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Production of Tomato (*Solanum lycopersicum* L.) in Different Nutrient Regime

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Abstract

A field level investigation was during the month of November, 2021–22 to observe integrated effect of different nutrient sources on growth, yield, quality and economics of tomato. The field work was conducted in Randomized Block Design consisting of eight different nutrient combinations like-Treatment-1: (control), Treatment-2: (100% Recommended Dose of Fertilizer), Treatment-3: [100% Recommended Dose of Fertilizer+15 t Farm yard manure-ha], Treatment-4 [75% Recommended Dose of Fertilizer+7.5 t ha^{-1} Farm Yard Manure+Biofertilizer (Phosphate Solubilizing Bacteria+Azotobacter)], Treatment-5 [75% Recommended Dose of Fertilizer+4 t ha^{-1} vermicompost+Biofertilizers (Phosphate Solubilizing Bacteria+Azotobacter), Treatment-6 [75% Recommended Dose of Fertilizer+2 t ha^{-1} vermicompost+Biofertilzers (Phosphate Solubilizing Bacteria+Azotobacter)], Treatment-7 [75% Recommended Dose of Fertilizer+0.5 t ha^{-1} Neem cake+Biofertilizers (Phosphate Solubilizing Bacteria+Azotobacter)], Treatment-8[75% Recommended Dose of Fertilizer+2 t ha^{-1} Mustardcake+Biofertilizers (Phosphate Solubilizing Bacteria+Azotobacter)]. Combined application of 75% Recommended Dose of Fertilizer+2 t ha^{-1} vermicompost+Biofertilzers (Phosphate Solubilizing Bacteria+Azotobacter) recorded significantly maximum values for the vegetative parameters. This treatment also recorded maximum values for number of fruits $plant^{-1}$ (45.89), fruit weight (35.62 g), yield $plot^{-1}$ (40 kg) and yield ha^{-1} (70.08 t) and benefit:cost ratio (2.8). Maximum TSS (4.8°Brix), ascorbic acid (24.05 mg 100 g^{-1}) and lycopene content (4.69 mg 100 g^{-1}) were noticed with 75% Recommended Dose of Fertilizer+4 t ha^{-1} vermicompost+Biofertilizers (Phosphate Solubilizing Bacteria+Azotobacter). Experiment data showed that combination of 2t ha^{-1} of vermicompost and mixture of phosphate solubilizing bacteria, Azotobacter along with 75% of recommended dose of fertilizer was proved as beneficial for sustainable production of tomato in new alluvial plains of West Bengal.

Keywords: Economics, growth, integrated, nutrient, quality, sustainable, tomato, yield

1. Introduction

Tomato is considered as "Protective Food", and generates income for poor farmers (Parmar et al., 2019). Tomato is packed with various health promoting substances like minerals, vitamins, proteins and essential amino acids (Ali et al., 2021). Lycopene and β-carotene are two important carotenoids found in tomatoes and both have been suggested to confer the anticancer properties of the fruit (Collins et al., 2022). India produced 191.769 million tons vegetable crops from the area of 10.35 million hectare with the productivity of 18.52 tonnes ha^{-1}. Whereas Tomato rank second in terms of acreage and production in the world with a coverage of 81.20 million hectare and total production of 20.57 million tons (Anonymous, 2020). Tomato is an exhaustive crop and mines adequate amount nitrogen from soil throughout growth period. Application of Synthetic fertilizers yields negative influence upon soil and environment as they produce hazardous by products and toxic gases such as CO_2, CH_4, and NH_4, etc. (Ramesh et al., 2023). Integrated use of fertilisers with organic manures can be environmentally safe, economically sound, socially reasonable, and ecologically sustainable (Midya et al., 2021). The escalating price of fertilizers with poor purchasing capacity of Indian farmers and their negative effect on soil health has led to use of bio-fertilizers and organic matter along with site specific and foliar application of inorganic fertilizers (Lather et al., 2021). Tomato is a heavy feeder crop and for production of flowers, fruitlets, and accumulation of sugars, organic acids, vitamins, pigments and anti-oxidants it requires large quantities of chemical fertilizers. On the other hand application of fertilizers, pesticides and herbicides plays fetches very high productivity per unit area, but their excess use can lead to environment pollution (Ramesh et al., 2023). Integrated nutrient management practice is mainly concerned towards the protection of soil productivity and to provide essential nutrients to for sustainable crop production through optimization of the benefits from all probable sources of organic, inorganic and biological ingredients in an integrated way (Saini et al., 2023). High yield potential tomato hybrids put tremendous pressure on soil for removal of nutrients. These nutrients are specific in function and must be supplied to the plant at the right time and in the right quantity (Singh et al., 2023). Combined application of inorganics and organics lead to better plant growth or yield with minimum damage on soil or less pollution (Rani and Tripura, 2021). Application of only organic sources of nutrients cannot bring remarkable increase in crop yields due to their low nutrient status. Therefore, for sustainable production, integrated use of organic and inorganic sources of nutrients needs to be adopted (Kumar et al., 2023).

Considering the present situation integrated use of organic and inorganic fertilizers to replace the portion of chemical fertilizers with organic manures is becoming a very promising practice for maintaining higher productivity and also for greater crop production stability (Sharma et al., 2022). The soil Gangetic plains of West Bengal is mainly characterized by sandy loam coupled with low organic matter. In these areas tomato hybrids are cultivated inorganically under open condition. Since tomato hybrids needs higher amount of nutrients, judicious application of nutrients is a key for maximum bumper production of and better quality fruits. Therefore, the present field programme was taken up to observe the combined effect of primary nutrients and biofertilizers on yield and quality of tomato.

2. Materials and Methods

The field work was carried out at C Block Farm. Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during autumn-winter months (November) months of 2021-2022 to enumerate the combined effect of different nutrient sources coupled with biofertilizers (PSB, Azotobacter) on tomato cultivar NS-292. The trial farm was located at 23.50N latitude and 800 E. Longitude with average altitude of 9.75 m above the MSL and the soil is sandy loam and slightly acidic. The experiment was laid out in Randomized Block Design comprising 3 replications and 8 treatments *viz.* T_1 Control; T_2 100% RDF [Nitrogen@120kg ha^{-1+}phosphorus 60@kg ha^{-1+}potassium@60kg ha^{-1}]; T_3 100% RDF+15t FYM ha^{-1}; T_4 75% RDF+7.5t FYM ha^{-1}+biofertilizers (PSB+Azotobacter); T_5 75% RDF+4t vermicompost ha^{-1}+biofertilizers (PSB+Azotobacter); T_6 75% RDF+2 t vermicompost ha^{-1}+biofertilizers (PSB+Azotobacter); T_7 75% RDF+0.5 t Neem Cake ha^{-1}+biofertilizers (PSB+Azotobacter) ; T_8 75% RDF+2t Mustard Cake ha^{-1}+biofertilizers (PSB+Azotobacter). Five weeks old healthy tomato seedlings were transplanted on raised bed of 3×2.5 m^2 size spaced at 60×50 cm^2. The crop received half of the recommended dose of nitrogen, full dose of phosphorus and potash as basal and remaining dose of N was top dressed 30 days after transplanting. Biofertilizer was added at the time of transplanting. The soil of the trial site was sandy loam and slightly acidic in nature. Data were analyzed by the methods out lined by Panse and Sukhatme (1967) and the significance was tested by referring to the values of F table proposed by Fisher and Yates (1967).Five randomly selected plants were tagged in each plot for recording growth, yield and quality parameters and the mean of the observations on these five plants was computed and recorded. Data on Growth parameters like plant height, No of leaves plant^{-1}, Number of branches plant^{-1}, Days to 50% flowering and for yield parameters data on Weight of fruit, Yield plot^{-1}, Total yield were recorded. biochemical parameters like Total soluble solids (TSS) by digital refractometer (0 to 32°Brix) and lycoene and ascorbic acid content of ripe tomato fruits were also estimated after following the procedure of Ranganna (1986). Economics of tomato production by use of various sources of organic and inorganic nutrients was worked out by considering the present price of inputs and produce net returns and benefit cost ratios were worked out for each nutrient treatment.

3. Results and Discussion

3.1. Growth parameters

Data presented in Table 1 showed that vegetative parameters of tomato showed significant variations for different treatment combinations. Soil application of vermicompost @ 2 t ha^{-1} coupled with 75% recommended dose of fertilizer and biofertilizer (PSB+Azotobacter) recorded significantly maximum plant height (82.23 cm) in T_6 over all the treatments

Table 1: Effect of integrated nutrient management on growth and yield parameters of tomato

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Days to 50% flowering
T_1	55.37	3.97	30.27	54.66
T_2	57.43	5.7	37.87	52.33
T_3	62.77	5.83	54.93	50.11
T_4	63.07	6.8	55.73	48.99
T_5	73.67	7.43	61.97	47.55
T_6	84.23	9.1	65.07	45.33
T_7	69.27	6.93	61.47	47.00
T_8	67.83	6.87	56.47	48.66
SEm±	3.90	0.71	2.73	0.24
CD (p=0.05)	11.94	2.17	8.28	0.75

under study except with T_5 and recorded 73.67 cm tall plant. Higher value plant height as in case of T6 probably due to effective utilization of applied nutrient elements with the combined action of inorganic nutrient and organic components like vermicompost and biofertilizer and which enhanced the physiological processes of tomato plant like photosynthesis, nitrogen metabolism and hormonal balance in the plant and finally enhanced cell elongation for taller plants. Significantly minimum plant height (55.37 cm) was recorded in T_1 (Control). Mohit et al. (2019) also observed the same results in tomato. Number of primary branches plant^{-1} of tomato also varied greatly for the same set of nutrient application. Significantly maximum number of branches plant^{-1} (9.1) was obtained in T_6 over all the treatments except the treatments T_5 and T_7 where it was statistically at par and recorded the values of (7.43) and (6.93) respectively. Significantly minimum number of branches plant^{-1} (3.97) was recorded in T_1. Application of organic manure such as vermicompost triggered the photosynthetic activity, chlorophyll synthesis, nitrogen metabolism and auxin contents in the plant and also, led to increase in the number of branches. This result was in conformity with the findings of Chatterjee et al. (2014) in tomato. Data pertaining to number of leaves plant^{-1} (Table 1) exhibited same trend as like of other parameters here also the treatment T_6 recorded significantly maximum number of leaves plant^{-1} (65.07) over other treatments except with T_5 and T_7 where it was statistically at par. Highest value for leaf number plant^{-1} might be due to combined effect of organic and inorganic sources of nutrients which increased the synthesis of metabolically active enzymes vis a vis production and translocation of the metabolites to the sink. Due to readily available form of nitrogen, which is the main constituents of chlorophyll, protein, and amino acids, results in increasing the cell division, protein synthesis and metabolites transport that helps to build up plant tissues, resulting increased number of leaves plant^{-1}.

3.2. Yield parameters

Data pertaining to days to 50% flowering (Table 1) varied significantly due to different treatment variations. The treatment T_6 took minimum days for 50% flowering (45.33) and was statistically significant over the other treatments. Whereas the maximum days to 50% flowering (54.66) was recorded in the T_1 (control). The earliness of flowering might be due to the reason of attributed to termination of early vegetative growth and partitioning of ample amount of reserved food materials for flower bud differentiation, but the late flowering for application of inorganic fertilizer and control plots probably due to extended vegetative phase of the plant by ready mineralization of inorganic nitrogen (Mohit et al. 2018). Tomato fruits weight is a key parameter for overall yield potential of the crop. Fruit weight has strong correlation with plot yield and depicts that heavier fruit is can determine and maximize tomato yield unit^{-1} area. In the present study treatment T_6 (75% RDF+2 t ha^{-1} vermicompost+PSB+Azotobacter) recorded significantly heaviest fruit (34.86 g) than all other nutrient doses except treatment T_5 (32.99 g) where it was *at par*. Closely higher values for the same was also obtained in the followed by in the treatments like T_7 (31.34 g), T_8 (29.76 g) and T_4 (28.19 g). The minimum value for individual fruit weight (20.00 g) was observed under T_1 (control). The increase in fruit weight might be due to fact that vermi compost along with inorganic fertilizer and biofertilizer have boosted up maximum availability of applied nutrients resulting higher accumulation of carbohydrates in flower heads coupled with increased fruit weight. The results are in accordance with the findings of Ramakrishnan and Selvakumar (2012) who found increased fruit weight with the application of biofertilizer compared to sole use of inorganic fertilizers. Data on number of fruits plant^{-1} presented in Table 2, clearly revealed that the treatment T_6 recorded significantly maximum number of fruits plant^{-1} (45.89) which was only statistically *at par* with T_5 (45.76) and T_7 (44.67). Application of biofertilizer and vermicompost produces considerable amount of biologically active substances like vitamins B, Nicotinic Acid, Pantothenic acid, biotin, heteroxins, gibberellins etc. which improves number of flowers plant^{-1} leading to more number of number of fruits plant^{-1}. Similar findings was observed by Singh et al. (2018) who recorded maximum number of fruit plant $^{-1}$ (38.1) of tomato with combined application of Azotobacter, VAM and recommended dose of fertilizers. The minimum number of fruits plant^{-1} (25.90) was obtained in control (T_1) plots. After perusal of yield data (Table 2) it was observed that significantly maximum yield of tomato plot^{-1} and ha^{-1} (40 kg and 64.17 t ha^{-1} respectively) was obtained in T_6. The minimum yield plot^{-1} and ha^{-1} (12.17 kg and 20.00 ton respectively) was recorded in control plot (T_1). Application of biofertilizers like PSB and Azotobacter increased the nutrient uptake capacity of plant and enhanced fruit yield. Organic components like vermi compost enriched with humic acid and humic substances which probably has improved the physical condition of the

Table 2: Effect of integrated nutrient management on yield parameters of tomato

Treatments	Single fruit weight (g)	No. of fruits plant^{-1}	Yield plot^{-1} (kg)	Yield ha^{-1} (t)
T_1	20.00	25.90	12.17	20.00
T_2	30.13	35.99	27.11	45.35
T_3	29.10	39.86	29.00	47.02
T_4	28.19	43.98	31.00	50.15
T_5	32.99	45.76	37.75	61.00
T_6	34.86	45.89	40.00	64.17
T_7	31.34	44.67	35.00	57.75
T_8	29.76	44.34	33.00	54.12
SEm±	0.56	0.46	0.75	0.62
CD (p=0.05)	1.72	1.42	2.31	1.91

soil through secretion of fulvic acid resulting better nitrogen mineralization and increasing the availability of the element throughout the growth period of the plant. This phenomenon ultimately increased photosynthetic activities with higher fruit yield. These findings were in conformity with the investigation of Chanda et al. (2011) in tomato.

3.3. Quality parameters

Data regarding quality parameters like TSS content of tomato fruit (Table 3) showed significant variations among the treatments under study. The treatment T_5 showed significantly maximum Total soluble solid (4.8°Brix) than all other treatments under study and followed by T_7 (4.7°Brix), T_3 (4.5°Brix) and T_6 (4.4°Brix). while the minimum total soluble solid (3.07°Brix) was obtained under the treatment T_1. The probable reason for increased TSS might be due to quick diversion of plant assimilates into growing fruits through combined response of organic inorganic sources of nutrients. Besides this phenomenon potassium nutrient also helps the conversion of starch molecules into simple sugars during ripening process by activating the sucrose synthetase enzyme, ultimate result in significance increase in TSS. Similar observation was also noticed by Mukesh et al. (2019) in tomato. Significantly maximum amount of ascorbic acid content (24.05 mg 100 g^{-1}) was observed T_5 over all other treatments. The lowest ascorbic acid content (17.76 mg 100 g^{-1}) was found in control (T_1) plots. Increase in ascorbic acid content might a case of application potassium which might have helped to slow down the enzymatic activity that catalyses the oxidation of ascorbic acid, thus helping the plants to gathere more vitamin C content in fruits. Higher values of ascorbic acid with combined application of organics and biofertilizer was also observed by Ibrahim and Fadni (2013) in tomato and by Jat et al. (2022) in capsicum.

Table 3: Effect of integrated nutrient management on quality parameters and economics of tomato

Treatments	TSS (°Brix)	Ascorbic Acid content (mg 100 g^{-1})	Lycopene content (mg 100 g^{-1})	Benefit: Cost ratio
T_1	3.07	17.76	2.45	1.6
T_2	4.07	17.90	2.49	1.7
T_3	4.50	18.20	2.55	1.0
T_4	4.10	24.05	2.61	1.8
T_5	4.87	22.47	4.69	1.9
T_6	4.40	19.89	2.73	2.8
T_7	4.70	19.89	4.50	1.6
T_8	4.43	19.03	2.81	1.4
SEm±	0.03	0.32	0.20	-
CD (p=0.05)	0.10	1.0	0.60	-

Data related to lycopene content (Table 3) revealed significant variation among the treatments. Maximum lycopene was noted in T_5 (4.69 mg 100 g^{-1}) which was significantly higher than all other treatments except T_7 which recorded a value of 4.5 mg 100 g^{-1}. Significantly lowest content of lycopene (2.45 mg 100 g^{-1}) was recorded in control plots (T_1). Siddaling et al. (2017) also reported that higher Lycopene content (6.51 mg 100 g^{-1}) of tomato with integrated application of 75% RDF, azotobacter and phosphorus solubilizing bacterium [PSB].

3.4. Economics of cultivation

After thorough perusal of data related to economics of cultivation (Table 3) it was found that maximum benefit: cost ratio (3.49) was observed in T_6 followed by T_5 (2.99). The treatment $T_1$was found least remunerative as recorded minimum (1.35) B:C ratio. Maximum and minimum yield of T_6 and T_1 plots recorded the maximum and least values of B:C ratio respectively. Mohit et al. (2019) also observed the similar result in tomato.

4. Conclusion

Soil application of 2 t of vermi compost ha^{-1} along with biofertilizer mixture (PSB+Azotobacter) and 75% recommended dose of fertilizer enhanced growth, yield, quality as well as the profitability of tomato. Replacement of 25% of recommended dose was possible when higher dose of organic amendments were applied all together.

5. Acknowledgement

Combined doses of 75% recommended dose of fertilizer along with 2 t of vermicompost ha^{-1} and biofertilizer (T_6) recorded significantly maximum values for the vegetative and yield and parameters and benefit:cost ratio. combination of 2 t ha^{-1} of vermicompost and mixture of PSB, Azotobacter along with 75% of recommended dose of fertilizer was proved as beneficial for sustainable production of tomato in new alluvial plains of West Bengal.

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