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# Effect of Farmyard Manure, Zinc and Boron on Growth and Yield of Brinjal (*Solanum melongena* L) in Farmers' Fields in Bihar, India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author HKS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BS and MKR managed the analyses of the study. Authors MKR and RKS managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

Zinc and boron are two most important micronutrients found deficient in the intensive vegetable growing fields of the northern parts of Bihar, India. Keeping the above in view, the field trials were conducted in ten farmers' fields during *Rabi* season of 2016-17 and 2017-18 with four treatments consisting of: i) Farmers' practice/control (T1), ii) 10.0 kg Zn + 1.0 kg B / ha (T2), iii) 5 t farmyard manure (FYM) $ha^{-1}$ with 5.0 kg Zn $ha^{-1}$ as basal + foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage + 1.0 kg B $ha^{-1}$ (T3) and iv) 5t FYM $ha^{-1}$ with 5.0 kg Zn $ha^{-1}$ as basal + foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage with 2.0 kg B $ha^{-1}$ (T4). The field trials were conducted with randomized complete block

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design under the supervision of Krishi Vigyan Kendra, Kishanganj, Bihar. Results revealed that the maximum fruit yield of 280.51 q/ha was recorded with 12.03 maximum fruit number and early days to first fruit harvest (60.86) by the application of 5t FYM $ha^{-1}$, 5.0 kg Zn $ha^{-1}$ as basal + foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution applied one at maximum vegetative growth stage and another at flower initiation stage with 2.0 kg B $ha^{-1}$ as basal application in comparison to farmer practice with 189.79 q/ha fruit yield, 6.07 numbers of fruit and days to first fruit harvest (70.11). This treatment also recorded the highest B:C ratio (3.82) in comparison to farmer practice (2.93) indicating an economically better response to farmers of the intensively brinjal cultivated region of the state.

*Keywords: Brinjal; farm yard manure; micronutrients; yield characteristics; B:C ratio.*

## 1. INTRODUCTION

The farming is one of the most important sources of farm income and creates an impact on the agricultural development and economy of India. The present area under vegetable production in the country is around 10.10 million hectares with a production of vegetable is 169.06 million tons. Our share in World vegetable production is 10.8% [1]. Brinjal belongs to the family Solanaceae. The cultivated brinjal is of Indian origin and has been in cultivation from long time [2] and center of origin was in the Indo Burma region [3]. Brinjal (*Solanum melongena* L.) is highly productive and usually finds its place as poor man's crop. It is an important vegetable due to its nutritive value, consisting of minerals like iron, phosphorus, calcium,and vitamins particularly 'B' group. Analysis of soil and plant samples has indicated that 49% soils in India are potentially deficient in Zn, 12% Fe, 5% Mn, 3% Cu, 33% B and 11% in Mo. Basal application to soil and/or foliar sprays of Zn, B and Mo and foliar sprays of Fe and Mn have been recommended as themost suitable methods for correcting such deficiencies in crops [4]. Micronutrients like boron, copper and zinc also play a positive role in increasing fruit as well as seed yield in brinjal. Micronutrients are those elements that are essential for plant growth, but which are required in smaller amounts. If these elements are not available sufficiently, plants will suffer from physiological stresses caused by inefficiency of several enzymatic systems and other related metabolic functions. Various responses were observed in growth and yield in crop species and in cultivars to trace elements deficiency [5].

Brinjal is one of the widely grown vegetables with high nutritive value and it is responsive to applied Zn and B in deficient soils for better growth, yield and quality of fruits [6,7]. Physiological stresses like leaf tip yellowing in eggplant are caused by boron deficiency, interveinal necrosis and little leaf are caused by Zn deficiency [8]. Application of macronutrients along with judicious use of farm yard manure (at recommendd dose of fertilizers) will not only enhance productivity but will also increase the total production and the efficiency of fertilizer use in brinjal crop, but at the same time depletes the available micronutrients from soil [7]. While doing so, there is an urgent need to augment supplies of customized fertilizers supplying secondary and micronutrients to support sufficient supply of all the nutrients to sustain the productivity vis-à-vis soil quality management in brinjal production.Therefore, keepingthe above points in view, present study was under taken with the objective to determine the effect of FYM, zinc and boron on growth, yield and fruit quality of brinjal.

## 2. MATERIALS AND METHODS

The experiment was laid out in a Complete Randomized Block Design during the rabi season (2016-17 and 2017-18) with ten replications under the supervision of Farm Science Centre, Kishanganj, on different farmer's fields in Kishanganj district of Bihar, India. The farmers were selected for the On-Farm Testing (OFT) of deferent doses of FYM with micronutrients (Zn and B) on the test crop brinjal with local variety Kateela (oval in shape and green in colour). The various treatments included were i) Farmers' practice (T1), ii) 10.0 kg Zn + 1.0 kg B / ha (T2), iii) 5 t FYM $ha^{-1}$ with 5.0 kg Zn $ha^{-1}$ as basal + foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage + 1.0 kg B $ha^{-1}$(T3)and 5t FYM $ha^{-1}$with 5.0 kg Zn $ha^{-1}$ as basal + foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another

at flower initiation stage along with 2.0 kg B $ha^{-1}$(T4).

For the nursery preparation, 300 g seeds of brinjal were sown in 100 $m^2$ nursery beds (FYM mixed soil) for transplantation in one hectare field. Need-based all the nursery management practices were practiced and kept uniform. The seedlings were ready for transplantation within 35 days of planting when they attain a height of approximately 15 cm with 2-3 true leaves.The seed bed was lightly irrigated 24 hours before uprooting the seedlings for transplantation to avoid root injury. During the initial survey of farmers field, it has been found that majority of the growers are not satisfied with the existing cultivars due to their low yield and they were not applying micronutrient fertilizers in brinjal. The tested soil samples of all the farmers' fields were found sandy loam to loam with more than 52% sand, 28.8 to 32.5% silt and less than 15.5% clay with pH ranging from 5.6 to7.8 of Teusa panchayat in Kishanganj district of Bihar. The soil samples were collected from each farmers' plot before sowing for determination of initial soil fertility status and physico-chemical parameters like soil pH, organic carbon content, available N, $P_2O_5$, $K_2O$, Zn, Fe, S, B,and Mn were measured [9] and presented in Table 1. The major fertilizers are recommended by the help of PUSA-STFRM kit before transplanting the crop in experimental fields. All intercultural operations (earthing up, weeding etc.) including irrigation was applied as and when required. In this experimentation, each farmer's field represents a replication of theimposition of treatments. Five competitive plants of each treatment and replications were selected for taking observations on six economically important traits *viz*., days to 50 % flowering, plant height (cm), days to 1st fruit harvest, number of fruits/ plant, fruit length (cm) and average fruit yield (q/ ha) as well as economic study (benefit-cost ratio) of experimental plots. The data of the two years (2016 and 2017) is pooled and the analysis of variance (ANOVA) for the experiment was carried out according to SPAR 2.0. The present work is aimed to study the effect of micronutrients particularly, Zn and B on yield and agro-morphological quality of brinjal.

## 3. RESULTS AND DISCUSSION

Results (Tables 1 and 2) showed that better performance of brinjal in terms of plant height, number of fruits/plant, days to first fruit harvest and average fruit yield during the rabi season of both years as well as pooled irrespective of the application of different doses of FYM, Zn and B on farmers field. Application of FYM, Zn and B significantly influenced the fruit yield and other agro-morphological parameters *viz*.,days to 50% flowering, plant height (cm), days to 1st fruit harvest, number of fruits/plants, fruit length (cm). The highest increase was found with the application of soil + foliar application of Zn and highest dose of B *i.e.* 2.0 kg B $ha^{-1}$. On average, fruit yield of brinjal varied between 189.79 to 280.51 q/ha with a mean value of 241.06 q/ha. It is clear that 5t FYM $ha^{-1}$, 5.0 kg Zn $ha^{-1}$ as basal + foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage along with application of 2.0 kg B $ha^{-1}$ ($T_4$) gave a significant increase in all quantitative yield characteristics as compared with control treatment (Fig. 1). Application of 5t FYM $ha^{-1}$, 5.0 kg Zn $ha^{-1}$ as basal + foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage along with application of 2.0 kg B $ha^{-1}$ produced the maximum number of fruits of 11.93, 12.14 and 12.03 in the year 2016-17, 2017-18 and pooled, respectively which are significantly superior over other treatment combinations as well as over existing farmers'practice (Table 2). Similar observations were also recorded for other agro-morphological parameters where $T_4$ was found superior over other treatments and poor expression of existing farmers' practice.There was a favourable effect of Zn on number of fruits per plant which may be ascribed to its involvement in all the six classes of enzymatic activities of plant metabolism, while the effect of B may be attributed to higher rate of pollen viability, pollen tube growth, male flowers fertility and increased sugar translocation in fruits. All of these physiological activities are attributed to more photosynthetic activity and higher production of sugars and ultimately more number of fruits per plant. These results are in accordance with there sults reported by Suganiya et al. [10] and Pandav et al. [11].

Results also showed that application of soil plus foliar doses of Zn (i.e. T3 and T4) has significant edge over only basal application of Zn (T2) in enhancing all the yield attributing characters of brinjal measured in this experiment thus indicating that micronutrient application through soil plus foliar is more effective than only basal application in soil. This may be due to the higher use efficiency of Zn through the foliar spray. Application of Zn fertilizers along with FYM

**Table 1. Physico-chemical properties and nutrient status of soil under study**

| Content | pH | EC (dS/m) | Organic Carbon (%) | Available N (kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) | Available zinc (ppm) | Available iron (ppm) | Available sulphur (ppm) | Available boron (ppm) | Available manganese (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Farmers' field-1** | 5.96 | 0.68 | 0.56 | 313.60 | 59.12 | 165.00 | 3.43 | 3.11 | 3.43 | 3.20 | 2.43 |
| **Farmers' field-2** | 5.03 | 0.53 | 0.37 | 207.20 | 16.50 | 131.00 | 0.31 | 3.96 | 2.11 | 0.66 | 4.11 |
| **Farmers' field-3** | 4.93 | 0.52 | 0.43 | 240.80 | 30.50 | 138.80 | 0.43 | 6.23 | 3.16 | 0.43 | 3.23 |
| **Farmers' field-4** | 4.96 | 0.76 | 0.32 | 179.20 | 32.50 | 128.00 | 0.13 | 5.32 | 2.11 | 1.46 | 4.11 |
| **Farmers' field-5** | 4.91 | 0.93 | 0.42 | 223.50 | 26.60 | 114.50 | 0.60 | 4.50 | 0.21 | 2.61 | 4.25 |
| **Farmers' field-6** | 5.70 | 0.42 | 0.35 | 196.00 | 26.13 | 290 | 0.03 | 4.63 | 0.31 | 3.17 | 4.11 |
| **Farmers' field-7** | 5.80 | 0.42 | 0.56 | 313.00 | 21.30 | 311.00 | 0.40 | 4.65 | 0.21 | 4.11 | 2.11 |
| **Farmers' field-8** | 6.10 | 0.43 | 0.75 | 420.00 | 60.13 | 200.00 | 0.23 | 4.40 | 0.21 | 4.11 | 2.44 |
| **Farmers' field-9** | 6.50 | 0.53 | 0.61 | 341.60 | 30.15 | 157.00 | 1.32 | 3.11 | 2.31 | 0.62 | 2.11 |
| **Farmers' field-10** | 6.03 | 0.42 | 0.53 | 296.80 | 68.63 | 112.30 | 1.20 | 4.86 | 0.42 | 0.44 | 2.44 |
| **Range** | **4.91-6.50** | **0.42-0.93** | **0.32-0.75** | **179.20-420.00** | **16.50-68.63** | **112.30-311.00** | **0.03-3.43** | **3.11-6.23** | **0.21-3.43** | **0.43-4.11** | **2.11-4.25** |
| **Mean** | **5.59** | **0.56** | **0.49** | **273.17** | **37.16** | **146.05** | **0.81** | **4.48** | **1.45** | **2.08** | **3.13** |

**Table 2. Mean (averaged over ten Farmers 'field) performance of farmyard manure, B and Zn on growth and yield of brinjal (database of year 2016-17, 2017-18 and pooled)**

| Treatment | Days to 50 % flowering | | | Plant height (cm) | | | Days to first fruit harvest | | | No of fruit/ plant | | | Fruit length (cm) | | | Average fruit yield (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016-17 | 2017-18 | pooled | 2016-17 | 2017-18 | pooled | 2016-17 | 2017-18 | pooled | 2016-17 | 2017-18 | pooled | 2016-17 | 2017-18 | pooled | 2016-17 | 2017-18 | pooled |
| T1 | 59.58 | 59.19 | 59.39 | 68.43 | 66.19 | 67.31 | 70.80 | 69.42 | 6.07 | 6.36 | 5.77 | 6.07 | 11.04 | 10.7 | 10.87 | 19.1 | 18.9 | 19.0 |
| T2 | 57.75 | 58.34 | 58.05 | 75.46 | 74.88 | 75.17 | 65.66 | 64.47 | 7.57 | 7.79 | 7.35 | 7.57 | 11.74 | 11.43 | 11.59 | 24.0 | 24.2 | 24.1 |
| T3 | 56.45 | 53.47 | 54.96 | 84.27 | 85.17 | 84.72 | 64.78 | 63.36 | 8.95 | 9.35 | 8.56 | 8.95 | 12.52 | 12.72 | 12.62 | 25.2 | 25.3 | 25.3 |
| T4 | 52.96 | 51.76 | 52.36 | 88.76 | 88.14 | 88.45 | 61.44 | 60.28 | 12.03 | 11.93 | 12.14 | 12.03 | 12.88 | 13.83 | 13.36 | 27.1 | 29.0 | 28.1 |
| **SEm ±** | **1.02** | **3.39** | **1.78** | **1.62** | **1.65** | **1.10** | **0.73** | **0.93** | **0.70** | **1.56** | **2.57** | **1.55** | **0.84** | **1.00** | **0.67** | **5.63** | **4.91** | **4.07** |
| **CD @ 5 %** | **2.10** | **6.95** | **3.65** | **3.31** | **3.37** | **2.26** | **1.50** | **1.91** | **1.44** | **3.19** | **5.26** | **3.18** | **1.71** | **2.06** | **1.37** | **11.53** | **10.06** | **8.34** |

*$T_1$- Control (RDF alone and no use of micronutrients),*
*$T_2$- 10.0 kg Zn + 1.0 kg B / ha,*
*$T_3$-5 t FYM ha$^{-1}$, 5.0 kg Zn ha$^{-1}$ as basal + Foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage + 1.0 kg B ha$^{-1}$and*
*$T_4$-5t FYM ha$^{-1}$, 5.0 kg Zn ha$^{-1}$ as basal + Foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage + 2.0 kg B ha$^{-1}$*

**Table 3. Economics (mean of two years)of brinjal productionin farmers'field**

| Treatments | Cost of cultivation (Rs/ha) | Gross Return (Rs/ha) | Net return (Rs/ha) | B:C ratio |
|---|---|---|---|---|
| **$T_1$-** Control (RDF alone and no use of micronutrients), | 39100 | 114540 | 75440 | 2.93 |
| **$T_2$**- 10.0 kg Zn + 1.0 kg B / ha, | 40200 | 144060 | 103860 | 3.58 |
| **$T_3$**-5 t FYM ha$^{-1}$, 5.0 kg Zn ha$^{-1}$ as basal + Foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage + 1.0 kg B ha$^{-1}$ | 41800 | 151440 | 109640 | 3.62 |
| **$T_4$**-5t FYM ha$^{-1}$, 5.0 kg Zn ha$^{-1}$ as basal + Foliar spray of Zn twice @ 0.5% $ZnSO_4.7H_2O$ solution - one at maximum vegetative growth stage and another at flower initiation stage, 2.0 kg B ha$^{-1}$ | 42600 | 162540 | 119940 | 3.82 |

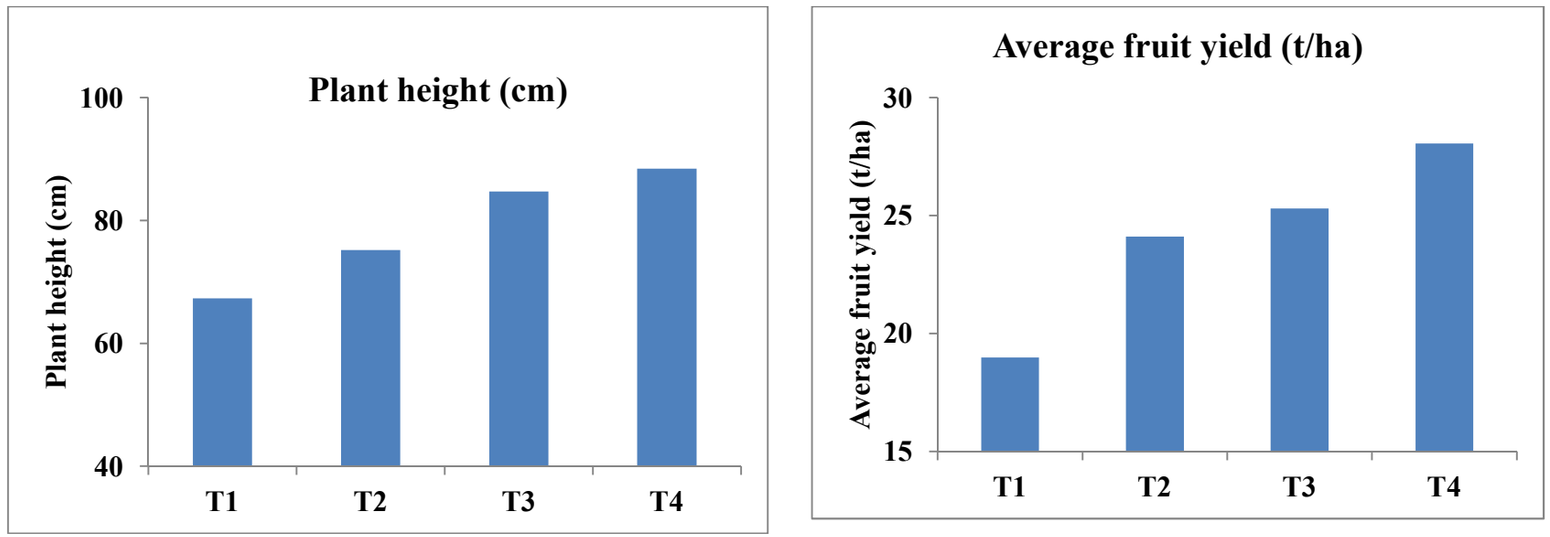


**Fig. 1. Influence of different application methods of Zn and B (with or without FYM) on plant height and fruit yield of brinjal**

enhanced the brinjal fruit yield to the extent of 10-24% over the control under different treatment combinations. The results are in line with the findings of Bose and Tripathi [12]. Furthermore, FYM act as a natural conditioner which improved soil properties and consequently soil productivity and nutrition uptake by brinjal crops. These results are in accordance with those reported by More [13]. These findings are in agreement with the findings of Harris and Mathuma [14], Meena et al. [15], Pandav et al. [11].

The returns over cost involvement (i.e. benefit: cost ratio) were calculated for brinjal cultivation in all the farmers' fields in both years and the results are presented in Table 3. A perusal of data revealed that the net returns were the highest in $T_4$ (Rs. 119940) with B:C ratio 3.82 than farmer practice (Rs. 74440) with B:C ratio 2.93. It could be inferred that in refined technology the efficiency of production was high, which may be due to higher yield and got more return.

## 4. CONCLUSION

The soil application of zinc and boron in addition to recommended doses of farm yard manure can be an effective practiceto deal with low productivity of the brinjal due to zinc and boron deficiency. Results also revealed that soil as well as foliar application of Zn and basal application of B could enhance yield and income of farmers of the studied area as compared to routine practices.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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