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COMPARATIVE EFFECTS OF FOLIAR AND SOIL APPLIED BORON ON GROWTH AND FODDER YIELD OF MAIZE

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ABSTRACT

A field experiment was conducted to compare the effect of foliar and soil-applied boron on the different growth stages and fodder yield of maize (*Zea mays* L.,) variety Akbar at Latif Experimental Farm, Sindh Agriculture University, Tandojam in spring 2006. Experimental results revealed that the foliar application of 0.5% boron as a boric acid at early, mid and late whorl stages resulted in taller plants (195.05 cm), thicker stem girth (5.21), more number of green leaves (8.00) plant^{-1}, less number of dry leaves (3.00) plant^{-1}, more fresh (58.04 t ha^{-1}) and dry fodder yield (17.59 t ha^{-1}). Soil and applied boron at 2 kg ha^{-1} did not remain effective for growth and yield of maize crop as compared to foliarly applied boron. There was significant effect of boron on its concentration in straw and its uptake when applied on foliage. It can be concluded from the study that application of B (0.5%) as foliar spray at early, mid and late whorl stage along with recommended dose of NPK fertilizers may be considered for getting higher fodder yield of maize under agro climatic conditions of Tandojam, Sindh.

Keywords: Boron, fodder, growth, maize, yield

INTRODUCTION

Almost all cultivated soils of Pakistan are alkaline and calcareous, with high base saturation and low organic matter contents (generally < 1%). Therefore, the major soil fertility problems are deficiencies of macro and some micronutrients. Deficiencies of various micronutrients are related to soil types and various crops. The soil and plant analysis showed that more than 50% of the cultivated soils of the country are unable to supply sufficient micronutrients to meet the needs of many crops (Khattak, 1995). Micronutrient deficiencies in Pakistan are harpening crop productivity as well as deteriorating produce quality. Also, the low micronutrient food and feedstuff are causing health hazards in human and animals. The second most extensive deficiency after zinc is of boron as it affects

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rice, cotton, wheat, rapeseed, mustard, maize, sorghum, potato, sugarcane, peanut, sugar beet, citrus and deciduous fruits (Rashid, 2006).

Boron (B) is one of the sixteen essential nutrient elements, required for proper growth and yield of crop plants (Tariq and Mott, 2006; Kakar *et al.,* 2000). It plays important role in water relations, cell wall formation; cations and anions absorption, pollen viability and metabolism of N, P, carbohydrates and fats in the plant (Oyinlola, 2007). Boron deficiency in plants results in terminal bud growth stoppage and death of young leaves. Sugar transport, pollen formation, seed germination and development of nodules are also affected in its absence. Seed and grain production are also reduced with low boron supply (Sillanpae, 1982).

Correcting micronutrient deficiencies through foliar application is an effective method due to easy absorption through leaves results in getting profitable yield (Asad *et al*., 2003; Parveen and Rehman, 2000). Advantages of foliar application of Zn, Mn, Cu, Fe and B over soil application have also been reported by Rimar *et al.* (1996) which include high effectiveness, rapid plant responses, convenience and elimination toxicity symptoms brought about by excessive soil accumulation of such nutrients.

Maize (*Zea mays* L.) is an important fodder crop of the gramineae family, which is the world's third leading cereal crop after wheat and rice. Its nutritious fodder is relished by all kinds of livestock especially milk animals. Fodder shortage is the major factor for the development of livestock industry in Pakistan as the available fodder production is approximately 52.54% less than actual requirement of animals (Bhatti and Soomro, 1988). Improvement in average yield per hectare can be made if proper soil fertility is maintained through the incorporation of organic materials and inorganic fertilizers including micronutrients. Looking the economic importance of maize crop as fodder, an experiment was conducted to study the comparative effect of foliar and soil applied boron along with recommended rates of NPK fertilizers on its growth and fodder yield under field conditions of Tandojam, Sindh, Pakistan.

MATERIALS AND METHODS

The experiment was conducted to study the comparative effects of foliar and soil-applied boron on the growth and fodder yield of maize (cv, Akbar) at Latif Experimental Farm, Sindh Agriculture University Tandojam during spring 2006. The composite soil samples from experimental site were taken at two depths (0-20 and 20-40 cm) before sowing and after harvest of the crop. These samples were then air-dried, ground, sieved and analyzed for various physical and chemical characteristics of soil. The soil texture was determined as per method described by Bouyoucos (1962). The soil samples were subjected to analysis for pH Richards (1954); Ec (Kanwar and Chopra, 1959); organic matter (Jackson, 1958), nitrogen by Kjeldahl method (Paul and Berry, 1921); available P and K by AB-DTPA (Soltanpour and Schwab, 1977; 1985), respectively. While, B was determined by dilute HCl method (Rashid *et al*., 1997) and subsequent measurement by using azomethine-H (Bingham, 1982). Leaf boron was determined as per method described by Rashid *et al*. (1997). The experiment was laid out in a Randomized Complete Block Design maintaining plot size of 15m^2 for all the treatments. The boron treatments tested during the study were: T1= B 00 (control) + NPK; T2= 1.5% B foliar application at early whorl stage + NPK; T3= 1% B foliar application at early + mid whorl stages+ NPK, T4= 0.5% B foliar application at early + midwhorl + last whorl stages + NPK and T5= 2 kg B ha^{-1} soil application at the time of sowing only + NPK.

Before sowing, the land was ploughed followed by clod crushing and leveling for achieving good seedbed. Well rotten farmyard manure was applied one month before sowing. Boron in the form of Boric acid (18% B) was applied to soil at the rate of 2 kg ha^{-1}. Phosphorus and potassium were applied at the rate of 75 and 40 kg ha^{-1} in the form of DAP (18% P_2O_5) and SOP (50% K_2O), respectively at the time of land preparation. While nitrogen was applied as Urea (46% N) at the rate of 150 kg ha^{-1} in three equal splits. The seed of maize variety Akbar was sown on February 15, using hand drill. All the recommended cultural practices and protection measures were followed during the growth period of the crop. The field was kept free from weeds by hand weeding. At maturity the crop was harvested and observations like seedling emergence (%), plant height (cm), stem girth (cm), number of green leaves plant^{-1}, number of dry leaves plant^{-1} and fresh and dry fodder yields (t ha^{-1}) were recorded using standard procedures. After harvest of the crop, boron concentration (mg kg^{-1}) in maize straw and residual boron (mg kg^{-1}) in soil were also determined. For plant tissue analyses fully developed flag leaves at tasseling stage were sampled from each treatment of all replications. Plant samples were then washed, oven dried (at 68 ^{0}C for 48 hours), powdered and stored in plastic bags for boron analylsis. The data thus collected were subjected to statistical analysis using analysis of variance technique (ANOVA) through MSTAT-C (1991) software package. Least Significant Difference (LSD) test was used to determine the differences among the treatment means.

RESULTS AND DISCUSSION

Physico-chemical characteristics of experimental site soil

The soil was low in organic matter, alkaline in reaction, moderately calcareous and clay loam in texture (Table 1). Nitrogen, phosphorus and boron were found deficient, whereas, potassium was medium to high level at both depths.

Seedling emergence (%)

The data regarding seed germination % is presented in Table 2. There was non-significant effect of boron application on seedling emergence %. The data pertaining to emergence % as affected by different boron levels and methods indicated that constant emergence % (76%) was noted in almost all treatment plots. However, little (78%) increase was observed where boron was applied to plant through soil at the rate of 2 kg ha^{-1} (T5). The results are in agreement with the findings of Dordas (2006) who stated that standard germination of alfalfa increased at the first rate of B application (400 mg B L^{-1}) and it did not change at the other rates (800 and 1200 mg B L^{-1}).

Table 1. Physico-chemical characteristics of experimental soil.

Characteristics (Unit)	0-20 (cm)	20-40 (cm)
Textural class	Clay loam	Clay loam
pH_5	7.78	8.10 Alkaline
Lime (%)	7.50	8.25 Moderately calcareous
Organic matter (%)	0.79	0.56 Low
Total N (%)	0.038	0.027 Deficient
P (mg kg^{-1})	3.65	2.61 Deficient
K (mg kg^{-1})	126.25	103.50 Adequate
B (mg kg^{-1})	0.181	0.159 Deficient

Plant height (cm)

The height of plant is an important growth character directly linked with the productive potential of plant in terms of fodder and grain yield. The results (Table 2) showed that foliar spray of boron significantly responded as compared to soil-applied boron. A maximum of 195.05 cm plant height was recorded in the plots fertilized with 0.5% B foliar application at early, mid and late whorl growth stages (T4), followed by 1% foliar application of B at early and mid whorl stages only. The plants, which received, soil-applied boron at 2 kg ha^{-1} had plant height of 191.67 cm (T5). Whereas, minimum plant height (186.37 cm) was recorded in control where no boron was applied. Above results are in mutual agreement with the findings of Gupta (1993), who stated that foliar applications of B in split doses to annual crops are superior to broadcast applications in terms of their vegetative growth.

Stem girth (cm)

The data indicated significant increase in stem girth under foliar application than soil-applied boron. The maximum stem thickness of 5.21 cm was recorded in T4 (0.5% boron foliar application at early, mid and late whorl stages) followed by 4.58 and 4.35 cm, in T3 and T5, respectively (Table 1). Whereas, minimum stem girth (93.10 cm) was recorded in T1 (control). These results are in line with the findings of Sakal *et al*. (1999) who stated that the foliar spray of 0.4% B (Boric acid solution) was the optimum concentration for achieving maximum stem girth during early and mid whorl growth stages of maize.

Number of green leaves

The data regarding the effect of different levels and methods of boron application on number of green leaves $plant^{-1}$ of maize variety Akbar (Table 1) revealed that the maximum number of green leaves (8.00) $plant^{-1}$ was recorded, when boron was applied through foliar spray at 0.5% at early, mid and late whorl stages (T4). Whereas, minimum number of green leaves (6.00) $plant^{-1}$ were observed in control treatment. An increase in number of green leaves might be due to the availability of boron at later growth stages of maize.

Number of dry leaves

The data regarding number of dry leaves plant^{-1} are presented in Table 1. The results showed that there was non-significant effect of boron on number of dry leaves plant^{-1}. The data pertaining to number of dry leaves indicated that maximum number of dry leaves (5.25) plant^{-1} was recorded in control treatment (T1). Whereas, the minimum number of dry leaves was noted in T4, where 0.5% B was applied through foliar spray at early, mid and late whorl stages.

Table 2. Effect of different boron levels and methods on growth attributes of maize (*Zea mays* L.).

Treatments	Boron levels & Application time	Method of Application	Emergence (%)	Plant height (cm)	Stem girth (cm)	Number of green leaves plant^{-1}	Number of dry leaves plant^{-1}
T1	0.0 control		75.0a	186.37c	3.10c	6.25c	5.25a
T2	1.5% (Early whorl)	Foliar	76.0a	190.97b	4.15bc	6.75bc	3.50b
T3	1.0% (Early + mid whorl)	Foliar	76.0a	192.52ab	4.58b	7.50ab	3.25b
T4	0.5% (Early +mid+ late whorl)	Foliar	76.0a	195.05a	5.21a	8.00a	3.00b
T5	2 Kg B ha^{-1} (Sowing time)	Soil	78.0a	191.67ab	4.35b	6.51bc	4.50ab
LSD (P<0.05)			3.49	15.44	1.38	1.87	1.35

Green fodder yield (t ha^{-1})

The results regarding green fodder yield presented in Table 3, showed that foliar application of boron responded significantly (P< 05%) as compared to soil applied B. The maximum green fodder yield (58.04 t ha^{-1}) was harvested with 0.5% B which was applied foliarly at early, mid and late whorl stages (T4). Whereas, minimum fodder yield (46.51 t ha^{-1}) was recorded from control treatment plots. The maximum harvest of green fodder is due to the fact that with foliar application of boron the plants took up boron readily as compared to soil-applied boron. Similar results have also been reported by Tariq *et al*. (2010) who were of the opinion that foliarly applied boron could give better results as compared to soil applied.

Dry fodder yield (t ha^{-1})

It is obvious from the results that foliar application of boron had significant effect (P<05%) on dry fodder yield as compared to soil-applied boron. The maximum dry matter yield of maize (17.59 t ha^{-1}) was obtained with 0.5% boron foliarly applied at early, mid and late whorl stages (26.45% increase over the control), followed by soil applied B at 2 kg ha^{-1} at the time of sowing (14.67 t ha^{-1}). Whereas, minimum dry fodder yield (13.91 t ha^{-1}) was obtained from control treatment (T1) plots. The results are in agreement with the findings of Arshadullah *et al*. (2010) who found that straw yield was significantly increased with increasing level of boron.

Table 3. Effect of different boron levels and methods on green and dry fodder yield of maize (*Zea mays* L.).

Treatments	Boron levels & Application time	Method of Application	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})
T1	0.0 control	-	46.51 d	13.91cd
T2	1.5% (Early whorl)	Foliar	54.02 c	15.72bc
T3	1.0% (Early+ mid whorl)	Foliar	56.44 b	16.14ab
T4	0.5% (Early+mid+ late whorl)	Foliar	58.04 a	17.59a
T5	2 Kg B ha^{-1} (Sowing time)	Soil	53.39 c	14.67c
LSD (P<0.05)			11.22	3.24

Boron content in straw (mg kg^{-1})

The results pertaining to boron content of maize straw (Table 1) indicated that the maximum accumulation of boron in straw (0.076 mg kg^{-1}) was found at 0.5% boron foliarly applied at early, mid and late whorl stages (an increase of 18.7% over control), followed by soil applied boron in T5 (0.074 mg kg^{-1}). Whereas, minimum (0.064 mg kg^{-1}) boron content was determined in control plots where no boron was applied. The results are in agreement with the findings of Sanchez and Righeltti (1998), who found that foliarly applied boron was efficiently found in leaves while, soil applied B remained mostly in the roots and little was translocated to the above ground portions of apple tree.

Residual boron in soil (mg kg^{-1})

The results regarding residual soil B presented in Table 3 showed that maximum residual B concentration in soil (1.52 and 1.15 mg kg^{-1}) after harvest of maize crop was found in T5, where it was applied at 2 kg ha^{-1} as compared to control plots where no B was applied either as foliar or in soil (0.153 and 0.134 mg kg^{-1}). Martens and Westermann (1991) also claimed that boron fertilizers have a longer effect on high silt and clay soils, compared with that on sandy soils as lower solubility materials also have more residual effects. They also mentioned that foliarly applied materials usually show no residual effects, whereas soil applications do.

Table 4. Effect of different boron levels and methods on its content in maize straw and soil after harvest.

Treatments	Boron levels & Application time	Method of application	Boron content in straw (mg kg^{-1})	Residual boron content in soil (ppm)	
				0-20 (cm)	20-40 (cm)
T1	0.0 control		0.064a	0.153	0.134
T2	1.5% (Early whorl)	Foliar	76.0bc	0.176	0.153
T3	1.0% (Early+ mid whorl)	Foliar	76.0b	0.179	0.149
T4	0.5% (Early+ mid+ late whorl)	Foliar	0.076a	0.180	0.148
T5	2 Kg B ha^{-1} (Sowing time)	Soil	0.074b	1.52	1.15
LSD (P<0.05)			3.37	0.0178	0.0150

CONCLUSION

It is concluded from the study that the application of boron at 0.5 % B ha^{-1} through foliar spray at early, mid and late whorl stages along with recommended dose of NPK fertilizers may be considered for getting higher fodder yield of maize under agro-climatic conditions of Tandojam, Sindh. From above findings, it is obvious that application of boron by foliar spray is more effective than soil application. Nutrients applied through foliage are absorbed right at the site where they are used as quite fast acting. On the other hand soil applied fertilizers might be less advantageous because of lower solubility in alkaline and calcareous soils as in case of B, when the soil solution has a high pH, the B it contains becomes less available to plants.

REFERENCES

Arshaullah, M., A. Ali., I. A. Mahmood, A. Amir and M. Salim. 2010. Effect of graded level of boron on paddy yield under salt-affected soils. Abstract: 13th Congress of Soil Sci. Faisalabad, Pakistan, 22-27 March, 2010.

Asad, A., F. B. C. Blamey and D. G. Edwards. 2003. Effect of boron foliar application on vegetative and reproductive growth of sunflower. Anal. Bot., 92: 565-570.

Bhatti, I. M. and A. H. Soomro. 1988. Cotton. *In* Agricultural inputs and Field crop Production in Sindh. Directorate General Agriculture Research, Sindh, Hyderabad, P. 208.

Bingham, F. T. 1982. Methods of soil analysis, part-2. Chemical and mineralogical properties. American society of agro. Medic. WI. USA. pp.431-448.

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

Dordas, C. 2006. Foliar boron application improves seed set, seed yield and seed quality of Alfalfa. Agron. J., 98: 907-913.

Gupta, U. C. 1993. Responses to boron on field and horticultural crop yields in boron and its Role in Crop Production. Ed. CRC Press Boca Raton, Florida.

Jackson, M. L. 1958. Soil chemical analysis. Prentice Hall. Inc. Englewood, Cliff, N. J. p. 372-374.

Kakar, K. M., M. Tariq, M. R. Tareen and W. Ullah. 2000. Shoot growth curve analysis of wheat (*Triticum aestivum* L.) receiving different levels of boron and Iron. Pak. J. Agron., 1 (1): 47-48.

Kanwar, T. S. and S. L. Chopra. 1959. Practical Agricultural Chemistry. S. Chand and Co., Delhi.

Khattak, J. 1995. Micronutrients in Pakistan Agriculture, Report. Pakistan Agricultural Research Council, Islamabad and Dept. Soil Science, NWFP Agriculture University Peshawar.

Martens, D. C and D. T. Westermann. 1991. Fertilizer applications for correcting micronutrient deficiencies. Soil Science Society of America, 677 S, Segie Rd., Madison, WI 53711, USA. Micronutrient in Agriculture, 2nd ed. SSSA Book Series, No. 4.

Tariq, M. and C. J. B. Mott. 2006. Effect of applied Boron on the accumulation of cations and their ratios to boron in radish (*Raphanus sativus* L.) Soil & Environ., 25 (1): 40-47,

Oyinlola, E. Y. 2007. Effect of boron fertilizer on yield and oil content of three sunflower cultivars in the Nigerian Savanna. J. Agron., 6 (3): 421-426.

Parveen, S. and H. Rehman. 2000. Effect of foliar application of zinc, manganese and boron in combination with urea on the yield of sweet orange. Pak. J. Agri. Res., 16 (2): 135-141.

Paul, A. E. and E. H. Berry. 1921. The Kjeldahl method and its modifications. J. Ass. Off. Agric. Chem., 5: 108-132.

Rashid, A., E. Rafique and N. Bughio. 1997. Micronutrient deficiencies in calcareous soils of Pakistan III. Nutrition of sorghum, Commun. Soil Sci. Plant Analysis, 25: 2883-2897.

Rashid, A. 2006. Indexes, diagnoses and management of micronutrient deficiencies in crops: Success stories and limitations in Pakistan. IFA Agriculture Conference Kunming, China, 27 Feb-02 March 2006. Optimizing resource use efficiency for sustainable intensification of agriculture. pp: 1-23.

Richards, L. A. 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA. Handbook 60, Washington DC.

Rimar, J. P., Balla and L. Princik. 1996. The comparison of application effectiveness of liquid with those in solid state in conditions of the East Solvak Lowland region. Rostlinna Vuroba., 42: 127-132.

Sakal, R., R. B. Sinha, A. P. Singh and N. S. Bhoga. 1999. Effect of boron and FYM alone and in combination on boron nutrition of crops in maize-lentil cropping system. Fertilizer News, 44 (11): 49-52.

Sillanpae, M. 1982. Micronutrients and nutrients status of Soils, a global study. FAO Soils Bulletin, No. 48, Rome.

Sanchez, E. Enrique, Timothy and L. Righetti. 1998. Effect of post harvest soil and foliar application of boron fertilizer on the partitioning and recycling of boron in Apple tree. Acta Hort., 474: 347-354.

Soltonpour, P. N and A. P. Schawab. 1977. A new soil test for simultaneous extraction of macro and micronutrients in alkaline soil. Commun. Soil Sci. Plant Analysis, 8: 195-297.

Soltanpour, P. N. and A. P. Schawab. 1985. Use of ammonium bicarbonate DTPA soil test to evaluate elemental availability and toxicity. Commun. Soil Sci. Plant Analysis, 10: 323-338.

Tariq, M., A. Akbar, L. Haq and Amanullah. 2010. Comparing application methods of boron fertilizer for the yield and quality of tobacco (*Nucotiana tabacum* L.). Abstract: 13th Congress of Soil Sci. Faisalabad, Pakistan, 22-27 March, 2010.

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