EFFECT OF ORGANIC MANURE AND SPACING ON GROWTH AND YIELD OF TOMATO

MD. ASHRAFUL ALAM PRODHAN

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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EFFECT OF ORGANIC MANURE AND SPACING ON GROWTH AND YIELD OF TOMATO

BY
MD. ASHRAFUL ALAM PRODHAN
Reg. No. 05-01699

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APPROVED BY:

Md. Arfan Ali
Assistant Professor
Department of Horticulture
SAU, Dhaka
Supervisor

Prof. Dr. Md. Nazrul Islam
Department of Horticulture
SAU, Dhaka
Co-Supervisor

Prof. Dr. Md. Ismail Hossain
Chairman
Examination Committee

DEDICATED

TO

MY BELOVED GRAND PARENTS

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The Author

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ABSTRACT

The experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, during October 2010 to April 2011 to find out the effect of organic manure and spacing on the growth and yield of tomato. The experiment consisted of two factors. Factor A: Four levels of organic manures, viz. M_0: Manure (0 t/ha), M_1: Cowdung (20 t/ha), M_2: Vermicompost (10 t/ha) and M_3: Compost (15 t/ha); Factor B: Three types of spacing, viz. S_1: 60 cm x 60 cm, S_2: 60 cm x 45 cm and S_3: 60 cm x 30 cm. The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The significant variations were observed for different parameters. In case of organic manures the highest yield (68.99 t/ha) was found from M_2 and the lowest (32.62 t/ha) from M_0. In case of spacing the highest yield (52.58 t/ha) was obtained from S_1 and the lowest (43.32 t/ha) from S_3. For combined effect the highest yield (75.75 t/ha) was obtained from M_2S_1 and the lowest (29.07 t/ha) from M_0S_1. The highest benefit cost ratio (2.43) was obtained from M_2S_1. So, vermicompost (10 t/ha) with 60 cm x 60 cm spacing was found suitable for growth and yield of tomato.

LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
et al.	and others
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
M_0	Control
M_1	Cowdung
M_2	Vermicompost
M_3	Compost
°C	Degree celsius
DAS	Date after seeding
etc	Etcetera
FAO	Food and Agriculture Organization
g	Gram
ha	Hectare
hr	Hour
kg	Kilogram
m	Meter
mm	Millimeter
Mo	Month
no.	Number
%	Percent
RCBD	Randomized Complete Block Design
m^2	Square meter
UNDP	United Nations Development Program
t	ton

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **“Effect of Organic Manure and Spacing on Growth and yield of tomato ”** submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **Md. Ashraful Alam Prodhan, Registration No. 05-01699**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

Dated: June, 2011
Place: Dhaka, Bangladesh

Md. Arfan Ali
Assistant Professor
Dept. of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae is one of the most important and popular vegetable crops. The centre of origin of the genus *Lycopersicon* is the Andean zone particularly Peru-Ecuador-Bolivian areas (Salunkhe *et al*., 1987), but cultivated tomato was originated in Mexico. The crop ranks top the list of canned vegetables (Chowdhury, 1979) and next to potato and sweet potato in the world vegetable production (FAO, 1997) and is adapted to a wide range of climates. However, in spite of its broad adaptation, production is concentrated in a few area and rather dry area (Cuortero and Fernandez, 1999).

The popularity of tomato and its different products are increasing day by day. They are extensively used in the canning industry for canning. Food value of tomato is very rich because of higher contents of vitamins A, B and C including calcium and carotene (Bose and Som, 1990). Tomato adds flavor to the foods and it is also popular for its medicinal value. It is widely employed in cannery and made into soups, conserves, pickles, ketchup, sauces, juices etc. Tomato juice has become an exceedingly popular appetizer and beverage. The well ripped tomato (per 100 g of edible portion) contains water (94.1%); energy (23 calories); calcium (1.0 gm); magnesium (7.0 mg); vitamin A (1000 IU); ascorbic acid (22 mg); thiamin (0.09 mg); riboflavin (0.03 mg); niacin (0.8 mg) (Mac Gillivary, 1961).

In Bangladesh, the yield of tomato is not enough satisfactory in comparison with other tomato growing countries of the World (Aditya *et al*., 1997). Bangladesh grew tomato in around 15.7 thousand hectares of land in the year 2007-2008 with a total production of 143 thousand tons (BBS, 2009). The low yield of tomato in Bangladesh is due to the deficiency of soil nutrients and it is now considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). The cultivation of tomato requires proper supply of plant nutrient. This requirement can be provided by applying inorganic fertilizer or organic manure or both.

The use of proper amount of organic manure such as cowdung, compost and vermicompost improve texture, structure, humus, color, aeration, water holding capacity and microbial activity of soil. 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. It also promotes the vegetative growth, flowering and fruit set of tomato.

Our farmers are habituated in the use of nitrogenous, phosphoric and potassic fertilizer than organic manure. On the other hand, organic manure is not always easily available. Moreover, the farmers are not fully aware about the importance of use of organic manure. So, in our country, the application of organic manure needs to be encouraged.

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 Babu, 2002).

Composting has been recognized as a low cost and environmentally sound process for treatment of many organic wastes (Hoitink *et al*., 1993). Bevacqua and Mellano (1993) reported that compost-treated soils had lower pHs and increased levels of organic matter, primary nutrients, and soluble salts. In crop studies, Bryan and Lance (1991) found that tomatoes grown in compost-amended soils yielded more. Maynard (1993) also reported increases in fruit yield of compost-amended plants compared with those growing in soil alone. Furthermore, composting and composts have been reported to suppress plant pathogens.

Spacing plays a vital role for proper growth and development of plant. Optimum spacing may ensure better growth and yield of tomato. In appropriate time, dose and proper method is prerequisite for any crop cultivation (Islam, 1992). Generally, a large amount of Organic Manure is required for the growth of tomato (Opena *et al*., 1988). It is especially important in a multi nutrient fertilizer application.

Therefore, to increase yield of production and better quality fruit, an attempt was made to study the effects of organic manure and spacing on plant growth and yield of tomato with the following objectives-

- to determine the optimum level of organic manure for growth and yield of tomato ;
- to determine the optimum spacing for attaining desirable yield of tomato ; and
- to evaluate the combine effects of organic manure and spacing on the yield of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the important vegetable crops in Bangladesh and other countries of the world and it has drawn attention by the researchers for its various ways of consumptions. But very few research works related to organic manures and spacing with growth, yield and development of tomato variety have been carried out. The research work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works and research findings related to organic manures and spacing in tomato, so far been done at home and abroad on this crop, have been reviewed in this chapter under the following heads-

2.1 Effect of organic manures on growth and yield of tomato

Cowdung

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 *(Lycopersicon esculentum)* 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% greater 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 wastw 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 groth, 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.

Hallorans *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 Cumulic Haplustoll 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.

Effect of compost on growth and yield of tomato

Compost have shown to enhance tomato plant growth in several occasions and these growth enhancements have been attributed to an improvement of the physical, chemical and biological properties of the growing substrate. Generally, replacement of peat with moderate amounts of compost produces beneficial effects on plant growth due to the increase on the bulk density of the growing media, and to the decrease on total porosity and amount of readily available water in the pots (Papafotiou *et al.*, 2005).

Chaoui *et al.*(2003) observed that the amount of nutrients in these amendments varies depending on the parent material from where they are originated, both compost constitute a slow release source of nutrients that supply the tomato plants with the nutrients when they are needed;

Edwards *et al.* (2004) and Grigatti *et al.* (2007) show that compost able to enhance the growth of a wide range of tomato species further what can be expected because of the supply of nutrients.

López-Bucio *et al.* (2003) observed that the compost application improvements in plant growth and morphology involve an enhancement of post-transplant success, since they determine a higher capacity to exploit soil resources and a higher photosynthetic capacity through the increase of the available surface for gas exchange and light interception, all of these features resulting in a potentially higher yield of the plants

2.2 Effect of Vermicompost on growth and yield of tomato

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. The application of vermicompost rendered better performance in respect of all round growth of mulberry plants in the lateritic soil of South West Bengal (Chakraborty *et al.*, 2008).

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.

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.

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; Vermicompos) 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 has been 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.

Tomati *et al*.,(1988) observed that Rootinitiation, increased root biomass, enhanced plant growth and development and sometimes, altera-tions in plant morphology are among the most frequently claimed effects of vermicompost treatment.

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 growthregulating 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.

Tomati *et al*., (1988) observed that a consequence more available nutrients and microbial metabolites are released into the soil due to present of vermicompost.

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.

Edwards and Burrows (1988) reported that vermicomposts increased ornamental seedling emergence compared with those in control commercial plant growth media, using a wide range of test plants such as pea, lettuce, wheat, cabbage, tomato and radish.

Edwards & Burrows (1988) reported that the experiments that we have described here, the addition of pig waste vermicompostconsistently 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 % vermicompostedpig solids into a standard commercial 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.

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.

Subler *et al.,* (1998) reported increased significant increases in tomato seedling weights after substitution of 10 % and 20% vermicompost 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.

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.

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).

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.

Arancon *et al.,* (2002) reported significantly increased growth and yields of field tomatoes (*Lycopersicon esculentum*) and peppers *(Capsicum anuum grossum*) 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 of 10 t/ha and 5 t/ha in 2000 compared with those receiving equivalent amounts of inorganic fertilizer.

Field experiments at The Ohio State University (Arancon *et al*, 2002) demonstrated that soils treated with vermicomposts supplemented to recommended rates with inorganic fertilizers, and planted with tomatoes, had amounts of, total N, orthophosphates, dehydrogenase enzyme activity, and the microbial biomass, that were usually greater than those that received equivalent amounts of inorganic fertilizers only.

In field experiments (Arancon *et al*, 2002) reported similar increases in growth and yields of tomatoes, peppers and strawberries in and the contribution of nutrients in the significant increases of growth and yield of the field crops was eliminated as a possibility, since all treatments were supplemented with organic fertilizers to equalize initial nutrient contents of the soil.

Gallardo-Lara & 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.

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.

Gutierrez *et al.*, (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.

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.

2.2 Effect of spacing on growth and yield of tomato

Vittum and Tapley (1957) in case of spacing, significant variation was observed in number of marketable fruit per plant. 50cm spacing gave higher number of marketable fruits (21) per plant.

Vittum and Tapley (1957) and Gupta and Shakla (1977) was found weight of marketable fruit per plant was also affected by spacing. Higher yield (1.99t/ha) was obtained from wider spacing. Marketable yield increased as planting density increased.

Significantly single fruit weight (111.17g) was obtained from wider spacing. Similar results are also found by Vittum and Tapely (1957) and Roy *et al*., (1954). Wider spacing gave the higher marketable yield (82.39 t/ha). Chen (1989) and Uddin *et al*., (1997) found similar results.

Tomato yield and quality are affected by fertility and spacing among other factors. Nitrogen levels affect many attributes in tomato quality and yield such as fruit firmness, fruit size, total soluble solids, number of fruits per plant and marketable fruit yield. Austin and Dunton (1970).

Pierce (1988) who showed that total season yields increased as plant population increased to an optimum level (20,000 plants) per hectare. They pointed out that increases in density generally increase both early and total yields per hectare.

Vittum and Tapley (1953) found that as densities increased, fruit size decreased, the small fruit size could be due to plant competition caused by population pressure resulting in rapid decrease in size at high densities.

The higher plant population led to competition for finite factors like oxygen, light, water and nutrients (Bleasdale, 1966). Where plants were closely spaced, fruit shading occurred, resulting in low respiration rates and slowed ripening reducing TSS.

Munger (1970) where closer spacing in the row decreased both fruit size and total soluble solids content**.**

Fad (1983) also indicated that closer spacing reduced soluble solids content of tomato fruits.

Pionke *et al*., (1999) observed that increasing plant populations, intra-plant competition becomes more important and eventually only flowers on the earliest clusters set fruits. These early yields increase as plant population increases, because there are more early clusters per unit area.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October 2010 to April 2011. The materials and methods that were used and followed for conducting the experiment are presented under the following headings-

3.1 Experimental site

The study was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find out the effect of organic manure and spacing on the growth and yield of tomato. The location of the experimental site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude and at an elevation of 8.2 m from sea level (Anonymous, 1989).

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and details soil characteristics were presented in Appendix I.

3.3 Climatic condition of the experimental site

The experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, and Dhaka and presented in Appendix II.

3.4 Planting materials

Seedlings of 30 days of BARI Tomato-2 (Ratan) were used. The seedlings of tomato were grown at the seedbed of Horticultural Farm Sher-e-Bangla Agricultural University.

3.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A:	Factor B:
Four levels of organic manure viz.	Three levels of Spacing viz.
i. M_0: Manure (0 t/ha)	i. S_1: 60 cm × 60 cm
ii M_1: Cowdung (20 t/ha)	ii. S_2: 60 cm × 45 cm
iii. M_2: Vermicompost (10 t/ha)	ii. S_3: 60 cm × 30 cm
iv. M_3: Compost (15 t/ha)	

Table 1: Treatment of the experiment

There were 12 (4 × 3) treatment combinations such as M_0S_1, M_0S_2 M_0S_3, M_1S_1, M_1S_2, M_1S_3, M_2S_1, M_2S_2, M_2S_3, $M_3S_{1,}$ M_3S_2 and M_3S_3.

3.6 Design and layout of the experiment

The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 283.02 m^2 with length 26.70 m and width 10.60 m. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatment combinations were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 2.2 m × 1.6 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.7 Raising of seedlings

Tomato seedlings were raised in three seedbeds of 3 m × 1 m size. The soil of the seedbeds was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed carefully from the seedbeds and 5 kg well rotten cow dung was mixed with the soil. Ten grams of seeds were sown on each seedbed on 5 November 2010. After sowing, seeds were covered with light soil. Heptachlor 40 WP was applied @ 4 kg/ha, around each seedbed as precautionary measure against ants and worm. Weeding, mulching, irrigation and shading were done as and when required.

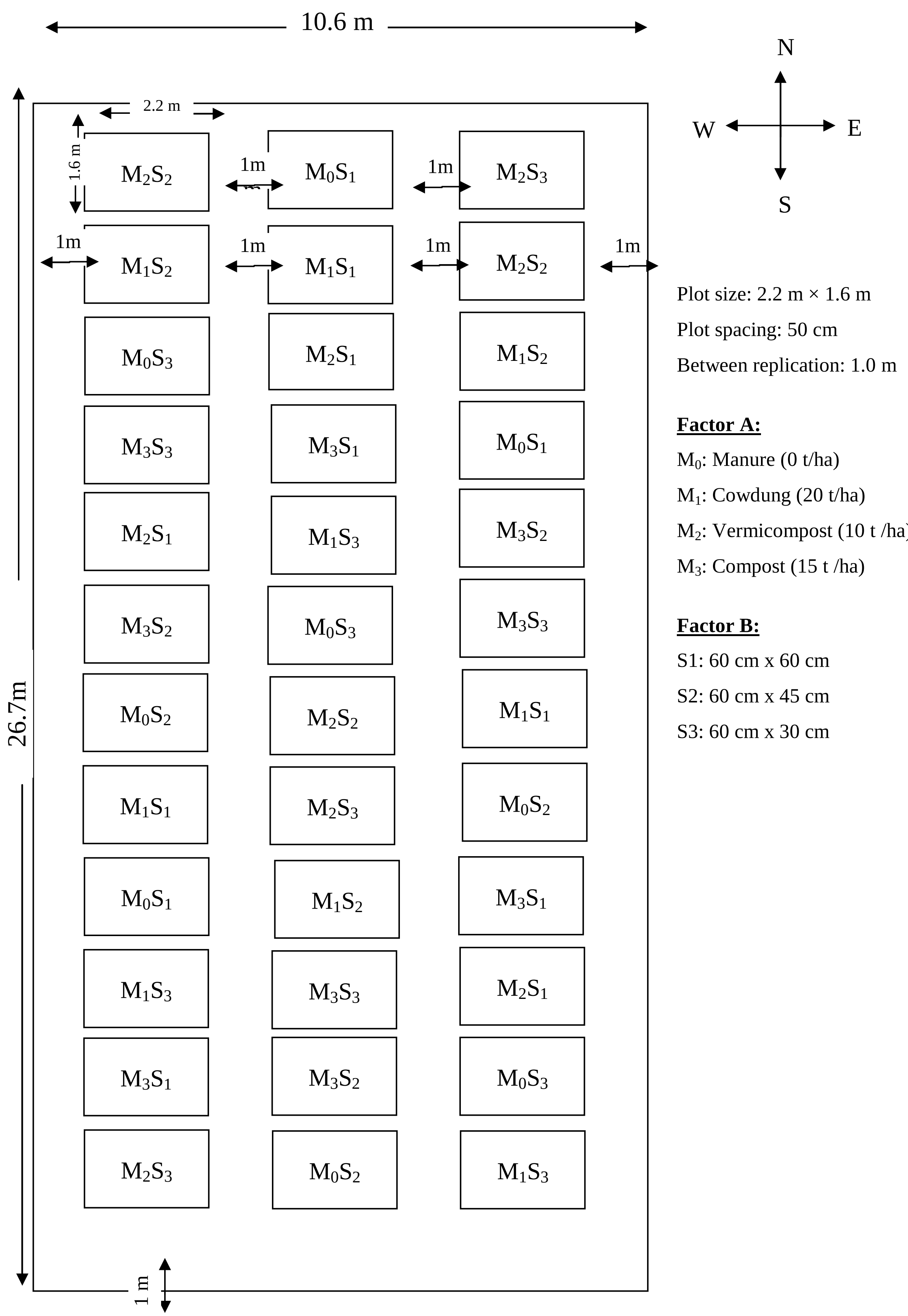


Figure 1. Layout of the experimental plot

3.8 Land preparation

The plot selected for conducting the experiment was opened in the last week of November 2010 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally a desirable tilth of soil was obtained for transplanting tomato seedlings. The experimental plot was partitioned into unit plots in accordance with the design mentioned in Figure 1. Organic manures as indicated below were mixed with the soil of each unit plot.

3.9 Application of manure

The entire amounts of M_1, M_2 and M_3 were applied during the final land preparation. Cowdung contain 0.7% Nitrogen, 0.5% P_2O_5, 0.3% K_2O, Vermicompost and Compost contain 1.5-2.5% Nitrogen, 1.5% P_2O_5, 1.3% K_2O, and 1.0 % Nitrogen, 0.8% P_2O_5, 0.6% K_2O respectively (www.organic manures nitrogen, phosphate and potassium status.com) .

3.10 Transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 6 December 2010 maintaining spacing of 60 cm × 60 cm, 60 cm × 45 cm, 60 cm × 30 cm between the rows and plants, respectively. The seedlings were watered after transplanting. Shading was provided using banana leaf sheaths for three days to protect the seedling from the hot sun and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.11 Intercultural operation

After transplanting of seedlings, various intercultural operations such as irrigation, weeding and top dressing etc. were accomplished for better growth and development of the tomato seedlings.

3.11.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after transplanting in every alternate day in the evening up to seedling establishment. Further irrigation was provided when needed. Excess water was effectively drained out at the time of heavy rain.

3.11.2 Sticking

When the plants were well established, staking was given to each plant by bamboo sticks to keep them erect within a few days of staking, as the plants grew up.

3.11.3 Weeding

Weeding was done to keep the plots clean and easy aeration of soil which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully. During weeding, soil was crusted when needed.

3.12 Plant protection

Malathion 57 EC was applied @ 2 ml L^{-1} against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly for a week after transplanting to a week before first harvesting. Furadan 10 G was also applied during final land preparation to control soil insecticide. During foggy weather precautionary measured against disease infection of tomato was taken by spraying Dithane M-45 fortnightly @ 2 g/L, at the early vegetative stage. Ridomil gold was also applied @ 2 g/L against blight disease of tomato.

3.13 Harvesting

Fruits were harvested at 3 days interval during maturing and ripening stage.The maturity was determined on the basis of red coloring of fruits. Harvesting was started from 22 February 2011 and was continued up to 2 April 2011.

3.14 Data collection

Five plants were randomly selected from each unit plot for the collection of data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect. Data on the following parameters were recorded from the sample plants during the course of experiment.

3.14.1 Plant height

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest stem and mean value was calculated. Plant height was also recorded at 10 days interval starting from 20 days of planting up to 60 days.

3.14.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAT to 60 DAT at 10 days interval.

3.14.3 Number of branches per plant

The total number of branches per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAT to 60 DAT at 10 days interval.

3.14.4 Days required for transplanting to 1st flowering

Days required for transplanting to initiation of flowering was counted from the date of transplanting to the initiation of flowering.

3.14.5 Days required for transplanting to 1st harvesting

Days required for transplanting to 1st harvesting was counted from the date of transplanting to the harvesting of fruits at first time.

3.14.6 Number of flower cluster per plant

The number of flower cluster was counted from the sample plants and the average numbers of flower clusters produced per plant were recorded.

3.14.7 Number of flowers per cluster

The number of flower was counted from the sample plants and the average number of flower produced per cluster was recorded on the basis of flower cluster per plant.

3.14.8 Number of flowers per plant

The number of flower per plant was counted from the sample plants and the average number of flowers per plant was recorded.

1.14.9 Number of fruits per cluster

The number of fruits per cluster was counted from the sample plants and the average number of fruits per clusters was recorded.

3.14.10 Number of fruits per plant

The number of fruit per plant was counted from the sample plants and the average number of fruits per plant was recorded.

3.14.11 Length of fruit

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 selected marketable fruits from each plot and there average was taken and expressed in cm.

3.14.12 Diameter of fruit

Diameter of fruit was measured at the middle portion of 10 selected marketable fruit from each plot with a slide calipers and there average was taken and expressed in cm.

3.14.13 Dry matter content of plant

After harvesting, 150 g plant sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature until constant weight. The final weight of the sample was taken. The dry matter contents of plant were computed by simple calculation from the weight recorded by the following formula:

$$\% \text{ Dry matter content of plant} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of plant}} \times 100$$

3.14.14 Dry matter content of fruit

After harvesting, randomly selected 150 g fruit sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down until constant weight at room temperature. The final weight of the sample was taken. The dry matter contents of fruit were computed by simple calculation from the weight recorded by the following formula:

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

3.14.15 Average weight of individual fruit

Among the total number of fruits during the period from first to final harvest the fruits, except the first and final harvest, was considered for determining the individual fruit weight by the following formula:

$$\text{Average weight of individual fruit} = \frac{\text{Total weight of fruit}}{\text{Total number of fruits}}$$

3.14.16 Yield per plant

Yield of tomato per plant was recorded as the whole fruit per plant and was expressed in kilogram (kg).

3.14.17 Yield per hectare

Yield per hectare of tomato fruits was calculated by converting the weight of plot yield into hectare and was expressed in ton.

3.15 Statistical analyses

The data obtained for different characteristics were statistically analyzed to find out the significant differences on yield and yield contributing charaM0eristics of tomato. The mean values of all the recorded parameters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the differences among means of the treatment combinations of was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.16 Economic analyses

The cost of production was analyzed in order to find out the most economic combination of Organic manure and Spacing. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple rate. The market price of tomato was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of organic manure and spacing on the growth and yield of tomato. Data on different growth parameters and yield of tomato were recorded and the analysis of variance (ANOVA) of the data is presented in the Appendix III-VII. The results have been presented and discussed, and possible interpretations are given under the following headings:

4.1 Plant height

Plant height of tomato showed significant variation at 20, 30, 40, 50 and 60 DAT due to the application of different levels of organic manure (Fig. 2). At 20 DAT, the longest plant (31.57 cm) was recorded from M_2 (10 ton/ha) which was statistically similar (28.18 cm) to M_3 (15 ton/ha) and followed (26.61 cm) by M_1 (20 ton/ha), whereas the shortest (19.72 cm) from M_0 (0 ton manure/ha). At 30 DAT, the longest plant was observed from M_2 (42.01 cm) which was statistically identical to M_3 (37.14 cm) and followed by M_1 (36.88 cm), while the shortest from M_0 (28.57 cm). At 40 DAT, the longest plant was obtained from M_2 (58.91 cm) which was statistically similar to M_3 (54.16 cm) and M_1 (53.71 cm), again the shortest was found from M_0

(42.97 cm). At 50 DAT, the longest plant was found from M_2 (76.30 cm) which was similar to M_3 (73.06 cm) and M_1 (70.00 cm) and the shortest from M_0 (57.62 cm). At 60 DAT, the longest plant was found from M_2 (89.97 cm) which was statistically identical to M_3 (88.17 cm) and M_1 (82.87 cm) whiles the shortest from M_0 (65.12 cm).

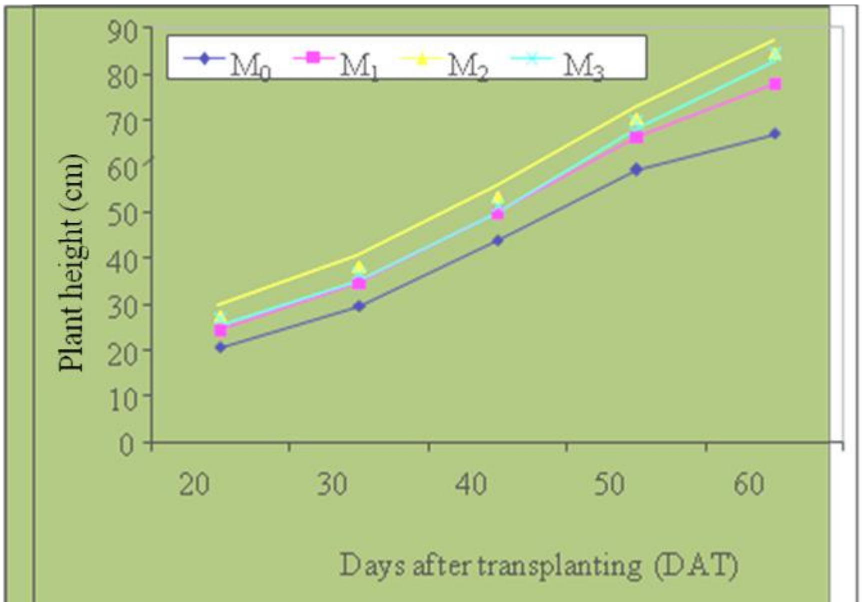


Figure 2. Effect of Organic Manure on plant height of tomato

M_0: Control

M_1: Cowdung

M_2: Vermicompost

M_3: Compost

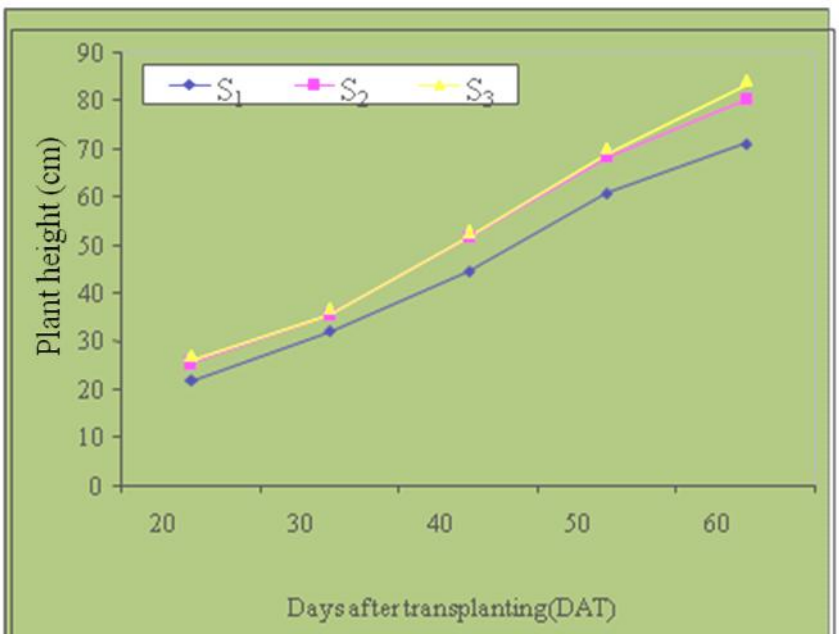


Figure 3. Effect of Spacing on plant height of tomato

S_1: 60 cm x 60 cm
S_2: 60 cm x 45 cm
S_3: 60 cm x 30 cm

Significant variation was recorded on plant height of tomato due to maintaining different type of spacing at 20, 30, 40, 50 and 60 DAT (Figure 3). The longest plant (31.57, 42.01, 58.91, 76.30 and 89.87 cm) was obtained from S_1 (60 cm ×60 cm) which was statistically similar (30.17, 40.65, 57.30, 74.67, and 92.02 cm) with S_2 (60 cm ×45 cm). Again, the shortest plant (19.72, 28.57, 42.97, 57.62 and 65.12 cm) was recorded from S_3 (60 cm ×30 cm) at 20, 30, 40, 50 and 60 DAT, respectively.

Combined effect of organic manure and spacing showed significant variation in terms of plant height of tomato at 20, 30, 40, 50 and 60 DAT (Table 2). The longest plant (31.57, 42.01, 58.91, 76.30 and 96.97 cm) was found from M_2S_1 (10ton Vermicompost/ha and 60 cm ×60 cm spacing), while the shortest plant (19.72, 28.57, 42.97 and 57.62 cm) was recorded from M_0S_3 (0 ton manuring/ha and 60×30 cm spacing) for 20, 30, 40 and 50 DAT, respectively while at 60 DAT the shortest plant (65.12 cm) was recorded from M_2S_3 (10 ton/ha and 60 cm ×30 cm spacing).

It was observed that 10 ton/ha Vermicompost doses of organic manure and 60 cm × 30 cm spacing showed optimum vegetative growth and the ultimate results was the tallest plant.

Table 2. Combined effect of Organic Manure and Spacing on plant height at different days after transplanting (DAT) of tomato

Treatments	Plant height (cm) at				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
M_0S_1	22.15 de	30.84 e	45.08 c	60.88 d	69.28 e
M_0S_2	20.06 e	29.61 e	44.11 c	59.47 d	66.10 e
M_0S_3	19.72 e	28.57 e	42.97 c	57.62 d	65.85 e
M_1S_1	26.61 bc	36.88 bc	53.71 a	70.00 abc	82.87 bc
M_1S_2	24.75 cd	35.85 cd	51.87 ab	68.31 bc	79.20 cd
M_1S_3	21.34 de	31.00 e	43.94 c	60.42 d	71.87 de
M_2S_1	31.57 a	42.01 a	58.91 a	76.30 a	96.97 a
M_2S_2	30.17 ab	40.65 ab	57.30 a	74.67 ab	92.02 ab
M_2S_3	20.59 e	31.86 de	43.33 c	59.70 d	65.12 e
M_3S_1	28.18 abc	37.11 bc	53.60 a	73.06 ab	88.17 abc
M_3S_2	27.32 bc	37.14 bc	54.16 a	72.42 ab	83.78 bc
M_3S_3	25.16 cd	35.50 cd	46.58 bc	63.28 cd	81.00 cd
$LSD_{(0.05)}$	3.579	4.042	6.340	6.643	9.066
Level of significance	0.05	0.05	0.05	0.05	0.05
CV (%)	8.52	6.87	7.54	5.91	6.82

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

4.2 Number of leaves per plant

Significant variation was found on number of leaves per plant of tomato at 20, 30, 40, 50 and 60 DAT due to application of different levels organic manure (Figure 4). At 20 DAT, the maximum number of leaves per plant (7.01) was found from M_2 which was statistically identical (6.73 and 6.87) with M_3 and by M_1, whereas the minimum number (4.63) from M_0. At 30 DAT, the maximum number of leaves per plant was recorded from M_2 (17.87) which was statistically similar to M_3 (17.17) and M_1 (17.13), while the minimum number from M_0 (13.40). At 40 DAT, the maximum number of leaves per plant was observed from M_2 (30.97) which were statistically similar to M_3 (30.57) and closely followed by M_1 (28.83), again the minimum number from M_0 (23.27). At 50 DAT, the maximum number of leaves per plant was obtained from M_2 (38.57) which was identical to M_3 (37.80) and followed by M_1 (35.87), whereas the minimum number from M_0 (28.79). At 60 DAT, the maximum number of leaves per plant was recorded from M_2 (55.33) which was statistically identical to M_3 (51.33) and M_1 (54.00), while the minimum number from M_0 (42.33). It was observed that 10 ton/ha vermicompost ensured optimum vegetative growth with maximum number of leaves per plant. So the optimum level of organic manure make the availability of macro and micro nutrients and the ultimate results was the maximum number of leaves per plant.

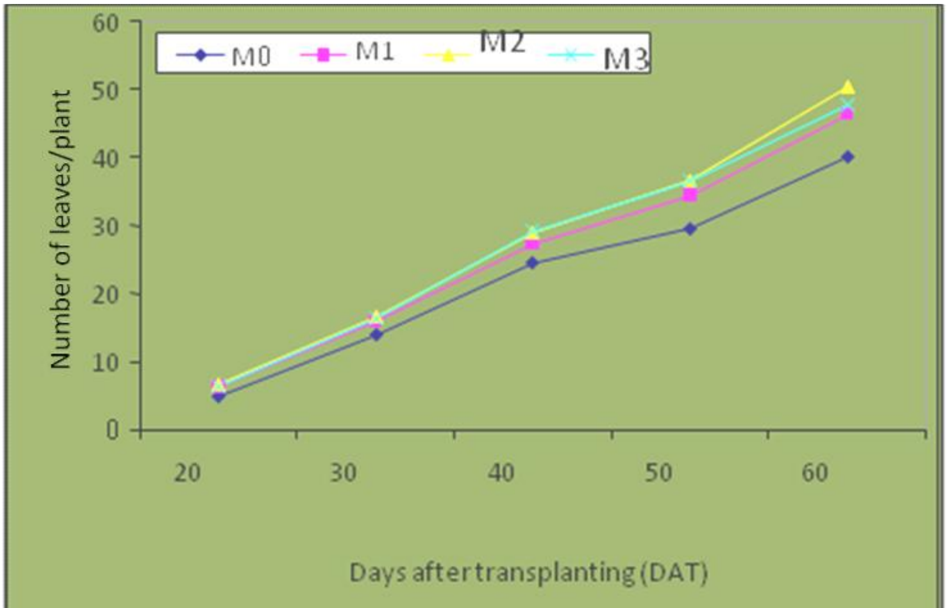


Figure 4. Effect of Organic manure on number of leaves per plant of tomato

M_0:Control

M_1: Cowdung

M_2: Vermicompost

M_3: Compost

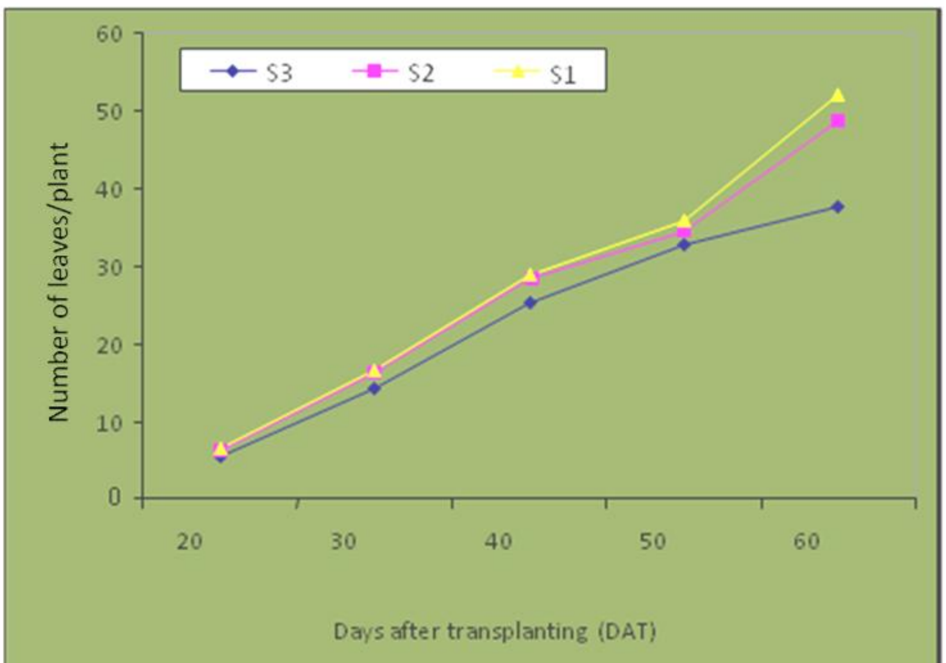


Figure 5. Effect of Spacing on number of leaves per plant of tomato

S_1: 60 cm x 60 cm
S_2: 60 cm x 45 cm
S_3: 60 cm x 30 cm

Different type of spacing varied significantly on number of leaves per plant of tomato at 20, 30, 40, 50 and 60 DAT (Figure 5). At 20 DAT, the maximum number of leaves per plant (7.20) was recorded from S_1 (60 cm ×60cm) which was statistically identical (7.03) to S_2 (60cm ×45cm) again, the minimum number (4.63) from S_3 (60 cm ×30cm). At 30 DAT, the maximum number of leaves per plant was recorded from S_1 (17.79) which were statistically identical to S_2 (17.67) again, the minimum number from S_3 (13.50). At 40 DAT, the maximum number of leaves per plant was recorded from S_1 (30.07) which were statistically similar to S_2 (30.63) whereas the minimum number was observed from S_3 (23.57). At 50 DAT, the maximum number of leaves per plant was found from S_1 (38.37) which were closely followed by S_2 (37.37) while, the minimum number from S_3 (27.97). At 60 DAT, the maximum number of leaves per plant was recorded from S_1 (54.33) which were statistically identical to S_2 (52.35) again, the minimum number from S_3 (37.53). Bose and Tripathi (1996) also reported similar results earlier.

Number of leaves per plant at 20, 30, 40, 50 and 60 DAT showed significant variation due to the combined effect of OM and Spacing (Table 3). The maximum number of leaves per plant (7.30, 17.97, 31.07, 39.37 and 61.33) was observed from M_2S_3 (Verrmicompost 10 ton/ha and 60cm x 30cm). On the other hand, the minimum number of leaves per plant (4.73, 13.60, 23.87, 28.97 and 32.33) was recorded from M_0S_1 (control and 60cm x 60cm) for 20, 30, 40 50 and 60 DAT.

Table 3. Combined effect of organic manure and spacing on number of leaves per plant at different days after transplanting (DAT) of tomato

Treatments	Number of leaves per plant at				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
M_0S_1	4.73 f	13.60 b	23.87 c	28.97 g	32.33 f
M_0S_2	4.77 f	13.83 b	24.60 c	29.57 g	38.67 ef
M_0S_3	4.90 ef	14.13 b	24.93 c	30.37 fg	41.99 de
M_1S_1	6.60 abc	16.73 a	28.27 ab	34.57 cde	50.00 bcd
M_1S_2	5.73 d	14.20 b	25.00 c	33.20 de	45.33 ef
M_1S_3	6.87 abc	17.13 a	28.83 ab	35.87 bc	54.00 abc
M_2S_1	5.50 de	13.90 b	25.10 c	32.53 ef	52.33 f
M_2S_2	7.03 ab	17.67 a	30.63 a	37.97 ab	57.33 ab
M_2S_3	7.30 a	17.97 a	31.07 a	39.37 a	61.33 a
M_3S_1	6.13 cd	15.10 b	26.30 bc	35.53 bcd	43.00 de
M_3S_2	6.47 bc	16.93 a	30.57 a	36.13 bc	48.67 cd
M_3S_3	6.73 abc	17.17 a	30.47 a	37.80 ab	51.33 bc
$LSD_{(0.05)}$	0.6857	1.628	2.538	2.432	7.683
Level of significance	0.05	0.05	0.05	0.05	0.05
CV (%)	6.67	9.12	5.46	11.18	9.83

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

4.3 Number of branches per plant

Application of different levels of organic manure differed significantly on number of branches per plant of tomato at 20, 30, 40, 50 and 60 DAT (Figure 6). At 20 DAT, the maximum number of branches per plant (6.40) was recorded from M_2 (10 ton/ha) which was statistically identical (5.84 and 5.76) to M_3 and M_1 , while the minimum number (3.30) from M_0. At 30 DAT, the maximum number of branches per plant was obtained from M_2 (8.42) which was statistically identical to M_3 (8.04) and followed by M_1 (7.02), while the minimum number from M_0 (5.62). At 40 DAT, the maximum number of branches per plant was obtained from M_2 (13.85) which was statistically identical to M_3 (13.39) and followed by M_1 (12.34), whereas the minimum number from M_0 (9.14). At 50 DAT, the maximum number of branches per plant was found from M_2 (18.45) which was identical to M_3 (18.39) and followed by M_1 (17.90), again the minimum number from M_0 (12.44). At 60 DAT, the maximum number of branches per plant was found from M_2 (23.50) which was statistically identical to M_3 (23.37) and M_1 (21.83), while the minimum number from M_0 (17.33).

Significant variation was observed at 20, 30, 40, 50 and 60 DAT for number of branches per plant of tomato for the effect of spacing (Figure 7). At 20 DAT, the maximum number of branches per plant (6.05) was attained from S_1 (60cm x 60cm) which was statistically identical (5.80) to S_2 (60 cm x 45 cm) and the minimum number (3.31) was observed from S_3 (60 cm x 30cm).

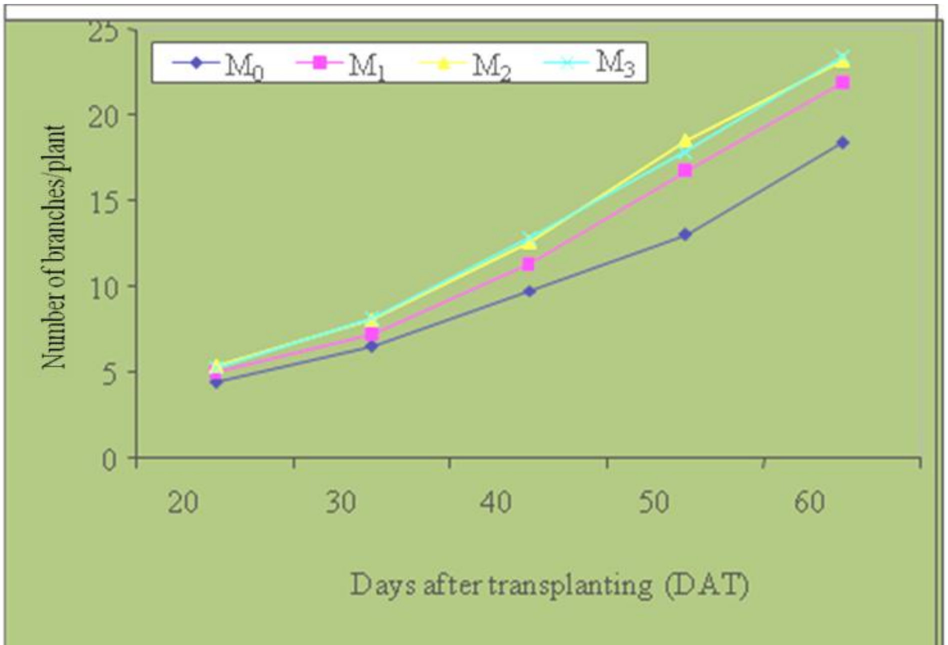


Figure 6. Effect of organic manure on number of branches/plant of tomato

M_0: Control

M_1: Cowdung

M_2: Vermicompost

M_3: Compost

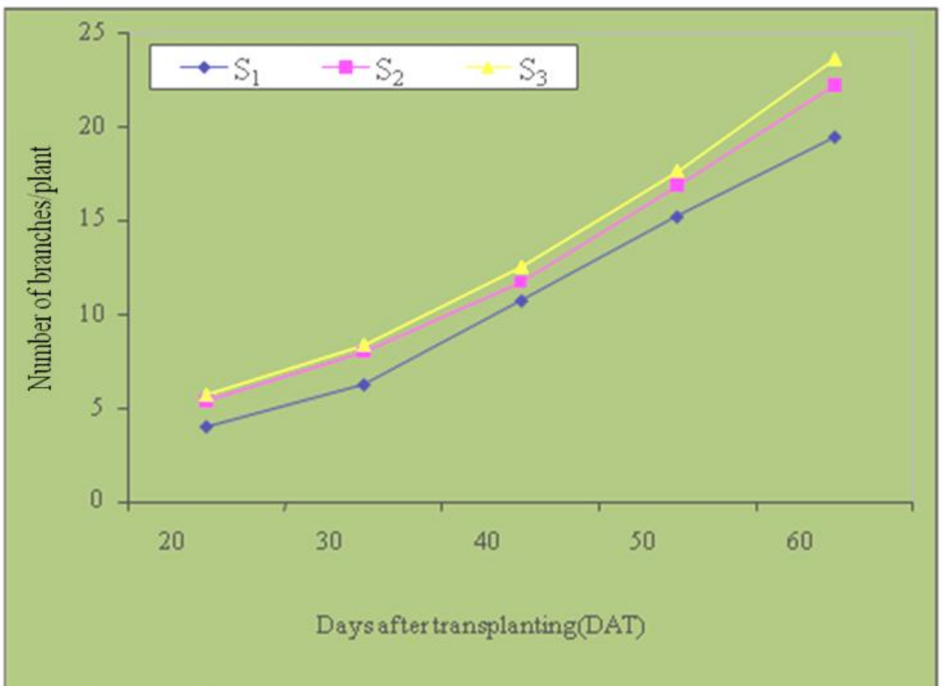


Figure 7. Effect of spacing on number of branches/plant of tomato

S_1: 60 cm x 60 cm
S_2: 60 cm x 45 cm
S_3: 60 cm x 30 cm

At 30 DAT, the maximum number of branches per plant was recorded from S_1 (7.82) which were statistically identical to S_2 (7.52) again, the minimum number was observed from S_3 (5.72). At 40 DAT, the maximum number of branches per plant was found from S_1 (13.85) which were closely followed by S_2 (13.73) while the minimum number was observed from S_3 (9.94). At 50 DAT, the maximum number of branches per plant was recorded from S_1 (18.45) which were statistically similar to S_2 (18.10) whereas, the minimum number was observed from S_3 (15.01). At 60 DAT, the maximum number of branches per plant was observed from S_1 (23.65) which were closely followed by S_2 (22.67) again, the minimum number from S_3 (19.96).

Significant variation was recorded for the combined effect of organic manure and spacing on number of branches per plant at 20, 30, 40, 50 and 60 DAT (Table 4). The maximum number of branches per plant (6.50, 9.42, 13.85, 20.45 and 26.13) was observed from M_2S_3 (10 ton/ha and 60cm x 30cm) whereas the minimum (3.31, 5.72, 9.14, 12.44 and 17.33) was recorded from M_0S_1 (0 ton/ha and 60cm x 60cm) for 20, 30, 40, 50 and 60 DAT, respectively.

It was revealed that 10 ton/ha Vermicompost ensured optimum vegetative growth with maximum number of branches per plant. Johnston *et al*. (2003) also reported maximum number of branches per plant with higher doses of organic manure. It was observed that with the increase of spacing number of branches per plant also increase a certain level. Similar findings also reported by Naresh Babu (2002) and Cengiz *et al*. (2009).

Table 4. Combined effect organic manure and spacing on number of branches per plant at different days after transplanting (DAT) of tomato

Treatments	Number of branches per plant at				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
M_0S_1	3.31 d	5.72 e	9.14 d	12.44 g	17.33 d
M_0S_2	4.45 c	6.64 de	9.76 cd	13.01 g	18.90 d
M_0S_3	4.59 c	6.77 de	10.38 cd	13.61 fg	19.13 d
M_1S_1	3.95 cd	6.19 e	10.42 cd	15.18 ef	19.67 cd
M_1S_2	5.46 b	7.59 cd	11.34 bc	17.13 cde	22.20 bc
M_1S_3	5.76 ab	8.02 bc	12.34 ab	17.90 bc	23.83 ab
M_2S_1	4.22 c	6.12 e	10.17 cd	15.40 def	22.83 d
M_2S_2	6.23 ab	9.12 a	13.73 a	19.73 ab	24.67 ab
M_2S_3	6.50 a	9.42 a	13.85 a	20.45 a	26.13 a
M_3S_1	4.20 c	6.36 e	12.46 ab	17.27 cd	20.13 cd
M_3S_2	5.64 ab	9.04 ab	12.56 ab	17.98 bc	24.60 ab
M_3S_3	5.84 ab	9.03 ab	13.39 a	18.39 bc	25.37 a
$LSD_{(0.05)}$	0.8138	0.9946	0.5193	1.914	2.796
Level of significance	0.05	0.05	0.05	0.05	0.05
CV (%)	9.59	7.83	7.73	6.83	7.60

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

4.4 Days required for transplanting to 1st flowering

Days required for transplanting to 1st flowering of tomato varied significantly due to the application of different levels of organic manures (Table 5). The highest days from transplanting to 1st flowering (32.40) was recorded from M_3 (15 ton/ha) which was statistically identical (32.33 and 30.47) to M_0 (0 ton manure/ha) and M_1 (20 ton/ha), respectively. On the other hand, the lowest days (28.67) was recorded from M_2 (10 ton/ha). Chapagain *et al*., (2003) also reported similar findings.

Types of spacing showed significant differences in terms of days required for transplanting to 1st flowering of tomato (Table 5). The highest period were days required transplanting to 1st flowering (31.90) was from S_3 (60 cm x 30 cm) which was statistically identical (31.30) to S_2 (60 cm x 45 cm) again, the lowest days (29.70) was recorded from S_1 (60 cm x 60 cm).

Organic manure and spacing showed significant variation due to the combined effect for days required for transplanting to 1st flowering (Table 6). The highest days from transplanting to 1st flowering (36.40) was found from M_0S_1 (0 ton manure/ha and 60 cm x 60 cm), while the lowest days (25.20) was recorded from M_2S_1 (10 ton/ha and (60 cm x 60 cm).

Table 5. Effect of organic manure and spacing on yield contributing characters of tomato

Treatments	Days required for transplanting to 1st flowering	Days required for transplanting to 1st harvesting	Number of flower cluster/plant	Number of flowers/cluster	Number of fruits/cluster	Number of fruits/plant
Levels of organic manure						
M_0	32.33 a	78.20 a	7.79 c	4.57 b	3.37 c	25.1 d
M_1	30.47 ab	75.19 b	9.59 b	5.68 a	3.45 c	33.15 c
M_2	28.67 b	70.88 c	10.76 a	6.02 a	4.19 a	45.12 a
M_3	32.40 a	77.84 a	9.79 b	5.99 a	3.80 b	37.21 b
$LSD_{(0.05)}$	2.068	1.741	0.4819	0.6206	0.3272	3.375
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
Types of spacing						
S_1	29.70 b	75.08 b	7.58 b	6.25 a	4.27 a	32.5 b
S_2	31.30 ab	74.97 b	8.95 a	5.97 a	3.95 b	35.75 a
S_3	31.90 a	76.78 a	8.75 a	4.47 b	4.36 a	38.15 a
$LSD_{(0.05)}$	1.791	1.507	0.4174	0.5375	0.2833	2.922
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	6.83	7.25	5.26	11.41	8.99	9.68

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

Table 6. Combined effect of organic manure and spacing on yield contributing characters of tomato

Treatments	Days required for transplanting to 1st flowering	Days required for transplanting to 1st harvesting	Number of flower cluster/plant	Number of flowers/cluster	Number of fruits/cluster	Number of fruits/plant
M_0S_1	36.40 a	77.93 a	8.37 d	4.13 b	2.50 c	20.88 e
M_0S_2	33.60 ab	74.93 b	9.07 b	6.20 a	3.90 a	26.30 de
M_0S_3	28.20 cd	75.90 a	7.80 e	4.20 b	3.60 b	28.05 d
M_1S_1	32.40 b	70.97 c	7.80 e	4.87 b	4.10 a	32.12 d
M_1S_2	33.20 ab	71.90 bc	7.77 e	4.63 b	4.15 a	32.48 d
M_1S_3	30.20 bc	71.67 bc	8.69 c	6.27 a	3.97 a	34.95 c
M_2S_1	25.20 d	70.80 c	10.17 a	6.97 a	4.33 a	43.40 bc
M_2S_2	30.80 bc	71.50 bc	10.07 a	6.63 a	4.27 a	46.55 ab
M_2S_3	29.60 bc	72.97 bc	10.10 a	6.80 a	4.23 a	48.70 a
M_3S_1	32.40 b	71.80 bc	9.80 a	4.87 b	3.70 b	35.12 d
M_3S_2	28.00 cd	71.67 bc	10.03 a	6.63 a	3.53 b	36.23 c
M_3S_3	31.20 bc	75.73 ab	9.70 a	6.53 a	4.10 a	39.80 ab
$LSD_{(0.05)}$	3.582	3.015	0.8347	1.075	0.5667	5.845
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	6.83	7.25	5.26	11.41	8.99	9.68

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

4.5 Days required for transplanting to 1st harvesting

Significant variation was recorded in days required for transplanting to 1st harvesting due to the application of different type of organic manure (Table 5). The highest days from transplanting to 1st harvesting (78.20) was observed from M_0 (0 ton manure/ha), statistically similar (75.19 and 77.84) with M_1 (20 t/ha) and M_3 (15 t/ha), respectively and the lowest days (70.88) from M_2 (10 ton/ha).

Significant difference was observed in days required for transplanting to 1st harvesting of tomato for different types of spacing (Table 5). The lowest days required for transplanting to 1st harvesting (74.97) was obtained from S_2 which was statistically similar (75.08) with S_1, while the highest days (76.78) was found from S_3 .

Combined effect of organic manure and spacing varied significantly for days from transplanting to 1st harvesting (Table 6). The highest days from transplanting to 1st harvesting (77.93) was observed from M_0S_1. On the other hand, the lowest days (70.80) was recorded from M_2S_1.

4.6 Number of flower cluster per plant

Number of flower cluster per plant of tomato showed significant variation due to the application of different levels of organic manures (Table 5). The highest number of flower cluster per plant (10.76) was obtained from M_2 which was statistically similar (9.79 and 9.59) to M_3 and M_1, respectively and the lowest number (7.79) from M_0.

Significant variation was observed on number of flower cluster per plant of tomato for application of different levels of spacing (Table 5). The highest number of flower cluster per plant (8.95) was found from S_2 (60cm x 45cm) which was statistically identical (8.75) with S_3 (60cm x 30cm) and the lowest number (7.58) was obtained from S_1 (60cm x 60cm).

Number of flower cluster per plant varied significantly for the combined effect of organic manures and spacing (Table 6). The highest number of flower cluster per plant (10.17) was recorded from M_2S_1, while the lowest number (7.77) was attained from M_1S_2.

4.7 Number of flowers per cluster

Number of flowers per cluster of tomato showed significant variation for different levels of organic manures (Table 5). The highest number of flowers per cluster (6.02) was observed from M_2 (10 ton/ha) which was statistically identical (5.99 and 5.68) with M_3 (15 t/ha) and M_1 (20 t/ha), respectively and the lowest number (4.57) from M_0 (0 t manure/ha).

The highest number of flowers per cluster (6.25) was observed from S_1 (60cm x 60cm) which was statistically similar (5.97) with S_2 (60cm x 45cm) again; the lowest number (4.47) was recorded from S_3 (60 cm x 30 cm) (Table 5).

Combined effect of organic manures and spacing showed significant differences for number of flowers per cluster (Table 6). The highest number of flowers per cluster

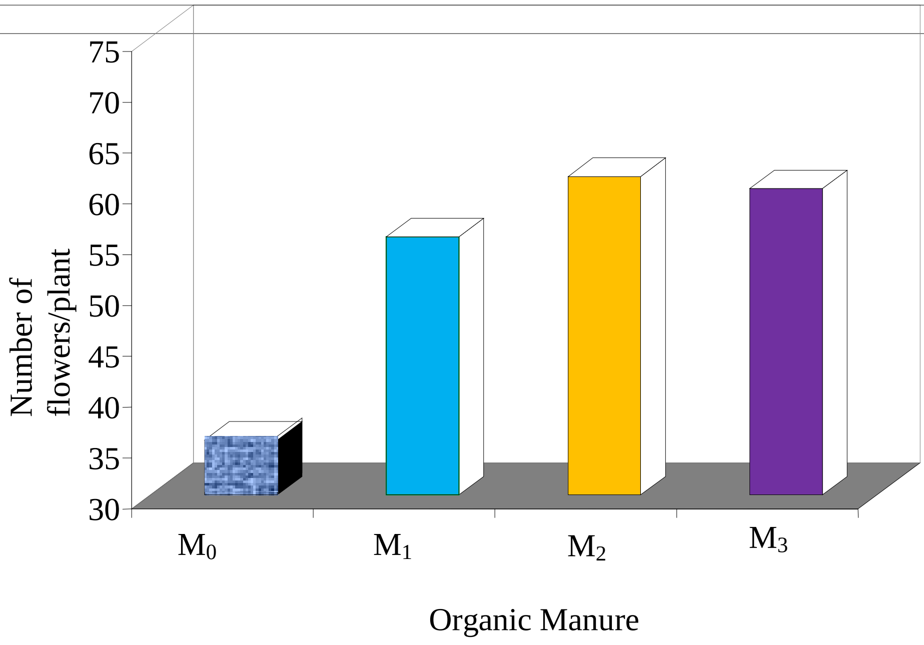
(6.97) was recorded from M_2S_1 (10 ton/ha and 60 cm x 60 cm). On the other hand, the lowest number (4.13) was found from M_0S_1 (0 t manure/ha and 60 cm x 60 cm) i.e. control condition.

4.8 Number of flowers per plant

Significant variation was recorded for the number of flowers per plant of tomato due to the application of different levels of organic manures (Figure 8). The highest number of flowers per plant (64.77) was observed from M_2 (10 ton/ha) which was statistically similar (58.64 and 54.40) with M_3 (15 t/ha) and M_1 (20 t/ha), respectively. On the other hand, the lowest number (35.41) was recorded from M_0 (0 t manure/ha).

Number of flowers per plant of tomato differed significantly for the different levels of spacing (Figure 9). The highest number of flowers per plant (64.12) was found from S_1 (60 cm x 60 cm) which was statistically identical (61.15) with S_2 (60 cm x 45 cm) again; the lowest number (40.15) was attained from S_3 (60 cm x 30 cm).

Interaction effect of organic manure and spacing showed significant variation in terms of number of flowers per plant (Figure 10). The highest number of flowers per plant (74.54) was obtained from M_2S_1 (10 ton/ha and 60 cm x 60 cm). On the other hand, the lowest number (32.09) was recorded from M_0S_2 (0 t manure/ha and 60 cm x 45 cm).



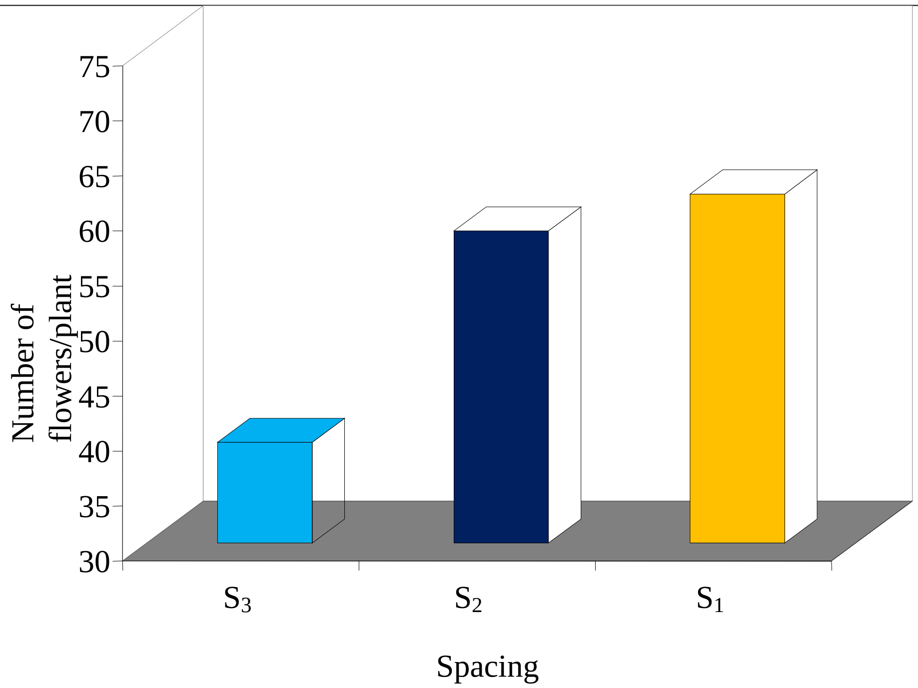
M_0: Control

M_1: Cowdung

M_2: Vermicompost

M_3: Compost

Figure 8. Effect of Organic on total number of flowers/plant of tomato

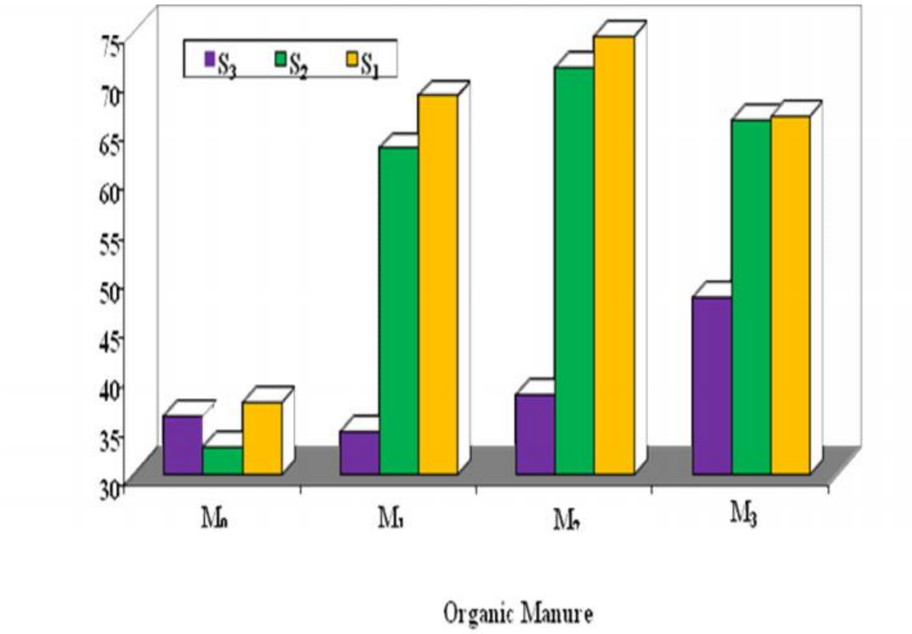


S_1: 60 cm x 60 cm

S_2: 60 cm x 45 cm

S_3: 60 cm x 30 cm

Figure 9. Effect of spacing on total number of flowers/plant of tomato



M$_0$: Control

M$_1$: Cowdung

M$_2$: Vermicompost

M$_3$: Compost

Figure 10. Interaction effect of Organic Manure and spacing on total number of flowers/plant of tomato

S$_1$: 60 cm x 60 cm
S$_2$: 60 cm x 45 cm
S$_3$: 60 cm x 30 cm

4.9 Number of fruits per cluster

Significant variation was recorded for the number of fruits per cluster of tomato due to the application of organic manure (Table 5). The highest number of fruits per cluster (4.19) was recorded from M_2 (10 ton/ha) which was statistically similar (3.80 and 3.45) with M_3 (15 t/ha) and M_1 (20 t/ha), respectively, while the lowest number (3.37) from M_0 (0t/ha).

Different types of spacing significantly affected the number of fruits per cluster of tomato (Table 5). The highest number of fruits per cluster (4.36) was found from S_3 (60 cm x 30 cm) which was closely followed (4.27) by again S_1 (60 cm x 60 cm). The lowest number (3.95) was observed from S_2 (60 cm x 45 cm).

Interaction effect of organic manure and spacing differed significantly for number of fruits per cluster (Table 6). The highest number of fruits per cluster (4.33) was attained from M_2S_1 (10 ton /ha and 60 cm x 60 cm). On the other hand, the lowest number (2.50) was observed from M_0S_1 (0 t/ha and 60cm x 60cm).

10. Number of fruits per plant

Number of fruits per plant of tomato showed significant differences for the application of Organic Manure (Table 5). The highest number of fruits per plant (45.12) was recorded from M_2 (10 ton/ha) which was followed by (37.21) to M_3 (15 t/ha) and also followed to (33.15) by M_1 (20t/ha), respectively. On the other hand, the lowest number (25.1) was observed from M_0 (0 t manure/ha).

Significant variation was recorded on number of fruits per plant of tomato due to the application of different levels of spacing (Table 5). The highest number of fruits per plant (38.15) was obtained from S_3 (60 cm x 30 cm) which was statistically identical (35.75) to S_2 (60 cm x 45 cm) while the lowest number (32.5) was found from S_1 (60 cm x 60 cm).

Number of fruits per plant varied significantly for the interaction effect of organic manure and spacing (Table 6). The highest number of fruits per plant (48.70) was recorded from M_2S_3 (10 ton/ha and 60 cm x 30 cm) and the lowest number (20.88) was attained from M_0S_1 (0t /ha and (60 cm x 60cm).

4.11 Length of fruit

Application of different levels of Organic Manure showed significant effect on length of fruit of tomato (Table 7). The highest length of fruit (5.13 cm) was recorded from M_2 (10 ton/ha) which was statistically identical (5.00 cm) to M_3 (15 t/ha) and closely followed (4.19 cm) by M_1 (20 ton/ha), respectively. On the other hand, the lowest length (4.16 cm) was recorded from M_0 (0 ton/ha).

Significant variation was found on length of fruit of tomato due to the application of different levels of spacing (Table 7). The highest length of fruit (4.85 cm) was observed from S_1 (60 cm x 60 cm) which was statistically similar (4.81 cm) to S_2 (60 cm x 45 cm) and the lowest length (4.20 cm) was observed from S_3 (60 cm x 30 cm).

Combined effect of organic manure and spacing showed significant differences in terms of fruit length (Table 8). The highest length of fruit (5.77 cm) was recorded from M_2S_1 (10 ton/ha and 60 cm x 60 cm) and the lowest length (3.57 cm) was found from M_0S_3 (0 ton/ha and 60 cm x 30 cm).

Table 7. Effect of organic manure and spacing on yield contributing characters and yield of tomato

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Dry matter content/plant (%)	Dry matter content/fruit (%)	Weight of Individual fruit (g)	Yield per hectare (ton)
Level of organic manure						
M_0	4.16 b	3.88 b	7.86 c	8.74 b	64.12 b	32.62 d
M_1	4.19 b	4.07 b	8.46 b	8.96 b	70.25 a	47.39 c
M_2	5.13 a	4.61 a	9.04 a	10.44 a	75.14 a	68.99 a
M_3	5.00 a	4.56 a	8.93 ab	10.26 a	71.23 a	53.94 b
$LSD_{(0.05)}$	0.313	0.3415	0.5470	0.5882	5.245	2.891
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
Level of Spacing						
S_1	4.85 a	4.58 a	8.79 a	10.13 a	79.50 a	52.58 a
S_2	4.81 a	4.49 a	8.95 a	10.01 a	68.25 b	49.65 a
S_3	4.20 b	3.76 b	7.97 b	8.66 b	55.80 c	43.32 b
$LSD_{(0.05)}$	0.2782	0.2957	0.4737	0.5094	4.542	5.28
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	7.12	8.16	6.53	6.26	6.50	8.67

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

Table 8. Combined Effect of organic manure and spacing on yield contributing characters and yield of tomato

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Dry matter content in plant (%)	Dry matter content in fruit (%)	Weight of individual fruit (g)	Yield per hectare (ton)
M_0S_1	4.30 de	4.03 bc	8.20 cdef	9.03 de	68.43 c	29.07 f
M_0S_2	4.08 ef	3.67 c	8.20 cdef	8.45 ef	65.41 cd	35.01f
M_0S_3	3.57 f	3.50 c	7.17 f	7.77 f	60.13 d	34.32 f
M_1S_1	4.69 cde	4.54 ab	8.90 abcd	9.93 cd	81.82 a	53.48 d
M_1S_2	4.31 de	4.17 bc	8.86 abcd	9.18 de	70.43 b	46.55 d
M_1S_3	4.10 ef	3.93 bc	7.61 ef	8.73 ef	60.42 d	42.97 e
M_2S_1	5.77 a	5.08 a	9.70 a	11.55 a	85.43 a	75.75 a
M_2S_2	5.51 ab	4.93 a	9.52 ab	11.14 a	75.06 b	69.58 ab
M_2S_3	4.11 ef	3.82 c	7.91 def	9.52 cde	66.90 d	66.30 b
M_3S_1	4.84 cd	5.03 a	8.55 bcde	10.58 abc	83.56 a	59.72 c
M_3S_2	5.14 bc	4.85 a	9.02 abc	10.69 ab	72.57 b	53.50 cd
M_3S_3	5.03 bc	3.79 c	9.21 abc	8.63 ef	60.70 d	49.16 d
$LSD_{(0.05)}$	0.5565	0.5914	0.9473	1.019	9.085	5.007
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	7.12	8.16	6.53	6.26	6.50	8.67

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

4.12 Diameter of fruit

Diameter of tomato fruit varied significantly for the application of organic manure (Table 7). The highest diameter of fruit (4.61 cm) was recorded from M_2 (10 ton/ha) which was statistically similar (4.56 cm) with M_3 (15 t/ha) and followed (4.07 cm) by M_1 (20t /ha), respectively, whereas the lowest diameter (3.88 cm) was recorded from M_0 (0 t /ha).

Significant difference was observed for diameter of fruit of tomato for application of different levels of spacing (Table 7). The highest diameter of fruit (4.58 cm) was recorded from S_1 (60 cm x 60cm) which was statistically similar (4.49 cm) with S_2 (60 cm x 45cm), while the lowest diameter (3.76 cm) was recorded from S_3 (60 cm x 30 cm).

Om and spacing significantly influenced the diameter of fruit for their interaction effect (Table 8). The highest diameter of fruit (5.08 cm) was recorded from M_2S_1 (10 ton /ha and 60 cm x 60 cm). On the other hand, the lowest diameter (3.50 cm) was recorded from M_0S_3 (0 ton and 60 cm x 30 cm).

4.13 Dry matter content in plant

Application of different levels of organic manure varied significantly on dry matter content in tomato plant (Table 7). The maximum dry matter content in plant (9.04%) was obtained from M_2 (10 ton/ha) which was statistically similar (8.93%) to M_3 (15 ton/ha) and followed (8.46%) by M_1 (20 ton/ha), respectively, while the minimum (7.86%) from M_0 (0 ton/ha).

Dry matter content in plant showed significant differences for application of different level of spacing (Table 7). The maximum dry matter content in plant (8.95%) was recorded from S_1 (60 cm x 60 cm) which was statistically identical (8.79%) with S_2 (60 cm x 45 cm) again, the minimum (7.97%) from S_3 (60 cm x 30 cm).

Interaction effect of Organic Manure and Spacing showed significant variation in terms of dry matter content in plant (Table 8). The maximum dry matter content in plant (9.70%) was attained from M_2S_1 (10 ton /ha and 60 cm x 60 cm) and the minimum (7.17%) was obtained from M_0S_3 (0 ton OM/ha and 60 cm x 30 cm) i.e. control condition.

4.14 Dry matter content in fruit

Dry matter content in fruit of tomato differed significantly due to the application of different levels of on (Table 7). The maximum dry matter content in fruit (10.44%) was recorded from M_2 (10 ton) which was statistically identical (10.26%) with M_3 (15 ton/ha) and flowed (8.96%) by M_1 (20 ton /ha), respectively. On the other hand, the minimum (8.74%) was attained from M_0 (0 ton /ha).

Significant variation was observed for dry matter content in fruit for application of different levels of spacing (Table 7). The maximum dry matter content in fruit (10.13%) was observed from S_1 (60 cm x 60 cm) which was statistically similar (10.01%) with S_2 (60 cm x 45 cm), whereas the minimum (8.66%) was recorded from S_3 (60 cm x 30 cm).

Interaction effect of organic manure and spacing showed significant variation in terms of dry matter content in fruit (Table 8). The maximum dry matter content in fruit (11.55%) was obtained from M_2S_1 (1o ton/ha and 60 cm x 60 cm). On the other hand, the minimum (7.77%) was recorded from M_0S_3 (0 ton and 60 cm x 30 cm).

4.15 Weight of Individual fruit

Weight of individual fruit of tomato varied significantly for the application of different levels of organic manure (Table 7). The highest weight of individual fruit (75.14 g) was found from M_2 (10 ton/ha) which was followed by (71.23 g and 70.25 g) to M_3 (15 ton/ha) and M_1 (20 ton/ha), respectively. The lowest weight (64.12 g) was observed from M_0 (0 ton/ha).

Application of different levels of spacing showed significant differences for weight of individual fruit (Table 7). The highest weight of individual fruit (79.50 g) was found from S_1 (60 cm x 60 cm) which was statistically followed by (68.25 g) with S_2 (60cm x 45 cm). On the other hand, the lowest weight (55.80 g) was obtained from S_3 (60 cm x 30 cm).

Significant variation was recorded for the interaction effect of organic manure and spacing fertilizer for weight of individual fruit (Table 8). The highest weight of individual fruit (85.43 g) was recorded from M_2S_1 (10 ton/ha and 60 cm x 60cm), while the lowest weight (60.13 g) was observed from M_0S_3 (0 ton/ha and 60 cm x 30 cm) i.e. control condition.

4.16 Yield per plant

Yield per plant of tomato varied significantly due to the application of different levels of organic manure (Figure 11). The highest yield per plant (3.67 kg) was observed from M_2 (10 ton/ha) which was closely followed (3.25 kg) by M_3 (15 ton/ha) and the lowest yield (2.25 kg) was recorded from M_0 (0 ton/ha) which was followed (2.77 kg) by M_1 (20 ton/ha).

Significant variation was recorded from different levels of spacing in terms of yield per plant (Figure 12). The highest yield per plant (3.58 kg) was found from S_1 (60 x 60cm) which was statistically similar (3.39 kg) to S_2 (60 cm x 45cm) again, the lowest yield (1.99 kg) from S_3 (60 cm x 30 cm).

Interaction effect of Organic Manure and Spacing showed significant differences for yield per plant of tomato (Figure 13). The highest yield per plant (4.68 kg) was recorded from M_2S_1 (10 ton/ha and 60 cm x 60 cm) whereas, the lowest yield (1.56 kg) was recorded from M_0S_1 (0 ton/ha and 60 cm x 60 cm).

It was observed that optimum doses of organic manure ensured optimum vegetative and reproductive growth and the ultimate results was the highest yield .

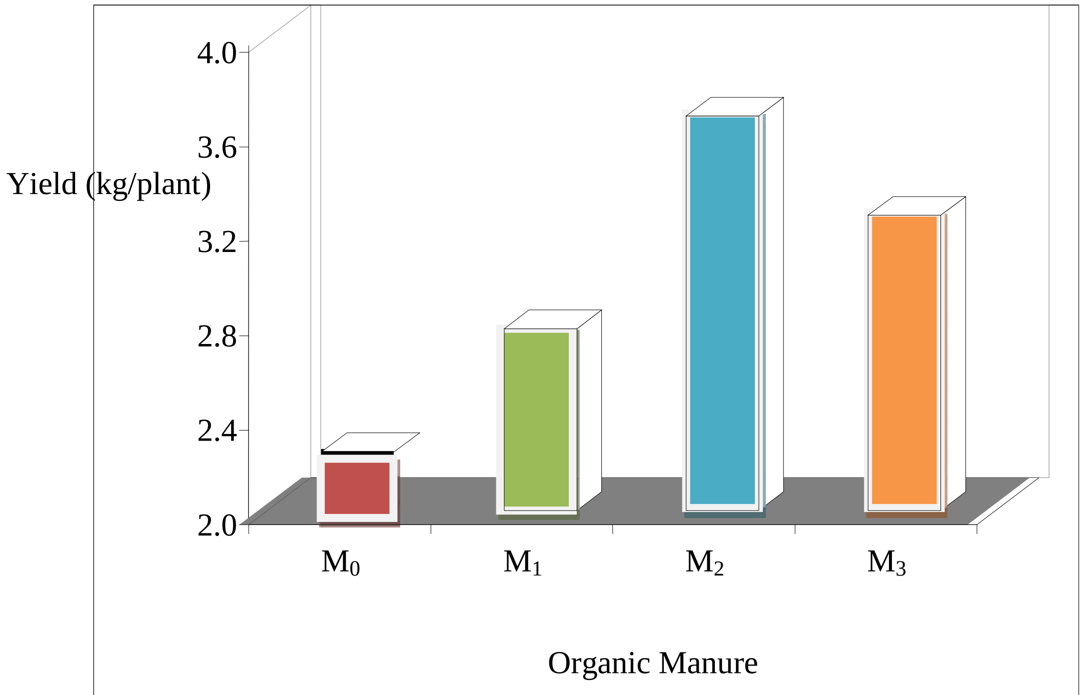


Figure 11. Effect of Organic Manure on yield per plant of tomato

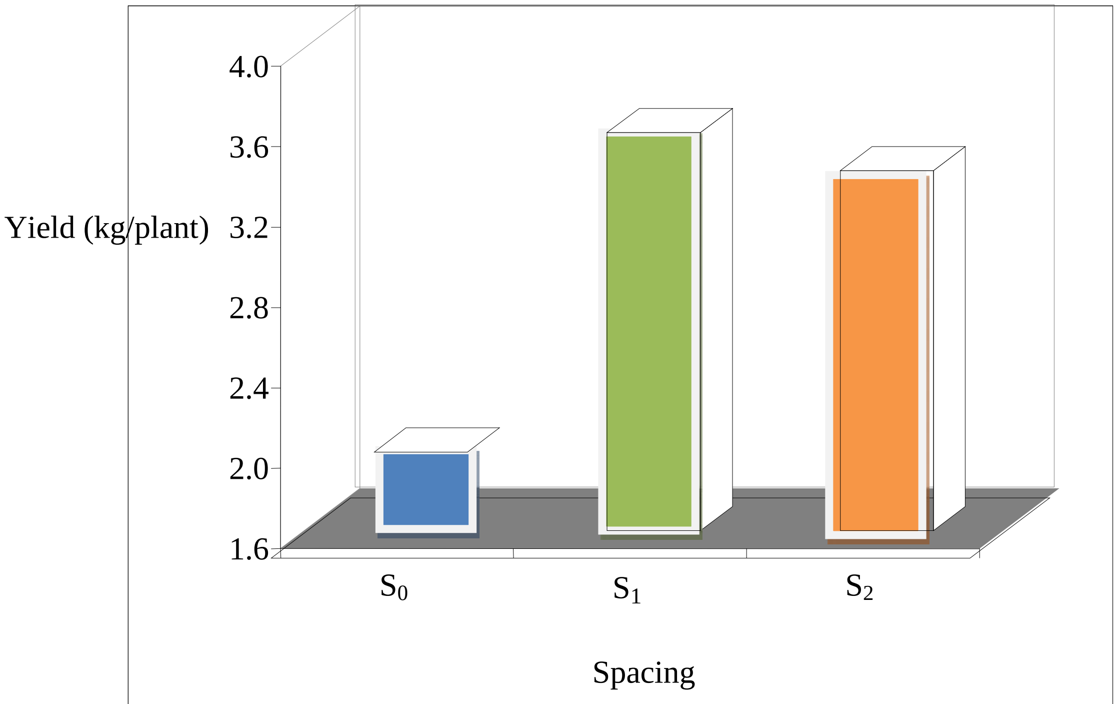


Figure 12. Effect of Spacing on yield per plantof tomato

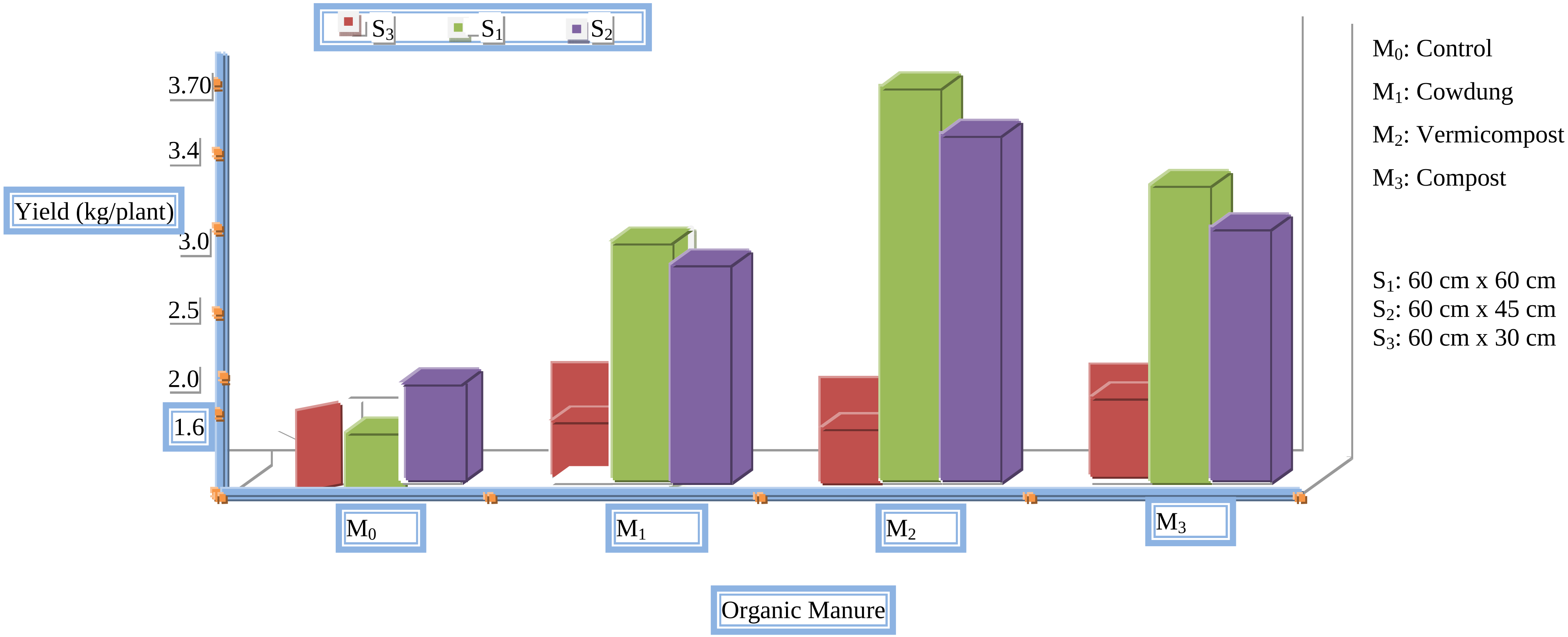


Figure 11. Interaction effect of Organic manure and Spacing on yield per plant of tomato

4.17 Yield per hectare

Significant variation was recorded on yield per hectare due to the different levels of organic manures (Table 7). The highest yield per hectare (68.99 ton) was obtained from M_2 (10 ton/ha) which was followed by (53.94 ton) with M_3 (15 ton/ha) and (47.39 ton) by M_1 (20 ton/ha), respectively, while the lowest yield (32.62 ton) from M_0 (0 ton/ha).

Yield per hectare of tomato varied significantly for the application of different levels of spacing (Table 7). The highest yield per hectare (52.58 ton) was recorded from S_1 (60 cm x 60 cm) which was statistically identical (49.65 ton) with S_2 (60 cm x 45 cm) and the lowest yield (43.32 ton) from S_3 (60 cm x 30 cm).

Interaction effect of organic manure and spacing fertilizer differed significantly for yield per hectare of tomato (Table 8). The highest yield per hectare (75.75 ton) was observed from M_2S_1 (10 ton/ha and 60 cm x 60 cm). On the other hand, the lowest yield (29.07 ton) was recorded from M_0S_1 (0 t manure/ha and 60 cm x 60 cm).

4.18 Economic analyses

Input costs for land preparation, seed cost, fertilizer cost and labor required for tomato cultivation for unit plot are converted into cost per hectare. Prices of tomato were considered in market rate basis. The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings-

Table 9. Cost and return of tomato cultivation as influenced by organic oanure and spacing

Treatment	Cost of production (Tk./ha)	Yield of tomato (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
M_0S_1	176617	29.07	218025	41,408	1.23
M_0S_2	176617	35.01	262575	85,958	1.48
M_0S_3	176617	34.32	257400	80,783	1.45
M_1S_1	215848	53.48	401100	185,252	1.85
M_1S_2	215848	46.55	349125	133,277	1.61
M_1S_3	215848	42.97	322275	106,427	1.49
M_2S_1	232661	75.45	565875	333,214	2.43
M_2S_2	232661	69.58	521850	289,189	2.24
M_2S_3	232661	66.3	497250	264,589	2.13
M_3S_1	221452	59.72	447900	226,448	2.02
M_3S_2	221452	53.5	401250	179,798	1.81
M_3S_3	221452	49.16	368700	147,248	1.66

Cost of tomato @ Tk. 7,500/ton

4.18.1 Gross return

In the combination of organic manure and spacing different gross return was recorded under the trial (Table 9). The highest gross return (Tk. 565,875) was obtained from M_2S_1 (10 ton/ha and 60 cm ×60 cm) and the second highest gross return (Tk. 521,850) was obtained in M_2S_2 (10 ton/ha and 60 cm x 45cm). The lowest gross return (Tk. 218,025) was obtained from M_0S_1 (0 ton manure/ha and 60 cm x 60 cm).

4.18.2 Net return

In case of net return, different treatment combination showed different result (Table 9). The highest net return (Tk. 333,214) was obtained from M_2S_1 and the second highest net return (Tk. 289,189) was obtained from M_2S_2. The lowest net return (Tk. 41,408) was obtained from M_0S_1.

4.18.3 Benefit cost ratio (BCR)

The combination of Organic Manure and Spacing fertilizer for benefit cost ratio was different in all treatment combinations (Table 9). The highest benefit cost ratio (2.43) was observed in M_2S_1 followed by M_2S_2 (2.24). The lowest benefit cost ratio (1.23) was obtained from M_0S_1. From the economic point of view, it is apparent that M_2S_1 treatment combination was the most profitable one than rest the of the treatment combinations under the study.

CHAPTER V

SUMMARY AND CONCLUSIONS

The experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, during October 2010 to April 2011 to find out the effect of organic manures and on the growth and yield of tomato. The experiment consisted of two factors. Factor A: levels of organic manures, viz. M_0: 0 t manure/ha (control), M_1: 20 ton/ha (Cowdung), M_2: 10 ton/ha (Vermicompost) and M_3: 15 ton/ha (Compost); Factor B: Three types of spacing, viz. S_1: 60 cm x 60 cm), S_2: 60 cm x 45 cm and S_3: 60 cm x 30 cm. The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

Data on different growth parameters and yield of tomato were recorded. At 20, 30, 40, 50 and 60 DAT, the longest plant (31.57, 42.01, 58.91, 76.80 and 89.97cm) was recorded from M_2 whereas the shortest (19.72, 28.57, 42.97, 57.62 and 65.12 cm) from $M_{0.}$ At 20, 30, 40, 50 and 60 DAT, the maximum number of leaves per plant (7.01, 17.87, 30.97, 38.57 and 55.33) was found from M_2 whereas the minimum number (4.63, 13.40, 23.27, 28.79 and 42.33) from M_0. At 20, 30, 40, 50 and 60 DAT, the maximum number of branches per plant (6.40, 8.42, 13.85, 18.45 and 23.50) was recorded from M_2 while the minimum number (3.30, 5.62, 9.14, 12.44 and 17.33) from M_0.

At 20, 30, 40, 50 and 60 DAT, the longest plant (31.57, 42.01, 58.91, 76.30 and 79.87 cm) was obtained from S_1; again the shortest plant (19.72, 28.57, 42.97, 57.62 and 65.12

cm) was recorded from S_3. At 20, 30, 40, 50 and 60 DAT, the maximum number of leaves per plant (7.20, 17.79, 30.07, 38.37 and 54.33) was recorded from S_1 again, the minimum number (4.63, 13.50, 23.57, 27.97 and 37.53) from S_3. At 20, 30, 40, 50 and 60 DAT, the maximum number of branches per plant (6.05, 7.82, 13.85, 18.10 and 23.65) was attained from $S_1$and the minimum number (3.31, 5.72, 9.94, 15.01 and 19.96) from S_3.

At 20, 30, 40, 50 and 60 DAT, the longest plant (31.57, 42.01, 58.91, 76.30 and 96.97 cm) was found from M_2S_1, while the shortest plant (19.72, 28.57, 42.97 57.62 and 65.85 cm) from M_0S_3. At 20, 30, 40, 50 and 60 DAT, the maximum number of leaves per plant (7.30, 17.97, 31.07, 39.37 and 61.33) was observed from M_2S_3 and the minimum (4.73, 13.60, 23.87, 28.97 and 32.33) from M_0S_1. At 20, 30, 40, 50 and 60 DAT, the maximum number of branches per plant (6.50, 9.42, 13.85, 20.45 and 26.13) was observed from M_2S_3 whereas the minimum (3.31, 5.72, 9.14, 12.44 and 17.33) from M_0S_1.

The maximum day from transplanting to 1st flowering (32.40) was found from M_3 and the lowest day (28.67) was recorded from M_2. The highest days from transplanting to 1st harvesting (81.20) was observed from M_0 again the lowest days (70.88) from M_2. The highest number of fruits per plant (45.12) was recorded from M_2 and the lowest number (25.1) was observed from M_0. The highest length of fruit (5.13 cm) was recorded from M_2 and the lowest length (4.16 cm) was recorded from M_0. The highest diameter of fruit (4.61 cm) was recorded from M_2 whereas the lowest diameter (3.88 cm) was recorded from M_0. The maximum dry matter content in plant (9.04%) was obtained from M_2 while the minimum (7.86%) from M_0. The maximum dry matter content in fruit (10.44%) was recorded from M_2 and the minimum (8.74%) was attained from M_0. The highest weight of individual fruit (75.14 g) was found from M_2 again the lowest weight (64.12 g) from M_0.

The highest yield per hectare (68.99 ton) was obtained from M_2 and the lowest yield (32.62 ton) from M_0.

The highest days required for transplanting to 1st flowering (31.90) was recorded from S_3 again, the lowest days (29.70) was obtained from S_1. The highest days required from transplanting to 1st harvesting (76.78) was obtained from S_3 while the lowest day (74.97) was found from S_2. The highest number of fruits per plant (38.15) was obtained from S_3 while the lowest number (32.5) was found from S_1. The highest length of fruit (4.85 cm) was observed from S_1 and the lowest length (4.20 cm) was observed from S_3. The highest diameter of fruit (4.58 cm) was recorded from S_1 while the lowest diameter (3.76 cm) was recorded from S_3. The maximum dry matter content in plant (8.95%) was recorded from S_1 and the minimum (7.97%) from S_3. The maximum dry matter content in fruit (10.13%) was observed from S_1, whereas the minimum (8.66%) from S_3. The highest weight of individual fruit (79.50 g) was found from S_1 and the lowest weight (55.80 g) from S_3. The highest yield per hectare (52.58 ton) was recorded from S_1 and the lowest yield (43.32 ton) from S_3.

The highest days from transplanting to 1st flowering (36.40) was found from M_0S_1 while the lowest (25.20) was recorded from M_2S_1. The highest day from transplanting to 1st harvesting (77.93) was observed from M_0S_1 and the lowest day (70.80) was recorded from M_2S_1. The highest number of fruits per plant (48.70) was recorded from M_2S_3 and the lowest number (20.88) was attained from M_0S_1. The highest length of fruit (5.77 cm) was recorded from M_2S_1 again the lowest length (3.57 cm) was found from M_0S_3. The highest diameter of fruit (5.08 cm) was recorded from M_2S_1 and the lowest diameter (3.50 cm) was recorded from M_0S_3. The maximum dry matter content in plant (9.70%) was attained from M_2S_1 and the minimum (7.17%) from M_0S_3. The maximum dry matter content in fruit (11.55%) was obtained from M_2S_1 and the minimum (7.77%) was recorded from M_0S_3. The highest weight of individual fruit (85.43 g) was recorded from M_2S_1 while the lowest (60.13 g) from M_0S_3. The highest yield per hectare (75.75 ton) was observed from M_2S_1 and the lowest yield (29.07 ton) from M_0S_1.

The highest net return (Tk. 333,214) was obtained from M_2S_1 and the lowest net return (Tk. 41,408) was obtained from M_0S_1. The highest (2.43) benefit was performed from M_2S_1 and the lowest (1.23) was obtained from M_0S_1.

Considering the findings of the present experiment, following conclusions may be drawn:

- ✓ Organic manure significantly influenced all the parameters Vermicompost @ 10 tons/hectare provides the maximum yield of tomato ;
- ✓ In respect of spacing 60 cm x 60 cm gave the highest marketable yield and the highest gross return;
- ✓ Vermicompost @ 10 tons/hectare along with 60 cm x 60 cm spacing provides the highest yield and highest economic return of tomato. .

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