RESPONSE OF WHEAT TO EXOGENOUS BORON SUPPLY AT VARIOUS GROWTH STAGES

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ABSTRACT

A field experiment to identify the most suitable growth stage for boron application was conducted at Agronomic Research Area, Bahauddin Zakariya University, Multan, Pakistan during, 2009. The boron application times included control, at tillering, jointing, booting and anthesis stage and the treatments were compared in randomized complete block design. The diverse response of plant growth parameters in the given study suggested the active involvement of boron in plant metabolism. The results revealed that boron application time has least significant effect on vegetative growth than reproductive ones. Therefore, the mean values obtained against boron application time for plant height, number of tillers and straw yield did not differed significantly over control. Whereas, boron application was potential contributor to total grains mass by improving the spike length, number of spikelets and grains spike^{-1}, 1000-grain weight, grain yield and harvest index over control and it ranged from 14.87 to 17.40 (cm), 18.33 to 21.67, 44.00 to 51.33, 31.33 to 38.38 (g), 2.88 to 3.56 (t ha^{-1}) and 38.50 to 47.16, respectively. It is concluded from the study that boron application in wheat is crucial for improving seed set and its application at booting and anthesis stage seems to be superior among the tested growth stages for enhancement of grains production and better economic returns.

Key Words: **Boron, Foliar application, Growth stages, Wheat yield and Yield components.**

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INTRODUCTION

Wheat has been the staple food of Adam's still ancient times and the world demand for wheat will be 40% more than that of later 1990s (Rosegrant, 1997). In Pakistan, an area of 8805000 hectares is under wheat with an annual production of 24214000 tons (GOP, 2010-11). Of the total world wheat production, 81% is used in the developing countries (CIMMYT, 2005). A remarkable improvement in grains yield of wheat has been attained and the present yield does not coincide its potential. The pollen sterility has been reported a major plant disorder responsible for the low grain yield of the wheat (Anantawiroon *et al.,* 1997). The potential factors responsible for sterility include environmental stresses like drought and high temperature (Saini and Aspinall, 1982) and insufficient boron availability during reproductive development (Subedi *et al*., 2000 and Rerkasem, 1995). The unavailability of boron during grain setting period results poor anther and pollen development (Cheng and Rerkasem, 1993) and the grain thus formed are often without starch (Dell and Huang, 1997). The key role of boron in plants includes membrane integrity, cell wall formation, pollen tube growth and utilization of carbohydrates (Marschner, 1995). The sterility induced by inadequate boron supply in wheat is of major concern in boron deficient soils (Lindsay, 1991; Rashid *et al.,*1997 and Shorrocks, 1997) and semi dwarf varieties (Rerkasem and Jamjod, 2004). Therefore, the problem can be handled by ensuring the continuous exogenous boron supply during reproductive development. The boron deficiency has least effect on vegetative growth than reproductive parts as boron concentration in leaves is 2 mg kg^{-1} dry matter which is five times less than boron in anther tissues (Rerkasem *et al*., 1997). That might be reason that leaves boron deficiency cannot serve the purpose of correcting deficiency. The huge differences between boron contents of vegetative and reproductive parts (anther, pollen and ovule development) and its limited translocation via phloem in wheat (Brown and Shelp, 1997), thereby necessitating the proper application time. The present study was therefore, conducted to identify the most suitable growth stage of wheat to formulate timely application of boron.

MATERIALS AND METHODS

A field experiment was performed at agronomic research area of University College of Agriculture, Bahauddin Zakariya University, Multan, Pakistan (71.43^{o} E and 30.2^{o} N) during the growing season, 2009. The soil used for this experiment was clay loam in texture and saline in nature, slightly calcarous, alkaline in reaction, low in organic matter and dilute HCL- extractable boron which is less than critical limit. The seed of wheat cultivar "Sehar-2006" was taken from Punjab Seed Corporation. The seeds were sown on raised beds 76.2 cm wide in rows having 25cm space with the help of bed planter. The crop was sown on 3rd week of November using a seed rate of 100 kg ha^{-1}. The boron application times i.e. control (T1), tillering (T2), jointing (T3), booting (T4) and anthesis (T5) were included as treatments. The difference among the wheat growth stages was made by using Feeks scale. The treatments were arranged in randomized complete block design and were thrice replicated. The crop was fertilized with recommended dose of NPK fertilizer (85-50-35 kg NPK ha^{-1}). Full dose of P, K and 1/3rd of N were mixed in soil during seed bed preparation. The remaining half portion of N was top dressed at first irrigation and other 1/3rd was applied with third irrigation. The boron was applied as foliar spray in form of Boll Guard (5 % boron W/V) @ 1250 mL ha^{-1} at respective growth stage. The weeds and insects associated with wheat were controlled by cultural approaches. The effect of boron application time on wheat was observed on plant height, number of fertile tillers, spike length, number of spikelets and grain $spike^{-1}$, 1000-grain weight, biological, grain and straw yield and harvest index. The plant height, number of fertile tillers, spike length, number of spikelets and grain $spike^{-1}$ were recorded at physiological maturity (20-30 % grain moisture). The plant height of ten randomly selected plants was measured with help of measuring tape from ground level to the top of spike. The number of fertile tillers was counted by the presence of spike at the head of tiller. For spike length, ten spikes were randomly selected and the spike length was taken from collar to spike top. The spikes selected for spike length were also used for recording number of spikelets and grain per spike. The crop was harvested at maturity stage (few days after physiological maturity). For biological, straw and grain yields, the whole plot was harvested. The harvested crop was tied in bundles and was left in respective plot for air drying up to 5 days. The tied bundles of individual plot were weighted on spring weight balance for biological yield. The crop was threshed manually to record the grain and straw yields of harvested area and was converted into hectare basis. The data regarding the 1000-grain weight was measured by taking three random samples (each of 1000 grain) from threshed mass of respective plot and were weighed on electronic balance. The harvest index was taken as the ratio of grains to biological yield. The economic analysis was based on the prevailing prices of inputs and revenue generated from the marketable produce. The recorded data on the yield and yield components were subjected to statistical analysis by using Fisher's analysis of variance technique. The significance of treatment means were compared by using LSD test at ($P<0.05$) (Steel *et al*., 1997).

RESULTS AND DISCUSSION

The data regarding yield and various yield components is presented in Table I. The given data clarify that non significant variations among boron application time were arouse for plant height, number of fertile tillers and straw yield and values recorded for these traits were statistically similar to the control treatment. From the results, it can be concluded that boron application is not much important for regulating the vegetative growth. The results might be attributed to pectin in the cell wall which is maintained at the lowest during vegetative growth in germanous plants (Blevins and Lukaszewski, 1998). Our findings are quite at line with those of Subedi et al. (1998), Uddin et al. (2008) and Shah (2008) for plant height, Subedi (1998) and Nazim et al. (2005) for number of fertile tillers and straw yield. In some studies, conducted by earlier fellows, the straw yield has been reported to increase with boron application (Wrobel, 2009 and Uddin et al., 2008). The contradiction regarding the straw yield might be the result of varietals behaviour for boron and its contribution from soil resources.

The boron application produced statistically higher figures for spike length, number of grain and spikelets $spike^{-1}$, 1000-grain weight, grain mass, biological yield and harvest index over the control treatment (Table I). The significant improvement in growth of reproductive parts suggested the positive role of boron to dry matter partitioning from source to sink and cell division in meristematic tissues. The mean values produced for spike length and number of spikelets $spike^{-1}$ against boron application at tillering and jointing stage did not differed significantly over control. Similarly, boron application at booting and anthesis stage also gave the statistically similar figures for spike length, number of spikelets, grains and biological yield and harvest index. Although boron application at booting stage was proved to be the most appropriate application time but it did not differ significantly with anthesis stage for most of reproductive traits. Over all boron application at booting stage gave 17.01%, 18.22%,16.65%, 22.50%, 23.61%, 7.35 % and 22.49 % increase in spike length, number of spikelets and grains ($spike^{-1}$), 1000-grain weight, grain yield, biological yield and harvest index, respectively over the control. The least increase in biological yield is due to non-significant effects of boron application on straw yield. The boron application at booting stage improves the grain setting by improving the grain filling process and reducing the male sterility often observed in boron deficient condition. Similar results have also been reported by Uddin *et al.* (2008) for spike length, number of grain and spikelets ($spike^{-1}$).

Table I *Plant morphological and yield traits of wheat as affected by boron supply at various growth stages*

Growthstage	*Plant height (cm)*	*No. of tillers (m^{-2})*	*Spike length (cm)*	*No. of spikelets ($spike^{-1}$)*	*No. of grains ($spike^{-1}$)*	*1000 grain weight (g)*	*Straw yield ($t\ ha^{-1}$)*	*Grain yield ($t\ ha^{-1}$)*	*Biological yield ($t\ ha^{-1}$)*	*Harvest index*
Control	100.63	414.00	14.87 b	18.33 c	44.00 d	31.33 c	7.47	2.88 d	10.34 c	38.50 d
Tillering	104.23	408.00	15.70 b	19.00bc	46.00 c	32.13 bc	7.59	3.14 c	10.73 b	41.36 c
Jointing	103.27	413.00	15.57 b	19.67 abc	47.67 bc	33.79 b	7.57	3.32 b	10.88 ab	43.87 b
Booting	104.30	409.33	17.40 a	21.67 a	51.33 a	38.38 a	7.56	3.56 a	11.10 a	47.16 a
Anthesis	110.30	412.33	17.00 a	21.00 ab	48.00 b	33.90 b	7.54	3.45 a	10.99 ab	45.81 ab
LSD Value ($P < 0.05$)	**NS**	**NS**	**1.0832**	**2.0044**	**1.7528**	**2.3314**	**NS**	**0.1294**	**0.3411**	**1.9778**

The mean values presented by various letters in columns are significantly different from one another at $P< 0.05$
NS=Non significant

The higher grains spike^{-1} is the result of positive role of boron in pollen function like germination, viability, development and growth (Subedi *et al.,* 1997). The grain yield has positive association with grain number and individual grain size and therefore, the higher grain yield (3.56 t ha^{-1}) was recorded with boron application at booting stage. The immobility problem of boron from vegetative to seed setting tissues might be reason of desireable results. Our findings agree well to Halder *et al*., 2007; Korzeniowska, 2008 and Wrobel, 2009 for grain yield. As biological yield is controlled by grain and straw mass, in this study, it was mainly dependent on grain mass. The higher value of grain yield with boron application without any respective increase in straw yield resulted remarkable increase in harvest index. The positive contribution of boron for biological yield and harvest index has also been confirmed by Spasovski *et al.* (1987), Shah (2008), Tombo *et al*. (2008) and Alam *et al*. (2000), respectively.

Economic Analysis

The effectiveness of treatment is mainly based on its economic. It is clear from the Table II that cost of production is less than the gross income even without boron application and therefore, farmers growing wheat has not been suffering in loss. All the tested treatments proved to be superior over the control for cost benefit ratio and the maximum net economic returns were achieved by boron application at booting and anthesis stage. The increase in cost benefit ratio is mainly due to its effects on grains yield which was significantly affected by boron application but not from the straw yield.

Table II *Economic analysis of Boron application treatments during 2009-10*

Growth stages	*Yield t ha^{-1}*	*Value Rs. ha^{-1}*	*Straw yield t ha^{-1}*	*Value Rs. ha^{-1}*	*Gross Income Rs ha^{-1}*	*Variable cost Rs. ha^{-1}*	*Permanent cost Rs. ha^{-1}*	*Total Cost Rs. ha^{-1}*	*Net Return Rs. ha^{-1}*	*Benefit cost ratio Rs.ha^{-1}*
Control	2.87	68273	7.47	28003	96276	16513	52247	68760	27516	1.40
Tillering	3.14	74528	7.59	28455	102983	18998	52247	71245	31738	1.45
Jointing	3.32	78763	7.56	28365	107128	19580	52247	71827	35301	1.50
Booting	3.56	84503	7.55	28295	112797	20399	52247	72646	40151	1.55
Anthesis	3.45	81969	7.53	28251	110220	20021	52247	72268	37952	1.53

I). Permanent cost included land preparation, seed, fertilizer, irrigation, application charges, land rent, land management, income tax and artisan charges. II) The variable cost included cost included cost of harvesting and threshing, boll guard (boron source) and its application charges

CONCLUSION AND RECOMMENDATIONS

The positive response of wheat in terms of grain yield suggested that boron contents of soil (0.47mg kg^{-1}) were not enough to supply boron to wheat. It is concluded that additional foliar application of boron should be made at booting and anthesis stage for obtaining higher grain yield.

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