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Effect of Foliar Boron Application on Rice (Oryza Sativa L.) Growth and Final Crop Harvest

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Abstract

Boron (B) is an essential micro nutrient and its deficiency caused a reduction in final crop harvest and quality of the yield. A field experiment was conducted to evaluate the effect of foliar application of B on yield and yield components of rice in calcareous soils under agro-climatic conditions of Lahore, Pakistan. The experiment was laid out in randomized complete block design (RCBD) with six B foliar application rates (0, 5, 10, 15, 20 and 25 mg L-1). The experiment was replicated three times. The results illustrated a significant effect of B foliar application on number of grains panicle-1, number of filled grains and final grain yield. The highest grain yield (352 g m-2) was recorded in 20 mg L-1 foliar application, whereas an increase in B application to 25 mg L-1 reduces the final grain yield significantly (313 g m-2). Detrimental effects of the highest B application on yield components were also observed. The decline in the quantity and quality rice yield resulted by increasing B application might be due to the toxic effect of higher concentration of B application.

Keywords: Micronutrients, Boron, Rice, Yield.

Contents

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1. Introduction

Crop plants require a sufficient supply of essential mineral elements for optimal crop growth and final harvest in terms of crop yield. An insufficient availability of essential nutrients (micro and macro) may cause stunted growth and limits the crop productivity. Boron is an essential micronutrient for plant growth [1] and has a key role in plant metabolism [2]. Its deficiency are reported commonly among crops grown in soil having higher amounts of free carbonates, low organic matter, and high pH [3, 4]. Crop removal from the field is the main driving force for decrease of soil nutrient levels because hardly any crop residue gets recycled back to the soil resulting in decreasing nutrient pool including B. In addition, abundant soil moisture (because of torrential monsoon rains during July-August, in flooded rice fields etc.) causes B leaching, beyond the root zone [5]. On the other hand, the dry surface soil layers, because of dry spells during the growing season, inhibit root absorption of B [6, 7]. Also, subsequent to green revolution, crop yields and crop intensification have risen and, hence, increased amounts of B are being removed from soils, year after year. Hence, these essential elements can be supplied as fertilizers in both intensive and extensive agricultural systems. However, excess B can cause toxicity to both plants and animals.

Fertilizer use efficiency including foliar application methods can be enhanced agronomically, through improved fertilizer- management practices by cultivating crops that acquire and/or utilize mineral elements more effectively [8, 9]. Field research in Pakistan has demonstrated yield increases due to B use on several crops, including wheat, rice, maize, groundnuts, tobacco, and potato. Boron application increased the yield of wheat (up to 14%), rice (up to 19%) and maize (up to 20%) [10]. Although monocotyledous crops are less sensitive to B deficiency as compared to dicotyledonous, cereals including maize, sorghum, wheat, rice and barley are also being affected by deficiency world scale [11, 12].

The total B concentration in soils ranges from 20-200 mg kg^{-1} [13]. Most of it is unavailable to plants [14]. The available (hot water soluble) fraction generally ranges from 0.4-5.0 mg kg^{-1} [15]. Boron availability decreases with increasing soil pH; thus it is often inadequately available in calcareous soils. Boron uptake by plants correlates well with the level of hot water soluble and HCL extractable soil B [16].

Keeping in view the deficiencies reported causing reduction in final crop harvest and less availability of B in calcareous soils, the objective of the present study was to evaluate the efficiency of boron foliar application on rice yield and yield components in calcareous soils of Pakistan.

2. Materials and Methods

A field experiment was conducted in Field Experimental Area of Directorate of Land Reclamation, Canal Bank Moghalpura Lahore, Pakistan. The experiment was consisted of six boron application levels (0, 5, 10, 15, 20 and 25 mg L^{-1}) and laid down in randomized complete block design and replicated thrice. The rice seedlings were transplanted in plots (40.5 m^2) and there were twenty lines of rice seedling 9 m length. Boron was applied as a solution of Borax and was sprayed on rice at three growth stages including tillering stage, booting stage and milking stage. Phosphorus (as diammonium phosphate) and nitrogen (as urea) was applied at the rates of 200 and 350 kg ha^{-1}, respectively and were added to the all plots. A thinning was carried out (how many days after transplanting) to final plant density of 19 plants m^{-2} at seedling stage. Weeds were mechanically controlled. Grain yields were taken at maturity by harvesting the 1 m^2 area of the two inner rows of each plot at the end of April. Grain yield was adjusted to a 10% moisture basis. The following growth and yield component variables were recorded for each plot: plant height, fresh weight, number of tillers $plant^{-1}$, number of panicles $plant^{-1}$, panicle length number of grains $panicle^{-1}$, grain yield, filled grains (%), , and 1000-seed weight. All data were analyzed by the GLM procedure using the Statistix (Version 8.1 Analytical Software). Means were compared using LSD Test at 5% probability level.

3. Results and Discussion

3.1. Yield and Yield Components

Results showed that B application had significant effects on grain yield, Number of Grains $Panicle^{-1}$ and filled grains (Table 1). The highest rice grain yield (352 g m^{-2}) was obtained in treatment with 20 mg L^{-1} solution of boron (Fig. 1). Increasing boron foliar application from 5 to 25 mg L^{-1} decreased grain yield (313 g m^{-2}) significantly. One possible explanation for the decline in grain yield of rice at the highest B application is the antagonism relation between Ca and B [17, 18]. It has been shown that the relative uptake rates of calcium significantly decreased in both shoot and root of plants as solution B concentrations was increased [19]. There are different reports on the effect of B on grain yield of rice. An increase in rice yield with increasing B has been reported [19, 20]. In contrast, it was observed that the grain yield of rice decreased as B fertilizes was increased [21].

Table-1. Mean square of analysis of variance for some measurements in this study

SOV	*d.f*	Yield/g	Biomass/ kg	No. of Grains $Panicle^{-1}$	Plant Height/ cm	Panicle Length/ mm	Filled Grains/ %	1000 Grains weight/g	No. of Tillers $plant^{-1}$	No. of Panicles $Plant^{-1}$
BLOCK	2	106.26^{NS}	0.00277^{NS}	2.657^{NS}	12.4689^{NS}	1.88222^{NS}	3.8672^{NS}	0.8156^{NS}	0.2756^{NS}	0.2572^{NS}
BORON	5	8177.14^{**}	0.06067^{NS}	551.613^{**}	66.5276^{NS}	9.03156^{NS}	35.8382^{**}	13.3329^{NS}	12.3206^{NS}	12.4206^{NS}
ERROR	10	20.29	0.00271	13.642	3.5936	2.08222	1.8499	2.1402	1.9822	0.4432
C.V (%)	-	1.64	2.41	2.97	1.83	6.63	1.92	6.83	9.47	4.86

Source: Unpublished Data

The highest number of grains per panicle and filled grains of rice (137.67 grains $panicle^{-1}$ and 74 % respectively) resulted in treatment with 20.0 mg/L solution of boron (Fig. 2 and 3). Increasing boron fertilizer from 5.0 to 25.0 mg/L decreased number of grains per panicle (123.33 grains $panicle^{-1}$) and filled grains (67.67 %) significantly. Filled grains are affected by B deficiency as it has key role in pollen vitality [22].

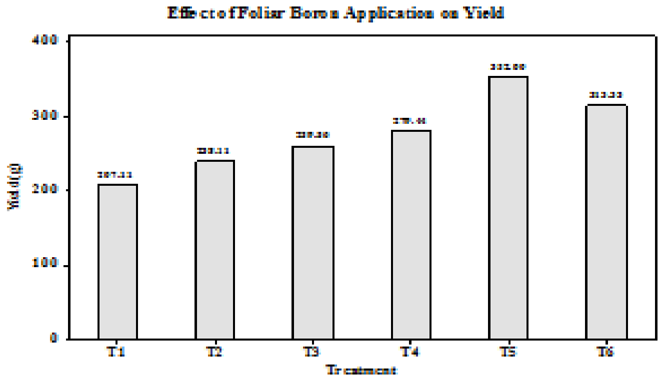

Figure-1. Effect of foliar application on rice yield
Source: Unpublished Data

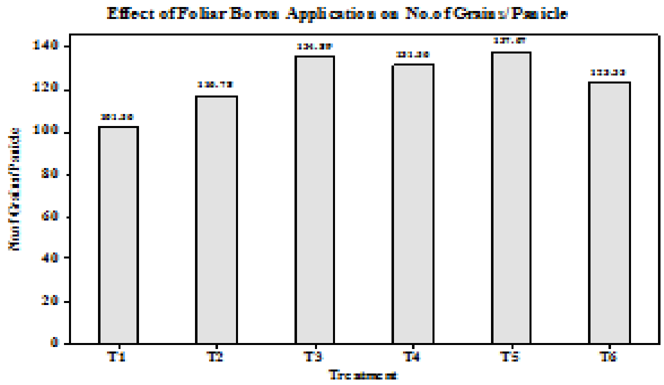

Figure-2. Effect of foliar application on number of grains
Source: Unpublished Data

One possible explanation for the decline in number of grains per panicle and filled grains of rice at the highest B application is the antagonism relation between Ca and B [17]. B application had no significant effect on 1000 grain weight (Table 1).

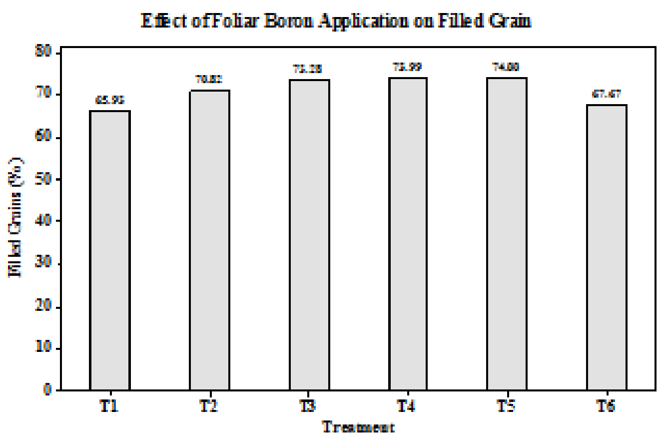

Figure-3. Effect of foliar application on number of filled grains
Source: Unpublished Data

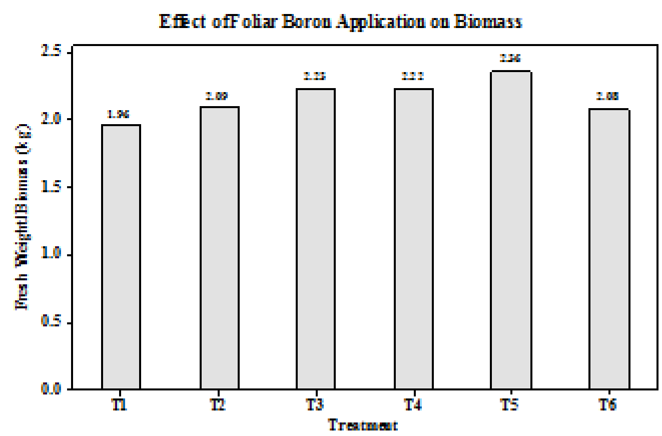

Figure-4. Effect of foliar application on number of filled grains
Source: Unpublished Data

3.2. Biomass Number of Tillers per Plant, Panicle Length and Plant Height

B application had no significant effect on biomass, number of tillers plant^{-1}, panicle length and plant height (Table 1). There was slight increase in biomass production due to B application (Fig. 4) but this increase was statistically non-significant. 20 mg/L gave maximum total biomass (2.36 kg m^{-2}) whereas minimum biomass (1.96 kg m^{-2}) was found in control treatment. These results are similar to those of Khan, et al. [20] who obtained non-significant difference in number of plants m^{-2}, total number of tiller plant^{-1} and number of fertile tillers plant^{-1} in response to applied fertilizer B, whereas, a significant improvement in number of grains per spike and 1000-grain weight was found when fertilizer B was sprayed on wheat foliage at three growth stages i.e. tillering, booting and milking. Similarly, it was reported that in spite of increase in grain yield of rice, vegetative parameters as number of tillers plant^{-1}, panicle length and plant height were not affected by B application [19, 23].

4. Conclusion

The result of this study indicated that application of B had significant effect on yield and most components of yield of rice. Application of 20 mg L^{-1} solution of B led to the highest grain yield of rice. Application of B fertilizer more than 20 mg/l decreased grain yield and other yield components. This decline was significant when 25 mg/l B was applied. The decline in the yield parameters of rice might be due to the toxicity of high B application particularly in calcareous soil. The results showed that *Oryza sativa* grown in a calcareous soil doesn't need more than 20 mg L^{-1} B as foliar application.

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