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Effect of organic manures and chemical fertilizers on fruit characteristics, quality and yield of tomato under naturally ventilated polyhouse

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Abstract
An experiment was carried out at Hi-tech Unit, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur during two consecutive years 2017 and 2018, to assess the effect of various organic manures, chemical fertilizers and biofertilizers of growth and its attributes of tomato under naturally ventilated polyhouse. The experiment was laid out in completely randomized design with eight treatment combinations and four replications. The pooled analysis revealed that maximum total soluble solids (5.21 ^{o}Brix), ascorbic acid content (18.43 mg/100g), titratable acidity (0.455 %) and number of fruits per plant (50.84) were observed with treatment T_5 100 per cent organic management while minimum days to first harvest (86.71) were observed with the applications of 100 per cent vermicompost + biofertilizers. Treatment T_7 (50 per cent organic + 50 per cent inorganic fertilizers) recorded significantly higher fruit weight (102.14 g) and total yield per plant (4990.91 g) under naturally ventilated polyhouse.

Keywords: Tomato, polyhouse, organic manures, chemical fertilizers, yield

Introduction
Tomato (*Solanum lycopersicon* L.) is one of the most important vegetable crops in the world. The tomato belongs to the family Solanaceae, genus Lycopersicon, which is a relatively small genus within the large and diverse family consisting of approximately 90 genera. The flavor of tomato fruits is controlled by various volatile compounds like ethanol and acetaldehyde. Tomato juice promotes gastric secretion, acts as a blood purifier and works as intestinal antiseptic. Lycopene has also been shown to protect against oxidative damage in many epidemiological and experimental studies. In addition to its antioxidant activity, other metabolic effects of lycopene have also been demonstrated. The richest source of lycopene in the diet is tomato and tomato derived products. Tomato consumption has been associated with decreased risk of breast cancer, head and neck cancers and might be strongly protective against neurodegenerative diseases. Tomato sauces and puree are said to help to lower urinary tract symptoms (BPH) and may have anticancer properties. Tomato consumption might be beneficial for reducing cardiovascular risk associated with diabetes.

The fruits are rich in lycopene which may have beneficial health effects. With the increase in population, the demand for the crop has significantly increased. As a result growers are forced to make heavy use of inorganic sources of plant nutrients. Escalating costs of inorganic fertilizers are hampering the way to increase the productivity per unit area. The majority of tomato growers do not produce good quality fruit at high yield due to lack of knowledge regarding improved production technologies including use of proper inorganic and inorganic fertilizers. Therefore, efforts are being made in this regard to integrate chemical fertilizers with organic manure which are eco-friendly to achieve sustainable productivity with minimum deterious effects of chemical fertilizers on soil health and environment. Keeping this in view, the present investigation was undertaken to find out the best combination of organic and inorganic fertilizers for obtaining the maximum fruit yield and quality of tomato for protected cultivation.

Materials and Methods
An experiment was carried out at Hi-tech Unit, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur during two consecutive years 2017 and 2018, to assess the

effect of various organic manures, chemical fertilizers and biofertilizers of growth and its attributes of tomato under naturally ventilated polyhouse. The experiment was laid out in completely randomized design with eight treatment combinations replicated four times. The treatments involved were T_1- 100 per cent RDF (RDF @ 180:100:100 NPK kg/ha), T_2- 100 per cent RDF+ biofertilizers, T_3- 100 per cent vermicompost @ 10 t/ha + biofertilizers (PSB + ZSB + *Azotobector* @ 4 kg/ha), T_4- 100 per cent vermicompost, T_5- 100 per cent Organic Management, T_6- 75 % Organic Management, T_7- 50 per cent Organic Management + 50 per cent inorganic fertilizers, T_8- 75 per cent Organic Management + 25 per cent inorganic fertilizers. The raised beds of 1 meter width having 45 cm above from ground level along with length of polyhouse were prepared the plot size was 7 m X 1 m and spacing was followed 50 cm X 45 cm. Basal dose of NADEP compost, vermi-compost, and none edible cakes were calculated as per treatment and thoroughly mixed in the soil one week before transplanting. Bio-fertilizers (PSB + ZSB + *Azotobector*) @ 4 kg per ha were inoculated and applied before transplanting as seedling root dip for 30 minutes. Fertigation schedule was followed and NPK was applied in liquid form along with irrigation water twice in a week as water soluble NPK mixture (19:19:19) and (0:52:34) along with micronutrient and calcium nitrate. All cultural practices were followed regularly during entire crop growth period and observations were recorded on yield parameter, quality attributes and fruit characteristics.

Table 1: Treatments details for tomato given with their notation

Notation	Treatments
T_1	100 per cent RDF (Inorganic source)
T_2	100 per cent RDF+ biofertilizers
T_3	100 per cent vermicompost + biofertilizers
T_4	100 per cent vermicompost
T_5	100 per cent Organic Management (1/3 of RDN by NADEP compost + 1/3 by vermicompost + 1/3 by non-edible cakes + biofertilizers)
T_6	75 % Organic Management (1/3 of RDN by NADEP compost + 1/3 by vermicompost + 1/3 by non-edible cakes + biofertilizers) + innovative practices (BD 500 @ 75 g per hectare before planting and 30 DAP + BD-501 @ 2.5 g per hectare 2-4 leaf stage + mataka khad 10 per cent at 30 DAP + Panchagavya @ 10 per cent 30 DAP (in case of cucumber 20 DAP)
T_7	50 per cent Organic Management (1/3 of RDN by NADEP compost + 1/3 by vermicompost + 1/3 by non-edible cakes + biofertilizers)+ 50 per cent inorganic fertilizers
T_8	75 per cent Organic Management (1/3 of RDN by NADEP compost + 1/3 by vermicompost + 1/3 by non-edible cakes + *Azotobacter*, integrated crop management) + 25 per cent inorganic fertilizers

Results and discussion

Experimental findings have been discussed on pooled basis considering the importance of different sources of organic, inorganic and biofertilizers. The combination of treatment having 50 per cent organic + 50 per cent inorganic fertilizers recorded significantly higher fruit weight (102.14 g) and fruit volume (108.01 cc) closely followed by fruit weight (99.83 g) and fruit volume (105.81) in 75 per cent organic + 25 per cent inorganic fertilizers might be due to improved nutrient absorption and translocation by plants by the addition of organic manures leading to increase uptake of NPK as reported by Prativa and Bhattarai (2011) [1]. Similar findings were also reported by Yeptho *et al.* (2012) [2], Singh *et al.* (2015) [3], Meena *et al.* (2017) [4] and Laxmi *et al.* (2015) [5] in tomato.

Maximum pooled value for fruit diameter (5.21 cm) and minimum days to first harvest (86.71) were observed with the applications of 100 per cent vermicompost + biofertilizers closely followed by 100 per cent organic management and 50 per cent organic and 50 per cent inorganic fertilizers for fruit diameter while 75 per cent organic management for days to first harvest while in case of maximum number of fruits per plant (50.84) were observed with the application of 100 per cent organic management was closely followed by T_8 and T_7, respectively. Biofertilizers fixes the atmospheric nitrogen in soil enhances the production of phytohormone like substance and increase uptake of nutrients. The biological activity of microorganism would have helped the soil status to become a ready to serve zone for essential nutrients to plant root system as reported by Premshekar and Rajshree (2009) [6]. These results were in accordance with Patil *et al.* (2009) [7], Kumar *et al.* (2010) [8], Yeptho *et al*. (2012) [2] in tomato and Lal and Kanaujia (2013) [9] and Raturi *et al.* (2019) [10] in capsicum. Application of different organic and inorganic fertilizers significantly influences the quality of tomato fruit (Table 2). Maximum total soluble solids (5.21 ^oBrix) and ascorbic acid content (18.43 mg/100g) were observed under 100 per cent organic management whereas specific gravity was found non-significant among various treatments, maximum value for specific gravity (0.950 g/cm^3) was found with the application of 100 per cent RDF + biofertilizers. Plants treated with organic manures increased the total soluble solids over application of inorganic fertilizers while combined application of organic and inorganic fertilizers also respond to higher ascorbic acid content. This might be due to effect of organic manures which have both micro and macro nutrients and biofertilizers improve the nutrient uptake improving the quality produce. Similar findings were also reported by Meena *et al.* (2017) [4], Premshekar and Rajshree (2009) [6], Laxmi *et al.* (2015) [5] and Murmu *et al.* (2013) [11] in tomato.

The higher content of lycopene (3.84 mg/100g) was observed with the application of 100 per cent RDF + biofertilizers closely followed by 75 per cent organic + 25 per cent inorganic fertilizers might be due to physiological influences of biofertilizers in combinations with inorganic and organic fertilizers under microclimate conditions which is present inside the polyhouse. Findings of Gajbhiye *et al.* (2010b) [12] in conformity with present results and similar findings were also reported by Murmu *et al.* (2013) [11] in tomato.

The variation in titratable acidity differed significantly due to application of different treatments combinations during both the year of investigation under naturally ventilated polyhouse. Maximum pooled value for titratable acidity (0.455 %) was recorded with the application of 100 per cent organic management which was at par with the value (0.445 %) observed in both the treatment T_3 and T_7, might be due to C/N ratio theory, when nitrogen is readily available in the soil after application of inorganic fertilizers, plants will primarily make compounds with high nitrogen content (e.g protein for growth), whereas when nitrogen availability is limited due to

slow release as in organic manures, plant metabolism changes more towards carbon containing compounds such as starch, cellulose and non N containing secondary metabolites compound such as phenolics and terpenoids as reported by Haukioja *et al.* (1998) [13]. Similar findings were also reported by Murmu *et al.* (2013) [11] and Kumar *et al.* (2017) [4] while working with tomato.

Among the different treatments highest total yield per plant (4990.91 g) and yield per meter square (13.31 kg) were observed with the application of 50 per cent organic and 50 per cent inorganic fertilizers which was significantly superior over other treatment combinations. The next better treatment in this regard 75 per cent organic and 25 per cent inorganic fertilizers and 100 per cent organic management produce (4823.85 g and 4734.00 g) per plant and (12.87 kg and 12.63 kg) per meter square, respectively, might be due to combined application of organic, inorganic fertilizers along with biofertilizers by the presence of sufficient quantities of available nutrients. It is well known fact that better nutrient utilization in the presence of biofertilizers, enhanced biological nitrogen fixation and better root system development as well as higher synthesis of plant growth hormones. Integrated nutrient management system involving organic and inorganic fertilizers is a better way to achieve higher yield as reported by Murmu *et al.* (2017). Similar findings were also reported by Kumar *et al.* (2017) [4], Prativa and Bhattarai (2011) [1], Nagre (2013) [14] and Singh *et al.* (2015) [3] while working with tomato.

Table 2: Effect of organic manures and chemical fertilizers on fruit characteristics of tomato under naturally ventilated polyhouse

Treatments	Fruit weight (g)			Fruit diameter (cm)			Fruit volume (cc)			Days to first harvest			Number of fruits per plant		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1	95.65	95.42	95.54	4.42	4.34	4.38	101.70	101.67	101.69	88.20	89.06	88.63	45.87	44.08	44.97
T_2	100.38	102.02	101.20	4.70	4.66	4.68	105.83	105.16	105.49	90.10	93.27	91.69	46.22	47.60	46.91
T_3	93.42	94.98	94.20	5.07	5.34	5.21	99.15	100.70	99.92	87.65	85.77	86.71	47.75	48.51	48.13
T_4	92.94	92.22	92.58	4.96	4.98	4.97	99.12	97.95	98.53	90.35	91.75	91.05	42.61	43.67	43.14
T_5	94.84	95.13	94.98	5.05	5.15	5.10	100.11	100.53	100.32	89.45	91.39	90.42	51.31	50.37	50.84
T_6	91.36	92.22	91.79	4.53	4.89	4.71	97.57	98.45	98.01	88.25	88.79	88.52	42.33	43.05	42.69
T_7	101.11	103.16	102.14	4.99	5.02	5.01	107.09	108.94	108.01	88.70	90.07	89.39	47.43	49.85	48.64
T_8	98.26	101.41	99.83	4.61	4.66	4.63	104.01	107.61	105.81	91.80	92.86	92.33	48.66	50.84	49.75
SEm±	1.60	1.63	1.16	0.12	0.11	0.08	1.47	1.81	1.19	0.66	0.86	0.55	0.97	0.72	0.64
CD 5%	4.67	4.76	3.30	0.36	0.33	0.25	4.29	5.29	3.40	1.93	2.51	1.57	2.83	2.11	1.84

Table 3: Effect of organic manures and chemical fertilizers on fruit quality of tomato under naturally ventilated polyhouse

Treatments	Specific gravity (g/cm^3)			Total soluble solids (^oBrix)			Ascorbic acid content (mg/100g)			Lycopene content (mg/100g)			Titratable Acidity (%)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1	0.940	0.938	0.939	4.15	4.12	4.14	14.76	13.19	13.97	3.34	3.24	3.29	0.394	0.408	0.401
T_2	0.949	0.951	0.950	4.71	4.78	4.74	16.77	16.53	16.65	3.78	3.91	3.84	0.411	0.403	0.407
T_3	0.942	0.943	0.943	5.12	5.03	5.07	17.56	16.66	17.11	3.34	3.16	3.25	0.438	0.451	0.445
T_4	0.938	0.942	0.940	4.99	5.13	5.06	15.61	15.42	15.51	3.21	3.18	3.19	0.422	0.426	0.424
T_5	0.947	0.946	0.947	5.31	5.10	5.21	17.92	18.95	18.43	3.53	3.76	3.65	0.451	0.458	0.455
T_6	0.936	0.937	0.937	5.09	5.21	5.15	14.05	16.20	15.13	3.41	3.46	3.43	0.429	0.436	0.433
T_7	0.944	0.947	0.945	4.81	4.78	4.80	17.01	17.47	17.24	3.63	3.59	3.61	0.444	0.446	0.445
T_8	0.945	0.942	0.944	4.78	4.80	4.79	16.72	18.07	17.40	3.74	3.80	3.77	0.439	0.442	0.440
SEm±	0.005	0.004	0.004	0.08	0.10	0.07	0.37	0.34	0.26	0.09	0.07	0.06	0.008	0.009	0.006
CD 5%	NS	NS	NS	0.24	0.30	0.20	1.08	0.99	0.76	0.27	0.23	0.18	0.023	0.025	0.017

Table 4: Effect of organic manures and chemical fertilizers on yield of tomato under naturally ventilated polyhouse

Treatments	Total yield per plant (g)			Yield per meter square (kg)		
	2017	2018	Pooled	2017	2018	Pooled
T_1	4419.24	4328.86	4374.05	11.79	11.55	11.67
T_2	4542.02	4485.85	4513.94	12.11	11.96	12.04
T_3	4172.93	4263.95	4218.44	11.13	11.37	11.25
T_4	3851.65	3920.94	3886.30	10.27	10.46	10.36
T_5	4650.35	4817.66	4734.00	12.40	12.85	12.63
T_6	3768.68	3886.17	3827.42	10.05	10.36	10.21
T_7	4997.71	4984.12	4990.91	13.33	13.29	13.31
T_8	4755.18	4892.52	4823.85	12.68	13.05	12.87
SEm±	54.01	60.67	41.63	0.14	0.16	0.11
CD 5%	157.64	177.09	118.37	0.42	0.47	0.31

Conclusion

On the basis of present study it may be concluded that integrated application of organic and inorganic fertilizers along with biofertilizers treatment T_7 (50 per cent organic and 50 per cent inorganic fertilizers) was found superior in terms of growth and yield parameters for tomato under naturally ventilated polyhouse conditions. Applications of organic manures along with biofertilizers, innovative practices and other organic substance responses well in terms of quality. Maximum TSS were registered with treatment T_5 (100 per cent organic management) as well as titratable acidity and ascorbic acid content of tomato with the same treatment.

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