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Impact of Different Sources of Boron on Yield and Quality of Tomato cv. Anand Roma

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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

In India, tomato occupies a prominent position among vegetable crops due to its wide adaptability, high yield potential, and economic returns. Among essential micronutrients, boron plays a pivotal role in plant growth and development. In Indian soils, boron deficiency has been observed to range from 2.9% to 60.0%. The study aims to investigate the impact of different sources of boron on the yield and quality of the tomato cv. Anand Roma. A field experiment was conducted during the *Kharif–Rabi* seasons of 2023–24 and 2024–25 at Horticulture Research Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The data recorded from the various observations were tabulated and then subjected to statistical analysis by using the method of analysis of variance (ANOVA). The experiment was laid out in a Randomized Block Design with

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three replications and comprised nine treatments: T_1 – absolute control, T_2 – foliar spray of borax @ 0.2%, T_3 – foliar spray of boric acid @ 0.2%, T_4 – foliar spray of nano boron @ 100 ppm, T_5 – foliar spray of nano boron @ 200 ppm, T_6 – foliar spray of nano boron @ 300 ppm, T_7 – foliar spray of nano boron @ 400 ppm, T_8 – soil application of 1 kg boron through borax, and T_9 – soil application of 1 kg boron through boric acid. Foliar sprays were carried out at 40, 55, and 70 days after transplanting. The highest fruit equatorial diameter (4.83 cm), polar diameter (7.71 cm), fruit volume (86.61 cc), number of fruits per plant (33.76), fruit weight (85.14 g), and maximum yield per ha (432.21 q) was obtained with treatment T_4 (foliar application of nano boron @ 100 ppm) while, the highest TSS (5.56 ^{0}Brix), lycopene (20.58 mg/100g), maximum total sugar content in fruit (0.86 %) and minimum titrable acidity content in fruit (0.42 %) was found in treatment T_5 (Foliar spray of nano boron @ 200 ppm). From the present investigation, it can be concluded that among different sources of boron, foliar spray of nano boron @ 100 ppm or borax @ 0.2 % at 40, 55 and 70 DATP observed maximum yield parameters and yield, while better quality parameters were found with foliar spray of nano boron @ 200 ppm at 40, 55 and 70 DATP.

Keywords: Nano boron; borax; boric acid; tomato; yield; quality.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops grown worldwide, valued both as a fresh vegetable and as a raw material for processing industries. It originated in the Andean region of South America, and is the second most cultivated vegetable crop throughout the world, following the potato, with approximately 181 million tonnes from 5 Mha, according to the Food and Agriculture Organisation Statistics (FAOSTAT) (Panno et al., 2021; Yue et al., 2023). It is a rich source of vitamins A and C, lycopene, and other antioxidants, contributing significantly to human nutrition. In India, tomato occupies a prominent position among vegetable crops due to its wide adaptability, high yield potential, and economic returns. However, achieving optimum yield and quality depends greatly on balanced nutrition and efficient nutrient management practices.

Among essential micronutrients, boron plays a pivotal role in plant growth and development. Also, Boron plays an important role in regulating plant hormone levels and promoting proper growth. Boron increases flower production and retention, pollen tube elongation and germination, and seed and fruit development. It is a component of plant cell walls and reproductive structures. It is a mobile nutrient within the soil (Singh & Umesha, 2023). It is involved in cell wall synthesis, sugar translocation, membrane integrity, pollen germination, and fruit and seed development (Tripathi et al., 2015). Deficiency of boron is frequently reported in coarse-textured soils, alkaline soils, and regions with low organic matter, leading to poor flowering, reduced fruit set, cracking, and inferior fruit quality in tomato. In Indian soils, boron deficiency has been observed to range from 2.9% to 60.0% (Shukla and Tiwari 2016).

Boron is vital for optimal crop growth and soil health, with its distribution influenced by several factors such as soil properties, environmental conditions, and land management practices. Therefore, understanding its distribution is crucial for developing effective soil management strategies (Tlili et al., 2025). Several sources of boron are available for agricultural use, including borax, boric acid, and advanced formulations such as nano-boron. However, these sources often suffer from low use efficiency due to leaching losses and limited availability in soil. Recent advancements in nanotechnology have introduced nano-boron formulations, which are expected to enhance nutrient uptake, improve efficiency, and reduce application rates owing to their higher surface area and controlled release characteristics. Evaluating the relative effectiveness of different boron sources is therefore crucial for optimising tomato production.

In recent years, nanotechnology-based nutrient formulations have emerged as a novel approach to enhance nutrient use efficiency. Nanoboron, owing to its ultra-small particle size, higher surface area, and controlled release properties, has the potential to improve absorption and translocation within plants, thereby enhancing growth, yield, and quality parameters at relatively lower doses compared to conventional sources.

2. MATERIALS AND METHODS

The field investigation was conducted during the *Kharif–Rabi* seasons of 2023–24 and 2024–25 at the Horticulture Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The tomato variety Anand Roma was used as the test crop. This variety was released in 2021 by the Main Vegetable Research Station, Anand Agricultural University, Anand, Gujarat. Seedlings of tomato were transplanted at a spacing of 90 × 60 cm. The experiment was laid out in randomized block design with three replications and comprised nine treatments: T_1 – absolute control, T_2 – foliar spray of borax @ 0.2%, T_3 – foliar spray of boric acid @ 0.2%, T_4 – foliar spray of nano boron @ 100 ppm, T_5 – foliar spray of nano boron @ 200 ppm, T_6 – foliar spray of nano boron @ 300 ppm, T_7 – foliar spray of nano boron @ 400 ppm, T_8 – soil application of 1 kg boron through borax, and T_9 – soil application of 1 kg boron through boric acid. Foliar spray of borax, boric acid, and nano-boron (as per treatment) was carried out three times at 40, 55, and 70 days after transplanting. All other recommended agronomic and plant protection practices were uniformly adopted for raising a healthy crop.

Observations on yield and quality parameters were recorded from five randomly tagged plants per treatment. For quality analysis, five fruits per treatment were randomly sampled, and all measurements were taken at the time of the third picking. For yield parameters, at the 3rd picking, five fruits from each randomly selected plant were taken for determining equatorial diameter. Each tomato fruit was placed on a flat surface and the equatorial diameter (the widest horizontal distance across the centre) was measured using a digital calliper and expressed in centimetres. The polar diameter was recorded as the distance from the stem end to the blossom end of the fruit, which was measured with a digital calliper and expressed in centimetres. Fruit volume was measured using the water displacement method. The average volume of fruits was calculated and expressed in cubic centimetres (cc). The number of fruits per plant was recorded at each harvest from five previously tagged plants, summed across pickings, and the mean value was expressed as fruits per plant. For determining average fruit weight, ten representative fruits from each tagged plant were weighed using a digital balance and the mean was expressed in grams. The total fruit yield from each net plot was recorded at every picking, and the cumulative yield was converted to quintals per hectare. Total Soluble Solids (TSS) of tomato fruit juice, expressed as °Brix, were measured using a hand refractometer. For lycopene Acetone extraction method and for the titrable acidity procedure given by Ranganna (1986) was adopted. The total soluble sugars were determined by using the phenol-sulfuric acid method as given by Dubois et al. (1956). The data recorded from the various observations were tabulated and then subjected to their statistical analysis by using the method of analysis of variance (ANOVA), and the pooled analysis over the years was carried out as described by Panse and Sukhatme (1967).

3. RESULTS AND DISCUSSION

3.1 Yield Parameters

The highest fruit equatorial diameter (4.83 cm), polar diameter (7.71 cm), and fruit volume (86.61 cc) were obtained with treatment T_4 (foliar application of nano boron @ 100 ppm), which was statistically at par with T_2 (Foliar spray of borax @ 0.2%) and T_3 (Foliar spray of boric acid @ 0.2%). The increase in fruit length may be due to enhanced accumulation of photosynthates, produced in the leaves and subsequently transported to the fruit, which ultimately increases fruit length. These findings are consistent with those reported by Salam et al. (2010) and Ali et al. (2015) in tomato.

Treatment T_4 (foliar spray of nano boron @ 100 ppm) recorded the highest number of fruits per plant (33.76), maximum fruit weight (85.14 g) and fruit yield per hectare (432.21 q). This treatment was found statistically at par with T_2 (foliar spray of borax @ 0.2%). The application of boron improves fruit set by reducing flower drop, which likely results in a higher number of flowers and fruits per cluster. This result is closely matched with Ibrahim & Farttoosi (2019) in mung bean when nano boron was applied. The gradual release of nano-fertilisers during the fruit growth period supports a steady supply of nutrients to the fruit mesocarp, effectively fulfilling the requirements for cell division and enlargement. This aligns with earlier research indicating that nano-fertilisers are absorbed more quickly and efficiently by plants to address their nutritional demands (Abd-Elall, 2018 in olive and Sayed & Gomaa, 2024 in date palm).

Table 1. Influence of different sources of boron on yield parameters of tomato (Two years pool data)

Treatments		Fruit equatorial diameter (cm)	Fruit polar diameter (cm)	Fruit volume (cc)	No. of fruits per plant	Fruit weight (g)	Fruit yield (q/ha)
T_1	Absolute control	3.63	6.55	69.47	24.36	62.72	310.48
T_2	Foliar spray of borax @ 0.2 %	4.58	7.53	82.52	30.72	78.18	413.95
T_3	Foliar spray of boric acid @ 0.2 %	4.50	7.43	80.58	29.01	74.10	381.24
T_4	Foliar spray of nano boron @ 100 ppm	4.83	7.71	86.61	33.76	85.14	432.21
T_5	Foliar spray of nano boron @ 200 ppm	4.31	7.22	77.24	27.99	73.76	366.94
T_6	Foliar spray of nano boron @ 300 ppm	3.86	6.82	75.40	26.53	71.07	339.78
T_7	Foliar spray of nano boron @ 400 ppm	3.81	6.69	70.30	25.06	70.46	333.86
T_8	Soil application of 1 kg boron through borax	4.29	7.15	76.68	27.15	71.95	354.19
T_9	Soil application of 1 kg of boron through boric acid	3.94	7.01	76.23	26.87	71.54	346.51
S.Em.±	**Y**	0.05	0.04	0.99	0.58	1.98	6.59
	T	0.12	0.10	2.10	1.24	2.54	13.99
	Y×T	0.17	0.14	2.97	1.75	3.59	19.79
C.D.at5 %	**Y**	0.16	NS	NS	NS	NS	19.00
	T	0.34	0.29	6.06	3.57	7.32	40.32
	Y×T	NS	NS	NS	NS	NS	NS
CV %		7.03	3.55	6.67	10.87	8.50	9.41

Table 2. Influence of different sources of boron on quality parameters of tomato (Two years pool data)

Treatments		TSS (^{0}Brix)	Lycopene (mg/100 g)	Total sugar (%)	Titrable acidity (%)
T_1	Absolute control	4.62	13.79	0.60	0.53
T_2	Foliar spray of borax @ 0.2 %	5.36	19.03	0.75	0.44
T_3	Foliar spray of boric acid @ 0.2 %	5.19	18.28	0.75	0.44
T_4	Foliar spray of nano boron @ 100 ppm	5.43	19.92	0.76	0.43
T_5	Foliar spray of nano boron @ 200 ppm	5.56	20.58	0.86	0.42
T_6	Foliar spray of nano boron @ 300 ppm	4.72	17.24	0.72	0.47
T_7	Foliar spray of nano boron @ 400 ppm	4.59	16.74	0.63	0.50
T_8	Soil application of 1 kg boron through borax	5.00	18.02	0.73	0.46
T_9	Soil application of 1 kg of boron through boric acid	4.78	18.15	0.72	0.46
S.Em.±	**Y**	0.03	0.18	0.01	0.003
	T	0.06	0.38	0.01	0.007
	Y×T	0.09	0.54	0.02	0.01
C.D.at 5 %	**Y**	0.08	0.52	NS	0.01
	T	0.18	1.11	0.03	0.02
	Y×T	NS	NS	NS	NS
CV %		3.15	5.27	4.38	3.92

3.2 Quality Parameter

The highest TSS (5.56 ^{0}Brix) and lycopene (20.58 mg/100g) were found in treatment T_5 (Foliar spray of nano boron @ 200 ppm), which was found statistically at par with treatment T_4 (Foliar spray of nano boron @ 100 ppm). The increase in TSS might be due to the application of nano boron, which easily absorbs by the leaves, which play a role in enhancing carbohydrate metabolism, sugar translocation, and photosynthetic efficiency. Lycopene synthesis in tomato fruits is connected to the plant's carbohydrate levels and general metabolic condition. These findings are consistent with the results reported by Rajani et al. (2022) in tomato and Vishekai et al. (2019) in olive with application of nano boron.

Maximum total sugar (0.86 %) was found in treatment T_5 (Foliar spray of nano boron @ 200 ppm). This might be due to the use of nano boron, which can promote the activation of genes and enzymes involved in carbohydrate metabolism, thereby boosting the production and build-up of total sugars. This finding is consistent with the results reported by Rajani et al. (2022) in tomato

Minimum titrable acidity (0.42 %) was found in treatment T_5 (Foliar spray of nano boron @ 200 ppm), which was found statistically at par with treatment T_4 (Foliar spray of nano boron @ 100 ppm), T_2 (Foliar spray of borax @ 0.2 %) and T_3 (Foliar spray of boric acid @ 0.2%). The lower acidity in fruit juice might be due to their utilisation in respiration and the rapid metabolic transformation of organic acids into sugars. Similar results were also reported by Genaidy et al. (2020) in olive.

4. CONCLUSION

From the present investigation, it can be concluded that among different sources of boron, foliar spray of nano boron @ 100 ppm or borax @ 0.2 % at 40, 55 and 70 DATP observed maximum yield parameters and yield, while better quality parameters were found with foliar spray of nano boron @ 200 ppm at 40, 55 and 70 DATP.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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