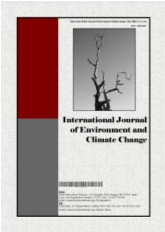

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Effect of Integrated Nutrient Management on the Growth, Yield and Quality in Tomato (*Solanum lycopersicum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out entitled Effect of integrated nutrient managment on the growth, yield and quality in tomato (*Solanum lycopersicum* L.) at the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during the Kharif-2021-22 with a view to determine the effect of integrated nutrient management on growth,yield and quality in tomato variety TMTH-2267 and to work out the economics of various treatments. Under this experiment, overall 10 treatment was laidout in a completely randomized block design (RBD) with three replications. From the present investigation it was concluded that T_1 (75% N through Urea +MOP + SSP + 25% through FYM + Boron + Azotobacter +PSB) was found to be best among all treatment in terms of yield and T6 (75% N through Urea+ MOP + SSP + 25% through Vermicompost + B + Zn + Azotobacter +PSB) in growth and quality of tomato i.e. plant spread, plant height, T.S.S. etc. The maximum net return of Rs. And maximum Cost:Benefit (B:C) ratio that is 3.25 was observed for T_6. Therefore, use of chemical fertilizers alongwith FYM, Boron, Azotobacter and PSB in crop production can enhance the yield and quality of crop especially in case of tomato.

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1. INTRODUCTION

Tomatoes are horticulture crop belongs to the family *Solanaceae* bearing chromosome number 2n=2X=24 [1]. It originated in South America [2]. The tomato plants typically grow to 1–3 meters (3–10 ft) in height and have a weak stem that often sprawls over the ground and vines over other plants. Flowers are generally borne in clusters of 4 to 8 but small fruited types may have 30 to 50 flowers per cluster. Tomato plants are dicots, and grow as a series of branching stems, with a terminal bud at the tip that does the actual growing. Tomato plays a major role in human nutrition, fruit contain 93.1% water, 1.9% protein, 0.3 g fat, 0.7% fibre, 3.6%carbohydrates, 23 calorie, 320 I.U vitamin A., 0.07 mg vitamin B1, 0.01 mg vitamin B2, 31 mg vitamin C, 20 mg calcium, 36 mg phosphorus and 0.8 mg iron.

1.1 Integrated Nutrient Management (INM)

Integrated nutrient management (INM) is an approach that involves the management of both organic and inorganic plant nutrients for optimal production of cultivated crops, forage, and tree species, while conserving the natural resource base essential for long-term sustainability. The crop is being cultivated as an important spring summer season vegetable in eastern Uttar Pradesh finding readymade market in plains of northern India fetching very remunerative prices for the farmers [3-6].

The growth, yield and fruit quality of tomato largely depend on number of various interacting factors. Among them, INM is the most crucial as well as basic factor. The continuous use of chemical fertilizer increases the concentration of heavy metals in the soil, disturbs soil health and quality which cannot support plant growth in long term basis [7-10]. Integrated Nutrient Management comprises organic, inorganic component and microorganism that are highly beneficial for sustainable crop production as it ameliorates soil environment, maintains adequate level of nutrients and provides favourable conditions for high tomato yield with desired quality. The integrated use of organic and inorganic fertilizers is the need of hour and is being advocated for sustainable agriculture [11-14]. When the inorganic fertilizers are not available timely due to higher prices and inadequate supply of it, organic manures can supplement the nutrients.

Nitrogen (N) plays a key role in nutrition of the plants. As a matter of fact, the plant life would not be possible without this element [15-17]. Adequate amount of nitrogen are also required to obtain good yield in vegetable crops. Phosphorous and potassium is considered as major nutrient in tomato cultivation which involves in all the metabolic process in the plant and there is considerable evidence to show that, this element plays an important role in photosynthesis and helps in building up of carbohydrate in the plant. The production of dry matter is further affected by the effect of potassium on rate of respiration [18-21].

The role of bio-fertilizers in improving soil fertility has long been studied in various crops. The bio-fertilizers such as Azotobacter, Phosphate Solubilising Bacteria and Arbuscular Mycorrhiza (AM fungi) helps to enhance overall soil fertility by modifying soil texture, soil structure integrity, aeration, increased nutrient availability there by greatly influencing plant growth and yield [22-24]. Azospirillum a diazotrophic bacterium which is widely distributed in soil rhizosphere and roots of a number of plants have ability to fix nitrogen. Many reports have indicated the importance of Azospirillum in vegetable crops. Bio-fertilizers are involved in symbiotic and associative microbial activities with higher plants [25-29]. These are natural mini-fertilizer factories that are economical and safer source of plant nutrition for increasing the agricultural production and improving fertility. Optimal and balanced use of nutrient inputs from mineral fertilisers are of fundamental importance to meet growing global demand for food. Efficient use of all nutrient sources, including organic sources, recyclable wastes, mineral fertilisers and bio-fertilisers should therefore be promoted through Integrated Nutrient Management. To achieve compliance with an increasing amount of agricultural, environmental, legislative and economical constraints, a well-defined fertilizer strategy needs to be developed which would lead to optimization of nutrient use, crop production and quality [30-33]. Thus, the integrated nutrient use of organic and inorganic fertilizers has assumed great significance in recent years. Keeping these points the present investigation entitled “Effect of integrated nutrient management on the growth, yield and quality in tomato (*Solanum lycopersicum* L.)” was undertaken with following mentioned objectives to find out suitable treatment of Integrated Nutrient Management in relation to growth, yield and quality in tomato and to work out the economics of various treatments.

2. MATERIALS AND METHODS

An Experiment on Tomato (*Solanum Lycopersicum L.)* was conducted during kharif season of 2021, in horticulture Research field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, and Technology & Sciences Prayagraj (U.P) India to understand the effect of Integrated nutrient management at different doses combination on fruit growth, yield and quality of tomato variety TMTH-2267. The experiment was conducted in Randomized Block design. Under the present investigation 10 treatments were prepared with different combination doses of integrated nutrient management mentioned in and replicated thrice. 50% of Urea was applied for nitrogen supply, MOP for potassium and SSP for phosphorous was applied as basal dose for all treatments at time of sowing, while two split dose of 25% of urea was applied at 25 days interval after transplanting. FYM, Poultry manure, Vermicompost, PSB and Azotobacter was applied as soil application as per respective treatment given in. Zinc and Boron was given as foliar spray as per doses for respective treatments.

2.1 Experimental Site and Geographical Location

The experiment was carried out at field in Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during the year 2021-2022 from July to November.

Allahabad is situated at an elevation of 78 meters above sea level at 25.87 North latitude and 81.15 East longitude. The mean (maximum and minimum) temperature was 37.98^{o}C and 24.21^{o}C respectively, mean (maximum and minimum) relative humidity was 87.16 percent and 50.26 percent during the crop growing season. The experimental soil was sandy loam in texture, nearly neutral in soil reaction (pH 6.9), low in organic carbon (0.389%), medium in available N (212.56 Kg/ha), medium available P (14.59 Kg/ha) and medium available K (225.1 Kg/ha).

2.2 Climate

This region has a sub-tropical climate prevailing in the south-east part of U.P. with both the extremes in temperature, ie, the winter and the summer. In cold winters, the temperature sometimes is as low as 32 F in December - January and very hot summer with temperature reaching upto115° F in the months of May and June. During winter, frosts and during summer. hot scorching winds are also not uncommon. The average rainfall is around 1013.4 (cm) with maximum concentration during July to September months with occasional showers in winters.

2.3 Nursery Techniques

The seeds were procured from Trimurti Science plants Pvt.Ltd.. The seeds of tomato were sown during July 2021 in 98 celled portray having mixture of cocopeat and vermicompost in 1:1 ratio as growing media during the nursery stage. Frequent irrigation and necessary plant protection measures were taken to raise good quality seedlings.

2.4 Layout and Treatment

The experiment was laid out in randomized block design (RBD) having 10 Treatment which were replicated 3 times. The treatment combinations are as follows: To (RDF of NPK(150:80:60)Kg/ha +10t FYM), T_1, 75% N through Urea +MOP + SSP +25% through Farm Yard Manure + Boron + Azotobacter + Phosphorous Solubilizing Bacteria , T_2, 75% N through Urea +MOP + SSP +25% through FYM + Boron + Azotobacter + Phosphorous Solubilizing Bacteria , T_3, 75% N through Urea +MOP + SSP +25% through FYM + Boron + Azotobacter + Phosphorous Solubilizing Bacteria ,T_4, 75% N through Urea +MOP + SSP +25% through FYM + Boron + Azotobacter + Phosphorous Solubilizing Bacteria., $T_5$75% N through Urea + MOP + SSP + 25% through Vermicompost + Zinc + Azotobacter + Phosphorous Solubilizing Bacteria, T_6, 75% N through Urea+ MOP + SSP + 25% through Vermicompost+ Boron + Zinc + Azotobacter + Phosphorous Solubilizing Bacteria, T_7, 75% N through Urea + MOP + SSP + 25% through Poultry Manure + Boron + Azotobacter + Phosphorous Solubilizing Bacteria ,T_8, 75% N through Urea + MOP + SSP + 25% through Poultry Manure +Zinc + Azotobacter + Phosphorous Solubilizing Bacteria & T_9, 75% N through Urea + MOP + SSP + 25% through Poultry Manure + Boron + Zinc + Azotobacter +Phosphorous Solubilizing Bacteria. During September the 4-5 weeks old seedlings having 4 leaf stage were transplanted in at a distance of 60 cm between the plants in each row and 45 cm between rows. Staking was done after a month of transplanting. Irrigation was provided frequently and all the recommended cultivation practices were followed.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The data from the Table 1 reveals different growth parameters. A critical analysis of ANOVA table shows that the data was affected by different treatments of integrated nutrient management.

In case of plant height, the data are presented in Table 1. It is evident from the table that there were significant differences among various treatment of tomato. The maximum plant height was observed in the T_5, which was (31.57cm), (72.80cm),(101.05cm), (103.99cm) at 30,60,90 DAT,and at harvest respectively followed by $T_{6,}$ (32.27cm), (73.16cm), (100.58cm), (103.05cm) at 30,60,90 DAT and at harvest respectively, while the minimum plant height (31.57 cm) (52.85cm), (79.20 cm), (82.88cm) at 30,60,90 DAT,and at harvest respectively. and the remaining treatments were moderate in their growth habit. The application of integrated nutrient management might have improved the soil physical and chemical properties and leading to the adequate supply of nutrients to the plants which might have promoted the maximum vegetative growth while the minimum plant growth was due to non-availability of nutrients. Similar findings were reported by Mahto et al. [34]; Prabhu et al. [35]; Chhonkar et al. [36] and Kumar et al. [37] in tomato.

It was found that T_0 with maximum value i.e. 13.71 branches per plant followed by T_1 with 12.36 branches per plant whereas the minimum score was observed in treatment T_4 with 6.82. It was found that T_6 with maximum value i.e. 52.30 plant spread followed by T_5 with 50.94 plant spread whereas the minimum score was observed in treatment T_0 with 45.68.

It was noticed that number of branches per plant and plant spread (cm) increased with increasing plant height successively with the increasing levels of micronutrient. Combination of INM also recorded maximum plant height and number of branches also which helped the plants in better photosynthesis to attain vigour. The findings of the present investigation are in conformity with the reports of Mahato et al. [34]; Prabhu et al. [35]; Chhonkar et al. [36] and Kumar et al. [37] in tomato.

3.2 Days to First Flowering, Days to 50% Flowering and First Fruit Setting

Among the application of INM the maximum days to first flowering was seen in with 42.88 days, followed by T_3 with 41.31 days whereas minimum days to first flowering 30.65 days was recorded in $T_{7.}$

Among the application of INM the maximum days to 50% flowering was seen in T_8 with 50.55 days, followed by T_3 with 48.86 days whereas minimum days to 50% flowering 39.03 days was recorded in $T_{6.}$

The application of INM the maximum days to first fruit setting was seen in T_8 with 58.59 days, followed by T_3 with 56.95 days whereas minimum days to first fruit setting 46.02 days was recorded in $T_{7.}$ Integration of different nutrient management favoured vigorous growth and synthesized more these hormones in plants, which might have helped to the translocation as well as more quantity of available phosphorus through the xylem vessels and their accumulation in the axillary buds that would have favoured the plant to enter into reproductive phase. Similar results have also been reported by Mahato et al. [34]; Prabhu et al. [35]; Patil et al. (2011) and Adeel et al. (2014) in tomato.

Among the application of INM the maximum days to first fruit picking was seen in T_8 with 71.37 days, followed by T_3 with 69.60 days whereas minimum days to first fruit picking 58.75 days was recorded in T_7.

3.3 Number of Flowers per Cluster, Number of Flower Clusters per Plant, Number of Fruits per Plant, Fruit Yield in kg per Plant

The Table 3 explains the different yield parametrs by the application of INM.The maximum number of flowers per cluster which was seen in T_6 with 7.47, followed by T_0 with 7.42 whereas minimum number of flowers per cluster 5.94 was recorded in T_2. Whereas maximum number of flower clusters per plant was observed in T_1 with 10.56, followed by T_0 with 9.69 while the minimum number of flower clusters per plant 6.79 was recorded in T_4.

Table 1. Effect of integrated nutrient management on plant height (cm) [30, 60, 90 DAT] and at harvest of the tomato, number of branches per plant and plant spread(cm)

Treatment Notation	Treatment Combination	30 DAT	60 DAT	90 DAT	At Harvest	Number of branches per plant	Plant spread (cm)
T_0	RDF of NPK(150:80:60)Kg/ha +10t Farm Yard Manure	31.69	52.85	79.20	82.88	13.71	45.68
T_1	75% N through Urea +MOP + SSP +25% through Farm Yard Manure + Boron + Azotobacter + Phosphorous Solubilizing Bacteria	33.41	59.91	87.90	91.64	12.36	48.09
T_2	75% N through Urea +MOP + SSP +25% through Farm Yard Manure +Zinc+ Azotobacter + Phosphorous Solubilizing Bacteria	31.55	59.14	91.41	95.13	10.59	47.16
T_3	75% N through Urea +MOP + SSP +25% through Farm Yard Manure + Boron + Azotobacter + Phosphorous Solubilizing Bacteria	33.76	60.31	91.55	95.60	7.59	50.47
T_4	75% N through Urea +MOP + SSP +25% through Farm Yard Manure + Boron + Azotobacter + Phosphorous Solubilizing Bacteria	33.25	73.29	98.69	102.32	6.82	50.64
T_5	75% N through Urea + MOP + SSP + 25% through Vermicompost + Zinc + Azotobacter + Phosphorous Solubilizing Bacteria	31.57	72.80	101.05	103.99	11.46	50.94
T_6	75% N through Urea+ MOP + SSP + 25% through Vermicompost+ Boron + Zinc + Azotobacter + Phosphorous Solubilizing Bacteria	32.27	73.16	100.58	103.05	10.32	52.30
T_7	75% N through Urea + MOP + SSP + 25% through Poultry Manure + Boron + Azotobacter + Phosphorous Solubilizing Bacteria	31.88	70.75	97.96	100.78	8.62	50.57

Treatment Notation	Treatment Combination	30 DAT	60 DAT	90 DAT	At Harvest	Number of branches per plant	Plant spread (cm)
T_8	75% N through Urea + MOP + SSP + 25% through Poultry Manure +Zinc + Azotobacter + Phosphorous Solubilizing Bacteria	35.69	71.68	99.55	102.97	9.53	50.75
T_9	75% N through Urea + MOP + SSP + 25% through Poultry Manure + Boron + Zinc + Azotobacter +Phosphorous Solubilizing Bacteria	31.66	73.60	93.25	96.80	11.69	49.66
	'F' Test	**S**	**S**	**S**	**S**	**S**	**S**
	C.D. at 5%	**2.56**	**5.96**	**8.57**	**9.05**	**0.97**	**3.83**
	S.E. (m)	**0.86**	**2.01**	**2.88**	**3.05**	**0.33**	**1.29**
	C.V.	**4.57**	**5.21**	**5.31**	**5.41**	**5.50**	**4.50**

Table 2. Effect of integrated nutrient management on days to 1st flowering, days to 50% flowering, days to 1st fruit setting, days to first fruit picking of tomato

Treatment Notation	Treatment Combination	Days to 1st flowering	Days to 50% flowering	Days to 1st fruit setting	Days to 1st fruit picking
T_0	RDF of NPK(150:80:60)Kg/ha +10tn FYM	34.04	41.59	49.68	62.33
T_1	75% N through Urea +MOP + SSP +25% through FYM + Boron + Azotobacter +PSB	34.97	42.52	50.61	63.26
T_2	75% N through Urea +MOP + SSP +25% through FYM +Zn+ Azotobacter +PSB	38.08	45.63	53.72	66.37
T_3	75% N through Urea + MOP + SSP +25% through FYM + B+ Zn+ Azotobacter +PSB	41.31	48.86	56.95	69.60
T_4	75% N through Urea + MOP + SSP + 25% through Vermicompost+ B + Azotobacter +PSB	39.69	47.24	55.33	67.98
T_5	75% N through Urea + MOP + SSP + 25% through Vermicompost + Zn + Azotobacter + PSB	35.77	43.32	51.41	64.06
T_6	75% N through Urea+ MOP + SSP + 25% through Vermicompost + B + Zn + Azotobacter +PSB	31.48	39.03	47.12	59.77
T_7	75% N through Urea + MOP + SSP + 25% through PM + B + Azotobacter + PSB	30.65	38.01	46.02	58.75
T_8	75% N through Urea + MOP + SSP + 25% through PM +Zn + Azotobacter + PSB	42.88	50.55	58.59	71.37
T_9	75% N through Urea + MOP + SSP + 25% through PM + B + Zn + Azotobacter +PSB	33.10	40.80	48.81	61.44

Treatment Notation	Treatment Combination	Days to 1^{st} flowering	Days to 50% flowering	Days to 1^{st} fruit setting	Days to 1^{st} fruit picking
	'F' Test	**S**	**S**	**S**	
	C.V.	**5.81**	**5.91**	**6.01**	**S**
	S.E. (m)	**1.21**	**1.49**	**1.80**	**6.11**
	C.D. at 5%	**3.61**	**4.44**	**5.34**	**2.28**
					6.76

Table 3. Effect of integrated nutrient management on days to number of flowers per plant and number of flower clusters, fruit yield per plant (Kg/plant) of tomato

Treatment Notation	Treatment Combination	Number of flowers per cluster	Number of flower clusters per plant	Number of fruits per plant	Fruit yield per plant (kg/plant)
T_0	RDF of NPK(150:80:60)Kg/ha +10tn FYM	7.42	9.69	59.22	2.91
T_1	75% N through Urea +MOP + SSP +25% through FYM + Boron + Azotobacter +PSB	6.50	10.56	54.82	3.44
T_2	75% N through Urea +MOP + SSP +25% through FYM +Zn+ Azotobacter +PSB	5.94	7.66	35.48	1.98
T_3	75% N through Urea + MOP + SSP +25% through FYM + B+ Zn+ Azotobacter +PSB	6.24	7.38	36.39	2.81
T_4	75% N through Urea + MOP + SSP + 25% through Vermicompost + B + Azotobacter +PSB	6.47	6.79	35.05	1.65
T_5	75% N through Urea + MOP + SSP + 25% through Vermicompost + Zn + Azotobacter + PSB	5.99	8.63	40.40	2.83
T_6	75% N through Urea+ MOP + SSP + 25% through Vermicompost + B + Zn + Azotobacter +PSB	7.47	7.76	43.86	2.18
T_7	75% N through Urea + MOP + SSP + 25% through PM + B + Azotobacter + PSB	7.00	7.22	37.41	2.38
T_8	75% N through Urea + MOP + SSP + 25% through PM +Zn + Azotobacter + PSB	6.14	7.44	32.15	2.23
T_9	75% N through Urea + MOP + SSP + 25% through PM + B + Zn + Azotobacter +PSB	6.30	7.17	32.14	1.81
	'F' Test	**0.41**	**0.87**	**4.47**	**S**
	C.V.	**0.14**	**0.29**	**1.50**	**6.51**
	S.E. (m)	**3.65**	**6.31**	**6.40**	**0.09**
	C.D. at 5%				**0.27**

The yield per plant was recorded in T_2 i.e. 3.44 kg per plant followed by T_0 2.91kg per plant while the minimum fruit yield was observed in T_4 1.65 kg per plant.

Integration of different nutrient management favoured vigorous growth and synthesized more these hormones in plants, which might have helped to the translocation as well as more quantity of available phosphorus through the xylem vessels and their accumulation in the axillary buds that would have favoured the plant to enter into reproductive phase. Similar results have also been reported by Sharma (2006); Arivazhagan et al. [38]; Laddha et al. (2018) and Kalgehi et al. (2021) in brinjal and Mahato et al. [34]; Prabhu et al. [35]; Patil et al. (2011) and Adeel et al. [39] in tomato.

4. CONCLUSION

From the present investigation it was concluded that T_1 was found to be best among all treatment in terms of yield and T_6 in growth and quality of tomato i.e. plant spread, plant height, T.S.S. etc. The highest B:C ratio that is 3.25 was observed for T_6.

It is concluded from the investigation that the treatment T_6 was found suitable for application in tomato cultivation. Therefore, combination of urea, MOP, SSP alongwith vermicompost, boron, zinc, azotobacter and PSB can be suggested for cultivation practices that would enhance crop yield. It also proved to be cost effective.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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