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Influence of Integrated Nutrient Management on Soil Fertility, Yield and Quality of Tomato (*Lycopersicon esculentum*)

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ABSTRACT

A field experiment was conducted at the Central Research Farm (Gayeshpur), Bidhan Chandra Krishi Viswavidyalaya, West Bengal during *rabi* season of 2017-18 and 2018-19 to find out the influence of integrated nutrient management on soil fertility and crop yield and quality parameters of tomato with various sources of nutrient. The experiment was carried out under the scope of soil test crop response based fertilizer recommendation for tomato constituting nine treatments involving FYM, vermicompost and biofertilizers (Azotobacter and PSB), and their combinations. It was found that the application of 50 % Soil Test Crop Response (STCR) recommended dose of chemical fertilizer + 4 t ha^{-1} vermicompost + 10 t ha^{-1} FYM + 5 kg ha^{-1} biofertilizer (T_9) treatment rendered highest yield and quality of tomato and improved soil fertility. Treatment combination of 75% STCR recommended dose of NPK with FYM and 100% STCR recommended dose of NPK were found to be the most profitable. However, the treatment combination 50 % STCR recommended dose of chemical fertilizer + 4 t ha^{-1} vermicompost + 10 t ha^{-1} FYM + 5 kg ha^{-1} biofertilizer also manifested higher benefit cost ratio.

Key words : Tomato, Integrated nutrient management, Soil fertility, Economic feasibility.

Introduction

Tomato occupies a prime position in the list of protective foods since it consists of vitamins, minerals and antioxidants which are essential for human health (Kallo, 1993). India ranks 2nd both in the area and production of tomato worldwide after China (Gupta *et al.*, 2021). Despite its high production in India, average productivity level remains low as compared to other tomato producing countries. The majority of tomato growers do not produce good quality fruit at high yield due to lack of knowledge regarding the improved production technologies including the use of proper inorganic and organic fertilizers (FAO, 2003). Tomato is heavy yielder hence requires adequate fertilizers for growth and high yield. Farmers use imbalance and injudiciously inorganic fertilizers and pesticides in order to harvest good yield. The continuous use of chemical fertilizers increases heavy metal concentration in soil and may have adverse effect on soil health

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and its fertility. Integrated nutrient management (INM) is a holistic approach that considers all the available farm resources that can be used as plant nutrients. The main principle of integrated nutrient management is to maximize the use of organic inputs while minimizing nutrient losses and to make supplementary use of chemical fertilizers. By keeping this point in view, an attempt has been made to investigate the level of substitution of inorganic fertilizers with organic manures and biofertilizers for maximizing tomato production maintaining the quality and good soil health in an integrated nutrient management system.

Materials and methods

The field experiment was carried out at under AICRP on STCR at Central Research Farm (Gayeshpur), Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia during *rabi* season of 2017-18 and 2018-19. The soil of the experimental site was sandy clay loam in texture having pH 7.01, 6.42 g kg^{-1} organic carbon, 312 kg ha^{-1} available N, 35 kg ha^{-1} available P and 188 kg ha^{-1} available K. The experiment was laid out in a randomized block design with nine treatments replicated thrice. The details of experiment are given in Table 1. One month-old tomato seedlings (var. Amlic) were transplanted at 90 × 60 cm spacing. The plot size was 5m × 5 m. Cultural activities with irrigation were done whenever required. Fertilizer dose (NPK) was applied based on Target Yield Model generated from AICRP-Soil Test Crop Response, BCKV based on target yield 55 t ha^{-1}. Half dose of nitrogen and full dose of phosphorus with potassium were applied as basal dose. The rest amount of nitrogen was applied in two split doses after transplantation in the main field. Biofertilizer (Azotobacter and PSB) were thoroughly mixed in soil before transplanting and FYM and vermicompost were incorporated in the field at the time of field preparation as per treatments. Data obtained from tomato crops for two consecutive years were pooled and statistically analyzed as procedure given by Gomez and Gomez (1984).

Table 1. Details of the treatments

Treatment	Details
T_1	STCR recommended dose (NPK 156:28:51)
T_2	Vermicompost (15 t ha^{-1})
T_3	FYM (40 t ha^{-1})
T_4	75%T_1+Vermicompost (4 t ha^{-1})
T_5	75%T_1+FYM (10 t ha^{-1})
T_6	50%T_1+Vermicompost (8 t ha^{-1})+Biofertilizer (PSB + Azotobacter) (5 kg ha^{-1})
T_7	50%T_1+FYM (20 t ha^{-1})+Biofertilizer (5 kg ha^{-1})
T_8	Vermicompost (8 t ha^{-1}) + FYM (20 t ha^{-1}) + Biofertilizer (5 kg ha^{-1})
T_9	50% T_1 + Vermicompost (4 t ha^{-1}) + FYM (10 t ha^{-1}) + Biofertilizer (5 kg ha^{-1})

Nutrient uptake by tomato as well as the soil analysis was performed by the standard methodology as outlined in Tandon, 2005.

The quality parameters of tomato namely, vitamin A, vitamin C, lycopene and phenol content were determined by using the standard methodology as outlined by Kumar *et al.* (2017), Adebisi *et al.* (2014). AOAC (1980) and Plaza *et al.*2023.

Results and discussions

Yield of tomato

Yield of tomato was significantly affected by addition of organic and inorganic fertilizers and it varies from 35.87 to 55.60 t ha^{-1},with a mean value of 49.33 t ha^{-1} (Fig. 1). Highest yield (55.60 t ha^{-1}) was observed in T_5 (integration of FYM with 75% STCR recommended dose of NPK fertilizer), which was statistically at par with other integrated treatment of organics with chemical fertilizer (T_4, T_6, T_7 and T_9) as well as the treatment with sole inorganic fertilizer (T_1). Bahadur *et al.* (2004) also reported that application of organic manures combined with recommended dose of inorganic fertilizers showed superior performance in yield attributing characters in tomato. This might be due to the availability of higher amount of nutrients to plant from the soil and thereby higher uptake of the essential nutrients by plant.

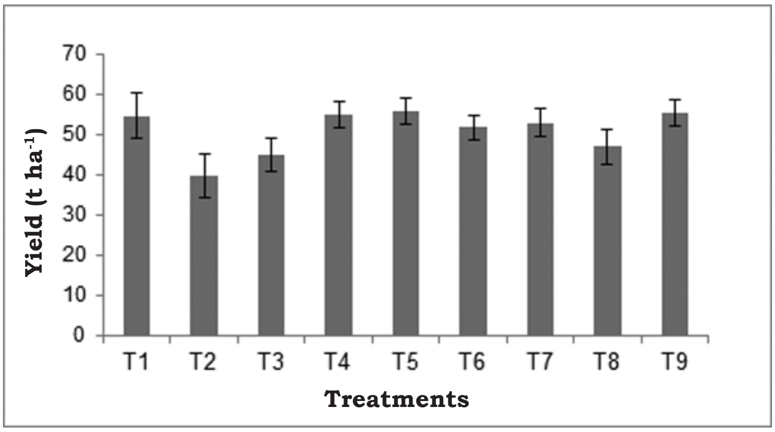

Fig. 1 : Effect of integrated nutrient management on Tomato yield

Uptake of major and micro nutrients by Tomato

The total uptake of N, P and K by tomato (Table 2) was found maximum in the treatment receiving combination of all organics along with 50% of STCR recommended dose of chemical fertilizer (T_9) and was 12.73, 38.96 and 12.36 per cent higher than T_1 respectively. It may be inferred that, when organics are applied along with inorganic fertilizers to soil, complex nitrogenous compounds slowly break down and make steady N supply throughout the growth period of crop, which might have attributed to more availability and its subsequent uptake by the crop. The increase in P and K uptake with application of FYM, vermicompost, and biofertilizers along with inorganic fertilizers may be attributed to better availability of the nutrients in rhizosphere (Hangarge *et al.*, 2002). The lower nutrient uptake from solely organics treated plots showed incapability of organic manures to supply nutrients when applied alone.

From the results (Table 2), the highest uptake of Zn, Cu, Fe and Mn was recorded (22.91, 24.68, 10.14 and 15.18 per cent higher than T_1, respectively) in the treatment (T_9) that received a combination of all organics along with 50 % STCR recommended dose of NPK fertilizer. Microbial decomposition of organic manures with simultaneous release of organic acids might have favored the availability of micronutrients in soil and their uptake by tomato crop. Integration of organic and inorganic fertilizers results in more uptake of nutrients as compared to sole use of organic or inorganic ones and control.

Table 2 : Effect of integrated nutrient management on uptake of major and micro nutrients by Tomato

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})
T_1	142.02	13.40	133.24	288.9	21.17	653.6	67.35
T_2	98.22	11.64	97.83	242.3	17.94	508.7	55.56
T_3	110.03	12.07	109.72	283.2	20.46	583.9	63.00
T_4	154.44	16.81	145.86	301.8	23.51	683.5	76.80
T_5	154.92	17.05	145.03	307.2	23.24	684.4	75.60
T_6	140.55	16.73	137.69	319.0	22.81	659.1	71.81
T_7	142.09	16.48	133.56	324.8	22.86	675.5	73.41
T_8	122.73	14.51	124.24	302.1	22.73	611.8	67.16
T_9	160.10	18.62	149.69	355.1	26.39	720.0	77.57
Mean	136.12	15.26	130.76	302.7	22.35	642.3	69.81
SEm (±)	4.96	0.55	4.82	9.61	0.55	10.02	1.06
CD (0.05)	14.88	1.64	14.44	28.81	1.66	30.04	3.18

Quality parameters of Tomato

Tomatoes are a very good source of antioxidants, vitamins C carotenoids (lycopene and â-carotene) and phenolic compounds. The nutritional aspects like vitamin A, vitamin C, lycopene and phenol content (presented in Table 3) were found highest in treatment T_8 i.e., combined treatment of all the organics. Organically grown fruits and vegetables have high levels of vitamin C and antioxidant activity than conventional grown products (Kumar *et al.*, 2017). However, crude protein content was found highest (13.16% higher than T_1 treatment) under the integrated treatment of all organics and chemical fertilizer (T_9).

Table 3 : Effect of integrated nutrient management on quality parameter of tomato

Treatment	Vitamin A (IU)	Vitamin C (mg 100g^{-1})	Lycopene (mg 100 g^{-1})	Phenol (mg GA 100 g^{-1})	Crude protein (%)
T_1	0.113	21.28	2.059	108.9	21.46
T_2	0.149	42.55	3.073	127.1	20.43
T_3	0.155	41.13	2.808	125.2	20.03
T_4	0.125	22.70	2.246	112.8	24.02
T_5	0.128	26.95	2.246	114.0	23.56
T_6	0.140	35.46	2.683	118.2	22.59
T_7	0.144	32.62	2.496	121.7	22.10
T_8	0.158	45.39	3.151	132.6	21.26
T_9	0.155	41.13	2.995	128.7	24.28
Mean	0.141	34.36	2.640	121.0	22.19
SEm (±)	0.008	3.61	0.145	1.99	0.684
CD (0.05)	0.023	10.83	0.434	5.97	2.05

Availability of major nutrients in soils of Tomato

The available N, P and K content of the post-harvest soil of tomato (Table 4) was found highest under integrated treatment of FYM, vermicompost and biofertilizer with 50% STCR recommended dose of NPK in T_9 (20.54, 42.02 and 18.64 % higher than T_1 i.e., sole application of inorganic fertilizer, respectively). The increase in available nitrogen might be attributed to the greater multiplication of soil microbes by application of nitrogen through nitrogenous fertilizers along with organics. Vermicompost, FYM and biofertilizer in combination with 50% STCR recommended dose of NPK might have helped in the solubilization of fixed P to soluble form making it easily available to the plant. The maximum oxidizable organic C content in post-harvest soil was recorded under treatment T_3 i.e. sole application of FYM (25.45 % higher than T_1) which is statistically at par with treatment T_8 and T_9. Kumar *et al.* (2000) reported that the application of organic manure in conjunction with recommended dose of fertilizers helped to build up the soil organic carbon as compared to control.

Effect of integrated nutrient management on available micronutrients in soils of Tomato

The availability of micronutrient (Zn, Cu and Fe) content in the post-harvest soil of tomato (Table 5) was noted in treatment T_8 i.e., combined treatment of all the organics which was statistically at par with T_9 (integrated treatment of all organics and chemical fertilizer). This sustained the findings of earlier worker (Vidyavathi *et al.*, 2012) who pointed out a significant effect of organic manures in improving the available soil micronutrients at all rates.

Table 4 : Effect of integrated nutrient management on availability of major nutrient and oxidizable organic carbon in post-harvest soil of tomato:

Treatment	Available N(kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Oxidizable organic carbon (g kg^{-1})
T_1	274.4	28.75	111.0	6.16
T_2	317.9	36.05	118.8	7.16
T_3	320.6	36.33	111.5	7.72
T_4	298.5	37.83	120.8	6.54
T_5	294.8	35.86	120.7	6.83
T_6	327.1	39.79	131.3	6.76
T_7	323.4	39.04	123.5	7.24
T_8	322.5	38.86	124.7	7.64
T_9	330.8	40.82	131.6	7.41
Mean	312.2	37.04	121.5	7.05
SEm (±)	6.17	1.70	4.56	0.11
CD (0.05)	18.50	5.09	13.68	0.33

Table 5 : Effect of integrated nutrient management on availability of micronutrient in soils of Tomato

Treatment	Available Zn (mg kg^{-1})	Available Cu (mg kg^{-1})	Available Fe (mg kg^{-1})	Available Mn (mg kg^{-1})
T_1	0.667	1.99	6.11	7.88
T_2	1.126	2.81	6.84	8.17
T_3	1.157	3.19	6.90	7.87
T_4	1.087	2.21	6.23	8.05
T_5	1.131	2.86	6.46	7.88
T_6	1.111	2.25	6.77	8.18
T_7	1.149	2.87	6.57	7.79
T_8	1.177	3.38	7.03	8.16
T_9	1.143	3.28	6.99	8.18
Mean	1.083	2.76	6.65	8.02
SEm (±)	0.08	0.082	0.077	0.105
CD (0.05)	0.242	0.246	0.232	NS

Economic feasibility of Tomato production

The regional adaptability of any cultivation practices in the yield of any crop is completely based on the economic value of a treatment. Perusal of the data (Table 6) revealed that the highest net return (340516 Rs. ha^{-1}) were obtained with treatment T_5 (75%T_1+FYM 10 t ha^{-1}) followed by treatment $T_1$and T_4. Highest benefit cost ratio of 2.58 was obtained from both the treatments T_5 and T_1 followed by T_4. The treatments with sole organic sources of nutrients are found to be the least profitable. Despite of their high cost, integrated treatment of inorganic fertilizer with a few organic sources are still profitable due to higher yield of tomato. Thus, substituting 25% dose of NPK by any one of the organics or 50% dose by combination of all the organics is advantageous. This sustained the finding of Singh *et al.* (2016) where high benefit cost ratio was found in the integrated treatments of inorganic fertilizers with organic source of fertilizers.

Table 6 : Effect of integrated nutrient management on benefit: cost ratio of tomato production

Treatment	Cost of Cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B : C Ratio
T_1	212016	546000	333984	2.58
T_2	248212	395067	146855	1.59
T_3	217712	448000	230288	2.06
T_4	223084	549333	326249	2.46
T_5	215484	556000	340516	2.58
T_6	235636	516667	281031	2.19
T_7	219212	528667	309455	2.41
T_8	242904	468000	223096	1.93
T_9	236476	552000	314524	2.33

Conclusion

On the basis of the present study, it can be concluded that the application of T_9 (50 % STCR recommended dose of chemical fertilizer + 4 t ha^{-1} vermicompost + 10 t ha^{-1} FYM + 5 kg ha^{-1} biofertilizer) treatment appeared to be the best for achieving the higher yield and nutritional value of fruit by maintaining the benefit cost ratio and improving the nutrient status of soil.

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