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Crop Response Based Assessment of Boron on Rice for Yield Maximization in Acid Alfisol of Ranchi District of Jharkhand, India

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Abstract—*A field experiment was conducted in Department of Soil Science and Agricultural Chemistry, College of Agriculture, BAU, Ranchi during kharif season 2012 and 13 to study the crop response based assessment crop response based assessment of boron for yield maximization in acid alfisol of ranchi district of Jharkhand. The recommended dose of N, P and K (80: 40: 30 kg ha-1) was applied in combination with four levels of boron (0, 1, 1.5 and 1 kg B ha-1 + 2 foliar sprays of 0.2% Borax at tillering and before flowering). The highest B concentration (1.57 mg kg-1 in grain and 14.9 mg kg-1 in straw) and yield (45.5 q ha-1 grain and 101.9 q ha-1 straw yield) was observed under the treatment 1 kg B ha-1 + 2 foliar spray of 0.2% borax at tillering and pre flowering stages, while minimum yield was found in control (36.6 q ha-1 grain and 86.6 q ha-1 straw yield). Similarly maximum nutrient use efficiency (4.6) was found in soil plus foliar application of boron. It was inferred that application of boron in soil @1 kg B ha-1 along with two foliar applications of it @ 0.2% at tillering and pre flowering stages ensures higher B content in plant, higher yield, improved grain quality in terms of boldness coupled with reduced the sterility percentage.*

1. INTRODUCTION

Boron is one of the essential nutrients, which are needed by plants for healthy growth. The possible roles of B in crops include sugar transport, cell wall synthesis, lignification, cell wall structure integrity, carbohydrate metabolism and as part of the cell membranes. Boron is known to influence the reproductive phase of the plants and therefore, influence pollen viability and seed setting.

The deficiency of boron is very common in Jharkhand (India). Red and lateritic soils of Jharkhand (specially the southern plateau region) falling under the soil order "Alfisol" are deficient in micronutrients including boron. Soils of about 56 per cent of the state are found to be deficient in available boron (<0.5 mg kg^{-1}) (Shukla *et al*.,2014).

Use of Boron fertilizer in rice is very helpful in enhancing the yield of crop and quality of produced but its use is almost negligible in India. Boron deficiency is one of the important yield limiting factors including heavy rainfall, low organic matter, coarse textured soil, intensive cultivation and imbalanced and non judicious fertilizer use.

Sometime plant unable to take the nutrient (Boron) from soil due to some chemical and physical properties like pH, soil moisture, texture, organic matter, leaching losses etc. in such cases foliar application of B is very helpful in fulfilling the requirement of deficiency. It is very necessary to define the dose and method of application because small amount needed for correction while avoiding over application and possible toxicity. Foliar application of boron is most efficient method due to rapidly availability of nutrients, as compared with soil application (Firdous *et al*., 2017). It is a cost effective because reasonable crop yield can be increased with a little extra cost on micronutrients application on most appropriate stage. The present study was therefore carried out to see best method of boron fertilization under rice cultivation and its impact on yield.

2. MATERIALS AND METHODS

This research work was carried out on an Alfisol of the Research Farm of Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Ranchi (Jharkhand) during the successive year (2012-13). The experiment was laid out in randomized block design with four replications. The experimental soil (0-15 cm depth) was analyzed for initial soil physicochemical properties.

This soil had a sandy loam texture, pH of 4.68, 0.41 % organic carbon, available N 330 kg ha^{-1} available P 30.6 kg $ha^{-1}$and 142.5kg ha^{-1} available K, DTPA extractable Zn, Fe, Mn and Cu content was 1.08, 15.27, 6.91, 1.02, mg kg^{-1}, respectively and available B with hot water extractable was 0.31 mg kg^{-1}.

Rice (var. Sahbhagi) was sown during *kharif* season, with a basal dose of 80:40:30 N, P_2O_5, and K_2O was applied before transplanting and one fourth of N top dressed after 25 DAT and rest one fourth after 50 DAT in the form of urea in split dose and having four levels of B : T_0 (control), T_1 (1 kg B ha^-

^{1}), T_2 (1.5 kg B ha^{-1}) and T_3 (1 kg B ha^{-1} + 2 foliar sprays of 0.2% Borax at tillering and before flowering). Boron was given as soil application in the form of borax.

Data on B content in grain and straw (mg kg^{-1}), panicle length, number of spike per panicle, 1000 grain weight and grain and straw yield (kg ha^{-1}) were recorded. Harvest index, sterility percentage, benefit cost ratio and nutrient use efficiency was calculated.

3. RESULTS AND DISCUSSION

The effect of B application on yield components of rice

The effect of B on yield components of rice is given in Table 1. Data on thousand grain weight, an indicator of grain boldness and also an important yield attributing character, has been found to be influenced significantly by the level of B applications during both the years. All the levels of B were significantly superior over control. Among the levels, T_1 and T_2 were at par with each other and the level T_3 was found significantly superior over control and T_1 but at par with T_2. Foliar applications of B ensure better crop nutrition at reproductive stage as a result increase in grain weight. As reported by Raza (2014) a significant improvement in 1000 grain weight was found by foliar application (Raza 2014).

Number of spike per panicle and panicle length were non - significantly increased, with increase in B levels. The levels of B application could produce longer panicles than the panicle length under control as also reported by Khan *et al*., 2006.

Effect on sterility

The unfilled or chaffy grain, being a function of sterility, is one of the most important yield attributing parameters which may or may not be due to the genetic characteristic of crop genotype but is definitely governed by the ambient weather condition at the time of flowering. High temperature and/or high rainfall at flowering stage often cause sterility leading to the chaffy grains (Pragyan and Kumar, 2011). The **sterility percentage** was calculated based on total number of grains and number of unfilled grains (Table 1). The pooled data on sterility worked out with different levels of B application revealed that the sterility percentage decreased significantly with the levels of B applications. All the levels of B application (T_1, T_2 and T_3) were found superior over control and among the levels T_3 was superior over T_1 and T_2. Here, the role of B application seems to be very positive in reducing the sterility percentage Rashid *et al*., (2004) also reported the similar result. In other word it can be inferred that the addition of B into the soil as well as its foliar application is capable of mitigating the ill effects of high temperature and /or high rainfall at flowering stage. They also reported that the B application increased the number of productive tillers as well as reduced the uneven maturity.

Table 1: Response of boron to rice on yield attributing parameter

	panicle length (cm)	number of spike per panicle	1000 grain weight (gm)	Total number of grains per panicle	Total number of unfilled grain per panicle	Sterility (%)
T0	22.7	10	22.1	140	19	12.3
T1	23.1	11	23.4	147	14	9.2
T2	23.1	11	24.2	154	12	7.8
T3	23.3	11	25.3	161	10	6.1
CD at 5%	NS	NS	1.36	5.69	2.03	1.37
CV %	4.33	5.97	6.87	4.52	19.1	18.9

Table 2: Response of boron to rice and its nutrient use efficiency (NUE) and BCR

	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	B content in grain (mg/kg)	B content straw (mg/kg)	NUE	BCR
T0	36.5	86.6	30.4	1.35	11.9	-	-
T1	41.8	90	30.5	1.47	13.4	1.87	4.6
T2	45	96.3	31.9	1.49	13.6	1.96	4.9
T3	45.5	101.9	31.6	1.57	14.9	4.6	5.7
CD at 5%	3.4	7.4	NS	1.2	4.7		
CV %	9.6	4.8	8.4	6.4	7.9		

Grain yield was significantly affected with foliar boron application. Maximum grain yield was recorded for application of boron (soil plus foliar) during both the years with mean yield 45.5q ha^{-1}, whereas minimum grain yield was recorded under control during both the years with mean yield 36.5 q ha^{-1}. The pooled data revealed that each incremental levels of B application contributed towards significantly higher yield over the control. Similar result has been reported by Khan *et al*., 2006. Among the levels, T_2 and T_3 were at par with each other, both being significantly superior over T_1 and over the control (T_0). However, soil as well as foliar application of boron has been reported to the increase the yield. In terms of **straw yield** also, the crop response exhibited the similar trend as in case of grain yield. The **harvest index** being an indicator of partitioning behavior showed a different trend than that observed in case of grain and straw yield. The harvest index were non significant, the B application level T_2 exhibited highest harvest index (30.05 %) than all other levels including control. These results are in accordance with the

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findings of Raza *et al*., 2014, who obtained non-significant difference in biological yield in response to applied Boron fertilizer.

Boron concentration in grain and straw

Boron content in grain and straw has been presented in table 2. The straw B content under all the levels of B applications was significantly higher over control. Among the levels, T_1 and T_2 were at par whereas T_3 was significantly superior over these two levels. Karim (2012) has reported significant increase in B concentrations due to foliar application of B

The maximum B was accumulated in straw than brown rice. This trend was maintained in both the years 2012 and 2013. The straw B content in pooled data was recorded to be 11.9, 13.4, 13.6 and 14.9 mg kg^{-1} under T_0, T_1, T_2 and T_3 respectively. The straw B content under all the levels of B applications were significantly higher over control. Among the levels, T_1 andT_2 were at par whereas T_3 was significantly superior over these two levels as well. Karim (2012) has reported significant increase in B concentrations due to foliar application of B.

Compared to straw the B content in brown rice was much less during both the year. The mean B contents were 1.3, 1.5, 1.5 and 1.6 mg kg^{-1} under T_0, T_1, T_2 and T_3 respectively. The variations among the levels of B applications were reflected into improved status of B content with every incremental levels of B application.

Nutrient use efficiency (NUE)

Nutrient use efficiency of different levels of B applications on rice has been presented in table 2. In case of B application the highest nutrient use efficiency 4.6 was achieved under the treatment T_3 with 1 kg B ha^{-1} alongwith two foliar application of 0.2% B in the form of borax at tillering and pre flowering stge. This considerable increase in nutrient use efficiency under the treatment T_3 is probably due to the additional application of B as two foliar sprays at two vegetative stages. Nutrient use efficiency of B application under the treatment T_1 and T_2 have been recorded to be 1.87 and 1.97 respectively, much lower than nutrient use efficiency achieved under T_3 (4.6). Hence, it is inferred that the foliar application of B, in addition to its soil application, promotes B uptake by the plants thereby increasing its use efficiency.

Benefit cost ratio (BCR)

The B application level T_3 could exhibit the highest benefit cost ratio of 5.7 which is marginally higher than the benefit cost ratio exhibited T_1 (4.6) and T_2 (4.9). This marginal increase in benefit cost ratio under T_3 could be attributed to the foliar application of B at vegetative stages.

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