Response of seed dressing with boron dust and slurry on wheat variety WK-1204 for grain yield and agronomic traits under poly bag and field study at Khumaltar, Nepal

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Abstract

Field and poly bag experiments were carried out at Khumaltar on wheat variety WK-1204 by dressing seed with sodium borate decahydrate dust (containing 11.34% elemental boron) and slurry per 100 g wheat seed. A total of nine treatments of Boron (B) dust and slurry to treat wheat seed at 2.2, 4.4, 6.4 and 8.8 gram per 100 g seed and basal application of B at 1.0 kg a.i./ha was in three replications for both field and poly bag experiments in randomized complete block design. The objective of the study was to find out the effect of boron seed dressing on grain yield and agronomic attributes of wheat variety under study. The result of the study revealed that grain yield and agronomic traits were highly and significantly correlated with seed dressing with boron dust at 2.2 to 8.8 g boron /100 g seed of wheat. This finding was consistent with field and poly bag experiments which were coherent with the findings of lab analysis for attributes of root and shoot length, and percentage of germination. However, seed dressing with boron slurry at 2.2 to 8.8 g/ 100 g wheat seed inhibited grain yield and agronomic attributes of wheat in the study. Therefore, seed dressing with boron dust at different level was superior over seed dressing with boron slurry for higher grain yield and yield related traits of wheat variety WK-1204 at Khumaltar condition. Boron deficiency for wheat could be corrected by seed dressing with boron dust at 2.2 to 8.6 g boron /100g wheat seed. This could be very economical and practical way of enhancing wheat production in hilly terrain areas of Nepal where one of the reasons of yield limitations is due to deficiency of boron.

Key words: seed dressing, boron dust and slurry, wheat grain yield and agronomic traits

Introduction

Boron (B), a micro nutrient, is one of the important mineral elements required for plants (Warington, 1923; Loomis & Durst, 1992). Boron is necessary to regulate several physiological processes on plant that includes cell division, carbohydrates metabolism, and assimilate translocation together with cell wall development (Marschner, 1995; Herrera-Rodriguez *et al;* 2010, Oosterhuis, 2001; Wang *et al;* 2003). It has been established multi-functional role of boron by many workers not only for physiological role but also for growth and productivity of crops as well. It is reported that boron is essential for germination and growth, flowering, grain formation and other physiological process of development of young terminal florets, pollen tube development of wheat (Matoh *et al;*

1992; Rerkasem and Loneragan 1994). Deficiency of boron in wheat leads to failure in fertilization, or sterility (Blevins and Lukaszewski 1998; Rerkasem and Jamjod 1997). Adverse climatic condition such as cloudy days and low or high temperature), very high soil pH, and water logging could influence the degree of crop response to boron application in wheat (Bell and Dell 1995; Saifuzzaman 1995; Mishra *et al;* 1992).

Bhatta, *et al* (2004) reported that of the thirty-one wheat genotypes evaluated under rice-wheat system in central mid hill of Nepal during the 1999 wheat growing season with and without application of boron revealed high genotypic variation in terms of sterility on wheat. They also found a clear-cut difference among genotypes in spike sterility. Same study reported a direct relation between sterility and boron minus (not applied boron) plots ranging from 1 to 100% spike sterility suggesting that boron deficiency was one of the major causes of sterility of wheat in mid hills of Nepal. The interesting finding of the study was that there was drastic reduction of sterility that ranged from 0-5% in plots that were applied boron (Bhatt, *et al;* 2004). Of the variety tested Achut and Annapurna-1 showed highest degree of sterility 70-80% in plots not applied boron indicating variety related response for boron as well.

Wheat is the third most important crop of Nepal with respect to area and production after rice and maize (MoAD, 2014). In 2014, area for wheat was 754474 ha with total production of 1883147 mt and productivity of 2496 kg/ha (MoAD, 2014). Wheat in Nepal is grown from 60-m in Terai where wheat follows rice (Paudel, 2011) and to the high hills and mountain up to 3335-m (Joshi *et al;* 2006). Bhatta, *et al* (2004) observed in mid hills of Nepal that one of major causes of sterility in wheat was due to deficiency of boron. It is very difficult to apply boron as basal application due to bulky product of boron and its location specific deficiency in the wheat growing areas in Nepal. Therefore, a cost effective method of boron application to the wheat was felt necessary to address the problem of wheat sterility due to born deficiency in the country. Most of the works related to boron application to wheat suggests a basal application of boron to correct the deficiency. In Nepal, wheat is mostly grown in the rugged hilly terrace where due to leaching and intensive cropping system there is a sporadic deficiency of nutrients including boron which has economic limitation in one hand and on the other hand commercial availability of boron for basal application is not readily accessible in a country like Nepal. It necessities that seed dressing of boron in various forms such as dust and slurry could be economically viable alternatives to address boron deficiency on wheat. There is a dearth of such study in Nepal. Hence, this study was conducted to address the issue of boron deficiency in Nepal thereby wheat productivity could be enhanced without substantially increasing cost of cultivation of wheat production.

Materials and methods

Poly bag and field experiment were conducted in the main season (Nov/Dec 2012 and Feb/Mar 2013) wheat planting at Khumaltar in altitude of 1368-m, longitude of 85^0 20’ E, and latitude of 27^0 40’ N. Seed quality analysis was performed to understand quality standard of seed for treatments under study. Black poly bag of 20 cm dia and 60 cm height were used. Soils from the Agronomy Farm, Khumaltar, was filled in the poly bag leaving 20 cm height unfilled to irrigate the bag thereby soil in the bag is not washed out. Most popular wheat variety for mid hills WK-1204 was selected for the purpose. Wheat was planted on 25th November 2012 both on poly bag and in the Agronomy Farm, Khumaltar. For field planting, row spacing of 25-cm in continuous planting was done whereas for poly bag, 10 seeds per poly bag was planted. Fertilizer dose of 100:50:20 N, P_20_5 and K_20 from di-ammonium phosphate (18:46%), urea (46%) and muriate of potash (60%), respectively, was applied. Half dose of N and full dose of P_20_5 and K_20 was applied as basal dose and remaining half dose of N was top dressed at dough stage of the crop. There were three replications with 9 treatments in both field and poly bag experiments randomized within each block. For field 1-m^2 plot for each treatment was maintained to record agronomic and phelogic data. The treatments consist of the following:

Treatment details

T_1 : 2.5 g/kg boron dust = 300 g boron per ha = 2.2 g sodium borate decahydrate per 100 g Seed

T_2 : 5 g/kg boron dust = 600 g boron per ha = 4.4 g sodium borate decahydrate per 100 g Seed

T_3 : 7.5 g/kg boron dust = 900 g boron per ha = 6.6 g sodium borate decahydrate per 100 g Seed

T_4 : 10 g/kg boron dust = 1200 g boron per ha = 8.8 g sodium borate decahydrate per 100 g Seed

T_5 : 2.5 g/kg boron slurry = 2.2 g sodium borate decahydrate per 100 g Seed

T_6 : 5 g/kg boron slurry = 4.4 g sodium borate decahydrate per 100 g Seed

T_7 : 7.5 g/kg boron slurry = 6.6 g sodium borate decahydrate per 100 g Seed

T_8 : 10 g/kg boron slurry = 8.8 g sodium borate decahydrate per 100 g Seed

T_9 : Boron Basal Dose (1 kg a.i./ha) = 9 g sodium borate decahydrate/plot (i.e., for 1 m^2 plot)

Intercultural operation consisting of weeding and irrigation was performed for field experiment as and when necessary while for poly bag experiment on the basis of availability of moisture irrigation was given from sowing to maturity stage. Same set of seed treated lots of seed was analyzed on seed lab to know the effect of boron treatment on wheat seed both dust and slurry. Lab analysis for boron treated seed of wheat was done for seed testing attributes such as percentage of germination, fresh seed and diseased seed and rlength of root and shoot. Sodium borate decahydrate (Borex), commercial form of boron, available in the market that contained 11.34% elementary boron, was used for the experiments. This chemical was used as dust, slurry (making paste like structure mixing with water) and actual ingredient (a.i.) for treating wheat seed before planting and basal application of boron in the plot before planting wheat in the field. Agronomic and yield attributes of wheat were recorded from the poly bag and experiment plot in standard way as suggested by the International Centre for Wheat and Maize (CIMMYT), Mexico and National Wheat Improvement Program (NWIP), Bhirahawa, Nepal. Laboratory analysis of seed was done in the Seed Science Technology Division, Khumaltar. Recorded data were analysed by using SPSS software version 13.0.

Result and discussion

Statistical analysis of grain yield and yield related traits of wheat under poly bag study, field study and lab analysis of boron dust and slurry treated seed revealed that there was no significant difference of those traits except interaction between poly bag plant height x replication (Table1). This suggest that attributes such percentage of field germination and leaf chlorophyll content, LAI, root and shoot length, plant population, plant height and grain yield irrespective of poly bag, field experiment and lab analysis for wheat variety WK-1204 were not affected by the effect of seed treatment with boron dust and slurry in various compositions (Table 1 and Table 2).

Table 1. Combined ANOVA as affected by interaction between different attributes * replication of wheat variety WK-1204 for boron treated experiments, Khumaltar, Nepal

Interaction Sources of variation	level	Sum of Squares	DF	Mean Square	F profanity level	Significant level
Field germination*replication	Between (Combined) Groups	1,138.89	3	379.63	0.74	0.54
	Within Groups	14,861.11	29	512.45		
	Total	16,000.00	32			
Poly plant height*replication	Between (Combined) Groups	495.38	3	165.13	4.38	0.01
	Within Groups	1,092.87	29	37.69		
	Total	1,588.24	32			
Poly chlorophyll*replication	Between (Combined) Groups	17.31	3	5.77	0.96	0.43
	Within Groups	175.24	29	6.04		
	Total	192.55	32			
Poly LAI * replication	Between (Combined) Groups	0.20	3	0.07	0.96	0.43
	Within Groups	1.97	29	0.07		
	Total	2.16	32			
Poly root length*replication	Between (Combined) Groups	480.17	3	160.06	2.70	0.06

Interaction level Sources of variation		Sum of Squares	DF	Mean Square	F profanity level	Significant level
	Within Groups	1,716.19	29	59.18		
	Total	2,196.36	32			
Lab root length*replication	Between (Combined) Groups	0.69	3	0.23	0.01	1.00
	Within Groups	916.01	32	28.63		
	Total	916.70	35			
Lab shoot length*replication	Between (Combined) Groups	1.44	3	0.48	0.08	0.97
	Within Groups	195.99	32	6.12		
	Total	197.43	35			
Field plant population*replication	Between (Combined) Groups	2,818.67	2	1,409.33	0.25	0.78
	Within Groups	136,278.00	24	5,678.25		
	Total	139,096.67	26			
Field plant height *replication	Between (Combined) Groups	32.66	2	16.33	0.95	0.40
	Within Groups	412.84	24	17.20		
	Total	445.50	26			
Field chlorophyll *replication	Between (Combined) Groups	2.17	2	1.09	0.29	0.75
	Within Groups	89.00	24	3.71		
	Total	91.17	26			
Field LAI * replication	Between (Combined) Groups	0.35	2	0.18	0.95	0.40
	Within Groups	4.44	24	0.19		
	Total	4.79	26			
Field grain yield g/m^2 * replication	Between (Combined) Groups	54,521.94	2	27,260.97	0.73	0.49
	Within Groups	901,542.56	24	37,564.27		
	Total	956,064.50	26			

Table 2. ANOVA for grain yield and yield attributes of wheat variety WK-1204 for boron treated field experiment, Khumaltar, Nepal

Attributes/ Source of variation		Sum of Squares	DF	Mean Square	F value	Significant level
Plant population/m^2	Between Groups	2818.667	2	1409.333	0.248	0.782
	Within Groups	136278.000	24	5678.250		
	Total	139096.667	26			
Plant height (cm)	Between Groups	32.661	2	16.330	0.949	0.401
	Within Groups	412.836	24	17.201		
	Total	445.496	26			
Leaf chlorophyll content (%)	Between Groups	2.172	2	1.086	0.293	0.749
	Within Groups	88.997	24	3.708		
	Total	91.169	26			
Leaf area index	Between Groups	.351	2	.175	0.948	0.402
	Within Groups	4.443	24	.185		
	Total	4.794	26			
Grain yield gram /m^2	Between Groups	54521.937	2	27260.969	0.726	0.494
	Within Groups	901542.564	24	37564.274		
	Total	956064.502	26			

Bivariate correlation of grain yield and agronomic traits for field experiment indicated that the relationship between plant height x plant population, LAI x plant population, and grain yield x plant population, LAI x plant height were positively highly significant whereas relationship between grain yield x LAI was positively significant (Table 3). Contrary to this the relationship between percentage leaf chlorophyll content x plant population, plant height, LAI, and grain yield/m^2 were negatively related (Table 3). The study exhibited that seed dressing of wheat with boron dust and slurry in different combinations could result highly positive and negative (not significant) relationship on grain yield and agronomic traits of wheat variety WK-1204 under study.

Table 3. Bivariate correlation coefficient for grain yield and yield attributes of wheat variety WK-1204 under boron treated field experiment, Khumaltar, Nepal (N=27)

Attributes	**Plant population/ m^2**	**Plant height (cm)**	**Leaf chlorophyll Content (%)**	**Leaf area Index**	**Grain yield gram /m^2**
Plant population/m^2	1.0				
Plant height (cm)	0.778(**)	1.0			
Leaf chlorophyll content (%)	-0.021	-0.201	1.0		
Leaf area index	0.670(**)	0.498(**)	-0.024	1.0	
Grain yield gram /m^2	0.860(**)	0.811(**)	-0.108	0.484(*)	1.0

Seed dressing with boron dust at 2.2 to 8.8 g/100 seed showed that plant population /m^2 indicating effectiveness of boron seed dressing in the field study (Fig. 1). For those treatments of T1 to T4 plant population and plant height also followed same pattern as that of grain yield of highly significant indicating that seed dressing of boron for wheat seed was effective compared to seed dressing with boron slurry with respect to these traits. Percentage of leaf chlorophyll content was not affected due to the effect of wheat seed treatment with boron dust and slurry. Basal application of boron was inferior to seed dressing with dust affecting these traits under study. Therefore, it is obvious that seed treatment of wheat with boron dust at 2.2 to 8.8 g/100 seed was found effective than that of seed treatment with boron slurry and basal application of boron to correct boron deficiency in the wheat under Khumaltar condition, Nepal.

Treatment details

T1:Seed trearment@2.2 g sodium borate decahydrate (SBDH) /100 g seed

T_2 : Seed treatment @4.4 g SBDH /100 g Seed

T_3 : Seed treatment @6.6 g SBDH/100 g Seed

T_4 : Seed treatment @8.8 g SBDH/ 100 g Seed

T_5 :Seed treatment @ 2.2 g sodium borate decahydrate slurry (SBDHS)/ 100 g Seed

T_6 : Seed treatment @4.4 g SBDHS/ 100 g Seed

T_7 : Seed treatment @6.6 g SBDHS/ 100 g Seed

T_8 : Seed treatment @8.8 g SBDHS/ 100 g Seed

T_9 : Basal application of SBDH @1 kg a.i./ha

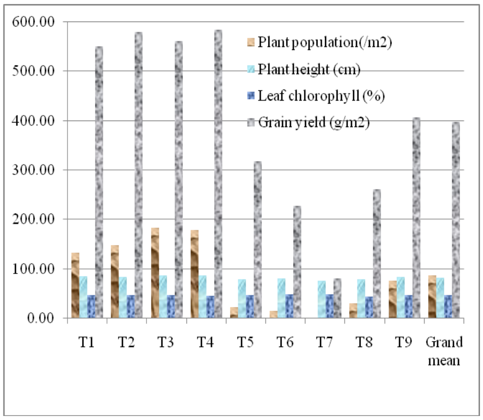

Fig. 1 Grain yield and yield attributes of wheat variety WK-1204 as affected by different seed treatment procedure of boron at Agronoy Farm, Khumaltar

Laboratory analysis of root, length, shoot length and percent germination of wheat seed treated with boron duct at 2.2 to 8.8 g/100 seed of WK-1204 vareiety of wheat exhibited high response of these attributes compared to boronn slurry treateed seed and basal apllicaaion of boron in the study (Fig.2). This pattern was consistent with the field study for for germination as indicated in the fiedl experiment (Fig.1). From lab and field study of seed treatment with boron dust it is inferred that seed treatment with boron dust is superior over seed treatment with boron slurry and basal apllication of boron from the the sodium borate decahydrate containing 11.34% elemental boron.

Treatment details

T1:Seed trearment@2.2 g sodium borate decahydrate (SBDH) /100 g seed

T_2 : Seed treatment @4.4 g SBDH /100 g Seed

T_3 : Seed treatment @6.6 g SBDH/100 g Seed

T_4 : Seed treatment @8.8 g SBDH/ 100 g Seed

T_5 :Seed treatment @ 2.2 g sodium borate decahydrate slurry (SBDHS)/ 100 g Seed

T_6 : Seed treatment @4.4 g SBDHS/ 100 g Seed

T_7 : Seed treatment @6.6 g SBDHS/ 100 g Seed

T_8 : Seed treatment @8.8 g SBDHS/ 100 g Seed

T_9 : Basal application of SBDH @1 kg a.i./ha

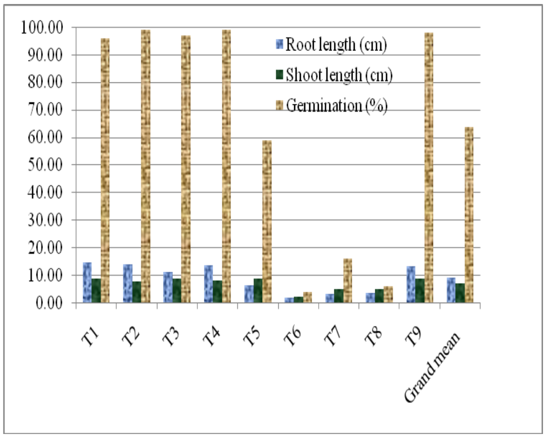

Fig. 2 Laboratory analysis of wheat seed WK-1204 as affected by different seed treatment procedure of boron at Khumaltar

Same pattern of enhanced in the percentage of germination and leaf chlorophyll content, and increased in plant height and root length was obseerd for seed dressing with boron dust ranging from 2.2 to 8.8 g/100 seed for wheat variety WK-1204 under poly bag study (Fig. 3). From field study, lab analysis and poly bag study of seed dressing with boron dust and slurry and basal apllication in the field it could be anecdotal that boron deficiency in wheat could be corrected through seed dressing of boron at 2.2 to 8.8 g/100 seed of wheat. This amount of boron for seed dressing is remarkebly superior over same quantity of slurry for seed treatment and basal application of boron at 1.0 kg a.i. per hectare.

Inhibition of germination, root and shoot length, LAI and grain yield of wheat with seed treated with boron slurry could be be the result of toxicity of born to the embroyo due to its high moisture and immediate contact of seed with boron that is intact with seed coat compared to dust aplication of born for seed dressing. Another reason for negative effect of boron slurry for seed treatment of wheat could be the direct contact of boron with root, shoot and seed compared to boron dust which could be available to the wheat plant in later stages of growth when wheat plant could absorb boron as it passes to late vagetative and reproductive phase in which there could be high demand of boron from the plant as well.

Treatment details

T1:Seed trearment@2.2 g sodium borate decahydrate (SBDH) /100 g seed
T_2 : Seed treatment @4.4 g SBDH /100 g Seed
T_3 : Seed treatment @6.6 g SBDH/100 g Seed
T_4 : Seed treatment @8.8 g SBDH/ 100 g Seed
T_5 :Seed treatment @ 2.2 g sodium borate decahydrate slurry (SBDHS)/ 100 g Seed
T_6 : Seed treatment @4.4 g SBDHS/ 100 g Seed
T_7 : Seed treatment @6.6 g SBDHS/ 100 g Seed
T_8 : Seed treatment @8.8 g SBDHS/ 100 g Seed
T_9 : Basal application of SBDH @1 kg a.i./ha

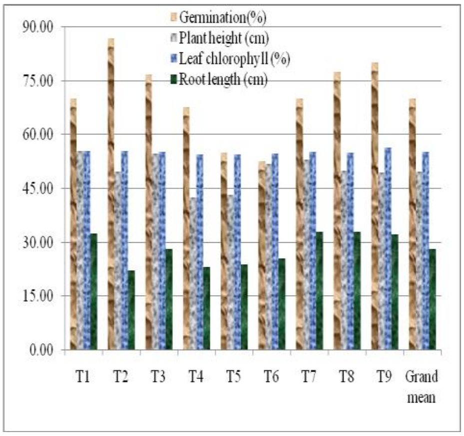

Fig. 3 Agronomic attributes of wheat variety WK-1204 as affected by different seed treatment procedure of boron under poly bag experiment at Khumaltar

Results obtained from these experiments showed that contribution of boron on grain yield and yield related attributes of wheat could be partly explained by the use of boron despite the fact that grain yield is a complex character that results from contribution of several plant parameters. Grain yield and yield related parameter of wheat are interrupted by boron deficiency and it is possible to overcome this problem by the application of B to the soil (Debnath, *et al;* 2011). There are cases that B deficiency in wheat and other crops could be corrected by seed dressing. However, despite the many methods applied to correct micronutrient deficiency in the soil and foliar application is one of the most prevalent methods of micronutrient correction. The cost involved and difficulty in obtaining high quality micronutrient fertilizers are major concerns in developing countries for poor farmers (Farooq *et al;* 2012). Rahman *et al* (2014) have reported seed priming with micronutrient in different concentration were attractive and easy alternatives to address micronutrient deficiency for chickpea. They have tested different concentration of boron and molybdenum for seed priming of chick pea in Bangladesh and found that seed treatment with 2.0 g B and 1.0 g Mo along with 40-30-40-20- 0. 2 kg N-P-K-S and Zn/ha gave higher seed yield of 119.6 kg/ha and 96% germination of chick pea in the study. In Pakistan, contrary to this finding, seed priming with boron solution (1, 1.5 and 2%) inhibited the germination of carrot seed whereas same percentage of solution of seed priming with Zn and Mn induced the highest emergence percentage, vigor index and highest mean shoot and root length of the carrot in the study (Muneeb *et al;* 20113). Therefore, seed priming for micro nutrients depends upon types of crops and concentration of micro nutrient. Our finding supports the enhanced grain yield and agronomic attributes of wheat when seed dressing was done with different concentration of boron dust. In Chaing Mai, Thailand, study revealed that the effect of B was by far the largest on grain set of wheat (Rarkasem *et al;* 1994).

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