

**“Effect of Organic, Inorganic and  
Biofertilizers on Growth and Yield of  
Tomato (*Lycopersicon esculentum* Mill)  
under Protected Condition”**

**THESIS**

*Submitted to the*

**Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur**

**In partial fulfillment of the requirements for  
the Degree of**

**MASTER OF SCIENCE**

*in*

**AGRICULTURE  
(HORTICULTURE)**

By

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**2015**

## CERTIFICATE-I

This is to certify that the thesis entitled, “**Effect of organic, inorganic and biofertilizers on growth and yield of tomato (*Lycopersicon esculentum* Mill) under protected condition**” submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE in VEGETABLE SCIENCE** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. Manish Tiwari** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been duly acknowledged by him.

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College of Agriculture, Rewa (M.P.)

**(Manish Tiwari)**

Date -----

# CONTENTS

CHAPTER	TITLE	PAGE NO.
I	INTRODUCTION	1-2
II	REVIEW OF LITERATURE	3-28
III	MATERIALS AND METHODS	29-41
IV	RESULTS	42-62
V	DISCUSSION	63-69
VI	SUMMARY, CONCLUSION AND SUGGESTIONS	70-74
	BIBLIOGRAPHY	75-80
	APPENDICES	81-87
	VITA	

## LIST OF TABLES

Table No.	Title	Page No.
3.1	Physico-chemical properties of soil collected from the experimental field	30
3.2	Meteorological data during <i>kharif</i> season 2014	31
3.3	Schedule of field operation during the course of investigation	36
3.4	ANOVA for randomized block design	39
4.1	Plant height of tomato at different growth stages as influenced by different fertility treatments	43
4.2	Number of branches/plant of tomato at different growth stages as influenced by different fertility treatments	45
4.3	Number of flower clusters/plant as influenced by different fertility treatments	47
4.4	Number of flower/clusters of tomato as influenced by different fertility treatments	48
4.5	Days to first fruit setting in tomato as influenced by different fertility treatments	50
4.6	Number of fruits/plant in tomato as influenced by different fertility treatments	52
4.7	Weight of tomato fruit as influenced by different fertility treatments	53
4.8	Yield of tomato as influenced by different fertility treatments	55
4.9	Dry matter of tomato fruit as influenced by different fertility treatments	56
4.10	Grading percentage of tomato as influenced by different fertility treatments	58
4.11	Total soluble solids in tomato as influenced by different fertility treatments	60
4.12	Net profit and B:C ratio from tomato as influenced by different fertility treatments	61
5.1	Growth, yield, quality and economics of tomato as influenced by organic, inorganic and biofertilizers	68
5.2	Quality and economics from tomato as influenced by organic, inorganic and biofertilizers	69

## LIST OF FIGURES

Figure No.	Title	Between Pages
1.	Meteorological observation during crop period	31-32
2.	Layout plan of the experiment	34-35
3.	Plant height (cm) 90 DAT of tomato at different growth stages as influenced by different fertility treatments	43-44
4.	Branches/plant (90 DAT) of tomato at different growth stages as influenced by different fertility treatments	45-46
5.	Flower clusters/plant as influenced by different fertility treatments	47-48
6.	Flower/cluster as influenced by different fertility treatments	48-49
7.	Days to first fruit setting as influenced by different fertility treatments	50-51
8.	Fruits/plant as influenced by different fertility treatments	52-53
9.	Weight of fruits (g) as influenced by different fertility treatments	53-54
10.	Yield of tomato (t/ha) as influenced by different fertility treatments	55-56
11.	Dry matter of fruits (%) as influenced by different fertility treatments	56-57
12.	Grading (%) of tomato fruits as influenced by different fertility treatments	58-59
13.	TSS (°Brix) as influenced by different fertility treatments	60-61
14.	Net income (Rs./ha) of tomato as influenced by different fertility treatments	62-63
15.	B:C ratio of tomato as influenced by different fertility treatments	64-65

## LIST OF ABBREVIATIONS

Words	Abbreviations
Centimetre	cm
Co-workers	<i>et al.</i>
Critical difference	C.D.
Degree centigrade	°C
Degree of Freedom	d.f.
Days after transplanting	DAT
Figure	Fig.
Fisher's value	"F" value
Gram(s)	g
Hectare	ha
Kilogram(s)	kg
Mean sum of square	M.S.S.
Metre	M
Muriate of Potash	MOP
Nitrogen	N
Non-significant	N.S.
Number	No.
Per	/
Per cent	%
Phosphorus	P <sub>2</sub> O <sub>5</sub>
Potash	K
Potential of hydrogen ions	pH
Quintal	q
Rupees	Rs
Serial No.	S.No.
Significant at 5% level	*
Significant at 1% level	**
Single Super phosphate	SSP
Source of variation	S.V.
Sum of square	S.S.
Square	sq.
Standard error of means	S.Em <sub>±</sub>
Standard error of difference	S.Ed

## INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) belongs to family solanaceae. Tomato is one of the important vegetable crop with wide spread production. Tomato is said to be the native of tropical America and grown under different sets of soil and climate in small gardens polyhouses and market gardens for fresh consumption and for processing purpose. It ranks potato and sweet potato in production. In India, tomato is grown in 905 thousand hectare area with a total production of 19104 thousands MT with as average productivity of 21.10 MT/ha (NHB 2013-14). In M.P., tomato is grown in as area of 65.72 thousands hectare with a production of 1937.30 thousands with a and productivity of 29.47 MT/ha (NHB 2013-14). Large quantities of tomato are used to produce sauce chutney, juice, ketchup, puree, paste and powder besides fresh consumption.

Liberal rash use of chemical fertilizers, pesticides, and fungicides are responsible for deterioration of soil health. In India, most of the farmers are small and marginal and hence it is very difficult for them to purchase the cost inorganic fertilizers . Organic manures on the other hand are eco-friendly and cheap . Due to increasing use of chemical fertilizers, the soil properties have also been declined. The use of organic fertilizers, play a major role for production the good quality and higher yielding cauliflower per unit area.

The beneficial effects of FYM and vermicompost on crop yield and soil productivity is the result of their usefulness as a store house of plant nutrients. These average sources of nutrients Improve soil aeration, root development and increase microbial and biological activities in the rhizosphere .

Besides supply of micronutrients Vermicompost being a rich source of macro and micronutrients and vitamins, plant growth regulators and beneficial micro flora appeared to be the best organic source in maintaining soil fertility on sustainable basis towards and eco-friendly environment (Edwards and

Arancon, 2004). The extensive use of biofertilizers in crop production is the major break through as a pollution free low-cost input technology During recent years. Hence organic manures and biofertilizers are the important components of integrated nutrient management. The use of vermicompost with inorganic fertilizers enhance utilization of nutrients by the soil microbial process (Lenin and Rangaswamy, 2002). Worm casts contain 5 times more N, 7 times more P and 11 times more K than ordinary soils. (Sharma and Agrawal, 2004).

Vermicompost application to different field crops has been known to reduce the requirement of chemical fertilizers without any reduction in crop yield (Giraddi, 2000 and Patil *et al.*, 2004).

There is a need to seek alternative nutrient sources which could be cheap and eco-friendly so that farmers may be able to reduce the investment on chemical fertilizers along with maintaining good soil environmental conditions leading to ecological sustainable farming. Organic fertilizers like fym vermicompost and biofertilizers are very popular among the farmers to produce quality product .

Keeping these points in view the present experiment was planned with the following objectives:

1. To study the effect of organic, inorganic and bio-fertilizers on growth and yield of tomato.
2. To study the combined effect of organic, inorganic and bio-fertilizers on tomato cultivation.
3. To workout the economics of the treatments.

## CHAPTER-II

# REVIEW OF LITERATURE

During the last few decades the experimental work on the usefulness of only inorganic fertilizers has been evaluated in India and abroad by different Scientists. Recently the response of tomato and other allied crops to different organic sources of nutrients have been found encouraging. The use of organic manures as well as vermicompost enhanced the growth and development quality and yield of vegetable crops as well as nutrient status of soil to a greater extent. Organic sources of nutrients including biofertilizers also economize the use of chemical fertilizers. Some of the important research findings on these aspects have been reviewed. The same are being presented in this chapter.

Balasubramaniam et al. (1998) in a pot study with tomato cv. Paiyur 1, using a soil neutral in reaction with a low salt concentration and poor organic carbon, the following treatments were assessed: T1, control; T2, 100% soil-test-based NPK + ZnSO<sub>4</sub> (50 kg/ha) + borax (10 kg/ha); T3, T2 + Tankslit [no details given] (40 t/ha); T4, T2 + composted coir pith (5 t/ha); T5, 75% soil-test-based NPK + ZnSO<sub>4</sub> (50 kg/ha) + borax (10 kg/ha) + Tankslit (40 t/ha); and T6, 75% soil-test-based NPK + ZnSO<sub>4</sub> (50 kg/ha) + borax (10 kg/ha) + composted coir pith (5 t/ha). T4 recorded the highest fruit yield of 1487.0 g/pot compared with 447.5 g/pot in the control. The dry matter production, content and uptake of nutrients, and the residual soil fertility were favourably influenced by this treatment.

Sendurkumaran et al. (1998) and Nanthakumar and Veeraraghavathatham (1999) also observed an increased yield in tomato and brinjal, respectively when plots were fertilized with both organic and inorganic sources. The quality parameters such as TSS, ascorbic acid, lycopene were comparatively higher in tomato when grown organically.

Kumaran et al. (1998) the effect of inorganic and organic fertilizers on growth and yield and quality of tomato was investigated at Coimbatore, India. FYM, neem cake, Azospirillum, phosphobacteria and NPK were applied in different combinations. Full FYM and PK were applied as a basal dressing the

remaining N being applied 30 days after transplanting. Results showed that a combination of organic and inorganic fertilizers gave the best results in terms of growth and yield. Plant height, branches/plant, mean fruit weight and number of fruits/plant were best with organic + inorganic fertilizers and Azospirillum and phosphobacteria. The quality parameters such as TSS, ascorbic acid and lycopene contents were comparatively higher in organically grown tomato plants.

Bhardwaj et al. (2000) conducted a field experiment at Jachh to find out the effect of organic sources of nutrients, i.e. farmyard manure, neem cake and rapeseed cake as partial or complete alternative to chemical fertilizers on yield of tomato, okra, cabbage and cauliflower and its economic feasibility. Application of sole organic sources of nutrients recorded 11-17% lower yield in different vegetable crops. However, application of 50% recommended NPK + 50% rapeseed cake (0.72 t/ha) in tomato, 50% recommended NPK + 50% neem cake (0.72 t/ha) in okra, 33.3% recommended NPK + 33.3% recommended NPK + 33.3% farmyard manure (6.66 t/ha) + 33.3% neem cake (0.48 t/ha) in cauliflower recorded higher yields which were statistically at par with recommended doses of chemical fertilizers. Net returns in organic produce of different vegetables were higher the produce received higher price in the market.

Sannigrahi and Barah (2000) conducted field experiments in Assam with *tomatoes*, French beans and cabbages yield response to the application of organic manures (FYM) or compost with or without NPK fertilizers and root inoculation with mycorrhizas. Tomatoes yield was highest (17.3 t/ha) with the application of the recommended NPK fertilizer, while the yield of French beans (36.1 t/ha) and cabbage (26.6 t/ha) were highest with 10 t FYM/ha + 15 kg N + 10 kg K<sub>2</sub>O and 10 t compost + inoculation + 40 kg N + 30 kg K<sub>2</sub>O, respectively.

Renuka et al. (2001) in a field experiment conducted on a sandy loam soil, in Bapatla, Andhra Pradesh, India, during 1998, the effect of organic manures on growth, development, yield and quality of tomato was investigated. Six kinds of organic manures, i.e. farmyard manure (FYM), vermicompost, biogas slurry, neem cake, Azospirillum and phosphobacteria,

in different combinations were tested in comparison with inorganic fertilizer treatment as control. It can be deduced that vigorous growth of tomato with early flowering and high yield (46.66 tonnes) could be obtained with the application of FYM + biogas slurry, recording an increased yield of two and half times over the control (18.44 tonnes). Thus, it can be inferred that tomato would respond to application of organic manures either alone or in combination with FYM. Further, application of organic manures maintained the soil pH near to neutral, besides keeping lower levels of electrical conductivity and bulk density.

Bhagavantagoudra and Rokhade (2002) found that application of *Azospirillum* through soil + seedling dipping along with 100% RDN recorded the highest C:B ratio of 4.29, followed by inoculation of *Azospirillum* (2.67). Among the methods, *Azospirillum* application through soil + seedling dipping was the best. However, in terms of N level, 100 and 75% RDN were at par and superior to 50% RDN. Treatment with 100% RDN along with inoculation of *Azospirillum* through soil + seedling dipping (Rs. 127822) accounting for 8.68% higher returns. Application of *Azospirillum* through soil + seedling dipping along with 100% RDN recorded 31.75 higher yield over the recommended dose of fertilizer without the application of *Azospirillum*.

Rafi et al.(2002) studies that application of 50% recommended dose of FYM @, 12.5 t/ha along with reduced levels of recommended doses of fertilizers (50% of the recommended doses of fertilizers of 100 : 50:50 NPK kg/ha) resulted in the highest yield with high quality of tomato.

Mohd et al. (2002) an experiment was carried out with tomato cv. Parbhani Yashashri in Parbhani, Maharashtra, India, during the rabi season of 2000-01, involving 15 treatments, i.e. 100% recommended dose of fertilizer (RDF; 100:50:50 kg NPK/ha) (T1), 75% RDF+25% Celrich (T2), 75% RDF+25% Teracare (T3), 75% RDF+25% farmyard manure (FYM) (T4), 75% RDF+25% vermicompost (T5), 50% RDF+50% Celrich (T6), 50% RDF+50% Teracare (T7), 50% RDF+50% FYM (T8), 50% RDF+50% vermicompost (T9), 25% RDF+75% Celrich (T10), 25% RDF+75% Teracare (T11), 25% RDF+75% FYM (T12), 25% RDF+75% vermicompost (T13), 100% organicfertilizers (25% each of Celrich, Teracare, FYM and

vermicompost) (T14) and untreated control (T15). The full dose of Celrich, Teracare, FYM and vermicompost was 2.0, 2.5, 25 and 25 tonnes/ha, respectively. Celrich is a bioorganic soil enricher containing 30% organic matter, 20% moisture and 45% sand and inoculated with biofertilizer, such as Azotobacter, Azospirillum and actinomycetes. Teracare consists of decomposed coconut coir pith and acts as a soil conditioner added with micronutrients. The plant height recorded at 90 days after sowing was maximum in T8 and was on par with T1 and T9. The shortest plants were recorded in T15. The highest number of primary branches was recorded in T8 and the least in T15. The least number of days required for 50% flowering, the maximum fruit set, fruit weight, number of fruits per plant and the highest yield per plant (2.34 kg) and per hectare (586.51 q) were observed in T8. The readymade organic manures (Celrich and Teracare) were inferior to the traditional organic manures (FYM and vermicompost).

Krishna et al. (2002) the effect of NPK fertilizer applied with or without organic manures (farmyard manure and Agrimagic) on the yield and quality of tomato cv. Avinash-2 was investigated during rabi 2000/01 in Bangalore, Karnataka, India. In general, NPK at 250:250:250 kg/ha plus Agrimagic at 16.87 t/ha or farmyard manure at 38 t/ha recorded the highest values for the different yield (plant height, branches per plant, clusters per plant, fruits per cluster, fruits per plant, fruit weight, fruit weight per plant, estimated fruit yield and total chlorophyll) and quality (pericarp thickness, fruit firmness, total soluble solids and titratable acidity) parameters. These treatments also recorded the longest shelf life and the lowest physiological weight loss of fruit.

Naidu et al. (2002) organic and inorganic fertilizers with and without biofertilizers gave significant effects on the growth and yield of tomato cv. Acc-99. Application of 100 kg N + 50 kg P<sub>2</sub>O<sub>5</sub> + 50 kg K<sub>2</sub>O + 20 t FYM/ha was significantly superior than the other combinations and gave maximum plant height (50.68 cm), number of leaves per plant (49.50), number of branches per plant (16.83), number of flower clusters per plant (19.25), number of fruits per plant (25.67 q/ha), and yield (218.65 q/ha) including a net return of Rs. 33 299 and 1:2.72 cost:benefit ratio.

Mohd et al. (2002) the study on the effect of organic and inorganic fertilizers on yield and quality of tomato (cv. Parbhani "Yashashri") conducted in Parbhani, Maharashtra, India, revealed that application of 50% recommended dose of farmyard manure (FYM) @ 12.5 t ha<sup>-1</sup> alongwith reduced levels of recommended doses of fertilizers (50% of the recommended dose of fertilizers of 100:50:50 NPK kg ha<sup>-1</sup>) resulted in the highest yield with high quality. The study also revealed that the ready made organic manures of commercial companies used in this study were inferior to traditional organic manures viz., FYM and vermicompost.

Gajbhiya et al. (2003) concluded that among biofertilizers, *Azotobacter* performed good for plant height, number of primary branches per plant, number of fruits per plant, weight of fruits per plant and fruit size. As far as chemical fertilizer effects are concerned, recommended dose of NPK (150 kg N + 60 kg P + 60 kg K/ha) obtained highest value of plant height, number of primary branches per plant, number of fruits per plant, weight of fruits per plant and fruit size. Biofertilizers in combination with chemical fertilizer B<sub>1</sub>N<sub>2</sub> (*Azotobacter* with 150 kg N + 60 kg P + 60 kg K/ha) was found to be the best treatment and significantly influenced plant height, number of primary branches per plant, number of fruits per plant, weight of fruits per plant and fruit size.

Nakano et al. (2003) examined the effects of fertilizer application, especially the effects of fertigation and types of fertilizer (inorganic and organic) on yields and delta <sup>15</sup>N and delta <sup>13</sup>C values of tomato (*Lycopersicon esculentum* Mill. cv. Saturn). Fertigation is a method in which an appropriate diluted liquid fertilizer is applied to the plants each time they are drip-irrigated. We developed a method of organic fertigation using corn steep liquor (CSL) as the liquid fertilizer, because it is an industrial byproduct of cornstarch manufacture and can be used very effectively. We compared fruit yield, mineral content, delta <sup>15</sup>N value, and delta <sup>13</sup>C value of tomatoes grown under three different fertilizer treatments, basal dressing: basal dressing with granular chemical fertilizer; inorganic fertigation: fertigation with liquid chemical fertilizer; and organic fertigation: fertigation with CSL. Mineral contents of tomatoes grown with basal dressing were generally

lower than those grown under either fertigation treatment. These results indicated that yields and mineral contents were influenced more by the method of fertilizer application than by whether the fertilizers were inorganic or organic. There were, however, significant differences in the  $\delta^{15}\text{N}$  values of tomato fruits grown under different types of fertilizer applications, especially between inorganic and organic fertilizers. The  $\delta^{15}\text{N}$  value of the chemical fertilizer used for basal dressing was  $0.81 \pm 0.45$  per mil, that of the chemical fertilizer for fertigation was  $0.00 \pm 0.04$  per mil, and that of CSL was  $8.50 \pm 0.71$  per mil. The  $\delta^{15}\text{N}$  values of the soils reflected the  $\delta^{15}\text{N}$  values of the fertilizers. Moreover, the  $\delta^{15}\text{N}$  values of the fruits corresponded to the  $\delta^{15}\text{N}$  values of the applied fertilizers. The  $\delta^{15}\text{N}$  values were  $3.18 \pm 1.34$  per mil in the fruits grown with a basal dressing of chemical fertilizer,  $0.30 \pm 0.61$  per mil in those grown under inorganic fertigation, and  $7.09 \pm 0.68$  per mil in those grown under organic fertigation. On the other hand, although the  $\delta^{13}\text{C}$  values in the soil also reflected the  $\delta^{13}\text{C}$  values of the applied fertilizers, there was no significant difference in the  $\delta^{13}\text{C}$  values of fruits among the different treatments. In conclusion, because the  $\delta^{15}\text{N}$  values of fertilizers correlated well with those of the fruits, it may be possible to use  $\delta^{15}\text{N}$  values as an indicator of organic products.

Sharma et al. (2004) a field experiment was conducted during the summer season of 2000 and 2001 at Kukumeri, Himachal Pradesh, under high hill dry temperate zone of North-western Himalaya, to study the effect of farmyard manure (0, 10 and 20 tonnes/ha) and fertilizers (75, 100 and 125%) on fruit yield and yield-attributing traits of tomato (*Lycopersicon esculentum*). The transplanting of 'EC 129601' tomato was done in the last week of May in both the years. The highest level of farmyard manure (20 tonnes/ha) resulted in significantly higher fruit yield (99.51 tonnes/ha) over other 2 levels (no application and 10 tonnes/ha) in each year. An application of 125% NPK (125, 33 and 41 kg N, P and K/ha) significantly outyielded the other 2 fertilizer levels of 75% and 100% NPK. The response to farmyard manure and inorganic fertilizers was also significant for fruits/plant, average fruit weight, plant height and branches/plant. With increase in yield from 85.31 to 99.51 tonnes/ha and 86.07-101.20 tonnes/ha and fruits/plant from 27.53 to

33.88 and 29.29-34.17, average fruit weight decreased (59.74-51.92 g and 60.04-54.03 g) at 20 tonnes farmyard manure/ha and 125% NPK compared to 10 tonnes farmyard manure/ha and recommended dose of NPK/ha (100%) respectively. The interaction effects of farmyard manure and inorganic fertilizer application were also significant for fruit yield. The maximum net returns were achieved (Rs 384 000/ha) with 20 tonnes farmyard manure + 125% NPK with benefit:cost ratio of 4.80. The fruit yield obtained with 20 tonnes farmyard manure/ha + 100% NPK (100, 26 and 33 kg N, P and K/ha) was better than 125% NPK alone, thereby showing saving of N, P and K to the tune of 25, 7 and 8 kg/ha, respectively, and an additional income of Rs 32 000/ha.

Patil et al. (2004) the effects of inorganic and organic fertilizers on the fruit yield and quality of tomato (cv. Parbhani Yashshri) was studied in Parbhani, Maharashtra, India, during rabi 2000/01. The treatments consisted of 100% recommended fertilizer rate (RFR; 100:50:50 kg NPK/ha), 75% RFR + 25% Celrich, Teracare, farmyard manure (FYM) or vermicompost; 50% RFR + 50% Celrich, Teracare, FYM or vermicompost; 25% RFR + 75% Celrich, Teracare, FYM or vermicompost; and 100% organic fertilizer (25% each of FYM, Teracare, Celrich and vermicompost). Celrich (2.0 t/ha), Teracare (2.5 t/ha), FYM (25.0 t/ha) and vermicompost (25.0 t/ha) were applied at 10 days before transplanting. Plant height, number of primary branches, and number of leaves were evaluated from 30 to 105 days after transplanting. The application of 50% RFR + 50% FYM resulted in the greatest plant height (120.70 cm), number of primary branches per plant (8.53), number of fruits per plant (52.0), average fruit weight (45.06 g), yield per plant (2.34 kg), and total soluble solid content (6.08%). The highest number of leaves per plant was obtained with 50% RFR + 50% FYM (118.10) and 50% RFR + 50% vermicompost (116.63). Ascorbic acid content (26.76, 26.53 and 25.97 mg/100 g) and shelf life (6.91, 7.00 and 6.22 days) were highest with 50% RFR + 50% FYM, 50% RFR + 50% vermicompost and 100% organic fertilizers.

Yadav et al. (2004) an experiment was conducted in Jaipur, Rajasthan, India, to determine the suitable combination of organic manure with inorganic fertilizer to increase the tomato production. Treatments

comprised: two levels of farmyard manure (FYM; 20 and 40 t/ha) alone or with one-half and full dose of recommended NPK (180:120:80 kg/ha), green manure (sunn hemp) alone and with one-half dose of recommended NPK on tomato hybrid ARTH-3 during the rabi seasons of 1996-97, 1997-98 and 1998-99. Application of FYM at 20 t/ha + full dose of NPK recorded the highest fruit yield (327.69 q/ha) with benefit:cost ratio of 1:1.49 and was at par with full dose of NPK alone. The lowest yield (113.5 q/ha) was observed in the treatment receiving only FYM at 20 t/ha. Slightly higher yield levels were obtained when the plants were supplied with FYM at 40 t/ha (184.66 q/ha) and green manuring (141.44 q/ha). The total soluble solids percent was highest (4.6%) upon treatment with 40 t FYM alone and lowest (3.5%) upon treatment with NPK alone. The maximum net return was obtained with full dose of NPK, followed by 20 t FYM + full dose of NPK, with cost:benefit ratios of 1:1.85 and 1:1.49, respectively.

Choudhury et al. (2005) an field experiment was conducted in the Experimental Farm of the Assam Agricultural University in Assam, India, to study the effect of inorganic fertilizers coupled with farmyard manure (FYM) and biofertilizer on organic carbon, available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O in soil as well as on plant growth parameters of tomato [*Lycopersicon esculentum*]. There were 7 treatments included in the study: (1) rock phosphate (RP) + phosphate-solubilizing bacteria (PSB) + urea + muriate of potash (MOP)+ FYM; (2) RP+MOP+urea; (3) single superphosphate (SSP) + MOP + Azotobacter (Az); (4) Az+urea+MOP+RP+PSB+FYM; (5) urea+ MOP+SSP; (6) PSB+MOP; and (7) control. The incorporation of Az, PSB, and FYM with inorganic fertilizers significantly improved the organic carbon content and available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O status of the soil. The highest plant height, number of leaves per plant and yield of tomato were obtained with the Az, PSB, FYM and inorganic fertilizers, followed by PSB, FYM and inorganic fertilizer treated soils. The population of Azotobacter in the native soil was less than the PSB. Inoculated and fertilizer nitrogen added soil maintained increased microbial population.

Shukla et al. (2006) an experiment was conducted in farmers' fields in Ded Gharat village, Kandaghat block of Solan district, Himachal Pradesh,

India, during 2002-03 and 2003-04 to study the effects of inorganic and organic fertilizers on the performance of tomato (*L. esculentum* cv. Naveen). The application of recommended rates of N, P and K (100, 75 and 55 kg/ha, respectively) with farmyard manure and vermicompost (250 and 12.5 quintal/ha, respectively) was superior in terms of yield per plant, yield/ha, number of fruits per plant, average fruit weight, number of fruits per cluster, and TSS [total soluble solids] content. The combined effects of N, P, K, farmyard manure and vermicompost on harvest duration and pericarp thickness were not significant. Vermicompost with N, P and K induced early flowering, whereas early picking was obtained with the application of vermicompost and P. [1 quintal=100 kg].

Selim et al. (2006) concluded this study examines energy use patterns and the relationship between energy inputs and yield for greenhouse tomato production in Antalya province of Turkey. The data used in this study were based on cross-sectional data collected from growers by using a face to face survey. The results revealed that diesel (34.35%), fertilizer (27.59%), electricity (16.01%), chemicals (10.19%) and human power (8.64%) consumed the bulk of energy. In the surveyed farms, average yield and energy consumption were calculated as around 160000 kg/ha and 106716.2 MJ/ha, respectively. The results also showed that output–input, specific energy and energy productivity were 1.2, 12380.3 MJ/t and 0.09 kg/MJ, respectively. The results implied that small size farms were more efficient than large ones in terms of output–input ratio.

Singh and NPS (2006) reported that the protected cultivation of vegetables offers distinct advantages of quality, productivity and favourable market price to the growers. Vegetable growers can substantially increase their income by protected cultivation of vegetables in off-season as the vegetables produced during their normal season generally do not fetch good returns due to large availability of these vegetable in the markets. Off-season cultivation of cucurbits under low plastic tunnels is one of the most profitable technologies under northern plains of India. Walk-in tunnels are also suitable and effective to raise off-season nursery and off-season vegetable cultivation due to their low initial cost. Insect-proof net houses can be used for virus-free cultivation of tomato, chilli, sweet pepper and other

vegetables mainly during the rainy season. These low cost structures are also suitable for growing pesticide-free green vegetables. Low cost greenhouses can be used for high quality vegetable cultivation for long duration (6-10 months) mainly in peri-urban areas of the country to fetch commensurate price of produces. Polytrenches have proved extremely useful for growing vegetables under cold desert conditions in upper reaches of Himalayas in the country.

Sarkar et al. (2006) studied the residual effect of boronated NPK with respect to NPK. In case of *rabi*, crops boronated NPK increased yield of all the crops tested from 4.3 to 66.7, 6.0 to 22.9, 1.9, 9.4, 2.4 to 27.2, 4.8, 5.4, 15.1 and 5.0 to 16.2% for mustard, wheat, lentil, coriander, potato, tomato, chilly, groundnut and cauliflower, respectively, compared to NPK alone. For the succeeding crops, boronated NPK also resulted in increase in grain/fiber yield of rice and jute to the extent of 1.0 to 5.1% over the NPK only. The benefit:cost ratio of the crops for boronated NPK also varied from 8 to 128 indicating the usefulness of the product for the vast B deficient area of the eastern states of India.

Kumar et al. (2007) an experiment was conducted during the 2003 and 2004 summer seasons in Uttar Pradesh, India, to study the effect of inorganic and biofertilizers on the growth, yield and quality of tomato cv. Pusa Hybrid 2. The treatments comprised: no biofertilizer ( $B_0$ ); Azotobacter ( $B_1$ ); Azospirillum ( $B_2$ ) and Phosphobacteria ( $B_3$ ); no inorganic fertilizers ( $N_0$ ); 40 kg N + 20 kg P/ha ( $N_1$ ); 80 kg N + 40 kg P/ha ( $N_2$ ); 120 kg N + 60 kg P/ha ( $N_3$ ). Data were recorded for plant height, number of primary branches, days taken to first flowering, number of fruits per plant, average yield, total soluble solids and ascorbic acid content. Among the biofertilizer treatments,  $B_2$  followed by  $B_1$  gave maximum plant growth, number of primary branches, days taken to first flowering, number of fruits per plant, average fruit weight, total soluble solids and ascorbic acid content. Among the inorganic fertilizers, the maximum values for yield and yield components were obtained with  $N_3$ . The combined effect of inorganic and biofertilizer application was significant for plant growth and yield, which was highest at  $B_2N_3$ .

Narayan et al. (2008) Treatments with organic manure, inorganic fertilizers and their combinations showed significant differences for fruit yield and yield attributing traits. Among the treatments, application of 20 t FYM/ha along with full dose of recommended NPK i.e. 150:60:60 kg NPK/ha recorded the highest fruit yield of 428.32 and 530.55 q/ha during the year 2002 and 2003, respectively with grand mean fruit yield of 479.43 q/ha. This treatment was on par with 40 tonnes FYM+1/2 dose of recommended NPK during 2002 and 2003, which recorded mean fruit yield of 456.17 q/ha. Both these treatments were significantly superior to recommended inorganic NPK fertilizer treatment (435.57 q/ha) as well as to application of different doses of organic manure alone such as FYM and green manure, indicating that integration of both organic manures and inorganic fertilizers are important for obtaining higher fruit yield in tomato. Addition of organic manure besides having favourable effect on crop yield was also found to be better in maintaining soil health and growth of succeeding crop.

Hari Prasad, et al. (2009) in the present study, 43 isolates of Phosphate solubilizing rhizobacteria (PSRB) were isolated from 37 rhizospheric soil samples of tomato collected from tomato growing regions of Karnataka. Among the 43 isolates, 33 were found to be positive for solubilizing both inorganic and organic forms of phosphorous. The isolates were analyzed for their ability to colonize roots of tomato and to increase the seed quality parameters under laboratory conditions. On the basis of above criteria, 16 isolates were selected for further studies. Organic acids from PSRB isolates were analyzed and phytase zymogram for two isolates viz., PSRB21 and 31 was prepared. Under greenhouse conditions, all selected isolates showed increased shoot length, root length, fresh weight, dry weight and phosphorous content of tomato seedlings to various extent with respect to control. Analysis of pH and available phosphorous in rhizosphere soil samples of 30 day-old seedlings revealed that the available phosphorous content was high in rhizospheric soil samples of plants raised from seeds bacterized with PSRB isolates over control. Even though all selected PSRB's were able to increase the plant growth, only few of them showed protection against fusarium wilt and none of them against early blight. (C) 2009 Kluwer Academic Publishers.

Shukla et al.(2009). A field experiment was conducted in Solan district, Himachal Pradesh, India, during 2002-03 and 2003-04 to study the effects of N fertilizer (100 kg/ha), P<sub>2</sub>O<sub>5</sub> (75 kg/ha), K<sub>2</sub>O (55 kg/ha), Azotobacter (Az; 113 kg/ha) and phosphate solubilizing bacteria (PSB; 113 kg/ha) on the performance of tomato hybrid Naveen 2000. The earliest flowering was recorded for NPK + PSB and NPK + Az. The application of N only resulted in the earliest maturity (60 days), followed by N and PSB (62 days each). P + Az delayed maturity to 82 days. The number of fruits per cluster was markedly increased by the application of K + Az. Fruit weight was greatest for NPK + Az + PSB, followed by N, K and NPK + PSB. The highest yield was obtained with NPK + Az + PSB, followed by NPK + PSB.

Sharma et al. (2010) the effects of biofertilizers (Azotobacter and Phosphobacterium) and inorganic fertilizers (150:60:60 kg NPK/ha) on the fruit quality of 10 tomato cultivars (Booster, Chiku, West Virginia, Pusa Gaurav, WIR-3900, Pusa Ruby, Campbell-28, P-120, Pusa Sheetal and DT-10) were studied. Application of Azotobacter registered highest locule number per fruit, lycopene content and vitamin-C content while, Phosphobacterium treatment recorded maximum pericarp thickness, total soluble solids and specific gravity. Highest total soluble solids and vitamin-C content in fruit was noted when half RD of NP and full RD of K were applied, which was statistically significant over the application of full RD of NPK. Application of recommended dose of NPK noted maximum number of locules per fruit, pericarp thickness, lycopene content and specific gravity. This might be due to better nutrient translocation to the developing fruit. The quality parameters like pericarp thickness was significantly higher with the treatment combination of full RD of NPK and Phosphobacterium whereas, application of half RD of NP and full RD of K along with Azotobacter registered highest value for total soluble solids, vitamin-C content and lycopene content.

Kavitha et al. (2010) field experiment was conducted at college farm, College of Agriculture, Rajendranagar, Hyderabad in kharif and rabi seasons of 2003-04 to study the direct and residual effect of sewage sludge, urban compost and FYM (@ 0, 20 and 40 t/ha) alone and in combination with inorganic fertilizers on yield, quality of edible parts (ascorbic acid, protein content, TSS of tomato fruit/cabbage head and sulphur content of cabbage

head at harvest) and economics in tomato-cabbage cropping sequence. Yield and quality parameters were increased significantly with the increasing fertility levels from 0 to 100% RDF. Direct and residual effect of organic manures significantly increased the yield and quality of edible parts compared to no manure application. The highest yield and quality of edible parts were received in the treatment sewage sludge applied @ 40 t/ha followed by 20 t/ha. In combined treatments, sewage sludge @ 40 t/ha alongwith 100% RDF and sewage sludge @ 40 t/ha alongwith 75% RDF were equally effective in increasing the yield and quality of edible parts in both the crops. The highest B:C ratio was obtained in sewage sludge @ 40 t/ha with 75% RDF (3.88).

Patil et al. (2010) the effect of different biofertilizers and inorganic fertilizers revealed that plant height, number of branches were significantly influenced by different biofertilizers in tomato. However, the increase in yield attributes like number of fruits, average weight of fruit, yield plant<sup>-1</sup> and yield hectare<sup>-1</sup> due to inorganic fertilizers was more or less similar with that produced by biofertilizers.

Patil et al. (2010) the research study was conducted in Belgaum district of Karnataka state during 2007-08, with the sample size of 140 respondents. The ex-post-facto research design was used for the study. The findings revealed that all the respondents adopted transplanting method in chilli and tomato crops, FYM application, deep summer ploughing, crop rotation, collection and destruction of affected plants and shoots and marketed through commission agents. Majority of the respondents were found to practice timely weeding (98.57%), raising of seedlings (96.43%), planting recommended aged seedlings (90.00%), use of vermicompost (83.57%) and cleaning of fruits (84.29%). Whereas comparatively less per cent of respondents were found to practice use of biopesticides (19.29%), mulching (15.00%), incorporation of crop residues (14.29%), composting (7.86%) and value addition (2.86%).

Kumar et al. (2011). The field experiment was conducted at the Horticulture Research Farm, Department of Horticulture, C.C.S. University, Meerut (U.P) during 2007-08. The experiment consisted 9 treatments of inorganic and biofertilizers. Three biofertilizers treatments i.e. B<sub>0</sub>, B<sub>1</sub>, (B<sub>0</sub>=no biofertilizer, B<sub>1</sub>=phosphobacteria) and B<sub>2</sub>=Azospirillum and

three, inorganic fertilizer treatments i.e.  $I_0$ ,  $I_1$ , and  $I_2$  ( $I_0$ =no inorganic fertilizer,  $I_1$ =60 kg N+30 kg P/ha),  $I_2$ =120 kg N+60 kg P/ha. The maximum plant height (77.32 cm), no. of branches/plant (12.28), diameter of fruits (58.72 cm) average fruit weight (5.06 g) and yield (360.82 q/ha), the earliest flowering (43.05 days) were noted in the treatment  $I_2$ , where nitrogen and phosphorus was applied 120 kg and 60 kg/ha, respectively and diameter of main stem showed non significant effect. But the interaction effect on plant height, number of branches/plant, diameter of main stem, days taken to first flowering, diameter of fruit, average fruit weight and yield gave the better performance at the treatment combination  $I_2B_2$  as compared to other treatments and control.

Zaman (2011) a field experiment was conducted with potato (*Solanum tuberosum*) during winter (rabi) seasons of 2005-06 and 2006-07 to study the effect of different organic and inorganic sources of nutrients on productivity, specific gravity and processing quality of potato cultivars. The experiment comprised three varieties, viz Kufri Chipsona 1 ( $V_1$ ), Kufri Chipsona 2 ( $V_2$ ), Kufri Jyoti ( $V_3$ ) and four nutrient sources viz. FYM @ 35 tonnes/ha ( $N_1$ ), FYM @ 30 tonnes/ha+bio-fertilizers ( $N_2$ ), FYM @ 25 tonnes/ha+mustard cake @ 1.0 tonne ( $N_3$ ), recommended dose of NPK (180:150:150 kg/ha N,  $P_2O_5$ ,  $K_2O$  respectively) ( $N_4$ ). Kufri Chipsona 1 recorded maximum dry weight of tuber, total number of tubers/ha, total tuber yield (28.18 and 28.39 tonnes/ha) and NPK uptake. Kufri Chipsona 2 attained maximum plant height, number of small tubers (<25 g). Kufri Chipsona 1 produced about 19.10, 18.44% more yield than Kufri Chipsona 2 and 6.22, 6.21% more yield than Kufri Jyoti in the successive two years. Chipsona varieties produced high dry matter, starch, specific gravity, acceptable chip colour content and low reducing sugar. Kufri Jyoti produced maximum germination percentage, vitamin C and reducing sugar content. Recommended dose of NPK ( $N_4$ ) showed the best performance in terms of growth and yield parameters as compared to organic sources of nutrients. FYM @ 30 tonnes/ha along with biofertilizers ( $N_2$ ) recorded maximum soil fertility build-up after harvest of the crop and also helped to achieve required processing qualities of potato tuber. It was concluded that Chipsona varieties were suitable processing cultivars as they met all the necessary requirements

and as well as integrated nutrient management using both manures and fertilizers gave high level of guarantee with improved quality potato production.

Irshad (2011) reported that tomato is one of the most important vegetable crops from nutritional as well as consumptional point of view. It tops the list of canned vegetables. In this study tomato plants were treated with organic manures (F.Y.M, Sewage sludge) and inorganic fertilizers (N.P.K, Zn, S) were analysed for biochemical composition. T.S.S, lycopene, carbohydrate, vit. C, acidity, oxalic acid and carotenoid content exhibited an increase at all the test concentrations and were found maximum in sewage sludge treated along with N.P.K (T<sub>7</sub>).

Hooda et al. (2011) studied foliar and soil borne diseases are major impediments in profitable cultivation of garden pea and tomato in North West Himalayas. Therefore, three modules (IPM, Chemical and organic) were tested in hill ecosystem for pest management in garden pea and tomato. Out of 3 modules tested in tomato, maximum severity of early blight, buckeye rot and fruit borer was observed in organic module (>6.8%) followed by chemical (>4.4%) and IPM modules (>2.1%). Highest percent pest control on pooled mean basis was recorded by IPM module (>82%) followed by chemical (>33%) and organic module (>55%) leading to significant yield enhancement (22.8% in organic, 67.5% in chemical and 105.3% in IPM modules) over their respective unprotected checks. The yield loss due to insect pests and diseases in organic, chemical module, organic unprotected check, chemical treated check and unprotected inorganic check compared to IPM module was 38.6%, 18.4%, 50.0%, 45.0% and 51.3% respectively. Benefit cost ratio ranged from 2.65 to 6.94 in the modules highest being IPM module (6.94). Amongst the 3 modules applied in garden pea, maximum incidence of pre-emergence rot, wilt, white rot, leaf blight, rust, ascochyta blight, powdery mildew, leaf miner and fruit borer were observed in organic module followed by IPM and chemical modules. Maximum percent pest control on pooled mean basis was in case of chemical module (>35%) followed by IPM (>27%) and organic module (>29%). All the modules led to significant yield enhancement (39% in organic, 88.6% in chemical and 80.7% in IPM modules)

over their respective unprotected checks. The yield loss due to pests in organic, IPM over chemical module was 32.4% and 4.2% respectively.

Sibounnavong et al. (2012) mycephyt promoted spore production of *Chaetomium cupreum* and *Chaetomium globosum* which act as biological fungicide for disease control. It is undoubtedly stated that *Chaetomium* powder can be synergized to Mycephyt which formulated as CM product. Mycephyt significantly inhibited the conidia production of *F. oxysporum* f sp. *lycopersici*. Comparison of GAP, PFP and organic methods in three varieties of tomato (Cherry, Loukthor and Sida) gave significantly better in growth parameters or plant stands than the non-treated control. It is indicated that organic method with potent bio-products as CM product for disease control, bioinsecticide (*Beauveria* and *Metarhizium*), bio-fertilizer would promote plant growth parameters of tomato var Cherry, Loukthor and Sida. The organic method gave significantly highest number of fruits in all tested varieties, followed by PFP and GAP. But in chemical method gave lower number of fruits when compared to organic, PFP, GAP and non-treated one. It is observed that the chemical method and non-treated control seriously faced the wilt incidence caused *F. oxysporum* f sp *lycopersici* thereafter diagnosis and isolated the pathogen to identify, especially Sida variety.

Mawalagedera et al. (2012). The rate of nutrient uptake and resultant yields of tomato (*Lycopersicon esculentum* Mill), grown in protected culture at different rates and methods of water and fertilizer applications were tested in a tropical environment. The experiment was conducted in a naturally ventilated glasshouse under hot and humid conditions where the mean daytime temperature and evapo-transpiration rate (ET) in the greenhouse were 29±3.7 degrees C and 65.6±4.7 mm/day, respectively. The standard irrigation method (T1) was subjected to changes by adjusting supply volume to 150% of ET (T2 and T4) and doubling the standard volume together with drainage collection and re-circulation (T3). Standard soluble inorganic fertilizer dosage (in T1 and T2) was adjusted to T3 by doubling the dosage of essential plant nutrients, except N and Ca from the early fruit development (12 weeks after planting). Inorganic fertilizer dosage was completely replaced with phospho-compost and foliar application of plant

extracts (T4). Plant and medium samples were tested for N, P and K compositions. Electrical conductivity and pH drifts in media and leachate were also determined. Results revealed the necessity of excess irrigation from the flower initiation stage of tomato preferably in the form of circulation culture. Significantly high N and P nutrition together with adequate K improved the fruit growth and yield. Overall yields were below the recorded averages due to hot, humid and overcast conditions. Further improvements are needed for K nutrition in the circulation culture of soluble fertilizers and for N nutrition in phospho-compost supplemented plant nutrient supply.

Farahat et al. (2012) the organic amendments, compost, neem and poultry as well as inorganic fertilizer, N P K and nematicide Nema-cur 10% G applied singly at two different doses were effective in reducing *M. incognita* number of galls, nematode reproduction and fecundity. Also, they ameliorated growth criteria of treated tomato plants. The effectiveness seemed to be material origin and concentration dependent. Neem, compost 1, 3 at higher doses (5 g/pot) gave the best results. Yet, achieved results were less than those of nemacur 10% G which overmatched all the organic and inorganic fertilizers. Nematode infection reduced total soluble sugars in roots but the opposite was the case in all treatments. Nematode infection supported root contents of amino acids, total phenols and tannins but they were diminished as a result of almost all treatments. Total soluble sugars and total carbohydrates in shoots decreased as a result of nematode infection but they were regained only by application of inorganic fertilizer. Total amino acids increased in shoots of infected plants and more increase was observed in almost all treatments. Nematode infection impaired tomato uptake of N P K; organic and inorganic fertilizers provoked plants up take, however nemacur improved plants up take of nitrogen only.

Mohammed et al. (2012) studied cDNA corresponding to two type-I vacuolar H<sup>+</sup>-inorganic pyrophosphatases (V-PPases) (SIVP1, SIVP2 and one type-II V-PPase (SIVP3) was isolated from tomato fruit to investigate their role in fruit development. Southern analysis revealed that type-I V-PPase genes form a multigene family, whereas there is only one type-II V-PPase gene in the tomato genome. Although SIVP1 and SIVP2 were differentially expressed in leaves and mature fruit, the highest levels of both SIVP1 and SIVP2 mRNA

were observed in fruit at 2-4 days after anthesis. The expression pattern of type-II SIVP3 was similar to that of SIVP2, and the highest levels of SIVP3 mRNA were also observed in fruit at 2-4 days after anthesis, thus suggesting that SIVP3 plays a role in early fruit development. Because SIVP1 and SIVP2 mRNA was more abundant than SIVP3 mRNA, expression of type-I V-PPases was analysed further. Type-I V-PPase mRNA was localized in ovules and their vicinities and in vascular tissue at an early stage of fruit development. Tomato RNAi lines in which the expression of type-I V-PPase genes was repressed using the fruit-specific promoter TPRP-F1 exhibited fruit growth retardation at an early stage of development. Although the major function of V-PPases in fruit has been believed to be the accumulation of materials such as sugars and organic acids in the vacuole during cell expansion and ripening, these results show that specific localization of V-PPase mRNA induced by pollination has a novel role in the cell division stage.

Shinde et al. (2012) recent studies report the effect of biofield treatment on changes in structural characteristics of organic and inorganic matter, on cancer cells in vitro and on overall plant development. This study tested the impact of the same treatment applied to lettuce and tomato seeds and transplants (*Lactuca sativa* var. capitata and *Lycopersicon esculentum* var. Roma) in commercial plantings with and without fertilizers and pesticides, in relation to yield, quality, and pest inhibition. Treated lettuce plants with fertilizer and pesticide applications were more vigorous, exhibited less incidence of soil-borne fungal wilt, and subsequent yield was statistically greater 43% compared to untreated plants. Treated plants with no fertilizer or pesticide applications in the field behaved similarly to untreated plants that received routine fertilizer and pest control inputs. Similarly, fertilizer applied and fertilizer non-applied treated tomato plants exhibited a 25% and 31% increase in total observable yields respectively. Treated tomato and lettuce plants also measured higher in total leaf tissue chlorophyll content. The combination of biofield treatment along with administration of chemical additives demonstrated the best results with statistically increased yields and higher pest resistance in both test cropping systems. The specific mechanisms that lead to these preliminary results have yet to be determined.

Singh et al. (2012) the experiment was conducted at Horticultural Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology; Meerut-250110 (U. R) during spring season, 2009 with cv. KANCHAN SPECIAL. The current approach of integrated nutrient management focused on disseminating the technical know how to major stakeholders to optimize use of organic and inorganic for sustainable agriculture. The experiment consisted eight treatments during the study. The highest yield of tomato was recorded with the application of FYM and recommended dose of NPK fertilizer. The yield parameters of summer tomatolike, no. of fruit/plant, fruit weight (g), fruit diameters (cm) and fruit yield (q/ha) was found significantly highest at the treatment combination T<sub>6</sub> (60 kg N+30 kg P<sub>2</sub>O<sub>5</sub>+40 kg K<sub>2</sub>O+30 tonnes FYM/ha.) followed by other treatments.

Swarnalatha et al. (2013) reported, Leaf samples of tomato plants showing severe leaf curl symptoms were collected from Pantnagar, Uttarakhand state of India. Full-length clones of a monopartite begomovirus were isolated and complete genome sequence was determined. Genome organization of this virus was found to be similar to those of other old world begomoviruses. Neither alpha satellite nor DNA B component was detected. The DNA-A molecule (2753 nt) sequences showed the highest levels of nucleotide sequence identity of 92.9 to 98.7% with the DNA-A of Ageratum enation virus (AEV) isolates and less identity of 77.1 to 86.3% with known tomato-infecting begomoviruses from India. The incidence of AEV in protected cultivation was upto 68.5% noticed.

Bajpai (2013) the present investigation was carried out with the objectives to study sensory characteristics of vegetables grown under organic and inorganic conditions. The recipes i.e. carrot vegetable, fenugreek leaves vegetable, garlic pickle, okra vegetable, Singaree vegetable, tomato chutney and tomato puree prepared by using organically grown, inorganically grown and conventionally grown vegetables were subjected to sensory evaluation by a panel of ten judges using 9-point hedonic scale. The results of the present study revealed significant differences for the sensory

characteristics between organically and inorganically grown vegetables. Sensory evaluation of vegetable revealed that recipes prepared using organically, grown vegetables scored better scores for some of the characteristics as compared to their inorganically and conventionally grown counterparts.

Gulati et al. (2013) a field experiment was conducted at Niche Area of Excellence Farm, Swami Keshwanand Rajasthan Agricultural University, Bikaner during rabi season of 2010-11. The soil of experimental site was loamy sand in texture containing 80.85, 20.91 and 240.00 kg/ha available nitrogen, phosphorus and potassium, respectively, in 0-15 cm soil depth with pH 8.89, EC 0.30 dS/m dehydrogenase activity 3.80 micro g TPF/g soils and organic carbon 790 mg/kg. The experiment consisted of 24 treatment combinations comprising four organic manure levels with three methods of fertilizer application and two doses of inorganic fertilizers. It was conducted in split-split plot design with four replications. The results showed that average fruit weight, fruit yield per plant, fruit yield, nutrient contents in fruit and plant, fertilizer use efficiency, net return and B:C ratio were maximum with compost 5 t/ha+2 t/ha lignite. However, these parameters were also significantly increased with daily method of fertigation. Significantly higher average fruit weight, fruit yield per plant, fruit yield, nutrient contents in fruit and plant, net return and B:C ratio were registered with 100% recommended dose of NPK as compared to 2/3rd recommended dose of NPK fertilizer.

Chattoo et al. (2013) a field trial in RBD with three replications was conducted over two seasons at Regional Research Station and Faculty of Agriculture, Wadura Sopore, SKUAST-K during kharif 2006 and 2007 to study the effect of organic manures and inorganic fertilizers on fruit and seed yield of tomato cultivar Shalimar-II. Pooled results indicated that integration of organic and inorganic fertilizers proved superior in improving fruit and seed yield over sole application of organic and inorganic fertilizers. Treatment T<sub>8</sub>-PM (2 t/ha)+RFD 50% i. e. 60:45:30 N: P<sub>2</sub>O<sub>s</sub> and K<sub>2</sub>O kg/ha registered maximum fruit yield (312.83 q/ha) and seed yield (144.81 kg/ha) with maximum returns per rupee invested of 2.50 and 2.88 for fruit and seed yield, respectively.

Sharma et al. (2013) in order to improve tomato productivity and restore soil health of degraded agriculture lands, different combinations of biofertilizers with vermicompost, Farm Yard Manure (FYM) or inorganic fertilizers were compared. Vermicompost was found better than FYM in available phosphorus, nitrogen, and presence of beneficial microbes like phosphorus solubilizing bacteria and *Azotobacter* spp. A tomato pot experiment was conducted with degraded soils under five nutrient sources i.e. inorganic fertilizers (urea and single super phosphate), vermicomposts, FYM, inorganic fertilizers and FYM (50:50) and absolute control (no fertilizer). Biofertilizers, *Azotobacter chroococcum* and *Piriformospora indica* were applied to all main treatments keeping uninoculated controls. Tomato seed germination and growth of tomato nurseries were found to be the best under vermicompost treatments. Tomato yielded highest and almost double under vermicomposts as compared to all other treatments. Biofertilizers showed a significant effect on tomato yields in all the treatments except in vermicompost treatment, which showed higher yields even without biofertilizers due to better native microbial flora. Soil organic carbon, soil moisture, respiration rate and phosphatase activities were found significantly higher in organic treatments with maximum under vermicompost and biofertilizers. It was concluded that vermicompost not only improved tomato productivity but also improved certain soil properties of a degraded soil.

Singh et al. (2014) reported that Bacterial wilt (*Ralstonia solanacearum*) is the most threatening disease of tomato in tropical regions and causes great loss to the tomato industry in open and protected cultivation. This study aimed to develop an eco-friendly management module for bacterial wilt of tomato for the Andaman and Nicobar Islands in India. For this, three experiments were conducted at the Central Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India, on genotype screening, grafting technique and growing media during 2009-2012. Among 70 genotypes tested, none were found to be resistant against *R. solanacearum* and had high level of incidence (41.5-94.2%). Graft compatibility of tomato was observed with *Solanum torvum* and *Solanum melongena*, which showed high level of bacterial wilt tolerance with 0.0% and 5.5% incidence, respectively. Cocopeat-based

growing media significantly ( $p < 0.05$ ) reduced bacterial wilt incidence (15.0-45.0%) compared with controls (40.0-56.7%) in potted tomatoes. Fruit yield from individual plants was negatively affected in grafted plants while a significant ( $p < 0.05$ ) increase was recorded from tomatoes in cocopeat-based growing media. Both options reduce wilt incidence significantly ( $p < 0.05$ ) and maintained the plant population with increased yield per unit area. These trials suggested three modules against bacterial wilt; first, tolerant genotype+grafting on *S. torvum* or *S. melongena* rootstocks+growing on cocopeat-vermicompost-lime (1.0:1.0:0.01) media; second, tolerant genotype+cocopeat-vermicompost-lime (1.0:1.0:0.01) media; and third tolerant genotype+grafting on *S. torvum* or *S. melongena* rootstocks. These are cost-effective and locally available eco-friendly modules, which can be adopted in bacterial wilt prone areas of tropical islands.

Khan et al. (2014) the study was conducted to investigate the response of various combinations of potassium from organic and inorganic sources on the mineral profile of two tomatocultivars i.e. Falcon and Rio Grande for two years. The response of tomato cultivars was assessed to six combinations viz. 0-0, 100-0, 75-25, 50-50, 25-75 and 0-100% of poultry manure (PM) and Sulphate of Potash (SOP). All the factors (K source, cultivar and year) alone and in combination significantly ( $P \leq 0.05$ ) affected the mineral profile of tomato fruit. The lowest mineral content of potassium ( $28.13 \text{ g kg}^{-1}$ ), zinc ( $19.20 \text{ mg kg}^{-1}$ ), copper ( $10.97 \text{ mg kg}^{-1}$ ), boron ( $16.39 \text{ mg kg}^{-1}$ ) and iron ( $206.03 \text{ mg kg}^{-1}$ ) was examined in Falcon cultivar in control treatment during 2009. However, lowest Ca content ( $453.28 \text{ mg kg}^{-1}$ ) was recorded in fruits of Rio Grande in control treatment during 2009. The treatment 75-25 resulted in highest contents of Ca ( $590.50 \text{ mg kg}^{-1}$ ) and Cu ( $15.12 \text{ mg kg}^{-1}$ ) in Rio Grande cultivar during 2010. Similarly highest concentration of K ( $44.27 \text{ g kg}^{-1}$ ), Zn ( $29.20 \text{ mg kg}^{-1}$ ) and B ( $28.02 \text{ mg kg}^{-1}$ ) was recorded for Rio Grande at treatment 50-50 of PM and SOP respectively. Whereas, the highest Fe ( $293.25 \text{ mg kg}^{-1}$ ), was recorded in cultivar Rio Grande at a treatment of 100-00 of PM and SOP. It was concluded that a combination of PM and SOP at 75-25 and 50-50 ratio may be used as an optimum fertilization dose for obtaining higher mineral contents of tomato crop.

Maaitah et al. (2014) the study was mainly aimed to investigated the response of potted-grown tomato (*Lycopersicon esculentum* Mill var. lorely F1) to inoculation with arbuscular mycorrhizal fungi (AMF) as well as the application of organic (0, 12.5 and 25 ton ha<sup>-1</sup>) and inorganic fertilizers (0, 625, 1250 and 1875 kg ha<sup>-1</sup>) under glasshouse conditions. This experiment was carried out during the 2011/2012 growing season at the Agricultural Research Station, Faculty of Agriculture, Mu'tah University in the Southern part of Jordan. The experimental treatments were arranged as a factorial in a complete randomized block design (CRBD) with 3 replications for each treatment. Results indicated that vegetative growth parameters viz., plant height, root length, leaf area and shoot dry weight at the flowering stage (50 days post planting) were increased with increasing the level of both inorganic and organic fertilizers regardless of mycorrhiza status. At the beginning of the harvesting time (80 days post planting), all vegetative parameters tested (shoot and root length, leaf area and shoot dry weight) were not significantly affected by the interaction between the fertilizer and the fungus. Furthermore, the main effects of fertilizer and fungus on growth parameters at both growing stages tested (50 and 80 days after planting) were significantly increased with increasing fertilizer level and mycorrhizal inoculation. Root colonization by mycorrhizal fungi in inoculated treatment was high, especially at low level of organic and chemical fertilizers. The highest level of inorganic fertilizer significantly reduced the root colonization.

Saini et al. (2014) a field experiment was conducted to determine the relative efficacy of FYM, vermicompost and chemical fertilizer on growth and yield parameters of tomato (*Lycopersicon esculentum* L.) and chilli (*Capsicum annum* L.) crops with the four treatments. Each treatment was replicated thrice in plots. Plot size, growth and yield parameters viz., height of plants, spread of plants and diameter of main stem, dry weight of whole plant, number of fruits per plant and total weight of fruits per plant were recorded. In both of the crop plants, maximal growth and yield were recorded in the treatment 'vermicompost+urea' and minimal in 'farm yard manure'. In case of tomato, 'urea' gave higher and significantly more growth and fruit yield over 'vermicompost'. Whereas the growth and yield of chilli plants grown in 'vermicompost' alone were almost at par with the plants grown in 'urea' alone.

Despite the differences in yield being non-significant, the chilli plants grown under 'vermicompost' treatment were sturdier. Tomato plants grown in vermicompost alone had more dry weight in comparison to those in urea alone. The best growth and yield of both tomato and chilli plants were achieved under the treatment 'vermicompost (50%)+urea (50% of normal dose)', which reveal that the use of vermicompost can effectively minimize the use of chemical fertilizers.

Chatterjee and Bandyopadhyay (2014) postulated the present study was aimed to assess the influence of integrated use of organic manures (FYM and vermicompost), inorganic fertilizers and azotobacter and phosphate solubilizing bacteria containing biofertilizers (Azophos) on plant nutrient uptake and post harvest soil fertility status of tomato cultivation. The field experiment was carried out by combining 14 different treatment combinations during winter season of 2005- 06 and 2006-07 at UBKV, Pundibari, CoochBehar, West Bengal, India. The pooled results revealed that uptake of major nutrients were significantly influenced by the combination of different sources of nutrients. The finding showed that application of 4 tonnes vermicompost per hectare supplemented with 75% of recommended inorganic fertilizer inoculated with Azophos resulted in maximum uptake of macro nutrients by the tomato plants. Similarly the soil status of N, P, and K was also increased by the same treatment combination. Integrated application of diverse source of nutrients not only increased the uptake of plant nutrients but also improved the post harvest soil fertility and subsequently helped for achieving the much desired crop production with sustainable soil health.

Rana et al. (2014) reported that the Vegetables are important component of balanced human diet. Advanced production technologies are being followed to measure productivity and quality of produce. Protected cultivation is an improved agro technique being used worldwide to register 3–4 times increase in production. Tomato is grown extensively in the plastic greenhouses for higher productivity. The growing conditions especially light and temperature are known to influence both composition and quality of tomato fruits. Hence, studies have been conducted to estimate the quality parameters of tomato grown both under open and in polyhouse with shade nets during cloudy weather in rainy season The results reveals that the fruits

harvested from the field had higher TSS:TA ratio (11.73), acidity (0.49%), total sugar (2.5%), ascorbic acid (14.7 mg 100g<sup>-1</sup>), TSS (5.76oB) and the lycopene content (8.7mg 100 g<sup>-1</sup>) than the fruits grown under protected conditions. However, the environment in the polyhouse favour the growth and development of tomato plant through increased plant height (1.4m) and number of branches. The fruit yield obtained from the polyhouse was higher (2.6 kg plant<sup>-1</sup>) than the open field (1.5 kg plant<sup>-1</sup>). Hence, both types of environmental conditions are favourable in some aspects. The parameters of economic importance like fruit weight and yield are better under protected conditions but the nutritional parameters like vitamin C and lycopene content are higher in open conditions during rainy season.

Mohammed et al. (2014) concluded experiment was carried out in vegetable Research Farm, during Mid-November to 8-May with following combination of which was T<sub>1</sub> (control), T<sub>2</sub> (FYM 1.5 kg/m<sup>2</sup>), T<sub>3</sub>(FYM 2.5 kg/m<sup>2</sup>), T<sub>4</sub> ((30.86 g N, 18.51 g P and 18.51 g K)/m<sup>2</sup>), T<sub>5</sub> ((30.86 g N, 18.51 g P and 18.51 g K)/m<sup>2</sup> + FYM 1.5 kg/m<sup>2</sup>), T<sub>6</sub> ((30.86 g N, 18.51 g P and 18.51 g K)/m<sup>2</sup> + FYM 2.5 kg/m<sup>2</sup>), T<sub>7</sub> ((46.29 g N, 37.02 g P and 37.02 g K)/m<sup>2</sup>), T<sub>8</sub> ((46.29 g N, 37.02 g P and 37.02 g K)/m<sup>2</sup> + FYM 1.5 kg/m<sup>2</sup>), T<sub>9</sub> ((46.29 g N, 37.02 g P and 37.02 g K)/m<sup>2</sup> + FYM 2.5 kg/m<sup>2</sup>), T<sub>10</sub> (Micronutrient 2.5 ml/l) T<sub>11</sub> (FYM 1.5 kg/m<sup>2</sup> + Micronutrient 2.5 ml/l), T<sub>12</sub> (FYM 2.5 kg/m<sup>2</sup> + Micronutrient 2.5 ml/l), T<sub>13</sub> ((30.86 g N, 18.51 g P and 18.51 g K)/m<sup>2</sup> + Micronutrient 2.5 ml/l), T<sub>14</sub> ((30.86 g N, 18.51 g P and 18.51 g K)/m<sup>2</sup> + FYM 1.5 kg/m<sup>2</sup> + Micronutrient 2.5 ml/l), T<sub>15</sub> ((30.86 g N, 18.51 g P and 18.51 g K)/m<sup>2</sup> + FYM 2.5 kg/m<sup>2</sup> + Micronutrient 2.5 ml/l), T<sub>16</sub> ((46.29 g N, 37.02 g P and 37.02 g K)/m<sup>2</sup> + Micronutrient 2.5 ml/l), T<sub>17</sub> ((46.29 g N, 37.02 g P and 37.02 g K)/m<sup>2</sup> + FYM 1.5 kg/m<sup>2</sup> + Micronutrient 2.5 ml/l) and T<sub>18</sub> ((46.29 g N, 37.02 g P and 37.02 g K)/m<sup>2</sup> + FYM 2.5 kg/m<sup>2</sup> + Micronutrient 2.5 ml/l). The cultivar of tomato was "heem shona" syngenta company. The highest high plant (2.83 m) was recorded in T<sub>18</sub> and the highest No. leaves per plant (41.33), dry weight of plant (248.67 g) and the maximum benefit:cost ratio (5.53) was obtained in T<sub>18</sub> treatment.

Singh et al. (2015) three genotypes (V<sub>1</sub>-Naveen 2000<sup>+</sup>, V<sub>2</sub>-Sun-7711 and V<sub>3</sub>-Solan Lalima), three mulches (M<sub>0</sub>-No mulch, M<sub>1</sub>-Pine needle mulch and M<sub>2</sub>-Black polyethylene) and three bio-fertilizers (B<sub>0</sub>-Recommended NPK,

B<sub>1</sub>-100% NPK+Azotobacter (1 g/plant)+PSB (1 g/plant) and B<sub>2</sub>-75% NPK+Azotobacter (1 g/plant)+PSB (1 g/plant)) were arranged in a split-split plot design with variety in main plot, bio-fertilizers in sub-plot and mulching in the ultimate plot. Among varieties, maximum available N, P, K, organic carbon and minimum pH and EC were observed with V<sub>3</sub> (Solan Lalima). Among the mulch materials M<sub>2</sub> (Black polythene) and among biofertilizers, B<sub>1</sub> (100% NPK+Azotobacter (1 g/plant)+PSB (1 g/plant)) were recorded to be the best regarding the nutrient availability and yield in tomato.

## **MATERIALS AND METHOD**

In this chapter the materials used and techniques adopted for the present investigation have been described under suitable headings and tables. The present investigation entitled “**Effect of organic, inorganic and biofertilizers on growth and yield of tomato (*Lycopersicon esculentum* Mill) under protected condition**” was carried out under agro-climatic and soil conditions of Kymore plateau of Madhya Pradesh during the rainy season of 2014. The materials used and technique adopted during the course of these studies are given below.

### **Experiment site**

The experiment was conducted in the Horticulture Department, College of Agriculture, Rewa (M.P.) during *kharif* 2014 with a view to ascertain the most suitable variety and spacing in the light of the recommended NPK fertilizer dose for winter tomato under agro-climatic and soil conditions of northern Madhya Pradesh. The topography of the experiment area was uniform with drip irrigation.

### **Soil of the experimental field**

The soil of poly house was clay loam. It was fairly rich in organic matter and had good water holding capacity. The source of irrigation drip irrigation. The details of the chemical analysis of the soil are given as below:

**Table 3.1: Physico-chemical properties of soil**

S.No.	Analysis	Content (%)	Category	Method used
<b>A. Mechanical composition</b>				
1	Sand (%)	24	-	Bouyoucos Hydrometer method (Piper, 1967)
2	Silt (%)	29	-	
3	Clay (%)	45.0	-	
4	Textural class		Sandy clay loam	
<b>B. Chemical composition</b>				
S.No.	Analysis	Values	Method adopted	
1	Soil pH	6.5	Glass electrode method (pH meter) (Jackson, 1967)	
2	Electrical conductivity (ds/m)	0.40	Conductivity meter at 25 <sup>0</sup> C (Jackson, 1967)	
3	Organic carbon (%)	0.58	Walkley and Black rapid titration method (Walkley and Black, 1934)	
4	Available Nitrogen (Kg N/ha)	218	Alkaline permanganate method (Jackson, 1967)	
5	Available phosphorus (kg P <sub>2</sub> O <sub>5</sub> /ha)	218	Olsen's method (Jackson, 1967)	
6	Available potash (kg/K <sub>2</sub> O/ha)	435	Flam photometer (Jackson, 1967)	
7	Available sulphur (kg/ha)	4.8	UV visible Spectro Photometer	
8	Available Zinc (ppm)	190		

**Climate and Season:**

Rewa is situated in the North eastern part of Madhya Pradesh at 20<sup>0</sup> 21' North latitude, 81<sup>0</sup> 15', East longitude, and 365.7 meters above sea level. It has subtropical climate, hot and dry summer and cold winter. The minimum and maximum temperature occasionally reaches 7.13 <sup>0</sup>C and 40.77 <sup>0</sup>C,

respectively. The average annual rainfall of the tract ranges from 900 to 1200 mm, which mostly occurs during July to September months and occasionally shower are received in winter also. January remains the coolest month of the years.

### Weather Conditions:

The weather conditions during the crop growth season play an important role in the growth and development of the plant and ultimately affect the crop yield. The meteorological data obtained from the observatory, at Agriculture College farm Rewa, are presented in Table 3.2 and depicted in Fig. 1.

**Table 3.2: Meteorological data during *kharif* season 2014**

Season	Month	Week number	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
			Max.	Min.	Max.	Min.	
<i>Kharif</i> 2014	June 2014	23	38.7	27.3	62	22	0.0
		24	38.2	28.2	72	32	10.5
		25	39.1	28.5	74	31	0.0
		26	39.8	26.3	80	48	20.7
	July 2014	27	36.5	23.3	100	65	28.3
		28	33.8	24.6	95	70	0.0
		29	35.2	22.6	90	60	75.0
		30	34.7	23.9	96	60	110.5
		31	30.3	24.1	96	72	0.0
	August 2014	32	31.8	20.6	100	73	65.3
		33	33.5	21.3	100	62	77.5
		34	35.6	21.6	97	56	0.0
		35	31.3	24.0	98	72	55.6
	September 2014	36	30.3	20.7	100	64	20.5
		37	29.9	20.6	99	70	0.0
		38	32.6	21.9	100	80	117.2
		39	34.7	20.6	97	72	135.5
	October 2014	40	32.6	18.7	100	74	26.5
		41	33.5	15.6	96	64	25.2
		42	33.3	17.2	97	72	0.0
43		30.7	15.1	96	62	0.0	
44		30.2	16.7	98	74	0.0	
November 2014	45	29.6	15.3	100	72	45.3	
	46	29.3	14.2	99	60	0.0	
<b>Total</b>							<b>814.2</b>

Standard metrological weather condition in weeks  
Source: Meteorological laboratory, College Research Farm Rewa (M.P.)

### Details of the treatments:

Details of the treatments and their notations used are given below:

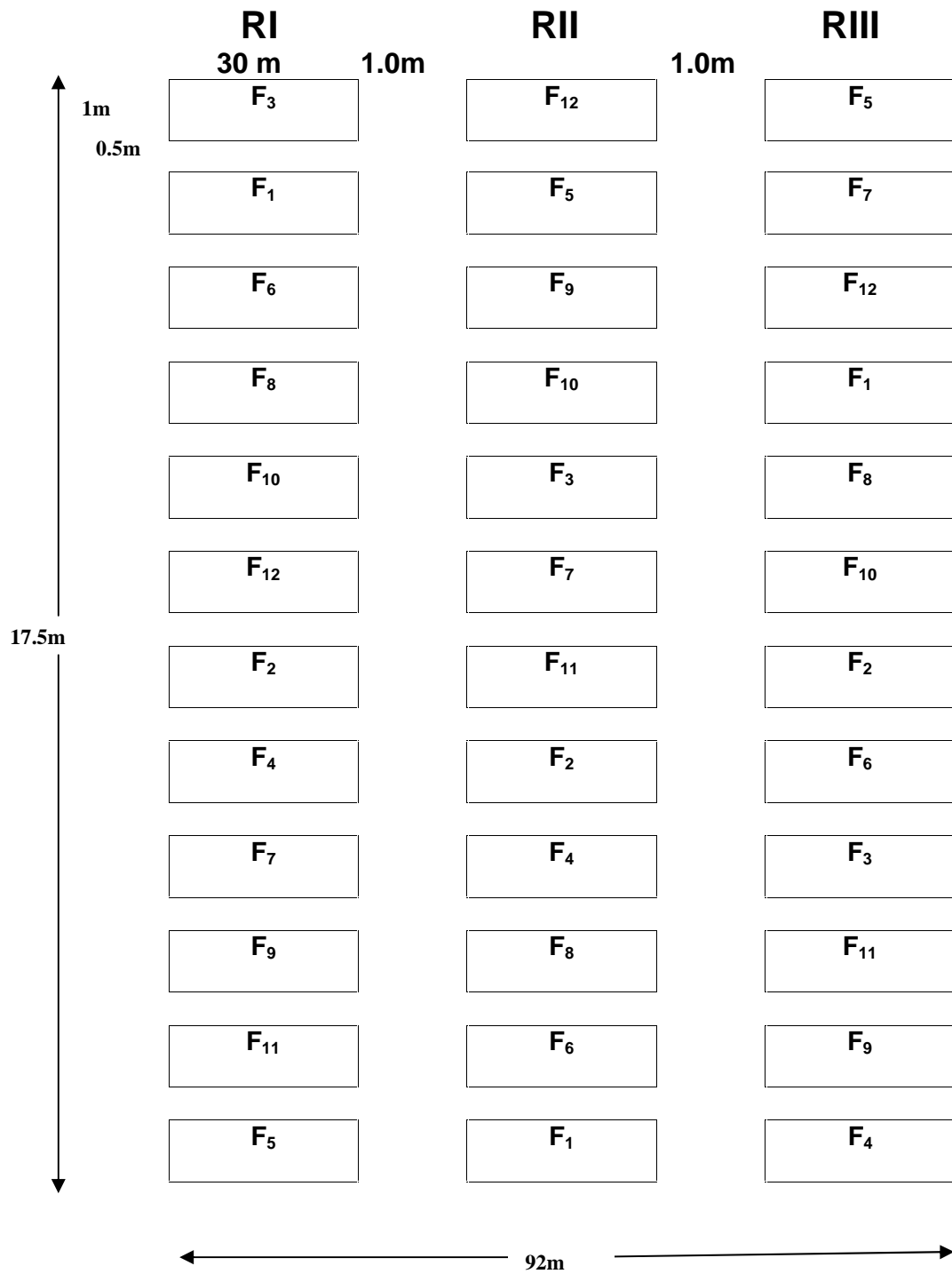
<b>Symbols</b>	<b>Treatments</b>	<b>Symbols</b>	<b>Treatments</b>
T <sub>1</sub>	FYM 20 t/ha	T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>
T <sub>2</sub>	Vermicompost 5 t/ha	T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	T <sub>12</sub>	RFD of NPK (100:60:80)

### Details of layout plan:

The experiment was laid out in randomized block design with three replications. Each replication consists of twelve treatments. All were randomized separately in each replication. The plan of layout is given in Fig.2 and others details are given below:

**Details of layout:**

1	Number of treatments	:	12
2	Number of replications	:	3
3	Total No. of plots	:	36
4	Size of plot (a) Gross area (b) Net area	:	30×1 m×m 29×0.7m×m
5	Row to Row distance	:	60cm
6	Plant to plant distance	:	45
7	Plot border	:	0.5m
8	Replication border	:	1.0m
9	Size of the field	:	92×17.5m×m
10	Fertilizers	:	NPK (100:60:80)
11	Date of sowing		22-07-2014
12	Date of transplanting		17-08-2014
13	Variety		Himshikhar



**Fig. 3.2** Layout plan of the experiment

### **Seed treatment**

The seeds were treated with thirum @ 2.5 g/kg seed before sowing

### **Seed rate and nursery raising**

The seed were sown on 22-7-2014 the rate of 500 g per hectare in the raised nursery beds (1 meter in width and 3 meter in length). Prior to sowing bed was properly solarised and pulverized. The sandy loam soil was selected for nursery raising seed were sown in lines 3 inches apart and properly covered with thatching material Irrigation was given regularly as and when required.

### **Fertilizer application**

The crop was grown with FYM and vermicompost as well as the 50 and 100% recommended of N:P:K (100:60:80 kg/ha) as per treatments. Full dose of phosphorus; potash and half dose of nitrogen were applied as basal dose. At the same time different of FYM and vermicompost were also applied as basal mixed with soil in each plot. The remaining half dose of nitrogen was applied 30 days after transplanting. *Azotabacter* biofertilizer was applied in rows according to the treatment.

### **Transplanting**

Four weeks old seedlings were transplanted on 17-8-2014 on the field. Nursery beds were properly prior to removal of seeding and care was taken to avoid root injury. Planting was done in evening. A light irrigation was given immediately after transplanting.

### **Gap filling**

Healthy seeding to maintain desired plant population in the plots were placed a week after replacing damaged and dead seedlings.

### **Weed control and interculture operations**

Two hoeings and two hand weedings were done with the help of khurpi and protect the plant against insect like leaf minor, Aphids, Heliothis etc. Spraying of mancozed at **20** and **45** after transplanting was done to protect the plant against diseases like blight, Alternaria spot etc.

## Irrigation

Crop was irrigated at the interval of 6-4 days and total Eight irrigations by drip system.

## Harvesting

First picking of matured fruits was done manually on 20.11.2014 and there after continuous picking was done at an interval of 10-15 days. Total five pickings were taken.

**Table 3.3. Schedule of field operation during the course of investigation**

S.No.	Operations	Date	Remark
1	Nursery raising	22.07.2014	Manually
2	Field operations	<b>05.08.2014</b>	Manually
3	Layout	<b>09.08.2014</b>	Manually
4	Soil sample collecting for chemical analysis of before sowing	<b>10.08.2014</b>	By hand augar
5	Application of fertilizers & manures	<b>16.08.2014</b>	Manually
6	Second split dose of urea (50%)	<b>15.09.2014</b>	Manually
7	Transplanting	<b>17.08.2014</b>	Manually
8	Gap filling	<b>12.09.2014</b>	Manually
9	Inter culture operations		Manually
	(a) weeding	<b>15.09.2014</b>	
	(b) Tagging	<b>20.09.2014</b>	
	(c) Plant protection	<b>15.10.2014</b>	
	(d) Last picking	<b>30.01.2015</b>	

## Observations recorded (at 30 days interval)

- (1) Growth characters
  - (a) Height of plant (cm)
  - (b) Number of branch per plant

- (2) Phenological characters
  - (a) Number of flower clusters per plant
  - (b) Number of flowers per cluster
  - (c) Days to first fruit setting
- (3) Yield attributes
  - (a) Number of fruits per cluster
  - (b) Fruits weight (g)
  - (c) Yield per plot (kg)
  - (d) Yield per hectare (q)
- (4) Quality characters
  - (a) Total soluble solids (TSS)
  - (b) Dry matter (%)
- (5) Grading Quality of the *tomato* fruits (%)
- (6) Economics
  - (a) Gross income (Rs/ha)
  - (b) Net income (Rs/ha)
  - (c) Expenditure (Rs/ha)
  - (d) B:C Ratio

### **Details of Observations recorded**

#### **A. Growth characters**

##### **1. Plant height (cm)**

The heights of five randomly–selected plants were measured at 30,60,and 90 days after transplanting from randomly-selected five plants and the scale The average was worked out.

##### **2. Number of braches per plant**

Number of branches per plant were recorded under each treatment at 30, 60, and 90 days after transplanting from randomly-selected five plants and the scale. The average was calculated.

### **3. Number of flower clusters per plant**

Number of flower cluster per plant were recorded under each treatment 30, 60 and 90 days after transplanting randomly selected flower cluster per plant.

### **4. Yield per hectare**

The yield in quintal per hectare was calculated by taking the total yield per plot under each treatment and then converted into per hectare.

## **B. Nutritional Quality characters**

### **1. Total soluble solids (TSS)**

The TSS (%) fruits was recorded under each treatment with the help of Pocket Refractometer and the average values were worked out.

### **2. Dry matter percentage of fruit**

Dry matter of each fruit was determined with the help of hot air oven by keeping the *tomato* fruits at 60°C for 48 hour under each treatment and the average was calculated.

## **Physical Quality Parameters**

### **Grading percentage**

The grading of *tomato* was done according to the *tomato* diameter in the following way.

'A' grade *tomato*    above 7 cm diameter

'B' grade *tomato*    5 to 7 cm diameter

'C' grade *tomato*    below 5 cm diameter

### **Statistical analysis**

The data obtained in respect of all the characters has been subjected to the following statistical analysis

## Mean

The mean of all the observations in each replication was worked out as follows:

$$\text{Mean } (\bar{x}) =$$

Where,

$\Sigma x$  = The sum of all the observations

$N$  = Number of observations:

## Analysis of variance

The variance is the measure of the variability and is defined as the average of the square deviation from the mean. The skeleton of variance is as follows:

**Table 3.5. ANOVA for randomized block design**

Source of variation	d.f.	Sum of square	Mean sum of square	F.cal.
Replications	r-1 (2)	Rss	RMS	RMS/EMS
Treatments	t-1 (11)	TSS	TMS	TMS/EMS
Error	(r-1) (t-1) (22)	ESS	EMS	
Total	rt-1 (35)			

Where,

$r$  = Number of replications

$t$  = Number of treatments

d.f. = degree of freedom

RSS = Replication sum of square

TSS = Treatment sum of square

ESS = Error sum of Square

RMS = Replication mean sum of square

TMS = Treatment mean sum of square

EMS = Error mean sum of square.

A significant value of F/test indicates that the test entries differ significantly among themselves which computing C.D.

$$S.E. (d) = \sqrt{\frac{2 S M E}{r}}$$

$$C.D.= t (0.05) \times SE$$

Where,

S.E. (d) = Standard error of difference

G.M. = Grand mean

C.D. = Critical difference

T (0.05) = t-value at 5% probability level.

### Statistical analysis and interpretation of data

The data collected during the investigation were analyzed statistically by the method of "Analysis of variance" The significance of various treatments was judged as suggested by Fisher (1952) applying 'F' test. The skeleton of analysis of variance is presented in Table 3.5

**Table 3.5 The skeleton of analysis of variance**

S.No.	Source of variation	D.F.	S.S	MSS	'F' Cal	F value at 5%
1	Replications	2	-	-	-	-
2	Fertilizer	11	-	-	-	-
3	Error	22	-	-	-	-
	Total	35	-	-	-	-

The 'F' test was applied for judging the significance of various treatments effect comparison of mean values corresponding to different significant effect was made by using critical difference at 5 percent level of significance which was calculated as given below:

$$S.E.(M) \pm = \sqrt{\frac{\text{Error Variance}}{\text{Replication}}}$$

$$S.E. (d) = S.E. (m) \pm \times 2$$

$$C.D. \text{ at } 5\% = S.E. (d) \times t \text{ } 5\% \text{ at error d.f.}$$

### **Presentation of data**

All the interpretation of the data in the chapter "Experimental" are based on "F" test and critical difference. The results of variance as influenced by different treatment have been illustrated by histogram.

### **Economics**

The cost of cultivation of each treatment was calculated per hectare on the basis of prevailing rates of labour, fertilizer, organic manures etc. irrigation and other expenditure. The total income per hectare was calculated as per the average wholesale price of tomato in the market. The net profit per hectare was obtained by deducting the cost to treatment from gross income.

## CHAPTER-IV

# RESULTS

The data obtained from the periodical field observations pertaining to growth, yield-attributing characters, yield and economics were tabulated and then statistically computed. The interpretation of the results has been made in this chapter based on the appropriate mean data in the tables and illustrations through bar diagrams. The details of the statistical analysis and calculation of economics from the different treatments are given in the materials and methods chapter as well as in the Appendices section.

### 4.1 Growth parameters

#### 4.1.1 Plant height

The data with respect to plant height recorded after 30, 60 and 90 days of transplanting are presented in Table 4.1 and illustrated through Fig.3. The increase in plant height, in general, was observed with the advancement of plant growth upto 90 days stage. It was, in general, enhanced steadily between 30 to 60 and 60 to 90 days period in all the treatments. At 30 days stage, the plant height in various treatments ranged from lowest 27.68 cm to highest 38.30 cm, whereas at 90 days stage, it ranged from 49.84 cm to 62.88 cm.

The plant height was found to deviate significantly due to different treatments at every stage of observations. Among the treatments, T<sub>11</sub> having FYM, vermicompost, biofertilizer and 50% NPK resulted in significantly higher plant height at every stages as compared to the remaining treatments. FYM 20 t/ha (T<sub>1</sub>) was found the second best treatment. Accordingly, at 90 days stage, the maximum height upto 62.88 cm was recorded in case of T<sub>11</sub>, followed by 61.52 cm in case of T<sub>1</sub>, 60.36 cm in case of T<sub>8</sub> and 58.47 cm in case of T<sub>9</sub> treatments in contrast to this, the significantly lowest height only 49.84 to 50.27 cm was recorded in case of T<sub>6</sub> and T<sub>7</sub> treatments having lower dose of fertilizers. The influence of T<sub>4</sub> treatment was also found in the lower order next to T<sub>6</sub> and T<sub>7</sub> treatments.

**Table 4.1 Plant height of tomato at different growth stages as influenced by different fertility treatments.**

Tr. No.	Treatments	Plant height (cm) DAT		
		30	60	90
T <sub>1</sub>	FYM 20 t/ha	36.78	45.38	61.52
T <sub>2</sub>	Vermicompost 5 t/ha	32.07	42.48	54.78
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	31.64	42.22	52.57
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	30.48	43.42	51.43
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	29.35	43.12	52.00
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	28.47	41.69	49.84
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	27.68	42.50	50.27
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	35.25	45.07	60.36
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	33.42	44.57	58.47
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	32.35	44.47	56.56
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	38.30	47.94	62.88
T <sub>12</sub>	RFD of NPK (100:60:80)	32.34	43.80	55.35
	<b>S.Em<sub>±</sub></b>	<b>0.15</b>	<b>0.14</b>	<b>0.15</b>
	<b>C.D. (5%)</b>	<b>0.42</b>	<b>0.41</b>	<b>0.45</b>

The treatments T<sub>1</sub>, T<sub>8</sub>, T<sub>9</sub> and T<sub>11</sub> were significantly superior to T<sub>12</sub> (100% NPK), FYM 20 t (T<sub>1</sub>) proved significantly superior to vermicompost 5 t (T<sub>2</sub>). The treatment T<sub>8</sub> (FYM + vermicompost + *Azotobacter*) and T<sub>9</sub> (FYM + *Azoto.*+ 50% NPK proved the third and fourth best treatments. As regard plant height T<sub>11</sub> was found significantly superior over all other treatments. T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub> and T<sub>11</sub> were found significantly superior over T<sub>12</sub> (RFD) as regards of plant height at 90 DAT, more or less a similar traits was observed at 30 and 60 DAT.

#### **4.1.2 Number of branches/plant**

The number of branches, in general, were found to enhance very fast with the enhancement of plant growth upto 60 days stage of observations. Thereafter the branches were formed almost at the slower rate from 60 days period of plant growth upto 90 days of transplanting.

The different treatments exerted significant impact upon this parameter at every stage. Out of the various treatments, T<sub>11</sub> having all the four inputs brought about significantly higher number of branches per plant at every stage of observations as compared to the rest of the treatments. The T<sub>9</sub> treatment was found the second best in raising this parameter. Accordingly, the maximum number of branches (17.77/plant) were noted at 90 days stage from T<sub>11</sub> treatment. This was followed by T<sub>9</sub> treatment (16.67 branches/plant). The treatments T<sub>1</sub>, T<sub>8</sub>, and T<sub>10</sub> recorded equally lower branches/plant. On the other hand, significantly less branch were observed in T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> treatments.

**Table 4.2 Number of branches/plant of tomato at different growth stages as influenced by different fertility treatments.**

Tr. No.	Treatments	Branches /plant DAT		
		30	60	90
T <sub>1</sub>	FYM 20 t/ha	14.55	15.64	15.76
T <sub>2</sub>	Vermicompost 5 t/ha	11.87	12.89	13.35
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	10.39	11.43	11.44
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	8.87	9.86	10.53
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	9.65	10.12	10.72
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	8.42	9.67	10.25
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	8.72	10.09	10.52
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	14.40	15.50	15.90
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	15.32	16.58	16.67
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	14.26	15.64	15.76
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	15.78	17.16	17.77
T <sub>12</sub>	RFD of NPK (100:60:80)	13.54	13.57	13.76
	<b>S.Em<sub>±</sub></b>	<b>0.16</b>	<b>0.08</b>	<b>0.05</b>
	<b>C.D. (5%)</b>	<b>0.47</b>	<b>0.24</b>	<b>0.15</b>

Thus when half dose of FYM or vermicompost when applied with biofertilizer, significantly less branches were resulted. The T<sub>1</sub> (20 t FYM/ha) was found significantly superior to vermicompost 5/ha (T<sub>2</sub>). Similarly T<sub>1</sub>, T<sub>8</sub>, T<sub>9</sub> and T<sub>10</sub> were found significantly superior to T<sub>12</sub> (100% NPK). This trend observed at every stage of observations.

## **4.2 Phenological characters**

### **4.2.1 Number of flower clusters/plant**

The flower clusters were counted per plant in each treatment. The mean data are highlighted in Table 4.3 and illustrated in Fig.5.

The treatment T<sub>11</sub> having FYM + vermicompost+*Azotobactor*+50% NPK gave significantly higher flower clusters (17.60/plant) over the remaining fertility treatments. However, this was equally followed by T<sub>1</sub>, T<sub>8</sub> and T<sub>9</sub> treatments. Flower cluster were further lowered down in case T<sub>3</sub>, T<sub>10</sub> and T<sub>12</sub>. On the other hand, and T<sub>5</sub> resulted in significantly lowest flower clusters (10.75/plant). There was no significant difference between T<sub>2</sub> and T<sub>4</sub> producing lower flower clusters (13.63 to 13.75/plant).

### **4.2.2 Number of flowers/ cluster**

The number of flowers/cluster was determined treatmentwise and the data so obtained were subjected to statistical computation. The mean data are presented in Table 4.4 and exhibited through bar diagram as in Fig. 6. The different fertility levels exerted significant deviation in this parameter.

**Table 4.3 Number of flower clusters/plant as influenced by different fertility treatments.**

<b>Tr. No.</b>	<b>Treatments</b>	<b>Number of flower clusters/plant</b>
T <sub>1</sub>	FYM 20 t/ha	16.27
T <sub>2</sub>	Vermicompost 5 t/ha	13.75
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	14.76
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	13.63
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	12.86
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	10.75
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	11.55
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	16.24
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	15.39
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	14.53
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	17.60
T <sub>12</sub>	RFD of NPK (100:60:80)	14.21
	<b>S.Em<sub>±</sub></b>	<b>0.07</b>
	<b>C.D. (5%)</b>	<b>0.19</b>

**Table 4.4 Number of flower/clusters of tomato as influenced by different fertility treatments.**

<b>Tr. No.</b>	<b>Treatments</b>	<b>Number of flower /clusters</b>
T <sub>1</sub>	FYM 20 t/ha	4.98
T <sub>2</sub>	Vermicompost 5 t/ha	3.86
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	3.95
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	3.71
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	3.80
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	3.57
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	3.78
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	4.75
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	4.62
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	4.38
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	5.25
T <sub>12</sub>	RFD of NPK (100:60:80)	4.16
	<b>S.Em<sub>±</sub></b>	<b>0.04</b>
	<b>C.D. (5%)</b>	<b>0.12</b>

The best fertility treatment was T<sub>11</sub> which resulted in significantly higher number of flowers (5.25/cluster) over rest of the treatments. The second and third best fertility treatments was T<sub>1</sub> and T<sub>8</sub> which produced 4.98 and 4.75 flowers/cluster, respectively. The fourth best fertility treatment was T<sub>9</sub> (4.62 flowers) and then T<sub>10</sub> (4.38 flowers/cluster). The 100% NPK brought about lower number flowers (4.16/cluster), which was significantly inferior than the above mentioned fertility levels. The significantly lowest number of flowers (3.57 to 3.80/cluster) was obtained from T<sub>4</sub>. The best fertility treatment was T<sub>11</sub> which resulted in significantly higher number of flowers (5.25/cluster) over rest of the treatments. The second and third best fertility treatments was T<sub>1</sub> and T<sub>8</sub> which produced 4.98 and 4.75 flowers/cluster, respectively. The fourth best fertility treatment was T<sub>9</sub> (4.62 flowers) and then T<sub>10</sub> (4.38 flowers/cluster). The 100% NPK brought about lower number flowers (4.16/cluster), which was significantly lowest than the above mentioned fertility level.

#### 4.2.3 Days to fruit setting

Days to first fruit setting was observed and the data were subjected to statistical analysis. The mean data are presented in Table 4.5 and illustrated in Fig.7

The treatment T<sub>11</sub> (FYM + vermicompost+Azotobactor+50% NPK) resulted in longest period taken to first fruit setting in tomato (48.47 days). This was followed by T<sub>1</sub> (20 t FYM/ha) where fruit setting was in 46.22 days. The period of fruit setting was decreased significantly in case of T<sub>8</sub> and T<sub>9</sub> (45.39 to 45.83 days). The treatments T<sub>10</sub> and T<sub>12</sub> further reduced the period of fruit setting (43.45 to 44.90 days). The treatments T<sub>4</sub> and T<sub>7</sub> took 40.33 to 40.53 days for fruit setting. The treatments T<sub>6</sub> and T<sub>5</sub> have taken minimum period for fruit setting 38.74 to 39.52 days. Respectively nine to ten days earlier than that from T<sub>11</sub>. The fruit setting was found five days earlier from 100% RDF (N<sub>100</sub>P<sub>60</sub>K<sub>80</sub>) as compared to T<sub>11</sub> (Fym+vermicompost+Azotobactor+50%).

**Table 4.5 Days to first fruit setting in tomato as influenced by different fertility treatments.**

<b>Tr. No.</b>	<b>Treatments</b>	<b>Days to first fruit setting</b>
T <sub>1</sub>	FYM 20 t/ha	46.22
T <sub>2</sub>	Vermicompost 5 t/ha	42.41
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	41.87
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	40.33
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	39.52
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	38.74
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	40.53
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	45.83
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	45.39
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	44.90
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	48.47
T <sub>12</sub>	RFD of NPK (100:60:80)	43.45
	<b>S.Em<sub>±</sub></b>	<b>0.05</b>
	<b>C.D. (5%)</b>	<b>0.14</b>

## 4.3 Yield attributes

### 4.3.1 Number of fruits/plant

The fruits/plant was counted in each fertility treatment and the data so obtained were subjected to statistical computation. The mean data are highlighted in Table 4.6 and illustrated through Fig. 8.

This parameter was influenced significantly due to various combinations of FYM, vermicompost, biofertilizer and NPK fertilizers. Out of these treatments, T<sub>11</sub> produced significantly highest number of fruits (25.83/plant) whereas T<sub>1</sub> and T<sub>10</sub> registered more number of fruits 24.49 and 24.53/plant being significantly superior to all the remaining treatments. The fourth and fifth best treatments were T<sub>9</sub> and T<sub>8</sub>. The significantly lowest fruits count (16.77/plant) over the all other treatments. The treatments having single organic source of nutrients (T<sub>1</sub> and T<sub>2</sub>) brought significant difference and FYM was found significantly superior to vermicompost for this parameter.

### 4.3.2 Weight of fruit

The weight of fruit was also measured in each fertility treatment and the data thus obtained were subjected to statistical computation. The mean data are presented in Table 4.7 and illustrated through Fig.9.

The fruit weight was influenced significantly due to different fertility treatments comprising combinations of organic and inorganic sources of nutrients. Among these treatments, T<sub>11</sub> continued to register this parameter also upto the maximum extent (59.50 g) being significantly higher to all the remaining treatments followed by T<sub>1</sub> (58.37 g). The treatments like T<sub>8</sub> and T<sub>9</sub> were next T<sub>11</sub>×T<sub>1</sub> as the fruit weight being 53.17 to 54.43 g. T<sub>6</sub> (FYM 10 t/ha+ Azotobactor) gave fruits of minimum weight (44.31g) as compared to other treatments. Which were found significantly superior to T<sub>6</sub> This was followed by T<sub>7</sub> treatments (2.5 t vermicompost/ha+Azotobactor 45.66 g).

**Table 4.6** Number of fruits/plant in tomato as influenced by different fertility treatments.

<b>Tr. No.</b>	<b>Treatments</b>	<b>Number of fruits/plant</b>
T <sub>1</sub>	FYM 20 t/ha	24.53
T <sub>2</sub>	Vermicompost 5 t/ha	21.83
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	20.52
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	19.67
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	18.49
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	16.77
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	17.64
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	22.71
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	23.17
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	24.49
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	25.83
T <sub>12</sub>	RFD of NPK (100:60:80)	21.27
	<b>S.Em<sub>±</sub></b>	<b>0.06</b>
	<b>C.D. (5%)</b>	<b>0.16</b>

**Table 4.7 Weight of tomato fruit as influenced by different fertility treatments.**

<b>Tr. No.</b>	<b>Treatments</b>	<b>Weight of tomato fruit(g)</b>
T <sub>1</sub>	FYM 20 t/ha	58.37
T <sub>2</sub>	Vermicompost 5 t/ha	46.56
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	47.65
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	46.46
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	47.08
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	44.31
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	45.66
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	54.43
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	53.17
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	49.87
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	59.50
T <sub>12</sub>	RFD of NPK (100:60:80)	48.86
	<b>S.Em<sub>±</sub></b>	<b>0.11</b>
	<b>C.D. (5%)</b>	<b>0.31</b>

### **4.3.3 Tomato yield/plot**

The per plot yield was recorded treatmentwise. The data thus obtained were subjected to statistical computation. The mean data are highlighted in Table 4.8 and illustrated through Fig.10.

The fertility treatments exerted significant influence upon this productivity parameter. The best treatment was T<sub>11</sub> 10t/ha FYM + 2.5t/ha vermi.+biof.+50% NPK was found significantly superior tomato yield as regards (36.57 t/ha) over rest of the treatments. T<sub>9</sub>, T<sub>1</sub> and T<sub>8</sub> also found the second best treatment superior as compared to other treatments T<sub>11</sub>. This was closely followed by T<sub>8</sub> and T<sub>9</sub> (35.39 to 35.74 t/ha tomato yield). The similar response of treatment was obtained from T<sub>3</sub> and T<sub>10</sub> producing equal tomato upto 35.18 to 35.20 t/ha.

This was followed by T<sub>2</sub> and T<sub>12</sub>. The treatments T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> gave lower productivity (33.01 to 33.56 t/ha). Among these treatments, T<sub>2</sub> was significantly superior to T<sub>3</sub> and T<sub>4</sub>. Similarly, T<sub>3</sub> was significantly superior to T<sub>4</sub>. Similarly, T<sub>3</sub> was significantly superior to T<sub>4</sub>. Significantly lowest tomato yield (33.01 t/ha) was achieved from treatment T<sub>6</sub> (half FYM + biofertilizer).

## **4.4 Quality characters**

### **4.4.1 Dry matter of fruit**

The dry matter content of fruits was recorded treatment wise and the data so obtained were statistically analyzed. The mean data are presented in Table 4.9 and illustrated through Fig.11.

**Table 4.8 Yield of tomato as influenced by different fertility treatments.**

<b>Tr. No.</b>	<b>Treatments</b>	<b>Yield of tomato (t/ha)</b>
T <sub>1</sub>	FYM 20 t/ha	35.48
T <sub>2</sub>	Vermicompost 5 t/ha	34.83
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	35.18
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	34.35
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	33.56
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	33.01
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	33.50
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	35.39
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	35.74
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	35.20
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	36.57
T <sub>12</sub>	RFD of NPK (100:60:80)	34.53
	<b>S.Em<sub>±</sub></b>	<b>0.14</b>
	<b>C.D. (5%)</b>	<b>0.39</b>

**Table 4.9 Dry matter of tomato fruit as influenced by different fertility treatments.**

<b>Tr. No.</b>	<b>Treatments</b>	<b>Dry matter of tomato fruit (%)</b>
T <sub>1</sub>	FYM 20 t/ha	7.80
T <sub>2</sub>	Vermicompost 5 t/ha	6.87
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	6.91
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	6.70
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	6.74
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	6.53
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	6.63
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	7.62
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	7.47
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	7.27
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	8.17
T <sub>12</sub>	RFD of NPK (100:60:80)	7.21
	<b>S.Em<sub>±</sub></b>	<b>0.02</b>
	<b>C.D. (5%)</b>	<b>0.06</b>

The different fertility treatments exerted significant impact upon this parameter. Amongst the treatments, T<sub>11</sub> having half FYM, half vermicompost, biofertilizer and 50% NPK resulted in significantly highest dry matter (8.17%) over all the remaining treatments. The second best treatment was T<sub>1</sub> having 20 t FYM/ha (7.80%). The third and fourth rank treatment was found in almost rest of the treatments. Vermicompost 5 t/ha (T<sub>2</sub>) was found equally effective as that of T<sub>3</sub> having half FYM + half vermicompost (6.87 to 6.91%). The treatments T<sub>10</sub> (Vermi 5 t/ha + biofertilizer + 50% NPK) and T<sub>12</sub> (100% NPK) also performed in the same range (7.21 to 7.27% DM). The treatments T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> recorded the significantly lower dry matter (6.53 to 6.745) as compared to the remaining treatments.

#### 4.4.2 Grading of tomato

The grading of tomato was done in each treatment based on A, B and C grades and the data were statistically analysed. The mean data are exhibited in Table 4.10 and diagrammatically illustrated through Fig.12.

The scrutiny of the data reveals that the T<sub>11</sub> having application of all the four types of inputs recorded significantly higher upto 54.59% "A" grade tomato as compared to all the remaining treatments. However, the second best fertility level was 20 t/ha FYM T<sub>1</sub> giving 52.16% "A" grade tomato. This was closely followed by T<sub>8</sub> (51.76%). The treatments T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> resulted in significantly lower "A" grade tomato. FYM 20 t/ha (T<sub>1</sub>) proved significantly superior to vermicompost 5 t/ha (T<sub>2</sub>). The treatments T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>10</sub> and T<sub>12</sub> were found at par respect to "A" grade tomato. Similarly, the treatments T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> also gave the "A" grade tomato in the identical range (48.49 to 48.64%). The best treatment T<sub>11</sub> produced highest (34.37%) "B" grade tomato and the lowest (11.04%) "C" grade tomato. This was followed by T<sub>8</sub> (34.32 and 13.79%) and then T<sub>1</sub> (34.20 and 13.64%, respectively). The treatment T<sub>9</sub> gave 33.71% "A" grade tomato and 15.66% "C" grade tomato. The lowest "B" and highest "C" grade tomato were obtained from T<sub>6</sub> and T<sub>8</sub> treatments. The treatments T<sub>3</sub> and T<sub>4</sub> resulted in equal "A" grade tomato (49.22 to 49.24%), "B" grade (32.39 to 32.44%) and equal "C" grade tomato (18.32 to 18.39%).

**Table 4.10 Grading percentage of tomato as influenced by different fertility treatments.**

Tr. No.	Treatments	Grading percentage of tomato		
		A	B	C
T <sub>1</sub>	FYM 20 t/ha	52.16	34.20	13.64
T <sub>2</sub>	Vermicompost 5 t/ha	49.34	32.47	16.52
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	49.24	32.44	18.32
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	49.22	32.39	18.39
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	48.64	32.16	19.13
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	48.49	31.24	20.27
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	48.61	31.39	20.00
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	51.76	34.32	13.76
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	50.62	33.71	15.66
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	49.41	32.58	17.78
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	54.59	34.37	11.04
T <sub>12</sub>	RFD of NPK (100:60:80)	49.63	33.18	17.19
	<b>S.Em<sub>±</sub></b>	<b>0.03</b>	<b>0.04</b>	<b>0.435</b>
	<b>C.D. (5%)</b>	<b>0.10</b>	<b>0.105</b>	<b>1.25</b>

#### **4.4.3 TSS**

The nutritional quality of tomato was recorded under each treatment and the data so obtained were subjected to statistical analysis. The mean values are presented in Table 4.11 and exhibited through Fig.13.

The TSS was found to deviate significantly due to different treatments. The general trend was that the increasing fertility levels i.e. organic + inorganic four sources of nutrients ( $T_{11}$ ) resulted in significant increase in TSS and the highest 10.84 °Brix (TSS) was found  $T_{11}$  treatment. This treatment proved significantly superior to rest of the treatments. However, the second best treatment was  $T_1$  giving 10.50 °Brix (TSS).

The significantly lowest 8.47 °Brix (TSS), respectively was noted in  $T_6$ . There was no significant difference between  $T_3$  and  $T_5$ . The TSS in  $T_{12}$  was found significantly less in comparison to  $T_1$ ,  $T_8$ ,  $T_9$  and  $T_{11}$  treatments.

#### **4.5 Net profit and B:C ratio**

The net profit and B:C ratio were estimated under each treatment based on the existing market rates on inputs and outputs. The mean data so obtained are presented in Table 4.12 and diagrammatically illustrated through Fig. 15.

**Table 4.11 Total soluble solids in tomato as influenced by different fertility treatments.**

<b>Tr. No.</b>	<b>Treatments</b>	<b>TSS (°Brix)</b>
T <sub>1</sub>	FYM 20 t/ha	10.50
T <sub>2</sub>	Vermicompost 5 t/ha	9.10
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	8.80
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	8.93
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	8.80
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	8.47
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	9.20
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	10.20
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	10.08
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	9.86
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	10.84
T <sub>12</sub>	RFD of NPK (100:60:80)	9.47
	<b>S.Em<sub>±</sub></b>	<b>0.03</b>
	<b>C.D. (5%)</b>	<b>0.09</b>

**Table 4.12 Net profit and B:C ratio from tomato as influenced by different fertility treatments.**

Tr. No.	Treatments	Net profit (Rs)	B:C ratio
T <sub>1</sub>	FYM 20 t/ha	128457	3.62
T <sub>2</sub>	Vermicompost 5 t/ha	125207	3.56
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	126957	3.59
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	130634	4.18
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	126684	4.08
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	125907	4.22
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	128357	4.28
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	127807	3.60
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	132584	3.88
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	124884	3.44
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	131734	3.58
T <sub>12</sub>	RFD of NPK (100:60:80)	139762	5.25
	<b>S.Em<sub>±</sub></b>	--	--
	<b>C.D. (5%)</b>	--	--

Among the fertilizer treatments, 100% recommended dose of fertilizer ( $N_{100}P_{60}K_{80}$ ) resulted in highest net profit upto Rs.139762/ha with highest 5.25 B:C ratio. However, this was followed by  $T_9$  (FYM + biofertilizer + 50% NPK) with Rs.132584/ha net income and. The treatment  $T_{11}$  and  $T_4$  gave almost equal net profit ranging from Rs.130634 to Rs.131734/ha, the B:C ratio ranged from 3.58 to 4.18 respectively. On the other hand, the lowest net profit (Rs.124884/ha) and B:C ratio (3.44) were recorded in  $T_{10}$ . The net profit of this  $T_{10}$  treatment was very low than that obtained from the other treatments. Among the separately applied organic sources of nutrients, the net profit ranged from the lowest (Rs.125207/ha) in case of vermicompost to the highest (Rs.128457/ha) in case of FYM. The treatments like  $T_3$ ,  $T_5$  and  $T_6$  also gave the lower net profit in comparison the other best combinations with other organic sources of nutrients. Thus, there was larger differences in the net profit obtained from the different treatments. The net profit from 100% NPK ( $T_{12}$ ) was higher by Rs.7178/ha as compared to the best treatment  $T_9$  where all the three types of nutrient inputs were applied together.

## CHAPTER-V

# DISCUSSION

Modern agriculture based is on the use of organic manures which are eco-friendly and low in cost. Organic fertilizers like vermicompost, neem cake and biofertilizers (PSB) are very popular among the farmers to produce quality product. In India most of the farmers are small and marginal. Therefore, it is very difficult for them to purchase the chemical fertilizers at higher cost. Organic manures on the other hand are eco-friendly cheapest sources of nutrients. Due to abundant additions of chemical fertilizers, decline in yield under continuous cropping system is very common. The effective utilization of organic and inorganic manure would not only provide economic benefits to the farmers but also improve and maintain soil fertility and sustainability in natural eco-system. It has become the matter of research for the use of organic manure which are eco-friendly and low in cost along with chemical fertilizers for the production of tomato crop.

The results of the present investigation entitled “**Effect of organic, inorganic and biofertilizers on growth and yield of tomato (*Lycopersicon esculentum* Mill) under protected condition**” have been summarized in Summary Table 5.1 and discussed in the light of the work done. The findings have been discussed in the headings viz. growth, flower and fruit development and yield parameters.

### 5.1 Plant growth parameters

The plant height and number of branches/plant were, in general, increased steadily between 30 and 90 days after transplanting (DAT) in all the treatments. At 90 days, the plant height ranged from 49.84 to 62.88 cm and number of branches from 10.25 to 17.77/plant in different treatments.

As regards with the treatments effect, out of organic x inorganic combinations, T<sub>11</sub> (FYM + vermin. + Azoto. + 50% NPK) performed the best in encouraging growth parameters upto significant extent at every stage of observations. At 90 DAT, the maximum plant height was 62.88 cm and branches 17.77/plant. This was followed by T<sub>1</sub> (20 t FY/ha only) and then T<sub>8</sub>, T<sub>9</sub> and T<sub>12</sub>. The treatments T<sub>6</sub> and T<sub>7</sub> (half FYM and *Azotobacter* or half

vermin). resulted in significantly lowest growth parameters (Summary Table 5.1).

The best performance of T<sub>11</sub> may be owing to fact that the combined inputs of FYM + vermin. + *Azoto.* +50% NPK played a unique role in the supply of essential plant nutrients in optimum quantity during growth period, thereby increased photosynthates and their translocation towards the vegetative organs. The second best fertility treatment was T<sub>1</sub> ( 20 t FYM/ha). FYM is considered the store house of plant nutrients including micronutrients and beneficial microbial activities with improved physical properties of the soil. Application of FYM upto 20 t/ha supplied sufficient plant nutrients to the actively growing plants as well as created sound physio-chemical and biological properties of the soil. The beneficial effect of FYM and vermicompost on crop yields and soil productivity is the result of their usefulness as a store-house of plant nutrients. These organic sources of nutrients improved soil aeration, root development and increase microbial and biological activities in the rhizosphere. As reported by Sendukumaran et al, 1998, Krishna et al, 2002, Gajbhiya et al,2003, Shukla et al, 2006, and Chatterjee et al., 2014. The treatments like T<sub>6</sub> and T<sub>7</sub> having half dose of FYM or vermicompost with *Azotobacter* resulted in minimum growth parameters because of decreased suboptimal supply of nutrients to the actively growing plant parts.

## 5.2 Phenological characters

The number of flower clusters/plant, number of flowers/cluster and days to first fruit setting was influenced significantly due to combined inputs of organic and inorganic sources of nutrients. The fertility treatment T<sub>11</sub> having four sources of applied nutrients (FYM + vermicompost+ *Azotobacter.* + 50% NPK) brought about significant results as regard the above phenological characters. The maximum phonological characters under T<sub>11</sub> was found superior over other treatments because of maximum clusters/plant (17.60), maximum, flowers/cluster (5.25) and long period of 48.47 days taken for first fruit set. This may be due to more vegetative growth (height and branches) consequently increased translocation of photosynthates towards reproductive organs. The required supply of nutrients may have increased the vegetative growth phase and as such longer period to first fruit setting. similar results

were reported by Bhardwaj et al. (2000), Sannigrahi and Barah (2000), Rafi et al. (2002), and Chatterjee et al. (2014).

The second best fertility treatment was T<sub>1</sub> (20 t FYM/ha). The flower clusters were 16.27/plant, flowers 4.98/cluster and 46.22 days to first fruit set. The lower doses of FYM or vermicompost along with *Azotobacter* inoculation were found significantly inferior, rest of the treatments as regards flower cluster and number of flowers per cluster. The lowest value for phenological features were exactly in accordance with the quantum of supply of nutrients from these fertility treatments (T<sub>6</sub> and T<sub>7</sub>).

### 5.3 Yield-attributing characters

The yield-attributing characters viz. number of fruits/plant and weight of fruit were influenced significantly due to different fertility treatments.

The fertility treatment T<sub>11</sub> comprising four sources of nutrients registered significantly maximum fruits (25.83/plant) as compared to the remaining treatments. Similarly the fruit weight was also significantly higher upto 59.50 g. The second best fertility treatment was T<sub>1</sub> (20 t FYM/ha) and then T<sub>8</sub> (10 t FYM + 2.5 t vermin.+*Azoto.*) and T<sub>9</sub> (FYM < 15 t/ha + *Azoro.* + 50% NPK). These parameters were further reduced significantly in case of T<sub>10</sub> (vermi. 5 t/ha + *Azoto.* + 50% NPK) and T<sub>12</sub> (N<sub>100</sub>P<sub>60</sub>K<sub>80</sub>) treatments. The minimum value for these parameters were recorded in (FYM or vermicompost with *Azotobacter*) T<sub>6</sub> and T<sub>7</sub>. Such variation in yield-attributing characters under different treatments was exactly in accordance with the growth parameters and phenological characters.

The significant variations in yield attributes due to treatments having applied organic sources of nutrients alone or with chemical or biofertilizers might be owing to variations in their nutrient composition, decomposition of organic residues, nutrient release pattern and carbon-nitrogen ratio. The variation in yield-attributes of tomato and onion due to different nutrient sources have also been reported by kumaran et al, 1998; Bhardwaj et al, 2000; Mawalagedra et al, 2012 and Chatterjee et al. (2014).

#### **5.4 Productivity of tomato**

The yield of tomato was found to deviate significantly due to different fertility levels having organic + inorganic sources of nutrients. Amongst these treatments, T<sub>11</sub> having four sources of nutrients registered significantly higher tomato yield (36.57 t/ha) over the remaining fertility treatments. However, this was equally followed by T<sub>1</sub> having 20 t FYM/ha (35.48 t/ha) and T<sub>9</sub> having 15 t FYM/ha + Azoto. + 50% NPK (35.74 t/ha). As reported in summary table 5.1, minimum yields were recorded under T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> where the quality of nutrients was probably suboptimum. As such significant variations in yield was as a result of quantum of nutrients supplied to from different sources. This most important factor influenced the vegetative growth and reproductive growth as well. The productivity of tomato from the various treatments was exactly in accordance with the yield-attributing characters. Similar trend was also reported by Rafi et al, 2002; selim et al. 2006; Zaman et al, 2011; Sharma et al, 2013 and Chatterjee et al. (2014).

#### **5.5 Physico-chemical qualities**

Amongst the combined application of organic and inorganic nutrients, T<sub>11</sub> continued to be the best with respect to quality also. The significantly highest dry matter content (8.17%), maximum number of "A" grade fruits (54.59%), TSS and maximum (10.84 °Brix) were recorded from the fertility treatment T<sub>11</sub>. The second best fertility treatment was T<sub>1</sub> (20 t FYM/ha). On the other hand, the lowest values 6.53 and 6.63% for dry matter "A" grade fruits and lower TSS were recorded under T<sub>6</sub> and T<sub>7</sub>. T<sub>6</sub> and T<sub>7</sub> were found to yield maximum "C" grade fruits also. The cumulative functions of applied nutrients as in T<sub>1</sub>, T<sub>11</sub>, T<sub>8</sub> and T<sub>9</sub> played unique differential role in metabolism which provided conducive conditions for better utilization of photosynthates towards qualitative changes in tomato also. The improvement in the tomato quality as a result of applied organic + inorganic nutrients has also been reported by Kumaran et al, 1998; renuka et al, 2008; Rafi et al, 2002; Krishna et al, 2002; Patil et al, 2004 and Kumar et al, 2007.

## 5.6 Economics of the treatments

The ultimate aim of the grower is to secure maximum income out of the present resource. The organic sources of nutrients not only produce highest and sustainable crop yields and quality produce but also maintain the soil fertility with maximum net income/ha.

Among the fertilizer treatments, 100% recommended dose of fertilizer ( $N_{100}P_{60}K_{80}$ ) resulted in highest net profit upto Rs.139762/ha with highest B:C ratio (5.25). Followed by  $T_9$  (FYM + biofertilizer + 50% NPK)  $T_{11}$  (FYM 10 t/ha, vermicompost 2.5 t/ha, Azotobactor + 50% NPK),  $T_4$  (FYM 10t/ha, 50% NPK + Azotobactor) and other the lowest net profit was under  $T_{10}$  treatment of Rs 124884. Thus the recommended dose of chemical fertilizers gave maximum net profit as compared to other treatment and the range was Rs 124884 to Rs 139762. The difference in net profit over RDF was in miner and ranged up to Rs 7178( $T_9$ ) to Rs 14787 ( $T_{10}$ ). The B/C ratio was maximum (5.25) in  $T_{12}$  when RDF was applied and the minimum (3.44) under  $T_{10}$  when 50% NPK + vermicompost and biofertilizer was applied. The maximum net profit was recorded  $T_{12}$  (RDF). The B/C ratio was also maximum (5.25) under  $T_{12}$ . The amount of net profit was found the lower along with B/C ratio in rest of the other treatments as maintained above. The present results corroborate with those of Naidu et al, 2002; Yadav et al, 2004; Kavitha et al, 2010; Gulati et al, 2013; Chatto et al, 2013 and Mohammad et al, 2014.

**Summary Table 5.1 Growth, yield, quality and economics of tomato as influenced by organic, inorganic and biofertilizers**

Tr. No.	Treatments	Plant height (cm) 90 DAT	Branches /plant 90 DAT	Flower clusters/plant	Flower /clusters	Days to first fruit setting	Fruits/plant	Weight of fruit(g)	Yield of tomato (t/ha)
T <sub>1</sub>	FYM 20 t/ha	61.52	15.76	16.27	4.98	46.22	24.53	58.37	35.48
T <sub>2</sub>	Vermicompost 5 t/ha	54.78	13.35	13.75	3.86	42.41	21.83	46.56	34.83
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	52.57	11.44	14.76	3.95	41.87	20.52	47.65	35.18
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	51.43	10.53	13.63	3.71	40.33	19.67	46.46	34.35
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	52.00	10.72	12.86	3.80	39.52	18.49	47.08	33.56
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	49.84	10.25	10.75	3.57	38.74	16.77	44.31	33.01
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	50.27	10.52	11.55	3.78	40.53	17.64	45.66	33.50
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	60.36	15.90	16.24	4.75	45.83	22.71	54.43	35.39
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	58.47	16.67	15.39	4.62	45.39	23.17	53.17	35.74
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	56.56	15.76	14.53	4.38	44.90	24.49	49.87	35.20
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	62.88	17.77	17.60	5.25	48.47	25.83	59.50	36.57
T <sub>12</sub>	RFD of NPK (100:60:80)	55.35	13.76	14.21	4.16	43.45	21.27	48.86	34.53
	<b>C.D. (P=0.05)</b>	<b>0.45</b>	<b>0.15</b>	<b>0.19</b>	<b>0.12</b>	<b>0.14</b>	<b>0.16</b>	<b>0.31</b>	<b>0.39</b>

**Summary Table 5.2 Quality and economics from tomato as influenced by organic, inorganic and biofertilizers**

Tr. No.	Treatments	Dry matter of fruit (%)	Grading % of tomato			TSS (°Brix)	Net profit (Rs)	B:C ratio	Net income over NPK (Rs./ha)	Yield of tomato (t/ha)
			A	B	C					
T <sub>1</sub>	FYM 20 t/ha	7.80	52.16	34.20	13.64	10.50	128457	3.62	11305	35.48
T <sub>2</sub>	Vermicompost 5 t/ha	6.87	49.34	32.47	16.52	9.10	125207	3.56	14555	34.83
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	6.91	49.24	32.44	18.32	8.80	126957	3.59	12805	35.18
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobacter</i>	6.70	49.22	32.39	18.39	8.93	130634	4.18	9128	34.35
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobacter</i>	6.74	48.64	32.16	19.13	8.80	126684	4.08	13078	33.56
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobacter</i>	6.53	48.49	31.24	20.27	8.47	125907	4.22	13855	33.01
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobacter</i>	6.63	48.61	31.39	20.00	9.20	128357	4.28	11405	33.50
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobacter</i>	7.62	51.76	34.32	13.76	10.20	127807	3.60	11955	35.39
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobacter</i> + 50% NPK	7.47	50.62	33.71	15.66	10.08	132584	3.88	7178	35.74
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobacter</i> ) + 50% NPK	7.27	49.41	32.58	17.78	9.86	124884	3.44	14878	35.20
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobacter</i> + 50% NPK	8.17	54.59	34.37	11.04	10.84	131734	3.58	8028	36.57
T <sub>12</sub>	RFD of NPK (100:60:80)	7.21	49.63	33.18	17.19	9.47	139762	5.25	--	34.53
	<b>C.D. (P=0.05)</b>	<b>0.06</b>	<b>0.10</b>	<b>0.105</b>	<b>1.25</b>	<b>0.09</b>	<b>--</b>	<b>--</b>	<b>--</b>	<b>0.39</b>

## CHAPTER-VI

### SUMMARY, CONCLUSION AND SUGGESTIONS

The present investigation entitled “**Effect of organic, inorganic and biofertilizers on growth and yield of tomato (*Lycopersicon esculentum* Mill) under protected condition**” was conducted during rainy season of 2014 in the polyhouse, Horticulture Section, College of Agriculture, Rewa to find out the combination of organic and inorganic nutrients to maximize the productivity of tomato in this region.

Treatments-12			
T <sub>1</sub>	FYM 20 t/ha	T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>
T <sub>2</sub>	Vermicompost 5 t/ha	T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	T <sub>12</sub>	RFD of NPK (100:60:80)

The twelve treatment combinations were replicated three times in a randomized block design. The NPK fertilizers were applied as urea, SSP and MOP per ha. The seedlings were transplanted on 17.08.2014 and the first picking was started from maturity.

#### **Characters under study**

Under growth characters (height of plants and number of branches) reproductive characters, (number of flower clusters per plant, flowers per cluster and days to fruit-set per cluster) were taken. And yield characters, (number of

fruits per plant, average fruit weight and yield) were studied. Nutritional quality and different grades of fruits was also determined.

The final data of growth and yield characters were statistically analysed. The results have been summarized in Table 5.1.

The fertility treatments were compared of

- (1.) FYM 20 t/ha
- (2.) Vermicompost 5 t/ha
- (3.) Combination of FYM + vermicompost + biofertilizers + NPK
- (4.) RDF.

Fertility treatment T<sub>11</sub> i.e. combination of FYM 10 t/ha + vermicompost 2.5 t/ha + biofertilizers + 50% RDF was found significantly superior cover T<sub>1</sub> (20 t FYM) T<sub>2</sub> (vermicompost 5 t/ha) and T<sub>12</sub> (RDF) as well as other treatment. Combination (except T<sub>11</sub>) were found significantly effective as regards plant height, number of branches, number of flower cluster, flower per cluster, number and weight of fruit per plant and finally the yield (per ha) as shown in summary table 5.1 and 5.2 further the B/C ratio and net income were maximum in T<sub>12</sub> (5.25 and Rs 139762 respectively). However the yield and net income per ha were maximum in T<sub>11</sub> besides maximum TSS (10.4 °Brix) and % of dry matter content (8.17).

### **Growth parameters**

The treatment T<sub>11</sub> (FYM + vermicompost + *Azotobacter*. + 50% NPK) resulted in significantly maximum plant height and branches/plant over the remaining treatments at 90 DAT, (height 62.88 cm and branches 17.77/plant). This was followed by T<sub>1</sub> (20 t FYM/ha) only and then T<sub>8</sub>, T<sub>9</sub> and T<sub>12</sub>. The treatments T<sub>6</sub> and T<sub>7</sub> (half dose of FYM or half vermicompost with *Azotobacter*) resulted in significantly lowest growth parameters.

### **Phenological characters**

The number of flower clusters/plant, number of flowers/cluster and days to first fruit set was influenced significantly due to combined inputs of organic and inorganic sources of nutrients. The fertility treatment T<sub>11</sub> four sources of applied

nutrients (FYM + vermicompost. + *Azotobacter*. + 50% NPK) brought about significantly higher all these phenological characters. The maximum phenological characters under T<sub>11</sub> treatment were 17.60 clusters/plant, 5.25 flowers/cluster and longer period upto 48.47 days taken to first fruit setting.

The second best fertility treatment was T<sub>1</sub> ( 20 t FYM/ha). The flower clusters were 16.27/plant, flowers 4.98/cluster and 46.22 days to first fruit setting. The significantly lowest all these parameters were observed in case of T<sub>6</sub>, and T<sub>7</sub> treatments where the dose of FYM or vermicompost was reduced to half with *Azotobacter* inoculation.

### **Yield-attributing characters**

The yield-attributing characters viz. number of fruits/plant and weight of fruit were influenced significantly due to different fertility treatments.

The fertility treatment T<sub>11</sub> comprising four sources of nutrients registered significantly maximum fruits (25.83/plant) as compared to the remaining treatments. Similarly the fruit weight was also significantly higher upto 59.50 g. The second best fertility treatment was T<sub>1</sub> (20 t FYM/ha) and then T<sub>8</sub> (10 t FYM + 2.5 t vermicompost.+*Azotobacter*.) and T<sub>9</sub> (FYM< 15 t/ha + *Azotobacter*. + 50% NPK). These parameters were further lowered down significantly in case of T<sub>10</sub> (vermicompost 5 t/ha + *Azotobacter*.+ 50% NPK) and T<sub>12</sub> (N<sub>100</sub>P<sub>60</sub>K<sub>80</sub>) treatments. The lowest parameters were recorded in fertility treatments ( half dose of FYM or vermicompost with *Azotobacter*) T<sub>6</sub> and T<sub>7</sub>. Such variations in yield-attributing characters from different treatments was exactly in accordance with the growth parameters as well as phenological characters obtained from such treatments.

### **Productivity of tomato**

The fresh yield of tomato was found to deviate significantly due to different fertility levels having organic + inorganic sources of nutrients. Amongst these treatments, T<sub>11</sub> four sources of nutrients registered significantly highest tomato yield (36.57 t/ha) over the remaining fertility treatments. However, this was equally followed by T<sub>1</sub> 20 t FYM/ha (35.48 t/ha) and T<sub>9</sub> 15 t FYM/ha +

*Azotobacter*. + 50% NPK (35.74 t/ha). This was equally followed by T<sub>3</sub> and T<sub>10</sub> (35.18 to 35.20 t/ha). The treatment T<sub>8</sub> also recorded tomato yield in the same range (35.39 t/ha). The yields in significantly lowest range (33.01 to 33.56 t/ha) were secured from T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> treatments having lesser quantities of applied nutrients

### **Physico-chemical qualities**

Amongst the combined application of organic-cum-inorganic nutrients, T<sub>11</sub> having four sources of nutrients was continued to be the best with respect to quality also. Accordingly, the significantly higher dry matter content per fruit (8.17%), "A" grade tomato (54.59%), TSS upto 10.84 °Brix was obtained from the fertility treatment T<sub>11</sub>. The second best fertility treatment was T<sub>1</sub> having 20 t FYM/ha (dry matter content 7.80, "A" grade tomato 52.16%, TSS 10.50 °Brix. The "C" grade tomato were in the lowest range. This was followed by T<sub>8</sub> and T<sub>9</sub> treatments. On the other hand, the significantly lowest values (6.53-6.63% dry matter content, 48.49-48.61% "A" grade tomato, 8.47-9.02 °Brix TSS and was obtained from T<sub>6</sub> and T<sub>7</sub> treatments (half dose of FYM or vermicompost with *Azotobacter* )

### **Economical gain**

Among the fertilizer treatments, 100% recommended dose of fertilizer (N<sub>100</sub>P<sub>60</sub>K<sub>80</sub>) resulted in highest net profit upto Rs.139762/ha with highest 5.25 B:C ratio. However, this was followed by T<sub>9</sub> (FYM + Biof. + 50% NPK) with Rs.132584/ha net income and 3.88 B:C ratio. The treatment T<sub>11</sub> and T<sub>4</sub> gave almost equal net profit ranging from Rs.130634 to Rs.131734/ha, the B:C ratio ranged from 3.58 to 4.18. On the other hand, the lowest net profit (Rs.124884/ha) and B:C ratio (3.44) were recorded in case of T<sub>10</sub> treatment. The net profit of this T<sub>10</sub> treatment was very low than that obtained from the other treatments. Among the separately applied organic sources of nutrients, the net profit ranged from the lowest (Rs.125207/ha) in case of vermicompost to the highest (Rs.128457/ha) in case of FYM. Thus, vermicompost and FYM were

found almost in the wide range in giving profit/ha. The treatments like T<sub>3</sub>, T<sub>5</sub> and T<sub>6</sub> also gave the lower net profit in comparison the other best combinations with other organic sources of nutrients. Thus, there was larger differences in the net profit obtained from the different treatments. The net profit from 100% NPK (T<sub>12</sub>) was higher by Rs.7178/ha as compared to the best treatment T<sub>9</sub> where all the three types of nutrient inputs were applied together.

## **CONCLUSION**

In view of the listed above, it may be concluded that out of the twelve treatments. The treatment T<sub>11</sub> (FYM 10 t/ha + vermicompost 2.5 t/ha + *Azotobacter* + 50% RDF (N<sub>50</sub>P<sub>30</sub>K<sub>40</sub>) has emerged as the best treatment with respect to growth, yield and quality of tomato var. Himshikhar.

However from the economical view point, T<sub>12</sub> having 100 % RDF (N<sub>100</sub>P<sub>60</sub>K<sub>80</sub>) was found the best for this region . Due to more income per ha and maximum B/C ratio.

## **SUGGESTIONS**

- (1.) Since these results are based on one-year experiment, further trials may be needed to substantiate the results.
- (2.) The soil fertility levels may be tested after crop harvest.

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# APPENDICES

## Appendix-I

### Prevailing market rates

S.No.	Particulars	Rate (Rs/ha)
1	Land preparation (a) One tractor ploughing and harrowing (each) (b) One disking and planking	1000
2	Labour rate	200
3	Cost of Seed	1500
4	FYM	1000
5	Vermicompost	4000
6	<i>Azotobactor</i>	200
7	Urea	610
8	Single superphosphate	450
9	Muriate of potash	700
10	Insecticide	420
11	Irrigation	700
12	Sale rate of tomato	5000/tonne

## Appendix-II

### Cost of fertilizers and manures

S.No.	Particulars	Rate (Rs/ha)
1	Urea (217 kg( N <sub>2</sub> ))	1326
2	Single superphosphate (375 kg) (P <sub>2</sub> O <sub>5</sub> )	1688
3	Muriate of potash (133 kg) (K <sub>2</sub> O)	931
4	<i>Azotobactor</i>	200
5	FYM (20 t)	1000
6	Vermicompost (5 t)	4000

### Appendix-III

#### Cost of expenditure (Rs/ha) without the cost of fertilizers and anures

S.No.	Particulars	Rate (Rs/ha)
1	Ploughing and harrowing (2 each)	1600
2	Discing and planking	600
3	Seed (150 g/ha)	225
4	Nursery raising and transplanting (50 labours)	10000
5	Weeding -1 (20 labours)	4000
6	Insecticide and spray (2 labours)	640
7	Irrigations (7)	4900
8	Transport cost	1500
9	Two harvesting (20 labours)	4000
10	Rental value	1000
11	Interest of working capital 10%	1378
	Total	28943

### Appendix-IV

#### Calculation of economical gain/ha from different treatment combinations

Tr. No.	Treatments	Tomato yield (t/ha)	Gross return (Rs/ha)	Cost of cultivation	Expdt. on the treatment	Total expenditure (Rs/ha)	Net income (Rs/ha)	B:C ratio
T <sub>1</sub>	FYM 20 t/ha	35.48	177400	28943	20000	48943	128457	3.62
T <sub>2</sub>	Vermicompost 5 t/ha	34.83	174150	28943	20000	48943	125207	3.56
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	35.18	175900	28943	20000	48943	126957	3.59
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobactor</i>	34.35	171750	28943	12173	41116	130634	4.18
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobactor</i>	33.56	167800	28943	12173	41116	126684	4.08
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobactor</i>	33.01	165050	28943	10200	39143	125907	4.22
T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobactor</i>	33.50	167500	28943	10200	39143	128357	4.28
T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i>	35.39	176950	28943	20200	49143	127807	3.60
T <sub>9</sub>	FYM 15 t/ha + <i>Azotobactor</i> + 50% NPK	35.74	178700	28943	17173	46116	132584	3.88
T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobactor</i> ) + 50% NPK	35.20	176000	28943	22173	51116	124884	3.44
T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobactor</i> + 50% NPK	36.57	182850	28943	22173	51116	131734	3.58
T <sub>12</sub>	RFD of NPK (100:60:80)	34.53	172650	28943	3945	32888	139762	5.25

Sale rate of tomato Rs. 5000/tonne

### Appendix-V

#### Analysis of variance for plant height (cm) at 30 DAT

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	94.18	47.09	550.52	2.83
Fertilizer	11	343.44	31.22	365.01	2.20
Error	22	1.88	0.09		
Total	35				

### Appendix- VI

#### Analysis of variance for plant height (cm) at 60 DAT

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	210.45	105.23	1278.56	2.83
Fertilizer	11	99.60	9.05	110.01	2.20
Error	22	1.81	0.08		
Total	35				

### Appendix- VII

#### Analysis of variance for plant height (cm) at 90 DAT

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	390.65	195.33	1984.27	2.83
Fertilizer	11	664.78	60.43	613.94	2.20
Error	22	2.17	0.10		
Total	35				

### Appendix- VIII

#### Analysis of variance for branches per plant at 30 DAT

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	21.27	10.63	98.33	2.83
Fertilizer	11	259.19	23.56	217.86	2.20
Error	22	2.38	0.11		
Total	35				

### Appendix- IX

#### Analysis of variance for branches per plant at 60 DAT

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	25.60	12.80	444.75	2.83
Fertilizer	11	271.373	24.67	857.11	2.20
Error	22	0.63	0.03		
Total	35				

### Appendix- X

#### Analysis of variance for branches per plant at 90 DAT

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	25.86	12.93	1128.52	2.83
Fertilizer	11	253.62	23.06	2012.71	2.20
Error	22	0.25	0.01		
Total	35				

### Appendix- XI

#### Analysis of variance for number of flower cluster per plant

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	25.21	12.60	733.57	2.83
Fertilizer	11	128.89	11.72	682.02	2.20
Error	22	0.38	0.02		
Total	35				

### Appendix- XII

#### Analysis of variance for number of flowers/cluster

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	4.90	2.45	376.86	2.83
Fertilizer	11	10.11	0.92	141.44	2.20
Error	22	0.14	0.01		
Total	35				

### Appendix- XIII

#### Analysis of variance for days to first fruit setting

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	100.16	50.08	5498.23	2.83
Fertilizer	11	308.16	28.01	3075.55	2.20
Error	22	0.20	0.01		
Total	35				

### Appendix- XIV

#### Analysis of variance for number of fruits per plant

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	96.80	48.40	3823.89	2.83
Fertilizer	11	275.48	25.04	1978.64	2.20
Error	22	0.28	0.01		
Total	35				

### Appendix- XV

#### Analysis of variance for fruit weight (g)

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	207.29	103.64	2160.18	2.83
Fertilizer	11	841.87	76.53	1595.14	2.20
Error	22	1.06	0.05		
Total	35				

### Appendix- XVI

#### Analysis of variance for tomato yield (t/ha)

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	203.22	101.61	1371.41	2.83
Fertilizer	11	35.50	3.23	43.56	2.20
Error	22	1.63	0.07		
Total	35				

### Appendix- XVII

#### Analysis of variance for TSS (°Brix)

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	24.16	12.08	3231.90	2.83
Fertilizer	11	19.08	1.73	463.87	2.20
Error	22	0.08	0.003		
Total	35				

### Appendix- XVIII

#### Analysis of variance for dry matter of fruit (%)

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	25.03	12.52	6198.37	2.83
Fertilizer	11	8.87	0.81	399.15	2.20
Error	22	0.04	0.002		
Total	35				

### Appendix- XIX

#### Analysis of variance for "A" grade (%)

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	221.68	110.84	24271.19	2.83
Fertilizer	11	111.57	10.14	2221.13	2.20
Error	22	0.1004	0.004		
Total	35				

### Appendix- XX

#### Analysis of variance for "B" grade (%)

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	218.72	109.36	20635.19	2.83
Fertilizer	11	38.78	3.53	665.28	2.20
Error	22	0.12	0.01		
Total	35				

### Appendix- XXI

#### Analysis of variance for "C" grade (%)

Source of variation	d.f.	S.S.	M.S.S.	F Cal.	F tab 5%
Rep	2	895.09	447.55	591.34	2.83
Fertilizer	11	261.79	23.80	31.45	2.20
Error	22	16.65	0.76		
Total	35				

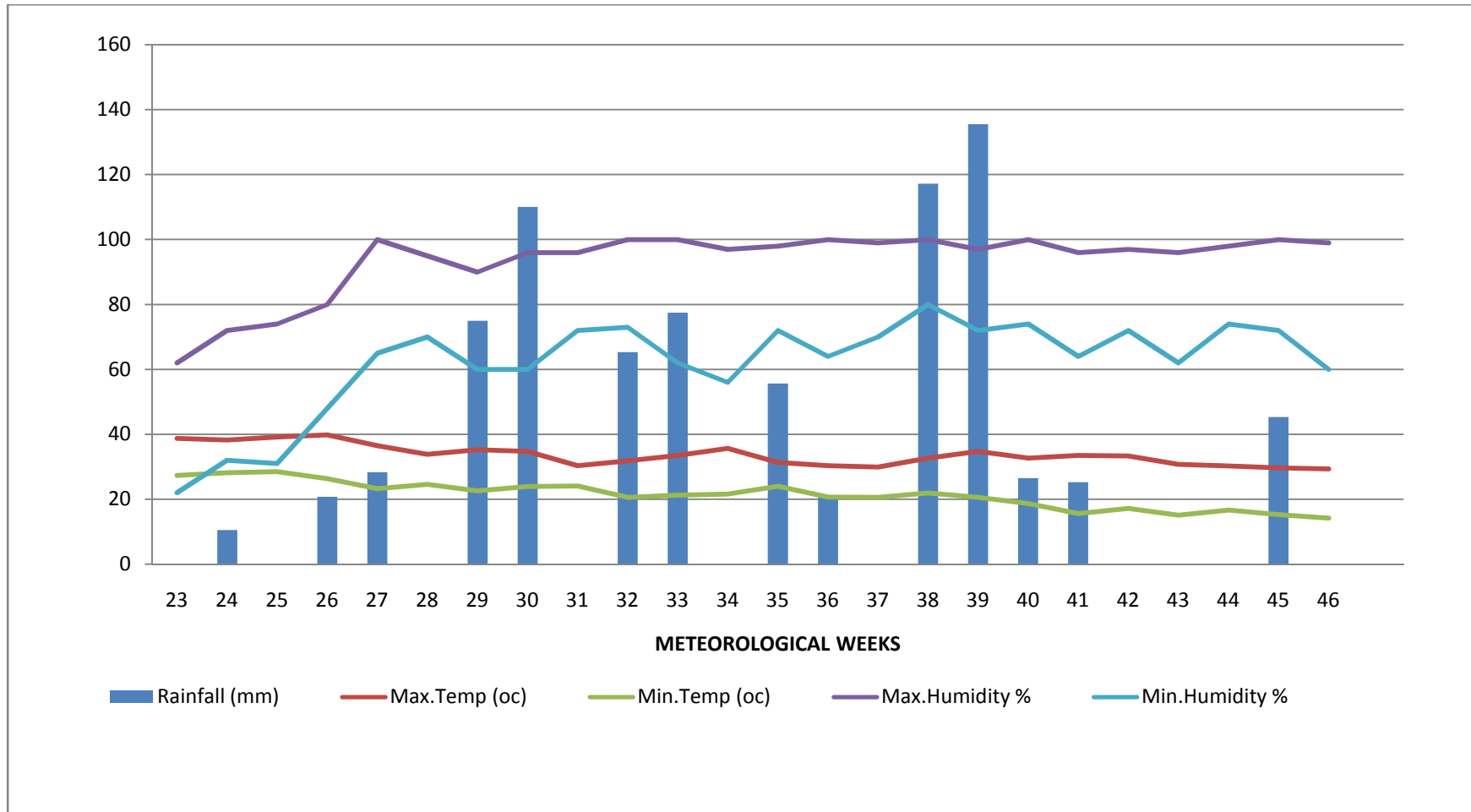
## VITA

The author was born on 02.06.1989 at Padra, Rewa (M.P.). He passed his High School Certificate Examination from Saraswati Higher Secondary School, Rewa (M.P.) in 2005 and Higher Secondary School Examination from the same school in 2007 .

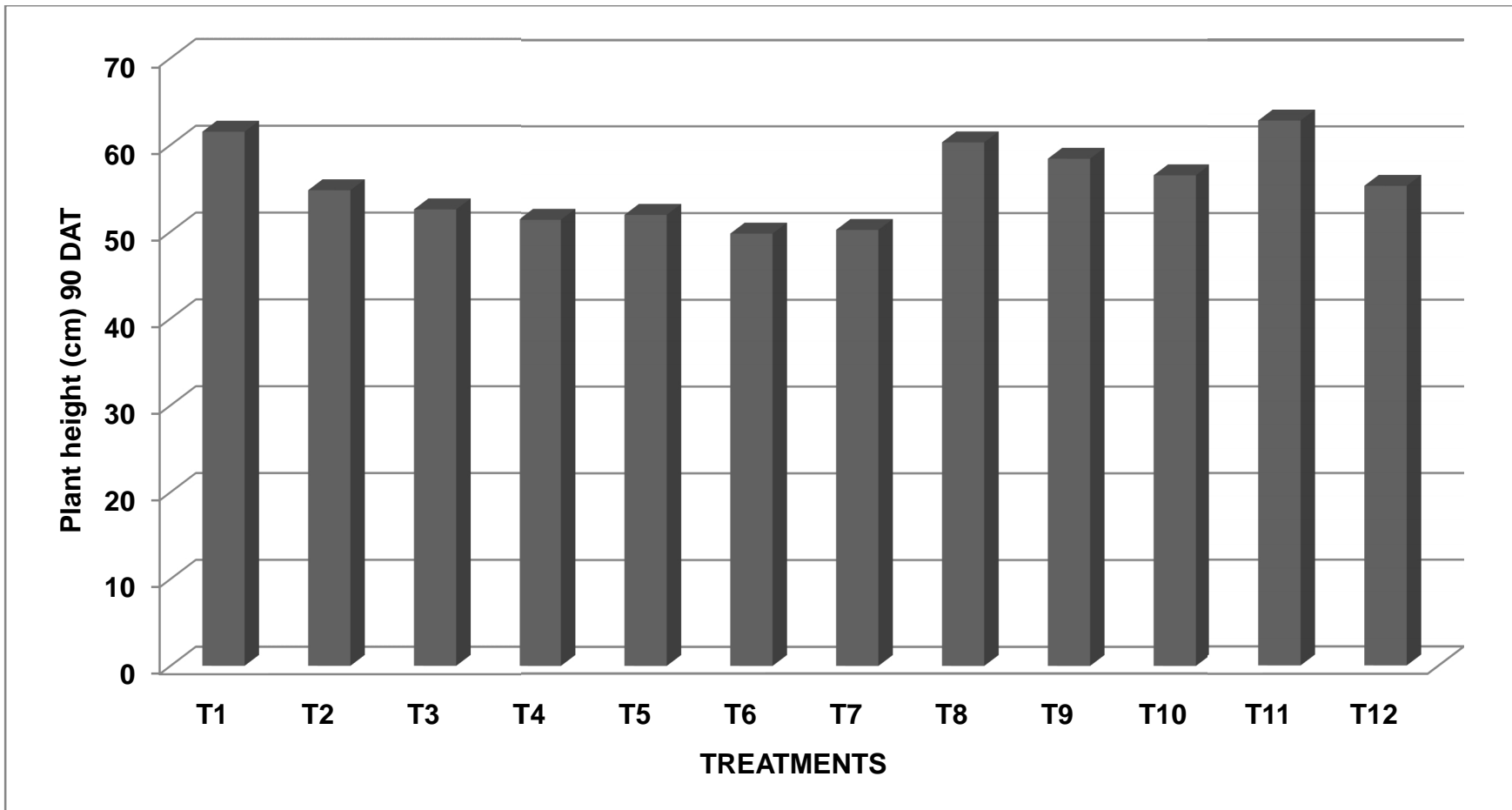
Thereafter, he opted for B.Sc. (Ag.) and completed the same degree course in 2013 from Jawaharlal Nehru Krishi Vishwa Vidyalaya Rewa campus (M.P.) with O.G.P.A. 7.45. He secured admission in M.Sc. (Ag.) Horticulture (Vegetable Science) at the J.N.K.V.V. Campus, College of Agriculture, Rewa (M.P.) and completed all the requirements for Master degree in Vegetable Science with O.G.P.A. 7.92 out of 10 point scale in the year 2015.

The author actively participated in NCC and various co-curricular activities of the college during his study.

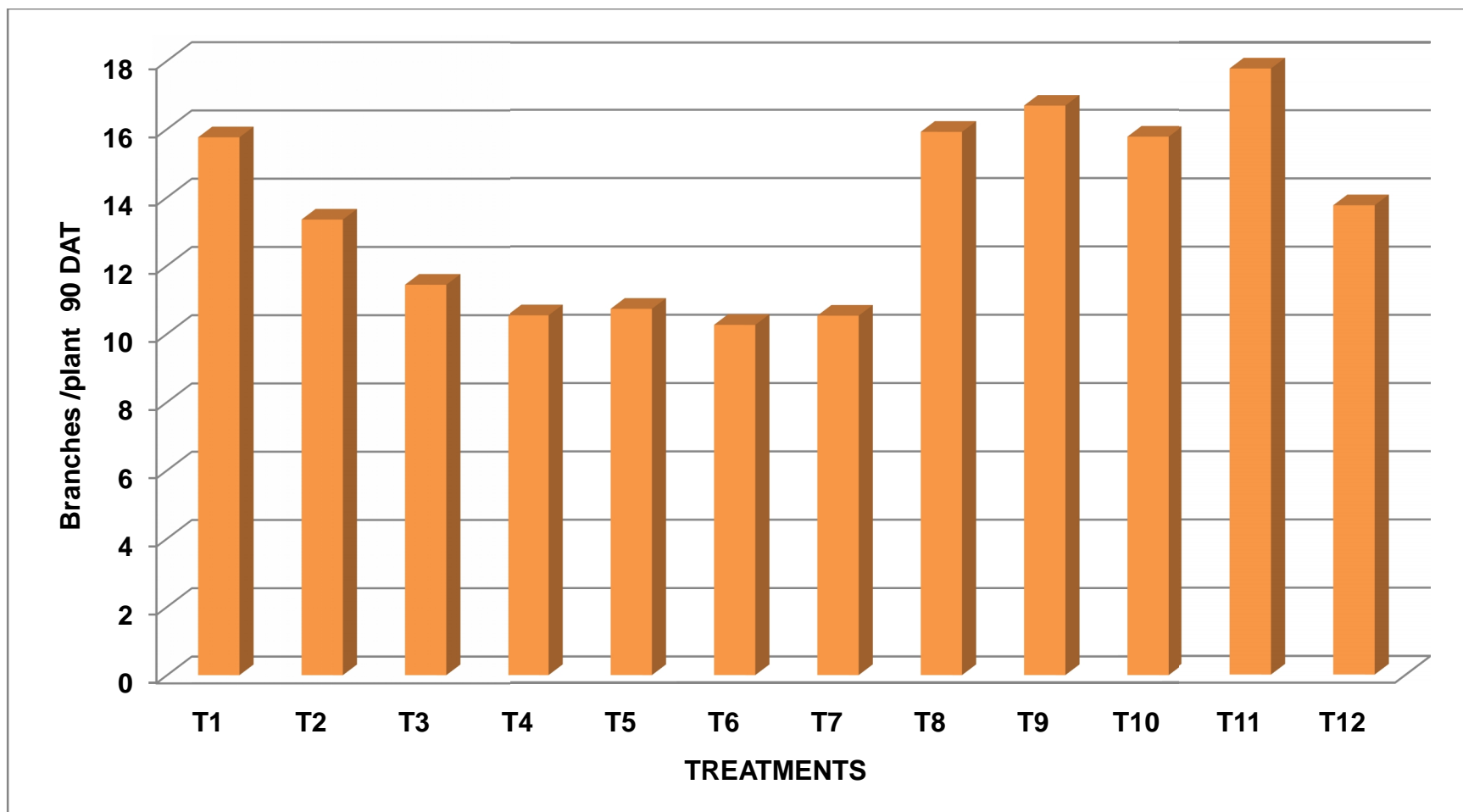
**Fig.1 Meteorological observation during crop period**



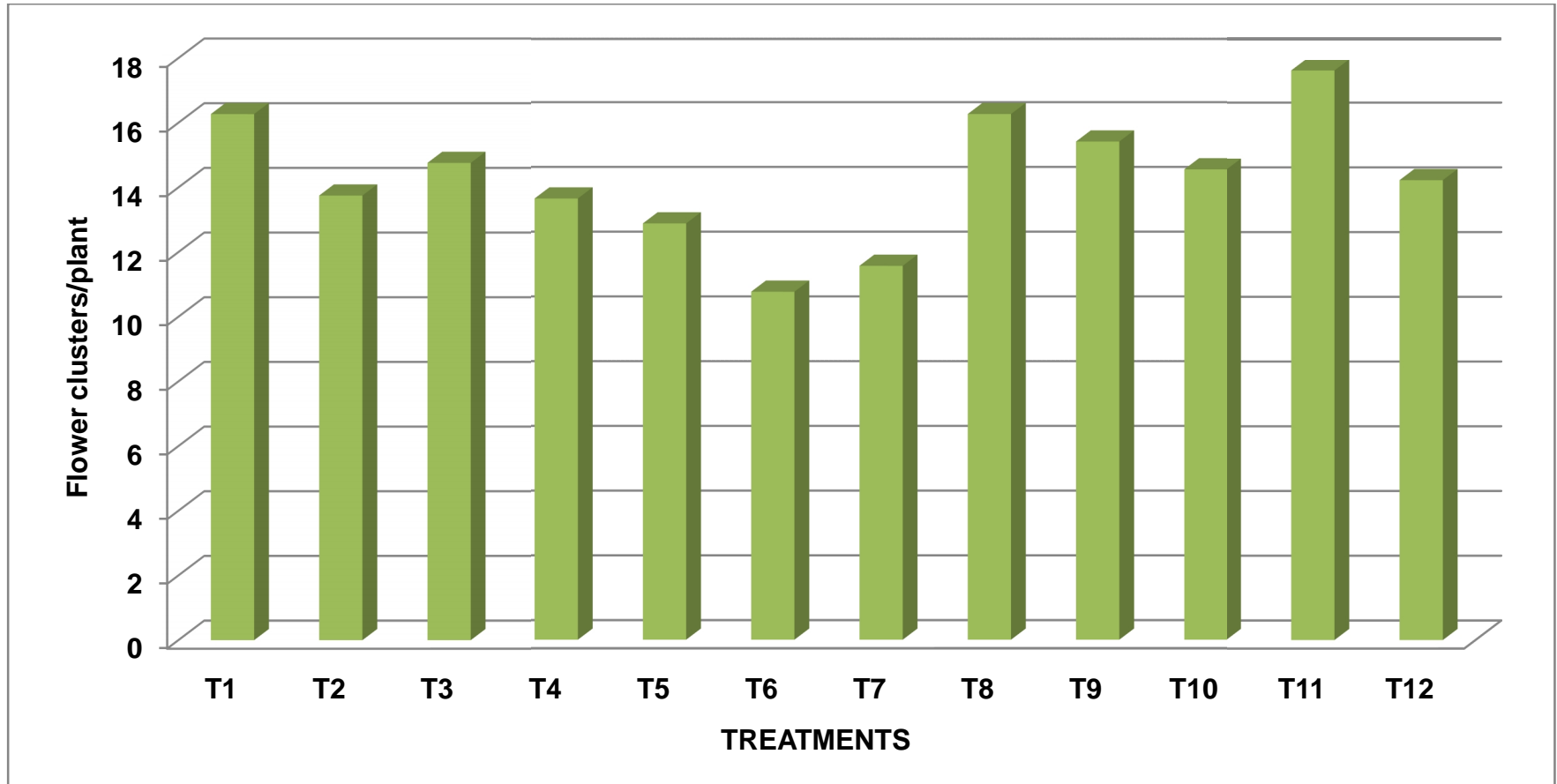
**Fig.3 Plant height (cm) 90 DAT of tomato at different growth stages as influenced by different fertility treatments**



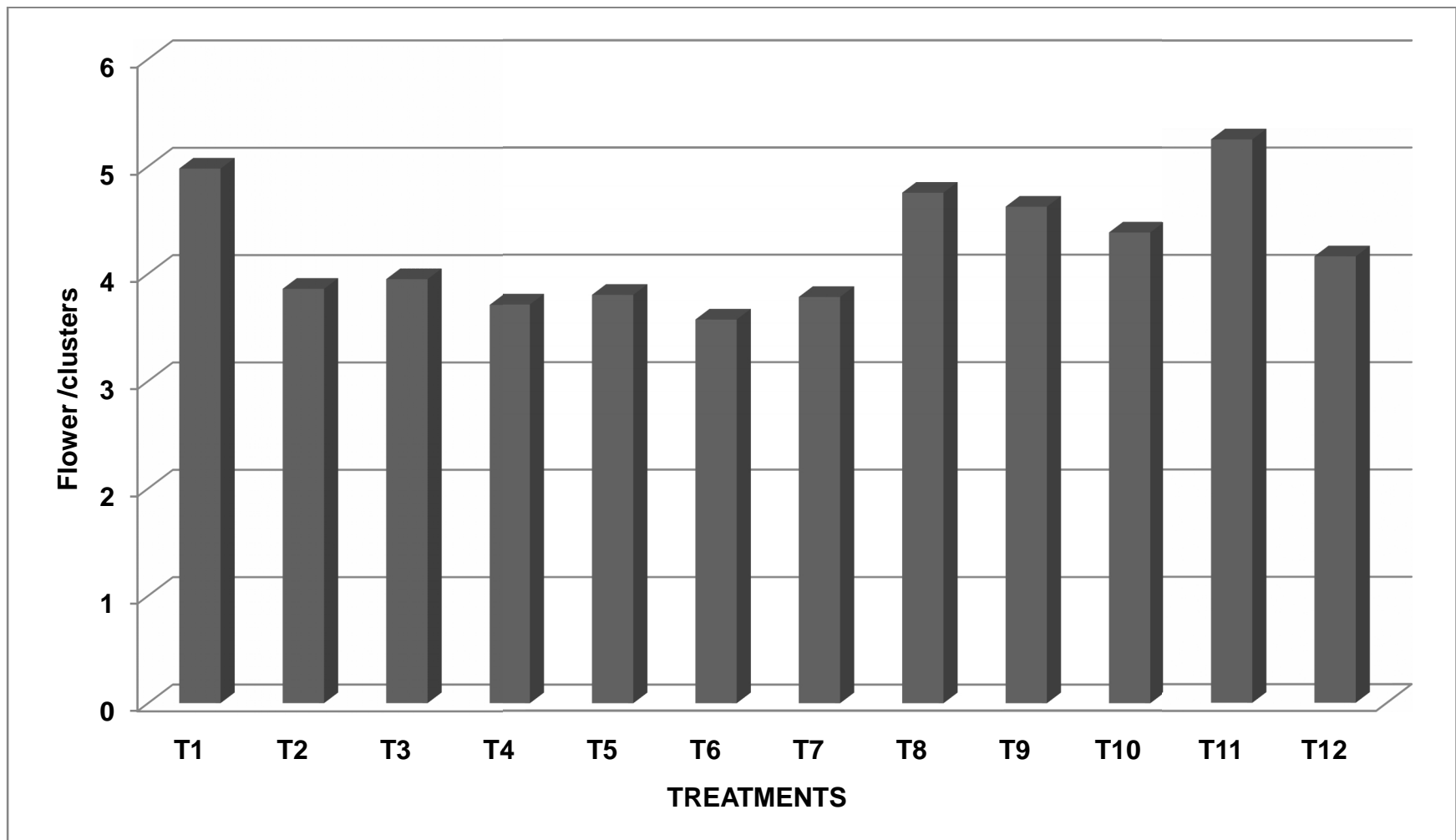
**Fig.4 Branches/plant (90 DAT) of tomato at different growth stages as influenced by different fertility treatments**



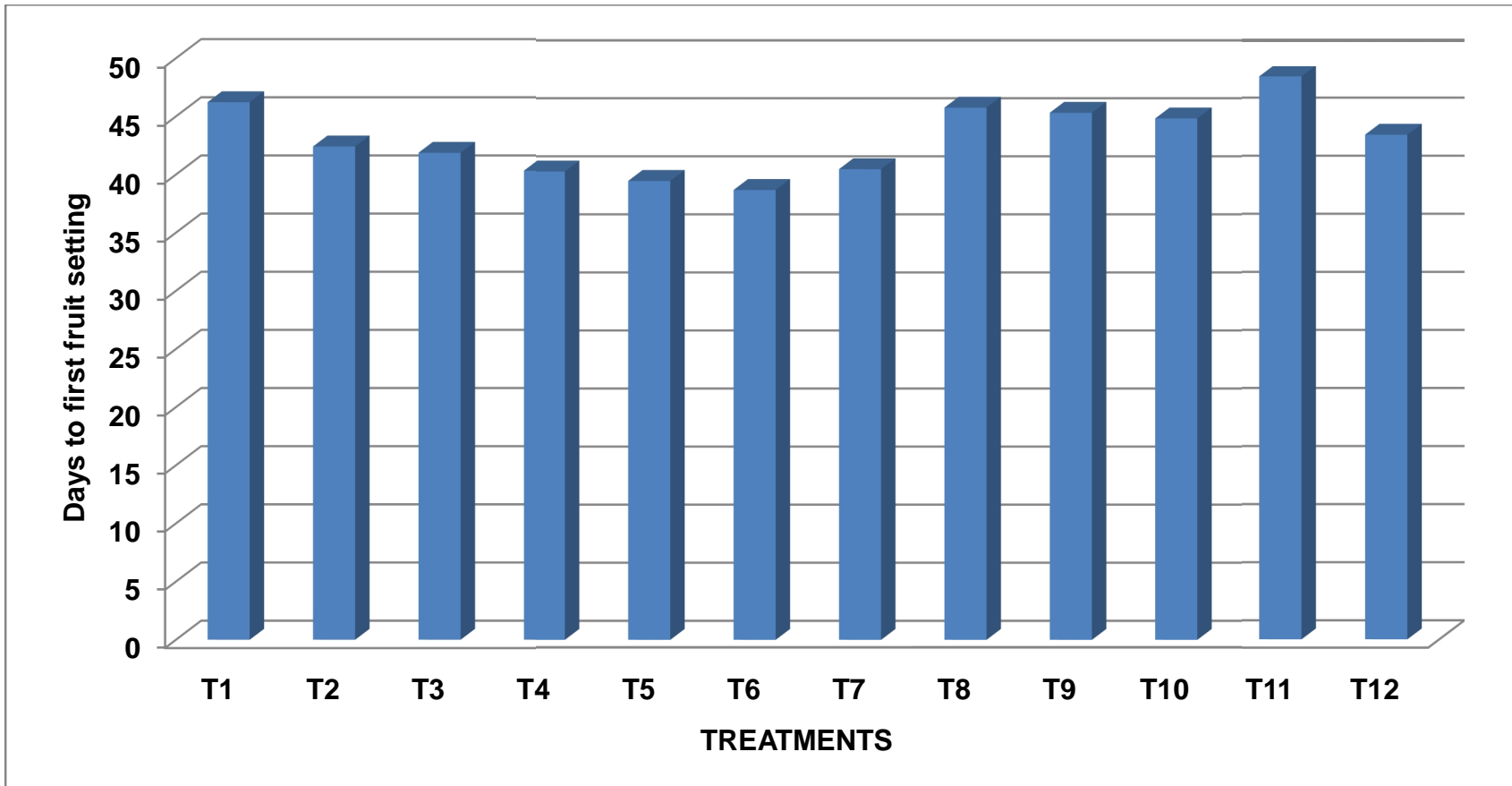
**Fig.5 Flower clusters/plant as influenced by different fertility treatments**



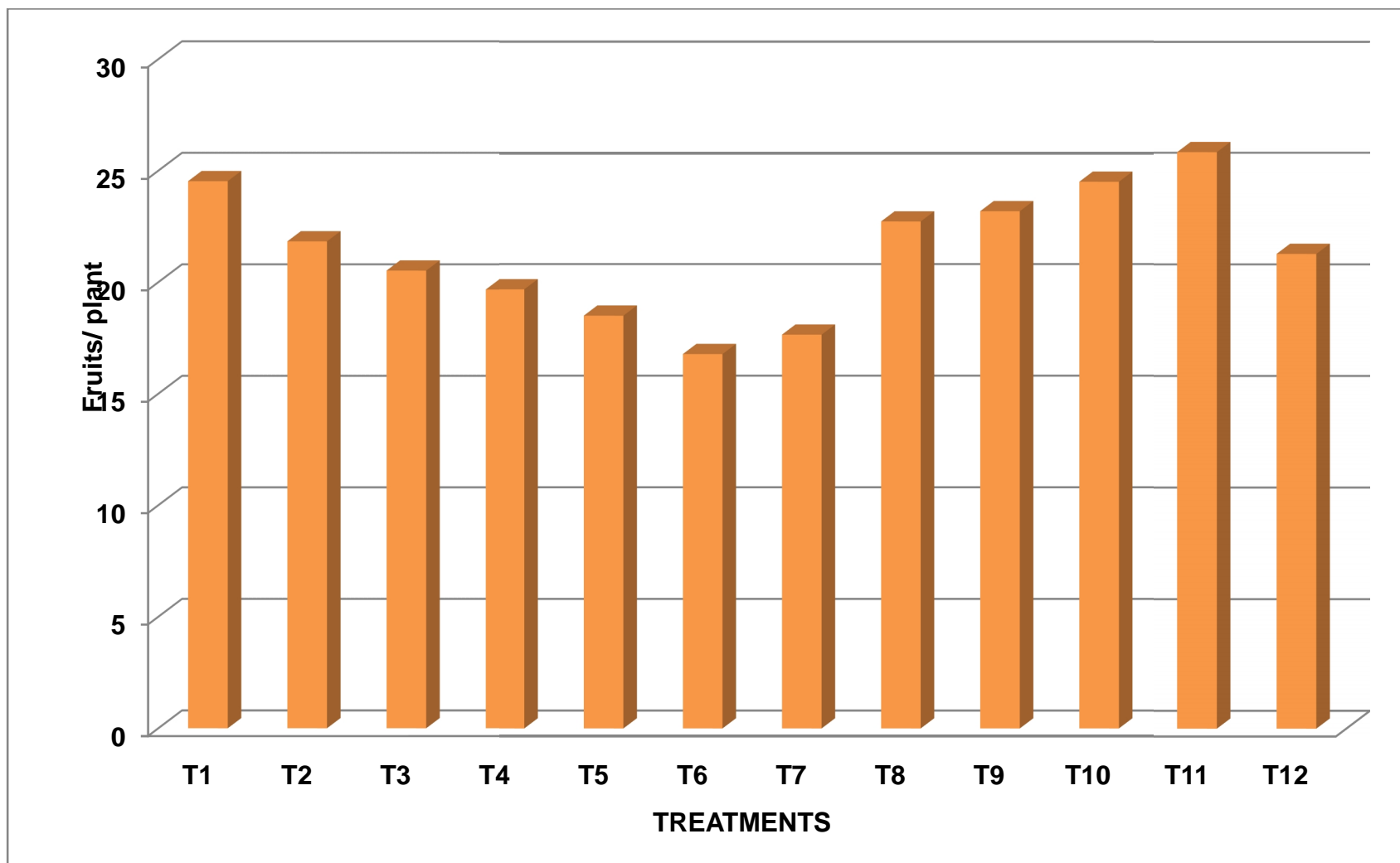
**Fig.6 Flower/cluster as influenced by different fertility treatments**



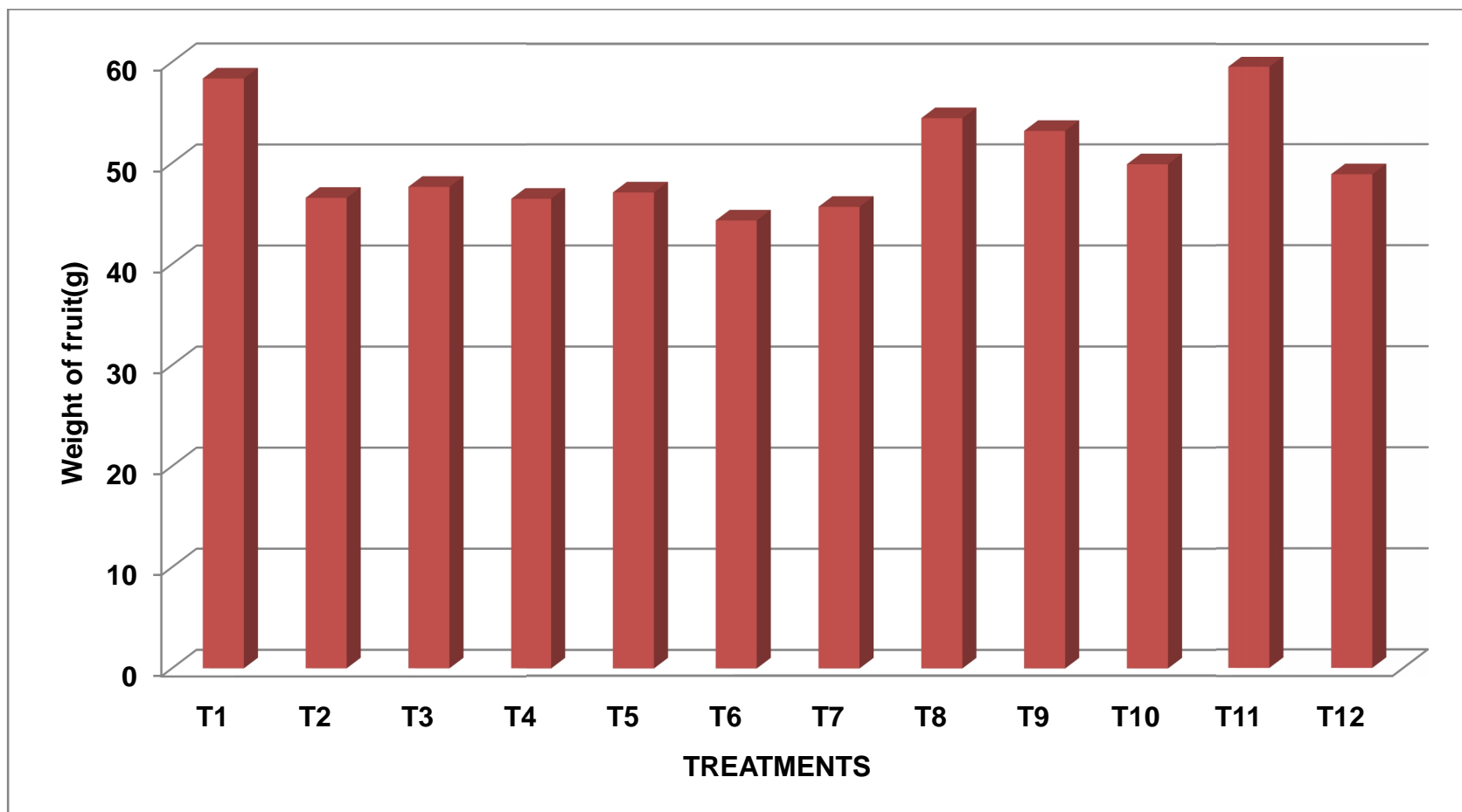
**Fig.7 Days to first fruit setting as influenced by different fertility treatments**



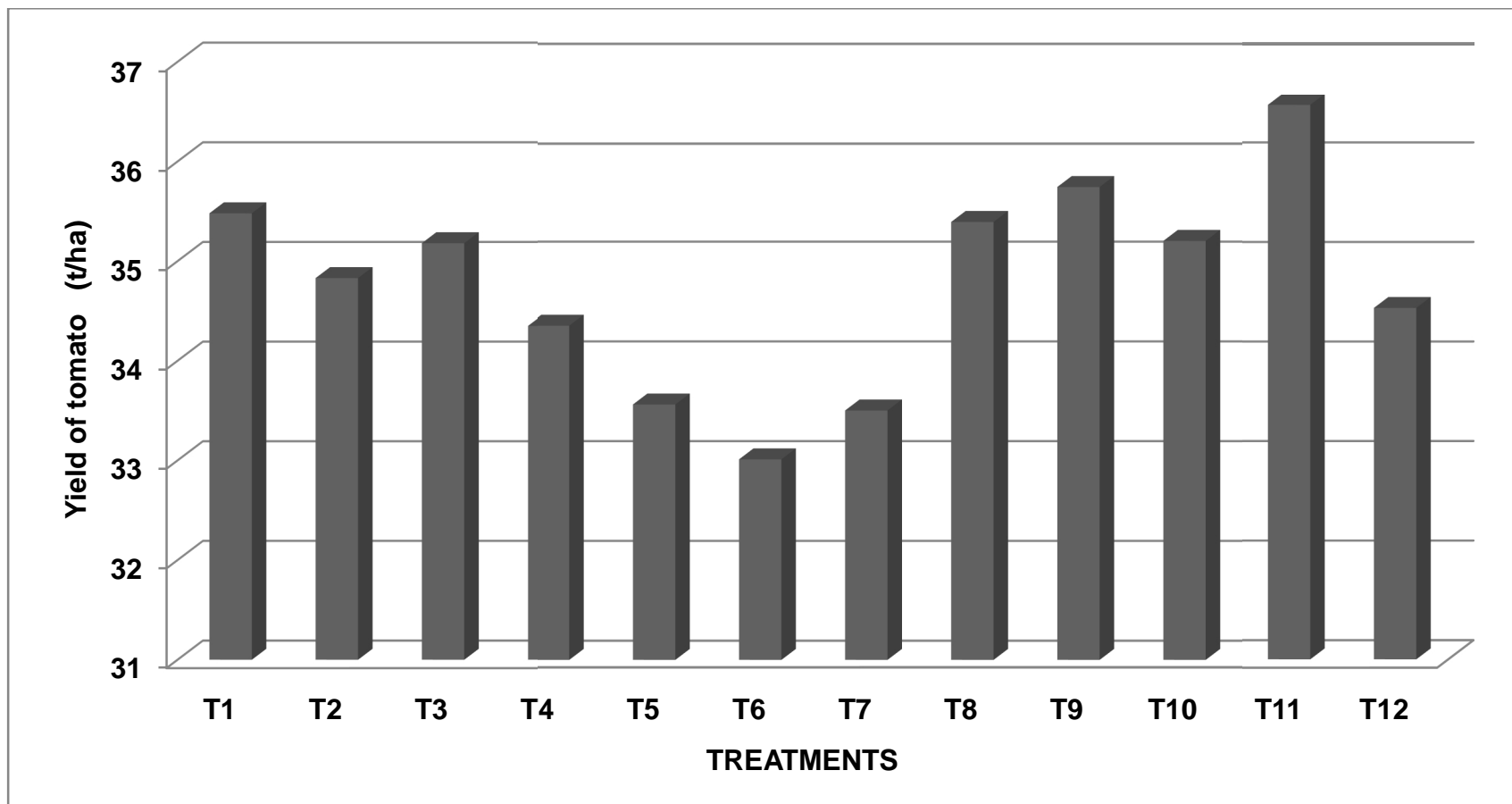
**Fig.8 Fruits/plant as influenced by different fertility treatments**



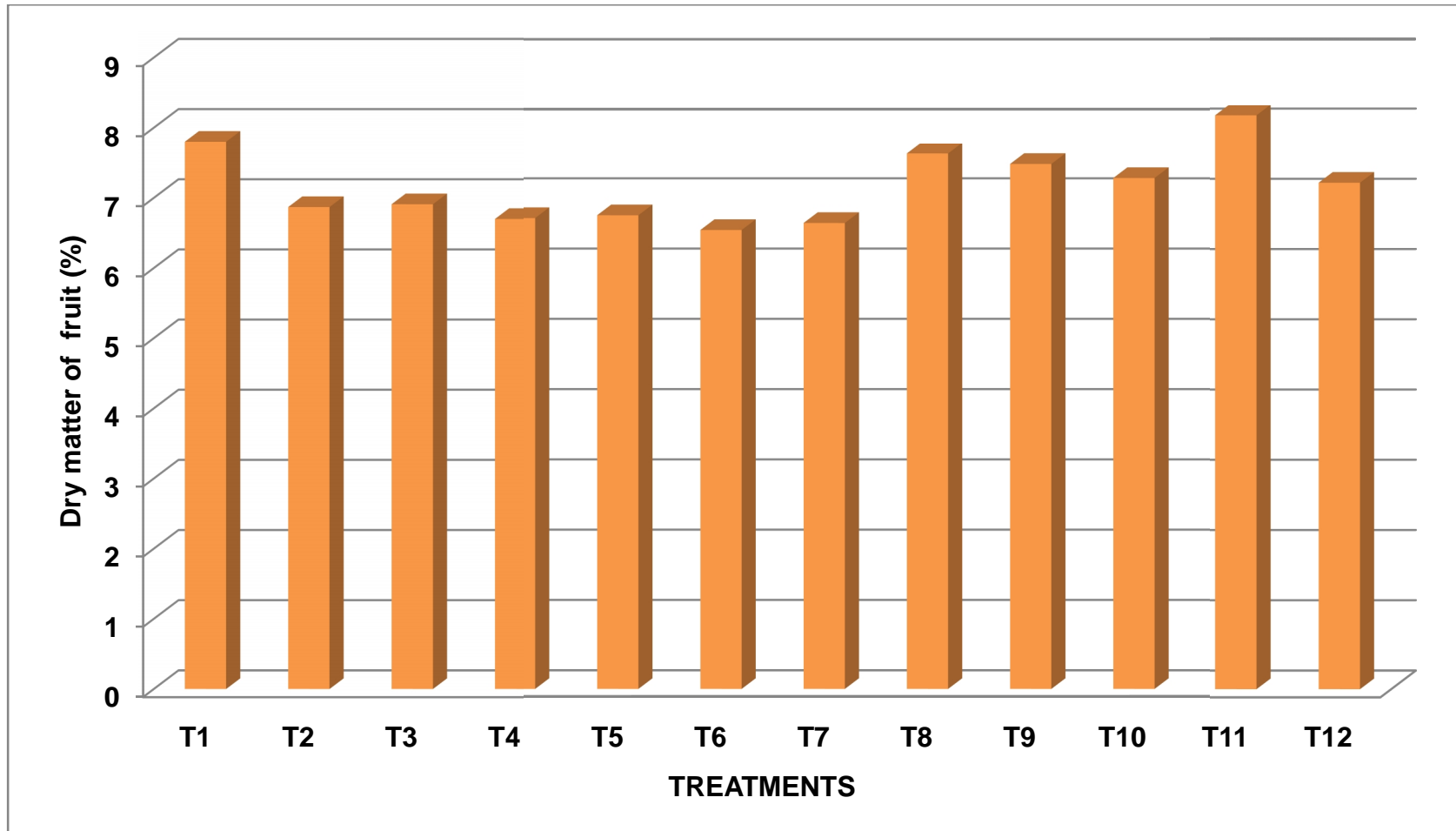
**Fig.9 Weight of fruits (g) as influenced by different fertility treatments**



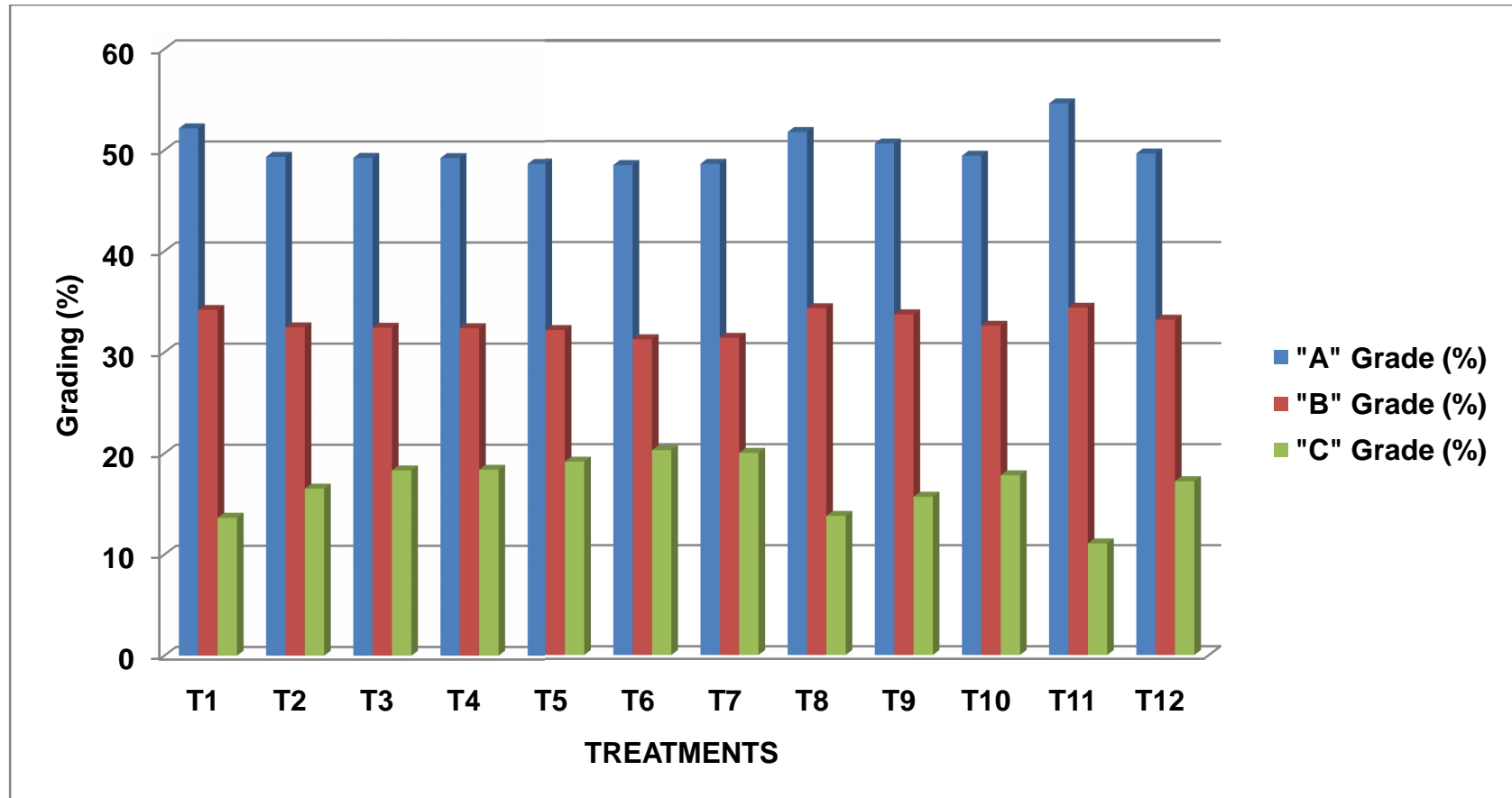
**Fig. 10 Yield of tomato (t/ha) as influenced by different fertility treatments**



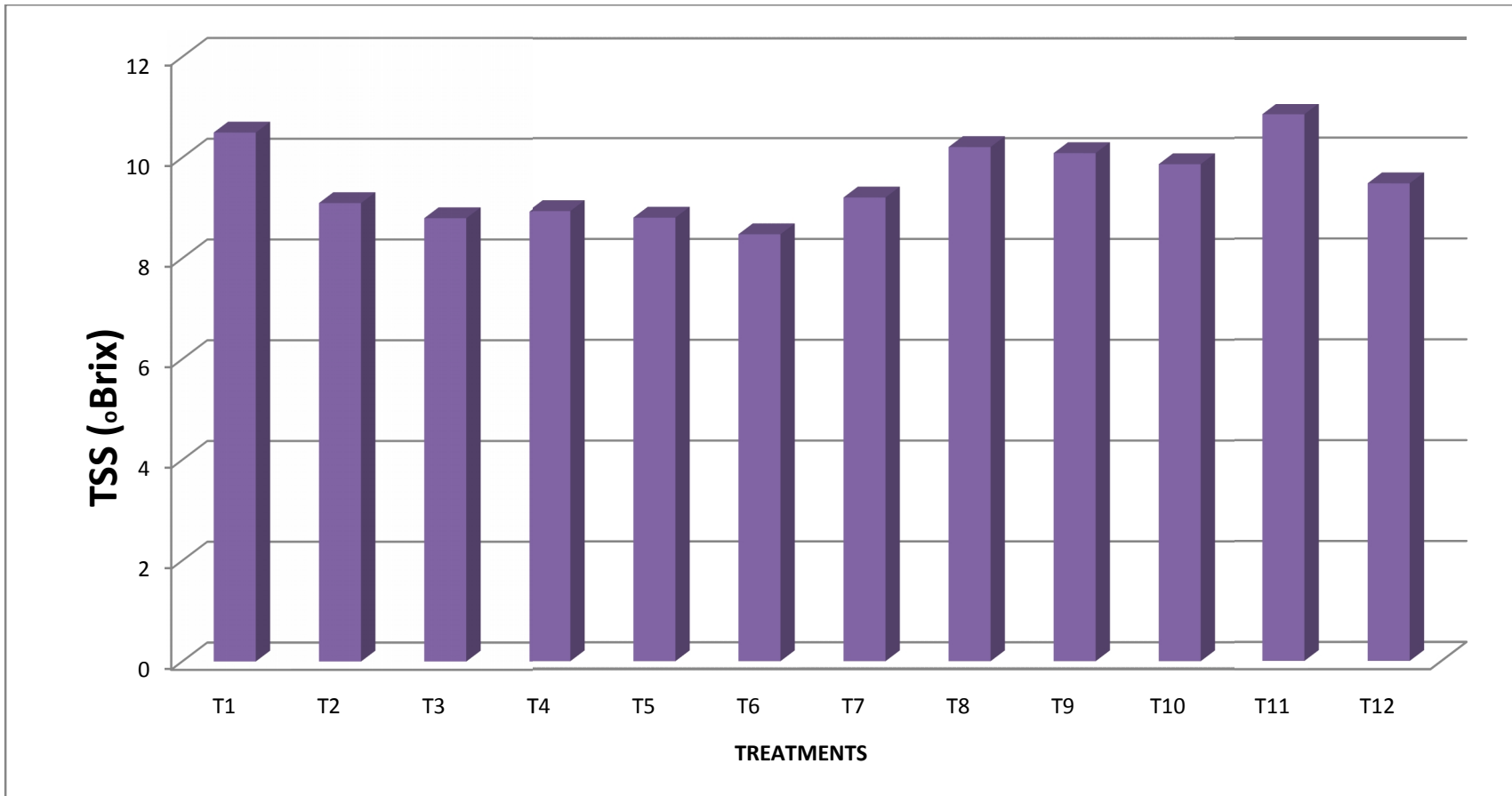
**Fig.11 Dry matter of fruits (%) as influenced by different fertility treatments**



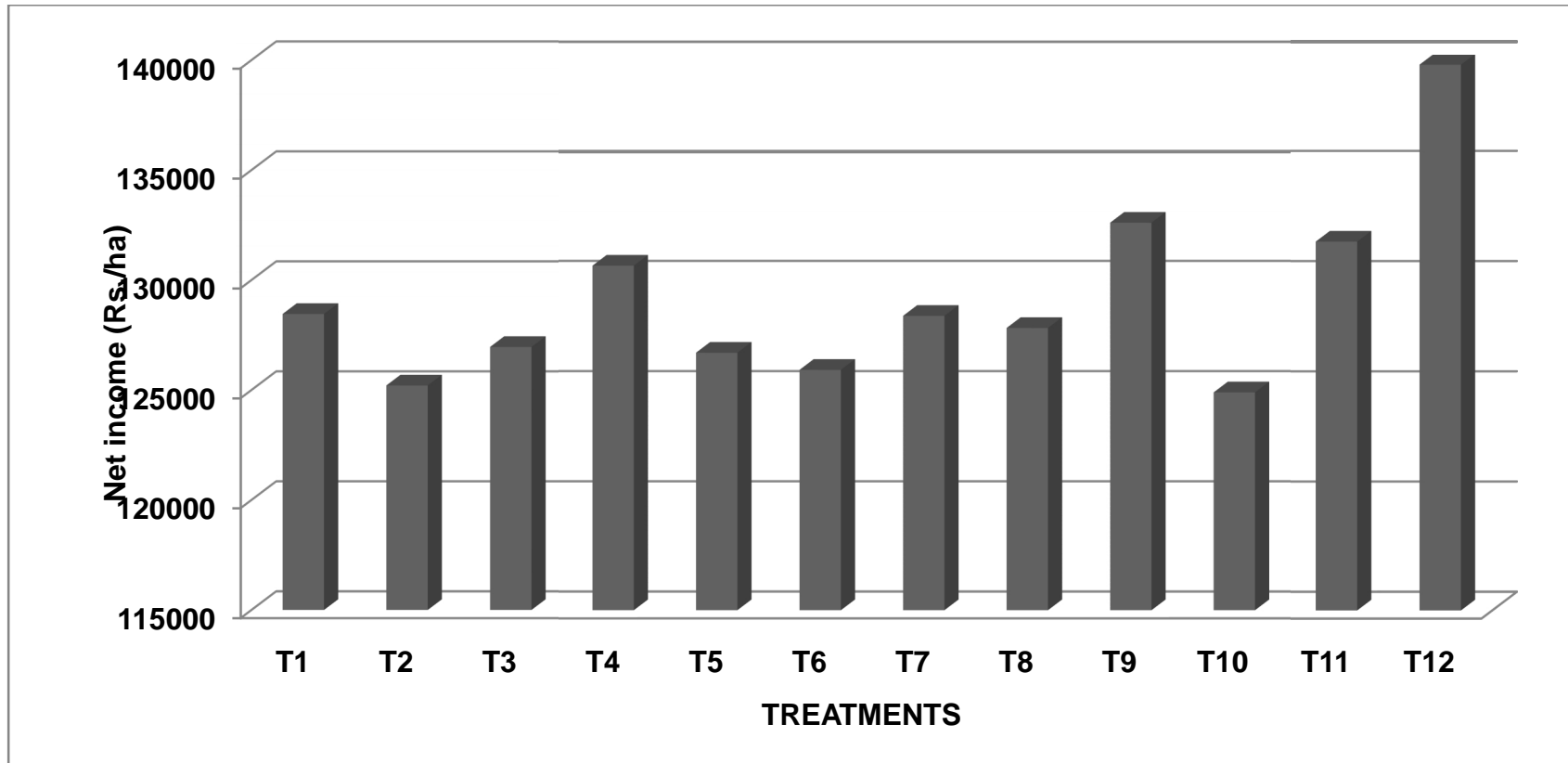
**Fig. 12 Grading (%) of tomato fruits as influenced by different fertility treatments**



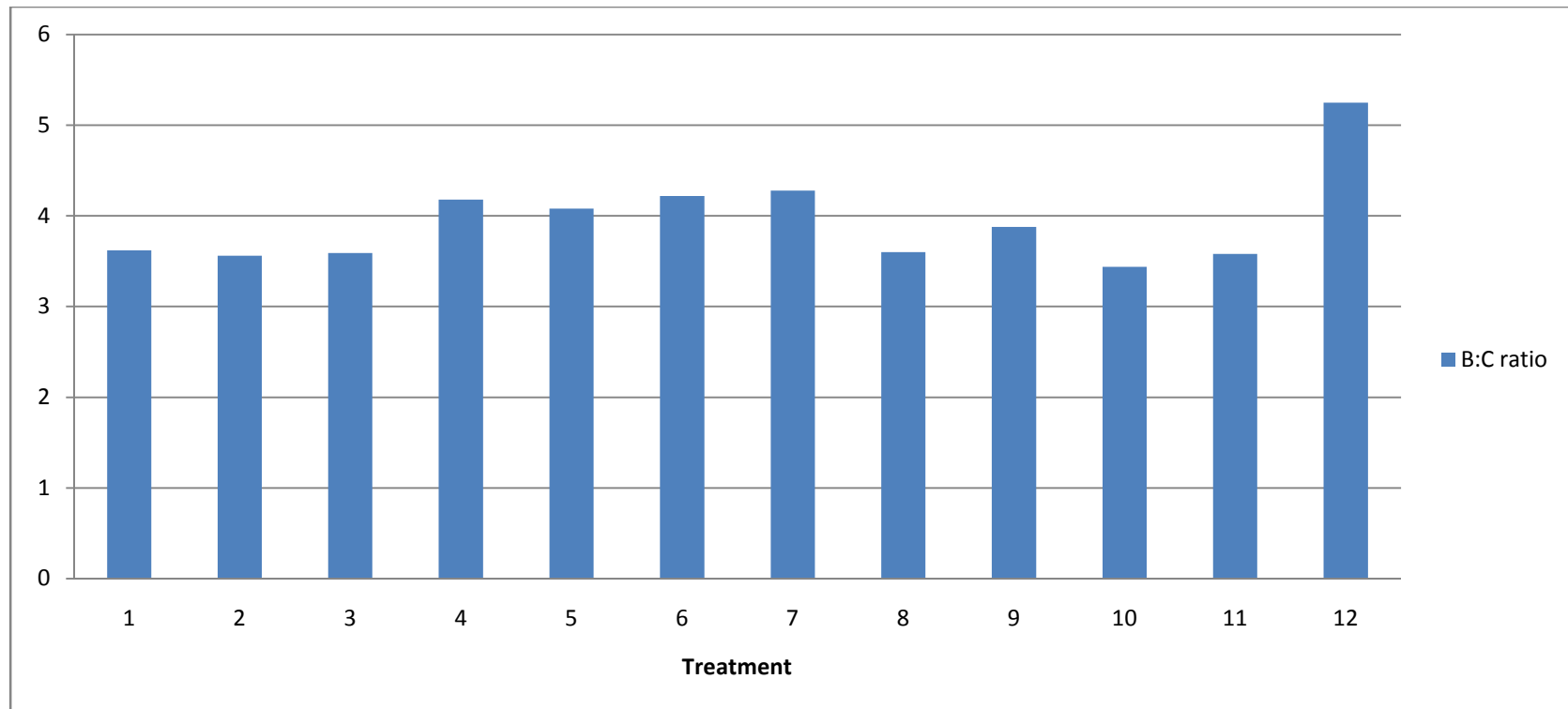
**Fig.13 TSS (°Brix) as influenced by different fertility treatments**



**Fig. 14 Net income (Rs./ha) of tomato as influenced by different fertility treatments**



**Fig. 15 B: C ratio of tomato as influenced by different fertility treatments**



## ABSTRACT

**Title of the thesis** : “Effect of organic, inorganic and biofertilizers on growth and yield of tomato (*Lycopersicon esculentum* Mill) under protected condition.”

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**Year of award of degree** : 2015

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(Dr. U.S. Bose)

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(Dr. U.S. Bose)

**Signature of student**  
(Manish Tiwari)

## ABSTRACT

The present investigation entitled **“Effect of organic, inorganic and biofertilizers on growth and yield of tomato (*Lycopersicon esculentum* Mill) under protected condition”** was conducted during rainy season of 2014 at the Vegetable Farm, Horticulture Section, College of Agriculture, Rewa to find out the best combination of organic, inorganic nutrients to maximize the productivity of tomato in this region.

The experiment was conducted in the Horticulture Department, College of Agriculture, Rewa (M.P.) during *kharif* 2014 with a view to ascertain the most suitable variety and spacing in the light of the recommended NPK fertilizer dose for winter tomato under agro-climatic and soil conditions of northern Madhya Pradesh.

The soil of the field was clay loam. It was fairly rich in organic matter and had good water holding capacity. The source of irrigation was drip irrigation system.

Rewa is situated in the North eastern part of Madhya Pradesh at 20° 21' North latitude, 81° 15', East longitude, and 365.7 meters above sea level. It has subtropical climate, hot and dry summer and cold winter are the main characteristics features of the region. The minimum and maximum temperature occasionally reaches 7.13 °C and 40.77 °C, respectively. The average annual rainfall of the tract ranges from 900 to 1200 mm, which mostly occurs during July to September months and occasional showers are received in winter also.

The twelve treatment combinations were replicated three times in a randomized block design. The NPK fertilizers were applied as urea, SSP and MOP/ha. The seedlings were transplanted on 17.08.2014 and the first picking was started from 2014.

## Treatments-12

T <sub>1</sub>	FYM 20 t/ha	T <sub>7</sub>	Vermicompost 5 t/ha + <i>Azotobacter</i>
T <sub>2</sub>	Vermicompost 5 t/ha	T <sub>8</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobacter</i>
T <sub>3</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha	T <sub>9</sub>	FYM 15 t/ha + <i>Azotobacter</i> + 50% NPK
T <sub>4</sub>	FYM 10 t/ha + 50% NPK + <i>Azotobacter</i>	T <sub>10</sub>	Vermicompost 5 t/ha + Biofertilizer( <i>Azotobacter</i> ) + 50% NPK
T <sub>5</sub>	Vermicompost 2.5 t/ha + 50% NPK + <i>Azotobacter</i>	T <sub>11</sub>	FYM 10 t/ha + Vermicompost 2.5 t/ha+ <i>Azotobacter</i> + 50% NPK
T <sub>6</sub>	FYM 10 t/ha + <i>Azotobacter</i>	T <sub>12</sub>	RFD of NPK (100:60:80)

Under growth characters height of plant and number of branches were studied. Under reproductive characters, number of flower clusters per plant, flowers per cluster and days to fruit-set per cluster were taken. In yield characters, number of fruits per plant, average fruit weight and yield per hectare were studied. Nutritional quality of fruit as well as grading of fruits was also determined.

Amongst the combined application of organic-cum-inorganic nutrients, T<sub>11</sub> having four sources of nutrients was continued to be the best with respect to quality also. Accordingly, the significantly higher dry matter of tomato fruit (8.17%), "A" grade tomato (54.59%), TSS upto 10.84 °Brix was obtained from the fertility treatment T<sub>11</sub>. The second best fertility treatment was T<sub>1</sub> having 20 t FYM/ha (dry matter 7.80, "A" grade tomato 52.16%, TSS 10.50 °Brix. The "C" grade tomato were in the lowest range. This was followed by T<sub>8</sub> and T<sub>9</sub> treatments. On the other hand, the significantly lowest values (6.53-6.63% dry matter, 48.49-48.61% "A" grade tomato, 8.47-9.02 °Brix TSS and was obtained from T<sub>6</sub> and T<sub>7</sub> treatments having half dose of FYM or vermicompost with *Azotobacter*

## **CONCLUSION**

In view of the findings and results presented above, it may be concluded that out of the twelve treatments comprising organic-cum-inorganic sources of nutrients, the treatment T<sub>11</sub>(FYM 10 t/ha + vermicompost 2.5 t/ha + *Azotobacter* + 50% NPK (N<sub>50</sub>P<sub>30</sub>K<sub>40</sub>) emerged as the best treatment with respect to growth, yield, quality of tomato var. Himshikhar.

However from the economical view point, T<sub>12</sub> having 100 % NPK (100:60:80) was the best for Polyhouse conditions of this region .

## **SUGGESTIONS**

Since these results are based on one-year experiment, further trials may be needed to substantiate the results.