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Growth and yield of Tomato (*Solanum lycopersicum* L.) as influenced by different source of organic manures and bio fertilizers

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ABSTRACT
A field experiment was carried out on tomato at Research Farm, Department of Horticulture, Agriculture College, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Indore , Madhya Pradesh during Kharif season, 2013-2014. Nine treatments of different organic and biofertilizers sources were tested in RCBD design with three replications. The results revealed that different sources of organic and biofertilizers had significant effect on growth, yield and quality of tomato. Application of T_6 Vermicompost 2 t/ha followed by T_1 Control (RDF 100:50:60 NPK kg/ha) recorded maximum value in growth and yield attributes of tomato.
***Key words**: Tomato, Organic manure, Bio fertilizers, Yield.*

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the most important vegetable among the vegetable crops grown widely both for fresh market and processing. Tomato fruit contains; moisture content 93.1%, protein 1.9%, fat 0.3gm, fiber 0.7%, carbohydrates 3.6%, calorie 23, vitamin 'A' 320 I. U., vitamin 'B_1' 0.07mg, vitamin 'B_2 0.01mg, nicotinic acid 0.4 mg, vitamin 'C' 31mg, calcium 20mg, phosphorus 36mg and iron 0.8mg. Tomato tops in the list of canned vegetables and are used to prepare ketchup, sauce, chutney, juice, puree, powder and paste. Fresh and ripe tomatoes are used as salad. Green tomatoes are also used for preserves and pickles. The pulp and juice of the tomato fruit is digestible, mild appetizer as a promoter of gastric secretion and blood purifier. India is next only to the China in area and production of vegetables. In India it is cultivated in area of 933.25 thousand hectare with production of 19377.44 thousand metric tonnes and productivity of 20.76 metric tonnes per hectare [1]. Major tomato growing states in India are Bihar, Karnataka, Orissa, Maharashtra and Andhra Pradesh. In Madhya Pradesh, it is grown in 60.84 thousand hectare of land with the annual production of 1484.55 thousand metric tonnes and productivity of 24.40 metric tonnes per hectare[1]. In Indore it is grown in 2000.00 hectare area with production of 36000.00 Mt and productivity of 18.00 T/ha [2]. 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 made on fertilizer along with maintaining good soil environmental conditions leading to ecological sustainable farming. Organic fertilizer like vermicompost, compost, FYM and poultry manure are very popular among the farmers and can easily be produced. Bio-fertilizers enhances the soil fertility and yield of crops by rendering unviable sources of primary nitrogen bound and phosphate into fixed and available form in order to help the plant for absorb the nutrients. Azospirillum has high nitrogen fixing capacity with low energy requirement. Bacteria such as Pseudomonas and Bacillus excrete acids into the growth medium and hence solubilise bound phosphates. These organisms are quite useful in the solubilisation of rock phosphates. At present, imprudent use of chemical fertilizer, pesticides and fungicides is

responsible for deterioration of soil health and ultimately our green plant. In India, most of the farmers are small and marginal. Therefore, it is very difficult for them to purchase the chemical fertilizer at the higher cost. Organic manure and bio-fertilizers on the other hand are eco-friendly and cheap sources of nutrient, however it has been observed that the crop response to organic manure and bio-fertilizers is not as spectacular. But due to increasing additions of chemical fertilizer, the chemical properties of soil decline in yield after continuous cropping. Therefore, to maintain the soil fertility and to supply plant nutrients in balanced proportion for optimum growth, yield and quality of crop with integrated approach is to be practiced under specific agro-ecological situation by combined use of organic and bio-fertilizers of plant nutrients.

MATERIALS AND METHODS

A field experiment was carried out on tomato variety Laxmi at Research Farm, Department of Horticulture, Agriculture College, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Indore, Madhya Pradesh during Kharif season, 2013-2014. Nine treatments viz., T_1 Control (RDF), T_2 FYM 15 t/ha, T_3 FYM 20 t/ha, T_4 FYM 25 t/ha ,T_5 FYM 30 t/ha, T_6 Vermicompost 2 t/ha ,T_7 Vermicompost 3 t/ha, T_8 Vermicompost 4 t/ha and T_9 Vermicompost 5 t/ha were tested in RCBD design with three replications. It is located at latitude 22.43° N and longitude of 75.66° E. It has subtropical climate having a temperature range of 21° C to 45° C and 6° C to 31° C in summer and winter seasons, respectively. The mean annual average rainfall is 964 mm. The soil of the experimental field has been grouped under medium black clay soil (Vertisols) belonging to Kamliakhedi series, which is a member of fine, smectitic, hyperthermic family of Vertic, Ustochrepts. The organic carbon content (0.26%) and available nitrogen (210.0 kg /ha) were low. The available phosphorus (12.6 kg/ha) and potash (425 kg /ha) were medium and high respectively. The soil pH was (7.8) slightly alkaline. Electrical conductivity (0.32 dS /m) of soil was found normal. Recommended dose of 100 kg nitrogen, 50 kg phosphorus and 60 kg potassium were used as urea, single super phosphate and murate of potash, respectively in treatment T_1. Plants were transplanted in the month of august, 2013 at a spacing of 60 x 45 cm row to row and plant to plant respectively. There were 50 plants in a 3x4.5 sq.m. plot. Observation were recorded on the following *viz.,* plant height (cm), number of branches per plant, dry weight per plant (g), leaf area (cm^2), leaf area index (LAI), NAR Net assimilation rate, crop growth rate, phenological characters, days taken to 50% flowering, days taken to 50% fruit set, number of flowers per plant, fruit set %, number of fruits per plant, fruit length (cm),fruits weight (g),yield per hectare (q)

RESULTS AND DISCUSSION

Morphological characters

Morphological characters viz., plant height, number of branches per plant, dry weight per plant, leaf area per plant, leaf area index, net assimilation rate and crop growth rate were studies in tomato variety Laxmi (Table 1). The plant height increased significantly at final harvest, the significantly (117.13 cm) were recorded in treatment T_1 Control (RDF 100:50:60 NPK kg/ha) followed by T_9 (Vermicompost 5 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) . This may be due to application of major and minor nutrients, through different organic manure and biofertilzers, increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant height. The findings is also consent with the findings of [3,4,5,6,7] . Number of branches per plant of tomato plants responded significantly to various treatments at different growth stages under research. At final harvesting the significantly maximum branches per plant were recorded under the treatment T_1 Control (RDF 100:50:60 NPK kg/ha) followed by T_9 (Vermicompost 5 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha). Probable reason for increased number of branches due to the increased rates of photosynthesis and photosynthates supply for maximum branches growth or change in endogenous auxin in turn in apical dominance. These findings are in agreement with the findings of [3,4,5,7,8,9] . Dry weight per plant was significantly increased by the different treatments of organic manure and biofertilizers. The treatment T_1 Control (RDF 100:50:60 NPK kg/ha) was found significantly superior as compared to other treatments. Highest dry weight per plant were recorded in T_1 Control (RDF 100:50:60 NPK kg/ha), followed by T_9 (Vermicompost 5 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) and which were at par with each other at 80 DAT only. This may be due to application of major and minor nutrients, through different organic, inorganic and bio-fertilizers levels, increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant growth ultimately dry weight of plant. Results are in consent with the finding reported by [6,10,11]. Leaf area per plant in treatment T_1

Control (RDF 100:50:60 NPK kg/ha) was recorded the significantly increased and was superior over other treatments of organic manure and biofertilizers. Leaf area was significantly increased by nitrogen, possibly because nitrogen helps in greater assimilation of food material by the plant which resulted in greater meristematic activities of cells and followed the number of leaves, length and width of leaf of plant. These findings are in agreement with the results reported by[10,12,13]. Leaf area index at 80 DAT, the significantly maximum leaf area index were observed under the treatment T_1 Control (RDF 100:50:60 NPK kg/ha) followed by T_9 (Vermicompost 5 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha). Leaf area index was also significantly increased by nitrogen, possibly because nitrogen helps in greater assimilation of food material by the plant which resulted in greater meristematic activities of cells and consequently the number of leaves, length and width of leaf of plant. These findings are in agreement with the results reported by[12, 13].

Phenological characters

Phenological characters, the days to 50% flowering, days to 50 per cent fruit set, number of flowers per plant, number of fruits per plant and per cent of fruit set were studies in tomato(Table 2).

Early 50 per cent flowering 47.58, 48.63 and 48.72 days were observed in treatments T_2 (FYM 15 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha), T_3 (FYM 20 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) and T_6 (Vermicompost 2 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha), respectively and which were at par with each other. This may be due to the fact that nitrogen in plants increased cell division and cell differentiation. Thus, plant remained in vegetative phase and resulted in imbalance between C: N ration thus delayed flowering at higher nitrogen level. The findings are in consent with findings of [6, 14]. Days to 50 per cent fruit set (62.28 and 61.23 days) were observed in treatments T_1 Control (RDF 100:50:60 NPK kg/ha) and T_9 (Vermicompost 5 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha), respectively and which were at par with each other. This trait is useful for obtaining higher return. This trait can be utilized in the breeding programme. Similar findings have been reported by [14]. Highest fruits per plant were recorded under the treatments T_1 Control (RDF 100:50:60 NPK kg/ha) and T_9 (Vermicompost 5 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) and which were at par with each other. This may be due to increased supply of major plant nutrients and are required in larger quantities for growth and development of plants. Nitrogen accelerates the development of growth and reproductive phases and protein synthesis, thus promoting yield attributing characters. Similar results have been reported by [4,5,7]. The per cent of fruit set varied from 76.88 to 69.84%. Among the different treatments the significantly maximum per cent of fruit set was observed in treatment T_1 Control (RDF 100:50:60 NPK kg/ha) (76.88%).

Yield characters

Yield characters, the fruit length, fruit weight and fruit yield per hectare were studies in tomato (Table2).

Fruit length was significantly influenced by the various treatments. Treatment T_6 (Vermicompost 2 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) was recorded highest fruit length followed by treatment T_7 (Vermicompost 3 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha). This may be due to increased supply of major plant nutrients. Nitrogen accelerates the development of growth and reproductive phases and protein synthesis, thus promoting fruit length. Similar results have been obtained by [7, 8].

Fruit weight of tomato responded significantly by the various treatments. The significantly maximum fruit weight was observed in the treatment T_6 (Vermicompost 2 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) followed by T_7 (Vermicompost 3 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha), T_8 (Vermicompost 4 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) as compared to other treatments. This may be due to increased supply of major plant nutrients and are required in larger quantities. Nitrogen accelerates the development of growth and reproductive phases and protein synthesis, thus promoting fruit weight. The findings are in agreement with the findings of [4,5,7,14,15[revealed that the foliar application of bio-fertilizer and humic (produced from vermicompost) fertilizer, enhance the mean fruit weight, which increased by 14-30 g per fruit.

Fruit yield per hectare was significantly influence by the different treatments. Significantly maximum fruit yield of tomato were exhibited in the treatment T_6 (Vermicompost 2 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) and T_1 Control (RDF 100:50:60 NPK kg/ha) and which were at par with each other. The probable reason for enhanced fruit yield may be due to cumulative effects of nutrient (macro and micro) on vegetative growth which ultimately lead to more photosynthetic activities while, application of fertigation grade nitrogen

levels enhance carbohydrate and nitrogen metabolism of pectic substances, as well as improve the water metabolism and water relation in the plants. Finding corroborates with their results obtained by [3,6]
It is revealed form the date obtained that a significantly maximum marketable fruit yield of 254.85q/ha was obtained in tomato hybrid Laxmi along cost benefit ratio 4.49 was obtained under treatment T_6 (Vermicompost 2 t/ha + Neem cake 2q/ha + PSB 2 kg + Azospirillum 2kg/ha) followed by T_1 Control (RDF 100:50:60 NPK kg/ha) gave fruit yield 227.59 q /ha with cost benefit ratio of Rs 4.04. Similar results have been reported by[3] [14] reported that the highest cost benefit ratio (1:2.02) was found due to application of *Azotobacter* and *Azospirillum* with recommended dose of NPK.

Tab.1. Effect of different source of organic manure and bio fertilizers on morphological characters of tomato.

Treat.	Treatments	Plant height (cm) at final harvest	No. of branches per plant at final harvest	Dry weight per plant (g) at80DAT	Leaf area (cm^2) per plant at80DAT	Leaf area index at 80DAT	Net assimilation rate ($mg/cm^2/day$) at80DAT	Crop growth rate ($g/m^2/day$) at80DAT
T_1	Control (RDF)	117.13	12.07	393.33	746.98	0.277	8.549	0.494
T_2	FYM 15 t/ha	103.93	9.67	246.67	557.45	0.207	6.365	0.259
T_3	FYM 20 t/ha	104.13	9.87	280.00	574.24	0.213	7.540	0.320
T_4	FYM 25 t/ha	105.20	10.00	300.00	670.68	0.248	7.037	0.349
T_5	FYM 30 t/ha	107.40	10.47	353.33	706.45	0.262	8.388	0.445
T_6	Vermicompost 2 t/ha	104.73	10.00	296.67	622.11	0.231	7.563	0.347
T_7	Vermicompost 3 t/ha	105.80	10.27	340.00	697.38	0.258	8.095	0.422
T_8	Vermicompost 4 t/ha	108.07	11.20	360.00	715.35	0.265	8.229	0.454
T_9	Vermicompost 5 t/ha	110.33	11.40	393.33	735.40	0.272	8.883	0.505
SEm±		0.54	0.20	5.85	0.53	0.00020	0.195	0.0109
C.D. at 5% level		1.64	0.60	17.56	1.61	0.00060	0.585	0.0329

Tab.2. Effect of different source of organic manure and bio fertilizers on phonological and yield characters of tomato.

Treat. Symb.	Treatments	Days to 50% flowering	Day to 50% fruit set	No. of flower per plant	No. of fruit per plant	Percentage of fruit set per plant	Fruit length (cm)	Fruit weight (g)	Fruit yield per hectare (q)	C: B ratio
T_1	Control (RDF)	54.30	62.28	125.40	96.47	76.88	4.78	91.93	227.59	1: 4.04
T_2	FYM 15 t/ha	47.58	54.30	103.53	72.47	69.84	3.60	75.93	119.47	1: 2.13
T_3	FYM 20 t/ha	48.63	55.40	106.80	78.27	73.19	3.97	81.53	135.27	1: 2.36
T_4	FYM 25 t/ha	49.60	57.47	109.40	79.80	72.56	4.23	82.87	150.34	1: 2.57
T_5	FYM 30 t/ha	51.70	59.65	112.93	82.80	73.29	4.48	88.13	176.57	1: 2.96
T_6	Vermicompost 2 t/ha	48.72	56.33	108.67	78.67	72.17	5.66	97.73	254.85	1: 4.49
T_7	Vermicompost 3 t/ha	50.30	58.46	111.27	80.73	72.00	5.06	91.60	221.68	1: 3.77
T_8	Vermicompost 4 t/ha	52.21	60.18	117.20	83.07	70.81	4.95	90.60	205.22	1: 3.38
T_9	Vermicompost 5 t/ha	53.17	61.23	119.87	87.93	73.25	4.58	84.40	160.73	1: 2.56
SEm±		0.67	0.57	2.10	3.74	0.70	0.11	1.91	9.84	-
C.D. at 5% level		2.01	1.72	6.32	11.22	2.10	0.33	5.72	29.51	-

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