

Original Research Article

Impact of Response to Foliar Spray of Boron along with Different and Fertilizer Management Strategies system on Growth, Yield and Quality of Brinjal (*Solanum melongena* L.)

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 specifically of boron on the growth, yield, and quality of Brinjal (*Solanum melongena* L.) The study conducted was laid with 18 treatments (Three replicates of six treatments) viz., INM levels (control, 100% inorganic NPK through inorganic source, 75% inorganic NPK through inorganic source + 25% VC (vermicompost), 50% inorganic NPK through inorganic source + 50% VC, 25% inorganic NPK through inorganic source + 75% VC, and 100% VC and boron levels (control, 100 ppm, and 200 ppm). In three replications the total 18 treatment combinations were tested as per randomized block design. 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 through inorganic source + 25% VC on the brinjal crop, while the application of inorganic 50% NPK through inorganic source + 50% VC significantly ($P < 0.05$) increased chlorophyll content ($\text{mg}\cdot\text{g}^{-1}$), 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 through inorganic source + 75% VC. The application of boron (200 ppm) 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 ha^{-1} (q), NP content in fruit (%), as compared to control and boron (100 ppm).

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

1. Introduction

Brinjal (*Solanum melongena* L.) which is commonly known as eggplant and also called 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

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Tah, 2011). ~~Its green leaves are t~~The main source of anti-ascorbic acid (vitamin- C)~~-is its green leaves.~~ Brinjal contains phyto-nutrients with ~~an~~ antioxidant ~~role~~activity. They ~~ahave re~~ useful in the ~~fight against~~anti-cancer, ~~have an~~ antiviral ~~role~~, antimicrobial,~~anti-inflammatory, laxative, antidiabetic, and anti~~reduce bad cholesterol~~hypercholesterolemic activities.~~ The ~~e~~Eggplant fruits contain a phenolic compound, the most abundant source of chlorogenic acid (Butu and Rodino, 2019). It ~~is having~~has medicinal properties and ~~is~~ used as ~~an~~ appetizer, aphrodisiac, and “cardiotonic” in Ayurveda,~~sometimes it is used to provide relief from inflammation as its fruit exhibits laxative properties, and also used for.~~White brinjal is to be good for diabetic patients. It is ~~also reported to be useful for~~ the treatment of bronchitis, asthma, ~~and~~ dysentery,~~for controlling the blood cholesterol etc.~~Along with the~~antioxidant property i~~It is rich in dietary fiber, potassium, calcium, manganese, copper, and vitamins A & B (Anonymous, 2012).

Brinjal being a ~~long-long~~duration crop requires a good manure and fertilizer (Manimegala and Gunasekaran, 2020).Nitrogen is considered ~~to be~~a building block in ~~the production of~~protein ~~synthesis~~ and is the main ingredient of protoplasm (Paul et al., 2017). Sat and Saimbhi(2003) reported that ~~by~~increasing the nitrogen considerably~~then it can delay~~the flowering of eggplant and the time requirement for fruit setting ~~also~~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 ~~the P~~potassium use, as it imparts increased ~~vigour and disease~~ resistance~~against diseases.~~ It ~~also~~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 ~~in of~~tomatoes through the formation of protein and chlorophyll by using available water.

The technique of organic vegetable production plays an important role in ~~produce~~producing ~~high high-value of~~vegetables (Mishra et al., 2018). Vermicompost consistently encourages biological activity which can cause ~~the~~ plant to ~~germination~~germinate of seeds, ~~to~~produce a flower, and ~~provide~~ a better yield than in commercial~~ly~~used media, independent of nutrient availability (Arancon et al., 2004). Vermicompost increases the surface area and ~~it's~~provides strong absorbability of nutrients, and retains more nutrients for a longer ~~time~~period (Mamta et al., 2012). Vermicompost is slowly releasing organic manure which has most of the macro ~~as well as~~and micronutrients ~~in~~ chelated from and fulfill the ~~plant~~ nutrients requirement of plant ~~for~~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~~ the growth, health, and ~~essential element for~~ carbohydrate metabolism of all crops. It is a component of ~~the~~ 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 ~~in~~ 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 ~~ultimately it~~ 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 ~~during from~~ July to December 2017. The details regarding the use of experimental techniques, materials, and criteria opted for the assessment of treatments during ~~the the~~ the course of investigation ~~is~~ are provided.

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

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% per cent RD** of **inorganic NPK** through **inorganic fertilizers**, N_2 = **75% per cent RD** of **inorganic NPK** through **inorganic fertilizers** + **25% per cent** through VC, N_3 = **50% per cent RD** of **inorganic NPK** through **inorganic fertilizers** + **50% per cent** through VC, N_4 = **25% per cent RD** of **inorganic NPK** through **inorganic fertilizers** + **75% per cent** 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 $60 \times 45 \text{ cm}^2$ in ~~the~~ the rainy season, 2017. The size of the experimental plots was $2.4 \times 2.25 \text{ m}^2$. Harvesting was ~~done carried out during in month of~~ December 2017. Data were collected from five randomly selected plants for each plot and the recorded parameters were plant height (cm), **Plant plant** spread (cm^2) for both directions (E-W & N-S), **Chlorophyll chlorophyll** contents in leaves (mg/g), **Fruit fruit** length (cm), **Average average** fruit weight (g), **Yield Yield** per hectare (q), **Nitrogen nitrogen** and **Phosphorus phosphorus** contents in fruit (**% per cent**).

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3. Results and Discussion

3.1. Plant height

The significantly maximum plant height at 30, 60₂ and 90 days after transplanting (19.15, 51.31₂ and 72.56 cm) were observed under the treatment N₂ (75% NPK + 25% VC), which was statistically at par with the application of treatment N₃ (50% NPK + 50% VC) because inorganic fertilizer have has more quantity of macronutrients that provide better vegetative growth of plants. The Nitrogen, Phosphorous, and potassium are considered as 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, 60₂ and 90 days after transplanting (12.80, 40.30₂ and 58.01 cm) were observed under control. The maximum plant height at 30, 60₂ and 90 days after transplanting (17.78, 49.68₂ and 69.98 cm) was recorded in treatment B₂ (with 200 ppm), and minimum plant height at 30, 60₂ and 90 days after transplanting (15.66, 43.25₂ and 61.13 cm) was observed under with B₀ (control). Growth attributes of brinjal increased with the application of boron at the initiation of flowering. Boron is also associated with the development of plant cell walls and results in improved shoot growth (Basavarajeshwari et al., 2008) and thus increased plant height, branches per plant, 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, 60₂ and 90 DAT (30.65, 56.22₂ and 81.29 cm) were observed under the treatment N₂ (75% NPK + 25% VC), which was statistically at par with treatment N₃ (50% NPK + 50% VC). While, minimum plant spread (E-W) at 30, 60₂ and 90 DAT (22.45, 44.06₂ and 68.50 cm) was observed under control. The plant spread (East-West) at 30, 60₂ and 90 DAT under the treatment N₂ (75% NPK + 25% VC) was registered at 36.52, 27.59₂ and 18.67% per cent higher as compared to control, respectively. The Nitrogen is a main constituent of protoplasm, cell nucleus, amino acids, proteins, chlorophyll₂ and many other metabolic products. Phosphorus is a constituent of nucleic acid, phytin₂ 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 treatment B₂ (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 the treatment B₂ (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 in the growth of cells in newly emerging shoots and roots while 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 the treatment N₂ (75% NPK+25% VC), which was statistically at par with the application of treatment N₃ (50% NPK+50% VC). The plant spread (N-S) at 30, 60, and 90 DAT under the treatment N₂ (75% NPK+25% VC) 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-light-textured soils. Most of these investigations have confirmed that manure compost and vermicompost usually has 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 treatment B₂ (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 the treatment B₂ (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. Leaf area of plant 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 of plant. 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 45DAT (1.315 mg.g⁻¹) was observed under the treatment N₃ (50% NPK+50% VC), which was statistically at par with the application of treatment N₄ (25% NPK+75% VC). 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 N₃ (50% NPK+50% VC) was found 29.68% per cent higher than the control. This might be due to the fact that 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 the chlorophyll formation ultimately the NPK are used for better vegetative growth. The effect of vermicompost on physico-chemical properties imparts favorable soil structure for root growth which influenced better plant growth. The maximum chlorophyll contents in leaves at 45DAT (1.270 mg/g) was recorded in treatment B₂ (200 ppm) and the minimum (1.130 mg.g⁻¹) was observed under in the control. The chlorophyll content in leaves under the treatment B₂ (200 ppm) was recorded at 12.38% per cent more over than the control. These results point out that the spray of boron, it 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 N₃ (~~50% NPK+50% VC~~) produced a significantly ($P < 0.05$) maximum fruit length (8.36 cm), which was statistically at par with the application of treatment N₄ (~~25% NPK+75% VC~~). While, the minimum fruit length (7.19 cm) was observed under control. The fruit length under the treatment N₃ (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 treatment B₂ (200 ppm), which was minimum (7.41 cm) under control. Application of treatment B₂ (200 ppm) registered an increase of 11.33% higher fruit length over control. These results indicated that the spray of boron, it 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 the treatment N₃ (~~50% NPK+50% VC~~), which was statistically at par with the application of treatment N₄ (~~25% NPK+75% VC~~). While the minimum fruit weight (70.53 g) was observed under control. The Fruit weight under the treatment N₃ (~~50% NPK+50% VC~~) was found 15.78% more as compared to the control. The application of boron gave a significantly maximum fruit weight (80.38 g) was recorded in treatment B₂ (200 ppm), and a minimum fruit weight (72.76 g) was observed under control. Application of treatment B₂ (200 ppm) registered an increase of 10.47% over control. Increased-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 the loss of water 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 the treatment N₃ (~~50% NPK+50% VC~~), which was statistically at par with the application of treatment N₄ (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 N₃ (~~50% NPK+50% VC~~) was found to be 56.28%.

more ~~over than the~~ control. The application of treatment N₃(~~50% RD of NPK+50% VC~~) 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). ~~Application~~
~~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 significantly increase in fruit yield per hectare (328.52 q ha⁻¹) was recorded in ~~treatment B₂ (200 ppm)~~, and ~~the~~ minimum (236.11) was observed under control. The fruit yield per ~~haectare-hectare~~ under the treatment B₂ (200 ppm) was recorded at 39.13% more ~~over 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 N₃ (50% NPK+50% VC), followed by N₄ (25% NPK+75% VC) and followed by N₂ (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 in ~~at treatment B₂ (200 ppm)~~, which was 11.89% more ~~over than~~ the control, and ~~the~~ minimum (2.69%) was observed under control. These results clearly indicated that the ~~boron spray of boron~~, besides increasing the growth and yield it 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 were ~~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 N₃(~~50% NPK+50% VC~~), which was statistically at par with ~~the~~ application of treatment N₄(~~25% NPK+75% VC~~), whereas, ~~the~~ minimum phosphorus content in fruit (0.43%) ~~were was~~ observed under control. The percent increase in phosphorus content in fruit under the treatment N₃(~~50% NPK+50% VC~~) 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 (B₂) 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

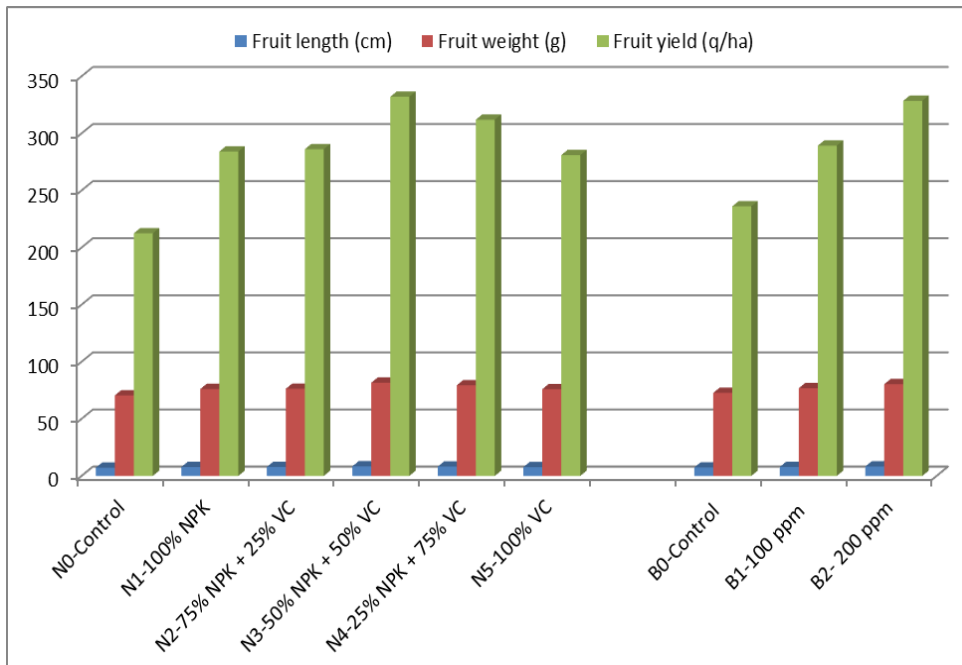


Fig. 1 Effect of NPK with vermicompost and boron on fruit length, fruit weight and fruit yield of brinjal

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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Comment [es1]: MUST BE UPDATED as 16.6% (4 out of 24) of the listed references were published in the past five years. The percentage has to increase to 30-40%. The old reference indicates less interest in the study field.

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