EFFECT OF MANURE AND POTASSIUM ON GROWTH AND YIELD OF TOMATO

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EFFECT OF MANURE AND POTASSIUM ON GROWTH AND YIELD OF TOMATO

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF MANURE AND POTASSIUM ON GROWTH AND YIELD OF TOMATO"** 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 *bonafide* research work carried out by **MD. RAIHAN KAUSER**, Registration No.**09-03549** 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, 2016
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Dedicated To

My Beloved Parents

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The Author

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2015 to March 2016 to find out the effect of different manures and potassium on growth and yield of tomato. The experiment consisted of two factors: Factor A: Three levels of manures. The treatments are M_0: 0 (control), M_1: cowdung 15 t ha^{-1} and M_2: vermicompost 3.75 t ha^{-1}. Factor B: Four levels of potassium. The treatments are K_0: (control); K_1: 200 kg MOP ha^{-1}; K_2: 220 kg MOP $ha^{-1}$and K_3: 240 kg MOP ha^{-1}. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the optimum level of manure and potassium on tomato. In case of manure, maximum yield $hectare^{-1}$ (69.10 t/ha) were recorded from M_2 treatment while the minimum result was from the control. For potassium, the maximum yield $hectare^{-1}$ (69.43 t/ha) were recorded from the K_2 treatment while the minimum from control. Due to interaction effect of manure and potassium application, the maximum yield $hectare^{-1}$ (79.96 t/ha) was recorded from the M_2K_2 treatment combination and the minimum from control. So, it can be concluded that, the combination of 3.75 t/ha vermicompost with 220 kg MOP ha^{-1} is the appropriate practice for tomato production.

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LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
a.i	Active ingredient
Adv.	Advanced
Agron .	Agronomy
Agric.	Agriculture Agricultural
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
RCBD	Randomized Complete Block Design
CV	Coefficient of Variation
cv.	Cultivar
EC	Emulsifiable Concentrate
df	Degrees of Freedom
DAS	Days After Sowing
LSD	Least significance difference
et al.	and others
etc.	etcetera
FAO	Food and Agricultural Organization
ns	Non Significant
J.	Journal

ABBREVIATIONS	ELABORATIONS
NS	Non Significant
Res.	Research
RH	Relative humidity
WCE	Weed control efficiency
SRDI	Soil Resource Development Institute
Sci.	Science 's
HI	Harvest Index
Vol.	Volume

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a solanaceous selfpollinated vegetable crop. It is one of the important, popular and nutritious vegetables grown in Bangladesh in both winter and summer season around all parts of the country (Haque*et al.,* 1999). It was originated in tropical America, particularly in Peru, Ecuador and Bolivia. It is popular for its taste, nutritional status and various uses. Tomato is cultivated all over the country due to its adaptability to wide range of soil and climate (Ahmad, 1976). It ranks third, next to potato and sweet potato, in terms of world vegetable production (FAO, 2015) and tops the list of canned vegetables (Choudhury, 1979). The present leading tomato producing countries of the world are China, United States of America, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (FAO, 2015).

Tomato fruit can be consumed either fresh, cooked or in the form of processed products such as jam, jelly, juice, ketchup, sauce etc. It is considered as 'poor man's apple' because of its attractive appearance and very high nutritive value, containing vitamin A, vitamin C (Thompson and Kelly,1957) and minerals like calcium, potassium etc. Nutritional value of red tomatoes (raw) per 100 g contains 18 kcal energy, 4.0 g carbohydrates, and 2.6 g sugars, 1.0 g dietary fiber, 0.2 g fat, 1.0 g protein, 95 g water, 13 mg vitamin C (Zhang *et al.*, 2009).

Apart from these, it also contains organic acids like citric, malic and aceiticacids which is found in fresh tomato fruit, promotes gastric secretion, acts as a blood purifier and works as intestinal antiseptic (Pruthi, 1993).Tomato is a rich source of lycopene and vitamins. Lycopene may help counteract the harmful effects of substances called free radicals, which are thought to contribute to age-related processes and a number of types of cancer, including, but not limited to, those of prostate, lung, stomach, pancreas, breast, cervex, colorectum, mouth and oesophagus (Masroor *et al.*, 1988).

In Bangladesh, tomato has great demand throughout the year, but its production is mainly concentrated during the winter season. Recent statistics showed that tomato covered 75602 acres of land and the total production was approximately 413610 metric tons (BBS, 2015). Thus, the average yield of 5471kg/acre which is quite low as compared to that of other tomato growing countries of the World (Aditya *et al*., 1997).The low yield of tomato in Bangladesh, however, is not an indication of the low yielding potentiality of this crop, but of the fact that the lower yield may be attributed to a number of reasons viz. unavailability of quality seeds of improved varieties, fertilizer management, disease infestation and improper moisture management.

Fertilizer management is one of the most important factors, which assured crop production. Use of chemical fertilizers in crop production is one of the important causes of environmental pollution. Now-a-days, there is growing awareness among the scientists in various parts of the world regarding the problems of environmental pollution through the use of chemicals in crop production. As an alternative to chemicals, scientists in the developed nations are trying to develop various bio-fertilizers for reducing environmental pollution and for obtaining pollution free crop production, especially vegetables. Use of organic manure in crop production has many advantages over chemical fertilizers.

Organic manure saves the crop plants from adverseenvironment. Organic manure is a source of food for the innumerable number of microorganisms and creatures like earthworm who breaks down these to micronutrients, which are easily absorbed by the plants.Organic manure plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization, improving the physical and physiological properties of soils. Organic manures such as cowdung, vermicompost improves the soil texture, structure, humus, color, aeration, water holding capacity, microbial activity of soil, slow release nutrient which support root development leading to higher growth and yield of tomato plants.

In our country, the soils of most regions have less than 1.5%, some soils even have less than 1% organic matter (BARC, 1997). Organic manure has the largest effect on yield and quality of tomato.The increase in vegetative growth of tomato could be attributed to physiological role of organic manure and its involvement in the metabolism of protein, synthesis of pectin, maintaining the correct water relation within the plant, resynthesis of adenosine triphosphate (ATP) and translocation of sugar at development of the flowering and fruiting stages (Bose and Tripathi, 1996). The improvement in quality parameters of tomato fruit due to organic manure application could be the result of overall growth and development of the crop (Naresh, 2002).

Potassium (K) is a key nutrient for enhancing productivity of vegetable crops and its content in vegetables has significant positive relationship with quality attributes (Bidariand Hebsur 2011).Potassium application increases the flower number, the peduncle length, the fruit set and the number of fruit (Besford and Maw, 1975). Additionally, it is also involved in the enrichment of lycopene contents of tomato fruit through synthesis of pigments or carotenoids (Bedari and Hebsur, 2011). Inside plant, K is found in ionic form only; it is co-factor of many enzymes. Major role of K in plant is osmotic adjustment. Under K deficient conditions, the fruit will be small in size, lack in red color and at early stage. Red color of fruit and ripening disorders closely related with K content of fruit (Perkins-Veazie and Robert, 2003). It is reported that the K application above the optimum level reduces the tomato fruit color disorders (Hartz*et al.,* 1999).Potassium also has significant contribution in photosynthesis, enzyme activation, cell turgor maintenance and ion homeostasis.

Therefore, in accordance with recent agricultural policy to increase yieldvertically andto get early yield and better quality fruit, an attempt was made to study the effects of manure and potassium on plant growth and yield of tomato with the following objectives-

- to find out the appropriate manure and its optimum level for growth and yield of tomato
- to determine the optimum level of potassium for attaining desirable yield of tomato
- to evaluate the suitable combination of manure and potassium for growth and yield of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important vegetables crops grown under field and greenhouse condition, which received much attention to the researchers throughout the world. Among various research works, investigations have been made in various parts of the world to determine the suitable manure and potassium for its successful cultivation. The manure and potassium plays an important role in tomato production. In Bangladesh, there are a little study on the influence of manureand potassium on the growth and yield in tomato. However, the relevant literature on tomato and some other related crops available in these connections have been reviewed here with the hope that this might contribute to the present study.

2.1 Effect of cowdungon growth and yield of tomato

Jagadeesha (2008) conducted a field experiment to study the effect of organic manures and biofertilziers on plant growth, seed yield and quality parameters in tomato. Results of field experiment (kharif 2007) revealed that, application of RDF (60:50:30 kg NPK/ha) + biofertilzier (Azospirillum and P solubilizing bacteria 2.5 kg/ha each) records higher plant height (64.37, 109.50 and 162.33 cm), number of leaves (92.50, 153.33 and 146.50), leaf area (898.05, 4314.31 and 4310.94 cm2) and leaf area index (898.05, 4314.31 and 4310.94 cm2) at 30, 60 and 90 DAT respectively and records lesser days to 50 per cent flowering (38.00) followed by FYM (50%) + vermicompost (50%) + biofertilzier. The application of RDF + biofertilziers records higher seed yield (106.87 kg/ha) followed by FYM (50%) + vermicompost (50%) (101.94 kg/ha) over FYM alone. The seed yield was significantly higher with the application of RDF + biofertilziers was attributed to number of fruits per plant (45.22) number of seeds per fruit (109.45) fruit weight per plant (1280.98 g) and 1000 seed weight (2.84 g).

Grimme*et al.*(2006) conducted a field trial taking well decomposed cowdung along with vermicompost at a range of different concentrations into a soil-less commercial bedding plant container medium, Metro-Mix 360 (MM 360), to evaluate their effects on the growth and yields of tomato in the greenhouse. Four-week-old tomato *(Lycopersiconesculentum)* were transplanted into 100%, 80%, 60%, 40%, 20% or 10%MM360 substituted with 0%, 10%, 20%, 40%, 60%, 80% and 100% well decomposed cowdung and vermicompost. All plants were watered three times weekly with 200 ppm Peters Nutrient Solution from the time of transplanting up to107 days. Tomato grown in potting mixtures containing 40% decomposed cowdung along with vermicomposts and 60% MM360 yielded 45% more fruit weights and had 17% 5greater mean number of fruits than those grown in MM360 only. The mean Heights, number of buds and numbers of flowers of tomatoes grown in potting mixtures containing 10-80% vermicompost although greater did not differ significantly from those of tomatoes grown in MM360. There were no positive correlations between the increase in tomato yields and the amounts of mineral-N and microbial biomass-N in the potting mixtures, or the concentrations of nitrogen in the shoot tissues of tomatoes.

Sangwoo*et al.*(2004) conducted an experiment taking two cowdung based and two plant-residue-based organic amendments to a simple peat-based potting mix were tested over two years for their ability to improve seedling biomass, out-planting success and yield in an organic tomato production system. Uniform, high quality transplants are essential for good field establishment of tomato and field-grown flowers. The health and vigor of these transplants can affect the long-term growth and quality of the harvestable portions. Healthy, vigorous starts will be less susceptible to insects and disease pressure and other streeses. Based upon these findings, excellent quality tomato transplants can be produced using either plant-based or cowdung based organic amendments.

Adediran*et al.* (2003) found that there is need to determine the efficacy of biological waste products in the production of vegetable seedlings. Tomato seeds were sown in the growing media and seedlings were allowed to grow for one month after emergence. Seedling height and stem diameter, plant fresh and dry matter were recorded. The results indicated that the germination of tomato generally increased with time and varied with treatments. The performance of the soilless media was in the order of Hygromix>cowdung. 95% germination was obtained with Hygromix by the first week. The compost on the average produced germination of 60% by three weeks. In the second experiment, each of the composts were added to complement Hygromix at a weight ratio (compost:Hygromix) of 0:1, 1:3, 1:1, 3:1 and 1:0 in 200mL plastic cups.

Ahammad*et al.* (1999) conducted an experiment in Gazipur, Bangladesh, during November 1996 to March 1997 to determine the tomato, cv. Ratan on roof garden. The pots were supplied with different organic residues i.e. cowdung, poultry manure, mustard oil cake and urea at all different treatment combinations. There were significant differences among the treatments with respect to vegetative growth, flowering and fruiting fruit characteristics and yield of grafted tomato. The highest fruit yield per plant (4.41 kg) was obtained in the poultry manure treatment.

Hossain and Majid (1997) conducted field trials to study on the effect of water hyacinth (*Eichlzornia*) compost and cowdung as organic fertilizers on gourds, tomatoes and aubergines near Dhaka. The compost was applied on gourds, tomatoes and aubergines near Dhaka. The compost was applied alone or in a 2:1 mixture with cowdung to the gourds and in a 1:1 mixture with cowdung to tomatoes and aubergines. Gourd yields were highest with 180 kg wet compost added per planting hole tomato yields were higher with mixture than with cowdung alone but aubergine yields were similar in two treatments.

Shaheed (1997) conducted an experiment to investigate the effect of organic manures on yield and quality of grafted tomato. He reported that mustard oil cake (150 g/plot) as an alternative of cowdung and poultry dropping played an important role in increasing the yield of grafted tomato.

Halloran*et al.* (1993) reported that chiken manure along with cowdung (0, 5, 10 and 15 t/ha) was broadcast and incorporated in a Puerto Rican CumulicHaplustoll and N (0, 56, 112 and 168 kg/ha) was applied by fertilization. A significant Olsen available P with chicken manure applications.Chicken manure did not increase tomato yields significantly, but it did increase the number of large and medium fruits.

Rahman (1993) reported that organic residues such as cowdung @15 t/ha in combination with other fertilizer played an important role in respect of growth and fruit yield of tomato.

Babafoly (1989) conducted that poultry manure and cowdung were separated to all other organic residues in terms of growth, vigour and yield of tomato.

Prezotti*et al*. (1988) stated that application of cowdung increased total productivity by 48% and improved the proportion of large fruits in the total yield.

Dumitrescu (1975) from his experiment on cowdung as organic manures of high fertilizing value reported that application of FYM at the rate of 20 t/ha gave higher total yield of tomato.

2.2 Effect of Vermicompost on growth and yield of tomato

Islam *et al.* (2017) conducted an experiment on tomato for yield and quality of fruits using different types of organic and inorganic fertilizers. The fertilization treatments were T1, vermicompost (12 t/ha); T2, compost (10 t/ha); T3,integrated plant nutrient system (IPNS) or mixed fertilizers (organic 2/3 part and inorganic 1/3 part); T4, inorganic fertilizers; and a control (T5). Results showed growth and yield (20.8 t/ha) intomato were higher in the IPNS treatment. A higher number of fruits per plant (73.7) and plant height(73.5 cm) were obtained from mixed fertilizers (organic 2/3 + inorganic 1/3) or IPNS (integrated plant nutrient system) in Roma VF than other treatments. Fruit yield and diameter were found statistically significant.

Hyder*et al*. 2015.Tomato fruit yield was the maximum (4.383 $t \cdot ha^{-1}$) at the application of2.0 t vermicompost ha^{-1} followed by 3.226 $t \cdot ha^{-1}$ where vermicompost was applied @ 1.5 $t \cdot ha^{-1}$. N,P and K content in tomato fruit and plant increased significantly with the application of increasing levels of vermicompost. The highest content of N (3.7%), P (0.67%), K (5.17%) in tomato fruit andN (3.4%), P (0.32%), K (3.2%) in tomato plant respectively were registered with soil application of vermicompost @ 2.0 $t \cdot ha^{-1}$. This study confirms that the vermicompost has a tremendous potential of plant nutrients supply forsustainablecropproduction.

Abafita*et al*. (2014) obtained results from the present research indicated that applied vermicompost especially; at 20% level had significantly improving effects on better growth and development of vermicompost treated tomatoes as they had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields. Low doses of vermicompost (10%) and high doses (40%) produced lower yields of the tomato plants. Generally, the addition of vermicompost led to improve the yield of tomato cultivars as compared to control. Hence, it could be suggested that treated plants, with this vermicompost increased the growth, yield and the above chemical compositions and pH of the soil.

Reshid*et al*. (2014) conducted that a plastic pot set-up with soil was used to determine the effects and efficiency level of vermicompost on the growth and yields of tomatoes (*Solanum lycopersicum* L.). The study was conducted through effect of increasing concentration of Vermicompost (control, 10%, 20%, 30% and 40%w/w) in target plant growth. The present study was carried out on the basis of Randomized Complete Block Design (RCBD) with 5 treatments and 3 replications. The obtained results from the present research indicated that applied vermicompost especially; at 20% level had significantly improving effects on better growth and development of vermicompost treated tomatoes as they had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields. Low doses of vermicompost (10%) and high doses

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Ali *et al.* (2014) conducted an experiment toinvestigate the potential of vermicompost and mustard oil cake leachate asfoliar organic fertilizer with reference to the growth, yield and TSS status ofBARI hybrid tomato 8 and then examined their effects on different parameters.Treatments of the experiment were: No foliar application (T); foliar applicationof leachate from vermicompost (T2) and foliar application of leachate frommustard oil cake (T3). The experimental data revealed that significant increasein growth; yield and TSS on BARI hybrid tomato-8 were observed due to foliarapplication of vermicompost and mustard oil cake. All parameters performedbetter results with the foliar application of the leachate from vermicompostwhich was very close the mustard oil cake. However, maximum number offruit (30.9/plant), yield (14.3 kg/plot) and TSS (4.7%) were found from thefoliar application of leachate from vermicompost which was followed bymustard oil cake (28.4 /plant, 12.7 kg/plot and 4.2% respectively) whereasminimum from control.

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

Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit fasterand higher growth rate with maximum number of leaves, height, stem diameter, leaf lengthand productivity.

Handa *et al.* (2011) Field trials was conducted a field trials where using different fertilizers having equal concentration of nutrients to determine their impact on different growth parameters of tomato plants. Six types of experimental plots were prepared whereT1 was kept as control and five others were treated by different category of fertilizers (T2-Chemical fertilizers, T3-Farm Yard Manure (FYM), T4-Vermicompost, T5 and T6- FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively).The treatment plots (T6) showed 73% better yield of fruits than control, Besides, vermicompost supplemented with N. P. K treated plots (T5) displayed better results with regard to fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches and number of fruits per plant from other fertilizers treated plants.

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

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

Getierrez and Samai(2007) reported that addition of vermicompost increased plant heights and yield of tomato (*Lycopersicum esculentum*) significantly which confirms the results of the their study.

The results increased plant heights and yield observed by Sinha and Valani (2009) that tomato plants on exclusive vermicompost and vermicompost with worms' maintained very good growth from the very beginning. Number of flowers and fruits per plant were also significantly high as compared to those on agrochemicals and conventional compost. Presence of live earthworms in soil made a significant difference on the flowering and fruiting of tomatoes.

Arancon *et al.* (2004) 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 theinorganic fertilizer-treated plots. Leaf areas, number of strawberry suckers, number of flowers, shoot weights and total marketable strawberry yieldsincreased 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.

Arancon *et al.* (2002a) reported significantly increased growth and yields of field tomatoes (*Lycopersicon esculentum*) and peppers (*Capsicum anuumgrossum)* when vermicomposts, produced commercially from cattle manure, food waste or recycled paper, were applied to field plots at rates of 20 t/ha and 10 t/ha in 1999 and at rates of10 t/ha and 5 t/ha in 2000 compared with those receiving equivalent amounts of inorganic fertilizer.

The increased yields of peppers or flowering of marigolds were not associated with the amounts of available mineral-N, nor amounts of microbial biomass, during the later growth and fruiting stages of peppers, marigolds or tomatoes since all plants were provided with needed nutrients (Atiyeh *et al.* 2002; Arancon *et al.* 2005).

Atiyeh *et al.* (2001) reported that the mixtures containing 25% and 50% pig manure in 75% and 25% Metro-Mix 360 increased the rates of seedling growth of tomatoes and greater increases in seedling growth were recorded with 5% pig manure substitution into MM360, when inorganic nutrients were supplied daily.

Atiyeh *et al.* (2000a) experiments showing tomato plants with decreased growth and yields at substitution rates of pig manure vermicomposts greater than 60% into MM360.

Atiyeh *et al.* (2000b) reported that the substitution of Metro-Mix 360 by 10% or 50% pig manure vermicompost increased the dry weights of tomato seedlings significantly compared to those grown in 100% Metro-Mix 360. The largest marketable fruit yields obtained were in response to a mixture of 80% Metro-Mix 360 and 20% vermicompost. Lower concentrations of vermicomposts (less than 50%) into the MM360 usually produced greater growth effects than those of large amounts: 20%vermicompost substitution resulted in 12.4% more tomato fruit weights than those in MM360 and substitutions of 10%, 20% and 40% vermicompost reduced the proportions of non-marketable fruits significantly and produced larger tomato fruits.

Kolte *et al*. (1999) reported that the Vermicompost applications to field soils combined with 50% of the recommended inorganic fertilizers increased the yields of tomatoes.

Patil *et al.* (1998) reported that the lower application rate of 2t/ha vermicomposts plus recommended amounts of inorganic fertilizers, increased tomato yields to a level similar to those of tomatoes in soils treated with 4 t/ha vermicomposts and 50% of the recommended rates of inorganic fertilizers.

Ghosh*et al.* (1999) observed that the effect of different fertilizers showed significant increase of the fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches, number of fruits and yields in terms of fruit production in all the treatments in comparison to controlled one. The yield of vermicompost treated plants was found to be 28,665 Kg/hectare, which was 47% more than the plants in control plots and was very nearer to inorganic fertilizer treated plants (Kg/hectare). This result was statistically significant at 1% level. It was also observed that the plants treated with vermicompost supplemented with chemical fertilizers displayed better results than the plants treated separately with vermicompost, chemical fertilizers, F.Y.M and F.Y.M. supplemented with chemical fertilizers treated plants. In this field trial experiment, it was observed that the plants treated with vermicompost supplemented with chemical fertilizers displayed better results than the plants treated separately with vermicompost, chemical fertilizer, F.Y.M and F.Y.M supplemented with chemical fertilizers treated plant.

Buckerfield *et al.* (1999) reported that vermicompost applications inhibited germination initially, but subsequently weekly applications of the diluted extracts improved plant growth and increased tomato yields significantly by up to 20%.

The growth of tomatoes, lettuces, and peppers were reported to be best at substitution into soils at rates of 8-10%, 8%, and 6%, respectively, using duck waste vermicompost and peat mixture (Wilson and Carlile, 1989).

Subler *et al.* (1998) reported increased plant growth in commercial media, Metro-Mix (MM360), with a range of vermicomposts of substituted compared to growth in traditional composts from biosolids and yard waste traditional composts using tomatoes and marigolds as test plants. Aiso increased significant increases in tomato seedling weights after substitution of 10 % and 20% vermicompost into MM360.

Kale, (1998) found that the nutrient level, especially the (macro or micro-nutrients) were found to be always higher than the compost derived from other methods. One of the unique features of vermicompost is that during the process of conversion of various organic wastes by earthworms, many of the nutrients are changed to their available forms in order to make them easily utilizable by plants.

Azarmi (1996) studied on tomato (*Lycopersicum esculentum* var. Super Beta) and the results of their study supported the findings of that vermicompost has positive effect on growth, yield and elemental contents of plant as compared to control. Chand *et al*., (2008) experimented on tomato plants to find out the effect of natural fertilizers on their yield and quality .They found that significantly highest yield was recorded in the treatment receiving enriched vermicompost along with 3 sprays of liquid manure.

Tomati and Galli, (1995); Edwards*et al.(*1998) observed that plant's response to vermicompost showed much better results than any other commercial potting or rooting media. Vermicompost can also influence a number of physical, biological and chemical processes of soil which have their bearings on plant's growth. In the present research, it was found that only organic fertilizer treated tomato plants (F. Y. M; Vermicompost) showed more branching than chemical fertilizer treated plants, but overall stem lengths were higher in chemically treated plants. An interesting result was that organic fertilizer supplemented with chemical fertilizer treated plants (F. Y. M supplemented with chemical fertilizers and - Vermicompost supplemented with chemical fertilizers) exhibited better results than the plants treated separately with different fertilizers treated plants (inorganic, T3- F.Y.M and Vermicompost). It hasbeen reported that N. P. K of organic manure require more time for their utilization by plants because of slow releasing of N.P.K. Many hybrid varieties have very high demand for the nutrients. These high demands for chemical fertilizer meets nutrients whereas organic manure initially form conducive environment with regard to physical parameters of soil which promote better root growth and other vegetative growth. It is assured that other factors, such as the presence of beneficial microorganisms or biologically active plant growth influencing substances such as phytohormone are released by beneficial microorganisms present in the vermicompost rich soil.

Buchanan *et al.* (1988) conduct to determine vermicomposts have higher level of available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous and soluble potassium, calcium and magnesium derived from the wastes. That attempted to evaluate comparative efficacies of vermicompost developed by indigenous method on tomato plants.

Edwards and Burrows (1988) reported that the experiments that we have described here, the addition of pig waste vermicompost consistently outperformed the addition of most of the composts, with theexception of biosolids compost, and other vermicomposts that we have investigated interms of its ability to enhance plant growth. Incorporation of 10 % or 20 % vermicomposted pig solids into a standardcommercial horticultural potting medium (Metro-Mix 360) enhanced the growth of marigold and tomato seedlings significantly as compared to the Metro-Mix 36 alone, even when all required mineral nutrients were supplied.

Gallardo-Lara and Nogales (1987) results in a reduced plant growth as compared to that in media with vermicomposted pig wastes. The improvements in plant growth could also be due to differences in the mineral element contents of the substrates, vermicomposts, and composts. Vermicomposted pig solids contained large concentrations of nitrates, thus increasing plant growth significantly to a level comparable to that of fertilized soil in the raspberry study. Composted biosolids also contained high levels of ammonium, resulting in a large increase in the growth of tomato plants.

Grappelli *et al. (*1985) observed that integration of vermicompost with inorganic fertilizers tended to increase the yield of crops viz-tomato, potato, rape seed, mulberry andmarigold over other traditional composts.

Wirwille and Mitchil (1950) observed that stem elongation, dwarfing and early flowering have been found to be because of the hormone effect in a wide variety of plants and in a number of physiological situations, stem elongation is promoted (or inhibited) by endogenous phytohormones, a class of growth regulating substances which inhibited stem elongation without affecting leaf or flower development (dwarfing agents). Plant and crop physiologists, microbiologists and agronomists agree that plant growth and development are strictly dependent on biological fertility factors. Earthworms stimulate microbial activities and metabolism and also influence microbial populations.

2.3 Effect of potassium on the growth and yield of tomato

Afzal *et al.* (2015) conducted an experiment to investigate the specificcontribution of potassium to yield and quality of tomato, a field experimentwas conducted on two tomato cultivars, Nagina and Roma. Foliar applicationwith varying levels (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0%) ofpotassium solutions was applied to the plants and compared with control(without K). Exogenous application of 0.6% K significantly improved plantheight, lycopene content, potassium, fruit weight and diameter. Exogenous application of 0.5, 0.6 and 0.7% K maximally improved ascorbic acid contentsof both tomato cultivars whereas 0.4 and 0.8% did not improve ascorbic acid contents. Due to positive correlation between K nutrition and fruit quality attributes, exogenous application of an appropriate K level can contribute tohigher yield and better quality of tomato fruits. Among all potassium levels,0.5–0.7% K maximally improved performance of tomato plants of both cultivars.

Ahmad *et al.* (2015) found the highest yield (23.3 t ha^{-1}), firmness (8.32 kg), fruit weight (83.24 g $fruit^{-1}$), total invert sugars (4.11 %), dry matter (6.33 %) and mineral matter (1.95 %) were recorded with the application of 120 kg ha^{-1} potassium at transplanting while the highest values of acidity (0.81%) , TSS (7.03 %) and ascorbic acid (30.33 mg 100 g^{-1}) were observed in treatment where potassium was applied @ 60 kg ha^{-1} in two splits.

Javaria *et al*. (2012) conducted a pot experiment which included six potassium fertilizer treatments (75, 150, 225, 300, 375, 450 Kg K_2O ha^{-1}) with basal doses of N and P (100 Kg and 80 Kg ha^{-1}, respectively). All potassium treatments significantly increased yield characteristics as well as post harvest quality of tomato fruit compared with untreated one (control). However, Treatment (NP+450 K_2O Kg ha^{-1}) surpassed all the other treatments in term of yield parameters. Potassium application significantly increased number of flowers $plant^{-1}$, fruit setting rate, number of truss $plant^{-1}$, fruits $plant^{-1}$ and yield ha^{-1}.

Iqbal*et al.* (2011) conducted an experiment to study the effect of N and K doses(60, 90 and 120kg ha^{-1} N and 90 kg, 110kg, 130kg of K) on growth,economical yield and yield components of tomato under the agro-climaticconditions of Swat. The parameters selected under study i.e plant height at flowering stage, days to flowering, days to maturity, number of primarybranches per plant, fruit length, fruit width, number of fruits per plant and total yield were significantly affected by the applications of N and K. The maximum days to flowering (52) in 0kg N and 110kg of K, maximum days to maturity(85.67) were taken when was obtained with the application of 120kg N and130kg ha^{-1} of K was applied. Maximum fruit length (5.96cm) was noted in 0kg of N and 130kg/N of K, while maximum fruit diameter (5.08cm) was noted when plants received 120kg N and 90kg K. in treatment 14 (120kg N and 90kg ha^{-1} of K), Economical yield (19 ton ha^{-1}) was obtained with 60kgN and130kg ha^{-1} of potassium.

Ehsan *et al.* (2010) conducted a field experiment to evaluate comparative effects of sulphate and muriate of potash (SOP and MOP) application on yield, chemical composition and quality of tomato (*Lycopersicon esculentum* M. cultivar Roma) at National Agricultural Research Centre Islamabad, Pakistan. Potassium from two sources i.e., MOP and SOP was applied @ 0, 100 and 200kg K ha^{-1} with constant dose of 200 kg N ha^{-1} and 65 kg P ha^{-1}. A significant increase in tomato yield with K application was observed. Potassium applied @100 kg K ha-1 as MOP produced significantly higher marketable tomatoes ascompared to SOP and control. Vitamin C contents in tomato fruits increasedwith K application in the form of MOP. The K use as MOP significantly reduced incidence of leaf blight disease and insect pest attack in tomato plantas compared to SOP and control treatments.

Harneet *et al.* (2004) had undertaken in Punjab, India during 2000-01 to study the effect of nitrogen and potassium application on the growth, yield and quality of spring crop of tomato cv. Punjab Upma. Treatments consisted of 16 combinations of 4 levels each of N (100, 140, 180, 220 kg/ha) and K (40, 60, 80, 100 kg/ha). Increasing the N level from 100 to 140 kg/ha and the K level from 40 to 60 kg/ha significantly increased marketable and total yields. Significant increase in juice content, ascorbic acid content, N and K concentrations in leaves was observed when the N level increased from 100 to 140 kg/ha. There was also a significant increase in the concentration of K in leaves when K level was increased from 40 to 60 kg/ha.

Gent (2004) determined if the yield of greenhouse tomato benefit from supplemental nitrogen (N) and potassium (K) supplied in amounts greater than that taken up by the plants, the yield and fruit and leaf tissue composition were compared for tomato plants grown in rock wool medium and supplied with sufficient N and K, or with N and/or K supply increased by approximately 30% over the control. In 1999, supplemental N in the form of NH_4NO_3 decreased yield, a trend that became more obvious as the season progressed. The K supply had no significant effect. In 2000, supplemental N in the form of $Mg(NO_3)_2$ increased early yield and fruit size. This effect disappeared later in the season. The different response to supplemental N in the two years may be due to the effect of the form of N supplied on vegetative tissue. NH_4NO_3 supplement increased N in leaf or petiole tissue more than the $Mg(NO_3)_2$ supplement. Supplemental N did not affect the composition of the fruit. Supplemental K increased N and K in leaf or petiole tissue. It did not affect K in fruit tissue but decrease Ca in fruit tissue in 1999.

Liu *et al*. (2004) conducted in a solar greenhouse using tomato cv. Zhongza 9 to investigate the light and temperature in the greenhouse, and the distribution of N, P and K in soil culture in winter-spring and autumn-winter crops. The distribution of total N, P and K was affected by light and temperature condition in the greenhouse. Both in winter-spring and autumn-winter crops, the distribution trend of total N, P and K was the same as that of dry material: mainly distributed in the stem and leaves before fruit formation stage, and in the fruits during fruit formation stage. In autumn-winter crop, because of the abominable light and temperature condition, the distributing proportion of N, P and K in early and middle stages of picking was higher than that in winter-spring crop. The total proportion changed with different elements and growth stages.

Chandra*et al.* (2003) conducted to the effects of N:P:K rate (200:100:150, 350:200:250 or 500:300:350 kg/ha) on the performance of 4 indeterminate tomato hybrids (Rakshita, Karnataka, Naveen and Sun 7611) were studied in a multi-span greenhouse during 2000-2001 and 2001-2002. In both years, Karnataka registered the greatest fruit diameter (6.97 and 6.98 cm), average fruit weight (83.28 and 83.88 g), fruit yield (2.85 and 3.07 kg/plant), calculated yield (8.55 and 9.21 kg/m^2), juice content (58.84 and 62.43%), gross income (94.05 and 101.31 rupees/m^2), net income (17.38 and 24.64 rupees/m2) and benefit:cost ratio (1.23 and 1.32), and the lowest cost of cultivation (76.67 rupees/m^2 in each year). Rakshita exhibited the greatest pulp content (77.46 and 78.73%), total soluble solids (6.07 and 6.27%) and shelf life (6.40 and 6.50 days). Among the fertilizer levels, N:P:K at 350:200:250 kg/ha was superior in terms of fruit diameter, average fruit weight, yield, gross income and benefit:cost ratio. The number of fruits per plant increased with the increase in the rate of NPK. The quality parameters were not significantly affected by the NPK level in both years.

Khalil *et al.* (2001) study was undertaken in Peshawar, Pakistan in the summer of 1995-96 to determine the appropriate nitrogen fertilizer for maximum tomato (cv. Peshawar Local) yield and its effects on various agronomic characters of tomato. Treatments comprised: untreated control; 150 kg ammonium nitrate/ha; 150 kg ammonium nitrate/ha + 100 kg P/ha + 50 kg K/ha; 150 kg ammonium sulfate; 150 kg ammonium sulfate/ha + 100 kg P/ha + 50 kg K/ha; 150 kg urea/ha; 150 kg urea/ha + 100 kg P/ha + 50 kg K/ha. Generally, ammonium sulfate fertilizer was the most efficient source of nitrogen for tomato production, followed by urea and ammonium nitrate. The ammonium sulfate + P + K treatment was the best among all treatments with respect to days to flower initiation (57 days), days to first picking (94 days), weight of individual fruit (50.8 g), weight of total fruits per plant (1990 g) and yield (21865 kg/ha). The control resulted in the significantly lowest response with respect to different agronomic characters under study.

Sun-Hong Mei *et al.* (2001) to the effect of K deficiency on the incidence of brown blotches in ripening fruits of tomatoes was investigated. K deficiency was associated with the occurrence of brown blotches, with more blotches observed in plants experiencing longer periods of K deficiency. Yield was reduced in K-deficient plants.

Ravinder *et al.* (2000) In experiments at Solan in 1996 and 1997, eight tomato hybrids (Meenakashi, Manisha, Menka, SolanSagun, FT-5XEC-174023, EC-174023XEC-174041, Rachna and Naveen) were treated with four NPK combinations (100:75:55; 150:112.5:82.5; 200:150:110; 250:187.5:137.5 kg $N:P_2O_5:K_2O$ ha^{-1}). The number of marketable fruits per plant and yield per plant were highest in Menka followed by Manisha. Of the fertilizers treatments, 200:150:110 kg $N:P_2O_5:K_2O$ ha^{-1} produced the highest yields.

Hartz *et al.* (1999) A survey of 140 processing tomato fields in central California was conducted in 1996-97 to examine the relationship between K nutrition and fruit quality for processing. Quality parameters evaluated were soluble solids (SS), pH, colour of a blended juice sample, and the percentage of fruits affected by the colour disorders yellow shoulder (YS) or internal white tissue (IWT). Juice colour and pH were not correlated with soil K availability or plant K status. SS was correlated with both soil exchangeable K and midseason leaf K concentration, but the regression relationships suggested that the impact of soil or plant K status on fruit SS was minor.

A fertilizer trail was conducted by Pansare *et al*. (1994) to find out the effect of different N, P and K on yield and quality of tomato. They found that the maximum yield of high quality tomatoes were obtained when straight fertilizers was added in the N, P, K ratio of 3:1:2 (150 kg N/ha, 50 kg P_2O_5/ha, 100 kg K_2O/ha).

Cerne and Briski (1993) conducted field trials on the fertilizer and irrigation requirement of tomato cv. Rutgers plants where 250 kg N and 72 kg P_2O_5/haplants 200 or 400 kg K_2O/ha in the first year, 0 or 200 kg K_20/ha in the second year, 0 or 40 t ; stable manure/ha were applied in all treatments. The combination of 400 kg K_2O/ha stable manure and irrigation gave the highest total yield in the 1st and 2nd years (1.03and 2.25 kg/plant respectively).

Silva and Vizzotto (1990) conducted field trail with the cultivar Angela Gigante 1-5, 100, the plants received N: P_2O_5: K_2O at 30-180; 75-450:30-180 kg/ha plus poultry manure at 0, 10 or 20 t/ha. The largest fruits and the highest yields (53 t/ha) were obtained by applying N: P_2O_5: K_2O at 104:259:140 kg/ha plus poultry manure at 20 t/ha.

Ahmed and Saha (1986) studied the effect of different levels of N, P and K as the growth and yield of four tomato varieties. They apply N at 35, 65 or 85 kg/ha, P_2O_5 at 65, 95 or 115 kg/ha and K_2O at 25, 35 or 45 kg/ha to the four cultivars. All cultivars gave the highest yield at the highest NPK rates namely, 44.78-52.0, 41.78-46.67, If 35.55-41.0 and 31.88-36.33 t/ha in Bikash. Tushti, Roma V. F and Asha-4, respectively.

Gupta *et al.* (1978) observed the effect of NPK on plant height, earliness, fruit size, and TSS and acidity contents. They found that tomato cvs H.S.101 and Sioun responded best in respect of yield to 75 kg N/ha and the cv. Pusa Ruby to 150 kg N/ha. All three cultivars responded to 60 kg P_2O_5 compared with nil P (control) but in the case of K: only Pusa Ruby responded to 60 kg K_2O/ha; in the other two cvs, the yield was depressed by the application of K.

Murphy *et al.* (1964) found that applicationsof potassium increased plant height by up to 65%on a sandy loam,, but the responses are correspondingly smaller on soils with greater reserves of potassium.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October, 2015 to March, 2016 to study theinfluence of different manures on growth and yield of five tomato germpalsms. This chapter includes materials and methods that were used in conducting the experiment and presented below under the following headings:

3.1 Location of the experimental field

The experiment was conducted at Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October 2015 to March 2016. The location of the experimental site was at $23^{0}46^{'}$ N latitude and $90^{0}22^{'}$ E longitudes with an elevation of 8.24 meter from sea level.

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of May to September and scattered rainfall during the rest of the year. Information regarding average monthly temperature as recorded by Bangladesh Meteorological Department (climate division) during the period of study has been presented in Appendix I.

3.3. Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8-6.5, ECE-25.28 (Haider, 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Plant materials collection

The tomato variety used in the experiment was "BARI Tomato-14". This is a high yielding indeterminate type variety. The seeds were collected from Olericulture division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) Joydebpur, Gazipur.

3.5. Raising of seedlings

Tomato seedlings were raised in two seedbeds of 2 m x 1m size. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed and 5 kg well rotten cow dung was mixed with the soil. Five (5) gram of tomato seeds was shown on each seedbed on 25October 2015. After sowing, seeds were covered with light soil. The emergence of the seedlings took place within 6 to 7 days after sowing. Weeding, mulching and irrigation were done as and when required.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A: Two types of manure

M_0 = Control (No manure)

M_1 = Cowdung (15 t ha^{-1})

M_2 = Vermicompost (3.75t ha^{-1})

Factor B: Four levels of potassium

K_0 = Control (No potassium application)

K_1 = 200 kgMOP ha^{-1}

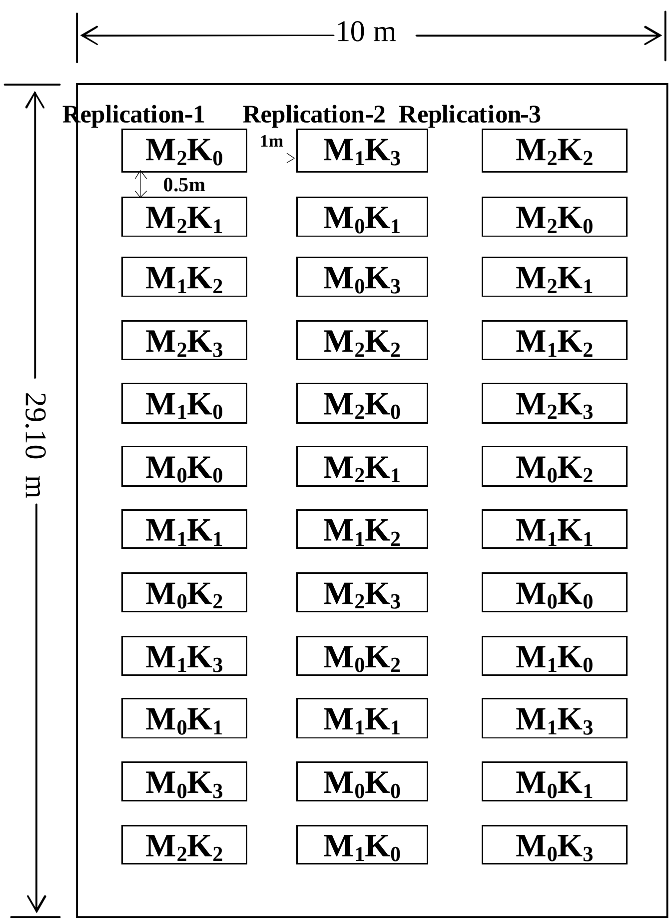
K_2 = 220 kg MOPha^{-1}

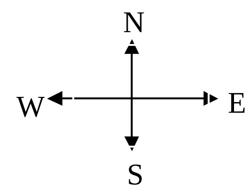
K_3 = 240 kg MOPha^{-1}

There were altogether 12 treatments combination used in each block.

3.7 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 29.1 m x 10 m was divided into three equal blocks. Each block was consists of 12 plots where 12 treatments were allotted randomly.There were 36 unit plots in the experiment. The size of each plot was 1.8 m x 2 m. The distance between two blocks and two plots were kept 1 m and 0.5 m respectively. A layout of the experiment has been shown in fig1.





Plot size: 2 m x 1.8 m
Spacing: 60 cm x 50 cm
Spacing between plots: 0.50 m
Spacing between replication: 1 m

Factor A : Manure

M_0 : Control (no manure)
M_1 :Cowdung 15 t ha^{-1}
M_2 :Vermicompost3.75 t ha^{-1}

Factor B : Potassium

P_0 : Control (potassium)
P_1 : 200 kg MOP ha^{-1}
P_2:220 kg MOP ha^{-1}
P_3:240 kg MOP ha^{-1}

Fig 1: Field layout of the experimental plot

3.8 Cultivation procedure

3.8.1Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The land of the experimental field was ploughed with a power tiller on 10 October, 2015. Later on the land was ploughed three times followed by laddering to obtain until desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was made ready. The field layout and design was followed after land preparation.

3.8.2 Manures and fertilizers and its methods of application

Fertilizer	Quantity	Application method
Cow dung	As per treatment	Basal dose
Vermicompost	As per treatment	Basal dose
Urea	400kg/ha	20,30 and 40 Days after transplanting (DAT)
TSP	300 kg/ha	Basal dose
MOP	As per treatment	20,30 and 40 DAT mixed with urea

Rashid (1999).

According to Rashid (1999),the entire amount of cowdung, vermicompost as per treatment and TSP were applied as basal dose during land preparation. Potassium was applied as per treatment and Urea and TSP was applied at the rate of 400 kg/ha and 300 kg/ha respectively. Urea and MoP were used as top dressing in equal splits at 20, 30 and 40 days after transplanting.

3.8.3Transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in 20 November, 2015 maintaining a spacing of 60 cm x 50 cm between the rows and plants, respectively. This allowed an accommodation of 12 plants in each plot. The seedbed was watered before uprooting the seedlings from the seedbed so as to minimize damage to the roots. The seedlings were watered after transplanting. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.8.4. Intercultural operations

After transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants, which are as follows:

3.8.4.1Gap filling

When the seedlings were well established, the soil around the base of each seedling was pulverized. A few gaps filling was done by healthy seedlings of the same stock where initial planted seedling failed to survive.

3.8.4.2Weeding

Numbers of weeding were accomplished as and whenever necessary to keep the crop free from weeds.

3.8.4.3Staking

When the plants were well established, staking was given to each plant by rope and plastic wire to keep them erect. Within a few days of staking, as the plants grew up, other cultural operations were carried out.

3.8.4.4Irrigation

Number of irrigation was given throughout the growing period by garden pipe and watering cane. The first irrigation was given immediate after the transplantation where as other were applied when and when required depending upon the condition of soil.

3.8.5.5 Plant protection

From seedling to harvesting stage i.e. any stage, tomato is very sensitive to diseases and pest. After getting a maturity stage protection measure was taken against diseases and pests. So that, any insect or fungal infection and insect infestation cannot appear in the plant.

3.8.4.6 Insect pests

Bavistin 50 WP and Ripcord 10 EC were applied @ 10 ml/L against the fungal diseases, leaf curl disease and insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly for a week after transplanting to two weeks before first harvesting.

3.9 Harvesting

Fruits were harvested at 7 to 8 days intervals during early ripe stage when they attained slightly red color. Harvesting was started from 8 February, 2016 and was continued up to end of 20 March, 2016.

3.10 Data collection

Six plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

3.10.1 Plant height

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants was recorded at 10 days interval starting from 20 days of planting up to 60 days to observe the plant height. The average height was computed and expressed in centimeter.

3.10.2 Number of leaves per plant

The number of leaves per plant was manually counted at 20, 30, 40, 50 and 60 days after transplanting from randomly selected tagged plants. The average of six plants were computed and expressed in average number of leaves per plant.

3.10.3 Number of branches per plant

The number of branches per plant was manually counted at 20, 30, 40, 50 and 60 days after transplanting from randomly selected tagged plants. The average of six plants were computed and expressed in average number of branch per plant.

3.10.4 Canopy size of the plant

The canopy size of the plant was manually counted at 20, 30, 40, 50 and 60 days after transplanting from randomly selected tagged plants. The average of six plants were computed and expressed in average canopy size of the plant.

3.10.5 Stem diameter of the plant

The stem diameter of the plant was manually measured by slide calipers at 20, 30, 40, 50 and 60 days after transplanting from tagged plants. The average of six plants were measured and expressed in average stem diameter of the plant.

3.10.6 Number of flower clusters per plant

The number of flower clusters was counted at 50 and 60 days after transplanting from the 6 sample plants and the average number of clusters produced per plant was recorded.

3.10.7 Number of flowers per cluster

The number of flowers per cluster was counted at 50 and 60 days after transplanting from the 6 sample plants. From each plant randomly five clusters were selected and counted the number of flowers per cluster to make an average value for one plant. The final average value of number of flowers per cluster was calculated from 6 random plants.

3.10.8 Number of fruits per cluster

The number of fruits per cluster was counted at 60 DAT and harvesting time from random selected 6 plants. From each plant randomly five clusters were selected and counted the number of fruits per cluster to make an average value for one plant. The final average value of number of fruits per cluster was calculated from 6 averages from six plants.

3.10.9 Length of fruit

Among the total number of fruit harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the length of fruit by slide calipers. The length of fruit was calculated by making the average of five fruits from each of the six plants.

3.10.10 Diameter of fruit

Among the total number of fruits harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the diameter of fruit by slide calipers. The diameter of fruit was calculated by making the average of five fruits from each of the six plants.

3.10.11 Fresh weight of individual fruit

Among the total number of fruit harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the individual fruit weight in gram. The weight was calculated from total weight of fruits was divided by total number of fruits of every harvest and finally making the average was made from four times harvesting data.

3.10.12Dry matter content of fruit (%)

After harvesting, randomly selected 100 gram of fruit sample previously sliced in to very thin pieces. The fruits were then dried in the sun for one day and placed in oven maintained at 60^0C for 72 hrs. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of the sample was taken. The dry matter was calculation by the following formula:

$$\text{Dry matter of fruit (\%)} = \frac{\text{Dry weight of fruit}}{\text{Fresh weight of fruit}} \times 100$$

3.10.13 Total Soluble Solid (TSS) percentage of fruit

The Total Soluble Solid (TSS)percentageof fruit of the plant was measured by a TSS meter (TSS Pro-6352), the product of USA.

3.10.14Chlorophyllcontent in leaf (%)

The Chlorophyll percentage of leaf of the plant was measured by a SPAD meter, a product of Konica Minolta Sensing Ltd, Singapore. At 60 days after transplanting from randomly selected six tagged plants. This machine gives the direct calculated value of the chlorophyll percentage of leaf of the plant. The Chlorophyll percentage of five tagged leaves of each plant was measured and calculated the average Chlorophyll percentage of leaf of each plant of 6 sample plants.

3.10.15 Carbon assimilation rate (%)

The Carbon assimilation rate of the plant was measured by an automatic "LC*pro*$^{+}$ (advanced photosynthesis measurement system) meter" which is a product of *ADC Ltd.*, Hertfordshire EN11 0NT, United Kingdom.At60 days after transplanting from six tagged plants of each plot. This machine gives the direct calculated result of carbon assimilation rate of the plant. The Carbon assimilation rate of five tagged leaves of each plant was measured and calculated the average Carbon assimilation rate of one plant.

3.10.16 Yield per plot (kg)

An electric balance was used to measure the weight of fruits per plot. The total fruit yield of each unit plot measured separately from each sample plant during the harvesting period and was expressed in kilogram (kg).

3.10.17 Yield per hectare (ton)

It was calculated by the following formula:

$$\text{Yield of tomato (t/ha)} = \frac{\text{Fruit yield per unit plot (kg) x 10000}}{\text{Area of unit plot in square meter x 1000}}$$

3.11 Statistical analysis

The recorded data on various parameters were statistically analyzed using MSTAT-C statistical package program. The mean for all the treatments was calculated and analysis of variance (ANOVA) for all the characters were performed by F- Difference between treatment means were determined by LSD according to Gomez and Gomez, (1984) at 5% level of significance.

CHAPTER IV

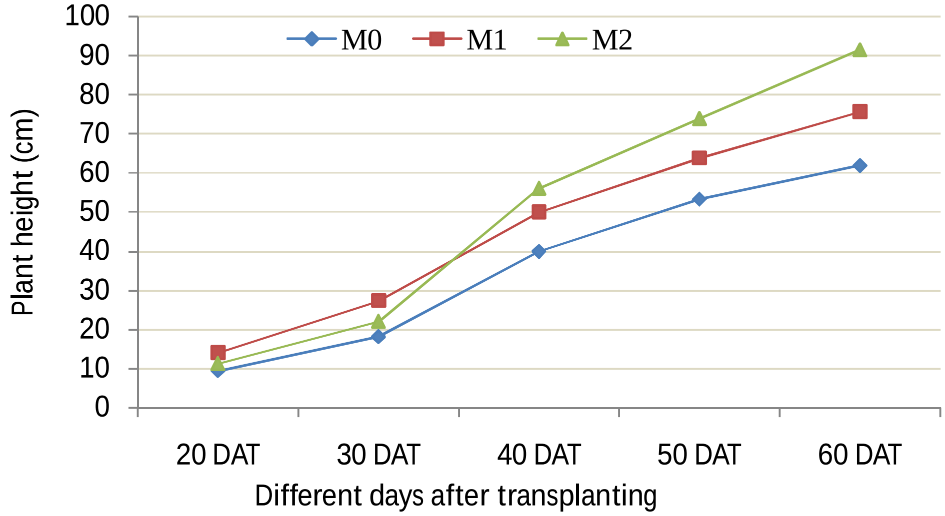
RESULT AND DISCUSSION

The present study was conducted to find the effect of manure and potassium on growth and yield of tomato. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in Appendix III-VIII. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings:

4.1 Plant height

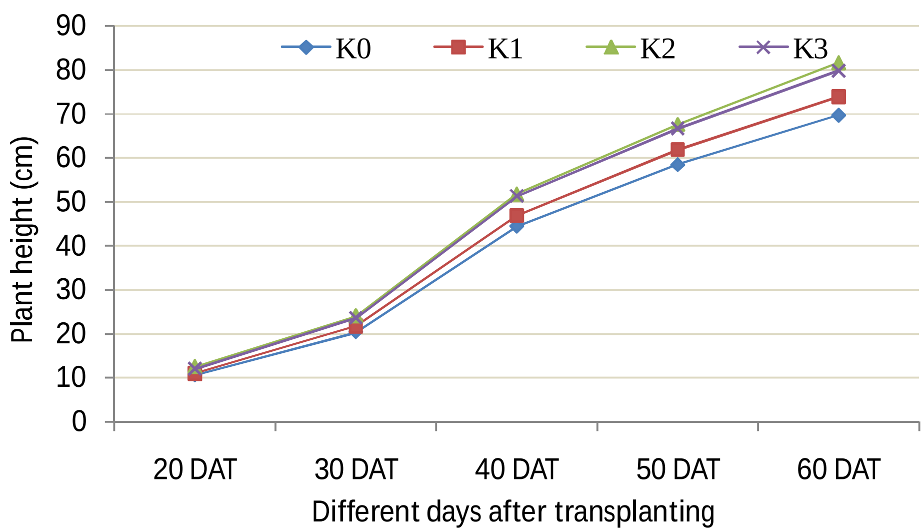
The significant difference was observed due to the application of different manures at 30, 40, 50 and 60 DAT except 20 DAT (Appendix III). At 20 and30 DATthe maximum plant height (14.04 cm and 27.33 cm) was obtained from M_1(cowdung 15 t ha^{-1}) treatment and at 40, 50 and 60 DAT, the highest plant height (50.00 cm, 63.87 cm and 75.66 cm) was recorded from M_2 (3.75 ton vermicompost ha^{-1}) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum plant height (9.46 cm, 18.13 cm, 39.96 cm, 53.29 cm and 61.87 cm) was recorded from M_0(control) treatment (Fig 2).Abafita *et al*. (2014) obtained results from the present research indicated that applied vermicompost especially; at 20% level had significantly improving effects on better growth and development of vermicompost treated tomatoes.Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate with maximum height, leaf length and productivity.

In case of potassium application significant difference was observedat 30, 40, 50 and 60 DAT except 20 DAT(Appendix III). At 20, 30, 40, 50 and 60 DAT the maximum plant height (12.64 cm, 24.14 cm, 51.88 cm, 67.66 cm and 81.75 cm) was obtained from K_2 (220 kg ha^{-1}) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum plant height (10.71 cm, 20.47 cm, 44.54 cm, 58.50 cm and 69.77 cm) was recorded from K_0(control) treatment (Fig 3).



M_0: No manure (control), M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}

Fig 2. Effect of manure on plant height of tomatoat different days after transplanting (DAT)



K_0: No potassium (control), K_1: 200 kg MOP ha^{-1},K_2: 220 kg MOP ha^{-1}, K_3: 240 kgMOP ha^{-1}

Fig 3. Effect of potassium on plant height of tomatoat different days after transplanting (DAT)

Ehsan *et al*. (2010) and Harneet *et al.* (2004) supported the similar results. Javaria *et al*. (2012) conducted a pot experiment and said that potassium application significantly increased plant height due to the potassium.

Table 1. Interaction effect manure and potassium on plant height of tomatoat different days after transplanting (DAT)

Treatment	Plant Height (cm)				
	20 DAT	**30 DAT**	**40 DAT**	**50 DAT**	**60 DAT**
M_0K_0	9.08 h	16.06 f	32.88 f	47.89 g	54.05 g
M_0K_1	9.25 h	18.12ef	38.16 f	52.66fg	61.83fg
M_0K_2	9.59 gh	18.96 de	44.16 e	56.33ef	65.10ef
M_0K_3	9.92 fgh	19.40 de	44.66 e	56.28 ef	66.50ef
M_1K_0	10.42fg	19.95 de	46.99 de	58.33ef	68.99ef
M_1K_1	10.86ef	21.07 d	48.26cde	61.44 de	71.49 de
M_1K_2	11.53 de	23.34 c	51.71bcd	67.27 cd	80.38 cd
M_1K_3	12.36 cd	24.06 c	53.04 bc	68.44bcd	81.77 c
M_2K_0	12.64 c	25.40bc	53.77bc	69.28 bc	86.27bc
M_2K_1	12.92 bc	26.34 b	54.38ab	71.50bc	88.60 bc
M_2K_2	13.81 b	27.45 b	59.77 a	79.39 a	99.77 a
M_2K_3	16.81 a	30.12 a	56.43ab	75.39 ab	91.49ab
LSD $_{(0.05)}$	1.01	**2.18**	**5.73**	**7.25**	**9.11**
CV %	**5.19**	**5.72**	**6.96**	**6.73**	**7.05**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

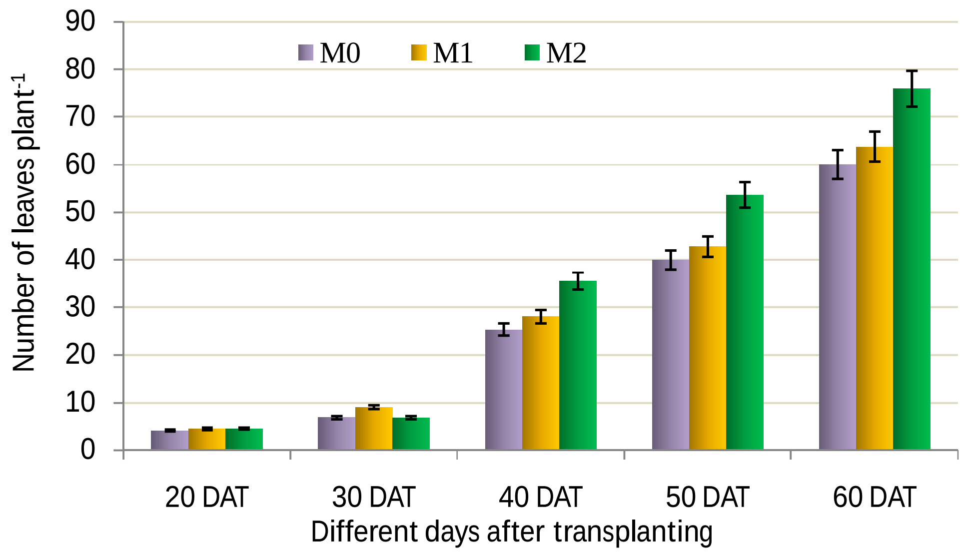
M_0: Control, M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}; K_0: Control, K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

The significant difference was observed due to the interaction effect of different manures and potassium application at 30, 40, 50 and 60 DAT except 20 DAT (Appendix III). At 20 and 30 DAT the maximum plant height (16.81 cm and 30.12 cm) was obtained from M_2K_3 (vermicompost 3.75 t ha $^{-1}$ and 240 kg MOPha^{-1}) treatment combination. and at 40, 50 and 60 DAT, the highest plant height (59.77 cm, 79.39 cm and 99.77 cm) was recorded from M_2K_2 (3.75 ton vermicompost ha^{-1} and 240 kg MOPha^{-1}) treatment combination. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum plant height (9.08 cm, 16.06 cm, 32.88 cm, 47.89 cm and 54.05 cm) was recorded from M_0K_0(control) treatment combination (Table 1).

4.2Number of leaves plant^{-1}

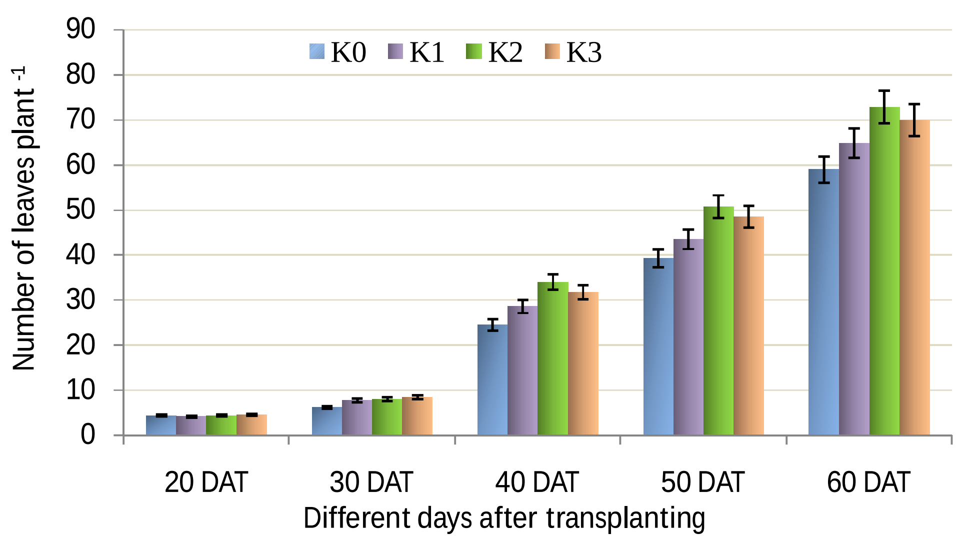
The significant difference was observed due to the application of different manures at 30, 40, 50 and 60 DAT except 20 DAT (Appendix IV). At 20 and 30 DAT the maximum number of leaves per plant (4.63 and 9.12) was obtained from M_1 (cowdung 15 t ha^{-1}) treatment and at 40, 50 and 60 DAT, the highest number of leaves per plant (35.62, 53.75 and 76.02) was recorded from M_2 (3.75 ton vermicompost ha^{-1}) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum number of leaves per plant (4.16, 6.94, 25.43, 40.02 and 60.11) was recorded from M_0(control) treatment (Fig 4).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.

Due to application of different levels of potassium showed significant differences on number of leaves at 30, 40, 50 and 60 DAT except 20 DAT (Appendix IV). At 20 and 30 DAT the maximum number of leaves per plant (4.63 and 8.54) was obtained from K_3 treatment and at 40, 50 and 60 DAT the maximum number of leaves per plant (34.01, 50.75 and 72.86) was obtained from K_2 (220 kg ha^{-1}) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum number of leaves per plant (4.44, 6.21, 24.53, 39.32 and 58.97) was recorded from K_0(control) treatment (Fig 5).Ehsan *et al.* (2010) and Harneet *et al.* (2004) supported the similar results. Khalil *et al.* (2001) supported the similar results.



M_0: No manure (control), M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}

Fig 4. Effect of manure on Number of leaves plant^{-1}of tomatoat different days after transplanting (DAT)



K_0: No potassium (control), K_1: 200 kg MOP ha^{-1},K_2: 220 kg MOP ha^{-1}, K_3: 240 kgMOP ha^{-1}

Fig 5. Effect of potassium on Number of leaves plant^{-1}of tomatoat different days after transplanting (DAT) leaves per plant (4.74 and 11.49) was obtained from M_2K_3 (vermicompost 3.75 t ha $^{-1}$ and 240 kg MOPha^{-1}) treatment combination and at 40, 50 and 60 DAT, the highest number of leaves per plant (43.34 cm, 64.38 cm and 88.52 cm) was recorded from M_2K_2 (3.75 ton vermicompost ha^{-1} and 240 kg MOPha^{-1}) treatment combination. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum number of leaves per plant (4.24, 5.82, 19.79, 33.10 and 50.52) was recorded from M_0K_0(control) treatment combination (Table 2).

Table 2. Interaction effect ofmanure and potassium on Number of leaves plant^{-1}of tomatoat different days after transplanting (DAT)

Treatment	**Number of leaves plant^{-1}**				
	20 DAT	**30 DAT**	**40 DAT**	**50 DAT**	**60 DAT**
M_0K_0	4.24ab	5.82 f	19.79 f	33.10 d	50.52 e
M_0K_1	3.69 b	7.82 cd	27.12 de	39.77 cd	60.52 d
M_0K_2	4.52 a	7.21 d	26.46 de	42.77 c	64.19 d
M_0K_3	4.19 ab	6.93def	28.34cde	44.43 c	65.19 d
M_1K_0	4.41 a	6.77def	26.68 de	42.77 c	63.86 d
M_1K_1	4.46 a	6.71def	24.68 ef	38.77 cd	58.86 de
M_1K_2	4.85 a	6.93def	32.23bcd	45.10 c	65.86 d
M_1K_3	4.41 a	7.15 de	29.01cde	44.77 c	66.86 cd
M_2K_0	4.69 a	6.04ef	27.12 de	42.10 c	62.52 d
M_2K_1	4.46 a	8.82 c	34.01bc	52.10 b	75.19bc
M_2K_2	4.52 a	10.15 b	43.34 a	64.38 a	88.52 a
M_2K_3	4.74 a	11.49 a	38.01ab	56.43 b	77.86 b
LSD $_{(0.05)}$	**0.70**	**1.14**	**6.50**	**6.81**	**8.51**
CV %	**9.4**	**8.85**	**12.92**	**8.83**	**7.54**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: Control, M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}; K_0: Control, K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

4.3Number of branches plant^{-1}

The significant difference was observed due to the application of different manures (Appendix IV). The maximum number of branches per plant (7.50) was obtained from M_1 (cowdung 15 t ha^{-1}) treatment and followed by (6.80) M_2 treatment. On the other hand, the minimum number of branches per plant (6.10) was recorded from M_0(control) treatment (Table 3). Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate. Joshi and Vig (2010) reported the similar results when plants were treated with vermicompost. Manatad and Jaquias (2008) also supported the results.

In case of potassium application significant difference was found (Appendix IV). The maximum number of branches per plant (7.56) was obtained from K_2 (220 kg MOP ha^{-1}) treatment and followed by (7.16) K_1 treatment. On the other hand the minimum number of branches per plant (5.38) was recorded from K_0(control) treatment (Table 4). Javaria *et al.* (2012) conducted a pot experiment and said that potassium application significantly increased plant height, number of branches plant^{-1}.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix IV). The maximum number of branches per plant (8.45) was obtained from M_2K_2 (vermicompost 3.75 t ha^{-1} and 220 kg MOPha^{-1}) treatment combination. On the other hand, the minimum number of branches per plant (4.45) was recorded from M_0K_0(control) treatment combination (Table 5).

4.4Canopy size (cm)

The significant difference was observed due to the application of different manures (Appendix V). The maximum canopy size (102.74 cm) was obtained from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (93.07 cm) M_1 treatment. On the other hand, the minimum canopy size (81.62 cm) was recorded from M_0(control) treatment (Table 3) Reshid *et al.* (2014) said that vermicompost treated tomatoes as they had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields.Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate.

In case of potassium application significant difference was found (Appendix V). The maximum canopy size (97.89 cm) was obtained from K_3 (240 kg MOP ha^{-1}) treatment and followed by (96.00 cm) K_1 treatment. On the other hand the minimum canopy size (85.11 cm) was recorded from K_0(control) treatment (Table 4).Ehsan *et al.* (2010) and Harneet *et al.* (2004) supported the similar results. Khalil *et al.* (2001) supported the similar results. Javaria *et al.* (2012) conducted a pot experiment and said that potassium application significantly increased plant growth.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix V). The maximum canopy size (112.00 cm) was obtained from M_2K_3 (vermicompost 3.75 t ha^{-1} and 240 kg MOPha^{-1}) treatment combination. On the other hand, the minimum canopy size (69.00 cm) was recorded from M_0K_0(control) treatment combination (Table 5).

Table 3. Effects of manureon number of branches plant^{-1}, canopy size, stem diameter and length of leaf of tomato

Treatment	**No. of branches plant^{-1}**	**Canopy size (cm)**	**Stem diameter (cm)**
M_0	6.10 c	81.62 c	2.11 c
M_1	7.50 a	93.07 b	2.23 b
M_2	6.80 b	102.74 a	2.40 a
LSD $_{(0.05)}$	**0.07**	**2.12**	**0.013**
CV %	**5.25**	**5.67**	**6.68**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: No manure (control), M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}

Table 4. Effects of potassium on number of branches plant^{-1}, canopy size, stem diameter and length of leaf of tomato

Treatment	No. of branches plant^{-1}	Canopy size (cm)	Stem diameter (cm)
K_0	5.38 c	85.11 d	1.98 d
K_1	7.16 b	91.00 c	2.32 b
K_2	7.56 a	96.00 b	2.40 a
K_3	7.09 b	97.89 a	2.28 c
LSD $_{(0.05)}$	**0.08**	**0.82**	**0.015**
CV %	**5.25**	**5.67**	**6.68**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

K_0: No potassium (control), K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

4.5Stem diameter (cm)

The significant difference was observed due to the application of different manures (Appendix V). The maximum stem diameter (2.40 cm) was obtained from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (2.23 cm) M_1 treatment. On the other hand, the minimum stem diameter (2.11 cm) was recorded from M_0(control) treatment (Table 3). Tharmaraj *et al.* (2011) narrated that vermicompost treated plants gave maximum number of leaves, height, stem diameter.

In case of potassium application significant difference was found (Appendix V). The maximum stem diameter (2.40 cm) was obtained from K_2 (220 kg MOP ha^{-1}) treatment and followed by (2.32 cm) K_1 treatment. On the other hand the minimum stem diameter (1.98 cm) was recorded from K_0(control) treatment (Table 4). Ehsan *et al.* (2010) and Harneet *et al.* (2004) supported the similar results. Khalil *et al.* (2001) supported the similar results.

Table 5. Interaction effect manure and potassium on number of branches plant^{-1}, canopy size, stem diameter and length of leaf of tomato

Treatment	No. of branches plant^{-1}	Canopy size (cm)	Stem diameter (cm)
M_0K_0	4.45 j	69.00 i	1.86 j
M_0K_1	6.58 g	82.00 h	2.19 g
M_0K_2	6.78 f	92.00 g	2.22 f
M_0K_3	6.58 g	91.67 g	2.18 g
M_1K_0	5.45 i	93.33 f	1.98 i
M_1K_1	7.25 d	95.00 e	2.30 d
M_1K_2	7.45 c	96.00 e	2.39 c
M_1K_3	7.05 e	96.00 e	2.26 e
M_2K_0	6.25 h	99.00 d	2.11 h
M_2K_1	7.65 b	102.00 c	2.48 b
M_2K_2	8.45 a	106.00 b	2.61 a
M_2K_3	7.65 b	112.00 a	2.41 c
LSD $_{(0.05)}$	**0.14**	**1.10**	**0.026**
CV %	**5.25**	**5.67**	**6.68**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: Control, M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}; K_0: Control, K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix V). The maximum stem diameter (2.61 cm) was obtained from M_2K_2 (vermicompost 3.75 t ha $^{-1}$ and 220 kg MOPha^{-1}) treatment combination. On the other hand, the minimum stem diameter (1.86 cm) was recorded from M_0K_0(control) treatment combination (Table 5).

4.6 Number of clusters plant^{-1}

The significant difference was observed due to the application of different manures (Appendix VI). The maximum number of clusters plant^{-1} (24.75) was obtained from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (16.91) M_1 treatment. On the other hand, the minimum number of clusters plant^{-1} (10.83) was recorded from M_0(control) treatment (Table 6). Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate with high productivity.

In case of potassium application significant difference was found (Appendix VI). The maximum number of clusters plant^{-1} (19.76) was obtained from K_2 (220 kg MOP ha^{-1}) treatment and followed by (17.99) K_3 treatment. On the other hand the minimum number of clusters plant^{-1} (13.21) was recorded from K_0(control) treatment (Table 7).Clarke (1944) found little effect of potassium application on flower production, although the proportion of flowers that matured into marketable fruit and hence the yield, increased with potassium level.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VI). The maximum number of clusters plant^{-1} (22.98) was obtained from M_2K_3 (vermicompost 3.75 t ha $^{-1}$ and 240 kg MOPha^{-1}) treatment combination. On the other hand, the minimum number of clusters plant^{-1} (7.98) was recorded from M_0K_0(control) treatment combination (Table 8).

4.7 Number of flowers cluster^{-1}

The significant difference was observed due to the application of different manures (Appendix VI). The maximum number of flowers cluster^{-1}(6.93) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (6.41) M_1 treatment. On the other hand, the minimum number of flowers cluster^{-1}(5.83) was recorded from M_0(control) treatment (Table 6).Joshi and Vig (2010) reported the similar results when plants were treated with vermicompost.

Manatad and Jaquias (2008) also supported the results. Goutam *et al.* (2011) also agreed with the results.

In case of potassium application significant difference was found (Appendix VI). The maximum number of flowers cluster^{-1}(7.08) was obtained from K_2 (220 kg MOP ha^{-1}) treatment and followed by (6.75) K_1 treatment. On the other hand the minimum number of flowers cluster^{-1}(5.15) was found from K_0(control) treatment (Table 7). Javaria *et al.* (2012) conducted a pot experiment and said that potassium application significantly increased plant height, number of flowers plant^{-1}, fruit setting rate, number of truss plant^{-1}, fruits plant^{-1} and yield ha $^{-1}$.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VI). The maximum number of flowers cluster^{-1} (7.88) was obtained from M_2K_2 (vermicompost 3.75 t ha $^{-1}$ and 220 kg MOPha^{-1}) treatment combination. On the other hand, the minimum number of flowers cluster^{-1} (4.88) was recorded from M_0K_0(control) treatment combination (Table 8).

4.8 Number of fruits cluster^{-1}

The significant difference was observed due to the application of different manures (Appendix VI). The maximum number of fruits cluster^{-1}(6.46) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (5.71) M_1 treatment. On the other hand, the minimum number of fruits cluster^{-1}(4.21) was recorded from M_0(control) treatment (Table 6).Ali *et al.* (2014) investigated that maximum number of fruit (30.9/plant) and yield (14.3 kg/plot) were found from the foliar application of leachate from vermicompost which was followed by mustard oil cake. Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate productivity.

Application of different levels of potassium, significant difference was found on number of fruits per cluster (Appendix VI). The maximum number of fruits cluster^{-1}(6.76) was obtained from K_2 (220 kg MOP ha^{-1}) treatment and followed by (5.98) K_3 treatment which is statistically identical (5.87) to K_2 treatment. On the other hand the minimum number of fruits cluster^{-1}(3.21) was found from K_0(control) treatment (Table 7). Javaria *et al*. (2012) conducted a pot experiment and said that potassium application significantly increased plant height, number of flowers plant^{-1}, fruit setting rate, number of truss plant^{-1}, fruits plant^{-1} and yield ha $^{-1}$.Clarke (1944) found little effect of potassium application on flower production, although the proportion of flowers that matured into marketable fruit and hence the yield, increased with potassium level.

Due to combined effect of different manures and potassium applicationexhibited significant difference on number of fruits per cluster (Appendix VI). The maximum number of fruits cluster^{-1} (7.21) was obtained from M_2K_2 (vermicompost 3.75 t ha $^{-1}$ and 220 kg MOPha^{-1}) treatment combination. On the other hand, the minimum number of fruits cluster^{-1} (3.21) was recorded from M_0K_0(control) treatment combination (Table 8).

Table 6. Effect of manure on number of clusters plant^{-1}, number of flowers cluster^{-1}, number of fruits cluster^{-1}and length of fruit of tomato

Treatment	No. of clusters plant^{-1}	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Length of fruit (cm)
M_0	10.83 c	5.83 c	4.21 c	4.58 c
M_1	16.91 b	6.41 b	5.71 b	4.81 b
M_2	24.75 a	6.93 a	6.46 a	5.40 a
LSD $_{(0.05)}$	**0.20**	**0.09**	**0.20**	**0.02**
CV %	**5.23**	**5.78**	**4.51**	**7.23**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: No manure (control), M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}

Table 7. Effect of potassium on number of clusters plant^{-1}, number of flowers cluster^{-1}, number of fruits cluster^{-1}and length of fruit of tomato

Treatment	No. of clusters plant^{-1}	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Length of fruit (cm)
K_0	13.21 d	5.15 d	3.21 c	4.15 d
K_1	14.99 c	6.75 b	5.87 b	5.07 b
K_2	19.76 a	7.08 a	6.76 a	5.00 c
K_3	17.99 b	6.59 c	5.98 b	5.49 a
LSD $_{(0.05)}$	**0.24**	**0.111**	**0.240**	**0.030**
CV %	**5.23**	**5.78**	**4.51**	**7.23**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

K_0: No potassium (control), K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

4.9Length of fruit (cm)

The significant difference was observed due to the application of different manures on length of fruits (Appendix VI). The maximum length of fruit(5.40 cm) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (4.81 cm) M_1 treatment. On the other hand, the minimum length of fruit(4.58 cm) was recorded from M_0(control) treatment (Table 6). Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate with maximum height, fruit length and productivity. Joshi and Vig (2010) reported the similar results when plants were treated with vermicompost. Manatad and Jaquias (2008) also supported the results. Goutam *et al.* (2011) also agreed with the results.

Fruit length showed significant differences due to application of different manures and levels of potassium (Appendix VI).However, the maximum length of fruit(5.49 cm) was obtained from K_3 (240 kg MOP ha^{-1}) treatment and followed by (5.07 cm) K_1 treatment. On the other hand the minimum length of fruit(4.15 cm) was found from K_0(control) treatment (Table 7). Ehsan *et al.*

(2010) and Harneet *et al.* (2004) supported the similar results. Khalil *et al.* (2001) supported the similar results. Javaria *et al.* (2012)supported the similar results.

Table 8. Interaction effect manure and potassium on number of clusters plant^{-1}, number of flowers cluster^{-1}, number of fruits cluster^{-1}and length of fruit of tomato

Treatment	No. of clusters plant^{-1}	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Length of fruit (cm)
M_0K_0	7.98 j	4.88 i	3.21 f	3.77 i
M_0K_1	8.98 i	6.02 f	4.21 e	4.83 f
M_0K_2	11.31gh	6.32 e	4.87 d	4.89 e
M_0K_3	10.98 h	6.12 f	4.54 de	4.81 f
M_1K_0	11.64 g	5.13 h	3.21 f	3.95 h
M_1K_1	13.98 f	6.96 c	6.02 c	5.14 c
M_1K_2	18.98 d	7.05 c	7.21 b	5.20 b
M_1K_3	17.98 e	6.53 d	6.02 c	4.97 d
M_2K_0	18.98 d	5.46 g	3.21 f	4.75 g
M_2K_1	19.98 c	7.28 b	6.51 b	5.25 b
M_2K_2	20.98 b	7.88 a	7.21 a	5.22 b
M_2K_3	22.98 a	7.13 bc	6.51 b	6.40 a
LSD $_{(0.05)}$	**0.41**	**0.192**	**0.41**	**0.052**
CV %	**5.23**	**5.78**	**4.51**	**7.23**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: Control, M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}; K_0: Control, K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VI). The maximum length of fruit (6.40 cm) was obtained from M_2K_3 (vermicompost 3.75 t ha $^{-1}$ and 240 kg MOPha^{-1}) treatment combination. On the other hand, the minimum length of fruit (3.77 cm) was recorded from M_0K_0(control) treatment combination (Table 8).

4.10Diameter of fruit (cm)

The significant difference was observed due to the application of different manures (Appendix VII). The maximum diameter of fruit(6.03 cm) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (5.77 cm) M_1 treatment. On the other hand, the minimum diameter of fruit(5.53 cm) was recorded from M_0(control) treatment (Table 9). Joshi and Vig (2010) reported the similar results when plants were treated with vermicompost.Manatad and Jaquias (2008) also supported the results. Goutam *et al.* (2011) also agreed with the results. Sinha and Valani (2009) that tomato plants on exclusive vermicompost and vermicompost with worms' maintained very good growth from the very beginning.

Diameter of fruit exhibited significant difference due to application of different levels of potassium (Appendix VII). The maximum diameter of fruit(6.29 cm) was obtained from K_2 (220 kg MOP ha^{-1}) treatment and followed by (6.18 cm) K_1 treatment. On the other hand the minimum diameter of fruit(4.51 cm) was found from K_0(control) treatment (Table 10).

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VII). The maximum diameter of fruit (6.64 cm) was obtained from M_2K_2 (vermicompost 3.75 t ha $^{-1}$ and 220 kg MOPha^{-1}) treatment combination. On the other hand, the minimum diameter of fruit (4.07 cm) was recorded from M_0K_0(control) treatment combination (Table 11).

4.11 Fresh weight of fruit (g)

The significant difference was observed due to the application of different manures (Appendix VII). The maximum fresh weight of fruit (88.69g) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (77.19 g)

M_1 treatment. On the other hand, the minimum fresh weight of fruit(57.69 g) was recorded from M_0(control) treatment (Table 9).Ali *et al.* (2014) investigated 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.Buchanan *et al.* (1988) and Tomati and Galli (1995) also supported the similar results. Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate and dry matter accumulation.

In case of potassium application significant difference was found (Appendix VII). The maximum fresh weight of fruit(84.80 g) was obtained from K_2 (220 kg MOP ha^{-1}) treatment and followed by (81.57 g) K_3 treatment which is statistically similar (81.02 g) to K_1 treatment. On the other hand the minimum fresh weight of fruit(50.69 g) was found from K_0(control) treatment (Table 10). Javaria *et al*. (2012) observed the similar results. Cerneand Briski (1993) conducted field trials and said that gave the highest total yield in the 1st and 2nd years.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VII). The maximum fresh weight of fruit (102.69 g) was obtained from M_2K_2 (vermicompost 3.75 t ha^{-1} and 220 kg MOP ha^{-1}) treatment combination. On the other hand, the minimum fresh weight of fruit (43.69 g) was recorded from M_0K_0(control) treatment combination (Table 11).

4.12 Dry matter content of fruit (%)

The significant difference was observed due to the application of different manures (Appendix VII). The maximum dry matter content of fruit(11.32 %) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (10.30 %) M_1 treatment. On the other hand, the minimum dry matter content of fruit(9.45 %) was recorded from M_0(control) treatment (Table 9). Sinha and Valani (2009) that tomato plants on exclusive vermicompost and vermicompost with worms' maintained very good growth and dry matter content from the very beginning. Arancon *et al.* (2004b) conducted an experiment and supported the similar results. Manatad and Jaquias (2008) also supported the results. Goutam *et al.* (2011) also agreed with the results. Grappelli *et al.* (1985) observed the similar results.

Due to potassium application significant difference was found on dry matter content of fruit (Appendix VII). The maximum dry matter content of fruit(11.55 %) was obtained from K_3 (240 kg MOP ha^{-1}) treatment and followed by (10.92 %) K_2treatment. On the other hand the minimum dry matter content of fruit(8.32 %) was found from K_0(control) treatment (Table 10).Cerne and Briski (1993) conducted field trials and said that gave the highest total yield in the 1st and 2nd years. Ehsan *et al.* (2010) and Harneet *et al.* (2004) supported the similar results. Khalil *et al.* (2001) supported the similar results.Ahmad *et al.* (2015) found the highest yield, fruit weight, dry matter (6.33 %) and mineral matter due to the application potassium.

Table 9. Effect of manureon diameter of fruit, fresh weight of fruit, dry matter content of fruit and TSS of tomato

Treatment	Diameter of fruit (cm)	Fresh weight of fruit (g)	Dry matter content of fruit (%)	TSS (%)
M_0	5.53 c	57.69 c	9.45 c	7.05 c
M_1	5.77 b	77.19 b	10.30 b	7.28 b
M_2	6.03 a	88.69 a	11.32 a	7.87 a
LSD $_{(0.05)}$	**0.014**	**1.66**	**0.15**	**0.026**
CV %	**6.23**	**5.98**	**7.45**	**6.85**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: No manure (control), M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}

Table 10. Effect of potassium on diameter of fruit, fresh weight of fruit, dry matter content of fruit and TSS of tomato

Treatment	Diameter of fruit (cm)	Fresh weight of fruit (g)	Dry matter content of fruit (%)	TSS (%)
K_0	4.51 d	50.69 c	8.32 d	6.62 d
K_1	6.18 b	81.02 b	10.64 c	7.47 c
K_2	6.29 a	84.80 a	10.92 b	7.54 b
K_3	6.13 c	81.57 b	11.55 a	7.96 a
LSD $_{(0.05)}$	**0.016**	**1.92**	**0.17**	**0.030**
CV %	**6.23**	**5.98**	**7.45**	**6.85**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

K_0: No potassium (control), K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VII). The maximum dry matter content of fruit (13.34 %) was obtained from M_2K_3 (vermicompost 3.75 t ha $^{-1}$ and 240 kg MOPha^{-1}) treatment combination. On the other hand, the minimum dry matter content of fruit (7.97 %) was recorded from M_0K_0(control) treatment combination (Table 11).

4.13 TSS (Total Soluble Solid) (%)

The significant difference was observed due to the application of different manures (Appendix VII). The maximum TSS of fruit (7.87 %) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (7.28 %) M_1 (cowdung 15 t ha^{-1}) treatment. On the other hand, the minimum TSS of fruit(7.05 %) was recorded from M_0(control) treatment (Table 9). Ali *et al.* (2014) investigated that increased TSS (4.7%) were found from the foliar application of leachate from vermicompost which was followed by mustard oil cake.Joshi and Vig (2010) reported the similar results when plants were treated with vermicompost.

Table 11. Interaction effect manure and potassium ondiameter of fruit, fresh weight of fruit, dry matter content of fruit and TSS of tomato

Treatment	Diameter of fruit (cm)	Fresh weight of fruit (g)	Dry matter content of fruit (%)	TSS (%)
M_0K_0	4.07 k	43.69 h	7.97 i	6.24 i
M_0K_1	6.01 h	59.69 ef	9.82 g	7.30 f
M_0K_2	6.05 g	65.02 d	10.22 f	7.36 e
M_0K_3	6.01 h	62.36 de	9.79 g	7.28 f
M_1K_0	4.64 j	49.69 g	8.40 h	6.42 h
M_1K_1	6.16 e	86.69 c	10.97 de	7.61 c
M_1K_2	6.19 d	86.69 c	11.10 cd	7.67 b
M_1K_3	6.12 f	85.69 c	10.76 e	7.44 d
M_2K_0	4.84 i	58.69 f	8.61 h	7.22 g
M_2K_1	6.37 b	96.69 b	11.39 c	7.72 b
M_2K_2	6.64 a	102.69 a	11.97 b	7.69 b
M_2K_3	6.27 c	96.69 b	13.34 a	8.87 a
LSD $_{(0.05)}$	**0.02**	**3.33**	**0.30**	**0.05**
CV %	**6.23**	**5.98**	**7.45**	**6.85**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: Control, M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}; K_0: Control, K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

In case of potassium application significant difference was found (Appendix VII). The maximum TSS of fruit (7.96 %) was obtained from K_3 (240 kg MOP ha^{-1}) treatment and followed by (7.54 %) K_2treatment. On the other hand the minimum TSS of fruit (6.62 %) was found from K_0(control) treatment (Table 10).Ahmad *et al.* (2015) found the highest yield, fruit weight, dry matter (6.33 %) and mineral matter and TSS due to the application potassium.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VII). The maximum

TSS of fruit (8.87 %) was obtained from M_2K_3 (vermicompost 3.75 t ha $^{-1}$ and 240 kg MOPha^{-1}) treatment combination. On the other hand, the minimum TSS of fruit (6.24 %) was recorded from M_0K_0(control) treatment combination (Table 11).

4.14 Chlorophyll content in leaf (%)

The significant difference was observed due to the application of different manures (Appendix VIII). The maximum chlorophyll content in leaf (58.55 %) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (53.97 %) M_1(cowdung 15 t ha^{-1}) treatment. On the other hand, the minimum chlorophyll content in leaf(52.71 %) was recorded from M_0(control) treatment (Table 12).Buchanan *et al*. (1988) and Tomati and Galli (1988) also supported the similar results. Manatad and Jaquias (2008) also supported the results. Goutam *et al.* (2011) also agreed with the results.

In case of potassium application significant difference was found (Appendix VIII). The maximum chlorophyll content in leaf(59.43 %) was obtained from K_3 (240 kg MOP ha^{-1}) treatment and followed by (55.82 %) K_1treatment. On the other hand the minimum chlorophyll content in leaf(49.59 %) was found from K_0(control) treatment (Table 13).Clarke (1944) found similar results.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VIII). The maximum chlorophyll content in leaf (67.69 %) was obtained from M_2K_3 (vermicompost 3.75 t ha^{-1} and 240 kg MOPha^{-1}) treatment combination. On the other hand, the minimum chlorophyll content in leaf (48.04 %) was recorded from M_0K_0(control) treatment combination (Table 14).

4.15 Carbon assimilation rate (%)

The significant difference was observed due to the application of different manures (Appendix VIII). The maximum carbon assimilation rate(10.43 %) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (9.22

%) M_1(cowdung 15 t ha^{-1}) treatment. On the other hand, the minimum carbon assimilation rate(7.66 %) was recorded from M_0(control) treatment (Table 12). Gallardo-Lara and Nogales (1987) observed the similar results.

In case of potassium application significant difference was found (Appendix VIII). The maximum carbon assimilation rate(10.53 %) was obtained from K_3 (240 kg MOP ha^{-1}) treatment and followed by (10.09 %) K_1 treatment. On the other hand the minimum carbon assimilation rate(6.12 %) was found from K_0(control) treatment (Table 13).Clarke (1944) supported the results. Ehsan*et al.* (2010) and Harneet *et al.* (2004) supported the similar results. Khalil *et al.* (2001) supported the similar results.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VIII).

Table 12. Effect of manure on chlorophyll content in leaf, carbon assimilation rate, yield $plot^{-1}$ and yield $hectare^{-1}$ of tomato plant

Treatment	Chlorophyll content in leaf (%)	Carbon assimilation rate (%)	Yield $plot^{-1}$ (kg)	Yield $hectare^{-1}$ (t ha^{-1})
M_0	52.71 c	7.66 c	18.64 c	50.75 c
M_1	58.55 a	9.22 b	22.03 b	60.18 b
M_2	53.97 b	10.43 a	25.24 a	69.10 a
LSD $_{(0.05)}$	**0.11**	**0.21**	**0.64**	**1.80**
CV %	**6.35**	**7.59**	**6.84**	**6.84**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: No manure (control), M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}

Table 13. Effect of potassium on chlorophyll content in leaf, carbon assimilation rate, yield plot^{-1} and yield hectare^{-1} of tomato plant

Treatment	Chlorophyll content in leaf (%)	Carbon assimilation rate	Yield plot^{-1} (kg)	Yield hectare^{-1} (t ha^{-1})
K_0	49.59 d	6.12 d	16.76 c	45.53 c
K_1	55.82 b	10.09 b	23.22 b	63.47 b
K_2	55.47 c	10.53 a	25.36 a	69.43 a
K_3	59.43 a	9.67 c	22.54 b	61.60 b
LSD $_{(0.05)}$	**0.12**	**0.25**	**0.75**	**2.08**
CV %	**6.35**	**7.59**	**6.84**	**6.84**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

K_0: No potassium (control), K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

The maximum carbon assimilation rate (12.15 %) was obtained from M_2K_2 (vermicompost 3.75 t ha^{-1} and 220 kg MOP ha^{-1}) treatment combination which is statistically similar to M_2K_1 (vermicompost 3.75 t ha^{-1} and 200 kg MOP ha^{-1}) treatment combination. On the other hand, the minimum carbon assimilation rate (4.15 %) was recorded from M_0K_0(control) treatment combination (Table 14).

4.16 Yield plot^{-1} (kg)

The significant difference was observed due to the application of different manures (Appendix VIII). The highest yield per plot(25.24 kg) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (22.03 kg) M_1 (cowdung 15 t ha^{-1}) treatment. On the other hand, the lowest yield per plot(18.64 kg) was recorded from M_0(control) treatment (Table 12). Arancon *et al.* (2002a) reported significantly increased growth and yields of field tomatoes. Kolte *et al.* (1999) reported that the vermicompost application can increase the yield. Azarmi (1996) studied on tomato and recorded the vermicompost increases the growth and yield of tomato with 3 sprays of liquid manure also.Buchanan *et al.* (1988) and Tomati and Galli (1988) also supported the similar results.

Table 14. Interaction effect manure and potassium onchlorophyll content in leaf, carbon assimilation rate, yield plot^{-1} and yield hectare^{-1} of tomato plant

Treatment	**Chlorophyll content in leaf (%)**	**Carbon assimilation rate**	**Yield plot^{-1} (kg)**	**Yield hectare^{-1} (t ha^{-1})**
M_0K_0	48.04 j	4.15 g	15.07 i	40.83 i
M_0K_1	54.20 g	8.64 e	19.21fg	52.34 fg
M_0K_2	54.47 f	9.23 d	21.03 e	57.39 e
M_0K_3	54.14 g	8.62 e	19.25 f	52.45 f
M_1K_0	49.47 i	6.95 f	17.27 h	46.95 h
M_1K_1	55.24 e	9.88 c	22.96 d	62.74 d
M_1K_2	56.14 d	10.23 bc	25.91 c	70.95 c
M_1K_3	55.04 e	9.85 c	22.00 de	60.08 de
M_2K_0	51.26 h	7.27 f	17.95 gh	48.83 gh
M_2K_1	57.24 c	11.76 a	27.49 b	75.33 b
M_2K_2	58.04 b	12.15 a	29.16 a	79.96 a
M_2K_3	67.69 a	10.54 b	26.39 bc	72.28 bc
LSD $_{(0.05)}$	**0.22**	**0.43**	**1.29**	**3.61**
CV %	**6.35**	**7.59**	**6.84**	**6.84**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

M_0: Control, M_1: Cowdung 15 t ha^{-1},M_2: Vermicompost 3.75 t ha^{-1}; K_0: Control, K_1: 200 kg ha^{-1},K_2: 220 kg ha^{-1}, K_3: 240 kg ha^{-1}

In case of potassium application significant difference was found (Appendix VIII). The highest yield per plot(25.36 kg) was obtained from K_3 (240 kg MOP ha^{-1}) treatment and followed by (23.22 kg) K_1 treatment which is statistically similar (22.54 kg) to K_3 treatment. On the other hand the lowest yield per plot(16.76 kg) was found from K_0(control) treatment (Table 13). Cerne and

Briski (1993) conducted field trials and said that gave the highest total yield in the 1st and 2nd years. Javaria *et al*. (2012) conducted a pot experiment and said that potassium application significantly increasedfruits plant^{-1} and yield ha $^{-1}$.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VIII). The highest yield per plot (29.16 kg) was obtained from M_2K_2 (vermicompost 3.75 t ha^{-1} and 220 kg MOP ha^{-1}) treatment combination. On the other hand, the lowest yield per plot (15.07 kg) was recorded from M_0K_0(control) treatment combination (Table 14).

4.17 Yield hectare^{-1} (t ha^{-1})

The significant difference was observed due to the application of different manures (Appendix VIII). The highest yield per hectare(69.10 ton) was found from M_2 (vermicompost 3.75 t ha^{-1}) treatment and followed by (60.18 ton) M_1 (cowdung 15 t ha^{-1}) treatment. On the other hand, the lowest yield per hectare(50.75 ton) was recorded from M_0(control) treatment (Table 12). Kolte *et al.* (1999) reported that the Vermicompost application can increase the yield. Joshi and Vig (2010) reported the similar results when plants were treated with vermicompost.Manatad and Jaquias (2008) also supported the results. Goutam *et al.* (2011) also agreed with the results. Ghosh *et al.* (1999) observed the similar results. Wilson and Carlile (1989) also supported the results. Azarmi (1996) studied on tomato and recorded the vermicompost increases the growth and yield of tomato with 3 sprays of liquid manure also.Buchanan *et al.* (1988) and Tomati and Galli (1988) also supported the similar results. Abafita *et al.* (2014) obtained results from the present research indicated that applied vermicompost especially; at 20% level had significantly improving effects on better growth and development of vermicompost treated tomatoes as they had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields.

In case of potassium application significant difference was found (Appendix VIII). The highest yield (69.43 t/ha) was obtained from K_3 (240 kg MOP ha^{-1}) treatment and followed by (63.47 t/ha) K_1 treatment which is statistically similar (61.60 ton) to K_3(240 kg MOP ha^{-1}) treatment. On the other hand the lowest yield per hectare(45.53 ton) was found from K_0(control) treatment (Table 13).Ahmad*et al.* (2015) found the highest yield, fruit weight, dry matter (6.33 %) and mineral matter and TSS due to the application potassium. Javaria *et al*. (2012) conducted a pot experiment and said that potassium application significantly increased plant height, number of flowers $plant^{-1}$, fruit setting rate, number of truss $plant^{-1}$, fruits $plant^{-1}$ and yield ha^{-1}.Cerneand Briski (1993) conducted field trials and said that gave the highest total yield in the 1st and 2nd years.

The significant difference was observed due to the interaction effect of different manures and potassium application (Appendix VIII). The highest yield (79.96 t/ha) was obtained from M_2K_2 (vermicompost 3.75 t ha^{-1} and 220 kg MOP ha^{-1}) treatment combination. On the other hand, the lowest yield (40.83 t/ha) was recorded from M_0K_0(control) treatment combination (Table 14).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October, 2015 to March 2016 to find out the effect of different manures and potassium on growth and yield of tomato. The experiment consisted of two factors: Factor A: Three levels of manures. The treatments are M_0: 0 (control), M_1: cowdung 15 t ha^{-1} and M_2: vermicompost 3.75 t ha^{-1}. Factor B: Four levels of potassium. The treatments are K_0: (control); K_1: 200 kg MOPha^{-1}; K_2: 220 kg MOP $ha^{-1}$and K_3: 240 kg MOP ha^{-1}. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the optimum level of manure and potassium on tomato.

In case of manure, the longest plant heightat 60 DAT (91.53 cm), maximum number of leaves per plant at 60 DAT(70.02), maximum size of canopy (102.74 cm), maximum size of stem diameter (2.40 cm), maximum number of clusters $plant^{-1}$ (24.75), the maximum number of flowers $cluster^{-1}$ (6.93), maximum number of fruits $cluster^{-1}$ (6.46), the highest length of fruit (5.40 cm), the highest diameter of fruit (6.03 cm), maximum fresh weight of fruit (88.59 g), the maximum dry matter content of fruit (11.32 %), the highest TSS (7.87%), the highest carbon assimilation rate (10.43 %), maximum yield of fruit $plot^{-1}$ (25.24 kg), and the maximum yield $hectare^{-1}$ (59.10 t/ha) were recorded from the treatment of 3.75 t ha^{-1}vermicompost that is M_2treatment. maximum number of branches per plant (7.50),maximum chlorophyll content in leaf (58.55 %),were recorded from the treatment of 15 t ha^{-1}cowdung that is M_1treatment.On the other handthe shortest plant height at 60 DAT (61.87 cm), minimum number of leaves per plant at 60 DAT (60.11), minimum size of canopy (81.62 cm), minimum size of stem diameter (2.11 cm), minimumnumber of clusters plant^{-1} (10.83), the minimum number of flowers cluster^{-1} (5.83), minimum number of fruits cluster^{-1} (4.21), the lowest length of fruit (4.58 cm), the lowest diameter of fruit (5.53 cm), minimum fresh weight of fruit (57.69 g), the minimum dry matter content of fruit (9.45 %), the lowest TSS (7.05%), the lowest carbon assimilation rate (7.66 %), minimum yield of fruit plot^{-1} (18.64 kg), and the minimum yield hectare^{-1} (50.75 t/ha) minimum number of branches per plant (6.10), minimum chlorophyll content in leaf (52.71 %), were recorded from the control treatment.

In case of potassium the longest plant height at 60 DAT (81.75 cm), maximum number of leaves per plant at 60 DAT (72.86), maximum number of branches per plant (7.56), maximum size of stem diameter (2.40 cm), maximum number of clusters plant^{-1} (19.76), the maximum number of flowers cluster^{-1} (7.08), maximum number of fruits cluster^{-1} (6.76), the highest diameter of fruit (6.29 cm), maximum fresh weight of fruit (84.80 g), the highest carbon assimilation rate (10.53 %), maximum yield of fruit plot^{-1} (25.36 kg), and the maximum yield hectare^{-1} (69.43 t/ha) were recorded from the 220 kg MOP ha^{-1}that is K_2treatment.The maximum size of canopy (97.89 cm), the highest length of fruit (5.49 cm), the maximum dry matter content of fruit (11.55 %), the highest TSS (7.96 %), maximum chlorophyll content in leaf (59.43 %),were recorded from the 240 kg MOP ha^{-1}that is K_3 treatment. On the other hand the shortest plant height at 60 DAT (69.77 cm), minimum number of leaves per plant at 60 DAT (58.97), minimum number of branches per plant (5.38), minimum size of canopy (85.11 cm), minimum size of stem diameter (1.98 cm), minimum number of clusters plant^{-1} (13.21), the minimum number of flowers cluster^{-1} (5.15), minimum number of fruits cluster^{-1} (3.21), the lowest length of fruit (4.15 cm), the lowest diameter of fruit (4.51 cm), minimum fresh weight of fruit (50.69 g), the minimum dry matter content of fruit (8.32 %), the lowest TSS (6.62%), minimum chlorophyll content in leaf (49.59 %), the lowest carbon assimilation rate (6.12 %), minimum yield of fruit plot^{-1} (16.76 kg), and the minimum yield hectare^{-1} (45.53 t/ha), were recorded from the K_0 treatment, that is control treatment.

In case of interaction effect of manure and potassium application, the longest plant height at 60 DAT (99.77 cm), maximum number of leaves per plant at 60 DAT (88.52),maximum number of branches per plant (8.45), maximum size of stem diameter (2.61 cm), the maximum number of flowers cluster^{-1} (7.88), maximum number of fruits cluster^{-1} (7.21), the highest diameter of fruit (6.64 cm), maximum fresh weight of fruit (102.69 g), the highest carbon assimilation rate (12.15%), maximum yield of fruit plot^{-1} (29.16 kg), and the maximum yield hectare^{-1} (79.96 t/ha) were recorded from the M_2K_2 (3.75 t/ha^{-1}vermicompost + 220 kg MOP) treatment combination. The maximum size of canopy (112.00 cm),maximum number of clusters plant^{-1} (22.98), the highest length of fruit (6.40 cm), the maximum dry matter content of fruit (13.34 %), the highest TSS (8.87 %), maximum chlorophyll content in leaf (67.69 %),were recorded from the M_2K_3 (3.75 t/ha^{-1} vermicompost + 240 kg MOP) treatment combination. On the other hand the shortest plant height at 60 DAT (54.05cm), minimum number of leaves per plant at 60 DAT (50.52), minimum number of branches per plant (4.45), minimum size of canopy (69.00 cm), minimum size of stem diameter (1.86 cm), minimum number of clusters plant^{-1} (7.98), the minimum number of flowers cluster^{-1} (4.88), minimum number of fruits cluster^{-1} (3.21), the lowest length of fruit (3.77 cm), the lowest diameter of fruit (4.07 cm), minimum fresh weight of fruit (43.69 g), the minimum dry matter content of fruit (7.97 %), the lowestTSS (6.24%), minimum chlorophyll content in leaf (48.04 %), the lowest carbon assimilation rate (4.15 %), minimum yield of fruit plot^{-1} (15.07 kg), and the minimum yield hectare^{-1} (40.83 t/ha%), were recorded from the M_0K_0 treatment, that is control treatment combination.

Conclusion

Based on the result of the present study it was found that application of 3.75 t vermicompost ha^{-1} and 220 kg MOP ha^{-1} (M_2K_2) treatment combination performed the highest yield (79.96 t/ha) of tomato. Considering the findings of the experiment, it can be concluded that -

- The combination of 3.75 t vermicompost $ha^{-1}$and 220 kg MOP ha^{-1} (M_2K_2) treatment combination is the appropriate practice for tomato production.

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APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2015 to May 2016

Month	Air temperature (^0C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
October,15	29.18	18.26	81	39
November,15	25.82	16.04	78	0
December,15	22.4	13.5	74	0
January,16	24.5	12.4	68	0
February,16	27.1	16.7	67	3
March,16	31.4	19.6	54	11
April, 16	35.3	22.4	51	15
May, 16	38.2	23.2	62	17

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix-III. Analysis of variance of data on plant height at different days after transplanting of tomato

Source of variation	Degrees of freedom (df)	Mean square of plant height at				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	2.676	9.381	49.259	118.20	225.31
Factor A (O.Manure)	2	63.842	255.211*	795.689*	1273.20*	2644.53*
Factor B (Potassium)	3	7.199^{ns}	25.564*	112.956*	165.390**	272.52**
Interaction(A X B)	6	3.148^{ns}	2.280*	13.178*	5.430**	23.02**
Error	22	0.362	1.658	11.480	18.350	28.94
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

NS: not significant

Appendix-IV. Analysis of variance of data on number of leaves at different days after transplanting of tomato

Source of variation	Degrees of freedom (df)	Mean square of number of leaves at				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.891	1.194	0.837	13.565	6.361
Factor A (O. Manure)	2	0.685^{ns}	19.508*	334.349*	631.131*	830.861*
Factor B (Potassium)	3	0.273^{ns}	9.216*	152.621*	236.372*	335.287**
Interaction(A X B)	6	0.138^{ns}	4.614*	31.701*	61.294**	89.898**
Error	22	0.173	0.459	14.761	16.187	25.27
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-V. Analysis of variance of data on number of branches plant^{-1}, canopy size and stem diameter of tomato

Source of variation	Degrees of freedom (df)	Mean square of		
		No. of branches plant^{-1}	Canopy size (cm)	Stem diameter (cm)
Replication	2	$3.23E^{-30}$	$2.73E^{-27}$	$4.85E^{-31}$
Factor A (O. Manure)	2	5.880*	1336.580*	0.250*
Factor B (Potassium)	3	8.410*	294.407*	0.308*
Interaction(A X B)	6	0.133*	78.213*	3.96*
Error	22	$7.27E^{-03}$	0.424	$2.36E^{-04}$
** : Significant at 1% level of probability; * : Significant at 5% level of probability				

Appendix-VI. Analysis of variance of data on number of clusters plant^{-1}, number of flowers cluster^{-1}, number of fruits cluster^{-1} and length of fruit of tomato

Source of variation	Degrees of freedom (df)	Mean square of			
		No. of clusters plant^{-1}	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Length of fruit (cm)
Replication	2	8.87E^{-29}	2.82E^{-30}	1.25E^{-30}	2.03E^{-30}
Factor A (O. Manure)	2	584.083*	3.633*	15.750*	2.167*
Factor B (Potassium)	3	77.963*	6.532*	21.657*	2.844*
Interaction(A X B)	6	4.601*	0.163*	1.824**	0.268**
Error	22	0.060	0.012	0.060	9.46E^{-04}
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VII. Analysis of variance of data on diameter of fruit, fresh weight of fruit, dry matter content of fruit and TSS of tomato

Source of variation	Degrees of freedom (df)	Mean square of			
		Diameter of fruit (cm)	Fresh weight of fruit (g)	Dry matter content of fruit (%)	TSS (%)
Replication	2	1.19E^{-29}	2.43E^{-27}	4.27E^{-29}	1.45E^{-29}
Factor A (O. Manure)	2	0.727*	2947*	10.541*	2.167*
Factor B (Potassium)	3	6.441*	2297.07*	17.874*	2.844**
Interaction(A X B)	6	0.060*	105.741**	0.966**	0.268*
Error	22	2.97E^{-04}	3.878	0.031	9.46E^{-04}
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VIII. Analysis of variance of data on chlorophyll content in leaf, carbon assimilation rate, Yield plot^{-1} and yield hectare^{-1}of tomato plant

Source of variation	Degrees of freedom (df)	Mean square of			
		Chlorophyll content in leaf(%)	Carbon assimilation rate	Yield plot^{-1} (kg)	Yield hectare^{-1} (t ha^{-1})
Replication	2	1.02E^{-27}	2.73E^{-29}	1.24E^{-28}	7.46E^{-28}
Factor A (O. Manure)	2	113.477*	23.151*	131.01*	1009.870*
Factor B (Potassium)	3	149.45*	36.708*	121.625*	938.497*
Interaction(A X B)	6	23.064*	0.844*	5.500**	42.422**
Error	22	0.016	0.065	0.589	4.547
** : Significant at 1% level of probability; * : Significant at 5% level of probability					