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SYNERGISTIC ROLE OF MICRONUTRIENTS AND PLANT GROWTH REGULATORS ON YIELD, SOIL FERTILITY AND NUTRIENT UPTAKE IN TOMATO

Raju S. Sulikeri[1*], Praveenkumar B. Naikodi[2], Dhananjaya Belavadi Nanjappa[2], S.M. Prasanna[3] and Yashavantakumar K. H.[4]

[1]Department of Soil Science, College of Horticulture, Bengaluru, Karnataka, India.
[2]Department of Soil Science, College of Horticulture, Bagalkot, Karnataka, India.
[3]Department of Soil Science, College of Horticulture, Bidar, Karnataka, India.
[4]Department of Vegetable Science, College of Horticulture, Bagalkot, Karnataka, India.
*Corresponding author E-mail: rajusulikeri123@gmail.com
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ABSTRACT

A field experiment entitled "Interaction Effects of Micronutrients and Plant Growth Regulators on Growth, Yield Dynamics and Nutrient Uptake in Tomato" was carried out during the kharif season of 2024–25 at the College of Horticulture, Bagalkot, using the tomato variety 'Abhilash'. The experiment was laid out in a Randomized Block Design comprising ten treatments replicated three times. The treatments consisted of different combinations of micronutrients (Zn, Fe, Cu and B) and plant growth regulators (GA_3 and NAA) applied through foliar spray. The combined application of these components significantly enhanced vegetative growth, flowering behaviour, yield attributes and fruit quality compared to the sole application of the recommended dose of fertilizers (RDF). Among the treatments, T_9 (GA_3 @ 60 ppm + NAA @ 60 ppm + $ZnSO_4$ @ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%) recorded the highest plant height (115.22 cm), branches per plant (18.68), dry matter accumulation (212.32 g), earliness in 50% flowering (32.94 days), clusters per plant (13.92), flowers per cluster (4.96), fruits per plant (42.62), average fruit weight (88.83 g), fruit length (4.44 cm), fruit width (6.29 cm) and fruit yield (3.80 kg/plant; 181.42 kg/plot; 74.04 t/ha). The same treatment also improved total soluble solids (5.27 °Brix), ascorbic acid content (31.66 mg/100 g) and achieved the highest benefit–cost ratio (3.19). Overall, the foliar application of micronutrients (0.015%) in combination with plant growth regulators (60 ppm) proved most effective for enhancing growth, yield, quality and nutrient uptake in tomato cv. *Abhilash*.
***Keywords* :** Micronutrients, Plant growth regulators, soil fertility, tomato

Introduction

Tomato (*Solanum lycopersicum*) is one of the most widely cultivated horticultural crops globally, valued for its rich nutritional content and role as a "protective food." In India, it is a daily dietary staple used in soups, salads, pickles, sauces and ketchup, while also supporting the agro-processing sector through numerous value-added products. The crop thrives in warm climates, optimally between 21–24°C during the day and around 18°C at night, though temperatures above 35°C or humidity exceeding 90% can impair fertilization and fruit set. Adaptable to diverse soils and climates, tomato is cultivated across nearly all agricultural regions. Globally, it occupies about 5.16 million hectares, yielding 189.13 million tonnes annually (FAO, 2021). Production is concentrated in ten leading countries, with India ranking second, contributing 20.69 million tonnes (11.12%) of global output (FAO, 2021; Pravitha *et al.*, 2024). Karnataka ranks third among Indian states, producing 10.23% of the nation's total yield.

Deficiency of essential micronutrients such as zinc, iron, manganese, copper, boron and magnesium severely limits tomato growth, yield and fruit quality. These trace elements regulate vital physiological and metabolic processes essential for plant development.

Foliar application of zinc and boron significantly enhances fruit number, yield and quality by improving photosynthate translocation and accumulation (Shukla, 2011). Zinc oxide nanoparticles have also shown promising effects on tomato productivity and plant vigor (Ahmed *et al*., 2021). Zinc and boron play crucial roles in chlorophyll synthesis, photosynthesis and carbohydrate metabolism, leading to yield improvements of up to 20% (Singh *et al*., 2020). Boron governs cell wall formation, flowering and fruit initiation, while zinc promotes protein and enzyme activity. Copper, though vital for enzymatic functions and vitamin A synthesis, can be phytotoxic at excessive levels (Maksymiec, 1998).

Plant growth regulators (PGRs) like gibberellic acid (GA_3) and naphthalene acetic acid (NAA) play a vital role in regulating key developmental processes of tomato, including flowering, fruit set, ripening and storage physiology. Applications of GA_3 and NAA have been shown to enhance growth, fruit quality and yield under diverse conditions (Rodrigues *et al*., 2001; Ali *et al*., 2022). GA_3 promotes flowering and fruit development, particularly under heat stress, by compensating for natural hormone deficiencies (Liverman and Johnson, 1957; Singh and Choudhury, 1966). Similarly, NAA accelerates ripening and improves fruit quality (Pundir and Yadav, 2001). Foliar application of micronutrients and PGRs ensures rapid absorption, overcoming soil nutrient limitations and directly stimulating metabolic and reproductive processes, ultimately resulting in improved fruit set, yield and overall crop performance (Sultana *et al*., 2016).

Materials and Method

The current study was conducted during the mid-kharif season of 2024–2025 at the College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka. The experiment was laid out in a Randomized Block Design (RBD) with ten treatments, each replicated three times. The study was carried out using the tomato (*Solanum lycopersicum* L.) variety 'Abhilash' known for its good yield potential and adaptability to local conditions. Healthy, 21-day-old seedlings of *Abhilash* were raised from a disease-free nursery and selected for uniform growth and vigor before transplanting. The total number of plants in each experimental plot was 48, spaced at 90 cm × 45 cm. The experiment consist of 10 treatments *Viz*., T_1- GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$ @ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015 %, T_2- GA_3 @ 40ppm + NAA @ 40ppm + $ZnSO_4$ @ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015%, T_3- GA_3 @ 60ppm + NAA 60ppm + $ZnSO_4$ @ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015%, T_4- GA_3 @ 20ppm + NAA @ 20ppm + Boric acid @ 0.015%, T_5- GA_3 @ 40ppm + NAA @ 40ppm + Boric acid @ 0.015%, T_6- GA_3 @ 60ppm + NAA @ 60ppm + Boric acid @ 0.015%,T_7 - GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$ @ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%, T_8- GA_3 @ 40ppm + NAA @ 40ppm+ $ZnSO_4$ @ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%, T_9- GA_3 @ 60ppm + NAA @ 60ppm + $ZnSO_4$ @ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%, T_{10}- RDF (25tonnes of FYM/ha, 250:250:250 kg of NPK/ha). Well-decomposed farmyard manure was incorporated into the soil 15 days prior to transplanting to enrich the nutrient base and improve soil structure. Following planting, chemical fertilizers were applied, supplying 50% of the recommended nitrogen along with the full doses of phosphorus and potassium. The micronutrients and plant growth regulators were subsequently administered at three critical phenological stages, vegetative growth, flowering and fruit development stage, according to the prescribed treatment schedule ensuring a consistent and balanced nutrient supply throughout the crop growth period.

Some of the growth parameters like Plant height, Number of branches per plant and Dry matter per plant. Plant height was recorded with the help of a measuring tape Dry matter per plant (g $plant^{-1}$) was calculated based on plant density after five randomly selected plants from each plot were uprooted, cleaned, their fresh weights recorded and plant parts oven-dried at 65–70 °C until a constant weight was obtained.

The yield-attributing parameters recorded included Days to 50% flowering, number of clusters per plant, flowers per cluster, fruits per cluster, fruits per plant, fruit weight, fruit length, fruit width and fruit yield ($plant^{-1}$, $plot^{-1}$ and ha^{-1}). For biochemical analysis, five healthy fruits were randomly selected at full maturity, where total soluble solids (TSS) were determined using a hand refractometer and ascorbic acid content was estimated through titration with a standard dye to a stable pink endpoint, expressed as mg 100 g^{-1} fresh weight (Thimmaiah, 1999). Nutrient uptake in leaves, stems, roots and fruits was calculated by multiplying the oven-dried weight (65°C for 48 h) of each part with its respective nutrient concentration and expressed per hectare as kg ha^{-1} for macronutrients and g ha^{-1} for micronutrients.

The mathematical equation to calculate it is as follows.

$$\text{Ascorbic acid (mg 100g}^{-1}) = \frac{\text{Dye factor} \times \text{Titrate value} \times \text{Vol.made up}}{\text{Aliquot of extraction} \times \text{Weight of sample taken}} \times 100$$

$$\text{Acidity (\%)} = \frac{\text{T.V.} \times \text{Vol.made up} \times \text{N.of NaOH} \times \text{equivalent weight of acid}}{\text{Volume of aliquot} \times \text{Weight of sample taken} \times 1000} \times 100$$

Result and Discussion

The micronutrients and plant growth regulators had a significant impact on the growth parameters the maximum plant height (115.22 cm), Number of branches per plant (18.68) and Dry matter per plant (212.32 g) were recorded in T_9 (Table 1).

In the present study, the highest plant height was primarily due to the foliar application of micronutrients and plant growth regulators. This enhancement in vegetative growth can be attributed to the synergistic action of gibberellic acid and naphthalene acetic acid in promoting cell elongation and division, coupled with improved nutrient uptake and utilization facilitated by micronutrients, resulting in vigorous plant development (Bapu, 2018; Panda, 2019). Similar findings have been reported by several researchers who observed that foliar feeding with micronutrients in combination with growth promoters accelerates metabolic activities, chlorophyll synthesis and photosynthetic efficiency, thereby enhancing vegetative growth. The integrated use of GA_3 and NAA ensures a balanced hormonal environment that stimulates apical dominance and internodal elongation. Consequently, the plants exhibit enhanced vigor and biomass accumulation, contributing to overall growth improvement.

In the present study, the highest number of branches per plant was recorded due to the foliar application of micronutrients and plant growth regulators. This increase can be attributed to the synergistic action of gibberellic acid, naphthalene acetic acid and essential micronutrients, which stimulated active cell division and lateral bud proliferation, thereby enhancing branch formation. These findings agree with the earlier reports of Abhi (2018) and Kumar *et al.* (2024). The foliar application of micronutrients along with plant growth regulators markedly enhanced total dry matter in tomato plants. This improvement is attributed to the combined effect of gibberellic acid, naphthalene acetic acid and essential micronutrients, which promoted chlorophyll stability, efficient nutrient absorption and effective translocation of assimilates to vegetative tissues. Such synergistic interactions contributed to greater biomass accumulation, supporting vigorous plant growth. These results align with the findings of Kumar *et al.* (2024) and Pandiyan *et al.* (2018).

The Days to 50% flowering (25.67), number of clusters per plant (13.92), flowers per cluster (4.96) and fruits per cluster (3.89), the number of fruits per plant (42.62), average fruit weight (88.83), fruit length (4.44) and fruit width (6.29) were recorded in T_9 (Table 2), while the lowest values of 50% flowering, number of clusters per plant, flowers per cluster, fruits per cluster, number of fruits per plant, average fruit weight, fruit length and fruit width were observed in T_{10}.

The reduction in days to 50% flowering under T_9 treatment may be due to the stimulatory role of GA_3 and NAA in enhancing cell division and elongation, leading to faster growth and earlier transition from vegetative to reproductive phase. Micronutrients such as Zn and B further aid in hormonal regulation, enzyme activation and pollen development, which collectively hasten flowering. Improved photosynthetic activity and nutrient translocation also create favourable conditions for early floral bud initiation. These findings agree with the results of Pandey *et al.* (2022) and Ujjwal *et al.* (2018), who also reported that the combined application of growth regulators and micronutrients promoted early flowering in tomato. The increase in the number of clusters, flowers and fruits per cluster under T_9 treatment can be attributed to the combined influence of GA_3 and NAA, which stimulate floral initiation and improve fruit set by enhancing hormonal balance and reproductive efficiency. Micronutrients such as Zn, B and Fe play a crucial role in pollen viability, stigma receptivity and carbohydrate metabolism, thereby improving fertilization and fruit retention. Enhanced photosynthetic activity and translocation of assimilates towards developing flowers further contributed to higher reproductive success. These findings agree with Pandey *et al.* (2022), Kushwaha *et al.* (2025) and Kumar *et al.* (2024), who also reported improved flowering and fruiting traits with combined foliar supplementation of growth regulators and micronutrients.

The increase in the number of fruits per plant and average fruit weight under T_9 treatment may be due to the synergistic action of GA_3 and NAA in promoting efficient pollination, fruit set and retention by reducing abscission. Micronutrients such as Zn, B and Fe further supported these effects by enhancing enzymatic activities, chlorophyll synthesis and assimilate mobilization towards developing fruits. Improved nutrient uptake and photosynthetic efficiency ensured adequate carbohydrate supply, resulting in better fruit growth and size. These findings are in close agreement with Choudhary *et al.* (2024) and Ravat *et al.* (2022), who also reported enhanced fruit yield attributes with the combined use of growth regulators and micronutrients in tomato.

The significant increase in fruit length and width under T_9 treatment can be attributed to the synergistic influence of GA_3 and NAA, which stimulate rapid cell division and elongation, leading to enhanced fruit growth. Micronutrients such as Zn, B and Fe further complemented this effect by improving metabolic activity, hormonal balance and carbohydrate translocation towards developing fruits. Enhanced photosynthetic rate and efficient utilization of assimilates contributed to better fruit filling and uniformity. These findings agree with Ahmed *et al.* (2023) and Lakshmi *et al*. (2022), who also reported that foliar supplementation of growth regulators along with micronutrients significantly improved fruit size and shape in tomato.

The micronutrients and plant growth regulators had a significant impact on the yield parameters, the maximum yield per plant (3.80 kg/plant), per plot (181.42 kg/plot) and per hectare (74.04 t/ha) were recorded in T_9 (Table 3). while the lowest Fruit yield per plant, per plot and per ha were observed in T_{10}.

The yield of tomato, evaluated per plant, per plot and per hectare, varied significantly among the treatments, with T_9 recording the highest values. This enhanced performance is attributed to the combined effect of growth regulators, which promoted flowering intensity, fruit set and retention, along with micronutrients that improved nutrient uptake, translocation and metabolic efficiency. The synergistic action of these treatments facilitated increased fruit number and size, leading to greater overall productivity. Additionally, improved physiological and biochemical functioning under this treatment likely contributed to sustained growth and higher biomass accumulation. These results agree with the findings of Pramanik *et al*. (2017), Kumar *et al*. (2024).

The micronutrients and plant growth regulators had a significant impact on the quality parameters, the maximum TSS (5.27 ^{0}Brix) and Ascorbic acid (31.66 mg/100g) were recorded in T_9 (Table 3). while the lowest TSS and Ascorbic acid were observed in T_{10}.

Significant variations in ascorbic acid and total soluble solids were observed among treatments, with T_9 recording the highest values of 31.66 mg/100 g and 5.27°Brix, respectively. This improvement may be due to the synergistic action of GA_3, NAA and micronutrients enhancing carbohydrate metabolism and sugar accumulation. Growth regulators stimulate antioxidant activity, resulting in higher ascorbic acid synthesis. Micronutrients improve photosynthesis and assimilate translocation, enriching fruit quality. These findings are consistent with Mellidou *et al*. (2021) and Rahman *et al*. (2019). The micronutrients and plant growth regulators had a significant influence on the economics (Table 3) and nutrient uptake of tomato. The highest values for both parameters were recorded in treatment T_9 (Table 4 and 5).

Despite incurring the highest cost of cultivation (Rs. 2,55,012 ha^{-1}), treatment T_9 recorded exceptional profitability. It produced a gross return of Rs. 8,14,435.63 ha^{-1}, a net return of Rs. 5,59,423.63 ha^{-1} and a B:C ratio of 3.19, outperforming all other treatments. This superior economic performance is attributed to enhanced photosynthesis, efficient nutrient utilization and improved fruit set. The combined improvement in yield quantity and quality contributed to higher revenue generation. These results agree with Raj *et al.* (2019) and Sathiyamurthy *et al.* (2017).

The highest uptake of nutrients like nitrogen (81.55 kg ha^{-1}), phosphorus (14.22 kg ha^{-1}), potassium (87.64 kg ha^{-1}), calcium (8.84 kg ha^{-1}), magnesium (4.69 kg ha^{-1}) and sulphur (7.52 kg ha^{-1}) was recorded under treatment T_9. This superior nutrient absorption can be attributed to the combined foliar application of GA_3, NAA and micronutrients, which enhanced root metabolic activity and increased membrane permeability, allowing more efficient uptake of nutrients from the soil. Additionally, the synergistic action of growth regulators and micronutrients stimulated enzymatic activities and promoted effective translocation of nutrients within plant tissues. As a result, both macro- and micronutrients accumulated at higher levels compared to other treatments. These observations are consistent with the findings of Dixit *et al*. (2018) and Thakur and Singh (2024). Treatment T_9 recorded the highest uptake of micronutrients, with zinc (41.88 ppm), iron (187.96 ppm), copper (13.87 ppm), manganese (87.39 ppm) and boron (52.98 ppm) showing maximum values. This superior uptake is attributed to the combined effect of foliar micronutrient application and growth regulators, where foliar feeding enabled direct absorption and GA_3 and NAA enhanced enzymatic activity, membrane permeability and root metabolism. The coordinated nutrient supply under T_9 promoted efficient translocation and accumulation of micronutrients, whereas the control (T_{10}) showed the lowest uptake. These findings agree with Ahmed *et al.* (2023) and Arifur *et al*. (2024).

Conclusion

Integrating the cumulative findings, it is evident that treatment T_9, comprising GA_3 @ 60 ppm + NAA @ 60 ppm + $ZnSO_4$ @ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%, exerted a highly beneficial effect on tomato growth and productivity. Foliar application of these growth regulators and micronutrients enhanced nutrient bioavailability, stimulated root and shoot development and promoted cell division and elongation. The treatment also accelerated flowering, improved fruit set and reduced flower and fruit drop, leading to higher fruit number, size and quality. Consequently, both quantitative and qualitative yield parameters improved, reflecting a synergistic enhancement of physiological, biochemical and agronomic performance, demonstrating the integrated advantage of combining PGRs with micronutrients for optimum tomato productivity.

Table 1: Plant height, number of branches per plant and dry matter per plant as influenced by foliar application of micronutrients and plant growth regulators

Treatment	Plant height (cm)	Number of branches	Dry matter per plant (g)
T_1	100.24	16.32	184.26
T_2	105.70	17.41	188.92
T_3	110.06	17.89	206.49
T_4	95.56	15.56	179.21
T_5	99.38	16.39	183.73
T_6	103.11	17.15	196.29
T_7	104.39	17.39	188.12
T_8	109.28	17.70	198.97
T_9	115.22	18.68	212.32
T_{10}	89.89	13.22	165.32
S. Em±	**1.44**	**0.25**	**3.02**
CD at 5 %	**4.35**	**0.75**	**9.07**

T_1- GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015 %
T_2- GA_3 @ 40ppm + NAA @ 40ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015%
T_3- GA_3 @ 60ppm + NAA 60ppm + $ZnSO_4$0.015% + $CuSO_4$ 0.015% + $FeSO_4$ @0.015%
T_4- GA_3 @ 20ppm + NAA @ 20ppm + Boric acid @ 0.015%
T_5- GA_3 @ 40ppm + NAA @ 40ppm + Boric acid@ 0.015%
T_6- GA_3 @ 60ppm + NAA @ 60ppm + Boric acid @ 0.015%
T_7 – GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_8- GA_3 @ 40ppm + NAA @ 40ppm+ $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_9- GA_3 @ 60ppm + NAA @ 60ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_{10}- RDF (25tonnes of FYM/ha, 250:250:250 kg of NPK/ha)

Table 2: Yield attributes as influenced by foliar application of micronutrients and plant growth regulators

Treatment	Days to 50% flowering	clusters per plant	Flowers per cluster	Fruits per cluster	Fruits per plant	Fruit weight
T_1	37.44	10.92	3.72	2.61	38.67	82.72
T_2	35.59	11.75	4.06	2.80	39.78	84.43
T_3	33.28	12.92	4.52	3.11	41.22	86.58
T_4	38.00	10.64	3.33	2.50	37.67	81.11
T_5	36.67	11.42	3.62	2.67	38.22	82.22
T_6	34.77	12.00	3.94	2.94	39.22	84.11
T_7	35.64	12.08	4.11	2.83	39.50	85.98
T_8	34.61	12.45	4.43	3.06	40.90	86.43
T_9	32.94	13.92	4.96	3.89	42.62	88.83
T_{10}	39.33	9.83	2.94	2.00	32.11	78.93
S. Em±	**0.79**	**0.22**	**0.14**	**0.20**	**0.38**	**0.64**
CD at 5%	**2.38**	**0.67**	**0.42**	**0.61**	**1.14**	**1.93**

T_1- GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015 %
T_2- GA_3 @ 40ppm + NAA @ 40ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015%
T_3- GA_3 @ 60ppm + NAA 60ppm + $ZnSO_4$0.015% + $CuSO_4$ 0.015% + $FeSO_4$ @0.015%
T_4- GA_3 @ 20ppm + NAA @ 20ppm + Boric acid @ 0.015%
T_5- GA_3 @ 40ppm + NAA @ 40ppm + Boric acid@ 0.015%
T_6- GA_3 @ 60ppm + NAA @ 60ppm + Boric acid @ 0.015%
T_7 – GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_8- GA_3 @ 40ppm + NAA @ 40ppm+ $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_9- GA_3 @ 60ppm + NAA @ 60ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_{10}- RDF (25tonnes of FYM/ha, 250:250:250 kg of NPK/ha)

Table 3: Yield attributes, quality attributes and economics of tomato as influenced by micronutrients and plant growth regulators

Treatment	Fruit length	Fruit width	Tomato yield			TSS (°Brix)	Ascorbic acid (mg/100g)	B:C ratio
			Per plant	Per plot	Per ha			
T_1	3.81	6.01	3.19	153.55	62.65	3.99	29.72	2.72
T_2	3.89	6.03	3.38	161.18	65.73	4.21	30.08	2.80
T_3	4.12	6.16	3.59	171.36	69.94	4.89	30.63	3.02
T_4	3.66	5.82	3.05	146.61	59.79	3.83	29.08	2.60
T_5	3.72	5.89	3.13	150.80	61.51	3.94	29.75	2.67
T_6	4.06	6.07	3.26	158.28	64.57	4.24	30.44	2.90
T_7	3.92	5.99	3.36	163.09	66.55	4.34	30.09	2.84
T_8	4.08	6.08	3.54	169.81	69.37	4.70	30.54	3.00
T_9	4.44	6.29	3.80	181.42	74.04	5.27	31.66	3.19
T_{10}	2.80	5.40	2.53	121.61	49.61	3.41	27.61	2.17
S. Em±	**0.05**	**0.9**	**0.06**	**2.74**	**1.18**	**0.15**	**0.26**	**-**
CD at 5 %	**0.15**	**0.27**	**0.18**	**8.23**	**3.54**	**0.46**	**0.79**	**-**

T_1- GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015 %
T_2- GA_3 @ 40ppm + NAA @ 40ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015%
T_3- GA_3 @ 60ppm + NAA 60ppm + $ZnSO_4$0.015% + $CuSO_4$ 0.015% + $FeSO_4$ @0.015%
T_4- GA_3 @ 20ppm + NAA @ 20ppm + Boric acid @ 0.015%
T_5- GA_3 @ 40ppm + NAA @ 40ppm + Boric acid@ 0.015%
T_6- GA_3 @ 60ppm + NAA @ 60ppm + Boric acid @ 0.015%
T_7 – GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_8- GA_3 @ 40ppm + NAA @ 40ppm+ $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_9- GA_3 @ 60ppm + NAA @ 60ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_{10}- RDF (25tonnes of FYM/ha, 250:250:250 kg of NPK/ha)

Table 4: Effects of micronutrients and plant growth regulators on macronutrients uptake (kg ha^{-1}) of tomato plants

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca (kg ha^{-1})	Ma (kg ha^{-1})	S (kg ha^{-1})
T_1	55.43	14.62	77.57	9.41	2.59	4.09
T_2	59.61	15.91	83.67	11.05	3.31	5.20
T_3	74.35	19.20	98.38	14.19	4.84	6.68
T_4	49.57	10.92	69.11	8.19	1.90	1.88
T_5	53.43	11.88	74.06	8.85	2.36	2.43
T_6	65.70	14.65	88.40	12.18	3.92	3.40
T_7	61.20	15.43	80.42	10.46	3.06	4.64
T_8	68.31	17.73	92.38	13.06	4.50	5.70
T_9	81.55	20.44	103.54	15.10	5.47	7.51
T_{10}	42.20	8.85	58.68	5.74	1.02	0.83
S. Em±	**2.53**	**0.87**	**1.81**	**0.47**	**0.21**	**0.45**
CD at 5 %	**7.59**	**2.60**	**5.42**	**1.41**	**0.62**	**1.34**

T_1- GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015 %
T_2- GA_3 @ 40ppm + NAA @ 40ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015%
T_3- GA_3 @ 60ppm + NAA 60ppm + $ZnSO_4$0.015% + $CuSO_4$ 0.015% + $FeSO_4$ @0.015%
T_4- GA_3 @ 20ppm + NAA @ 20ppm + Boric acid @ 0.015%
T_5- GA_3 @ 40ppm + NAA @ 40ppm + Boric acid@ 0.015%
T_6- GA_3 @ 60ppm + NAA @ 60ppm + Boric acid @ 0.015%
T_7 – GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_8- GA_3 @ 40ppm + NAA @ 40ppm+ $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_9- GA_3 @ 60ppm + NAA @ 60ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_{10}- RDF (25tonnes of FYM/ha, 250:250:250 kg of NPK/ha)

Table 5: Effects of micronutrients and plant growth regulators on micronutrients uptake (g ha^{-1}) of tomato plants

Treatment	Zn (g ha^{-1})	Fe (g ha^{-1})	Cu (g ha^{-1})	Mn (g ha^{-1})	B (g ha^{-1})
T_1	130.18	291.53	18.33	174.84	64.74
T_2	135.79	301.17	19.68	183.08	67.89
T_3	156.27	332.12	23.69	211.59	77.28
T_4	96.02	255.70	14.99	164.67	86.62
T_5	104.35	264.04	15.83	174.15	90.42
T_6	118.49	284.78	17.41	194.28	98.20
T_7	133.47	299.17	19.30	182.21	91.27
T_8	149.89	318.41	21.80	199.78	98.63
T_9	165.76	343.57	25.63	222.90	107.51
T_{10}	79.30	217.88	11.60	143.23	50.88
S. Em±	**3.88**	**5.01**	**0.83**	**2.76**	**3.15**
CD at 5%	**11.63**	**15.01**	**2.48**	**8.27**	**9.44**

T_1- GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015 %
T_2- GA_3 @ 40ppm + NAA @ 40ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015%
T_3- GA_3 @ 60ppm + NAA 60ppm + $ZnSO_4$0.015% + $CuSO_4$ 0.015% + $FeSO_4$ @0.015%
T_4- GA_3 @ 20ppm + NAA @ 20ppm + Boric acid @ 0.015%
T_5- GA_3 @ 40ppm + NAA @ 40ppm + Boric acid@ 0.015%
T_6- GA_3 @ 60ppm + NAA @ 60ppm + Boric acid @ 0.015%
T_7 – GA_3 @ 20ppm + NAA @ 20ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_8- GA_3 @ 40ppm + NAA @ 40ppm+ $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_9- GA_3 @ 60ppm + NAA @ 60ppm + $ZnSO_4$@ 0.015% + $CuSO_4$ @ 0.015% + $FeSO_4$ @ 0.015% + Boric acid @ 0.015%
T_{10}- RDF (25tonnes of FYM/ha, 250:250:250 kg of NPK/ha)

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