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Impact of boron application on wheat yield

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Abstract
To evaluate the effect of foliar application of boron on yield and yield components of wheat, the present experiment was conducted at Birsa Agricultural University, Ranchi during winter seasons of 2012-13 and 2013-14. Treatments included four levels of B (T1: 0 kg ha^{-1}, T2: 1 kg ha^{-1} and T3: 1.5 kg ha^{-1} B added to the soil and T4: 1kg B ha^{-1} as soil along with foliar spray at pre flowering and panicle initiation stage) in a randomized block design. The results of this study showed that each incremental levels of B application contributed towards significantly higher yield and yield attributing character over the control and sterility percentage decreased significantly with the levels of B applications. The highest grain yield was obtained in T4 treatment (3.88 t ha^{-1}) followed by T3 (3.77 t ha^{-1}) and T2 (3.53 t ha^{-1}) and least was recorded in T1 (3.25 t ha^{-1}). Maximum sterility percentage was found in T1 (19.9%) whereas minimum was recorded in T4 (9.8%). It can be concluded that the application of B @ 1 kg ha^{-1} followed by foliar application of boron is helpful in enhancing the productivity of wheat by reducing the sterility percentage.

Keywords: Boron, Foliar Application, Grain Yield, Wheat and sterility percentage

Introduction
Most of soils in Jharkhand (India) are acidic in nature, low in organic matter content. Nutrient mining with intensive cropping and inadequate and imbalance fertilizer use has caused deficiency in micronutrients including boron. Boron is an essential micronutrient for development and growth of plants but its deficiency is wide spread in Jharkhand. Soils of about 45 per cent of the state are found to be deficient in available boron (Anonymous, 2006) [1].

The primary function of boron is related to cell wall formation (Matoh, 1997) [8], so boron-deficient plants may get stunted growth. Sugar transport in plants, flower retention and pollen formation and germination also are affected by boron deficiency. Boron plays an essential role in fertilization in higher plants (Marschner, 1995) [7]. B deficiency may cause spikelet sterility in wheat. The grain set fails to develop because anthers are not fully developed with a few malformed pollen grains.

The aim of the study is to have a scientific assessment of the effect of soil and foliar fertilization of boron applied to wheat grown under boron deficient soil.

Materials and methods
A field experiment was conducted in randomized block design with three replications during rabi 2012-13 and 2013-14 at Birsa Agricultural University, Ranchi. The test crop wheat (var. K9107) was selected with treatment comprising of four levels of boron (T1: 0 kg ha^{-1} (control), T2:1 kg B ha^{-1}, T3: 1.5 kg B ha^{-1}, T4: 1 kg B ha^{-1} along with two foliar spray at pre flowering and panicle initiation stage). At the time of sowing 120:60:40 N, P2O5, and K2O were applied. Half of the nitrogen was applied as basal dose and one fourth of nitrogen was top dressed after 30 DAS and rest one fourth after 60 DAS in the form of urea.

The soil of experimental field was sandy loam in texture, nitrogen (330.0 kg ha^{-1}), phosphorus (30.63 kg ha^{-1}), potash (142.5 kg ha^{-1}) and boron content (0.31 mg kg^{-1}) and high in organic carbon (0.41 %) with pH (4.68).

Data on spike length, 1000-grain (wheat) weight (g), total no of grains and unfilled grains per panicle were recorded. Based on these data, sterility percentage and harvest index were calculated. Grain and straw yield were recorded at maturity. Plant tissues were dry ashed and B concentration in the digests was determined colorimeterically using azomethine–H (Bingham, 1982) [3].

Result and Discussion

Effect of boron on yield and yield attributing character

Wheat yield was significantly increased due to the application of boron in both the years, 2012 and 2013 (Table 1). Highest grain yield (3.93 t ha^{-1}) was obtained from T4 treatment (1 kg B ha^{-1}soil application along with two foliar spray at pre flowering and panicle initiation stage) which was statistically a par with T3 but significantly higher than T2 and T1 (Control) during 2012-13. Similar trend was observed during 2013-14 also. However, lesser grain yield was obtained in 2013-14 under all the levels of B application compared to corresponding grain yield obtained in 2012-13. For both the years, lowest yield was with the control i.e. T1 treatment. The pooled data revealed that each incremental level of B application contributed towards significantly higher yield over the control. Among the levels T3 and T4 were at par with each other, both being significantly superior over T2 and over the control (T1). Here with respect to the crop performance (in terms of grain yield), the level T3 (1.5 kg^{-1} ha^{-1} B application in soil) and level T4 (1.0 kg^{-1} ha^{-1}plus two foliar application) seem to have brought about the almost similar impact on the grain yield. Boron has been reported to play a vital role in pollen tube germination and grain setting. Hence, B application increased the grain yield. The result of the study agreed with that of Debnath *et al*., (2011) [4] and Tahir *et al*., (2009) [11].

In terms of straw yield also the crop response exhibited similar trend as in case of grain yield. Straw yield was highest (7.39 t ha^{-1}) under T3 during both the years. Straw yield obtained under T3 and T4 were at par and all the levels (T2 to T4) were significantly higher over control (T1). The pattern of increase/ decrease in straw yield in 2013 was similar to that of 2012. The similar pattern of yield was also reflected under pooled analysis. It is noted here that application of B could significantly increase the straw yield. But in foliar spray along with soil application, the straw yield was comparatively less than higher dose of B application (1.5 kg B ha^{-1}). As compared to grain yield, straw yield was less affected by the application of boron as the straw yield is more or less same in T3 and T4 levels of B application. Similar finding has been reported by Asad and Rafique (2000) [2].

The harvest index being an indicator of partitioning behavior showed a different trend than that observed in case of grain and straw yield. There was no significant effect of B application as on harvest index during both the years under report. Similar findings were also reported by Shafique and Maqsood (2010) [10], Keram *et al*., (2013) [6], and Raza *et al*., (2014) [9] as they observed that the total biomass of wheat crop was statistically non-significant.

Data on crop responses, in terms of yield attributing parameters like number of spike per panicle, spike length, number of filled and unfilled grains, sterility percentage and test weight have been presented in Table 2 and 3 and are discussed here under.

The spike length non significantly varied with B treatments, with the highest length (10.2 cm) recorded in T4 treatment and the lowest length (9.5 cm) in T1 (control) in 2012-13 whereas it varied from 9.5 cm (T1) to 10.3cm (T4) during 2013-14. The pooled data exhibited spike length variations from 9.6 cm to 10.2 cm.

The test weight (1000 grain weight), an indicator of grain boldness and also an important yield attributing character has been found to be influenced significantly by the level of B applications. All the levels were significantly superior over T1 (control); T2 and T3 were at par with each other. The level T4 was found significantly superior over T1 (control) and T2 but at par with T3. This may be due to provision of B at initial stages which might have enhanced the accumulation of assimilate in the grains. Similar results were achieved by Raza *et al*., (2014) [9]; Tahir *et al*., (2009) [11]; Haldar *et al*., (2007) [5].

The unfilled or chaffy grain being a function of sterility is one of the most important yield attributing parameter which may or may not be due to the genetic characteristic of crop genotype but is definitely governed by the ambient weather condition at the time of flowering. Total number of grains per spike was increase significantly with B applications (Haldar *et al*., 2007) [5] and Ali *et al*., (2013) [9], Debnath *et al*., (2011) [4]. The pooled data on sterility percentage decreased significantly with the level of B application (Table 2). It seems from the experimental result that foliar application of boron showed the reduction in sterility percentage. Similarly, there was reduction in the percentage of chaffy grains due to boron application, as compared to control with no boron application. The results showed that boron application in wheat crop enhanced the yield.

Table 1: Crop response to different levels of B application on yield (t ha^{-1}) of wheat

Level of B application	2012			2013			Pooled		
	Grain yield	Straw yield	Harvest index	Grain yield	Straw yield	Harvest index	Grain yield	Straw yield	Harvest index
T1	3.31	5.99	34.6	3.21	5.94	35	3.25	5.97	34.8
T2	3.57	6.59	33.7	3.48	6.54	34.6	3.53	6.57	34.1
T3	3.75	7.39	32.9	3.79	7.32	34	3.77	7.35	33.4
T4	3.92	7.26	34.2	3.84	7.18	34.8	3.88	7.22	34.5
CD at 5 %	3.2	4.5	NS	3.88	4.73	NS	2.21	3.26	NS
CV %	10.4	8.0	6.8	12.9	8.4	11.5	7.3	5.8	4.7

Table 2: Crop response to B on yield attributing parameter in wheat

Level of B application	Total number of grains $panicle^{-1}$			Total number of unfilled grain $panicle^{-1}$			Sterility (%)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T1	35	35	35	7	7	7	20.1	19.8	19.9
T2	36	37	36	5	5	5	14.6	14.6	14.6
T3	39	39	39	4	4	4	12.1	11.8	12.0
T4	40	40	40	3	4	4	9.8	9.9	9.8
CD at 5%	2.9	1.6	1.6	0.5	0.3	0.2	1.9	1.0	0.7
CV %	9.0	5.1	5.2	11.7	6.5	5.7	16.1	8.7	6.2

Table 3: Crop response to B on yield attributing parameter in wheat

Level of B application	Panicle length (cm)			1000 grain weight (g)		
	2012	**2013**	**Pooled**	**2012**	**2013**	**Pooled**
T1	9.7	9.5	9.6	39.5	38.9	39.2
T2	9.8	9.7	9.7	40.8	40.2	40.5
T3	10.2	10.0	10.1	42.3	41.7	42.0
T4	10.3	10.1	10.2	44.1	43.4	43.8
CD at 5%	NS	NS	NS	2.6	2.6	2.6
CV %	7.3	7.2	7.2	7.6	7.6	7.6

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