Original Research Article

Effect of foliar spray of boron and time of application on yield and quality and their economic of beetroot (*Beta vulgaris* L.)

ABSTRACT

The present investigation was carried out at Hi-Tech Unit, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur. The twelve treatments comprising of various combinations of 4 levels of boron, viz., B_0 - 0, B_1 - 100, B_2 - 150 and B_3 - 200 ppm and three spray application times, viz., D_1 - 30, D_2 - 45 and D_3 - 60 DAS. The treatments for beetroot crop were evaluated with three replications under factorial randomized block design. The experimental results show that different concentrations of boron, application times and their combinations significantly affected yield and quality of beetroot. Among treatments with different concentration of boron maximum yield per plot (45.44 kg), yield of root (454.45 q/ha), dry matter (18.08 %), protein on dry weight basis (2.54 %), ascorbic acid content (3.48 mg $100g^{-1}$), total soluble solids (16.10 ^{o}Brix) and beta carotene content (1438.34 IU) were recorded with treatment B_3D_1 (200 ppm boron spray at 30 DAS) and alsosignificantly produced higher gross return (₹ 238340.00), maximum net return (₹ 170230.00) and benefit cost ratio of 2.50, *i.e.*, generating highest net return of ₹ 2.50 per rupee invested.

Key words: Beetroot, Boron, Foliar application, Time of spray, yield &quality etc.

Introduction

Boron is involved in cell wall and cell membrane's structural and functional integrity, ion fluxes (H^+, K^+, PO_4^{3-}, $Rb^+$and Ca^{2+}) across membranes, cell division and elongation, nitrogen and carbohydrate metabolism, sugar transport, cytoskeletal proteins and plasmalemma-bound enzymes, nucleic acid, indole acetic acid, polyamines, ascorbic acid and phenol metabolism and transport (Shireen*et al.*, 2018). N fixation, is involved in the metabolism of protein and carbohydrate (Blevins and Lukaszewski 1998), sugar translocation (Armin and Asgharipour 2012) as well as the synergistic influence on N, phosphorus, and potassium uptake (Turan*et al*. 2010,Padbhushan and Kumar 2015). Boron is required in the plant to facilitate sugar transport, it increases root weight and diameter, increases dry matter accumulation and enhances quality, these changes together result in an increase in sugar beet yield (Eweida*et al.*, 1994). Boron deficiency, on the other hand, is linked to a disruption in plant hormone synthesis and nucleic acid metabolism. As all of these functions are essential to meristematic tissues, boron deficiency primarily causes harm to actively growing organs such as shoot and root tips, causing the entire plant to be stunted or rosetting (Motagally, 2015). The method of fertiliser application has a significant impact on its efficiency, foliar sprays are known to be an efficient alternative to soil fertilization, especially in the case of micronutrients (Eichert and Fernández, 2012). It has several advantages, including convenience, quick plant response and prevention of toxicity caused by excessive soil deposition of these nutrients over soil application (Obreza*et al*., 2010). Sugar beet uptake boron (B) in the form of B $(OH)_3$ or H_3BO_3 from the soil by roots (Marschner 1993). Also, B is one of the seven basic micro-nutrients required for the regular and balanced growth of most plant species (Turan*et al*. 2010. The higher quantities of free calcium carbonate, too higher quantities of phosphorus, and lower soil organic matter along with high soil pH decrease B uptake of plants and obtaining maximum benefit from B application (Niaz*et al*. 2016). Sugar beet continuously required relatively high levels of soil available B as compared to other crops (Dridi*et al*. 2018).

MATERIAL AND METHODS

The present experiment on beetroot was conducted during winter season of the year 2020-21 at Hi-tech Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur which is situated at 24°35'N and 74°42'E latitude at an 585.5 meters above mean sea level. The data recorded for evaluation of different treatments in beetroot was statistically analyzed using standard procedure as suggested by Panse and Sukhatme (1985) for analysis of variance of Factorial RBD in order to test the significance of experimental findings. The experiment comprised of 12 treatment combinations of 4 levels of boron and 3 application times T_1-B_0D_{1-} oron application @ 0 ppm on 30 DAS, T_2-B_0D_{2-} Boron application @ 0 ppm on 45 DAS, T_3-B_0D_{3-} Boron application @ 0 ppm on 60 DAS, T_4- B_1D_{1-} Boron application @ 100 ppm on 30 DAS, T_5- B_1D_2 -Boron application @ 100 ppm on 45 DAS, T_6-B_1D_3 -Boron application @ 100 ppm on 60 DAS, T_7- B_2D_{1-} Boron application @ 150 ppm on 30 DAS, T_8-B_2D_{2-} Boron application @ 150 ppm on 45 DAS, T_9-B_2D_3 -Boron application @ 150 ppm on 60 DAS, T_{10}-

B_3D_{1-} Boron application @ 200 ppm on 30 DAS, T_{11}-B_3D_{2-} Boron application @ 200 ppm on 45 DAS, T_{12}-B_3D_{3-} Boron application @ 200 ppm on 60 DAS.

Results and Discussion

Data in Table 1 manifest that a significant effectthat various treatments with varying concentration of boron significantly influencedyield. Maximum yield per plot and total yield (45.44 kg and 454.45 q/ha, respectively) was recorded with treatment B_3 (boron spray at 200 ppm These results may be due to the increased foliage fresh weight, root diameter and root length which can be attributed to the positive role of boron on translocation of photosynthates from leaves to roots. Nemeata (2017) also concluded that increased concentration of boron applied as foliar spray led to an increase in yield per plot and total yield. Similar findings were also reported by Makhlouf*et al.* (2020) Yield per plot and total yield had significant divergence for different combinations and maximum yield per plot and total yield (47.67 kg and 476.68 q/ha, respectively) was recorded for treatment B_3D_1 (200 ppm boron spray at 30 DAS),Similar results were found by Abbas *et al.* (2014.

Results also suggested that among different concentrations of boron spray, highest dry matter (18.08 %) was recorded with application of boron spray at 200 ppm in treatment B_3, while lowest value for this parameter was found with treatment B_0 (boron spray at 0 ppm). This may be due to the fact that boron plays an important role in the physiological functioning of higher plants. It is involved in the structural and functional integrity of the cell wall and membranes. This might have led to an increased thickness in the cell wall of the roots. Boron also affects ion fluxes across the membranes. This may interact to increase the cell permeability leading to easier movement of water outside of the cell. These results are in line with the results found by Enan*et al.* (2016) and El-Tantawy (2017) who recorded increased dry weight of roots in sugar beet with increasing concentration of boron. Different spray application times also had significant effect, with maximum dry matter percentage (17.40 %) was recorded with treatment D_1 (boron spray at 30 DAS), while minimum value was found in treatment D_3 (boron spray at 60 DAS). Data presented in Table 1 clearly showed that dry matter % was significantly influenced by different combinations of boron concentration and time of application of foliar spray. The maximum value for dry matter (19.47 %) was measured with application of boron at 200 pm concentration sprayed on 30 DAS, *i.e.*, treatment B_3D_1, whereas minimum dry matter percentage was observed in treatment B_0D_3 (0 ppm boron spray at 60 DAS).

It is clear from the results presented (Table 2) in preceding chapter that various concentrations of boron significantly affected protein on dry weight basis of beetroot. The data showed that maximum protein on dry weight basis (2.54 %) was recorded with application of boron at 200 ppm in treatment B_3 whereas, minimum value for protein content (1.94 %) was recorded with B_0 (boron spray at 0 ppm). Nemeata*et al.* (2019) also recorded an increase in nitrogen content with increasing boron concentration, which corresponds with an increase in protein content. According to the collected data maximum protein percentage (2.42%) reported in treatment D_1 (spray at 30 DAS) as compared to minimum protein percentage (2.11%) found in the treatment D_3 (boron spray at 60 DAS).The timely availability of boron at the earlier stage of development might have added to the better quality. In interaction of varied boron levels and timing of spray according to the analysed data, maximum protein percentage (2.74 %) was recorded in treatment B_3D_1 (200 ppm boron spray at 30 DAS) while, minimum value (1.89 %) was noticed with the treatment B_0D_2 (0 ppm boron spray at 45 DAS). In case of treatment with different boron levels, highest ascorbic acid content (3.48 mg/100 g) was found with treatment B_3 (boron spray at 200 ppm), which was closely followed (3.34 mg/100 g) bytreatment B_2 (boron spray at 150 ppm). Similar results showing an increase in ascorbic acid content with an increase in rate of boron application to the soil were obtained by Yatsenko*et al.* (2020) while working with garlic. Treatment of roots with spray at different times also had a significant impact on ascorbic acid content in roots. Maximum ascorbic acid content in roots (3.33 mg/100 g) was derived from treatment D_1 (boron spray at 30 DAS) while minimum ascorbic acid content (2.95 mg/100 g) was recorded in those treated with D_3 (boron spray at 60 DAS). Various treatment combinations also had positive impact with respect to ascorbic acid content. Maximum value (3.62 mg/100 g) was found in B_3D_1 (200 ppm boron spray at 30 DAS) while minimum value (2.72 mg/100 g) was in B_0D_2 (0 ppm boron spray at 45 DAS). While, ascorbic acid content (3.58 g/100 g) with treatment B_2D_1 (150 ppm boron spray at 30 DAS) was at par (3.62 mg/100 g)with B_3D_1.

Analysis of collected data showed that highest TSS (16.10 ^{o}Brix) was obtained with the treatment B_3 (boron spray at 200 ppm), whereas minimum TSS (13.81 ^{o}Brix) was observed in the treatment B_0 (boron spray at 0 ppm). Time of spray also had a significant effect on TSS, and maximum TSS (15.61 ^{o}Brix) was found in the treatment D_1 (boron spray at 30 DAS). In different treatment combinations a significant difference was observed in the TSS. The maximum TSS content (16.97 ^{o}Brix) was recorded with treatment B_3D_1 (200 ppm boron spray at 30 DAS), while minimum TSS (13.73^{o}Brix) was reported with treatment B_0D_2 (0 ppm boron spray at 45 DAS).Makhlouf*et al.* (2020) reported that extracted sugar (%) was increased when boron concentration was increased from 75 ppm to 100 ppm. Concentration of boron also had a significant impact on beta carotene content of beetroot with maximum value (1438.84 IU) being recorded with treatment B_3 (boron spray at 200 ppm), while minimum value (1326.19 IU) was recorded with B_0 (boron spray at 0 ppm). This is in accordance with the findings by Makhlouf*et al.* (2020) when they observed that increase in boron concentration led to an increase in carotenoid content of sugar beet. Application of spray at different time also had a significant effect on the beta carotene content of beetroot. Maximum value of beta carotene (1429.83 IU) was recorded with treatment D_1 (boron spray at 30 DAS), while minimum (1358.63 IU) was recorded with treatment D_3 (boron spray at 60 DAS). Highest beta carotene content (1522.53 IU) was reported with treatment B_3D_1 (200 ppm boron spray at 30 DAS) while lowest beta carotene content (1316 IU) was recorded with B_0D_2 (0 ppm spray of boron at 45 DAS). Improved quality characters might be due to the fact that boron is an essential element which has varied important physiological and metabolic roles. Boron is actively involved in sugar metabolism, sugar transport, metabolism and transport of ascorbic acid, nitrogen metabolism and stability of cytoskeletal proteins.The economics of beetroot production is a very important part of cultivation. Higher profits and less cultivation cost are expedient for getting higher returns. Economic evaluation of different treatments for beetroot under one hectare area, are given in Table 3. Economic analysis showed that application of boron spray at 200 ppm under treatment B_3, registered highest benefit cost ratio of 2.34. Findings of Attia*et al.* (2018) also concur with the our economic analysis, as they also recorded higher net returns from the sugar beet crop which was under treatment of boron at 0.20 g/l. Economic analysis also showed that among different combinations of boron concentration and spray time, treatment B_3D_1 (200 ppm boron spray at 30 DAS) significantly produced higher gross return (₹ 238340.00), maximum net return (₹ 170230.00) and benefit cost ratio of 2.50, *i.e.*, generating highest net return of ₹ 2.50 per rupee invested.

CONCLUSION:

On the basis of experiment it may be concluded that among defferent combinations of concentrations of boron and time of application of boron spray also had a significant effect on beetroot, treatment B_3D_1 (200 ppm boron spray at 30 DAS) was found to have superior performance in terms of yield, quality and economic of beetroot then the rest of treatments.

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Table: 1 Main effects and interaction effects of concentration of boron, time of application and their combinations on dry matter percentage, Yield per plot (kg), Total yield of root (q/ha).

Treatment	Yield per plot (kg)	Total yield of root (q/ha)	Dry matter percentage (%)
Boron			
B_0	37.99	379.96	14.53
B_1	41.89	418.89	16.27
B_2	44.75	447.50	17.62
B_3	45.44	454.45	18.08
SEm±	0.807	8.074	0.129
CD at 5%	2.368	23.680	0.379
Time of application			
D_1	43.88	438.83	17.40
D_2	42.60	426.04	16.72
D_3	41.07	410.72	15.76
SEm±	0.699	6.992	0.112
CD at 5%	2.051	20.507	0.329
B x D			
T_1 -B_0D_1	37.61	376.12	14.59
T_2 -B_0D_2	38.08	380.82	14.63
T_3 -B_0D_3	38.30	382.92	14.37
T_4 -B_1D_1	43.58	435.84	16.93
T_5 -B_1D_2	41.33	413.33	16.24
T_6 -B_1D_3	40.75	407.48	15.65
T_7 -B_2D_1	46.67	466.68	18.61
T_8 -B_2D_2	45.17	451.67	17.80
T_9 -B_2D_3	42.41	424.15	16.45
T_{10} -B_3D_1	47.67	476.68	19.47
T_{11} -B_3D_2	45.83	458.34	18.20
T_{12} -B_3D_3	42.83	428.33	16.59
SEm±	1.398	13.98	0.224
CD at 5%	NS	NS	0.657

Table: 2 Main effects and interaction effects of concentration of boron, time of application and their combinations on dry matter percentage, protein on dry weight basis, ascorbic acid content in roots, TSS and beta carotene of beetroot.

Treatment	Protein on dry weight basis (%)	Ascorbic acid content in roots (mg/100 g)	TSS (^{o}Brix)	Beta Carotene (IU)
Boron				
B_0	1.94	2.73	13.81	1326.19
B_1	2.11	3.05	14.82	1369.74
B_2	2.41	3.34	15.56	1415.78
B_3	2.54	3.48	16.10	1438.84
SEm±	0.028	0.0240	0.116	11.22
CD at 5%	0.081	0.071	0.341	32.91
Time of application				
D_1	2.42	3.33	15.61	1429.83
D_2	2.21	3.17	15.02	1374.45
D_3	2.11	2.95	14.58	1358.63
SEm±	0.024	0.021	0.101	9.717
CD at 5%	0.070	0.062	0.295	28.500
B x D				
T_1 -B_0D_1	1.92	2.75	13.83	1328.05
T_2 -B_0D_2	1.89	2.72	13.73	1316.93
T_3 -B_0D_3	2.00	2.74	13.86	1333.60
T_4 -B_1D_1	2.34	3.37	15.63	1408.39
T_5 -B_1D_2	2.01	2.98	14.60	1353.43
T_6 -B_1D_3	1.98	2.80	14.23	1347.39
T_7 -B_2D_1	2.70	3.58	16.00	1460.68
T_8 -B_2D_2	2.37	3.46	15.77	1411.72
T_9 -B_2D_3	2.18	2.98	14.90	1374.93
T_{10} -B_3D_1	2.74	3.62	16.97	1522.53
T_{11} -B_3D_2	2.60	3.53	16.00	1415.73
T_{12} -B_3D_3	2.28	3.29	15.33	1378.58
SEm±	0.048	0.042	0.201	19.430
CD at 5%	0.140	0.124	0.591	57.001

Table: 3 Main effects and interaction effects of concentration of boron, time of application and their combinations on economics of beetroot

Treatment	Total yield of root (q/ha)	Total cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C Ratio
Boron					
B_0	379.96	67510.00	189980.00	122470.00	1.81
B_1	418.89	67810.00	209445.00	141635.00	2.09
B_2	447.50	67960.00	223750.00	155790.00	2.29
B_3	454.45	68110.00	227225.00	159115.00	2.34
Time of application					
D_1	438.83	67510.00	219415.00	151905.00	2.25
D_2	426.04	67510.00	213020.00	145510.00	2.16
D_3	410.72	67510.00	205360.00	137850.00	2.04
B x D					
T_1 -B_0D_1	376.12	67510.00	188060.00	120550.00	1.79
T_2 -B_0D_2	380.82	67510.00	190410.00	122900.00	1.82
T_3 -B_0D_3	382.92	67510.00	191460.00	123950.00	1.84
T_4 -B_1D_1	435.84	67810.00	217920.00	150110.00	2.21
T_5 -B_1D_2	413.33	67810.00	206665.00	138855.00	2.05
T_6 -B_1D_3	407.48	67810.00	203740.00	135930.00	2.00
T_7 -B_2D_1	466.68	67960.00	233340.00	165380.00	2.43
T_8 -B_2D_2	451.67	67960.00	225835.00	157875.00	2.32
T_9 -B_2D_3	424.15	67960.00	212075.00	144115.00	2.12
T_{10} -B_3D_1	476.68	68110.00	238340.00	170230.00	2.50
T_{11} -B_3D_2	458.34	68110.00	229170.00	161060.00	2.36
T_{12} -B_3D_3	428.33	68110.00	214165.00	146055.00	2.14