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Effect of integrated nutrient management and micronutrients on growth, yield and economics of tomato cv. GAT-5

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Abstract
The present investigation was carried out at Department of Horticulture, College of Agriculture, Anand Agricultural University, Vaso during *Rabi* season for the year 2019-20 and 2020-21. The experiment was laid out in randomized block design with factorial concept having fourteen treatment combinations with three replications comprising two factors having two levels of micronutrients and seven levels of INM. Different treatments of INM and micronutrients improved the growth, yield parameters of tomato. Among treatments of micronutrients, Zinc @ 100 ppm recorded significantly maximum plant height (119.86 cm), crop growth rate (60-90 DAT) (7.21 g/m^2/day), relative growth rate (30-60 DAT) (71.40 mg/g/m^2), relative growth rate (60-90 DAT) (77.33 mg/g/m^2). Boron @ 100 ppm recorded significantly minimum days to 50% flowering (35.36), days to first picking (65.38), maximum number of fruits per plant (31.39), fruit yield per plant (2.15 kg), fruit yield per plot (28.83 kg), fruit yield per hectare (39.55 t). Among INM treatments N_5: 50% RDF + 50% N from FYM + Bio NPK recorded significantly maximum plant height (125.97 cm), number of primary branches (7.08), crop growth rate (30-60 DAT) (7.50 g/m^2/day), crop growth rate (60-90 DAT) (7.94 g/m^2/day), relative growth rate (30-60 DAT) (75.25 mg/g/m^2), relative growth rate (60-90 DAT) (76.92 mg/g/m^2), harvest index (62.72%), maximum fruit diameter (7.37 cm), fruit weight (86.72 g) and fruit volume (83.02 cc), maximum number of fruits per plant (32.32), fruit yield per plant (2.32 kg), fruit yield per plot (31.03 kg) and fruit yield per hectare (42.57 t) while minimum days to 50% flowering (35.00), days to first picking (66.00) recorded with treatment N6: 50% RDF + 50% N from Vermicompost + Bio NPK. Interaction effect of micronutrient and INM found non-significant for all parameters. Boron @ 100 ppm recorded the highest net realization (Rs. 208925) and BCR (3.1) while among INM treatments, N5: 50% RDF + 50% N from FYM + Bio NPK recorded the highest net realization (Rs. 219552) and BCR (2.8).

Keywords: Tomato, INM, micronutrients, growth, yield, economics

Introduction
Tomato (*Solanum lycopersicum* Mill.) is one of the most popular vegetable crops grown all over the world due to its wider adaptability to various agro-climatic conditions as well as in culinary purposes. The crop is native to Central and South America. In the world, it ranks second in importance after potato, but tops the list of processed vegetables (Chaudhary, 1996) [3]. Tomato is one of the most common, leading, widely consumed, popular, staple, day neutral, self pollinated, annual and economically important solanaceous fruit vegetable crop. Its fruits are very popular among people of all social strata and consumed in variety of ways. It is equally liked by both poor and rich and is quite high in nutritive value. Apart from this, it also embodies certain ayurvedic medicinal properties. It is also a very good source of income for small and marginal farmers and also contributes to the nutrition of the consumer (Singh *et al*., 2010) [19].

Being a nutrient exhaustive, this crop requires ample supply of plant nutrients for satisfactory growth, yield and quality. The productivity of a crop is controlled by many factors of which mineral nutrition is by and large the most important one but the application of all the needed nutrients through chemical fertilizers had deleterious effect on soil fertility leading to unsustainable yield. It has been realized worldwide that chemical fertilizers while increasing crop yield may have adverse effect on soil health and its fertility in case of imbalance use. Further, indiscriminate use of chemicals, on account of environmental concern and high cost, could not sustain vegetable production.

Micronutrients have an important role in the plant activities and foliar application can improve the vegetative growth, fruit set and yield of tomato by increasing photosynthesis of green plants. Micronutrients are not only essential for better growth, yield and quality but also important like other major nutrients in spite of their requirement in micro quantity. Micronutrients also help in uptake of major nutrients and also vital to the growth of plants acting as catalyst in promoting various organic reaction from cell development to respiration, photosynthesis, chlorophyll formation, enzyme activity, hormones synthesis and nitrogen fixation. Considerable research work has been done on the aspect of foliar application of micronutrient in different crops and the experimental results indicated not only increase in yield but also helpful to sustain crop production.

Zinc is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. It has important role in metal component of different enzymes (Marschner, 1995) [9] and essential trace element in various functions of the plant like increases the rate of chlorophyll, antioxidant enzymes and essential component of many proteins (Sbartai *et al.*, 2011) [17]. Growth and development would stop if specific enzymes were not present in plant tissue. Carbohydrate, protein, and chlorophyll formation is significantly reduced in zinc-deficient plants. Therefore, a constant and continuous supply of zinc is needed for optimum growth and maximum yield.

Boron is one of the micronutrient; the primary function of B is in plant cell wall structural integrity. Under B deficiency, normal cell wall expansion is disrupted. Boron is needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates (Bose and Tripathi, 1996) [1]. Boron also plays an important role in flowering and fruit formation (Nonnecke, 1989) [10]. Boron deficiency affects the growing points of roots and youngest leaves. The leaves become wrinkled and curled with light green colour. Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins.

Materials and Methods

A field experiment was conducted during *Rabi* season of the year 2019-20 and 2020-21 at experimental farm, Department of Horticulture, College of Agriculture, Anand Agricultural University, Vaso. Chemical properties of soil is given in table 1. The variety was Gujarat Anand Tomato-5. The seeds of this variety was obtained from Anand Agricultual University. Transplanting was done in 1st week of November. In this experiment, two factors *viz.* (1) INM which consisted 7 levels i.e N_1: 100% RDF (100:50:50 NPK kg/ha.), N_2: 75% RDF + 25% N from FYM + Bio NPK, N_3: 75% RDF + 25% N from Vermicompost + Bio NPK, N_4: 75% RDF + 25% N from Castor cake + Bio NPK, N_5: 50% RDF + 50% N from FYM + Bio NPK, N_6: 50% RDF + 50% N from Vermicompost + Bio NPK, N_7: 50% RDF + 50% N from Castor cake + Bio NPK and (2) Micronutrients which consisted 2 levels i.e. M_1: Zinc @ 100 ppm and M_2: Boron @ 100 ppm. There were 14 treatment combinations. The experiment was conducted in Randomised Block Design with factorial concept. Bio NPK Consortium was collected from the Department of Agricultural Microbiology, Anand Agricultural University, Anand. Bio-NPK is liquid bio-fertilizer consists of nitrogen fixers (*Azotobacter* & *Azospirillum*) + PSB and KMB (3 different *Bacillus* sp.). Bio NPK consortium was applied by dipping seedlings before transplanting in Bio NPK @ 5 ml/litre of water and mixing with organic manures @1 litre/60 kg of manures. Zinc and boron was applied as a foliar spray @ 100 ppm three times at 10 days interval starting from 30 days after transplanting. The observations regarding growth and yield parameters were recorded by average of five randomly selected plants and analysed.

Table 1: Chemical properties of the experimental soil

Sr. No.	Soil characteristics	Value (0-15 cm depth)
1.	Organic carbon (%)	0.36
2.	Available nitrogen (kg ha^{-1})	240.50
3.	Available phosphorus (kg ha^{-1})	39.50
4.	Available potash (kg ha^{-1})	241.50
5.	Soil pH (1 :2.5, soil: water ratio)	8.0
6.	EC (ds/m) (1:2.5, soil: water ratio)	1.20

Results and Discussion

Effect of INM on growth and yield of tomato

Maximum plant height (125.97 cm) and number of primary branches (7.08) was recorded with N_5 (50% RDF + 50% N from FYM + Bio NPK). This might be due to application organic fertilizers with Bio-NPK which increased the photosynthetic activity, chlorophyll formation, nutrients metabolism and hormonal content in the plant which enhanced the metabolic activity through the supply of important macro and micronutrients. Similar result was found by Kumar *et al.* (2017) [6], Parmar *et al.* (2019) [11], Singh *et al.* (2015) [18] in tomato and by Kumar *et al*. (2021) [7], Waskel *et al.* (2019) [21] in brinjal.

Minimum days to 50% flowering (35.00) and minimum days to first picking (66.00) was recorded with N_6 (50% RDF + 50% N from Vermicompost + Bio NPK). This might be due to the fact that earliness in flowering could be attributed by enhancement of vegetative growth by application of FYM with Bio-NPK which makes nutrients readily available to the plants and storing sufficient reserved food materials for differentiation to flower buds. Similar result was observed by Geetharani and Parthiban (2014) [4], Kumar *et al*. (2017) [6]. Parmar *et al.* (2019) [11], Prativa and Bhattarai (2011) [14], Singh *et al*. (2015) [18] in tomato.

Maximum crop growth rate (30-60 DAT) (7.50 g/m^2/day), crop growth rate (60-90 DAT) (7.94 g/m^2/day), relative growth rate (30-60 DAT) (75.25 mg/g/m^2), relative growth rate (60-90 DAT) (81.33 mg/g/m^2) and harvest index (62.72%) found with N_5 (50% RDF + 50% N from FYM + Bio NPK). This might be due to organic manures improve the soil physical conditions and promotes microbial and soil organic matter, which in there produces organic acids, which inhibits IAA oxides enzymes, results in enhancing the promoting effect of Auxin- IAA, which has direct effect on plant growth. Similar results were observed by Isah *et al.* (2014) [5] in tomato.

Maximum fruit diameter (7.37 cm), fruit weight (86.72 g) and fruit volume (83.02 cc) was observed with N_5 (50% RDF + 50% N from FYM + Bio NPK). This might be due to increased supply of major plant nutrients. Nitrogen and other nutrients accelerate the growth and reproductive phases and protein synthesis, thus promoting fruit diameter of tomato. These results are closely matched with Parmar *et al.* (2019) [11], Singh *et al*. (2015) [18] in tomato and with Paswan *et al.* (2022) [12], Waskel *et al.* (2019) [21] in brinjal.

Maximum number of fruits per plant (33.01), fruit yield per plant (2.32 kg), fruit yield per plot (31.03 kg) and fruit yield per hectare (42.57 t) was recorded with N_5 (50% RDF + 50%

N from FYM + Bio NPK). The increase in the tomato yield per plant may be attributed by the higher absorption of N, P and K which might have favourably affected the chlorophyll content of leaves resulting increased synthesis of carbohydrates which results in more vegetative growth and reproductive growth. Same results were reported by Kumar *et al.* (2017) [6]. Laxmi *et al.* (2015) [8], Singh *et al.* (2015) [18] in tomato and by Patidar and Bajpai (2018) [13], Waskel *et al.* (2019) [21] in brinjal.

Effect of Micronutrients on growth and yield of tomato

Maximum plant height (119.86 cm) was recorded with M_1 (Zinc @ 100 ppm). This might be due to role of zinc in carbohydrate, protein, chlorophyll synthesis, more photosynthesis rate and also in different enzymatic and metabolic activities. Same results were observed by Chand *et al.* (2018) [2], Saravaiya *et al.* (2014) [15], Sathiyamurthy *et al.* (2017) [16], Swetha *et al.* (2018) [20].

Minimum days to 50% flowering (35.36), days to first picking (65.38) was recorded with M_2 (Boron @ 100 ppm). The reason for early days to 50% flowering might be due to boron plays important role in synthesis of growth hormones which causes early reproductive growth of the plant. Same results were obtained by Patil *et al.* (2014) [15], Saravaiya *et al.* (2014) [15], Swetha *et al.* (2018) [20] in tomato.

Maximum crop growth rate (60-90 DAT) (7.21 g/m^2/day), relative growth rate (30-60 DAT) (71.40 $mg/g/m^2$), relative growth rate (60-90 DAT) (77.33 $mg/g/m^2$) was found with M_1 (Zinc @ 100 ppm). The increase in growth rate might be due to involvement of zinc in metabolic and enzymatic process of plant.

Maximum number of fruits per plant (31.39), fruit yield per plant (2.15 kg), fruit yield per plot (28.83 kg), fruit yield per hectare (39.55 t) was recorded with M_2 (Boron @ 100 ppm). The increase in yield of tomato by application of boron might be due to higher rate of photosynthesis and sugar formation results into translocation of more photosynthates to growing fruits which ultimately led to higher fruit set and fruit yield per plant and hectare.

Effect of INM and micronutrients on economics of tomato

The mean data on cost of cultivation incurred with gross realization, net realization and benefit cost ratio of tomato cv. GAT-5 as affected by different treatments of micronutrients and INM are presented in Table 4.36. The data revealed that among the different treatments of micronutrients, M_2 (Boron @ 100 ppm) recorded the highest net realization (Rs. 208925) and BCR (3.1) while among INM treatments, N_5 (50% RDF + 50% N from FYM + Bio NPK) recorded the highest net realization (Rs. 219123) and BCR (2.8).

Interaction effect of INM and micronutrients on growth, yield of tomato

There is no significant interaction found between different treatments of INM and micronutrients in all parameters.

Table 2: Effect of INM and micronutrients on growth of tomato (Pooled of two years)

Code	Treatment	Plant height (cm)	Number of primary branches	Days to 50% flowering	Days to first picking	Crop growth rate (30-60 DAT) ($g/day/m^2$)	Crop growth rate (60-90 DAT) ($g/day/m^2$)	Relative growth rate (30-60 DAT) ($mg/g/m^2$)	Relative growth rate (60-90 DAT) ($mg/g/m^2$)
Micronutrient (M)									
M_1	Zinc @100 ppm	119.86	6.79	36.52	68.45	6.71	7.21	71.40	77.33
M_2	Boron @ 100 ppm	114.86	6.64	35.36	65.38	6.38	6.84	65.74	74.00
S.Em.±		1.14	0.07	0.11	0.13	0.12	0.11	0.89	0.93
CD at 5%		3.24	NS	0.32	0.37	NS	0.31	2.52	2.63
INM (N)									
N_1	100% RDF	106.76	6.17	37.42	68.00	5.58	6.16	62.67	71.08
N_2	75% RDF + 25% N from FYM + Bio NPK	120.98	6.75	35.50	66.50	6.33	6.75	67.58	76.08
N_3	75% RDF + 25% N from Vermicompost + Bio NPK	114.93	6.83	35.83	66.83	6.52	6.87	67.08	76.00
N_4	75% RDF + 25% N from Castor cake + Bio NPK	119.17	6.75	36.08	67.17	6.30	6.86	69.08	76.92
N_5	50% RDF + 50% N from FYM + Bio NPK	125.97	7.08	35.75	66.83	7.50	7.94	75.25	81.33
N_6	50% RDF + 50% N from Vermicompost + Bio NPK	118.93	6.67	35.00	66.00	6.89	7.39	68.42	73.17
N_7	50% RDF + 50% N from Castor cake + Bio NPK	114.78	6.75	36.00	67.08	6.70	7.20	69.92	75.08
S.Em.±		2.13	0.13	0.21	0.24	0.23	0.21	1.66	1.73
CD at 5 %		6.06	0.36	0.59	0.69	0.64	0.59	4.71	4.91
Year		Sig.	NS	Sig.	Sig.	Sig.	NS	Sig.	NS
Sig. interaction		-	-	-	-	-	-	-	-
CV %		6.30	6.50	2.02	1.25	11.95	10.24	8.39	7.92

Table 3: Effect of INM and micronutrients on yield of tomato (Pooled of two years)

Code	Treatment	Harvest index (%)	Fruit diameter (cm)	Fruit weight (g)	Fruit volume (cc)	Number of fruits per plant	Fruit yield per plant (kg)	Fruit yield per plot (kg)	Fruit yield per hectare (t)
	Micronutrient (M)								
M_1	Zinc @100 ppm	57.05	7.27	77.57	76.68	28.69	2.01	26.01	35.68
M_2	Boron @ 100 ppm	59.06	7.09	79.34	78.21	31.39	2.15	28.83	39.55
	S.Em.±	0.98	0.07	0.81	0.76	0.45	0.04	0.45	0.62
	CD at 5%	NS	NS	NS	NS	1.26	0.11	1.29	1.77
	INM (N)								
N_1	100% RDF	52.72	6.71	70.01	70.22	26.43	1.74	23.43	32.14
N_2	75% RDF + 25% N from FYM + Bio NPK	57.44	7.27	76.24	75.96	29.70	2.12	26.48	36.33
N_3	75% RDF + 25% N from Vermicompost + Bio NPK	59.43	7.21	77.55	77.03	29.02	2.05	27.45	37.65
N_4	75% RDF + 25% N from Castor cake + Bio NPK	59.45	7.25	76.57	77.62	29.14	2.04	26.54	36.41
N_5	50% RDF + 50% N from FYM + Bio NPK	62.72	7.37	86.72	83.02	33.01	2.32	31.03	42.57
N_6	50% RDF + 50% N from Vermicompost + Bio NPK	57.03	7.22	81.90	79.76	32.63	2.18	28.98	39.75
N_7	50% RDF + 50% N from Castor cake + Bio NPK	57.60	7.25	80.19	78.53	30.33	2.15	28.05	38.47
	S.Em.±	1.83	0.13	1.51	1.42	0.83	0.07	0.85	1.17
	CD at 5%	5.19	0.36	4.28	4.03	2.37	0.20	2.41	3.31
	Year	NS	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.
	Sig. interaction	-	-	-	-	-	-	-	-
	CV %	10.91	6.12	6.65	6.36	9.62	11.51	10.74	10.74

Fig 1: General view of experimental plot

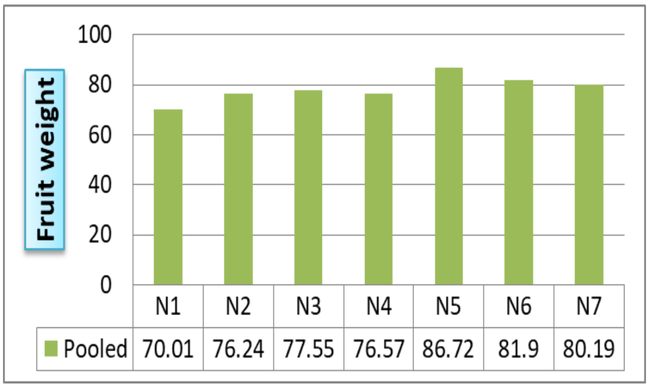

Fig 3: Effect of INM on fruit weight of tomato (g)

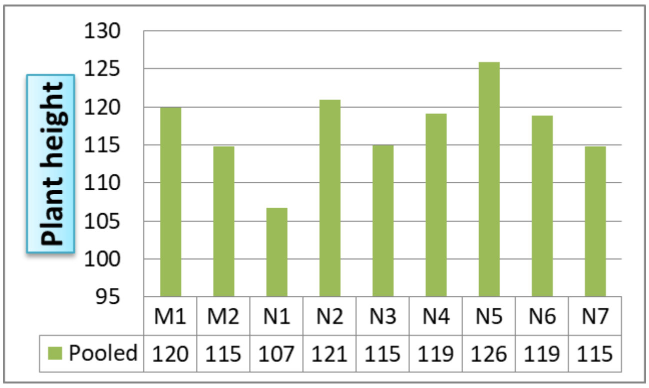

Fig 2: Effect of Micronutrient and INM on plant height of tomato (cm)

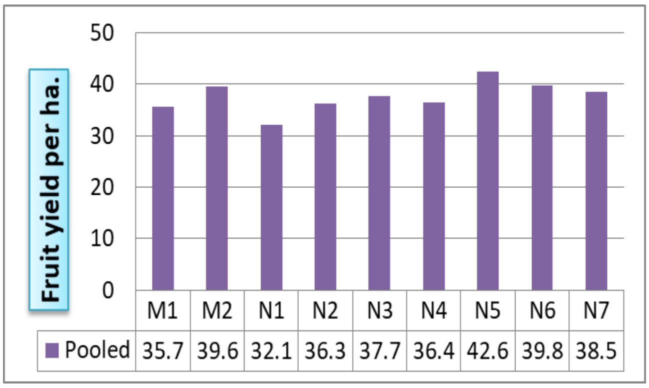

Fig 4: Effect of Micronutrient and INM on fruit yield per hectare (t)

Conclusion

From the field study conducted for two years, it can be concluded that spraying of micronutrients i.e. zinc @ 100 ppm improved growth parameters of tomato while boron @ 100 ppm improved yield parameters with high net realization and BCR. Application of INM treatments i.e. 50% RDF + 50% N from FYM + Bio NPK improved growth and yield parameters with high net realization and BCR. Further, combined effect of micronutrients and INM found non-significant for all the parameters.

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