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Paddy Yield as Affected by Boron Application Directly Sown on Raised Bed Under Saline Sodic Soils

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Abstract. A field experiment was carried out to investigate the effect of different levels of boron (0.5, 1, 1.5 and 2 kg B/ha) on growth, yield and ionic concentration of rice directly sown on raised beds under saline sodic soils (ECe=5.65 dS/m, pH=8.57 and SAR=17.38) at Malik Farm, Farooqabad during 2009. Treatments were arranged using randomized complete block design (RCBD) with three replications. The crop was harvested at maturity and data on tillering, plant height, spike length, number of grains/spike, 1000-grain weight, straw and paddy yields were recorded. Tillering, number of grains/spike, 1000- grain weight and paddy yield significantly ($P \leq 0.05$) increased by different levels of B. 1000 grains weight (29 g) and grain yield was the maximum (4.65 t/ha) at the application of 1.5 kg B/ha and 31% more than control treatment. Maximum plant height (141 cm) and numbers of grains/spike (203) were recorded with B application @ 1 kg/ha, B concentration in grain and straw increased with increasing the rate of boron application. Positive correlation (r = 0.856) was found between B contents in grain and paddy grain yield. Economical analysis showed that maximum value cost ratio (14.9:1) this achieved with the application of 1.5 kg B/ha.

Keywords: rice, B application, salt affected soil

Introduction

Rice is highly valued cash crop that earns substantial foreign exchange. In Pakistan rice is grown on an area of 2.96 million hectare with production of 6.952 million tons (GOP, 2009). Salinity poses threat to crop production in many areas of the world including Pakistan (Ashraf and Foolad, 2007; Hasegawa *et al.,* 2000; Greenway and Munns, 1980). It has been estimated that almost 40,000 ha of arable land in Pakistan is being lost due to salinity and the area is rapidly increasing each year (Ashraf *et al.,* 2008; Ahmad *et al.,* 2006). Crop response to B application can be enhanced as the availability of B decreases with increase in soil pH. Over limed and alkaline soils commonly contribute to boron deficiency (Cook and Millar, 1939). In Pakistan, its deficiency is wide spread (Rashid and Raffique, 1992; Sillanpaa, 1990) and 10-45% in rice fields (Zia, 1993; Tahir *et al.,* 1990). Furthermore high amount of Ca in soil reduces B availability to crops (Wang *et al.,* 2001). Soil texture, pH, $CaCO_3$ and organic matter affect availability of B in soil and boron was suspected to be deficient in a number of Pakistani soils especially in rainfed area (Sillanpaa, 1982). Dunn *et al.* (2005) reported that rice yield increased with B use in Missouri, USA. Large numbers of experiments in China have demonstrated the value of applying urea plus boron rather than urea alone. In rice crop the average yield increase due to urea plus B over those achieved by urea alone was 10% (Shorrocks, 1997). In Pakistan, Chaudhary *et al.* (1976) reported marked increases in rice yield with the application of boron. The objectives of the study were:

i. To investigate the effect of B application on paddy yield sown directly on raised bed under saline-sodic soil.
ii. To investigate the optimum economical boron dose for paddy yield when sown directly on raised beds.

Materials and Methods

Effect of different B levels (0.5, 1.0, 1.5 and 2.0 kg/B ha) on growth, yield and ionic concentration of fine rice (supper Basmati) in directly sown on raised beds under saline sodic soil at MK Farm, Farooqabad, District Sheikhpura was studied during Kharif season, 2009. The treatments were arranged using randomized complete block design (RCBD) with three replications. The treatments under investigation were: control, 0.5, 1, 1.5 and 2 kg B/ha using borax (11.3% B). Basal dose of N, P_2O_5 and K_2O @ 100, 80 and 50 kg/ha, respectively

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were applied to all treatments. Half of N and full dose of P and K were applied at the time of sowing. The remaining ½ dose of N was applied at tillering stage. The crop was irrigated with tubewell water (Table 2) throughout the growth period. Necessary plant protection measures were done whenever required. The crop was allowed to stand till maturity and data on tillering, plant height, spike length, number of grains/spike, 1000-grain weight, straw and paddy yields were recorded at the time of plant harvest. Plant samples were oven dried at 60 ºC to a constant weight and dry matter yield was recorded. Ground plant samples were digested in perchloric-nitric acid (2:1) mixture (Rhoades, 1982) to estimate Na, K, and Ca by atomic absorption spectroscopy. Boron was also measured both in plant tissues and grain by wet digestion method as described by Walsh (1973). Data obtained were subjected for statistical analysis using MSTATC package.

Results and Discussion

Growth and yield. Physicochemical analysis of the experimental site having ECe=5.65 dS/m, pH=8.57 and SAR=17.38 (Table 1) shows that the soil is saline - sodic in nature and loamy in texture, having low organic matter (0.33%) where B application was studied. Analysis of tube well water is presented in Table 2 by which the crop was irrigated. Data in Table 3 indicates that different levels of boron application to rice had statistically significant effect on plant height, number of tillers, spike length and 1000 grain weight under directly sown on raised bed. Plant height was significantly ($P < 0.05$) affected by different levels of boron application. Maximum plant height (141 cm) was recorded in treatment receiving 1 kg B/ha and plant height (139 cm) recorded in treatment receiving 1.5 kg B/ha was statistically at par. Minimum height (128 cm) was recorded in control treatment. The maximum number of tillers (35) was produced in treatment receiving 0.5 kg B/ha followed by treatment receiving 1 kg B/ha. The lowest number of tillers (26) was attained in control treatment. Spike length is an important yield determining parameter. The maximum spike length (30 cm) was recorded in treatment receiving 2 kg B/ha followed by treatment receiving 1.5 kg B/ha (28 cm). The minimum spike length (26 cm) was recorded in control treatment. The maximum number of grain per spike (203) was recorded in treatment receiving 1.0 kg B/ha, followed by treatment receiving 2 kg B/ha (187). The positive effect of B on the number of grains per spike has also been observed by many workers (Rashid *et al.,* 2002; Jahiruddin *et al.,* 1995; Abedin *et al.,* 1994; Mandal and Das, 1988). While minimum number of grain/spike (163) was recorded in treatment receiving 1.5 kg B/ha. The maximum 1000 grain weight (29 g) was noticed in treatment receiving 1.5 kg B/ha. However 1000 grain weight achieved in treatment receiving 1 kg B/ha was statistically at par (28 g). The lowest 1000 grain weight was recorded in control treatment (23 g). The straw and paddy yields increased with increasing rate of boron and paddy yield was the maximum with 1.5 kg B/ha registering 31% more than that of control treatments. Ehsan *et al.* (2009) reported that B application @1.5 kg/ha to salt affected soil improved growth and paddy yield. Maximum straw yield (21.62 t/ha) was recorded with the application of 1.5 kg B/ha closely followed by 21.54 t/ha with the treatment of 0.5 B kg /ha (Table 3). The paddy yield significantly enhanced by B application but it started declined when 2 kg B/ha was applied, since excess amount may become toxic. These results are in consonance to Abedin *et al.* (1994) Jahiruddin *et al.* (1992) and Rekasem *et al.* (1989).

Ionic concentration. Ionic concentration in straw and grain was found to be non significant except B concentration in straw and grain (Table 4). Maximum

Table 1. Physicochemical analysis of the soil at MK farm

Parameters	Unit	Value
pH (1:1)	-	8.57
ECe (1:1)	dS/m	5.65
SAR	$(mmol_c/L)^{1/2}$	17.38
$CaCO_3$	%	7
OM	%	0.33
Sand	%	33
Silt	%	42
Clay	%	25
Textural class	-	Loam

Table 2. Analysis of tube well water

Parameters	Unit	Value
pH	-	8.3
ECe	dS/m	1.6
RSC	mmol/L	14.7
HCO_3	meq/L	16.3

Table 3. Effect of Boron on the rice growth and yield*

Treatment	Plant height (cm)	No. of tillers (cm)	Spike length	No of grain/ spike	1000 grain weight (g)	Straw yield (t/ha)	Grain yield (t/ha)
T1=Control	128 d	26 e	26 b	172 c	23 c	20.5 b	3.55 d
T2=0.50 kg B/ha	134 b	35 a	28 b	184 b	24 c	21.5 a	3.85 c
T3=1.0 kg B/ha	141 a	33 b	25 c	203 a	28 ab	20.5 b	4.21 b
T4=1.50 kg B/ha	139 a	28 d	28 b	163 d	29 a	21.6 a	4.65 a
T5=2.0 kg B/ha	131 c	30. c	30 a	187 b	27 b	18.6 c	4.33b
LSD	1.5	1.14	1.11	3.64	1.45	0.206	0.157

*Values followed by same letter(s) are not statistically similar at 5 percent level of significance.

Table 4. Effect of B on ionic concentration*

Treatment	Ca% grain	Na% grain	K% grain	B (mg/kg) grain	Ca% straw	Na% straw	K% straw	B (mg/kg) straw
T1=Control	0.08	0.12	0.24	5.16 d	0.23	0.23	2.15	2.16 d
T2=0.50 kg B/ha	0.13	0.09	0.28	5.56 d	0.22	0.21	2.17	3.30 c
T3=1.0 kg B/ha	0.12	0.11	0.28	8.86 b	0.23	0.26	2.18	3.73 bc
T4=1.50 kg B/ha	0.12	0.14	0.30	9.40 a	0.20	0.19	2.12	4.22 ab
T5=2.0 kg B/ha	0.10	0.10	0.23	6.66 c	0.21	0.26	2.17	4.70 a
LSD	NS	NS	NS	0.50	NS	NS	NS	0.47

*Values followed by same letter(s) are not statistically similar at 5 percent level of significance.

Table 5. Economic analysis, partial budget analysis and dominance analysis of Boron on rice productivity

	T1	T2	T3	T4	T5
Dose (kg B/ha)	Control	0.50	1.0 kg	1.50 kg	2.0
Input cost (Rs.)	0	500	1,000	1,500	2,000
Application cost (Rs.)	-	-	-	-	-
Total cost that vary (Rs.)	0	500	1,000	1,500	2,000
Yield grain (kg/ha)	3550	3850	4210	4650	4330
Yield adjusted (10% Low)	3195	3465	3789	4185	3897
Output price (Rs./kg)	24	24	24	24	24
Yield straw (kg/ha)	21540	20540	20500	21620	18610
Yield adjusted (10% Low)	19386	18486	18450	19458	16749
Output price (Rs./kg)	3	3	3	3	3
Gross field benefits (Rs.)	134838	138618	146286	158814	143775
Net benefits (Rs.)	134838	138118	145286	157314	141775
Dominance Analysis	-	-	-	-	-
TCV (Total cost that vary)	0	500	1,000	1,500	2.000
NB	134838	138118	145286	157314	141775
VCR*	-	6.5:1	10.4:1	14.9:1	3.5:1

*Value cost ratio between values of additional crop produce to the additional money spent on B fertilizer.

B concentration in grain (9.4 mg/kg) was found with the application of 1.5 kg B/ha followed by (8.86 mg/kg) in 1 kg B/ha. The highest concentration of B in straw (4.7 mg/kg) was recorded at 2 kg B/ha followed by (4.22 mg/kg) in 1.5 kg B/ha.

Data in Fig. 1 indicates significant positive correlation (r = 0.856) between B contents in grain and paddy yield. It indicates that presence of significantly higher B contents in grain enhances paddy yield under saline sodic soil.

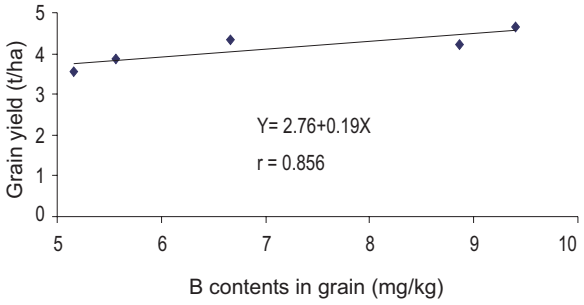

Fig. 1. Correlation between B contents in grain and paddy grain yield.

Economical analysis. All the agronomic practices and plant protection measures were same. The input cost in treatments receiving 0.5 kg B/ha, 1 kg B/ha, 1.5 kg B/ha and 2 kg B/ha was Rs. 500, Rs.1000, Rs 1500 and Rs.2000, respectively. Net benefits attained by treatments receiving 0.5 kg B/ha, 1 kg B/ha, 1.5 kg B/ha and 2 kg B/ha were Rs. 138,118, 145,286, 157,314 and 141,775 respectively which were 2, 7, 16 and 5 percent higher than control treatment (Table 5).

The contribution of B towards paddy yield was investigated. Data (Table 5) indicated treatments receiving 1.5 kg B/ha attained the highest value cost ratio (14.9:1) followed by application of 1 kg B/ha (10.4:1).

Conclusion

Grain yield was the maximum (4.65 t/ha) at the application of 1.5 kg B/ha and 31% more than control treatment and further more presence of significantly higher B contents in grain enhances paddy grain yield under saline sodic soils. Economical analysis showed that it is highly attractive with value cost ratio (14.9:1).

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