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Effect of organic manures and biofertilizers on plant growth, yield and quality traits of Tomato (*Solanum lycopersicum* Mill.) var. Pusa Ruby

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Abstract
Present investigation entitled "Effect of organic manures and biofertilizers on plant growth, yield and quality traits of Tomato (*Solanum lycopersicum* Mill.)" var. Pusa Ruby" was conducted during the *Rabi* season of 2022 - 23 at Agriculture Research Farm, Rama university, Mandhana, Kanpur. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments *viz.* T_1 = Control, T_2 =FYM Poultry manure @ 8 t/ha, T_3 =Vermicompost @ 8 t/ha, T_4 = Neemmanure @ 5 t/ha T_5 = Biovita Granules @ 20 kg/ha, T_6 = Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha, T_7 =FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha, T_8=Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha and T_9 =Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha. The result of the study revealed that the maximum plant height (156.40cm), Number of leaves (98.50), leaf area index (0.960cm), canopy spread (0.243), Days to first flower (40.4), Number of branches per plant (18.49), Number of flowers / plant (32.29), Number of fruit/ plant (20.06), fruit diameter (7.02cm), fruit weight (68.80gm), TSS(6.22º Brix), Ascorbic acid (22.620mg/ 100gm), Reducing sugar, (3.740%), total sugar (4.120%) yield per plot (31.41) and B:C ratio (3.15). Basis on these results treatment T_6 can be suggested to the local farmer of Kanpur regions to obtain higher yield and net return in tomato.

Keywords: Tomato, organic manures, biofertilizers, *Solanum lycopersicum*

Introduction
Tomato (*Solanum lycopersicun* L.) is one of the most important vegetable crops belong to the family *solanaceae*. Due to its greater flexibility in varied agro-climatic conditions, it is produced all over the world for fresh and processed applications. It originated in Peru, Equador and Bolivia regions of Central and South America (Vavilov, 1951) [5].

A fresh tomato fruit contains Calories 18 g, Fat 0.2 g, Sodium 5.0 mg, Potassium 237 mg, Carbohydrate 3.0 g, Protein 0.9 g, Vitamin C 22%, Iron 1%. It has also been reported useful in controlling liver problems, indigestion, arthritis and urinary disorders (Chauhan, 1983) [1]. Its adaptability in both fresh and processed forms has greatly contributed to its quick and widespread acceptance as a significant food product. Its worth is second only to potatoes, but its processing capabilities are the best of all the vegetables. (Sandhu *et al.* 1990) [3]. It is grown throughout the world both in open as well as under protected conditions. In India tomato is grown over an area of 0.81 M hectares with an annual production of 21003 Mt and in Madhya Pradesh, area 37 thousand hectare fallowed by Haryana 14 hectare, Uttar Pradesh 12.8 thousand hectare, Himachal Pradesh area under tomato is 1.3 thousand hectares and production is 577 Mt. (Horticultural Statistics division DAC & FW,2020-21). To meet out requirement vegetable of the country there is a necessity to increase the production as well as the productivity. By providing high-quality inputs, one can boost crop production. The most crucial input in any agricultural production programme, seed determines whether a crop will succeed or fail. Without wholesome, high-quality seed, every dollar spent on additional inputs is wasted. One of the most crucial requirements for increasing crop output is good quality seed. Due to the usage of chemical fertilisers, vegetable and high-quality seed output has greatly expanded during the "green revolution." Because they are a labor-intensive crop and a heavy feeder, tomatoes require a lot of organic and inorganic fertilizers (Gajbhiye *et al.* 2003).

The extensive use of chemical fertilizers has led to soil sickness, ecological hazards and depletion of non-renewable sources of energy. Moreover, they deteriorate the quality of the produce and are expensive too, leading to reduction in net profit returns to the farmers.

On the other hand, there is sufficient evidence that the intensive agricultural systems have also caused decline in vitamins and mineral contents Introduction 2 of fresh fruits and vegetables. Excessive use of nitrogen fertilizers and imbalanced use of fertilizers have resulted in yield stagnation and deterioration of soil health and poor quality of the vegetable produce. Proper and regular application of farm organic wastes and bio-inoculants are of utmost importance in maintaining the fertility and productivity of agricultural soils (Yadav, 2010) [2]. Organic farming leads to reduction in total crop yield by 9.2 percent, but it provides higher net profits to the farmers by 22.0 percent as compared to conventional farming due the availability of premium prices (20-40%) for the certified organic produce and reduction in cost of cultivation by 11.7 percent (Ramesh *et al*. 2010) [2].

Every year, the demand and acceptance of organic farming is increasing at the rate of 2025 percent. In India, efforts are being made for organic farming of spices, tea, coffee, flowers and vegetables. In the world, organic farming is done in an area of 32.2 lakh hectare, in 141 countries. The certified area under this is 7.2 lakh hectare. In India, total area under organic farming by March, 2009 was 1.2 lakh hectare, out of which 51000 hectare is certified. A total of 7, 14,000 farmers are engaged in organic farming in India (Paul and Rameshwar, 2010) [4].

Biofertilizers help in improving biological activities of desirable microorganisms in the soil and also improve the crop yield and quality of produce. The microorganisms like Azotobacter are considered important not only for their nitrogen fixing efficiency, but also for their ability to produce antibacterial, antifungal compound and growth regulators. Likewise, some phosphate solubilizing microbes like PSB are found to be effective in improving phosphorous use efficiency. Moreover, traditional organic manures release the nutrients slowly, hence their effect is exhibited not only on the instant crop but it is also reflected on the performance of the other succeeding crops (Kumar and Srivastava, 2006). Therefore, the only way to produce high-quality fruits and seed without having a negative impact on the ecology and health of the soil is to employ organic manures and biofertilizers. Attempts have been made in the current studies to use organic manures and biofertilizers for tomato fruit and seed yield with the following general aims in mind:

Material and Method

Present investigation entitled "Effect of organic manures and biofertilizers on plant growth, yield and quality traits of Tomato (*Solanum lycopersicum* Mill.)" var. Pusa Ruby" was conducted during the *Rabi* season of 2022 - 23 at Agriculture Research Farm, Rama university, Mandhana, Kanpur. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments *viz.* T_1 = Control, T_2 =FYM Poultry manure @ 8 t/ha, T_3 =Vermicompost @ 8 t/ha, T_4 = Neemmanure @ 5 t/ha T_5 = Biovita Granules @ 20 kg/ha, T_6 = Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha, T_7 =FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter*) @ 5 kg/ha, T_8=Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha and T_9 =Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha. The crop was raised at spacing of 90 X 30 cm and plot size of 3.6 X 2.4 m. Standard culture practices recommended for cauliflower was followed uniformly in all experimental plots. Experimental data was subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984).

Table 1: Growth and yield parameters

Treatments	Growth Parameters					Yield Parameters			
	Plant Height	Number of leaves	Leaf Area Index	Canopy	Branch Length	Days taken to first flower	Number of Branche's per plant	Number of flowers	Number of fruit plant
T_1 =Control	138.30	73.10	0.650	0.114	42.520	45.8	11.68	20.28	10.30
T_2 =FYM Poultry manure @ 8 t/ha	141.40	76.70	0.690	0.145	44.310	44.5	13.44	22.54	12.60
T_3 =Vermicompost @ 8 t/ha	143.20	80.40	0.740	0.155	45.470	44.0	13.45	23.05	13.30
T_4 = Neemmanure @ 5 t/ha	145.40	83.40	0.790	0.166	46.540	43.7	14.33	24.73	15.06
T_5 = Biovita Granules @ 20 kg/ha	147.80	86.40	0.830	0.187	47.630	43.2	15.45	25.55	16.60
T_6 = Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha	156.40	98.50	0.960	0.243	52.410	40.4	18.49	32.29	20.60
T_7 =FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha	153.60	95.60	0.910	0.226	51.260	41.2	18.01	30.51	20.06
T_8=Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha	151.50	92.30	0.880	0.205	50.020	41.6	17.83	29.93	18.60
T_9 = Neemmanure @ 5 t/ha + Biofertilizers (KSB) @ 5 kg/ha	149.20	90.40	0.850	0.196	48.850	42.3	16.55	27.25	17.30
CV %	1.34	2.321	0.007	0.127	1.875	1.223	0.217	0.246	0.332
C.D.	5.717	4.211	0.021	0.008	1.562	2.345	0.458	0.744	0.681

Table 1: Fruit and yield diameter weight

	Fruit Diameter	Fruit Weight	Yield per plot	Yield per hectare	TSS	Ascorbic Acid	Reducing Sugar	Total Sugar	B:C Ratio
Control	3.20	50.10	22.78		4.200	14.940	1.810	7	1.58
T1 =Control	3.90	52.30	24.29		4.600	16.150	1.860	3.320	1.86
T2 =FYM Poultry manure @ 8 t/ha	4.40	54.60	25.15		4.800	17.320	1.920	3.570	2.05
T3 =Vermicompost @ 8 t/ha	4.90	57.80	26.63		5.000	18.460	1.980	3.650	2.16
T4 = Neemmanure @ 5 t/ha	5.70	59.40	27.35		5.200	19.630	2.010	3.740	2.32
T5 = Biovita Granules @ 20 kg/ha	7.30	68.80	32.49		6.00	22.00	2.540	4.260	3.00
T6 = Biofertilizers (*Azotobacter* + PSB	7.02	66.50	31.41		6.200	22. 620	2.480	4.120	3.15

+ KSB) each @5 kg/ha									
T7 =FYM Poultry manure @ 8 t/ha + Biofertilizers(*Azotobacter*) @ 5 kg/ha	6.70	64.20	31.03		6.000	21.740	2.320	4.050	2.74
T8=Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5kg/ha	6.10	62.40	28.75		5.600	20.880	2.190	3.840	2.51
CV%	0.099	0.709	0.193		0.085	0.310	0.028	0.045	1.58
C.D.	0.300	2.144	0.584		0.256	0.938			1.86

Result

The plant height was ranges from 138.30 cm to 156.40 cm. The maximum plant height was recorded in the treatment T_6 {Biofertilizers (*Azotobacter*+PSB+KSB) each @5 kg/ha} and followed by the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha} and T_8 {Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha} and minimum plant height (138.30 cm) was recorded in the treatment T_1 (control).

The maximum number of leaves per plant i.e. 98.5 recorded in T_6 {Biofertilizers *Azotobacter* + PSB + KSB) each @ 5 kg/ha} were significantly higher over all but followed by T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter*) @ 5 kg/ha} and T_8 {Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha}. Lowest no of leaves i.e. 73.1 were recorded in the treatment T_1 (control).

The significantly higher leaf area index was recorded i.e. 0.96 in the treatment T_6 followed by the 0.91 and 0.88 which is present in the treatment T_7 and treatment T_8. The lowest leaf area index in noticed i.e. 0.65 in the treatment control.

The maximum canopy m^{-2} was recoded i.e 0.243 m^{-2} in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followd by 0.226 m^{-2} in the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha. The minimum canopy was found in the treatment T_1 (control) followed by 0.145 m^{-2} in the treatment T_2 {FYM Poultry manure @ 8 t/ha}.

The maximum branch length was recoded i.e 52.41 cm in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followd by 51.26 cm in the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha. The minimum length of branch (42.52 cm) was found in the treatment T1 (control) followed by 44.31 cm in the treatment T_2 {FYM Poultry manure @ 8 t/ha}.

The range of first flower appearance was noticed from the 40.4th day to 45.8th day in different treatment. The earliest flower appear in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followed by the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha}and T_8 {Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha}. The last flower appearance was noticed in the treatment T_1 followed by the treatment T_2 {FYM Poultry manure @ 8 t/ha} and T_3 {Vermicompost @ 8 t/ha.

The growth of branches in plants found significant because of proper availability of nutrients in available form. The maximum no. of branches i.e 18.49 was found in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} which is significant over all treatment followed by (18.01) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha}. The minimum no. of branches i.e 11.68 was recorded in the treatment T_1 (control).

The maximum no. of flower i.e 32.29 was found in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} which is significant over all treatment followed by (30.51) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha}. The minimum no. of flower i.e 20.28 was recorded in the treatment T_1 (control) followed by (22.54) the treatment T_2 {FYM Poultry manure @ 8 t/ha}.

The maximum no. of fruits (20.60) were found in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha}which is significant over all treatment followed by (20.06) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha} and treatment T_8 {Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha}. The minimum no. of fruits i.e 10.30 were recorded in the treatment T_1 (control) followed by (12.60) the treatment T_2 {FYM Poultry manure @ 8 t/ha} and treatment T_3 {Vermicompost @ 8 t/ha}.

The maximum diameter of fruit (7.3 cm) was found in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followed by (7.02 cm) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha}.The minimum diameter of fruit i.e 3.2 cm was recorded in the treatment T_1 (control).The maximum fruit weight of 68.68g. was found in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followed by (66.50 g) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha}.The minimum fruit weight of 50.10 g was recorded in the treatment T1 (control).

The maximum yield per plot (32.49 kg) was found in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followed by (31.41 kg.) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha} and (31.03 kg) treatment T_8 {Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha}. The least fruit yield per plot i.e 22.78 kg. was recorded in the treatment T_1 (control) followed by (24.29 kg.) the treatment T_2 {FYM Poultry manure @ 8 t/ha} and treatment T_3 {Vermicompost @ 8 t/ha}.

The maximum TSS in fruit (6.6 ° Brix) was found in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followed by (6.2° Brix) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha}.The lowest TSS in fruit i.e 4.2° Brix was recorded in the treatment T_1 (control).

The highest ascorbic acid in fruit (22.68 mg) was recorded in the in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followed by (22.12 mg) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha} and treatment T_8 {Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha}.The lowest ascorbic acid in fruit (14.94 mg) was recorded in the treatment T_1 (control) followed by (16.15 mg) the treatment T_2 {FYM Poultry manure @ 8 t/ha} and treatment T_3 {Vermicompost @ 8 t/ha}.

The maximum reducing sugar in fruit (2.54%) was found in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followed by the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5

kg/ha}.The least reducing sugar in fruit i.e 1.81% was recorded in the treatment T_1 (control).
The highest total sugar in fruit (4.26%) was recorded in the in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha} followed by (4.12%) the treatment T_7 {FYM Poultry manure @ 8 t/ha + Biofertilizers (*Azotobacter)* @ 5 kg/ha} and treatment T_8 {Vermicompost @ 8 t/ha + Biofertilizers (PSB) @ 5 kg/ha}.The lowest total sugar 3.04% in fruit was recorded in the treatment T_1 (control) followed by 3.30% and 3.57% which is present in the treatment T_2 {FYM Poultry manure @ 8 t/ha} and treatment T_3{Vermicompost @ 8 t/ha} respectively.
The highest gross return (379995 Rs.), net return (259361 Rs.) and cost benefit ratio (3.15) were recorded in the treatment T_6 {Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha}. Whereas lowest gross return (167574 Rs.), net return (61514 Rs.) and cost benefit ratio (1.58) were recorded in the control treatment.

Conclusion

The experiment entitled "Effect of organic manures and biofertilizers on plant growth)", yield and quality traits of Tomato (Solanum lycopersicum Mill.) var. Pusa Ruby". was conducted on Agricultural Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur during the *Rabi* season of 2022-23. It was finally observed that the treatment combination ({Biofertilizers (*Azotobacter* + PSB + KSB) each @ 5 kg/ha}) consisted biofertilizers that increases the growth in term of plant height, no. of branches, branch length, no of branches, no. of flower per plant, leaf area, canopy, quality production in terms of number of fruits per plant, yield per plot, TSS, ascorbic acid, reducing sugar, total sugar. The profit of the cultivation of control treatment had non-significant result because there is no organic manures and biofertilizers are used.
The continuous use of fetilizers reduces the soil capacity for long terms but use of organic manure and biofertilizers helps in improving the soil texture, soil structure, water holding capacity and health of soil and human as well.

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