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Impact of Various Concentrations of Foliar Boron and Zinc on Growth and Productivity of Tomato cv. NS4266 in a Naturally Ventilated Polyhouse

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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 study highlights the effect of Micronutrient Zinc and Boron on Growth, Yield, and Quality Parameters of Tomato (*Solanum lycopersicum* L.) under Naturally Ventilated Polyhouse Conditions. Study was conducted during the winter season of 2023-2024 at the Vegetable

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Research Farm, Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kalyanpur, Kanpur. The experimental design employed was a randomized block design comprising nine treatment combinations, each replicated three times. The investigation evaluated the impact of various concentrations of zinc and boron (0.1% and 0.2%) on the growth, yield, and quality attributes of tomato cultivar NS 4266 grown under polyhouse conditions. The results showed that the highest plant height (232.533 cm), earliest flowering (28 days), thickest stem girth (25.367 cm), and shortest internodal length (8.533 cm) were recorded with the combination of 0.2% zinc and 0.2% boron. Yield parameters indicated the highest number of clusters per plant (12.600), fruits per plant (64.5), fruits per cluster (13.467), polar diameter (6.367 cm), equatorial diameter (7.600 cm), average fruit weight (88.333g), and fruit yield per plant (13.300 kg) and per 1000 m² (262.267 kg) with the same treatment. Quality parameters, including maximum shelf life (9 days), total chlorophyll content (1.800 mg/g), and total soluble solids (8.233 ºBrix), were also superior when zinc and boron were applied at 0.2%.

Keywords: Tomato; micronutrient; growth; quality and yield.

1. INTRODUCTION

"The tomato *(Solanum lycopersicon* Mill.) is one of the world's most important vegetables, with a total production of about 186.8 million metric tons in 2020" (FAOSTAT, 2021). "Depending on the situation, tomatoes can be classified as either a fruit or a vegetable. Tomatoes are a fruit, but supermarkets designate them as vegetables because of their flavor and nutritional value, according to Encyclopedia Britannica Because of its great nutritional content and versatility in the kitchen, this member of the Solanaceae family is consumed both raw and processed in a variety of forms, such as salads, soups, and sauces" (Shukla et al., 2017). Antioxidant is an outstanding property of tomato (Borguini & Ferraz Da Silva Torres, 2009), "The major advantages of protected cultivation is to increase the photosynthesis efficiency rate and decreasing the rate of transpiration" (Kumar et al., 2017). "Through photosynthesis of green plants its yield contributing character, fruit set, and fruit yield of tomato are expanded with the use of foliar application" (Adams, 2004). In order to complete its life cycle, tomatoes require both macro and micronutrients (Fageria, 1992; Brady & Weil, 2002). "Tomato growth and yield can be greatly impacted by nutrient shortages, which can lower productivity and quality. Micronutrients like Zinc, Iron, Manganese, Copper, Boron and Magnesium have an important role in the physiology of tomato crop and are required for physiological activities Researchers have recently found the impact of zinc oxide nanoparticles in tomatoes" (Ahmed et al., 2021). "Zinc (Zn) and boron (B) are critical plant elements that are needed for proper growth and development of plants and play important roles in numerous physiological processes" (Singh et al., 2020). "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 up to 20 per cent but also helpful to sustain crop production It is involved in various metabolic processes, including chlorophyll production, photosynthesis, and carbohydrate metabolism. Boron, another essential micronutrient, is necessary for cell division, cell wall synthesis, and pollen germination" (Camacho-Critobal et al., 2008). If the optimum dose of boron is not apply then toxicity effects may appears (Gupta, 1993; Marschner, 1989). Due to deficiency of boron different kinds of disorder are occurs like Shoulder check crack and minimize by the application of boron (Huang & Snapp, 2004). "Inadequate availability of zinc and boron in the soil can limit their uptake by tomato plants, resulting in nutrient deficiencies and subsequent negative impacts on growth and yield. Foliar application of zinc and boron has been widely recognized as an effective strategy to enhance nutrient uptake and address deficiencies in crops, including tomatoes" (Shukla et al., 2017). After utilizing these micronutrients, the yield and quality of tomato is improved (Ali et al., 2008). Observations were recorded for different traits. At the stage of last picking plant height was measured by meter (m) from ground level to tip of the main shoot with the help of meter tape. The number of days taken from the date of sowing to date on which first flower appeared in each plot were recorded as days to first flowering. The total number of fruits from five randomly selected plant were weighed and Total weight of fruits of the five randomly selected plants was recorded and the average yield of fruits per plant was worked out in Quintal (Q) by summing up of all the pickings.

2. MATERIALS AND METHODS

Experimental site and location: The present investigation entitled "Effect of micronutrient (zinc and boron) on growth, quality and yield parameters on tomato (*Solanum lycopersicon* L.) in naturally ventilated polyhouse" was conducted during rabi season 2023-2024 at vegetable research farm, Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kalyanpur, Kanpur. The experiment laid out into randomized block design (RBD) with 3 replications and consisted of 9 treatment *viz.* T_1 Zn 0.0%+ B 0.0%, T_2 Zn 0.0% + B 0.1% , T_3 Zn 0.0%+ B 0.2%,T_4 Zn 0.1% + B 0.0% , T_5 Zn 0.1%+ B 0.1%, T_6 Zn 0.1% + B 0.2% , T_7 Zn 0.2%+ B 0.0% , T_8 Zn 0.2% +B 0.1% , T_9 Zn 0.2%+ B 0.2%.

2.1 Observations Recorded

Growth and yield parameters: Among the growth and yield parameters following parameters were observed *viz.* plant height, (metre) internodal length (centimetre), days to first flowering, stem girth (centimetre), cluster per plant, fruit number per plant, polar diameter (centimetre), equatorial diameter (centimetre), average fruit weight (gram), fruit yield (Q), fruit yield per 1000m^2(Q)

Quality parameter: Among the quality parameter following parameters were observed *viz.* shelf life, total soluble solid (°brix) total chlorophyll content

3. RESULTS AND DISCUSSION

3.1 Effect on Vegetative Parameters

Plant height: The results obtained under these vegetative parameters were accentuated and significantly prejudiced by different foliar application of micronutrient under protected culture in the present study. The robust vegetative growth is an essential prerequisite for better yield. After 85 days of transplanting when plant height was measured it was highest in treatment T_9 (232.533) [0.2% zinc and 0.2% boron] which remained at par with treatment T_8 (Zinc (0.2% + boron 0.1%), T_7 (Zinc (0.2%) + boron 0.0%). The lowest height of plant is observed in treatment T_1 (180.5) control which remained at par with treatment T_4 (Zinc 0.1%+Boron 0.1%), T_2 (Zinc0.0% + Boron 0.1%). Similar research has been made by Naga et al. (2013), Singh and Tiwari (2013).

Days to first flowering: After 85 days of transplanting when days to first flowering was observed it was found highest in T_9 (Zinc 0.2% + Boron 0.1%) which remained at par with T_8 (Zinc 0.2% + Boron 0.1%), T_7 (Zinc 0.2%+ Boron 0.0%). The lowest days to first flowering was observed in treatment T_2 (Zinc 0.0%+0.1%) which remained at par with T_3 (Zinc 0.0% + Boron 0.2%). Similar research has been made by Mallick and Muthukrishnan (1980).

Stem girth(cm): After 85 days of transplanting when stem girth was observed it was found highest in treatment T_9 (Zinc 0.2% + Boron 0.2%) at par with T_8 (Zinc 0.2% + Boron 0.1%), T_6 (Zinc 0.1% + Boron 0.2%). The lowest value of stem girth is found in treatment T_1(control) which remained at par with T_4(Zinc 0.1% +Boron 0.0%), T_3(Zinc 0.0% +Boron 0.2%). highest in treatment T_9 (Zinc 0.2% + Boron 0.2%) which remained at par withT_8 (Zinc 0.2% + Boron 0.1%). The lowest value of stem girth is found in treatment T_1(control spray) which remained at par with treatment T_2 (Zinc 0.0% +Boron 0.1%).

Internodal length (cm): After 85 days of transplanting when internodal length was observed it was found highest in treatment T_9(Zinc 0.2% + Boron 0.2%) which is 8.533 remain at par with treatment T_8(8.400), the lowest internodal length was found in treatment T_1(control) without any nutrient which was 6.4 remain at par with treatment T_2(0.0% Zinc + 0.1% Boron) (6.633).

3.2 Effect on Quality Parameters

Shelf life: After 85 days of transplanting shelf life was observed which was found highest in treatment T_9(9.00) (Zinc 0.2%+Boron 0.2%) which remained at par with treatment T_8(Zinc 0.2% + Boron 0.1%). The lowest shelf life was obtained in treatment T_1 (7.00) (control spray) which remain at par with treatment T_2(Zinc 0.0% + Boron 0.1%). Similar kind of research has been made on impact of boron and zinc by Raj et al. (2001); Salam et al. (2010).

TSS (brix): After 85 days of transplanting total soluble solid was observed which was found highest in treatment T_9 (8.233) (Zinc 0.2%+ Boron 0.2%) which remain at par with T_8 (Zinc 0.2% + Boron 0.1%). The lowest total soluble solid was found in treatment T_1(control spray) which remain at par with treatment T_2(Zinc 0.0%+ Boron 0.1%). Similar kind of research has been made on impact of boron and zinc by Sinha et al. (2006), Raj et al. (2001); Salam et al. (2010).

Table 1. Variability in plant parameters in different treatment efficacy

Treatment	Treatment detail	Plant height (m)	Stem girth (cm)	Internodal length (cm)	Days to first flowering	Shelf life	TSS °brix	Total chlorophyll content
T_1	Control spray	180.512	21.567	6.453	30.333	7.000	4.167	1.300
T_2	Zinc 0.0%+Boron 0.1%	191.333	23.500	6.633	30.000	6.000	4.300	1.397
T_3	Zinc 0.0% +Boron 0.2%	199.267	22.433	7.267	30.000	7.000	4.500	1.467
T_4	Zinc 0.1% +Boron 0.0%	189.667	21.700	6.733	29.667	6.000	4.633	1.550
T_5	Zinc 0.1%+Boron 0.1%	200.633	22.600	6.733	29.667	7.000	4.733	1.510
T_6	Zinc0.1% + Boron 0.2%	197.533	24.400	7.233	29.333	8.000	6.700	1.650
T_7	Zinc 0.2%	195.533	23.200	8.333	29.333	6.000	6.733	1.690
T_8	Zinc 0.2%+Boron 0.1%	210.267	24.467	8.400	29.000	8.000	7.533	1.733
T_9	Zinc 0.2%+ Boron 0.2%	232.533	25.367	8.533	28.000	9.000	8.233	1.800
	CD	1.473	1.402	1.200	N/A	1.697	1.285	N/A
	SE(m)	0.487	0.464	0.397	0.818	0.561	0.425	0.425
	SE(d)	0.689	0.656	0.561	1.157	0.793	0.601	0.602
	CV	0.422	3.454	9.326	5.641	13.66	12.85	47.03

Table 2. Variability in fruit parameters in different treatment efficacy

Treatment	Treatment detail	Cluster per plant	fruit per plant	Polar diameter (cm)	Equatorial diameter (cm)	Average fruit weight (g)	Fruit yield per plant (Q)	Fruit yield Per 1000m^2 (Q)
T_1	Control spray	8.000	50.467	4.513	6.200	60.200	7.067	200.433
T_2	Zinc 0.0%+Boron 0.1%	8.467	53.367	4.433	6.433	64.100	9.800	240.2
T_3	Zinc 0.0% +Boron 0.2%	8.500	55.467	5.273	6.567	69.433	10.867	246.3
T_4	Zinc 0.1% +Boron 0.0%	8.567	57.533	5.487	6.667	73.433	10.400	250.6
T_5	Zinc 0.1%+Boron 0.1%	10.133	59.3	5.633	6.733	75.600	11.567	249.3
T_6	Zinc0.1% + Boron 0.2%	10.633	60.533	6.067	6.800	78.333	10.633	248.733
T_7	Zinc 0.2%	11.400	61.267	5.867	7.467	83.300	11.367	256.367
T_8	Zinc 0.2%+Boron 0.1%	11.767	63.467	5.697	7.533	85.733	11.500	256.367
T_9	Zinc 0.2%+ Boron 0.2%	12.600	64.5	6.367	7.600	88.333	13.300	262.267
	CD	1.254	1.48	0.943	N/A	1.848	1.124	2.199
	SE(m)	0.415	0.49	0.312	0.442	0.611	0.372	0.727
	SE(d)	0.587	0.692	0.441	0.625	0.864	0.525	1.028
	CV	7.17	1.451	9.856	11.17	1.404	6.002	0.513

Leaf chlorophyll content: After 85 days of transplanting leaf chlorophyll content was found which was highest in T_9(1.800) (Zinc 0.2% + Boron 0.2%) which remained at par with treatment T_8(Zinc 0.2% + Boron 0.1%). The lowest leaf chlorophyll content was found in treatment T_1 (1.300) (control spray) which remained at par with T_2(Zinc 0.0% + Boron 0.1%).

Cluster per plant: After 85 days of transplanting number of clusters per plant was observed and it was found highest in treatment T_9(Zinc 0.2%+Boron 0.2%) which remained at par with treatment T_8(Zinc 0.2%+ 0.1%). The lowest value of cluster number per plant is found in T_1(control spray) which remained at par with treatment T_2(zinc 0.0% + Boron 0.1%), T_3(Zinc 0.0% +Boron0.2%). Similar kind of research has been made on impact of Zinc and boron on number of cluster per plant by, Paithankar et al. (2004).

Fruit per plant: After 85 days of transplanting number of fruits per plant was observed and it was found highest in treatment T_9 (Zinc 0.2% + Boron 0.2%) which remained at par with treatment T_8 (Zinc 0.2%+ Boron 0.1%). The lowest number of fruits per plant was observed in T_1 (Control spray) which remained at par with T_2(Zinc0.0% +Boron 0.1%). Similar kind of research has been made on impact of zinc and boron on number of fruits per plant by, Mallick and Muthukrishnan (1980).

Polar diameter (cm): After 85 days of transplanting fruit diameter was observed, polar diameter was found highest in treatment T_9 (6.367) (Zinc0.2% + Boron 0.2%) which remained at par with T_8 (Zinc 0.2% + Boron 0.1%). The lowest value of fruit diameter was observed in treatment T_2 (4.433) (control spray) which remained at par with treatment T_1(control spray). Similar kind of research has been made on impact of boron and zinc on polar diameter by Kumar et al. (2012).

Equatorial diameter (cm): After 85 days of transplanting fruit diameter was observed, equatorial diameter was found highest in treatment T_9 (7.600) (Zinc 0.2%+ Boron 0.2%) which remained at par with treatment T_8(Zinc 0.2%+ Boron 0.1%), T_7(Zinc 0.2%+ Boron 0.0%). The lowest value of equatorial diameter was found in treatment T_1(control spray) which remained at par with treatment T_2(Zinc 0.0% +Boron 0.1%). Similar kind of research has been made on impact of boron and zinc on polar diameter by Kumar et al. (2012).

Average fruit weight (g): After 85 days of transplanting average fruit weight was observed, it was found highest in treatment T_9 (88.333) (Zinc 0.2%+ Boron 0.2%) which remain at par with treatment T_8(Zinc 0.2% + Boron 0.1%). the lowest value of average weight found in treatment T_1 (60.200) (control spray) which remained at par with treatment T_2(64.100) (Zinc 0.0% + Boron 0.1%).

Fruit yield per plant and Fruit yield per 1000m^2 (Quintal): After 85 days of transplanting fruit yield per plant and fruit yield per 1000m^2 was found highest in treatment T_9 (13.300) (Zinc 0.2%+Boron 0.1%) which remained at par with treatment T_8(Zinc 0.2% + Boron 0.1%) and fruit yield per 1000m^2 was found highest in treatment T_9(262.267) (Zinc 0.2%+ Boron 0.1%) which remain at par with treatment T_8(Zinc 0.2%+ Boron 0.1%). The lowest fruit yield was found in treatment T_1 (7.067) (control spray) which remain at par with treatment T_2(Zinc 0.0% + Boron 0.1%). The lowest fruit yield per 1000m^2 was found in treatment T_1 (200.433) (control spray) which remain at par with treatment T_2(Zinc 0.0% + Boron 0.1%). Similar kind of research has been made on impact of boron and zinc on fruit yield by Swati Barche et al. (2011), Bose and Tripathi (1996).

4. CONCLUSION

The results show that enhanced growth, yield, and quality parameters were obtained with foliar spray applications of varying dosages of zinc and boron as zinc mono and borax. The most effective combination for achieving maximum growth, yield, and quality metrics is treatment number nine, which applies 0.2% zinc and 0.2% boron as a foliar spray.

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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