Impact of Foliar Boron and Fertilizer Management systems on Growth, Yield and Quality of Brinjal

ABSTRACT

A field experiment was conducted during the rainy season of 2017–18 at Horticulture Farm, S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan to study the role of foliar spray of boron on the growth, yield, and quality of Brinjal (*Solanum melongena* L.) The study was laid with 18 treatments (TThree replicates of six treatments) *viz.*, INM levels (control, 100% inorganic NPK, 75% inorganic NPK +25%VC (vermicompost), 50% inorganic NPK +50%VC, 25% inorganic NPK +75% VC, and 100%VC and boron levels (control, 100 ppm, and 200 ppm). It was observed that there was a significant ($P < 0.05$) increase in the plant height and plant spread at 30, 60, and 90 DAT on the application of 75% inorganic NPK +25%VC on the brinjal crop, while the application of inorganic 50% NPK +50%VC significantly ($P < 0.05$) increased chlorophyll content ($mg.g^{-1}$), fruit length (cm), fruit weight (g), fruit yield ha^{-1} (q), Nitrogen and Phosphorus content in fruit (%), as compared to control but statistically at par with 25% inorganic NPK +75%VC. The application of boron (200ppm) significantly ($P < 0.05$) increased the plant height and plant spread at 30, 60, and 90 DAT(cm), chlorophyll content (mg/g), fruit length (cm), fruit weight (g), fruit yield $hectare^{-1}$(q), NP content in fruit (%), as compared to control and boron (100 ppm).

Keywords: Brinjal, growth, NPK, quality, vermicompost.

1. Introduction

"Brinjal (*Solanum melongena* L.) which is commonly known as eggplant or aubergine belongs to the family *Solanaceae*. It is believed that brinjal is native to southern India and is one of the most popular vegetables grown throughout the tropics and subtropics" (Chowdhury and Tah, 2011). "Its green leaves are the main source of anti-ascorbic acid (vitamin C). Brinjal contains phytonutrients with antioxidant activity. They have anti-cancer, antiviral, antimicrobial, anti-inflammatory, laxative, antidiabetic, and anti-hypercholesterolemic activities. Eggplant fruits contain a phenolic compound, the most abundant source of chlorogenic acid" (Butu and Rodino, 2019). It has medicinal properties and is used as an appetizer, aphrodisiac, and "cardiotonic" in Ayurveda, and also used for the treatment of bronchitis, asthma, and dysentery. It is rich in dietary fiber, potassium, calcium, manganese, copper, and vitamins A & B (Anonymous, 2012).

"Brinjal being a long-duration crop requires good manure and fertilizer" (Manimegala and Gunasekaran, 2020). Nitrogen is considered a building block in protein synthesis and is the main ingredient of protoplasm (Paul et al., 2017). Sat and Saimbhi (2003) reported that increasing the nitrogen considerably can delay the flowering of eggplant and the time requirement for fruit setting increased significantly. "Phosphorus plays a key role in the formation of the plasma membrane, nucleic acids, coenzymes, organic molecules, many phosphorylated products, carbohydrates synthesis, and nutrient contents like Ca, Mg, N, K, and S" (Badiger et al., 2006). Crop productivity can be significantly increased with potassium use, as it imparts increased disease resistance. It regulates water balance within the plant cell through the process of anabolism, respiration, and transpiration and in turn, reduces the tendency to wilt. It improves the taste and quality of tomatoes through the formation of protein and chlorophyll by using available water.

"The technique of organic vegetable production plays an important role in producing high-value vegetables" (Mishra et al., 2018). "Vermicompost consistently encourages biological activity which can cause the plant to germinate seeds, produce a flower, and provide a better yield than in commercially used media, independent of nutrient availability" (Arancon et al., 2004). "Vermicompost increases the surface area and provides strong absorbability of nutrients, and retains more nutrients for a longer period" (Mamta et al., 2012). "Vermicompost is slowly releasing organic manure which has most of the macro and micronutrients chelated from and fulfill the plant nutrient requirement of plant for a longer period, its use has been advocated in integrated nutrient management (INM) system in vegetable crops. Vermicomposts are characterized by high porosity, water-holding capacity, drainage, aeration, and microbial activity" (Manimegala and Gunasekaran, 2020).

"Boron (B) is a micronutrient critical to the growth, health, and carbohydrate metabolism of all crops. It is a component of the plant cell wall and reproductive structures. It is a mobile nutrient in the soil, meaning it is prone to movement in the soil. Boron role plays a diverse range of plant functions including maintenance of structural and functional integrity of biological membranes, cell wall formation and stability, movement of sugar, seed set, and pollination. In plants deficiency of boron nutrients results into delaying in pollen germination, pollen tube development, and halts flowering and fruit setting" (Jokanovi, 2020).

2. Materials and Methods

The field experiment was conducted at Horticulture farm, Department of Horticulture, S.K.N. COA, Jobner, Rajasthan, India from July to December 2017. The details regarding the use of experimental techniques, materials, and criteria opted for the assessment of treatments during the investigation are provided.

The soil texture in the experimental field was loamy sand, slightly alkaline, poor in organic carbon with low nitrogen (135.05 $kg.ha^{-1}$), phosphorus (16.67 $kg.ha^{-1}$), and medium in potassium contents (150.83 $kg.ha^{-1}$).

In the experiment, Pant Rituraj variety of brinjal was used. Treatments were considered as six levels of INM & Vermicompost, *viz*., N_0= Control, N_1=100% RD of inorganic NPK, N_2=75% RD of inorganic NPK +25% through VC, N_3=50% RD of inorganic NPK +50% through VC, N_4=25% RD of inorganic NPK +75% through VC, N_5=100% RD of NPK through vermicompost and three levels of boron *viz*., B_0= Control, B_1= 100 ppm, B_2= 200 ppm.

The experiment was laid out in an RBD (Randomized Block Design) with three replications. Thirty days old seedlings were transplanted at the spacing of 60×45 cm^2 in the rainy season, 2017. The size of the experimental plots was 2.4×2.25 m^2. Harvesting was carried out in December 2017. Data were collected from five randomly selected plants for each plot and the recoded parameters were plant height (cm), plant spread (cm^2) for both directions (E-W & N-S), chlorophyll contents in leaves (mg/g), fruit length (cm), average fruit weight (g), Yield per hectare (q), nitrogen and phosphorus contents in fruit (%).

3. Results and Discussion

3.1. Plant height

The significant maxi plant height at 30, 60, and 90 days after transplanting (19.15, 51.31, and 72.56 cm) was observed under the treatment N_2, which was statistically at par with the application of treatment N_3 because inorganic fertilizer has more quantity of macronutrients that provide better vegetative growth. Nitrogen, phosphorous, and potassium are considered major nutrients required for the proper growth and development of the plant. This might be due to the better nutritional environment in the root zone for the growth and development of the plant by the application of NPK with vermicompost. Potassium fertilization improved overall crop growth in terms of plant height and number of branches per plant.

Whereas, minimum plant height at 30, 60, and 90 days after transplanting (12.80, 40.30, and 58.01 cm) were observed. The maximum plant height at 30, 60, and 90 days after transplanting (17.78, 49.68, and 69.98 cm) was recorded with 200 ppm, and minimum plant height at 30, 60, and 90 days after transplanting (15.66, 43.25, and 61.13 cm) was observed with B_0. "Growth attributes of brinjal increased with the application of boron at the initiation of flowering. Boron is also associated with the development of cell walls and results in improved shoot growth (Basavarajeshwari et al., 2008) and thus increased plant height, branches, and leaves per plant (Oyinlola, 2004) which greatly confirmed the present results".

3.2. Plant spread (E-W)

The maximum plant spread (East-West) at 30, 60, and 90 DAT (30.65, 56.22, and 81.29 cm) were observed under treatment N_2, which was statistically at par with treatment N_3. While, minimum plant spread (E-W) at 30, 60, and 90 DAT (22.45, 44.06, and 68.50 cm) was observed under control. "The plant spread (East-West) at 30, 60, and 90 DAT under the treatment N_2 was registered at 36.52, 27.59, and 18.67% higher, respectively. Nitrogen is a main constituent of protoplasm, cell nucleus, amino acids, proteins, chlorophyll, and many other metabolic products. Phosphorus is a constituent of nucleic acid, phytin, and phospholipids. The beneficial influence of phosphorus in the early stages of growth may be explained by early stimulation of the root system through efficient translocation to the root or certain growth stimulation compounds formed on account of the protoplasmic activity of tops in phosphorus-fed plants when enhanced absorption of nitrogen and other nutrients and their utilization" (Parihar and Tripathi, 2003). Application of boron significantly ($P < 0.05$) influenced the plant spread (E-W) at 30, 60, and 90 DAT (29.33, 54.28, and 79.90) in 200 ppm and minimum plant spread (E-W) at 30, 60, and 90 DAT (25.64, 46.85, and 70.85) was observed under control. The plant spread (E-W) at 30, 60, and 90 DAT under 200 ppm was noted 14.39, 15.85, and 12.87% more over control, respectively. "Boron is associated directly and indirectly with several plant functions, as it involves the growth of cells in newly emerging shoots and roots in some plants", (Miwa et al., 2008).

3.3. Plant spread (N-S)

The maximum plant spread (N-S) at 30, 60, and 90 DAT (29.85, 58.15, and 85.50 cm) were observed under treatment N_2, which was statistically at par with the application of treatment N_3. The plant spread (N-S) at 30, 60, and 90 DAT under the treatment N_2 was found 28.11, 28.45, and 17.42% higher than the control, respectively. "The response to potassium fertilization in terms of overall improvement in growth parameters is further supported by the fact that the leaching losses of potassium were more in light-textured soils. Most of these investigations have confirmed that manure compost and vermicompost usually have significant beneficial effects on plant growth", (Kashyap et al., 2014). Similarly, the application of different levels of boron also had significant increase in plant spread (N-S) at 30, 60, and 90 DAT (28.88, 55.86, and 84.46) in 200 ppm, and minimum plant spread (N-S) at 30, 60, and 90 DAT (24.86, 47.95, and 75.17) was noted under control. The plant spread (N-S) at 30, 60, and 90 DAT under 200 ppm was recorded at 16.17, 16.49, and 12.35% more over control, respectively. Foliar sprays of Boron increased the nitrogen content of the leaves. The leaf area was significantly ($P < 0.05$) increased by nitrogen, possibly because nitrogen helps in greater assimilation of food material by the plant which resulted in greater meristematic activities of cells and accordingly the number of leaves, length, and width of the leaf. The findings are also in agreement with the findings of Solanki et al. (2017) in brinjal.

Table:1 Effect of NPK with vermicompost and boron on Plant height & Plant spread at different growth stages of brinjal

Treatments	Plant height (cm)			Plant spread (cm)					
				(E-W)			(N-S)		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
INM levels									
N_0-Control	12.80	40.30	58.01	22.45	44.06	68.50	23.30	45.27	72.81
N_1-100% NPK	16.85	46.56	65.52	28.11	51.31	74.79	27.19	52.15	79.31
N_2-75% NPK+25% VC	19.15	51.31	72.56	30.65	56.22	81.29	29.85	58.15	85.50
N_3-50% NPK+50% VC	17.88	48.61	68.99	29.36	52.89	79.77	27.88	54.69	84.34
N_4-25% NPK+75% VC	17.57	47.29	65.78	28.70	51.67	75.22	27.45	52.57	79.46
N_5-100% VC	15.43	44.79	63.50	25.82	48.56	74.49	25.73	49.96	78.56
SEm±	**0.44**	**1.15**	**1.90**	**0.72**	**1.47**	**1.77**	**0.73**	**1.56**	**2.00**
CD (P=0.05)	**1.28**	**3.32**	**5.47**	**2.06**	**4.21**	**5.09**	**2.09**	**4.47**	**5.73**
Boron levels									
B_0-Control	15.66	43.25	61.13	25.64	46.85	70.85	24.86	47.95	75.17
B_1-100 ppm	16.84	46.51	66.07	27.58	51.22	76.28	26.96	52.59	80.36
B_2-200 ppm	17.78	49.68	69.98	29.33	54.28	79.90	28.88	55.86	84.46
SEm±	**0.31**	**0.82**	**1.35**	**0.51**	**1.04**	**1.25**	**0.51**	**1.10**	**1.41**
CD (P=0.05)	**0.90**	**2.34**	**3.87**	**1.45**	**2.98**	**3.60**	**1.47**	**3.16**	**4.05**

3.4. Chlorophyll content in leaves

Maximum chlorophyll content in leaves at 45 DAT (1.315 $mg.g^{-1}$) was observed under the treatment N_3, which was statistically at par with the application of treatment N_4. Whereas, minimum chlorophyll content in leaves at 45DAT (1.014 mg.g^{-1}) was observed under control. The chlorophyll content in leaves under the treatment N_3 was found 29.68% higher than the control. This might be because NPK with vermicompost helped in the expansion of leaf area and chlorophyll contents which together might have accelerated the photosynthetic rates and in turn increased the supply of carbohydrates to plants. Potassium helps in chlorophyll formation ultimately the NPK is used for better vegetative growth. The effect of vermicompost on physicochemical properties imparts favorable soil structure for root growth which influenced better plant growth. The maximum chlorophyll contents in leaves at 45 DAT (1.270 mg/g) were recorded at 200 ppm and the minimum (1.130 mg.g^{-1}) in the control. The chlorophyll content in leaves under the treatment B_2 (200 ppm) was recorded at 12.38% more than the control. These results point out that the spray of boron also helps in enhancing quality parameters such as the chlorophyll content of brinjal (Selvi et al., 2004).

3.5. Fruit length

The application of treatment N_3 produced a significant ($P < 0.05$) maximum fruit length (8.36 cm), which was statistically at par with the application of treatment N_4. While, the minimum fruit length (7.19 cm) was observed under control. The fruit length under the treatment N_3 (50% NPK+50% VC) was registered 16.27% more as compared to the control and the application of boron produced the maximum fruit length (8.25 cm) in 200 ppm, which was minimum (7.41 cm) under control. Application of 200 ppm registered an increase of 11.33% higher fruit length over control. These results indicated that the spray of boron also helps in enhancing fruit size. Similar quality parameters were also reported by Selvi et al. (2004).

3.6. Fruit weight

The maximum fruit weight (81.66 g) was recorded under treatment N_3, which was statistically at par with the application of treatment N_4, While the minimum fruit weight (70.53 g) was observed under control. The Fruit weight under the treatment N_3 was found 15.78% more as compared to the control. The application of boron gave a significant maximum fruit weight (80.38 g) in 200 ppm, and a minimum fruit weight (72.76 g) was observed under control. Application of 200 ppm registered an increase of 10.47% over control. The increased number of fruits due to the foliar spray of micronutrients might be attributed to enhanced photosynthetic activity, resulting in increased production and accumulation of carbohydrates and a favorable effect on vegetative growth and retention of flowers and fruits, which might have increased number and weight of fruits. Boron plays an important role in the uptake of calcium and the transport of carbohydrates. In case of B deficiency the rate of respiration increases and therefore more water loss. In boron-deficient plants, enzymatic activity increases which increases water loss from the fruit surface. Boron availability increases calcium synthesis which reduces respiration that might decrease the amount of moisture loss from the fruit surface Stanley *et al*., (1995) also obtained similar results.

3.7. Fruit yield

The maximum fruit yield ha^{-1} (332.10 $q.ha^{-1}$) was observed under treatment N_3, which was statistically at par with the application of treatment N_4 (311.95 $q.ha^{-1}$). Whereas, minimum fruit yield per hectare (212.49 $q.ha^{-1}$) was observed under control. The percent increase in fruit yield per hectare under the treatment N_3 was found to be 56.28% more than the control. The application of treatment N_3 favored the metabolic and auxin activities in plants and ultimately resulted in increased fruit size, fruit weight, number of fruits per plant, yield per plant, and yield ha^{-1}, (Kumar, and Gowda, 2010). The application of different boron levels also had a significant ($P < 0.05$) effect on fruit yield per hectare as compared to the control. The significant increase in fruit yield per hectare (328.52 q ha^{-1}) was recorded in 200 ppm, and the minimum (236.11) was observed under control. The fruit yield per hectare under the treatment B_2 (200 ppm) was recorded at 39.13% more than the control. Boron deficiency commonly results in empty pollen grains, poor pollen strength, and a reduced number of flowers per plant. The highest fruit set percentage might be due to optimum boron application, as boron plays important role in maintaining cell integrity, improving respiration, enhancing metabolic activities, and uptake of nutrients. Nonnecke (1989) and Suganiya and Kumuthini (2015) also obtained similar results.

3.8. Nitrogen content in fruit

The maximum nitrogen content in fruit (3.16%) was observed under the treatment N_3 (50% NPK+50% VC), followed by N_4 (25% NPK+75% VC) and followed by N_2 (75% NPK+25% VC). Whereas minimum nitrogen content in fruit (2.17%) was observed under control and the application of different levels of boron brought out a significant ($P < 0.05$) increase in nitrogen content in fruit as compared to control. Similar results were reported by Laxmi et al., 2015. The maximum nitrogen content in fruit (3.01%) was recorded at 200 ppm, which was 11.89% more than the control, and the minimum (2.69%) was observed under control. These results indicated that the boron spray, besides increasing the growth and yield also helps in enhancing the quality parameters of brinjal fruits. Similar parameters were also reported by Selvi et al. (2004). Adequate B is also required for effective nitrogen fixation and nodulation in legume crops. The results showed that the effect of different treatments on nutrient concentration and seed protein was significant ($P < 0.05$), (Salih and Hemn, 2013).

3.9. Phosphorus content in fruit

The maximum phosphorus content in fruit (0.54%) was observed under the treatment N_3, which was statistically at par with the application of treatment N_4, whereas, the minimum phosphorus content in fruit (0.43%) was observed under control. The percent increase in phosphorus content in fruit under the treatment N_3 was found to be 25.58% over control. Among the various organic manures, the compost produced by earthworms (vermicompost), is a rich source of macro and micronutrients. It is evident from the data that phosphorus content in fruit with the application of boron 200 ppm was recorded as the maximum phosphorus content in fruit (0.52%) as compared to other treatments, while the minimum phosphorus content was recorded under control (0.45%). Boron deficiency adversely affects the quality and yield of many vegetables especially tomatoes (Imtiaz *et al*., 2010).

Table:2 Effect of NPK with vermicompost and boron on fruit length, fruit weight, fruit yield, chlorophyll content in leaves, nitrogen and phosphorous content in fruit of brinjal

Treatments	Fruit length (cm)	Fruit weight (g)	Fruit yield (q ha^{-1})	Nitrogen Content in Fruit (%)	Phosphorous Content in Fruit (%)	Chlorophyll content in leaves (mg/g)
INM levels						
N_0-Control	7.19	70.53	212.49	2.17	0.43	1.014
N_1-100% NPK	7.78	76.12	284.11	2.92	0.48	1.204
N_2-75% NPK+25% VC	7.85	76.30	286.13	2.95	0.49	1.214
N_3-50% NPK+50% VC	8.36	81.66	332.10	3.16	0.54	1.315
N_4-25% NPK+75% VC	8.21	79.39	311.95	3.06	0.52	1.275
N_5-100% VC	7.68	75.97	281.00	2.89	0.46	1.198
SEm±	**0.17**	**1.41**	**11.07**	**0.05**	**0.01**	**0.025**
CD (P=0.05)	**0.48**	**4.05**	**31.81**	**0.14**	**0.03**	**0.073**
Boron levels						
B_0-Control	7.41	72.76	236.11	2.69	0.45	1.130
B_1-100 ppm	7.88	76.84	289.26	2.88	0.49	1.210
B_2-200 ppm	8.25	80.38	328.52	3.01	0.52	1.270
SEm±	**0.12**	**1.00**	**7.83**	**0.04**	**0.01**	**0.018**
CD (*p*=0.05)	**0.34**	**2.86**	**22.49**	**0.10**	**0.02**	**0.051**

4. Conclusion

The treatment 50% NPK+50% VC or treatment boron (200 ppm) was found significantly better in terms of growth, yield, and quality compared to other treatments. Thus, the application of 50% NPK+50% VC or Boron 200 ppm to brinjal is recommended. The results are only indicative and require further experimentation to arrive at a more consistent and final conclusion.

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