Pak. J. Bot., 43(2): 1021-1031, 2011.

RESPONSE OF TWO RICE VARIETIES VIZ., KHUSHBOO-95 AND MEHAK TO DIFFERENT LEVELS OF BORON

JAVAID AHMED SHAH*, MUHMMAD YOUSUF MEMON, MUHMMAD ASLAM, NIZAMUDDIN DEPAR, NIAZ ALI SIAL AND PARVEZ KHAN

**Soil Science Division Nuclear Institute of Agriculture, Tando Jam-70060, Pakistan*
**Corresponding author E-mail: javaidshah_nia@yahoo.com; Phone: 022-3880868, 2765750*

Abstract

Boron is the deficient micronutrient in the soils of Pakistan. Boron (B) deficiency is wide spread in rice growing areas of Pakistan. Low and very high soil B depress grain yield of cereals. A field experiment was conducted to determine the effect of different levels of B on the yield and yield components of rice genotypes. Two rice varieties viz., Khushboo-95 and Mehak were grown in field with four B levels 0, 0.5, 0.75 and 1.0 kg ha^{-1}. The application of boron at 0.5, 0.75 and 1.0 kg ha^{-1} enhanced the paddy yield of Khushboo-95 by 9, 13 and 19% and Mehak by 7, 11 and 15%, respectively. The calculated VCR (value cost ratio) of Khushboo-95 enhanced by 12.1, 14.3 and 15.4 and Mehak by 9.5, 11 and 11.5, respectively over control with the each increment of B level. Boron application @ 0.75 and 1.0 kg ha^{-1} significantly enhanced the straw yield of Khushboo-95, whereas the straw yield of Mehak was significantly increased at 1.0 kg B ha^{-1}. The effect of boron application was not observed on plant height and number of branches per panicle in both varieties. The number of productive tillers/plant, panicle length and 1000-grain weight of both varieties and number of grains/panicle in Khushboo-95 were significantly enhanced at 1.0 kg B ha^{-1}. Boron concentration in youngest fully developed leaves of both varieties was significantly enhanced with each increment of applied B.

Introduction

Boron is an essential micronutrient for plant growth and reproduction. It is important for carbohydrate metabolism and translocation (Siddiky *et al*., 2007) and also plays an indispensable role in plant cell formation, integrity of plasma membranes, pollen tube growth and increases pollination and seed development (Oosterhuis, 2001). After zinc boron is second most widespread deficient micronutrient in paddy soils of Pakistan (Shorrocks, 2006; Chaudhri & Hisiani, 1970). Boron deficiency in wheat and rice crops have been reported from many countries including Pakistan (Rerkasem & Jamod, 2004; Anon., 1998 and Rashid *et al.,* 2004). Positive responses to B application were initially observed in rice cultivars Basmti-370 and IR-6, grown in major rice growing areas of the Punjab (Chaudhry *et al.*, 1976). Similarly, paddy yield increased by 14-25% over control in cvs. Supper Basmati, Basmati-385 and KS-282 grown in rice belt of Punjab and in cv. IR-6 grown in Sindh province (Rashid *et al*., 2004). Yield increases because boron reduced panicle sterility (on lower portion of the ear) and increased productive tillers per hill. Post harvest grain shedding also reduced with improved B nutrition. Recently, a long-term research on rice-wheat system on four major soil types in Punjab province revealed that the average increase in first rice crop's paddy yield with B applied @ 1.0 kg B ha^{-1} was 25% over control. Residual effect of B on the succeeding wheat crop was also appreciable, mean grain yield increase being 22-24% over control (Rashid, 2006). The actual length and magnitude of residual effect of soil applied B will depend on many soil factors, notably the once influencing its adsorption/desorption and leaching. Therefore,

the prediction of actual B requirements of crop varieties is difficult, except after having local experimentation in various soil types, crop varieties and cropping systems. Khushboo-95 is a high yielding aromatic variety developed from Jajai-77 by inducing genetic mutation. This variety is comparatively more dwarf and has 60% more yielding potential than its parent variety. Mehak is also high yielding, fine grained variety developed from Basmati-370 through gamma rays (150 Gy). This mutant variety possesses strong aroma and is tolerant to insect pests. It has consistently better paddy yield as compared to its mother variety. The present study was conducted to evaluate the performance of two rice cultivars (Khushboo-95 and Mehak) to different boron levels in the agro-climatic condition of Sindh.

Materials and Methods

A field experiment was conducted in factorial randomized complete block design with four replications at saline agriculture farmers participatory development project site Badin during 2008 to examine the yield of rice varieties Khushboo-95 and Mehak at different B levels. Plot size was 5x5 m^2 for each treatment. The composite soil samples were collected from experimental site at 0-20 cm depth before the sowing of crop. After processing, the soil samples were analyzed for some physico-chemical properties. The textural class was determined as per method described by Bouyoucos (1962). The soil samples were subjected to analysis for pH, EC, $CaCo_3$ % and organic matter (Jackson, 1973). Hot water boron was determined colorimetrically by using azomethine-H (Bingham, 1982). The experimental site was heavy in texture (clay loam), non-saline (ECe 3.1 dS m^{-1}), slightly alkaline (pH 7.7), poor in organic matter (0.79%) and boron (0.49 mg kg^{-1}) and moderately calcareous (7.4%). Four treatments control (without B), 0.5, 0.75 and 1.0 kg B ha^{-1} were applied in the form of H_3BO_3 as basal dose. Recommended dose of N (80 kg ha^{-1}), P (60 kg ha^{-1}) and Zn (6 kg ha^{-1}) was applied in the form of urea, DAP and zinc sulphate, respectively. All phosphorus and half dose of nitrogen were applied as basal dose before the transplantation, whereas, remaining half dose of nitrogen was applied at the time of panicle initiation. Total Zn was applied after 15 days of transplantation. At panicle initiation stage youngest fully developed leaves samples of four plants from each plot were collected for B analysis (Rashid, 2006) and were dry ashed (Gaines & Mitchell, 1979). Yield and yield attributes of both varieties were recorded. Statistical analyses of the data were performed on PC employing STATISTICS software (Steel *et al*., 1997).

Results and Discussion

Yield components: The effect of B on yield components of both rice genotypes is given in Table 1 and 2. Number of productive tillers per plant, panicle length and 1000-grain weight in both rice varieties and number of grains per panicle in Khushboo-95 were significantly increased, when B applied at 1.0 kg ha^{-1}. Rashid (2006) reported that application of B in rice reduces panicle sterility, attribute to better grain filling and uniform crop maturity, increased number of grain/panicle and number of productive tiller/plant. However non-significant effect of B was observed in plant height and number of branches per panicles in both varieties. Ehsan *et al.*, (2009) reported that application of B improved all growth parameters i.e., tillering capacity, shoot and root length, and shoot and root weight.

Table 1. Effects of different levels of applied boron on some yield components of Khushboo-95.

Treatments (B kg ha^{-1})	No. of productive tillers (plant^{-1})	Plant height (cm)	Panicle length (cm)	No. of branches (panicle^{-1})	No. of grains (panicle^{-1})	1000-grain weight (g)
Control	10.8 c	136.1 N.S	29.7 b	9.8 N.S	122.0 b	23.0 b
0.5	12.0 bc	136.8	30.2 ab	9.8	129.8 b	23.6 ab
0.75	12.5 b	139.1	30.3 ab	9.8	131.0 ab	23.6 ab
1.0	14.0 a	139.1	30.8 a	10.0	140.8 a	24.5 a

Means not sharing a letter differ significant at $p<0.05$; N.S = Non-significant

Table 2. Effects of different levels of applied boron on some yield components of Mehak.

Treatments (B kg ha^{-1})	No. of productive tillers (plant^{-1})	Plant height (cm)	Panicle length (cm)	No. of branches (panicle^{-1})	No. of grains (panicle^{-1})	1000-grain weight (g)
Control	12.0 c	117.4 N.S	27.6 b	9.5 N.S	112.3 N.S	19.8 b
0.5	13.5 b	119.4	27.9 ab	9.3	117.3	20.3 b
0.75	13.8 b	119.5	28.0 ab	9.5	118.3	20.9 ab
1.0	15.3 a	120.1	28.3 a	9.5	121.0	21.7 a

Means not sharing a letter differ significant at $p<0.05$; N.S = Non-significant

Table 3. Boron concentration (mg kg^{-1}) in youngest fully developed leaves at different B levels.

Treatments (B kg ha^{-1})	Khushboo-95	Mehak
Control	9.72 d	7.86 d
0.5	10.65 c	8.54 c
0.75	11.22 b	8.90 b
1.0	12.09 a	9.51 a

Means not sharing a letter differ significant at $p<0.05$

Boron concentration in youngest fully developed leaf: The result of B concentration in youngest fully developed leaves at panicle initiation stage of both rice varieties is given in Table 3. Boron concentration in youngest fully developed leaves in both rice varieties was significantly increased with each increment of applied B. The highest B content (12.09 mg kg^{-1}) in Khushboo-95 and (9.51 mg kg^{-1}) in Mehak was recorded where B was applied at 1.0 kg ha^{-1}. Nable *et al*., (1990) and Akram *et al.,* (2006) reported that increasing supply of boron increased the accumulation of boron in roots and shoots. Similarly Kausar *et al.,* (2001) have also reported that boron application increased its concentration in the whole shoot of various rice varieties. Poul *et al.,* (2000) reported that boron sufficient rages in paddy youngest fully developed leaf at panicle initiation stage may vary from 6-15 ppm, depending upon species.

The results presented in Table 5 showed that co-efficient of correlation of boron concentration in youngest fully developed leaf is positive and significant with yield and yield attributes in both varieties. Whereas, the co-efficient of correlation between boron concentration in youngest fully developed leaf and number of branches per panicle in both varieties was found positive but non-significant. A strong linear correlation was found for boron application with B concentration in youngest fully developed leaf of both rice varieties (Figs. 7 and 8).

Grain and straw yield: The effect of boron application on grain and straw yield of rice varieties Khushboo-95 and Mehak is given in Table 4. The yielding ability of two cultivars at different levels of B differed significantly. The application of boron at 0.5,

0.75 and 1 kg ha^{-1} enhanced the paddy yield of Khushboo-95 by 9, 13 and 19% and Mehak by 7, 11 and 15%, respectively (Fig. 9 and 10). Paddy yield increased because of increase in number of productive tillers per plant and 1000-grain weight. Rashid (2006) reported that the application of B at 0.75 kg ha^{-1} increased paddy yield by 14-25% over control in cvs. Super Basmati, Basmati-385 and in KS-282 growing in rice belt of the Punjab and in cv. IR-6 growing in Sindh province. Similarly, Dunn *et al.,* (2005) also reported that rice yield increased with 0.5 to 1.0 lb boron per acre.

Increase in the rate of B enhanced the straw yield of both varieties. The application of B at 0.75 and 1.0 kg ha^{-1} significantly enhanced the straw yield of Khushboo-95 by 17 and 20%, respectively. Similarly straw yield of Mehak significantly increased by 19% when B was applied at 1.0 kg ha^{-1}. This trend of increase in straw yield of both varieties with the increment of B levels may be due to the increase in number of productive tillers per plant. Rashid *at al.,* (2002) reported that B deficiency cased differential straw yield reduction, maximum of 43% in CV. Super Basmati and minimum of 2% in CV. Basmati-370. However, increase in straw yield to B application was greater than these for paddy yield i.e. 77% in CV. Supper Basmati and only 2% in CV. Basmati-370.

The results showed that correlation of boron application is positive and significant with B concentration in youngest fully developed leaf, yield and yield attributes of both rice varieties (Table 6). A strong linear correlation was found in boron application v/s yield and yield attributes. (Figs. 1-6 and 9-10).

Value cost ratio: The calculated VCR (value cost ratio) of Khushboo-95 enhanced by 12.1, 14.3 and 15.4 and Mehak by 9.5, 11 and 11.5, respectively over control with the each increment of B level (Table 4). This showed that B application was quite economical. Rashid (2006) reported that the B application is highly cost effective i.e., one rupee spent on fertilizer B enhances seed cotton yield worth Rs. 16.0 and of rice paddy yield worth Rs. 30.0.

Table 4. Effects of B on yield and yield parameters of rice varieties.

Treatments (B kg ha^{-1})	Paddy yield (kg ha^{-1})		Straw yield (kg ha^{-1})		VCR	
	Khuahboo-95	Mehak	Khuahboo-95	Mehak	Khuahboo-95	Mehak
Control	4435 d	3940 d	5732 b	4083 b	---	---
0.5	4818 c	4203 c	5799 b	4250 ab	12.1	9.5
0.75	4997 b	4384 b	6720 a	4475 ab	14.3	11.0
1.0	5281 a	4533 a	6868 a	4859 a	15.4	11.5

Means not sharing a letter differ significant at $p<0.05$

Table 5. Coefficient of correlation (r) of boron concentration in youngest fully developed leaf with yield and yield attributes of both rice varieties (Khushboo-95 and Mehak).

Yield and yield attributes	Khushboo-95	Mehak
Plant height (cm)	0.908 *	0.934 *
No. of prod. tillers $plant^{-1}$	0.993 ***	0.992 **
Panicle length (cm)	0.989 **	0.997 ***
1000-grain weight (g)	0.960 **	0.987 **
No. of branches $panicle^{-1}$	0.784	0.157
No. of grain $panicle^{-1}$	0.981 **	0.983 **
Grain yield (kg ha^{-1})	0.998 ***	0.992 **

*Significant at the 0.05, **Significant at the 0.01, ***Significant at the 0.001 levels of probability

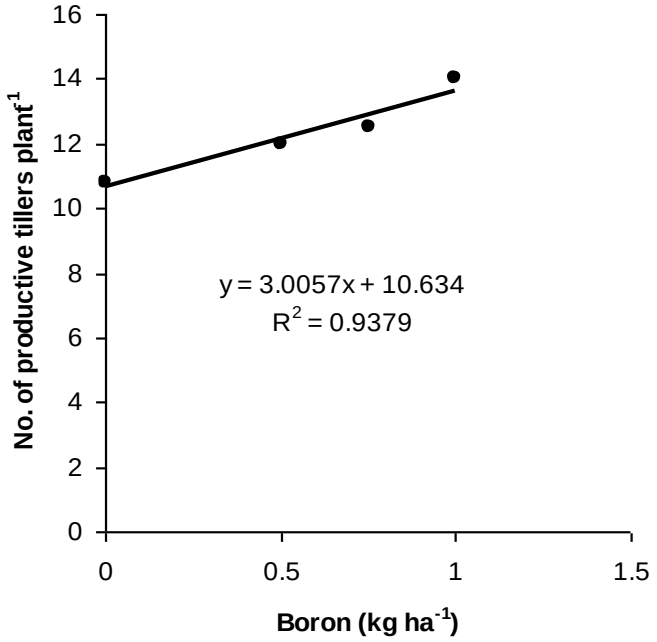

Fig. 1. Relationship between B application and No. of productive tillers in Khushboo-95.

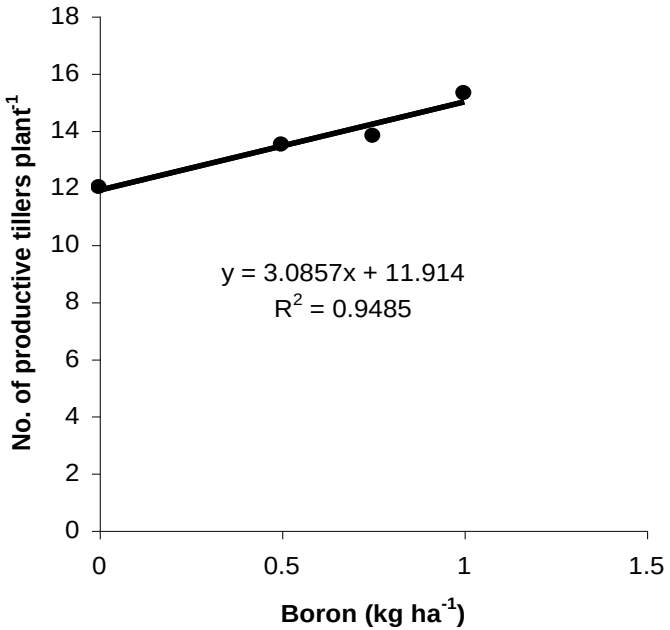

Fig. 2. Relationship between B application and No. of productive tillers in Mehak.

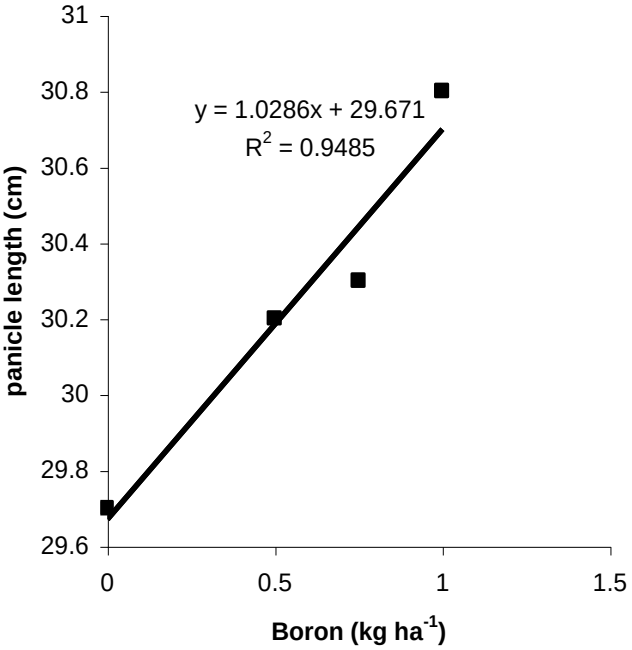

Fig. 3. Relationship between B application and panicle length of Khushboo-95.

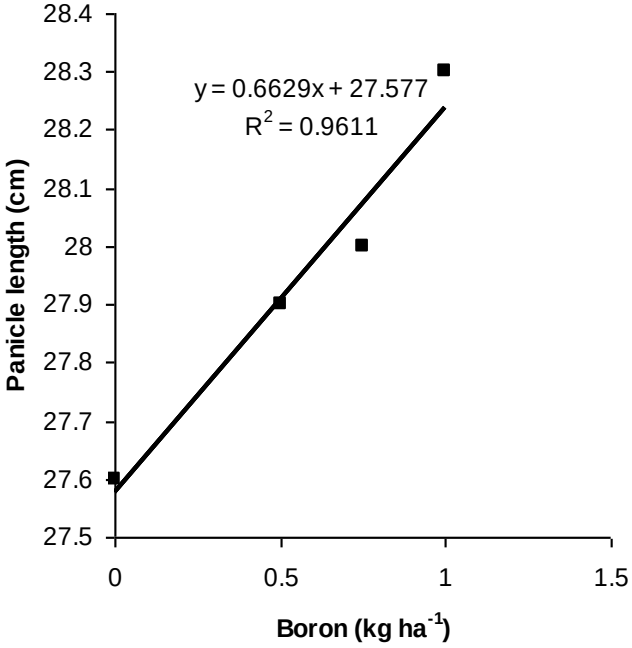

Fig. 4. Relationship between B application and panicle length of Mehak.

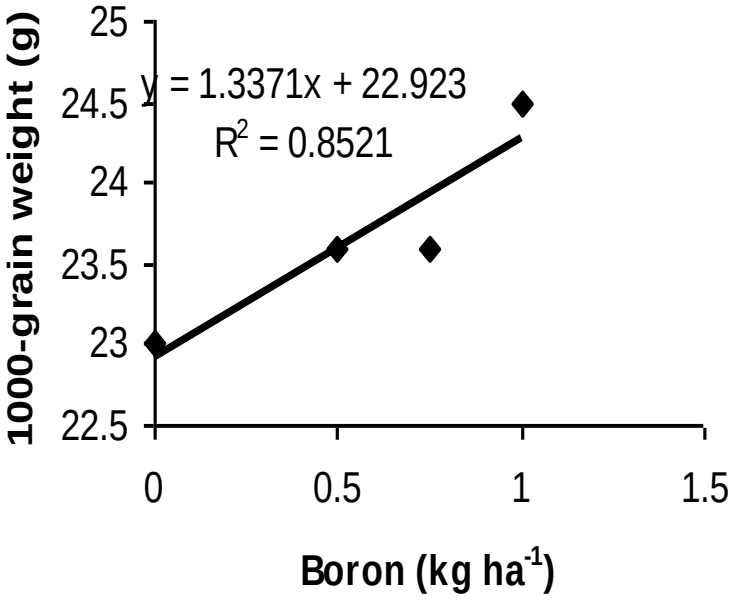

Fig. 5. Relationship between B application and 1000-grain weight of Khushboo-95.

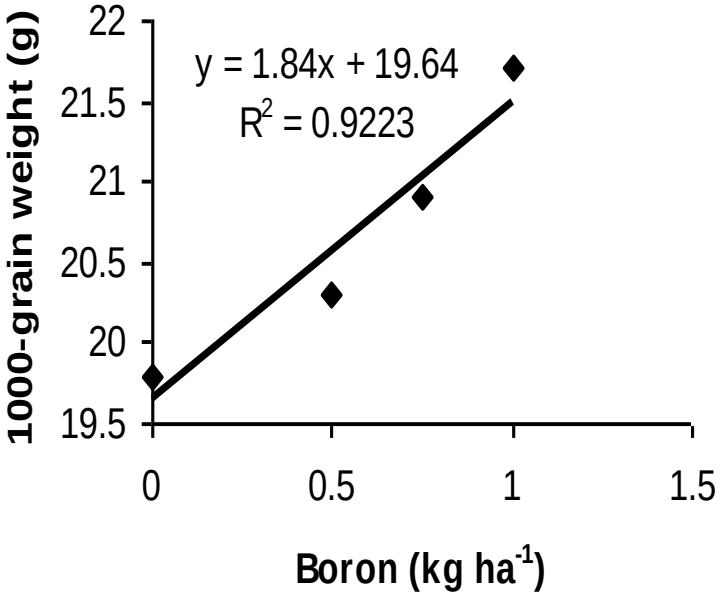

Fig. 6. Relationship between B application and 1000-grain weight of Mehak .

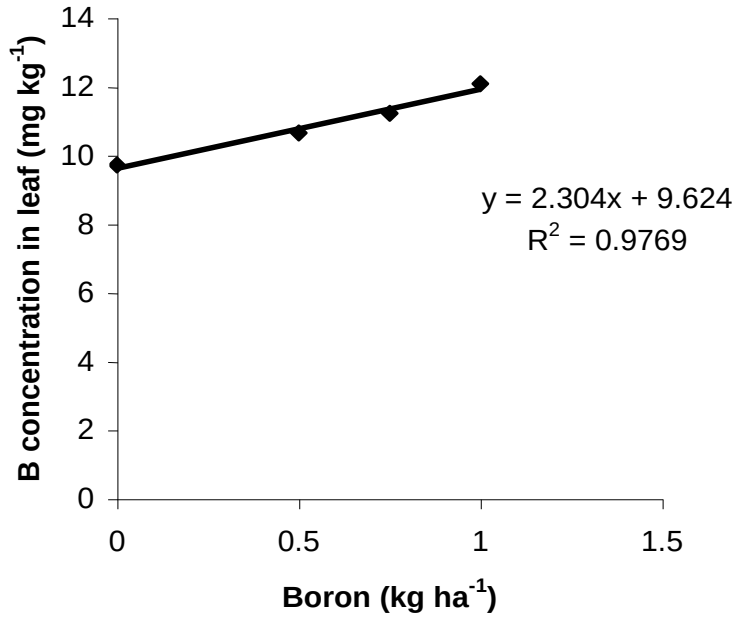

Fig. 7. Relationship between B application and B content in leaf of Khushboo-95.

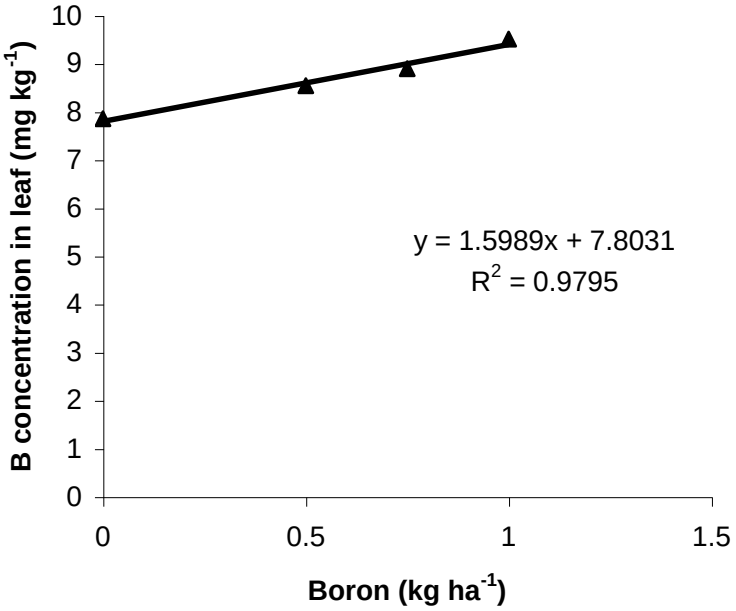

Fig. 8. Relationship between B application and B content in leaf of Mehak.

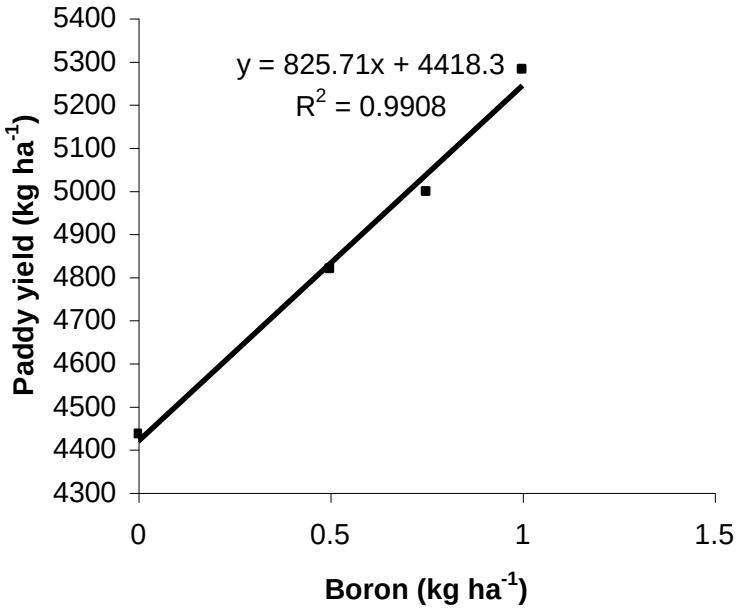

Fig. 9. Relationship between B application and paddy yield in Khushboo-95.

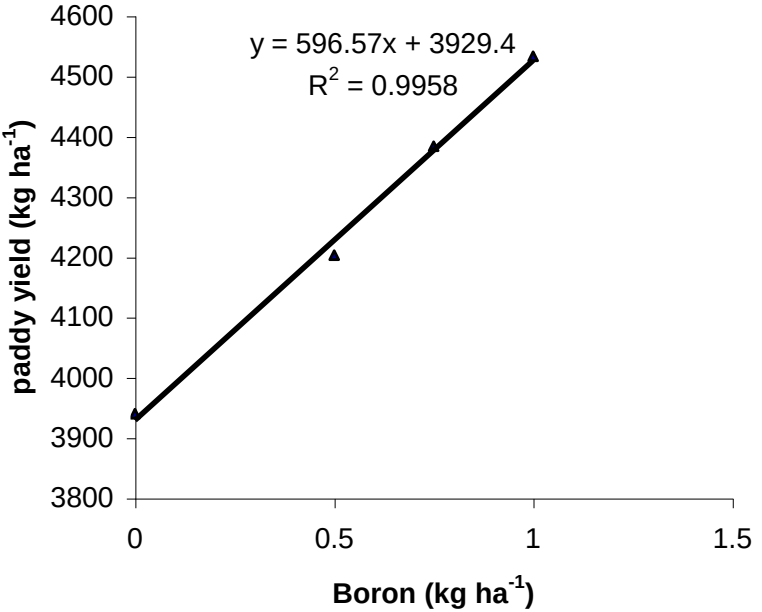

Fig. 10. Relationship between B application and paddy yield in Mehak.

Table 6. Coefficient of correlation (r) of boron application with B concentration in youngest fully developed leaf, yield and yield attributes of both rice varieties (Khushboo-95 and Mehak).

Yield and yield attributes	Khushboo-95	Mehak
B content in leaf	0.988 **	0.989 **
Plant height (cm)	0.918 *	0.964 **
No. of productive tillers plant^{-1}	0.968 **	0.974 **
Panicle length (cm)	0.974 **	0.980 **
1000-grain weight (g)	0.923 *	0.960 **
No. of branches panicle^{-1}	0.683	0.097
No. of grain panicle^{-1}	0.954 *	0.991 **
Grain yield (kg ha^{-1})	0.995 ***	0.997 ***

*Significant at the 0.05, **Significant at the 0.01, ***Significant at the 0.001 levels of probability

Conclusion

It is concluded that B application has significantly enhanced the yield and yield components of both rice genotypes. The application of B at 1.0 kg ha^{-1} enhanced paddy, straw and other yield attributes of both rice varieties and was found quite economical. Highest boron concentration in flag leaves in both varieties was also observed, when B was applied at 1.0 kg ha^{-1}.

References

Akram, M.S., Q. Ali, H. Athar and A.S. Bhatti. 2006. Ion uptake and distribution in *Panicum antidotale* Retz., under salt stress. *Pak. J. Bot.,* 38: 1661-1669.

Anonymous. 1998. Micronutrients in agriculture: *Pakistan perspective. National fertilizer development centre, Islamabad, Pakistan.* pp. 51.

Bingham, F.T. 1982. Boron. In: *Methods of soil analysis*, PART 2: *Chemical and microbiological properties*. (Eds.): A.L. Page *et al*. *American Society of Agronomy, Madison*, WI. USA, pp. 431-448.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle-size analysis of soils. *Agron. J*., 54: 464-465.

Chaudhri, T.M. and G.R. Hisiani. 1970. Effect of B on the yield of seed cotton. *The Pakistan Cottons*, p. 13-15.

Chaudhry, F.M., A. Latif, A. Rashid and S.M. Alam. 1976. Response of rice varieties to field application of micronutrient fertilizers. *Pakistan Journal of Scientific and Industrial Research* 19: 134-139.

Dunn, D., G. Stevens and A. Kendig. 2005. Boron fertilization of rice with soil and foliar applications. *Online. Crop Management doi:* 10. 1094/CM-2005-0210-01-RS.

Ehsan, H. M., K. Rizwana, A. Muhammad and S. M. Shahzad. 2009. Is boron required to improve rice growth and yield in saline environment? *Pak. J. Bot*., 41(3): 1339-1350.

Gaines, T.P. and G.A. Mitchell. 1979. Boron determination in plant tissue by azomethine-H. *Communication in soil science and plant analysis.* 10: 1099-1108.

Jackson, M.L. 1973. *Soil chemical analysis*. Prentice hall of India, New Delhi. Pp: 498.

Kausar, M.A, S. Ali and M. Iqbal. 2001. Copper and boron nutrition of three rice varieties on alkaline calcareous soils. *Pak. J. Soil Sci*., 20 (3):15-20.

Nable, R.O., B. Cartwright and R.C. Lance. 1990. Genotypic differences in boron accumulation in barley: relative susceptibilities to boron deficiency and toxicity. In: *Genetic Aspects of Plant Mineral Nutrition*. (Eds.): N. El Bassam, M. Dambroth, B. Loughman. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 243-251.

Oosterhuis, D. 2001. Physiology and nutrition of high yielding cotton in the USA. *Informacoes Agronomicas* Nº95-Setembro.p. 18-24.

Poul, F., Bell and J.L. Kovar. 2000. Rice. In reference sufficiency ranges for plant analyses in the southern region of the United States. *Southern cooperative series Bulletin No. 394*. North Carolina Dept. of Agric. and consumer services. Agronomic Division. 4300. Reedy creek road, Raleigh, NC. pp. 25-26.

Rashid, A. 2006. Boron deficiency in soils and crops of Pakistan, *Diagnosis and management. Booklet.* PARC. Islamabad. pp. 10-12, 20.

Rashid, A., M. Yaseen, M. Ashraf and R. A. Mann. 2004. Boron deficiency in calcareous soil reduces rice yield and impairs grain quality. *International Rice Research Notes*, 29(1): 58-60.

Rashid, A., S. Muhammad and E. Rafique. 2002. Genotypic variation in boron uptake and utilization by rice and wheat. in *Boron in Plant and Animal Nutrition.* (Eds.): Goldboch *et al.*, Kluwer Academic/Plenum Publisher, New York. pp. 105-110.

Rerkasem, B. and S. Jamod. 2004. Boron deficiency in wheat: a review. *Field crops research* 89: 173-186.

Shorrocks; V.M. 2006. Micronutrients and nutrient status of soils: A Global study, *FAO soils Bull. No. 48, Rome.* pp. 444.

Siddiky, MA., N.K. Halder, K.U. Ahammad, K. Anam and M. Rafiuddin. 2007. Response of brinjal to zinc and boron fertilization. *International Journal of Sustainable Agricultural Technology*, 3(3): 40-45.

Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1997. *Principles and Procedures of Statistics*: A biometrical approach. 3rd Ed. McGraw-Hill Book International Company Singapore.

(Received for publication 2 February 2010)