron (M_B) whereas minimum (52.0cm^2) in control (M_0) at mature stage (Figure 7). These results occurred owing to the use of micronutrients specially zinc that played an important role in the representation of auxins that increased cell division and chlorophyll in the leaf. Havlin *et al.* (2005) reported that zinc is involved in chlorophyll formation, production of auxin, protein and carbohydrates synthesis and in the development of leaf surfaces. Similar findings in respect of leaf area were also reported by (Manjit *et al.*, 2015).

Combined effect of organic fertilizers and micronutrients to leaf area of strawberry plant also showed significant variation (Appendix V). Maximum leaf area (69.1cm^2) was found from $O_{ver}M_{Zn}$ treatment whereas minimum (42.5cm^2) in O_0M_0 (Table 4). The study indicates that vermicompost treated with zinc showed the excellent combination in terms of leaf area.

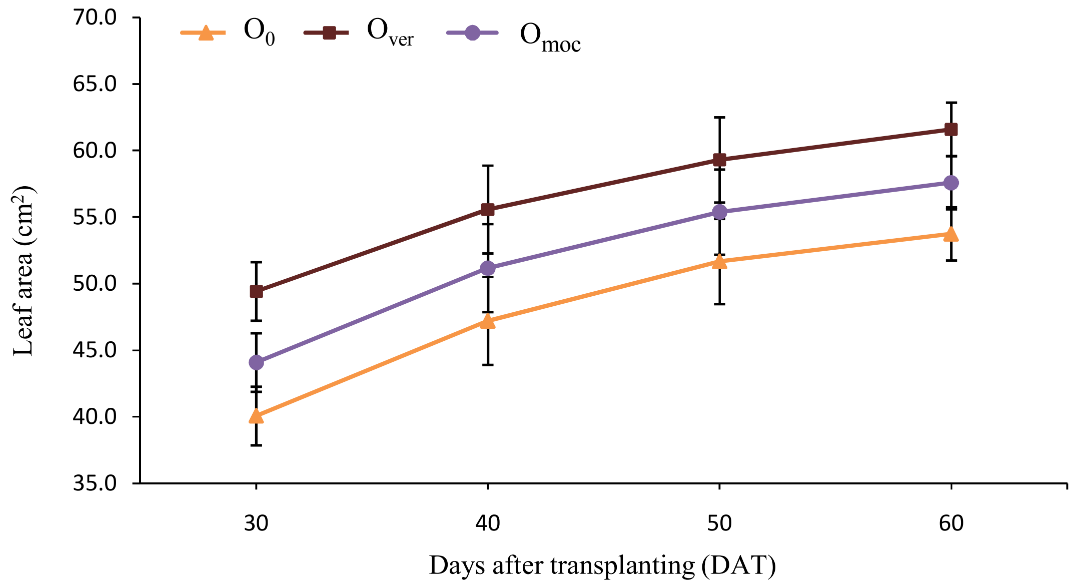

Figure 6. Influence of organic fertilizers on leaf area of Strawberry at different days after transplanting. (O_0: Control; O_{ver} : Vermicompost; O_{moc} :Mustard Oil Cake), Vertical error bar showing $LSD_{0.05}$ value 2.2, 3.3, 3.2 and 2.0 at 30, 40 , 50 and 60 DAT respectively.

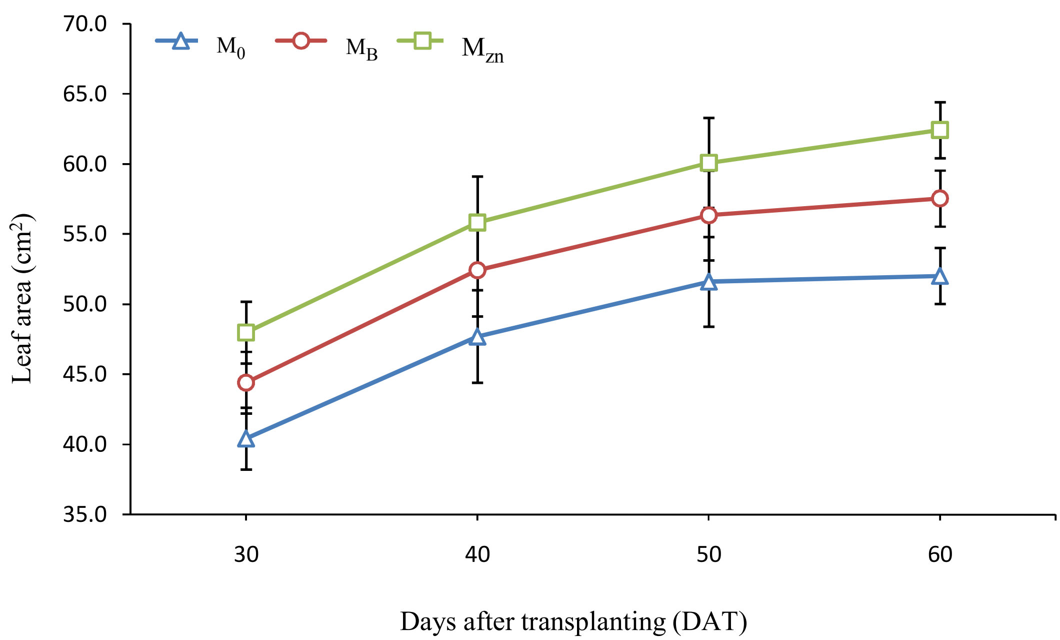

Figure 7. Influence of micronutrients on leaf area of strawberry at different days after transplanting. (M_0: Control; M_B: Boron; M_{Zn}: Zinc), Vertical error bar showing $LSD_{0.05}$ value 2.2, 3.3, 3.2 and 2.0 at 30, 40, 50 and 60 DAT respectively.

Table 4. Combined effect of organic fertilizers and micronutrients on leaf area of strawberry at different days after transplanting

Treatments	Leaf area (cm^2)			
	30 DAT	**40 DAT**	**50 DAT**	**60 DAT**
O_0M_0	29.8 f	37.1 e	37.9 e	42.5 f
O_0M_B	40.3 de	49.0 cd	50.0 cd	52.7 de
O_0M_{Zn}	38.3 e	46.5 d	49.1 d	51.0 de
$O_{ver}M_0$	42.3 d	46.0 d	47.0 d	50.2 e
$O_{ver}M_B$	49.0 b	56.7 b	58.0 b	59.6 b
$O_{ver}M_{Zn}$	57.0 a	64.0 a	65.9 a	69.1 a
$O_{moc}M_0$	46.3 bc	54.0 bc	55.0 bc	57.4 bc
$O_{moc}M_B$	44.0 cd	51.6 bcd	52.0 cd	54.4 cd
$O_{moc}M_{Zn}$	42.0 de	48.0 d	50.1 cd	51.9 de
$LSD_{0.05}$	3.9	5.7	5.5	3.5
CV%	6.2	7.8	7.3	4.4

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

O_0: Control

O_{ver}: Vermicompost

O_{moc}: Mustard oil cake

M_0: Control

M_B: Boron

M_{Zn}: Zinc

4.5 Days to flowering

Significant variation was found among the performance of organic fertilizers for the days required to flowering from days after transplantation of strawberry. (Appendix VI). Early flowering (39.7days) was recorded in vermicompost (O_{ver}) treated plants that was followed (41.1 days) by mustard oil cake (O_{moc}) where delayed (44.7 days) in control (O_0) (Table 5). Early flowering was initiated due to the foliar application of vermicompost leachate. It made the nutrient readily available for the plant and accelerated to early flowering. Chaoui *et al.* (2005) reported that vermicompost has been shown to have high levels of available nitrogen, phosphorous, potassium, micronutrients, enzyme activities and growth regulators. Chamani *et al.* (2008) observed that plant produced early flowering due to the incorporation of vermicompost. Similar findings in terms of days to flowering were also found from (Edwards *et al.,* 2004).

Micronutrients exposed commencing variation for days required to flowering from the days after transplantation of strawberry plantlets (Appendix VI). Early flowering (38.6 days) was recorded in zinc (M_{Zn}) treated plants that was followed (43.1 days) by boron (M_B) whereas delayed (44.9 days) in control (M_0) (Table 6). Foliar application of zinc reduced the days required to flowering. It might be due to the fact that zinc is an important micronutrient for plant involved in the biosynthesis of plant hormone Indole-3 Acetic Acid (IAA) and also played an important role in nucleic acid and protein synthesis. Nawaz *et al.* (2012) observed the significant effect of zinc on days to flowering in *Lycopersicum esculentum*. Similar findings about days to flowering were also found from (Sing *et al*., 2010).

Interaction effect of organic fertilizers and micronutrients on days to flowering of strawberry also displayed significant variation (Appendix VI). Early flowering (35.8 days) was recorded from $O_{ver}M_{Zn}$ treated plant whereas delayed (49.1 days) in O_0M_0 (Table 7).

4.6 Days to fruit setting

Significant variation was received among the organic fertilizers performance on days required to fruit setting from days after transplantation of strawberry plantlets (Appendix VI). Lowest days (46.7 days) required to fruit setting was counted in vermicompost (O_{ver}) treated plants that was followed (47.9 days) by mustard oil cake (O_{moc}) where maximum (53.1 days) in control (O_0) (Table 5).Vermicompost produced early flowering in the strawberry plant that induced lowest time to fruit setting. Mehraj *et al.* (2014) reported that application of vermicompost stimulated the flowering earlier and enhanced fruit setting in strawberry plant.

Micronutrients pretended indicatory variation on strawberry plant in respect of days to fruit setting (Appendix IV). Shortest period of fruit setting (43.8 days) was recorded in zinc (M_{Zn}) treated plants that was followed (50.4 days) by boron (M_B) whereas longest period (52.4 days) in control (M_0) (Table 6). Zinc commenced flowering promptly and induced fruit setting earlier. Similar results about days to fruit setting were also observed from (Marjan *et al.,* 2013).

Interaction effect of organic fertilizers and micronutrients on days to fruit setting of strawberry also displayed significant variation (Appendix VI). Early fruiting (40.6 days) was recorded from $O_{ver}M_{Zn}$ treatment whereas late (62.8 days) in O_0M_0 treatment (Table 7).

4.7 Days to fruit harvesting

Significant variation was observed among the control, vermicompost and mustard oil cake performance for the days required to fruit harvesting from the days after transplantation of strawberry plantlets (Appendix IV). Minimum days required to fruit harvesting (67.4 days) was counted in the vermicompost (O_{ver}) treated plants that was followed (69.3 days) by mustard oil cake (O_{moc}) whereas delayed (75.3 days) in control (O_0) (Table 5).Vermicompost treated plant produced early flowering and fruiting, which commenced early harvesting of fruits.

Micronutrients exposed significant variation on strawberry plant in respect of days to harvesting (Appendix IV). Shortest period of harvesting (66.2 days) was recorded in zinc (M_{Zn}) treated plant that was followed (70.6 days) by boron (M_B) where longest (75.2 days) in control (M_0) (Table 6). Zinc generated early flowering and fruiting which stimulated early harvesting.

Combined effect of organic fertilizers and micronutrients also showed commencing difference on days to harvesting of strawberry fruits (Appendix IV). $O_{ver}M_{Zn}$ treated plants represented superior combination (61.6 days required) for harvesting where O_0M_0 displayed inferior combination (86.4 days required) (Table 7).

Strawberry is a fruit crop of temperate region. Low temperature is needed for its growth and development. High temperature adversely influences the strawberry production. In Bangladesh, after the end of January temperature increases rapidly and strawberry plant face major problem in fruiting and ripening. In order to overcome this problem early flowering, fruiting and harvesting is very much needed. From the study it can be said that vermicompost along with zinc can play vital role in case of early flowering, fruiting and harvesting which is very much important for higher yield.

Table 5. Effect of organic fertilizers on crop duration related attributes of strawberry

Treatments	Days to flowering	Days to fruit setting	Days to fruit harvesting
O_0	44.7 a	53.1 a	75.3 a
O_{ver}	39.7 c	46.7 c	67.4 c
O_{moc}	41.1 b	47.9 b	69.3 b
$LSD_{0.05}$	1.1	1.2	1.7
CV%	4.2	4.5	3.3

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

O_0: Control

O_{ver}: Vermicompost

O_{moc}: Mustard oil cake

Table 6. Effect of micronutrients on crop duration related attributes of strawberry

Treatments	Days to flowering	Days to fruit setting	Days to fruit harvesting
M_0	44.9 a	52.4 a	75.2 a
M_B	43.1 b	50.4 b	70.6 b
M_{Zn}	38.6 c	43.8 c	66.2 c
$LSD_{0.05}$	1.1	1.2	1.7
CV%	4.2	4.5	3.3

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

M_0: Control

M_B: Boron

M_{Zn}: Zinc

Table 7. Combined effect of organic fertilizers and micronutrients on crop duration related attributes of strawberry

Treatments	Days to flowering	Days to fruit setting	Days to fruit harvesting
O_0M_0	49.1 a	62.8 a	86.4 a
O_0M_B	43.8 b	49.4 c	68.3 ef
O_0M_{Zn}	41.1 c	47.0 d	71.3 cd
$O_{ver}M_0$	38.8 d	44.5 e	66.3 f
$O_{ver}M_B$	44.6 b	54.9 b	74.3 b
$O_{ver}M_{Zn}$	35.8 e	40.6 f	61.6 g
$O_{moc}M_0$	43.4 b	49.9 c	72.9 bc
$O_{moc}M_B$	41 c	46.8 d	69.3 de
$O_{moc}M_{Zn}$	38.9 d	43.8 e	65.8 f
$LSD_{0.05}$	1.9	2.1	2.9
CV%	4.2	4.5	3.3

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

O_0: Control — M_0: Control

O_{ver}: Vermicompost — M_B: Boron

O_{moc}: Mustard oil cake — M_{Zn}: Zinc

4.8 Number of Runners/plant

Significant variation was found among the organic fertilizers performance on strawberry plant in terms of runner number at mature stage (Appendix V). Maximum number of runners (5.9) was found in vermicompost (O_{ver}) treated plant where minimum (3.9) in control (O_0) at mature stage (Table 8). Vermicompost exhibit plant growth regulating substances and also enhance soil biological function that increased number of runners. Arancon *et al.* (2004a and 2004b) found that vermicompost application of strawberry increased 36% of runners. Similar findings related to number of runners were also observed from (Cristina and Jorge, 2011).

Micronutrients generated indicatory variation on strawberry plant in respect of number of runners at mature stage (Appendix V). Maximum number of runners (5.5) was found in zinc (M_{Zn}) treated plants where minimum (4.0) in control (M_0) at mature stage (Table 9). The micronutrient zinc increased the number of runner because it acts as growth promoting substances. Zinc is essential for normal plant growth and development as carbohydrates; protein metabolism and pollination depend on it (Cakmak *et al*., 1989).

Combined effect of organic fertilizers and micronutrients to number of runner also showed significant variation at mature stage (Appendix V). Maximum number of runner (7.1) was found from $O_{ver}M_{Zn}$ treatment whereas minimum (3.6) in O_0M_0 (Table 10). The study implies that vermicompost treated with zinc showed the best in terms of runner number of strawberry. Runner system helps the plant for establishment and to produce new leaves. However the energy to be controlled carefully in terms of flowers and fruits. In this aspect foliar application of vermicompost and zinc on leaves are useful.

4.9 Number of flower buds/plant

Significant variation was found among the organic fertilizers performance on strawberry in relation to number of flower buds at mature stage (Appendix V). Maximum number of flower buds (31.6) was found in vermicompost (O_{ver}) treated plant that was followed (30.1) by mustard oil cake (O_{moc}) where minimum (26.6) in control (O_0) at mature stage (Table 8). Vermicompost improves soil biodiversity by promoting beneficial microbes directly and control plant pathogens, nematodes and other pests indirectly, which enhanced number of flower buds in strawberry. Similar findings were found from (Jayakumar and Natarajan, 2012).

Micronutrients emerged significant variation in relation to number of flower buds per plant at mature stage (Appendix V). Maximum number of flower buds (31.5) was found in zinc (M_{Zn}) treated plants that was followed (29.5) by boron (M_B) where minimum (27.8) in control (M_0) at mature stage (Table 9). Zinc stimulated reproductive growth of the plant and increased the number of flower buds. Abdollahi *et. al.* (2012) found that application of zinc had positive effects on reproductive growth including number of inflorescence and yield.

Combined effect of organic fertilizers and micronutrients in relation to number of flower buds per plant also generated significant variation at mature stage (Appendix V). Maximum number of flower buds (33.7) was found from $O_{ver}M_{Zn}$ treated plant whereas minimum (27.1) in O_0M_0 (Table 10). The study implies that vermicompost treated with zinc showed the best combination in relation to number of flower buds per plant.

4.10 Number of flowers per plant

Number of flowers per plant was significantly varied among different organic fertilizers treatment (Appendix V). Number of flowers was maximum (29.6) in vermicompost (O_{ver}) treated plant where minimum (26.6) in control (O_0) (Table 8). Vermicompost increased number of flowers because of plant growth influencing substances such as hormones and humates produced by microorganisms during vermicomposting. Aracon *et al.* (2006a and 2006b) reported that vermicompost contains humic acid which act as a beneficial role for increased flower number of pepper, marigold and strawberry. Sinha *et al.*, (2010) observed that application of vermicompost increased number of flowers in *Pisum sp.* and *Cicer sp*. Similar results in relation to number of flowers were also found from (Hatamzadeh and Masouleh, 2011).

Micronutrients were significantly subjective on the strawberry plant in respect of number of flowers per plant (Appendix V). Highest (29.5) number of flowers was found in zinc (M_{Zn}) treated plant while lowest (25.2) in control (M_0) (Table 9). Zinc plays vital role in cell division and photosynthesis that improves reproductive growth of the plant, hence number of flowers increased. Kazemi (2014) reported that application of zinc had positive effect on the reproductive growth of plant and increased number of flowers in strawberry. Similar findings about number of flowers were also observed from (Nasiri *et al.,* 2010).

Combined effect of organic fertilizers and micronutrients also displayed significant variation in relation to number of flowers per plant (Appendix V). Maximum (26.7) number of flowers was counted in $O_{ver}M_{Zn}$ treatment where minimum (15.5) in control O_0M_0 (Table 10). The study indicates that vermicompost treated with zinc showed the best combination in respect of number of flowers per plant.

4.11 Number of fruits per plant

Number of fruits per plant was significantly varied among control, vermicompost and mustard oil cake performance (Appendix V). Number of fruits was maximum (26.9) in vermicompost (O_{ver}) treated plant that was followed (25.1) by mustard oil cake (O_{moc}) where minimum (23.8) in control (O_0) (Table 8). Humic acid is very much important to bear more fruits in plants. Vermicompost contains humic acid, larger population of bacteria, physico-chemical and biological properties, thus enhanced number of fruits in strawberry. Atefe *et al.* (2012) reported that vermicompost treated strawberry plants bear more fruits due to the greater supply of humic acid. Aracon *et al.* (2006a and 2006b) found that application of vermicompost increased fruit number of pepper, marigold and strawberry. Similar findings about number of fruits were also found from (Sinha *et al.*, 2010; Nair *et al.*, 1997).

Micronutrients generated significant variation on the production of fruits per plant (Appendix V). Highest (26.3) number of fruits was found in zinc (M_{Zn}) treated plant that was followed (24.6) by boron (M_B) whereas lowest (23.8) in control (M_0) (Table 9). Zinc has an important role in photosynthesis and plant metabolism which increased number of fruits. Abdollahi *et al.* (2012) showed that application of $ZnSO_4$ increased number, size and quality of strawberry fruits. Similar results in relation to number of fruits were also found from (Chaturvedi *et al*., 2005).

Combined effect of organic fertilizers and micronutrients also displayed significant variation in relation to number of fruits per plant (Appendix V). Maximum (25.3) number of fruits was counted in $O_{ver}M_{Zn}$ treatment where minimum (14.4) in control O_0M_0 (Table 10). Present study showed that vermicompost along with zinc performed as a best combination in number of fruits per plant.

4.12 Fruit length

Significant variation was found for fruit length of strawberry plant due to the application of different organic fertilizers (Appendix V). Longest (4.8cm) fruit was found in vermicompost (O_{ver}) treated plant that was followed (4.0 cm) by mustard oil cake (O_{moc}) where shortest (3.6cm) in control (O_0) (Table 8). Vermicompost has growth promoting substances like NAA that normally increase the leaf area. Maximum leaf area enabled the CHO concentration in crown and roots at the time of fruiting, thus fruit length was increased. Application of vermicompost on strawberry plant increased the length of fruit (Atefe *et al.*, 2012). Ali *et al.* (2014) reported that application of vermicompost leachates increased the length of tomato fruits. Similar findings about fruit length were also found from (Manatad and Jaquias, 2008).

Micronutrients generated cabalistic variation on the fruit length of strawberry plant (Appendix V). Longest (4.8cm) fruit length of strawberry was found in zinc (M_{Zn}) treated plant that was followed (3.8 cm) by boron (M_B) where shortest (3.1cm) in control (M_0) (Table 9). Foliar application of zinc improved the internal physiology of developing fruit in terms of better supply of water, nutrients, and other compounds for their proper growth and development, thus size of fruits was increased. Similar findings in respect of fruit length were also observed from (Dutta and Banik, 2007).

Combination of organic fertilizers and micronutrients also showed significant variation in terms of fruit length (Appendix V). Longest (5.6cm) fruit length of strawberry was found from $O_{ver}M_{Zn}$ treatment where shortest (2.9cm) in control O_0M_0 (Table 10). The study indicates that vermicompost treated with zinc displayed the best interaction in relation to fruit length of strawberry.

4.13 Fruit diameter

Significant variation was found for fruit diameter due to the application of different organic fertilizers (Appendix V). Longest (31.9mm) fruit diameter of strawberry was found in vermicompost (O_{ver}) treated plant that was followed (30.0mm) by mustard oil cake where shortest (24.9mm) in control (O_0) (Table 8). Vermicompost treated strawberry plants furnished maximum diameter of fruit. It may be due to the beneficial effect on biochemical activities of the soil. Vermicompost boosted up the diameter of fruit in various crops like watermelon, tomatoes, sweet pepper (Manatad and Jaquias, 2008). Similar results about fruit diameter also observed from (Ali and Jahan, 2001).

Micronutrients showed significant variation on fruit diameter of strawberry (Appendix V). Longest (32.6 mm) fruit diameter of strawberry was found in zinc (M_{Zn}) treated plant that was followed (29.4mm) by boron (M_B) where shortest (24.8mm) in control (M_0) (Table 9). Zinc has positive effect on carbohydrates and protein synthesis that increases fruit growth. Etehadnejad and Aboutalebi (2014) found that foliar application of zinc increased diameter of fruits. Similar findings in terms of fruit diameter were also found from (Naga Sivaiah *et al.,* 2013).

Unification of the organic fertilizers and micronutrients also showed significant variation in terms of fruit diameter (Appendix V). Longest (35.4mm) fruit diameter of strawberry was found from $O_{ver}M_{Zn}$ treatment whereas shortest (18.8mm) in control O_0M_0 (Table 10). The study indicates that vermicompost treated with zinc showed the better combination in relation to fruit diameter of strawberry.

4.14 Percentage of brix

Percentage of brix in strawberry fruits varied significantly due to the application of different organic fertilizers (Appendix V). Highest brix (7.8%) was observed in vermicompost (O_{ver}) treated plant that was followed (7.5%) by the mustard oil cake (M_B) whereas lowest (4.2%) in control (O_0) (Table 8). Micronutrients are very much important in sweetness of many fruits. Vermicompost makes the micronutrients in readily available form for plant and due to the availability of these nutrients sweetness of strawberry fruits was increased. From the chemical analysis it was observed that vermicompost contains huge amount of important nutrients like sodium, potassium, calcium, magnesium, copper, nitrate and chloride (Amir and Ishaq, 2011).Vermicompost increased the organic acid (malic and citric acid), sugars (fructose, glucose and total sugars), soluble and insoluble solids (Shiow and Shin-Shan, 2002). Similar findings in relation to percentage of brix in strawberry fruits were also found by (Singh *et al.*, 2010; Giraddi, 1993).

Micronutrients pretended significant differences on percentage of brix in strawberry fruits (Appendix V). Maximum brix (7.3%) was found in zinc (M_{Zn}) treated plants where minimum (5.6%) in control (M_0) (Table 9). Zinc promotes TSS of fruits, thus percentage of brix increased. Application of zinc sulfate increased TSS in fruit of guava (Dobroluybsikii *et al.*, 1982). Zinc has also shown to have an important role in photosynthesis and enzyme activation, resulting in increasing sugar and decreasing acidity (Abedy, 2001).

Combination of organic fertilizers and micronutrients was significantly influenced on percentage of brix in strawberry fruits (Appendix V). It was observed that maximum brix (9.7%) was provided by $O_{ver}M_{Zn}$ where minimum (3.5%) from control O_0M_0 (Table 10). The study indicates that vermicompost treated with zinc showed the best in terms of percentage of brix in strawberry.

4.15 Single fruit weight

Single fruit weight of strawberry plant significantly differed due to the application of different organic fertilizers (Appendix VII). Maximum (14.3g) single fruit weight of strawberry was found in vermicompost (O_{ver}) treated plant that was followed (13.5g) by mustard oil cake (O_{moc}) where minimum (12.0g) in control (O_0) (Table 8). Vermicompost helps the plant to get adequate nutrients because it has huge amount of nutrients and also has the capability to increase uptake of NPK, thus enhanced fruit weight. Nagavallemma *et al.* (2004) reported that application of vermicompost reduces the C:N ratio that can responsible for the maximum fruit weight. Similar findings about fruit weight were also observed from (Attarde *et al.*, 2012; Singh *et al.*, 2010; Nair and Peter, 1990).

Micronutrients displayed significant variation on single fruit weight of strawberry (Appendix V). Maximum (14.0g) fruit weight was found in zinc (M_{Zn}) treated plant that was followed (13.3g) by boron (M_B) whereas minimum (12.4g) in control (M_0) (Table 9). The increased in fruit weight might be due to the enhanced in cell size and intercellular space in fruits. Shivanandam *et al.* (2007) reported that zinc has as component of almost 60 enzymes and it has a role in synthesis of growth promoter hormone (auxin) which directly associated with improvement of fresh weight of fruits.

Interaction effect of organic fertilizers and micronutrients also showed significant variation in respect of single fruit weight of strawberry (Appendix VII). Maximum (14.7g) fruit weight was found in $O_{ver}M_{Zn}$ treatment whereas minimum (11.2g) in control O_0M_0 (Table 10). The study indicates that vermicompost treated with zinc showed the best in fruit weight of strawberry.

4.16 Total fruit weight

Total fruit weight of strawberry was significantly varied due to the application of different organic fertilizers (Appendix VII). The total fruit weight of strawberry per plant was seen maximum (383.7g) in vermicompost (O_{ver}) that was followed by (339.3g) whereas minimum (286.9g) in control (O_0) (Table 8). Maximum fruit size and large number of fruits was the major reason for higher fruit weight through vermicompost. Atefe *et al.*, (2012) reported that application of vermicompost improved indexes of yield like fruit length, fruit number and fruit weight. Vanmathi and Selvakumari (2012) found maximum fruit weight in *Hibiscus esculentus* through vermicompost application. Vermicompost produced maximum fruit size and more number of fruits in tomato plants (Renuka and Ravishankar, 2001).

Micronutrients revealed effective variation in terms of total fruit weight of strawberry plant (Appendix V). The total fruit weight of strawberry was found maximum (369.9g) in zinc (M_{Zn}) treated plant that was followed (327.5g) by boron (M_B) whereas minimum (291.2g) in control (M_0) (Table 9). Zinc played vital role in increasing number of fruits and fruit weight of strawberry through normal growth and development as it is the component of many essential enzyme and proteins. Similar findings about were found by (Aliraza gurmani *et al.,* 2012, Marschneret *et al.,* 1995).

Combined effect of organic fertilizers and micronutrients also showed significant variation in respect of total fruit weight of strawberry per plant (Appendix V). The total fruit weight of strawberry was found maximum (410.4g) in $O_{ver}M_{Zn}$ treatment where minimum (258.2g) in control O_0M_0 (Table 10). The study implies that vermicompost treated with zinc showed the best in total fruit weight of strawberry.

4.17 Yield/ ha

For the commercial cultivation of strawberry, if strawberry plantlets are planted maintaining plant to plant 15 inches (38.1 cm) and row to row 36 inches (91.44 cm) distance on raised bed which could provide approximately 28735.0 plants/ha (Strik, 1993). Application of organic fertilizers displayed significant differences on strawberry plant in relation to yield per hectare (Appendix VII). Vermicompost (O_{ver}) treated plant yielded maximum (11.0 t/ha) that was followed (9.8 t/ha) by mustard oil cake (O_{moc}) whereas minimum (8.2 t/ha) in control (O_0) (Table 8). Vermicompost is a great source of nutrients and also minimizes the yield loss. Barik *et al.* (2006) reported that vermicompost is not only a great source of nutrients but also contains beneficial microbes like nitrogen fixing bacteria, which protect fruits from reduction by pathogen, physiological disorders and strawberries disease. Similar findings were also found from (Jayakumar and Natarajan, 2012; Singh *et al.,* 2010).

Micronutrients exposed significant variation on the strawberry plant in terms of yield per hectare (Appendix VII). Zinc (M_{Zn}) treated strawberry plant generated maximum yield (10.6 t/ha) that was followed (9.4 t/ha) by boron (M_B) whereas least (8.1 t/ha) in control (M_0) (Table 9). Zinc treated strawberry plant produced maximum and large sized fruits which stimulated better yield. Aliraza gurmani *et. al.* (2012) observed that application of zinc as a micronutrients increased plant growth and fruit yield in tomato plants. Similar findings were also observed from (Chaturvedi *et al.,* 2005).

Combined effect of organic fertilizers and micronutrients also showed the significant variation on strawberry plant in respect of yield per hectare (Appendix VII). The yield of strawberry plant per hectare was found maximum (11.8 t/ha) in $O_{ver}M_{Zn}$ treated plant where minimum (7.4 t/ha) in control O_0M_0 (Table 10). The study implies that vermicompost treated with zinc showed the best combination in relation to yield of strawberry plant per hectare.

Table 8. Effect of organic fertilizers on the growth related attributes of strawberry

Treatments	Number of runners/plant	Number of flower buds/plant	Number of flowers/plant	Number of fruits/plant	Fruit length(cm)	Fruit diameter(mm)	Brix (%)	Single Fruit weight(g)	Total Fruit weight(g/plant)	Yield(t/ha)
O_0	3.9 c	28.6 c	26.6 c	23.8 c	3.6 c	24.9 c	4.2 c	12.0 c	286.9 c	8.2 c
O_{ver}	5.9 a	31.6 a	29.6 a	26.9 a	4.8 a	31.9 a	7.8 a	14.3 a	383.7 a	11.0 a
O_{moc}	5.0 b	30.1 b	28.1 b	25.1 b	4.0 b	30.0 b	7.5 b	13.5 b	339.3 b	9.8 b
$LSD_{0.05}$	0.3	1.4	1.4	1.1	0.3	0.9	0.3	0.7	20.1	0.6
CV%	7.2	5.6	5.9	5.1	7.7	3.5	5.8	6.6	7.1	6.8

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

O_0: Control

O_{ver}: Vermicompost

O_{moc}: Mustard oil cake

Table 9. Effect of micronutrients on the growth related attributes of strawberry

Treatments	Number of runners/plant	Number of flower buds/plant	Number of flowers/plant	Number of fruits/plant	Fruit length(cm)	Fruit diameter(mm)	Brix (%)	Single Fruit weight(g)	Total Fruit weight(g/plant)	Yield(t/ha)
M_0	4.0 c	27.8 c	25.2 c	23.8 c	3.1 c	24.8 c	5.6 c	12.4 c	291.2 c	8.1 c
M_B	5.0 b	29.5 b	27.5 b	24.6 b	3.8 b	29.4 b	6.5 b	13.3 b	327.5 b	9.4 b
M_{Zn}	5.5 a	31.5 a	29.5 a	26.3 a	4.8 a	32.6 a	7.3 a	14.0 a	369.9 a	10.6 a
$LSD_{0.05}$	0.3	1.4	1.4	1.1	0.3	0.9	0.3	0.7	20.1	0.6
CV%	7.2	5.6	5.9	5.1	7.7	3.5	5.8	6.6	7.1	6.8

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

M_0: Control

M_B: Boron

M_{Zn}: Zinc

Table 10. Combined effect of organic fertilizers and micronutrients on the growth related attributes of strawberry

Treatments	Number of runners/plant	Number of flower buds/plant	Number of flowers/plant	Number of fruits/plant	Fruit length(cm)	Fruit diameter(mm)	Brix (%)	Single Fruit weight(g)	Total Fruit weight(g/plant)	Yield(t/ha)
O_0M_0	3.6 e	27.1 d	25.0 d	23.2 d	2.9 e	18.8 f	3.5 g	11.2 d	258.2 e	7.4 d
O_0M_B	4.2 d	28.5 cd	26.5 cd	23.5 d	3.7 d	25.9 e	4.3 f	11.9 cd	279.8 de	8.0 d
O_0M_{Zn}	3.9 de	30.1 bc	28.1 bc	24.8 bcd	4.3 bc	30.1 c	4.7 f	13.0 bc	322.8 c	9.3 c
$O_{ver}M_0$	4.0 de	29.5 bcd	27.5 bc	26.3 ab	4.7 b	27.9 d	6.1 e	14.0 ab	366.3 b	10.6 b
$O_{ver}M_B$	4.9 c	31.5 ab	29.5 ab	26.5 ab	3.9 cd	32.4 b	7.3 cd	14.1 ab	374.3 b	10.8 b
$O_{ver}M_{Zn}$	7.1 a	33.7 a	31.7 a	28.0 a	5.6 a	35.4 a	9.7 a	14.7 a	410.4 a	11.8 a
$O_{moc}M_0$	4.4 cd	31.0 b	29.0 b	25.5 bc	3.5 d	27.6 d	7.0 d	12.2 cd	312.9 cd	9.0 c
$O_{moc}M_B$	6.0 b	28.4 cd	26.4 cd	23.8 cd	3.9 cd	30.1 c	7.9 b	13.8 ab	328.4 c	9.5 c
$O_{moc}M_{Zn}$	4.8 c	30.8 bc	28.8 bc	26.1 b	4.5 b	32.3 b	7.6 bc	14.4 a	376.5 ab	10.8 b
$LSD_{0.05}$	0.5	2.4	2.4	1.9	0.5	1.5	0.5	1.3	34.8	1.0
CV%	7.2	5.6	5.9	5.1	7.7	3.5	5.8	6.6	7.1	6.8

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

O_0: Control — M_0: Control

O_{ver}: Vermicompost — M_B: Boron

O_{moc}: Mustard oil cake — M_{Zn}: Zinc

4.18 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seedling transplanting to harvesting of strawberry were recorded as per plot and converted into cost per hectare. Price of strawberry was considered as per market rate. The economic analysis are presented under the following headings-

- **Gross return**

The combination of different organic fertilizers and micronutrients showed different value in terms of gross return (Table 10). The highest gross return (Tk. 20, 65, 000/ha) was obtained from the treatment combination $O_{ver}M_{Zn}$ and the second highest gross return (Tk. 18, 93, 500/ha) was found in $O_{moc}M_{Zn}$. The lowest gross return (Tk. 12, 95, 000/ha) was obtained from O_0M_0.

- **Net return**

In case of net return, different organic fertilizers and micronutrients showed different levels of net return under the present trial (Table 10). The highest net return (Tk. 11, 86, 195/ha) was found from the treatment combination $O_{ver}M_{Zn}$ and the second highest net return (Tk. 10, 02, 476/ha) was obtained from the combination $O_{ver}M_B$. The lowest (Tk. 4, 48, 983/ha) net return was obtained O_0M_0.

- **Benefit cost ratio**

In the combination of different organic fertilizers and micronutrients the highest benefit cost ratio (2.35) was noted from the $O_{ver}M_{Zn}$ and the second highest benefit cost ratio (2.14) was estimated from the combination of $O_{ver}M_B$. The lowest benefit cost ratio (1.53) was obtained from O_0M_0 (Table 10). From economic point of view, it is apparent from the above results that the combination of $O_{ver}M_{Zn}$ was better than rest of the combination.

Table 11. Cost and return of strawberry production as influenced by different organic fertilizers and micronutrients

Treatments	Cost of production/ha	Yield(t/ha)	Gross return(Tk./ha)	Net return(Tk./ha)	BCR
O_0M_0	846017.3	7.4	1295000	448983	1.53
O_0M_B	847434.1	8.0	1404375	556941	1.66
O_0M_{Zn}	847465	9.3	1627500	780035	1.92
$O_{ver}M_0$	877442.3	10.6	1846250	968808	2.10
$O_{ver}M_B$	878774.1	10.8	1881250	1002476	2.14
$O_{ver}M_{Zn}$	878805	11.8	2065000	1186195	2.35
$O_{moc}M_0$	902324.8	9.0	1575000	672675	1.75
$O_{moc}M_B$	903656.6	9.5	1653750	750093	1.83
$O_{moc}M_{Zn}$	903687.5	10.8	1893500	989813	2.10

Selling cost of strawberry fruit = Tk. 175/ kg

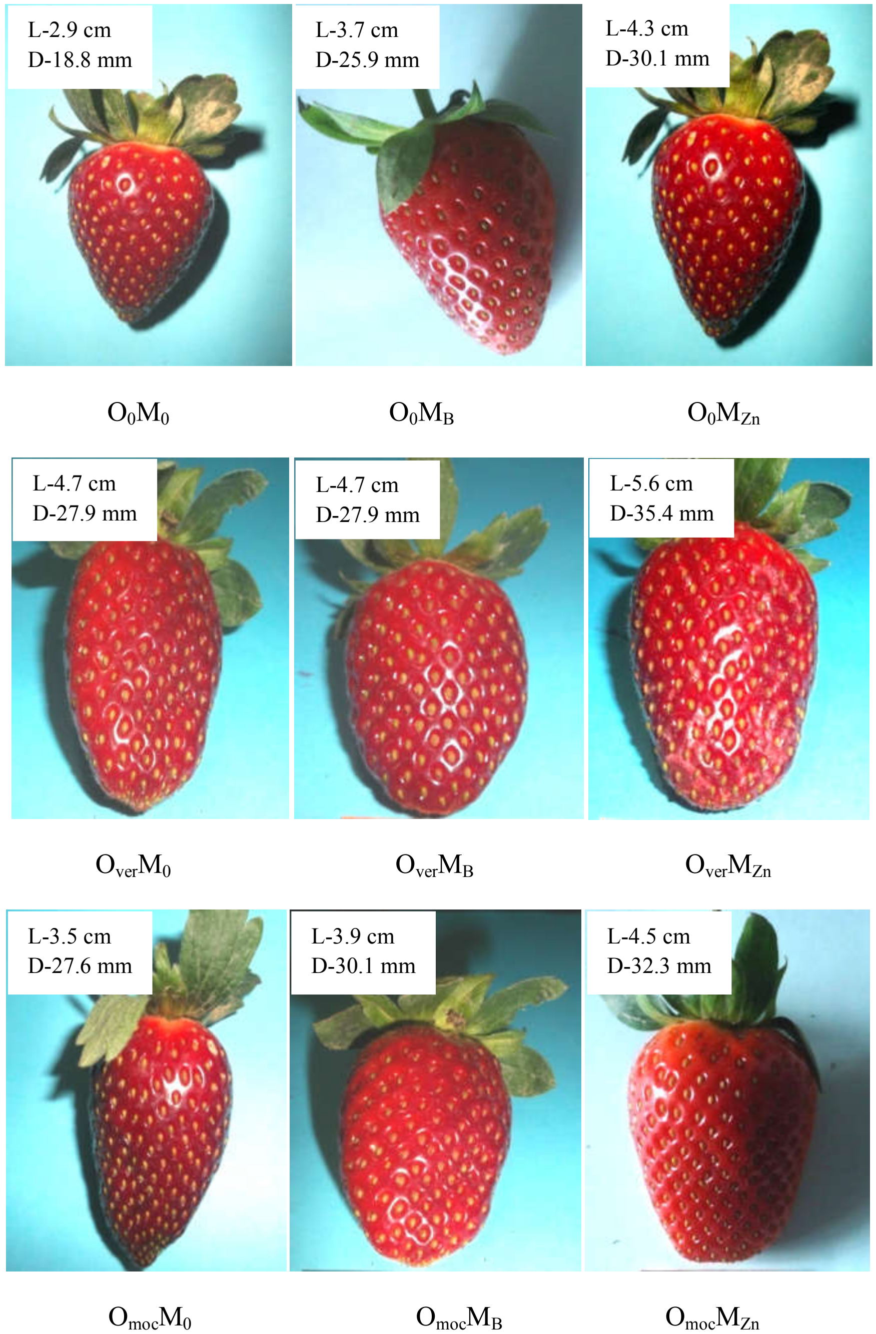

Plate 5: Influence of organic fertilizers and micronutrients on size of strawberry fruit

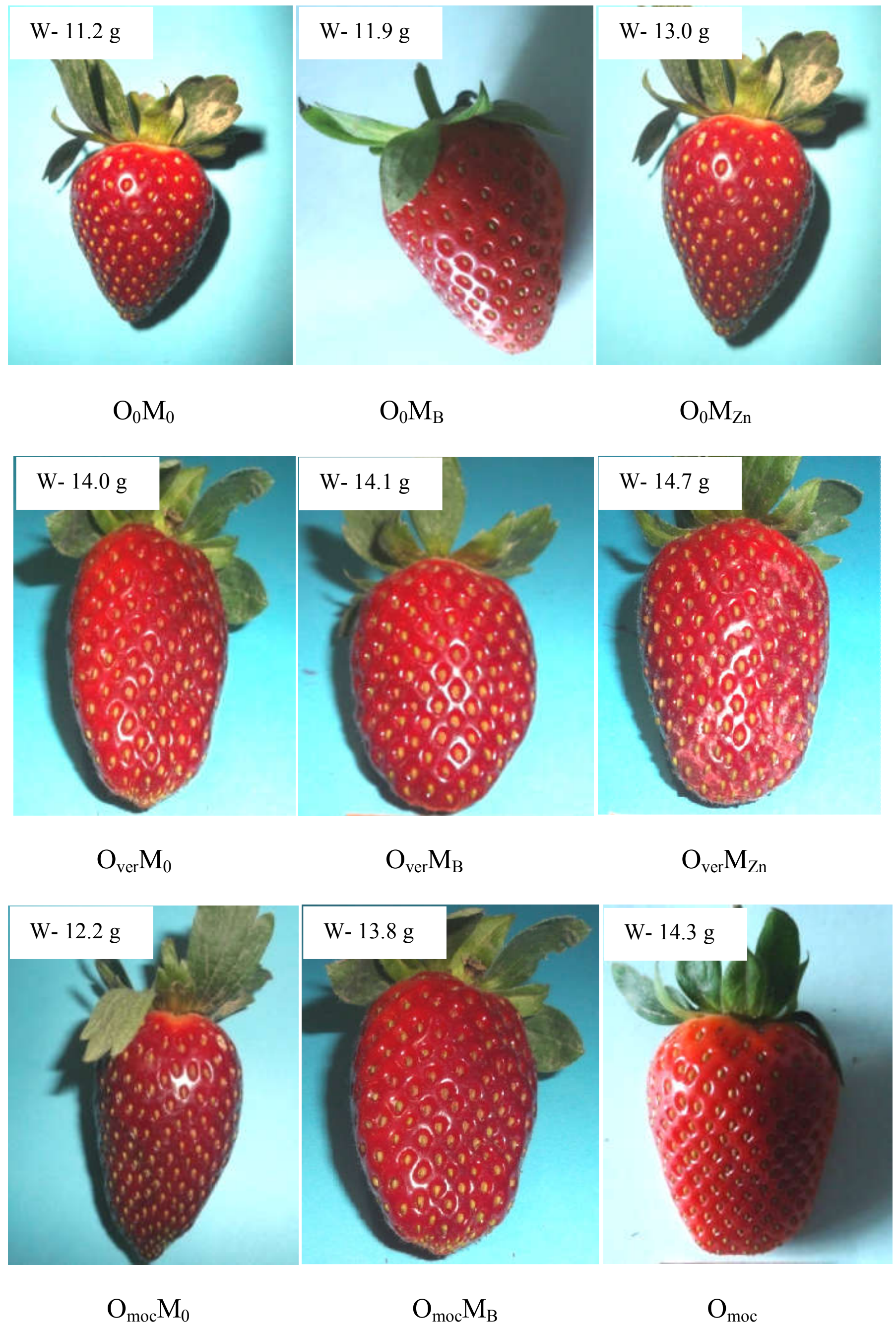

Plate 6: Influence of organic fertilizers and micronutrients on weight of strawberry fruit

CHAPTER V
SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

Strawberry is an important horticultural high value crop. It is one of the most delicious and sweet flavored fruits in the world. Though it is an exotic fruit but it has an opportunity to grow commercially in Bangladesh. But there are lack of information and records which serve as a guideline in the development of technology for profitable production. In order to improve strawberry production, a research was conducted to find out the effect of organic fertilizers and micronutrients on growth and yield of strawberry at horticultural farm, Sher-e-Bangla Agricultural University, Dhaka during the period from May 2014 to April 2015. Two factorial experiment included three levels of organic fertilizers viz. O_0 (Control), O_{ver} (Vermicompost), O_{moc} (Mustard oil cake) and three levels of micronutrients viz. M_0 (Control), M_{Zn} (Zinc), M_B (Boron) was outlined in Randomized Complete Block Design (RCBD) with four replications.

Collected data were statistically analyzed to find out the best organic fertilizer, micronutrient and unification. Summary of the results and conclusion have been described in this chapter.

Monitoring plant height among Organic fertilizers, highest plant height (19.6cm) was found from O_{ver} (vermicompost) while lowest (15.3cm) in O_0 (control) at 60 DAT. On the other hand, zinc (M_{Zn}) provided highest plant height (18.9cm) whereas lowest (16.2cm) from control (M_0) at 60 DAT. In the unification of organic fertilizers and micronutrients, $O_{ver}M_{Zn}$ treatment provided topmost plant height (21.9cm) while lowest (14.0cm) from O_0M_0 at 60 DAT.

Observing number of leaves among Organic fertilizers, maximum number of leaves (19.9) were found from O_{ver} (vermicompost) while minimum (15.2) in O_0 (control) at 60 DAT. On the other hand, zinc (M_{Zn}) provided maximum number of leaves (19.2) whereas minimum (16.2) from control (M_0) at 60 DAT. In combination of organic fertilizers and micronutrients, $O_{ver}M_{Zn}$ treatment provided maximum number of leaves (23.1) while minimum (13.4) from O_0M_0 at 60 DAT.

Noticing leaf area among Organic fertilizers, maximum leaf area (61.6cm^2) was found from O_{ver} (vermicompost) while minimum (53.7cm^2) in O_0 (control) at 60 DAT. On the other hand, Zinc (M_{Zn}) provided maximum leaf area (62.4cm^2) among micronutrients whereas minimum (52.0) from control (M_0) at 60 DAT. In the interaction of organic fertilizers and micronutrients, $O_{ver}M_{Zn}$ treatment provided maximum leaf area (23.1) while minimum (13.4) from O_0M_0 at 60 DAT.

In organic fertilizers treated plant, O_{ver} (vermicompost) had taken shortest period for flowering (39.7 days), fruit setting (46.7 days) and fruit harvesting (67.4 days) whereas O_0 (control) had taken longest period for flowering (44.7days), fruit setting (53.1 days) and fruit harvesting (75.3 days). Regarding on micronutrients, zinc (M_{Zn}) treated plant had taken shortest period for flowering (38.6 days), fruit setting (43.8days) and fruit harvesting (66.2 days) whereas M_0 (control) had taken longest period for flowering (44.9 days), fruit setting (52.4 days) and fruit harvesting (75.2 days). In combination of organic fertilizers and micronutrients, $O_{ver}M_{Zn}$ treated plant had taken shortest period of time for flowering (35.8 days), fruit setting (40.6 days) and fruit harvesting (61.6 days) whereas O_0M_0 had taken longest period of time for flowering (49.1 days), fruit setting (62.8 days) and fruit harvesting (86.4 days).

In the Organic fertilizers treated plant, O_{ver} (vermicompost) procreated maximum numbers of runners (5.9), flower buds (31.6), flowers (29.6/plant) and fruits (26.9/plant) while O_0 (control) generated minimum number of runners (3.9), flower buds (28.6), flowers (26.6/plant) fruits (23.8/plant) at mature stage. In case of Micronutrients treated plant, M_{Zn} (zinc) procreated maximum numbers of runners (5.5), flower buds (31.5), flowers (29.5/plant) and fruits (26.3/plant) while M_0 (control) generated minimum number of runners (4.0), flower buds (27.8), flowers (25.2/plant) and fruits (23.8/plant) at mature stage. In amalgamation of organic fertilizers and micronutrients $O_{ver}M_{Zn}$ treatment procreated paramount number of runners (7.1), flower buds (33.7), flowers (31.7/plant) and fruits (28.0/plant) where minimum number of runners (3.6), flower buds (27.1), flowers (25.0/plant) and fruits (23.2/plant) from O_0M_0 at mature stage.

Observing strawberry plant treated with organic fertilizers, foremost fruit length (4.8cm), fruit diameter (31.9mm) and percentage of brix (7.8) was achieved from O_{ver} (vermicompost) whereas lowest fruit length (3.6cm), fruit diameter (24.9mm) and percentage of brix (4.2) was found from control (O_0). Meanwhile strawberry plant treated with micronutrients, topmost fruit length (4.8cm), fruit diameter (32.6mm) and percentage of brix (7.3) was achieved from M_{Zn} (zinc) whereas minimum fruit length (3.1cm), fruit diameter (24.8mm) and percentage of brix (5.6) was found from control (M_0). In the coalition of organic fertilizers and micronutrients, foremost fruit length (5.6cm), fruit diameter (35.4mm) and brix (9.7%) was achieved from $O_{ver}M_{Zn}$ treated strawberry plant whereas lowest fruit length (2.9cm), fruit diameter (18.8mm) and brix (3.5%) was found from O_0M_0.

Considering strawberry plant treated with organic fertilizers, paramount single fruit weight (14.3g), total fruit weight (383.7g/plant) and yield (11.0 t/ha) was obtained from O_{ver} (vermicompost) while minimum single fruit weight (12.0g), total fruit weight (286.9g/plant) and yield (8.2t/ha) was achieved in control (O_0). On the other hand strawberry plant treated with micronutrients, maximum single fruit weight (14.0g), total fruit weight (369.9g/plant) and yield (10.6 t/ha) was found from M_{zn} (zinc) whereas minimum single fruit weight (12.4g), total fruit weight (291.2g/plant) and yield (8.1t/ha) was gained in control (M_0). In the unification of organic fertilizers and micronutrients, $O_{ver}M_{Zn}$ treated strawberry plant produced highest single fruit weight (14.7g), total fruit weight (410.4g/plant) and yield (11.8 t/ha) while O_0M_0 provided lowest single fruit weight (11.2g), total fruit weight (258.2g/plant) and yield (7.4 t/ha). In the different organic fertilizers and micronutrients, the highest benefit cost ration (2.35) was found from $O_{ver}M_{Zn}$ whereas minimum (1.53) in O_0M_0.

From the economic point of view, it is apparent from the above results that the combination of $O_{ver}M_{Zn}$ was better than rest of the combination.

5.2 Conclusion

Considering the above discussion it may be concluded that

- Among the organic fertilizers, vermicompost (O_{ver}) treated plant showed greatest vegetative growth (plant height, number of leaves, leaf area and runner numbers), early flowering, fruiting and harvesting.
- Besides, number of flowers, fruits, fruit length, fruit diameter, percentage of brix, single fruit weight, total fruit weight/plant and yield/ha were also superior to vermicompost (O_{ver}).
- In case of micronutrients, zinc (M_{Zn}) procreated best performance in respect of all parameters.
- So it can easily enunciate that vermicompost was the excellent organic fertilizers and zinc was the best micronutrients for growth and yield of strawberry.
- Considering the result of the present experiment, further studies might be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances.

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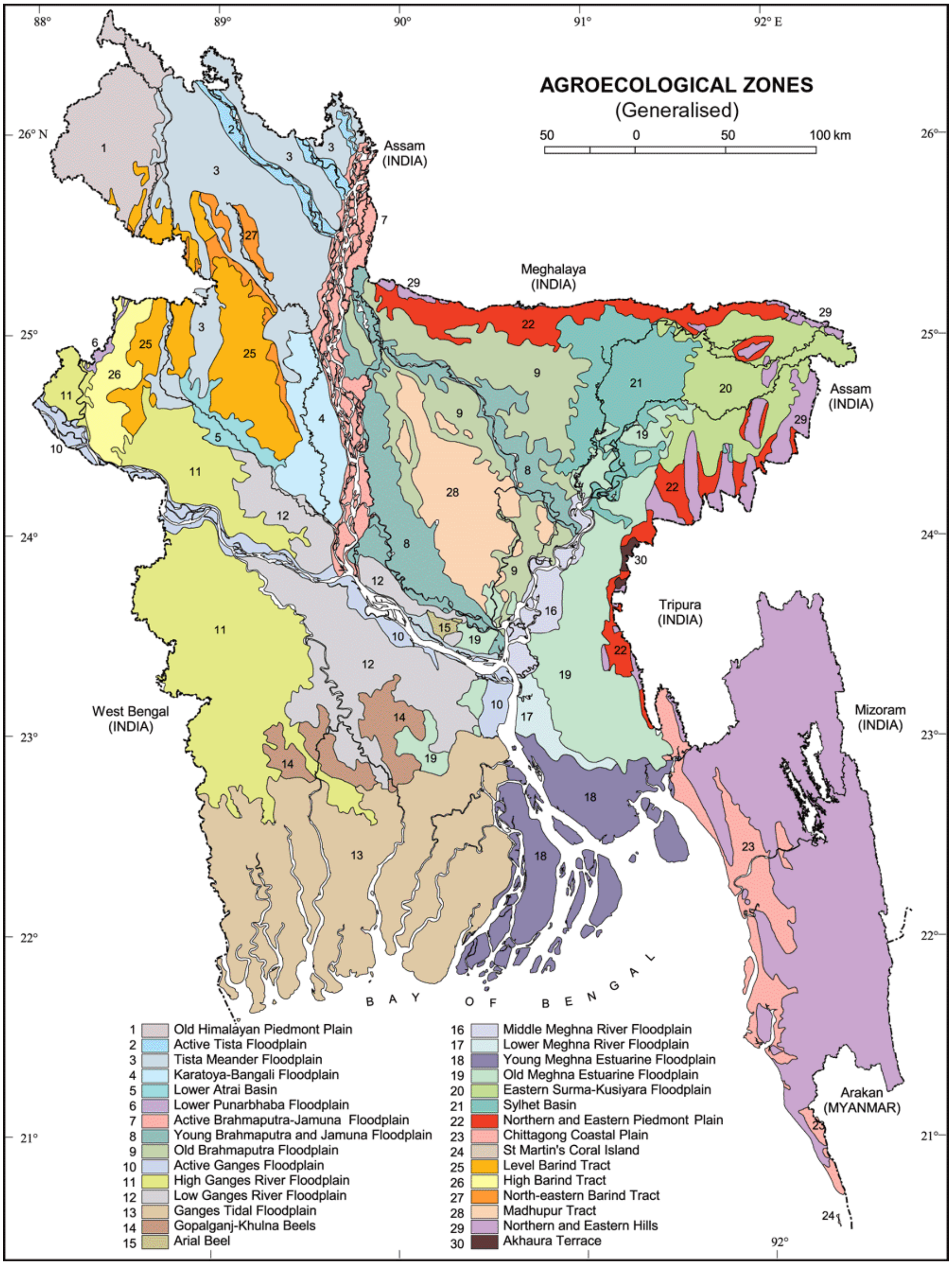
APPENDICES



★ Mark showing experimental land area

Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour at experimental site during the period of experiment in field

Month	*Air temperature (ºc)		*Relative Humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
October, 2014	26.5	19.4	81	22	6.9
November, 2014	25.8	16.0	78	00	6.8
December, 2014	22.4	13.5	74	00	6.3
January, 2015	24.5	12.4	68	00	5.7
February, 2015	27.1	16.7	67	30	6.7
March, 2015	31.4	19.6	54	11	8.2

* Monthly average

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka –1212

Appendix III. Analysis of variances of the data on plant height of strawberry at different days after transplanting

Source of variation	Degrees of Freedom (df)	Mean square for plant height			
		30DAT	40DAT	50DAT	60DAT
Replication	3	1.100	0.254	1.766	1.766
Factor A	2	12.805*	18.938*	56.872*	56.872*
Factor B	2	10.776*	13.227*	10.05*	10.05*
Interaction (A×B)	4	2.74*	1.891*	7.497*	7.497*
Error	24	0.413	0.736	0.917	0.917

*: Significant at 0.05 level of probability

Appendix IV. Analysis of variances of the data on number of leaves of strawberry at different days after transplanting

Source of variation	Degrees of Freedom (df)	Mean square for number of leaves			
		30DAT	40DAT	50DAT	60DAT
Replication	3	0.181	0.481	1.353	1.2421
Factor A	2	16.679*	14.554*	66.648*	66.6*
Factor B	2	11.556*	13.871*	27.358*	27.4*
Interaction (A×B)	4	1.66*	6.603*	8.367*	8.37*
Error	24	0.185	0.203	1.09	1.09

*: Significant at 0.05 level of probability

Appendix V. Analysis of variances of the data on leaf area of strawberry at different days after transplanting

Source of variation	Degrees of Freedom (df)	Mean square for leaf area			
		30DAT	40DAT	50DAT	60DAT
Replication	3	47.426	45.922	10.910	14.051
Factor A	2	541.69*	394.65*	387.23*	355*
Factor B	2	133.02*	192.12*	239.19*	174*
Interaction (A×B)	4	113.02*	164.73*	165.67*	166*
Error	24	7.072	15.402	14.184	5.61

*: Significant at 0.05 level of probability

Appendix VI. Analysis of variances of the data on crop duration related attributes of strawberry

Source of variation	Degrees of freedom (df)	Mean square for crop duration		
		Days to flowering	Days to fruit setting	Days to harvesting
Replication	3	6.666	0.471	23.125
Factor A	2	77.883*	151.81*	209.404*
Factor B	2	95.52*	250.647*	241.363*
Interaction (A×B)	4	36.241*	149.927*	172.947*
Error	24	3.044	4.905	5.321

*: Significant at 0.05 level of probability

Appendix VII. Analysis of variances of the data on growth and yield related attributes of strawberry

Source of variation	Degrees of freedom (df)	Mean square for growth and yield of strawberry									
		Number of runners/plant	Number of flower buds/plant	Number of flowers/plant	Number of fruits/plant	Fruit length	Fruit diameter	Brix	Single fruit weight	Total fruit weight	yield
Replication	3	0.059	397.699	389.332	102.195	0.048	0.552	0.439	13.389	5907.497	7.902
Factor A	2	6.661*	40.23*	27.03*	29.4*	3.891*	156*	47.5*	15.48*	28140*	23.439*
Factor B	2	5.117*	18.86*	19.718*	9.21*	4.324*	186*	9.37*	7.76*	10631*	8.904*
Interaction(A×B)	4	3.832*	20.393*	8.132*	1.43*	0.779*	11.8*	3.09*	0.8*	143.2*	0.133*
Error	24	0.117	1.732	2.711	1.63	0.101	1.03	0.14	0.77	567.3	0.428

*: Significant at 0.05 level of probability

Appendix VIII. Production cost of strawberry per hectare

A. Input cost (Tk. /ha)

Treatment combination	Labour cost	Ploughing cost	Number of plantlets/ha	Cost of plantlets	Nett cost	Water for plant establishment	Manure and fertilizer						Insecticides	Total(A)
							cowdung	urea	TSP	MP	ver/moc	B/Zn		
O_0M_0	25000	15000	28735	632170	30000	3000	12000	2500	1800	1500	0	0	2000	753705
O_0M_B	26000	15000	28735	632170	30000	3000	12000	2500	1800	1500	0	160	2000	754945
O_0M_{Zn}	26000	15000	28735	632170	30000	3000	12000	2500	1800	1500	0	180	2000	754975
$O_{ver}M_0$	28000	15000	28735	632170	30000	3000	12000	2500	1800	1500	25000	0	2000	784705
$O_{ver}M_B$	29000	15000	28735	632170	30000	3000	12000	2500	1800	1500	25000	160	2000	785945
$O_{ver}M_{Zn}$	29000	15000	28735	632170	30000	3000	12000	2500	1800	1500	25000	180	2000	785975
$O_{moc}M_0$	28000	15000	28735	632170	30000	3000	12000	2500	1800	1500	45000	0	2000	809205
$O_{moc}M_B$	29000	15000	28735	632170	30000	3000	12000	2500	1800	1500	45000	160	2000	810445
$O_{moc}M_{Zn}$	29000	15000	28735	632170	30000	3000	12000	2500	1800	1500	45000	180	2000	810475

Purchase cost per seedling = Tk.22/-

Appendix IX. Production cost of strawberry per hectare

B. Overhead cost (Tk. /ha)

Treatment combination	Cost of lease of land (Tk.7% of value of land cost/year)	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 7% of cost/year)	Total (B)	Total cost of production (Tk./ha) [Input cost (A) + overhead cost (B)]
O_0M_0	17500	44007.25	30805.08	92312.33	846017.3
O_0M_B	17500	44111.25	30877.88	92489.13	847434.1
O_0M_{Zn}	17500	44111.75	30878.23	92489.98	847465.0
$O_{ver}M_0$	17500	44257.25	30980.08	92737.33	877442.3
$O_{ver}M_B$	17500	44311.25	31017.88	92829.13	878774.1
$O_{ver}M_{Zn}$	17500	44311.75	31018.23	92829.98	878805.0
$O_{moc}M_0$	17500	44482.25	31137.58	93119.83	902324.8
$O_{moc}M_B$	17500	44536.25	31175.38	93211.63	903656.6
$O_{moc}M_{Zn}$	17500	44536.75	31175.73	93212.48	903687.5