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Effect of Boron Application on Rice Yield Under Wheat Rice System

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ABSTRACT

A field experiment was conducted during 2004 - 05 on wheat and rice to study the response of boron application in wheat-rice system. Two levels of boron viz. 1 and 2 kg ha^{-1} with control were studied with the basal dose of N, P_2O_5 and K_2O as 120 - 90 - 60 kg ha^{-1}. Wheat variety Naseer 2000 and rice variety IRRI- 6, both were planted in RCB design with three replications in a permanent layout. Boron application significantly affected wheat grain yield that ranged from 2.70 to 3.49 t ha^{-1} giving highest increase of 19.9% over control from 1.0 kg ha^{-1}. The number of tillers m^{-2}, spike m^{-2}, spike length, plant height and 1000 grain weight of wheat were also significantly different from control for the same treatment. Paddy yield was also significantly affected by boron application, which ranged from 3.51 to 6.11 t ha^{-1}. The highest yield was obtained from 2 kg B ha^{-1} (T7) when applied to both crops. The number of spikes m^{-2}, number of spikes $plant^{-1}$, spike length, plant height and 1000 grain weight paddy were significantly affected over control. The direct application of 1 and 2 kg B ha^{-1} gave an increase of 59.6 and 62.1%, cumulative application of 1 and 2 kg B ha^{-1} increased the paddy yield 61.1 and 74.1%, while residual application of 1 and 2 kg B ha^{-1} increased the yield by 36.8 and 48.8% over control. The direct application of 2 kg B ha^{-1} to each crop can be recommended for economical yield. Boron concentration in the leaves of wheat and rice was significantly affected by the application of boron that ranged from 10.37 - 14.91 and 3.52 - 5.81 mg kg^{-1}, respectively. Similarly the boron concentration in soil was also significantly affected by boron concentration in wheat and rice and ranged from 0.18 - 0.51 and 0.17 - 0.61 mg kg^{-1}, respectively. The highest concentration in leaf and soil in wheat was found from 2 kg ha^{-1}, while cumulative application of 2 kg ha^{-1} proved to be the highest in both the crops.

Key Words: Boron; Rice; Yield; Wheat-rice system

INTRODUCTION

Among micro-nutrients, Boron (B) has found a wider use for agronomic and horticultural crops. Boron is associated with one or more of the following processes: calcium utilization, cell division, flowering and fruiting, carbohydrate and nitrogen metabolism, disease resistance, water relations, and catalyst for certain reactions (Berger, 1949; Sprague, 1951). Qayyum *et al.* (1986) concluded from their research work on minor elements that boron deficiency in N.W.F.P (Mardan, Peshawar and D.I.Khan) is wide-spread. About 89% of the sites were found below the critical limits for boron contents. At Agricultural University Peshawar, 2 kg B ha^{-1} gave the highest yield of wheat with an increase of 26% over control. Similarly at Tarnab (Peshawar) the highest yield of wheat (3.21 t ha^{-1}) giving an increase of 27.4 % over control with the application of 5 kg B ha^{-1}. However in D.I.Khan 10.0 kg B ha^{-1} gave the highest yield (3.39 t ha^{-1}) of wheat with an increase of 41.8% over control. Research work conducted in Punjab revealed that Paddy (IRRI 6) yield was increased by 6.2 % over control with 5 kg B ha^{-1} while with the same level of boron, wheat (Maxi Pak) yield was increased by 26% over control. Khattak and Parveen (1988) reported that soil samples (540) were collected from NWFP and analyzed for various micro-nutrients (Zn, Cu, Fe, Mn and B) showed that samples out of 60, 6, 26 and 21% of the samples were found deficient in B, Cu, Fe and Zn, respectively. Field experiments conducted in Punjab during 1984 and 1985 to study the response of boron application on wheat showed that grain yield of wheat was increased by 21% due to application of 4 kg B ha^{-1}. Increasing the dose up to 10 kg B ha^{-1}, no adverse effect on the grain yield was noticed. Boron application also increased Boron concentration in plant tissues to greater extent than in grains. (Kauser *et al.* 1988). Soil Fertility Survey and Soil Testing Institute Lahore, Punjab during 1985 and 1986 conducted a lot of experiments on micro-nutrients effect on wheat and reported that 4 kg B ha^{-1} gave the highest increase of 21.5% over control in wheat and the yield ranged from 4173 to 5068 kg ha^{-1} (Bajwa, 1988).

Iqtidar (1979) concluded from his experiments that B @ 2 kg ha^{-1} gave the highest increase of 26% wheat yield over control. Hussain & Yasin, (2003) reported that the wheat yield was increased by 13% over control with

the application of one kg B ha^{-1}, similarly 16% yield increase of Paddy over control was observed with the same level of boron. The levels of boron used were 0, 0.5, 1.0 and 2 kg ha^{-1}. Rashid *et al.* (2002) reported in a country report an increase of 5 to 26 % in rice yield increase with B application. Ali *et al.* (1996) reported a maximum increase in paddy grain yield due to B application which was 34.6 and 19 % at 2.0 kg B ha^{-1} on Mirpur and Satgara soils, respectively. Husssin & Yasin, (2004) conducted field experiments to study the residual effect of Zn and B in rice-wheat system. Wheat grain yield ranged from 3.45 to 3.53 t ha^{-1}. Highest yield was produced from 5 kg Zn+2 kg B ha^{-1}, lowest from control. Cumulative application of boron gave an increase of 10 % over control, direct application gave an increase of 9 % over control. However, residual effect of B increased paddy yield by 4 % over control.

A lot of work has been conducted to find out the optimum level of boron on wheat and rice in NWFP and Punjab. This study was conducted on the residual, direct and cumulative application of boron in wheat-rice system.

MATERIALS AND METHODS

The experiment was laid out at Arid Zone Research Farm, D.I. Khan in Randomized Complete Block Design with seven treatments replicated three times. The treatments comprised of Check (T1), 1 kg B ha^{-1} to wheat and nil to rice (T2), Nil to wheat and 1 kg B ha^{-1} to rice (T3), 2 kg B ha^{-1} to wheat and nil to rice (T4), Nil to wheat and 2 kg B ha^{-1} to rice (T5), 1 kg B ha^{-1} to wheat and 1 kg ha^{-1} B $ha^{-1}$to rice (T6), 2 kg B ha^{-1} to wheat and 2 kg B ha^{-1} to rice (T7). The basal dose of 120 - 90 - 60 kg ha^{-1} of N, P_2O_5 and K_2O along with Borax was applied in the form of Urea, TSP, SOP and boron. All P, K, B and half N was applied at sowing remaining half N was applied at 2nd irrigation in wheat and at panicle initiation to rice crop. The wheat variety Naseer 2000 and IRRI 6 of rice was planted during the study. The wheat was sown during second week of November, while rice was planted during 1st week of June. The treatment plot size of 2.40 m X 6.0 m was kept for both the crops as rice was planted in the same layout of wheat. All the other cultural practices were followed uniformly throughout the growing period of each crop.

Before initiating the experiment a composite soil sample was analyzed for physico-chemical properties (Table I). The soil and leaf samples from individual treatments of wheat and rice were taken at the proper time and were analyzed at NARC, PARC for boron concentration. The post harvest data i.e. number of tillers m^{-2}, spikes m^{-2}, spikes $plant^{-1}$ and spike length and plant height in wheat and rice were recorded at proper time. The net plot of 0.60 m x 5.0 m was harvested manually for 1000 grain weight and grain yield of both wheat and rice. All the relevant data were statistically analyzed according to the procedures given by Bhatti (2006) using MSTAT-C computer programme. The leaf samples were collected at panicle initiation stage. After complete drying of the samples at 70°C for 24 hours, they were ground by grinder. The finally ground leaf samples were then subjected to wet digestion for B determination; the readings were taken on spectrophotometer (Walsh. 1973).

RESULTS AND DISCUSSION

Boron concentration in soil. Boron (B) concentration in soil was affected significantly by the application of boron in wheat and rice crop (Table II), which reanged from 0.18 to 0.51 mg kg^{-1}. The highest concentration (0.51 mg kg^{-1}) was recorded by the application of 2 kg B ha^{-1} (T7) followed by 0.35 and 0.34 mg kg^{-1} achieved from one kg B ha^{-1} (T6 and T2, respectively) while lowest concentration was found in check plot. Similarly in rice, boron concentration was significantly affected in soil, that ranged from 0.17 to 0.61 mg kg^{-1}. The significantly highest boron contents were recorded by the cumulative application of 2 kg B ha^{-1} to rice and wheat (T7) followed by 0.45 mg kg^{-1} obtained from 1 kg B ha^{-1} application to rice and wheat (T6) but statistically they were at par. The lowest concentration of boron was found in check. (T1). The concentration of boron in rest of the treatments was comparable with one another. The concentration of direct application of 1 kg B ha^{-1} (T3) was same as recorded by the residual application of 1 or 2 kg B ha^{-1} (T2 and T4).

Boron concentration in leaves. The application of boron significantly increased the boron content of leaves of both wheat and rice crops (Table. II) that ranged from 10.37 to 14.91 mg kg^{-1} in wheat. The highest concentration of

Table I. Physico-chemical characteristics of soil

Soil properties	Value
pH (1:2)	8.00
E.C dsm^{-1} (1:2)	0.46
CaCo3 Eq.(%)	10.5
Organic matter (%)	0.58
Nitrogen %	0.029
Sod Bicarbonate Extractable P (mg kg^{-1})	4.0
Amm.Acetate Extractable K (mg kg^{-1})	85.0
B (mg kg^{-1})	0.29
Sand (%)	22.0
Silt (%)	46.0
Clay (%)	32.0
Textural class	Silty clay

Table II. Boron concentration mg kg^{-1} in leaves and soil

Treatments	Boron kg ha^{-1} to crop		Wheat		Rice	
	Wheat	Rice	Soil	Leaves	Soil	Leaves
1	0	0	0.18 c	10.37 c	0.17 e	3.52 d
2	1	0	0.34 b	12.77 b	0.28 d	3.94 cd
3	0	1	0.19 c	10.77 c	0.34 cd	4.51 bc
4	2	0	0.46 a	14.00 a	0.32 cd	4.20 c
5	0	2	0.18 c	10.32 c	0.40 bc	4.90 b
6	1	1	0.35 b	12.65 b	0.45 b	5.04 b
7	2	2	0.51 a	14.91 a	0.61 a	5.81 a
LSD (0.05)			0.05	0.97	0.07	0.58

Means followed by same letter(s) do not differ significantly at $P \leq 0.05$

Table III. Wheat response to boron application under wheat rice system

Treatments	Boron kg ha^{-1} to crop		Grain yield kg ha^{-1}	Increase over control %	1000 grain weight (g)	Plant height cm	No. of tillers m^{-2}	No. of spikes m^{-2}	Spike length cm
	Wheat	Rice							
1	0	0	2910 bc	-	33.12 d	93.5 c	409 c	328 c	9.6 e
2	1	0	3490 a	19.9	36.70 a	103.9 a	532 a	404 a	10.9 a
3	0	1	2709 c	-	34.21 cd	97.8 b	428 bc	330 c	9.8 d
4	2	0	3287 ab	13.0	36.36 ab	100.6 b	477 abc	376 c	10.7 ab
5	0	2	2888 bc	-	35.24 ab	99.2 b	431 bc	325 c	10.1 c
6	1	1	3227 ab	11.0	36.24 ab	100.0 b	496 ab	389 ab	10.9 a
7	2	2	3131 bc	8.0	35.54 ab	100.0 b	429 bc	350 bc	10. 6 b
LSD (0.05)			430		1.28	2.3	79	10	0.2

Means followed by same letter(s) do not differ significantly at $P \leq 0.05$

Table IV. Rice response to boron application under wheat rice system

Treatments	Boron kg ha^{-1} to crop		Grain yield kg ha^{-1}	Increase over control %	1000 grain weight g	Plant height cm	No. of spikes m^{-2}	No. of spikes plant^{-1}	Spike length cm
	Wheat	Rice							
1	0	0	3512 f	-	21.58 d	101.9 d	259 d	17.8 e	21.53 b
2	1	0	4806 e	36.8	22.25 b	105.8 c	289 c	18.7 d	22.53 b
3	0	1	5605 c	59.6	22.12 b	110.0 b	314 b	23.5 b	24.20 a
4	2	0	5227 d	48.8	22.28 b	106.9 c	295 c	20.1 c	22.60 b
5	0	2	5695 b	62.1	22.35 ab	111.2 a	342 a	25.4 a	24.40 a
6	1	1	5658 b	61.1	22.44 a	110.2 ab	319 b	25.3 a	24.30 a
7	2	2	6114 a	74.1	22.06 a	111.5 a	344 a	25.9 a	24.50 a
LSD (0.05)			41		0.10	1.2	15	0.8	1.32

Means followed by same letter(s) do not differ significantly at $P \leq 0.05$

14.91 and 14.00mg kg^{-1} of boron was recorded by 2 kg B ha^{-1} (T7 and T4, respectively) followed by 12.65 and 12.77 mg kg^{-1} from one kg B ha^{-1} (T6 and T2, respectively) and lowest was received in check plots. Similarly, the boron concentration in rice leaves was also significantly affected by boron application and ranged from 3.52 to 5.81 mg kg^{-1}. The highest concentration was recorded by the application of 2 kg B ha^{-1} to wheat and rice crop (T7) while lowest from check. The boron concentration of 5.04, 4.90 and 4.51 mg kg^{-1} were recorded from cumulative application 1 kg (T6), direct application of 2 kg (T5) and 1 kg B ha^{-1} (T3), respectively and were significantly from one another. The boron concentration was comparatively less in residual application of 2 (T4) and 1 kg B ha^{-1} (T2), than direct or cumulative application of boron.

Wheat grain yield and components affected by boron. Residual/cumulative effect of boron on rice (Table III) showed that B application increased wheat grain yield significantly over check plots (No boron) which ranged from 2709 to 3490 kg ha^{-1}. The highest grain yield of 3490 kg ha^{-1} was recorded by the application of 1 kg B ha^{-1} (T2), followed by 3287 kg ha^{-1} with application of 2 kg B ha^{-1} (T4), while the grain yield of 3227 kg ha^{-1} was obtained from T6. However, these treatments were at par with one another. The lowest grain yield was obtained from T3, T5 and T1 (2709, 2888 and 2910 kg ha^{-1}, respectively) being at par with one another. Boron application also affected 1000 grain weight that ranged from 33.12 to 36.70 g. The highest grain weights of 36.36 and 35.54 g were recorded with the application of one kg B ha^{-1} (T4 and T7, respectively) while lowest from check plots. Wheat plants also responded significantly to boron application and attained maximum height of 103.9 cm with the application of 1 kg B ha^{-1} (T2), followed by 100.6 cm plant height with the application of 2 kg B ha^{-1}(T4) being significantly from each other. Minimum heights of 93.5, 97.8 and 99.2 cm were obtained from T1, T3 and T5. However, T3 and T5 were at par with each other and significantly different from T1. The number of tillers m^{-2} was also significantly affected by boron application. The highest numbers of 532 and 496 tillers m^{-2} were noticed by one kg B ha^{-1} (T2 and T6, respectively) while lowest number of tillers was recorded from check plot (T1). The number of spike m^{-2} and spike length was also influenced by boron application. The highest number of spikes 404 and 389 m^{-2} were recorded by the application of 1 kg B ha^{-1} (T2 and T6, respectively), while 350 spikes m^{-2} were obtained by 2 kg B ha^{-1} (T7) and lowest from check plots (T1). The impact of boron on spike length was also significant that ranged from 21.53-24.50 cm. The maximum spike length was recorded by the application of one kg B ha^{-1} (T2 and T6) while lowest from check plots (T1).

Rice grain yield and components affected by boron. After the harvest of wheat, paddy was planted in the same plots. The paddy yield was significantly affected by boron application (Table IV) which ranged from 3512 to 6114 kg ha^{-1}. The highest yield was obtained by the cumulative application of 2 kg B ha^{-1} (T7) while the lowest from control (T1). The highest increase of 74% over control was also achieved from cumulative application of 2 kg B ha^{-1} (T7). The second higher yield of 5695 kg ha^{-1} was achieved by the direct application of 2 kg B ha^{-1} (T5) being significantly different from T7. Boron application also affected 1000 grain weight significantly that ranged from 21.58 to 22.44 g. The highest weight was recorded with the cumulative application of 1 kg B ha^{-1} (T6). Rice plant height also

responded significantly to boron application and ranged from 101.9 to 111.5 cm. The maximum height was recorded from cumulative application of 2 kg B ha^{-1} (T7) and was at par with direct application of 2 kg B ha^{-1} (111.2 cm; T5), while minimum height was observed in check (T1). The no. of spike m^{-2}, number of spike $plant^{-1}$ and spike length was also influenced with B application. The maximum number of spike m^{-2} (344) were obtained by cumulative application of 2 kg B ha^{-1} (T7) and being comparable with cumulative application of 1 kg B ha^{-1} (T6) and also direct application of 2 kg B ha^{-1} (T5) while the significant minimum number of spike $plant^{-1}$ (17.8) was observed in check (T1). The highest spike length (24.5 cm) was recorded with the cumulative application of 2 kg B ha^{-1} (T7) and was at par with cumulative application of 1 kg B ha^{-1} (T6) and direct application of 1 (T3) and 2 kg B ha^{-1} (T5). The lowest spike length (21.5 cm) was recorded in check (T1) and also it was at par with residual effect of 1 (T2) and 2 kg B ha^{-1} (T4).

The increase in paddy yield due to residual, direct and cumulative effect of 2 kg B ha^{-1} was 48.8% (T4), 62% (T5) and 74%(T7), respectively over control. However, the percent increase due to residual, direct and cumulative effect of 1 kg B ha^{-1} was 36.8% (T2), 59.6% (T3) and 61.0 (T6), respectively over control. Soil analysis before laying out experiments showed that the soil was deficient in B according to the criteria given by Rashid *et al* (1996). These responses to both the crops to B application are the results of this deficiency. However B contents of leaves of wheat crop did not show deficiency of B even in control plots (Jones *et al.*, 1991), but in case of rice leaves B contents showed deficiency in control as well as single application of B. (Jones *et al* 1991).

The results of the present study are in agreement with the findings of Qayyum *et al.* (1986), Kauser *et al.* (1988), Bajwa (1988) and Hussain and Yasin (2003, 2004) who reported significantly responses of wheat and rice to B application under calcareous soil conditions.

CONCLUSION

For wheat crop, 1 kg B ha^{-1} produced significantly highest yield of wheat and can be recommended for wheat crop only. In case of wheat-rice cropping system 2 kg B ha^{-1} to each crop gave the significantly highest yield and should be applied for getting maximum yield of rice.

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