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Yield and Quality of Tomato (*Solanum lycopersicon* Mill.) as Influenced by Application of Organic Substances under Protected Condition

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A B S T R A C T

Organic substances imparted significant effects on the growth, yield and quality parameters of tomato during the experimentation and maximum plant height of 113.87 cm at 60 DAT and 173.40 cm at 120 DAT was reported with application of RDF-N:P:K (180:100:100) kg/ha, while at highest plant height at 180 DAT was observed with application of FYM (25 t/ha) + VC (10 t/ha) + Waste Decomposer (500 l/ha). Same treatment also found best for most of traits like number of branches (8.72), minimum days to first harvest (85.33), number of fruits per plant (52.4), fruit weight (103.69 g), fruit diameter (5.34 cm), fruit volume (108.87 cc), yield per plant (5.43 kg), yield per square meter (12.05 kg), TSS (5.19 %) of fruit, moisture content (93.90 %) of fruit, lycopene content (3.82 mg/100 g), acidity (0.458 %), ascorbic acid (18.95 mg/100 g), sugars (2.80 %), chlorophyll content of tomato leaf (0.582 mg/g) and highest net return of Rs. 172070.00 per ha.

Introduction

Tomato (*Solanum lycopersicon* Mill.) is one of the most popular and widely grown vegetable crops all over the India. It belongs to family solanaceae of genus *Solenum* having chromosome number 2n=24. It is believed to native from Peru, Ecuador and Bolivia on the basis of availability of numerous cultivated and wild relatives that exist in these areas (Taylor, 1986). Tomato is cultivated in subtropics to tropics of the India and it being cultivated in open fields, kitchen gardens and it is also grown as 'forced crop' under protected cultivation in shade net house and polyhouse conditions. It is rich in vitamins, minerals and antioxidants which are essential for human health.

The open field production of vegetables encounter many production constraints like heavy rain, thunderstorms, excessive solar radiation, low and high temperature and humidity levels, exposure to high insect pest load and fungal disease (Ameta *et al.*, 2019). Environment is the most determinate factor in the growth and development of vegetables crops, as changing levels of temperature, humidity, wind flow *etc.* productivity of crop adversely affected. Protected cultivation is a

sustainable approach to increase the production, by utilizing available vertical space, in addition to use hybrid seed, GAP (Good agricultural practices), other improved agro techniques. Besides environmental protection, it ensures high quality produce and more production per unit area with increased input use efficiency. The microclimate can be modified inside the polyhouse consequently, ensuring a minimum use of insecticides. In recent years, there has been increase in the use of chemical fertilizers to obtain higher yields from hybrids and improved varieties (Yadav *et. al*, 2017). Use of chemical fertilizers alone increased the crop yield in the initial years but adversely affected the sustainability over subsequent years (Singh *et al.*, 2015). This necessitated review of various approaches for ensuring effective use of renewable sources. Application of organic manures to soil such as farm yard manure, vermi-compost, *neem* cake and biodynamic manures have been found to have beneficial effects on horticultural crops production. National Centre of Organic Farming, Ghaziabad, (UP) launched waste decomposer culture in 2015. It is a consortium of few beneficial micro-organisms which is isolated by Krishan Chandra (2004) from *Desi* cow dung and took 11 years to standardize the mass multiplication technique at farm level. Waste decomposer works as biofertilizer, biocontroller as well as soil health reviver. It enhances composting of bio wastes and can be used as biopesticide in drip irrigation or foliar spray to control most of the plant diseases. It readily makes the unavailable mass of nutrients, present in applied organic sources and soil available.

Materials and Methods

The experiment was carried out during July, 2019 to February, 2020 at Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur (Rajasthan) with 13 treatments in Completely Randomized Design. The dimension of polyhouse size was 28 m x 32 m (896 sq. m.) and enveloped with 200 micron thick polyethylene sheet with UV stabilization, aluminate sheet, insect proof net and foldable side covers. The initial status of soil pH was 7.6, EC 1.6 and organic carbon 0.55%. The treatments of experiment were T_1-Control (RDF) - @ 180:100:100 NPK kg/ha, T_2- FYM (25 t/ha), T_3- Vermicompost (10 t/ha), T_4- FYM (12.5 t/ha) + vermicompost (5 t/ha), T_5- FYM (25 t/ha) + *neem* cake (250 kg/ha), T_6- Vermicompost (10 t/ha) + *neem* cake (250 kg/ha), T_7- FYM (12.5 t/hac) + vermicompost (5 t/ha) + *neem* cake (250 kg/ha), T_8- FYM (25 t/ha) + castor cake (250 kg/ha), T_9- Vermicompost (10 t/ha) + castor cake (250 kg/ha), T_{10}- FYM (12.5 t/hac) + vermicompost (5 t/ha) + castor cake (250 kg/ha), T_{11}- FYM (25 t/ha) + waste decomposer (500 l/ha), T_{12}- Vermicompost (10 t/ha) + waste decomposer (500 l/ha), T_{13} - FYM (25 t/ha) + vermicompost (10 t/ha) + waste decomposer (500 l/ha). F_1 hybrid variety "Dev (NP 5031)" of tomato was used in this experiment. It is semi- determinate hybrid with good foliage cover, fruit color red, fruit shape - square round, very good firmness, wide adaptability with excellent shipping quality. Five weeks old seedling were transplanted on raised beds at the spacing of 60 cm x 45 cm as per layout in the evening hours followed by quick light irrigation through drip system. Recommended dose of fertilizer N:P:K @ 180:100:100 kg/ha was calculated according to experimental area and accomplished through application of various fertilizers *viz.*, urea, DAP, 19:19:19, 0:0:50 were applied as basal and remaining dose as split doses. Tomato harvesting was started at 85-90 days after transplanting. Data were recorded for plant height at 60, 120 and 180 days after transplanting (cm), number of branches per plant (at final harvest), days to first harvest, number of fruits per plant, fruit

weight (g), fruit diameter (cm), fruit volume (cc), yield per plant (kg), yield per meter square (kg), total soluble solids (%), moisture content (%), lycopene content (mg/100 g), acidity (%), ascorbic acid content (mg/100 g), sugar (%), chlorophyll content in leaves (mg/g) from randomly selected five tagged plants of each treatment and further analyzed. All data were subjected to analysis of variance to determine the treatment effects.

Results and Discussion

The data pertaining to the effect of different organic manures, oil cakes and waste decomposer on yield and quality attributes of tomato were analyzed as per completely randomized design with a view to test their significance and showed significant differences among various treatments studied.

Growth attributes

The mean data on the plant height (at 60 DAT, 120 DAT and 180 DAT), number of branches (at final harvest) and days to first harvest as influenced by various treatments are presented in Table-1, clearly indicated that different combinations of organic manures, oil cakes and waste decomposer had significant effect on vegetative growth parameters.

The result revealed that the application of treatment T_1 (RDF – 180:100:100 NPK kg/ha) recorded the maximum plant height at 60, 120 DAT. Present results are in conformity with findings of Haque *et al.*, (2011). Kumar *et al.*, (2013) also reported maximum plant height (19.78 cm) under application of inorganic fertilizers., further Laxmi *et al.*, (2015) seen maximum plant height (133.53 cm) while working with tomato due to the application of 50% inorganic fertilizers along with 50% FYM. Maximum number of branches per plant and minimum days to first harvest were reported for the treatment T_{13} (FYM @ 25 t/ha + VC @10 t/ha + Waste Decomposer @ 500 l/ha), these results are in close conformity with the finding of Manohar *et al.*, (2013).

It might be due to waste decomposer as it facilitates the decomposition process of organic manures which induces readily available form of nutrients *i.e.*, N, P and K increase amount of organic acids, organic carbon compound and humus as well as lower down the C:N ratio which leads to mineralization process resulting in enhanced growth parameters, without it organic manures slowly decomposes which affects nutrient availability to the plants.

Yield attributes

The results of the present investigation showed that response of various treatments on different yield contributing parameters *viz.*, number of fruit per plant, fruit weight (g), fruit volume (cc), fruit diameter (cm), yield per plant (kg) and yield per square meter (kg) were differed significantly (Table-2). The results revealed that the application of treatment T_{13} (FYM @ 25 t/ha + VC @ 10 t/ha + Waste Decomposer @ 500 l/ha), recorded the maximum number of fruits per plant (52.45), fruit weight (103.69 g), fruit volume (108.87 cc), fruit diameter (5.34 cm), yield per plant (5.43 kg) and yield per square meter (12.05 kg), this treatment performed best, which may be due to increased dose of organic manures *viz.* FYM and vermicompost.

Findings of Singh *et al.*, (2017) was also in conformity as they reported high impact on number of fruits per plant and yield per hectare in tomato with the application of organic manures along with biofertilizers. Same trend was also observed by Meena and Verma (2019) while working with tomato with the application of vermicompost.

Table.1 Effect of organic manures, oil cakes and waste decomposer on yield and quality of polyhouse grown tomato

Treatments	Plant height (cm)			Number of branches	Days to first harvest	Number of fruits/ plant	Fruit weight (g)	Fruit diameter (cm)	Fruit volume (cc)	Yield/ plant (kg)	Yield/ square meter (kg)
	60 DAT	120 DAT	180 DAT								
T_1	113.87	173.40	217.22	7.83	87.12	49.22	100.03	5.17	105.03	4.92	10.92
T_2	92.14	154.72	204.66	6.21	91.08	42.33	91.31	4.31	95.87	3.86	8.56
T_3	92.98	155.29	205.54	6.42	90.42	43.08	92.19	4.46	96.79	3.97	8.81
T_4	94.94	157.77	207.05	6.62	91.65	44.11	93.39	4.53	98.05	4.11	9.12
T_5	98.73	160.03	209.37	7.04	90.32	46.01	95.49	4.73	100.26	4.39	9.74
T_6	97.96	159.49	210.60	6.94	91.11	45.56	94.17	4.69	98.87	4.29	9.52
T_7	99.23	162.39	212.00	7.26	89.86	46.91	96.89	4.84	101.73	4.54	10.07
T_8	101.36	163.10	212.91	7.45	89.09	47.65	97.01	4.9	101.86	4.62	10.25
T_9	103.23	165.90	213.47	7.71	87.82	48.83	99.01	5.14	103.99	4.83	10.72
T_{10}	102.79	164.64	214.12	7.53	88.12	48.09	98.51	5.05	103.43	4.73	10.50
T_{11}	106.42	168.42	218.68	7.89	86.29	50.09	101.55	5.21	106.62	5.08	11.27
T_{12}	107.01	169.01	219.32	7.97	85.98	51.11	102.23	5.28	107.34	5.22	11.58
T_{13}	111.34	172.34	222.64	8.72	85.33	52.45	103.69	5.34	108.87	5.43	12.05
SEm±	**2.42**	**1.80**	**3.94**	**0.27**	**1.55**	**1.06**	**1.22**	**0.10**	**1.10**	**0.49**	**0.41**
CD @ 5%	**7.35**	**5.23**	**NS**	**0.78**	**NS**	**3.09**	**3.54**	**0.28**	**3.21**	**0.63**	**1.18**

NS = Non-significant

Table.2 Effect of organic manures, oil cakes and waste decomposer on yield and quality of polyhouse grown tomato

Treatments	Total soluble solids (%)	Moisture content (%)	Lycopene content (mg/100 g)	Titratable Acidity (%)	Ascorbic acid content (mg/100 g)	Sugars (%)	Chlorophyll content in leaf (mg/g)	Yield (q/1000m^2)	Net Return (Rs per 1000 m^2)	B:C Ratio
T_1	4.99	93.5	3.78	0.449	16.61	2.69	0.539	109.2	154285.00	2.41
T_2	4.14	92.2	3.16	0.403	14.05	2.35	0.468	85.6	108310.00	1.72
T_3	4.19	92.3	3.21	0.409	14.27	2.38	0.474	88.1	109810.00	1.65
T_4	4.25	92.5	3.33	0.414	14.64	2.40	0.486	91.2	117760.00	1.82
T_5	4.41	92.8	3.43	0.427	15.11	2.49	0.499	97.4	131510.00	2.08
T_6	4.39	92.6	3.39	0.421	14.98	2.45	0.492	95.2	123610.00	1.85
T_7	4.55	92.9	3.51	0.433	15.39	2.53	0.502	100.7	136360.00	2.10
T_8	4.68	93	3.64	0.439	15.59	2.58	0.509	102.5	141610.00	2.23
T_9	4.86	93.3	3.72	0.446	16.33	2.64	0.531	107.2	147510.00	2.21
T_{10}	4.78	93.1	3.69	0.443	15.86	2.60	0.517	105.0	144860.00	2.22
T_{11}	4.92	93.7	3.86	0.452	17.45	2.72	0.543	112.7	162470.00	2.58
T_{12}	5.07	93.8	3.82	0.454	17.91	2.77	0.559	115.8	165170.00	2.49
T_{13}	5.19	93.9	3.91	0.458	18.95	2.80	0.582	120.5	172070.00	2.50
SEm±	**0.07**	**0.88**	**0.06**	**0.066**	**0.74**	**0.15**	**0.20**			
CD @ 5%	**0.20**	**NS**	**0.16**	**NS**	**2.15**	**0.20**	**NS**			

NS = Non-significant

Quality attributes

Response of various treatment combinations on different quality parameters *viz.,* TSS (%), lycopene content (mg/100 g), ascorbic acid (mg/100 g) and sugars (%) was differed significantly, whereas acidity (%), moisture content (%) and chlorophyll content of leaves (mg/g) showed no significant difference. TSS of the fruit was found to be significantly affected by higher level of organic manures, however, highest TSS (5.42%) was found under the treatment T_{13} (FYM @ 25 t/ha + VC @ 10 t/ha + Waste Decomposer @ 500 l/ha). Meena *et al.,* (2014) reported highest TSS (5.03^0Brix) by application of 100% vermicompost alone in tomato cultivar Pusa Sheetal. Rajawat *et al.,* (2019) also obtained almost similar range of TSS (4.14 to 5.21^0Brix) in tomato through 100% organic management under polyhouse conditions. The results shown that highest value of lycopene content was recorded using treatment T_{13} (FYM @ 25 t/ha + @ Vermicompost 10 t/ha + Waste decomposer @ 500 l/ha) which may be related to application of vermicompost that add secondary nutrients like copper, manganese and zinc that takes part in many vital metabolic processes and are cofactor of many antioxidant enzymes therefore, producing a significantly higher color ratio to increase the redness of tomato. Murmu *et al.,* (2012) recorded maximum color value (1.54) of tomato fruit in vermicompost based treatments as compared to another treatments which are treated with chemical fertilizers. The higher level of ascorbic acid in tomato fruit is found due to accomplishment of major and minor nutrients through application of organic manures and reduction in the ascorbic acid oxidase enzyme which is responsible for annihilation of ascorbic acid content in the plants. Rajawat *et al.,* (2019) reported maximum ascorbic acid content (18.43 mg/100 g) with the application of 100% organic management. These results are in close conformity with the findings of Laxmi *et al.,* (2015), who concluded that highest ascorbic acid content (26.54 mg/100 g) was recorded with the application of 50% vermicompost along with 50% recommended dose of fertilizers. The higher content of sugar was observed with treatment T_{13} (FYM @ 25 t/ha + VC @ 10 t/ha + Waste Decomposer @ 500 l/ha), which might be due the effect of growth hormones, micro and macro nutrients produced by organic manures which may also lead to the greater absorption of minerals from the soil. Similar results were reported by Pal *et al.,* (2015) while working with tomato, they reported that application of FYM along with vermicompost resulted highest sugar (3.82%) in tomato cultivar Azad T-6.

Economics of treatment

Data pertains to economics of tomato for 1000 m^2 area under polyhouse conditions was affected by various treatments. Economics analysis showed that treatment T_{13} (FYM @ 25 t/ha + VC @ 10 t/ha + Waste Decomposer @ 500 l/ha) significantly produces higher gross return (Rs. 241000.00) and net return (Rs. 172070.00) with B:C ratio (2.50) as compared to other treatments.

On the basis of present investigation it may be concluded that among the various treatments, T_{13} [FYM (25 t/ha) + VC (10 t/ha) + Waste Decomposer (500 l/ha)] was found best as it was best performer in most of traits like minimum days to first harvest, maximum number of branches per plant, number of fruits per plant, fruit diameter, fruit weight and fruit volume, yield per plant, yield per square meter and quality attributes *viz.,* TSS, moisture content, lycopene content, ascorbic acid, acidity, sugars, chlorophyll content of leaf and net return.

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