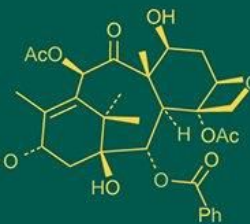
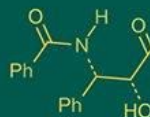


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Dishika Bhattacharjee
M.Sc. (Horticulture),
Department of Vegetable
Science, Faculty of
Horticulture, College of
Agriculture, Indira Gandhi
Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Annu Verma
Professor, Department of
Vegetable Science, Faculty of
Horticulture, College of
Agriculture, Indira Gandhi
Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Corresponding Author:
Dishika Bhattacharjee
M.Sc. (Horticulture),
Department of Vegetable
Science, Faculty of
Horticulture, College of
Agriculture, Indira Gandhi
Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Assessment of boron and paclobutrazol foliar sprays on yield attributes of Beetroot (*Beta vulgaris* L.) under polyhouse conditions

Dishika Bhattacharjee and Annu Verma

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Abstract

A study was carried out to evaluate the effect of foliar spray of boron and paclobutrazol on yield of Beetroot (*Beta vulgaris* L.) grown under polyhouse condition at the the Center of Excellence on Protected Cultivation and Precision Farming Unit, under polyhouse conditions, at the College of Agriculture (CoA), Raipur, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur (C.G.), during the rabi season of 2024. The experiment was assigned in factorial randomized block design (FRBD) with 3 replications, consisting sixteen treatments. The experiment having two factors, boron and paclobutrazol. Boron was used as micronutrient while paclobutrazol was applied as PGR in the experiment. The different levels of boron (4 levels) are B₀- 0 ppm, B₁- 100 ppm, B₂- 150 ppm, B₃- 200 ppm and Paclobutrazol (4levels) P₀- 0 ppm, P₁- 100 ppm, P₂- 200 ppm, P₃- 300 ppm were tried and the results was recorded at 30, 45, 60, 75 DAS respectively. Results revealed that among the different levels of boron, the level B₃ (Boron 200 ppm) was observed superior for yield characters, while the minimum value was recorded in Boron 0 ppm. Among the different levels of PBZ, PBZ 300 ppm was observed superior for yield characters. In interaction effect the maximum root length (cm), root girth (cm), root weight (g) per plant, yield per plot (kg/plot), yield per ha (q/ha) was recorded in boron 200 ppm. Based on the results, it can be concluded that the treatment combination (Boron 200 ppm) produced higher root yield per hectare.

Keywords: Beetroot (*Beta vulgaris* L), Boron, Paclobutrazol (PBZ), yield

Introduction

Beetroot (*Beta vulgaris* L.), belonging to the Chenopodiaceae family, is a highly nutritious root vegetable believed to have originated in the Mediterranean region with a chromosome number of 2n = 18. It is valued for its rich composition of minerals, vitamins, and bioactive compounds and is widely used in traditional medicine for its antioxidant, antimicrobial, anti-inflammatory, diuretic, and other therapeutic properties (Yadav *et al.*, 2016) [18]. Beetroot contributes to cardiovascular health by lowering blood pressure and cholesterol, helps regulate blood glucose levels in diabetics, alleviates anaemia, and reduces fatigue. In India, beetroot is mainly cultivated in Haryana, Uttar Pradesh, Himachal Pradesh, Maharashtra, and Tamil Nadu (Kale *et al.*, 2018) [10].

Boron is an essential micronutrient involved in cell wall integrity, membrane stability, carbohydrate and nitrogen metabolism, sugar transport, and enzyme activity (Shireen *et al.*, 2018) [14]. Its deficiency in sugar beet results in a physiological disorder known as “brown heart,” causing internal tissue browning and loss of root quality (Vera-Maldonado *et al.*, 2024) [17].

Paclobutrazol is a triazole-based, water-soluble plant growth regulator that inhibits gibberellic acid synthesis and is widely used in agriculture (Davis and Curry, 1991) [6]. It induces morphological changes such as reduced stomatal size, increased leaf thickness, and enhanced root density, thereby improving stress tolerance and disease resistance (Chaney *et al.*, 2005) [4].

Materials and Methods

The experiment was conducted at the Center of Excellence on Protected Cultivation and Precision Farming Unit, under polyhouse conditions, at the College of Agriculture (CoA),

Raipur, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur (C.G.), during the rabi season of 2024. The experimental plot size was $2.8 \times 3 \text{ m}^2$ with plant spacing $45 \text{ cm} \times 10 \text{ cm}$. Sixteen treatments of the Beetroot crop were used in this experiment, which was set up in a factorial randomized block design (FRBD) with three replications. The experiment involved two factors- boron and paclobutrazol to assess their effects on plant response. The different levels of boron (4 levels) were B₀- 0 ppm, B₁- 100 ppm, B₂- 150 ppm, B₃- 200 ppm and Paclobutrazol (4 levels) P₀- 0 ppm, P₁- 100 ppm, P₂- 200 ppm, P₃- 300 ppm respectively.

Statistical Analysis

Pre-harvest observations were the statistically analysed following studies of Gomez & Gomez (1984) [8] by using the F-test the significance of treatment effects was determined. Differences among treatments were tested at a 5% probability level using standard error and critical difference values. Analysis of variance (ANOVA) was conducted using OPSTAT and MS Excel software.

Results and Discussion

Root length (cm)

At different levels of boron, boron 200 ppm significantly increased root length (9.72 cm) over the control (8.73 cm), likely due to its role in enhancing cell division and meristematic activity through cytokinin regulation (Attia *et al.*, 2018; Makhoulf *et al.*, 2020; Mekdad *et al.*, 2020) [2, 11, 12]. Among different levels of PBZ, the highest root length (9.41 cm) was recorded at 300 ppm, attributed to improved photosynthetic efficiency and assimilate translocation (Tekalign and Hammes, 2004) [15]. The boron $\times$ PBZ interaction was significant, with the maximum root length (10.33 cm) under the combined application of boron 200 ppm and PBZ 0 ppm, indicating a synergistic effect on root elongation.

Root girth (cm)

The highest root girth (5.73 cm) was recorded with 200 ppm boron, while the lowest (5.13 cm) occurred at 0 ppm boron at different levels of boron. Among different paclobutrazol levels, PBZ at 300 ppm produced the maximum root girth (5.64 cm), whereas the control showed the minimum. Increased root girth under higher boron levels may be due to improved sugar assimilation and translocation, enhancing root development, as also reported by Nemeata *et al.* (2017) [13]. Similarly, PBZ likely improved root girth by increasing chlorophyll content and photosynthetic rate, leading to greater assimilate accumulation (Tekalign and Hammes,

2004) [15]. The highest interaction effect (6.34 cm) was observed with 200 ppm boron, while the lowest (4.35 cm) occurred in the control.

Root weight (g plant⁻¹)

The highest root weight (153.33 g) was obtained with 200 ppm boron, while the lowest (137.88 g) occurred at 0 ppm boron, likely due to boron's role in enhancing photosynthate translocation to roots. Similar effects were reported by Makhoulf *et al.* (2020) [11], Mekdad and Shaaban (2020) [12], Abbas *et al.* (2014), and Dewdar *et al.* (2015) [7]. Among paclobutrazol treatments, PBZ at 300 ppm produced the maximum root weight (152.68 g), whereas the control recorded the minimum (141.72 g). The highest interaction effect (163.23 g) was observed with 200 ppm boron + PBZ 0 ppm, while the control showed the lowest (130.40 g), confirming the combined positive influence of boron and paclobutrazol on beetroot root weight.

Root yield (kg plot⁻¹)

The highest yield per plot (7.67 kg) was recorded with 200 ppm boron, while the lowest (6.89 kg) occurred at 0 ppm, likely due to boron's role in enhancing foliage growth, root size, and photosynthate translocation (Nemeata, 2017; Makhoulf *et al.*, 2020; Mekdad and Shaaban, 2020) [13, 11, 12]. Among paclobutrazol treatments, PBZ at 300 ppm produced the maximum yield (7.63 kg), whereas the control showed the minimum (7.09 kg), supporting the findings of Xu *et al.* (2023). The highest interaction yield (8.19 kg plot⁻¹) was obtained with 200 ppm boron + PBZ 0 ppm, while the control recorded the lowest (6.52 kg plot⁻¹).

Root yield (q ha⁻¹)

1. Foliar application of boron and paclobutrazol (PBZ) significantly enhanced beetroot yield under polyhouse conditions. Among different levels of boron, the highest yield recorded with boron at 200 ppm can be attributed to its role in promoting cell division, carbohydrate translocation, and root development, which agrees with the findings of Abbas *et al.* (2014) [1], Dewdar *et al.* (2015), and Nemeata (2017) [13] in sugar beet. Similarly, at different levels of paclobutrazol, PBZ at 300 ppm improved yield by enhancing assimilate partitioning towards storage roots through hormonal regulation (Tekalign and Hammes, 2005; Gomathinayagam *et al.*, 2007) [16]. The significant boron $\times$ PBZ interaction indicates a synergistic effect, resulting in superior root bulking and overall productivity under protected cultivation.

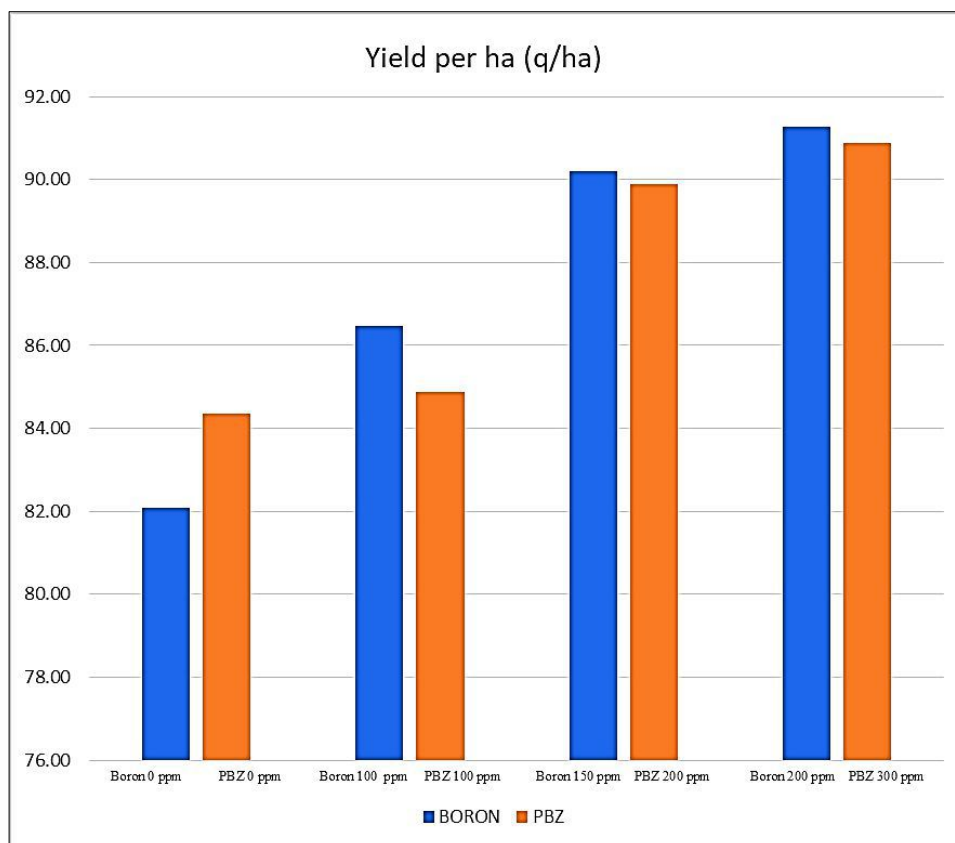


Fig 1: A view of Boron 0 ppm, Boron 100 ppm, Boron 150 ppm, Boron 200 ppm and PBZ 0 ppm, PBZ 100 ppm, PBZ 200 ppm, PBZ 300 ppm



Fig 2: A view of Boron 100 ppm, 150 ppm, 200 ppm beetroot



Fig 3: A view of PBZ 100 ppm, 200 ppm, 300 ppm beetroot



Fig 4: A view of Boron 100 ppm+ PBZ 100 ppm, Boron 100 ppm + PBZ 200 ppm, Boron 100 ppm + PBZ 300 ppm



Fig 5: A view of Boron 150 ppm+ PBZ 100 ppm, Boron 150 ppm + PBZ 200 ppm, Boron 150 ppm + PBZ 300 ppm



Fig 6: A view of Boron 200 ppm+ PBZ 100 ppm, Boron 200 ppm + PBZ 200 ppm, Boron 200 ppm + PBZ 300 ppm



Fig 7: A view of Control (Water spray)

Table 1: Main effects and interaction effects of concentration of boron, PBZ and their combinations on Root length(cm), Root girth(cm), Root weight(g)per plant Root yield (Kg plot⁻¹), Root yield (q ha⁻¹).

Treatments	Root length(cm)	Root girth(cm)	Root weight(g)per plant	Root yield (Kg plot ⁻¹)	Root yield (q ha ⁻¹)
Boron levels					
B0(boron 0 ppm)	8.73	5.13	137.88	6.89	82.07
B1(boron 100 ppm)	8.78	5.30	145.26	7.26	86.46
B2(Boron 150 ppm)	9.42	5.71	151.51	7.58	90.19
B3(Boron 200 ppm)	9.72	5.73	153.33	7.67	91.26
SEm±	0.158	0.084	2.656	0.132	1.581
CD at 5%	0.459	0.243	7.671	0.384	4.568
Paclobutrazol levels					
P0(PBZ 0 ppm)	8.90	5.30	141.72	7.09	84.36
P1(PBZ 100 ppm)	8.93	5.32	142.58	7.13	84.87
P2(PBZ 200 ppm)	9.39	5.62	150.99	7.55	89.88
P3 (PBZ 300 ppm)	9.41	5.64	152.68	7.63	90.88
SEm±	0.158	0.084	2.656	0.132	1.581
CD at 5%	0.459	0.243	7.671	0.384	4.568
Interaction					
SEm±	0.317	0.168	5.312	0.265	3.162
CD at 5%	0.917	0.486	15.343	0.767	9.135
C.V.	6.01%	5.33%	6.26%	6.26%	6.26%

Conclusion

Boron at 200 ppm recorded the highest root length, girth, root weight per plant, and yield per plot and hectare, while the lowest values were observed under 0 ppm boron at different levels of boron. Among paclobutrazol levels, PBZ at 300 ppm produced the maximum values for all yield attributes, whereas the control recorded the minimum. The interaction effect showed that the combination involving boron 200 ppm + PBZ 0 ppm resulted in superior root length, girth, and root weight, and consistently achieved the highest yield under polyhouse conditions.

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