ENHANCEMENT OF WHEAT GRAIN YIELD AND YIELD COMPONENTS THROUGH FOLIAR APPLICATION OF ZINC AND BORON

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ABSTRACT

To evaluate the effect of foliar application of zinc and boron on yield and yield components of wheat, the present experiment was conducted at Agricultural Research Farm of NWFP Agricultural University Peshawar during winter seasons of 2004-05 and 2005-06. Solutions of zinc, boron and zinc plus boron were used as foliar spray, each applied at tillering, jointing and boot stage. Water application and no spray application were used as control. During both of the seasons, significant increase was recorded in number of spikes m^{-2}, grains $spike^{-1}$, thousand grain weight, biological yield and grain yield for foliar application of zinc and boron as compared to both control treatments. Combined application of zinc and boron resulted in maximum grains $spike^{-1}$ (56, during 2004-05 and 48.2 during 2005-06 with 52.2 as mean over years), thousand grains weight (52.2 as mean over years), biological yield (8750 kg ha^{-1} during 2004-05 and 11389 kg ha^{-1} during 2005-06 with 10069.4 kg ha^{-1} as mean value) and grain yield (2833 kg ha^{-1}, during 2004-05 and 2555 kg ha^{-1}, during 2005-06). Water application and control treatments resulted in minimum number of spikes m^{-2}, grains $spike^{-1}$, thousand grain weight, biological yield and grain yield, during both of the growing seasons. The present experiment shows that foliar application of zinc and boron results in increased grain yield and yield components of wheat, and thus is recommended to increase crop production.

Key Words: Zinc, Boron, Foliar Application, Grain Yield, Wheat

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INTRODUCTION

Both zinc and boron are known to be required for all higher plants as essential crop nutrients and are well documented to be involved in photosynthesis, N-fixation, respiration and other biochemical pathways (Cakmak and Marschner, 1988, Goldbach *et al.,* 1991). Zinc, in addition, is reported to be having possible role in reducing the toxic effects of excessive boron (Singh *et al.,* 1990).

Intensive cropping system with no or little micronutrients application has resulted in increased soil deficiency for different micronutrients. Widespread Zn deficiencies have been identified in the country. Soils with intensive cropping systems show even more prominent deficiencies (Deb, 1986). Similarly, boron deficiency also results in impaired crop growth and development. Application of these micronutrients results in better crop growth and thus in increased crop yield (Torun *et al*., 2001; Grewal *et al*., 1997). Jahiruddin *et al.* (1995) reported a prominent crop response to B application. Several studies have revealed that zinc fertilization not only increases yield but also increases zinc concentration in grains (Torun *et al*., 2001 and Grewal *et al*., 1997). Similarly, different experiments have been conducted to evaluate the response of wheat genotypes to boron application and a wide range of genotypic variation in response to B deficiency (Rerkasem and Jamjod, 1997) and toxicity (Paull *et al*. 1991) have been reported. Jahiruddin *et al*. (1995), Abedin *et al*. (1994), and Rerkasem *et al*. (1989) obtained higher yield of wheat with the application of B to the crop.

Availability of these micronutrients, however, is strongly influenced by soil physico-chemical characteristics. These micronutrients especially zinc is readily fixed in soil and plant roots are unable to absorb these nutrients adequately from dry topsoil (Graham *et al*., 1992; Foth and Ellis, 1996). Thus micronutrients application to cultivation zone may not fulfill crop requirement. Foliar spray of these micronutrients has been reported to be equally or even more effective as soil application (Modaihsh, 1997, Torun *et al*., 2001 and Grewal *et al*., 1997) to overcome micronutrients deficiency in subsoil. Liew (1988) have reported increase in crop production due to micronutrients application and had advocated foliar application to be 6-20 time more efficient than soil application, depending on soil type. Recently, Arif et. al. (2006) and Ali *et al*., (2008) also reported better crop production for foliar application of a both macro and micronutrients in combination. The present study was conducted to determine the impact of foliar application of zinc and boron for improved crop yield.

MATERIALS AND METHODS

To evaluate the effect of foliar application of zinc and boron on yield and yield components of wheat (*Triticum aestivum* L.), the present experiment was conducted at Agricultural Research Farm of NWFP Agricultural University, Peshawar during winter seasons of 2004-05 and 2005-06. The experimental site is located at 34^{o}N, 71.30 E with an altitude of 450 meters above sea level having silty-loam soil of pH 7.7- 8 and less than 1% organic matter.

The experiment was laid out in randomized complete block design with four replications. Solutions for foliar application were prepared using zinc sulphate for zinc and boric acid for boron @ 20g L-1 and 30 g L-1, respectively. Water spray application and no spray application were considered as control. Saleem-2000 was used as a testing genotype. Seeds were sown through drill with 30 cm row to row distance @ 100 kg ha-1. The plot size was 15m x 5m. Treatments were allotted to these plots at random within each replication. All other recommended crop production practices were applied uniformly to all treatments.

Data were recorded on number of spikes m-2, grains spike-1, thousand grain weight, biological yield and grain yield. The data were statistically analyzed using combined analysis of variance over years appropriate for randomized complete block design. Means were compared using LSD test at 0.05 level of probability when the F-values were significant (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

Number of Spikes m^{-2}

Data regarding number of spikes m-2 are shown in Fig. 1. Analysis of the data revealed that foliar application of zinc and boron significantly affected number of spikes m-2 during the two years. Maximum number of spikes m-2 were produced by the foliar application of zinc (271.7, during 2005-06 with 235.4 as mean value over two years) followed by foliar application of boron (266, during 2005-06 and 234.8 as mean value over two years). Foliar application of these two micronutrients, individually as well as in combination resulted in more number of spikes m-2 as compared to control (162.2, during 2004-05 and 228 during 2005-06 with 195.3 as mean over years). Soylu *et al*., (2005) and Guenis *et al*., (2003) have also reported significant variations for number of spikes m-2 for foliar application of boron. Similarly, Kenbaev and Sade (2002) reported increase in number of spike m-2 for application of zinc.

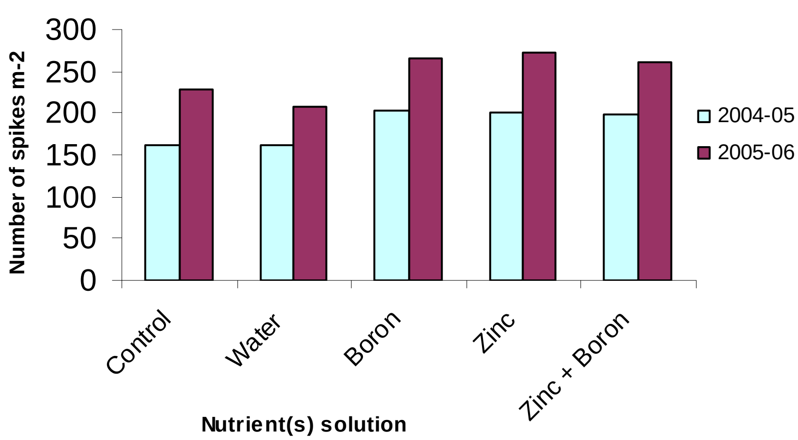

Fig. 1. ***Effect of foliar application of zinc and boron on number of spikes m-2, during 2004-05 and 2005-06. (LSD values for treatment and interaction are 24.33 and 34.41, respectively)***

Number of Grains Spike^{-1}

Statistical analysis of the data showed that number of grains spike^{-1} was significantly affected by foliar application of zinc and boron, during both growing seasons (Fig. 2). Highest number of grains spike^{-1} was produced by combined application of both zinc and boron (56, during 2004-05 and 48.2 during 2005-06 with 52.2 as mean over years) followed by foliar application of boron (41, during 2004-05 and 39.8 as mean value). These were significantly higher than both of the control treatments i.e., water spray (32.5 during 2004-05 and 32.5 during 2005-06) and no spray (32.1 during 2004-05 and 30.0, during 2005-06). This increase was stable over both the years showing non significant difference between the two years. These results are in line with that of Guenis *et al*., (2003) who also reported marked increase in number of grains spike^{-1} of wheat for application of Boron. Our results are in line with that of Soleimani (2006) who also reported increase in number of grains spike^{-1} for foliar application of zinc.

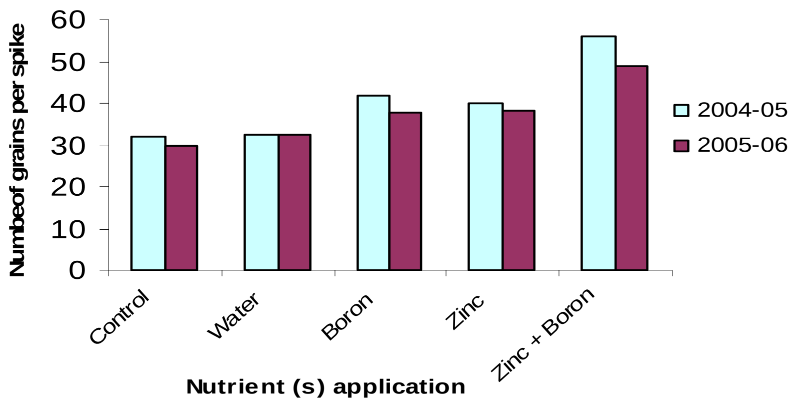

Fig. 2. ***Effect of foliar application of zinc and boron on number of number of grains spike^{-1} of wheat, during 2004-05 and 2005-06. (LSD values for treatment and interaction are 4.97 and 7.034, respectively)***

Thousand Grain Weight (g)

Data on thousand grain weight revealed significant increase in grain weight for foliar application of zinc and boron, during the two tested cropping seasons, 2004-05 and 2005-06 (Fig. 3). Combined application of both zinc and boron resulted in increased grain weight (52.2 g as mean over years) followed by foliar application of zinc (with mean weight of 50.1 g over two years). Application of nutrients solution as foliar spray resulted in significantly higher grain weight as compared to both of the control treatments i.e., water spray (43 g) and no spray (41 g). The observed increase was stable over both growing seasons. Foliar application of crop nutrients at latter stages will ensure better crop nutrition at anthesis and grain filling stage which in turn may result in increased grain weight. These results are in agreement with those of Soylu *et al*. (2005) who reported significant variations for thousand grains weight for foliar application of boron. Similarly Kenbaev and Sade (2002) and Hosseini (2006) have reported increase in yield components for application of zinc.

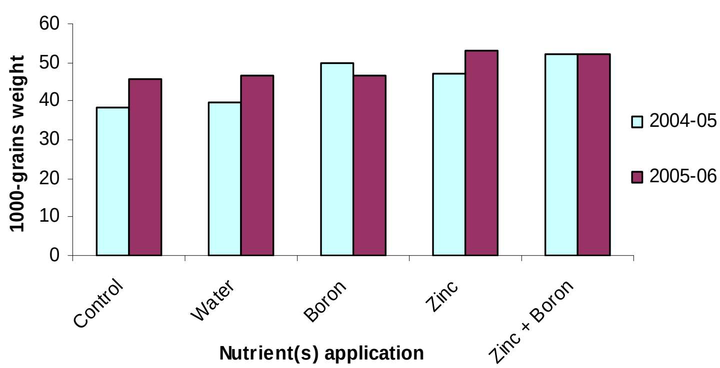

Fig. 3. ***Effect of foliar application of zinc and boron on thousand grains weight of wheat, during 2004-5 and 2005-6. (LSD values for treatment and interaction are 3.76 and 5.325, respectively)***

Biological Yield

Significant increase in biological yield was observed for foliar application of the two micronutrients (zinc and boron) over both the years (Fig. 4). Foliar application of zinc and boron in combination resulted in higher biological yield (8750 kg ha^{-1} during 2004-05 and 11389 kg ha^{-1} during 2005-06 with 10069.4 kg ha^{-1} as mean value). During both years higher biological yield was obtained for foliar application of zinc and boron as compared to control treatments i.e., water spray (6513.9 kg ha^{-1}) and no spray (6763.9 kg ha^{-1}). This may be due to better crop nutrition through foliar application of the applied nutrients which may result in improved crop growth. These results are endorsed by Torun *et al.*, (2001) and Grewal *et al.* (1997) who have reported increased dry matter production for application of zinc and boron over control.

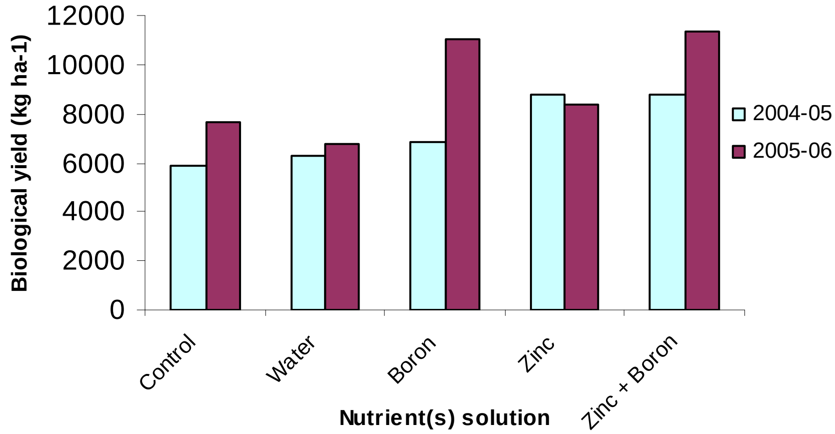

Fig. 4. ***Effect of foliar application of zinc and boron on biological yield of wheat, during 2004-05 and 2005-06. (LSD values for treatment and interaction are 1432 and 2025, respectively)***

Grain Yield (kg ha^{-1})

Data on grain yield indicated significant increase for foliar application of zinc and boron over control treatments. Mean grain yields of the treatments during cropping seasons 2004-05 and 2005-06 are presented in Fig. 5. Maximum grain yield was recorded for combined application of zinc and boron during both the growing seasons 2004-05 (2833 kg ha^{-1}) and 2005-06 (2555 kg ha^{-1}) followed by foliar application of boron (with mean yield 2354 kg ha^{-1}). Foliar application of these two micronutrients resulted in increased grain yield over both control treatments i.e., water application (1791 kg ha^{-1}) and no application (1520 kg ha^{-1}) and was stable over the years.. Micronutrients application to leaves of growing crop will ensure better crop nutrition at anthesis and grain filling stage which in turn may result in increased grain yield. These results agree with Torun *et al*. (2001), Zorita *et al*. (2001) and Grewal *et al*. (1997), who reported increased grain yield for zinc application. Similarly, Abedin *et al*. (1994), and Rerkasem *et al*. (1989) obtained higher yield of wheat with the application of B. The results are in accordance with Hussain *et al*. (1995) and Arif *et al*. (2006).

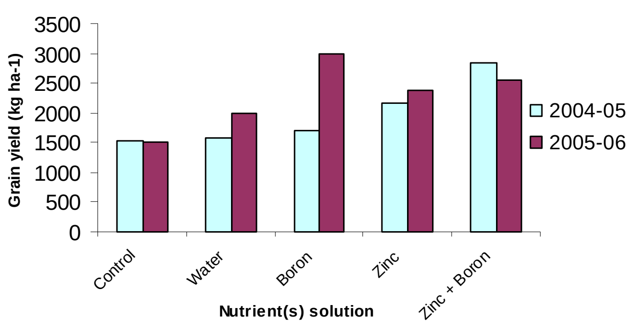

Fig. 5. ***Effect of foliar application of zinc and boron on grain yield of wheat, during 2004-05 and 2005-06. (LSD values for treatment and interaction are 541.3 and 765.5, respectively)***

CONCLUSION AND RECOMMENDATION

The present experiment shows that foliar application of zinc and boron results in increased grain yield and yield components of wheat during both the growing seasons. Thus foliar sprays of micronutrients are suggested to be applied for better crop nutrition and increased crop growth, which will ensure higher yields.

REFERENCES

Abedin, M.J., M. Jihiruddin, M.S. Hoque, M.R. Islam and M.U. Ahmed. 1994. Application of boron for improving grain yield of wheat. Progress Agric. 5(1): 75-79.

Ali, S., A. R. Khan, G. Mairaj, M. Arif, M. Fida and S. Bibi. 2008. Assessment of different crop nutrients management practices for improvement of crop yield. Aust. J. Crop Sci. 2(3):150-157.

Arif, M., M. A. Chohan, S. Ali, R. Gul and S. Khan. 2006. Response of wheat to foliar application of nutrients. J. Agric. Biol. Sci. 1: 30-34.

Arif, M., S. Ali, A. Khan, T. Jan and H. Akbar. 2006. Influence of farm yard manure application on various wheat cultivars. Sarhad J. Agric. 22(1): 27-29.

Cakmak, I. and H. Marschner. 1988. Increase in membrane permeability and exudation in roots of zinc deficient plants. J. Plant Physiol. 132: 356-361.

Deb, D.L.. 1986. Zinc and Sulphur deficiency (in rice production) in Bangladesh. FAO-UNDP Tech. Report, AG.TCP/3GD/2203:164p.

Foth, H. D. and B.G. Ellis. 1996. Soil fertility (2^{nd} ed.). Lewis Pub. New York.

Goldbach, H.E., J. Blaser-Grill, N. Lindemann, M. Porzelt, C. Hörrmann, B. Lupp and B. Gessner. 1991. Influence of boron on net proton release and its relation to other metabolic processes. Curr. Top. Plant Biochem. Physiol. 42: 925-929.

Graham, R.D., J.S. Ascher and S.C. Hynes. 1992. Selecting zinc-efficient genotypes for soils of low zinc status. Plant and Soil 146: 241-250.

Graham, R.D., R.M. Welch, D.L. Grunes, E.E. Cary and W.A. Norvell. 1987. Effect of zinc deficiency on the accumulation of boron and other mineral nutrients in barley. Soil Sci. Soc. Am. J. 51, 652-657.

Grewal, H.S., L. Zhonggu and R.D. Graham. 1997. Influence of subsoil zinc on dry matter production, seed yield and distribution of zinc in oilseed rape genotypes differing in zinc efficiency. Plant and Soil. 192 (2): 181 - 189

Guenis, A., M. Alpaslan and A. Unal. 2003 .Effects of boron fertilization on the yield and some yield components of bread and durum wheat. Turk J. Agric. 27: 329-335.

Hussain, T., G. Jilani, J.F. Parr and R. Ahmad. 1995. Transition from conventional to alternative agriculture in Pakistan: the role of green manures in substituting for inorganic N fertilizers in a rice-wheat farming system. American J. Alternative-Agric. 10(3): 133-137.

Hosseini, S.M. 2006. Zinc- Boron interaction effects on yield, yield components and chemical composition of wheat. The 18^{th} World Congress of Soil Sci.

Jahiruddin, M., M.S. Ali, M.A. Hossain, M.U. Ahmed and M.M. Hoque. 1995. Effect of Boron on grain set, yield and some others of wheat cultivers. Bangladesh J. Agric. Sci. 22: 179-184.

Kenbaev, B. and B. Sade. 2002. Response of field-grown barley cultivars grown on zinc-deficient soil to zinc application. Comm. Soil Sci. Plant Anal. 33: 33-5544.

Liew, C.S. 1988. Foliar fertilizers from Uniroyal and their potential in Pakistan. Proc. of Seminar on micronutrient in soils and crops in Pak. 277. (Abst.).

Modaihsh, A.S. 1997. Foliar application of chelated and non-chelated metals for supplying micronutrients to wheat grown on calcareous soil. Exp. Agric. 33: 237-245.

Paull, J.G., A.J. Rathjen and B. Cartwright . 1991. Major gene control of tolerance of wheat (*Triticum aestivum* L.) to high concentrations of soil boron. Euphytica 55, 217-228.

Rerkasem, B. and S. Jamjod. 1997. Genotypic variation in plant response to low boron and implications for plant breeding. Plant and Soil 193: 169-180.

Rerkasem, B., D.A. Saunders and B. Dell. 1989. Grain set failure and boron deficiency in wheat. Thailand. J. Agric. (Chiangmai Univ.) 5:1-10.

Singh, J.P., D.J. Dahiya and R.P. Narwal. 1990. Boron uptake and toxicity in wheat in relation to zinc supply. Fert. Res. 24: 105-110.

Soleimani, R. 2006. The effects of integrated application of micronutrient on wheat in low organic carbon conditions of alkaline soils of western Iran. 18^{th} World Congr. of Soil Sci.

Steel, R.G.D. and J.H. Torrie. 1984. Principles and procedures of statistics: a biometrical approach. McGraw Hill Co. New York, NY, USA.

Soylu, S., B. Sade, A. Topal, N. Akgun and S. Gezgin. 2005. Responses of irrigated durum and bread wheat cultivars to boron application in a low boron calcareous soil. Turk. J. Agric. 29: 275-286.

Torun, A., I. GÃ. ltekin, M. Kalayci , A. Yilmaz, S. Eker, I. Cakmak. 2001. Effects of zinc fertilization on grain yield and shoot concentrations of zinc, boron, and phosphorus of 25 wheat cultivars grown on a zinc-deficient and boron-toxic soil. J. Plant Nutr. 24(11): 1817 – 1829.

Zorita, M.D., M.V.F. Canigia and G.A. Grosso. 2001. Applications of Foliar Fertilizers Containing Glycinebetaine Improve Wheat Yields. J. Agron. Crop Sci. 186: 209.