Int.J.Curr.Microbiol.App.Sci (2018) *7*(12): 1133-1140

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 12 (2018)**
Journal homepage: http://www.ijcmas.com

EXCELLENT PUBLISHERS

Original Research Article https://doi.org/10.20546/ijcmas.2018.712.139

Effect of Boron and Lime on Yield assessment of Wheat (*Triticum aestivum L.*)

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Keywords

Wheat, Lime, Boron, Seed treatment, Soil treatment

Article Info

Accepted:
10 November 2018
Available Online:
10 December 2018

A B S T R A C T

Wheat (*Triticum aestivum L.*) production is often affected due to micronutrient status in soil. Micronutrient deficiency in soil including Boron is very much prominent in India, due to prevalent environmental and soil conditions (viz., wide variation in soil pH, organic matter, salt stress, supply of micronutrients etc.) among the various methods of incorporating micronutrients into the soil system, seed treatment with seed priming and seed coating are attractive, easy cost effective and beneficial over the soil and foliar application. A field experiment was conducted with wheat (Cv. K1009) over two years (2014-15 and 2015-16) during *Rabi* season in an acid soil of *Terai* region of West Bengal. Liming material was applied to attain an optimum pH for the growth of the crop. Full dose and half dose of boron as seed treatment and soil application was applied. Combined effect of lime and B (through soil application and seed treatment) was assessed on yield of wheat. The highest yield (5.37 t ha^{-1}) was obtained under seed treatment (T_9) over soil treatment (4.7 t ha^{-1} at T_9) after the combined effect of full dose of lime and boron with uniform application of N, P and K. The performance under seed treatment was better compare to the soil application in terms of yield of wheat.

Introduction

Wheat (*Triticum aestivum L.*) is one of the important cereals and India is considered as the third largest producer of wheat in the world with the production of 86,530 thousand mt (FAS; USDA, 2016). But deficiency of micronutrients are wide spread in many Asian countries including India due to wide variation in soil pH, low organic matter, salt stress, prolonged drought, imbalanced NPK fertilizers and supply of micronutrient (Nadrim *et al.*, 2012).

Under the present study, wheat was grown on moderately acidic soil having pH 4.5-5.5 (due to excessive leaching) i.e. *Terai* soil of West Bengal. In this region alluvial-acid soil and marshy acid soil are found which are under cultivation. The rice-wheat system is the most important cropping pattern in this region and considered to be the major determinant factor of the agriculture-based economy. The management of an acid soil is required for improving the potential of the soil for higher yield and productivity of the crops. Under the ICAR Network Project (Panda *et al.*, 2012) different crops and effect of liming material were studied and found that liming alone increased the yields of different crops by 14-52% in which the increase production of wheat (52%) in West Bengal has been marked followed by Mustard (35%).

Among the various cereal crops, wheat is considered to have low requirement for B and is less sensitive for its deficiency. Besides this, its deficiency hamper its nutritional value. Wheat suffers from the nutritional disorders and has been reported from different parts of the world including South Asian countries like India and Pakistan (Rashid *et al.*, 1996, Sharrocks, 1997, Rerkasem and Jamjod, 2004). Hence, B fertilization is the simple and cost effective solution to the problem.

Various methods of the incorporation of the micronutrients are known, of which soil and foliar application are more common. Now-a-days, seed treatment techniques with micronutrients comprising seed priming and seed coating are attractive, easy and cost effective over other application technique (Farooq *et al.*, 2012). Based on the above perspectives, the present study was undertaken 1) to assess the individual and combined effect of lime and boron on wheat.2) to study the methods of application of boron on the potential yield of wheat.

Materials and Methods

Experimental site

A field experiment was carried out at the agricultural farm of Uttar Banga KrishiViswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. The farm is located within the *Terai* Agro-climatic zone and its geographic location is 26º19'86" N latitude and 89º23'53" E longitude**.** The elevation of the farm is 43 meters above the mean sea level. The field experiment with different treatments (Table 1) was carried out in the same field during the winter season (*Rabi* season) of 2014-15 and 2015-16.The local topography of the study area is almost flat with good drainage facilities. Before laying out the experimental plots, a set of surface soil samples were collected over the whole experimental area, composite together and tested in the laboratory following the standard methods. The measured physico-chemical properties (Table 2) were analysed by the standard method (Jackson, 1967) used as the baseline measurement for the experimental plots.

Experimental designs and treatments

A set of fifty four experimental plots (4 m × 3 m) were laid out following randomized block design (RBD) for this experiment and nine treatments combinations (Table 1) with three replications were developed for seed as well as the soil treatment. Treatment T_1 (L_0B_0) was control receiving recommended dose of N,P and K without application of lime and boron and T_2 to T_9 received recommended doses of N, P, and K, and lime and boron having different doses. The composite soil samples from the experimental site were collected and analyzed before the start of the field experiment. Nitrogen (N @100 kgha^{-1}), phosphorus (P_2O_5@60 kgha^{-1}) and potassium (K_2O @40 kgha^{-1}), in the form of urea, single super phosphate, Murate of potash; B as boric acid (0.5% as full dose and 0.25% as half dose) were applied as seed treatment (soaking of seed in boric acid solution for 10-12 hrs then sun dried) and in other case the treatments of B as borax(10kg ha^{-1} as full dose and 5 kg ha^{-1} as half dose) were applied to the soil. Similarly full and half doses of lime, i.e., 4.2 tons ha^{-1} and 2.1tons ha^{-1} were applied to the soil prior to 15 days of sowing to manage the acidity of soil. Full dose of P, K and half of the recommended dose of N were applied as basal and incorporated into the soil. The remaining half of the recommended dose of N was applied as top dressing at 21 days after sowing (DAS), after completion of the first weeding.

Agronomic observations

The wheat variety of K- 1009 was used for this experiment at the seed rate of 100 kg ha^{-1}. Sowing was completed in rows (spacing 23 cm) in North South direction using a duck-foot tyne at a depth of 2.5 to 3 cm. The height (from ground level) of five randomly selected plants were recorded and averaged from each plot. The crop was harvested from net plot area discarding the border row and final yield of wheat and straw was recorded after sun drying and thrashing. The yields were recorded and harvest index i.e. [(Economic Yield/Biological Yield) ×100] of the crop was calculated. Soil samples initially collected were tested for important pH, EC, oxidisable organic carbon, textural classes, available- N, available- P and available- K and available B by the standard methods (Jackson, 1967).

Statistical analysis

The statistical analysis for the collected data was done by employing the GEN STAT (Version -11.10.1504). The significant difference between the treatments was tested using ANOVA and LSD. The interaction between the effect of B and lime was tested using two-way ANOVA.

Results and Discussion

The important physico-chemical properties (Table 2) of the soils collected from the plots, where boron - treated seeds were sown and those with soil application were determined by the standard methods. In both the cases, the soils were acidic (pH from 5.2 – 5.8) in reaction and non-saline in nature. The soils were sandy loam in texture having oxidisable organic carbon ranging from 0.68 – 0.78%. The native nutrient (N-P-K) status is somewhat low. The extractable-boron (kg ha^{-1}) ranged from 0.72 – 0.78 in soils.

Table.1 Details of treatment combination used during field trial

A. The plots having the seeds treated with Boron as Boric acid

Treatments	Doses
T_1	Control (L_0B_0)
T_2	NPK+ No Lime +Half boron (L_0BH)
T_3	NPK+ No Lime + Full boron (L_0BF)
T_4	NPK+ Half lime+ No boron (L_H B_0)
T_5	NPK+ Half lime+ Half boron (L_HB_H)
T_6	NPK+ Half lime + Full boron (L_HB_F)
T_7	NPK+ Full lime+ No boron (L_FB_0)
T_8	NPK+ Full lime+ Half boron (L_F B_H)
T_9	NPK+ Full lime +Full boron (L_F B_F)

where, L_0B_H= No lime and Boron as 0.25%; L_0B_F=No lime and Boron as 0.5%; L_HB_0= Lime as 2.1 tons ha^{-1} and No boron; L_HB_H= Lime as 2.1 tons ha^{-1} and Boron as 0.25%; L_HB_F = Lime as 2.1 tons ha^{-1} and Boron as 0.5%; L_FB_0= Lime as 4.2 tons ha^{-1} and No Boron; L_F B_H= Lime as 4.2 tons ha^{-1} and Boron as 0.25%; L_F B_F = Lime as 4.2 tons ha^{-1} and boron as 0.5% of Boric acid solution

B. The plots with soil application of Boron as Borax

Treatments	Doses
T_1	Control (L_0B_0)
T_2	NPK+ No Lime +Half boron (L_0B_H)
T_3	NPK+ No Lime + Full boron (L_0B_F)
T_4	NPK+ Half lime+ No boron (L_H B_0)
T_5	NPK+ Half lime+ Half boron (L_HB_H)
T_6	NPK+ Half lime + Full boron (L_HB_F)
T_7	NPK+ Full lime+ No boron (L_FB_0)
T_8	NPK+ Full lime+ Half boron (L_F B_H)
T_9	NPK+ Full lime +Full boron (L_F B_F)
where, L_0B_H= No lime and Borax as 5 kg ha^{-1}; L_0B_F=No lime and Borax as 10 kg ha^{-1}; L_HB_0= Lime as 2.1 tons ha^{-1} and No boron; L_HB_H= Lime as 2.1 tons ha^{-1} and Borax as 5 kg ha^{-1}; L_HB_F = Lime as 2.1 tons ha^{-1} and Borax as 10 kg ha^{-1}; L_FB_0= Lime as 4.2 tons ha^{-1} and No Boron; L_F B_H= Lime as 4.2 tons ha^{-1} and Borax 5 kg ha^{-1}; L_F B_F = Lime as 4.2 tons ha^{-1} and Borax as 10 kg ha^{-1}	
N: P:K = 100:60:40 kg ha-1as Recommended dose (RD) **Lime = 4.2 tons ha-1 as full dose and 2.1 tons ha-1 as half dose** **Boric acid = 0.5 % as full dose and 0.25% as half dose (for seed treatment)** **Borax = 10 kg ha-1 as full dose and 5 kg ha-1 as half dose (for soil application)**	

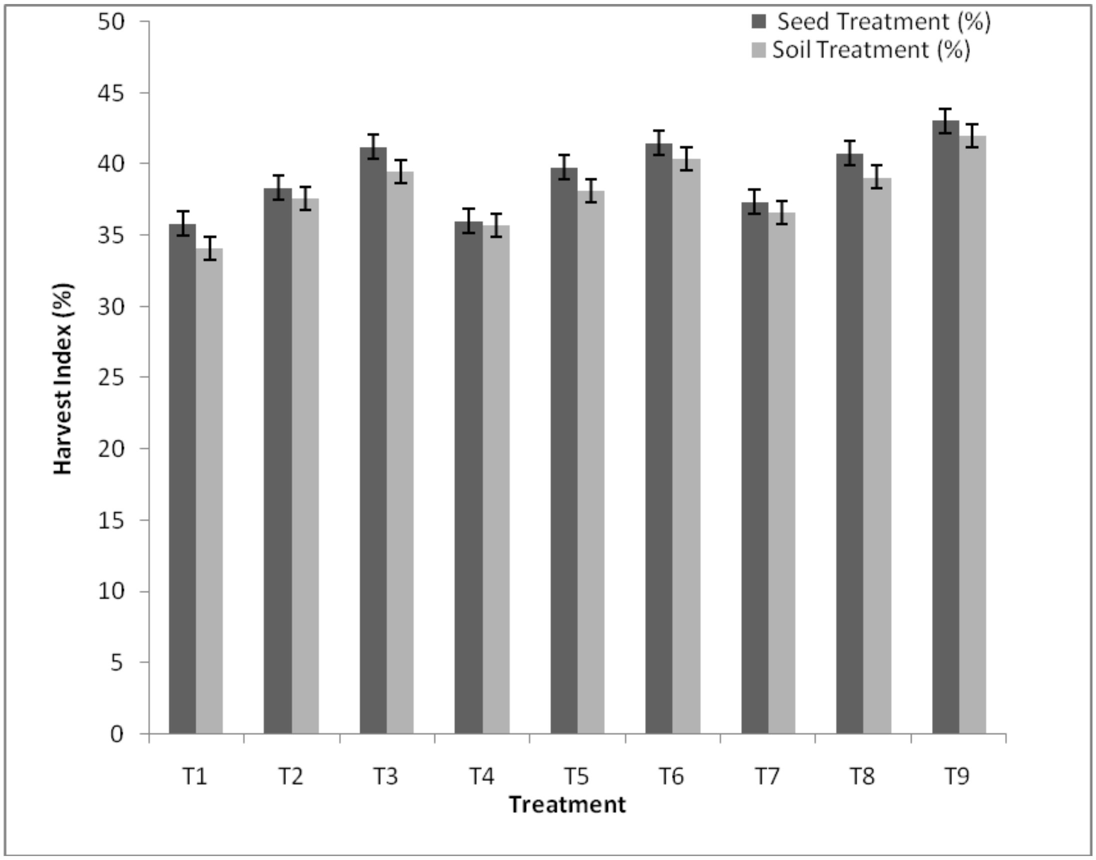
Table.2 Physico-chemical properties of soil collected from the different plots under seed treatment and soil application of boron

Parameters	Seed Treatment	Soil Treatment
pH (soil: water suspension) **pH SMP buffer**	5.2 5.8	5.3 5.6
EC (dSm^{-1})	0.17	0.19
Sand (%)	52.62	50.32
Silt (%)	28.18	26.14
Clay (%)	19.20	15.62
Organic carbon (%)	0.78	0.68
Nitrogen (kg ha^{-1})	162	157
Phosphorus(kg ha^{-1})	9.8	10.5
Potassium (kg ha^{-1})	80	78.5
Boron (kg ha^{-1})	0.78	0.72

Table.3 Biometric parameters of wheat under seed treatment and soil treatment

Treatments		Seed Treatment					Soil Treatment				
		Plant height (cm)	Grains per spike	Test weight (gm)	Straw yield (t ha^{1})	Grain yield (t ha^{-1})	Plant (cm height)	Grains per spike	Test weight (gm)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
T_1		89.3	32	13.43	3.40	1.90	81.45	31	12.59	3.85	1.99
T_2		94.7	40	17.68	5.90	3.67	87.95	37	17.55	5.50	3.32
T_3		97.5	46	21.28	6.50	4.56	91.85	43	19.14	6.32	4.12
T_4		92.2	35	15.40	4.80	2.70	83.90	33	15.96	4.78	2.66
T_5		95.6	42	18.93	6.20	4.10	89.65	39	18.14	5.60	3.45
T_6		98.6	49	22.76	6.90	4.89	95.90	46	19.89	6.50	4.41
T_7		93.9	37	16.56	5.20	3.10	85.15	34	16.62	5.30	3.06
T_8		97.0	44	19.97	6.40	4.40	90.80	41	18.78	6.30	4.04
T_9		103.1	52	24.93	7.10	5.37	99.05	48	20.76	6.60	4.78
Average		95.8	41.8	18.99	5.82	3.88	89.5	39.1	17.71	5.6	3.53
Lime	S.E.	0.4	0.3	0.3	0.01	0.03	0.1	0.2	0.1	0.1	0.05
	LSD	1.3	0.8	0.9	0.05	0.08	0.4	0.7	0.3	0.3	0.2
Boron	S.E	0.4	0.3	0.3	0.02	0.03	0.1	0.2	0.1	0.1	0.05
	LSD	1.3	0.8	0.9	0.05	0.08	0.4	0.7	0.3	0.3	0.2
Lime × Boron	S.E	0.7	0.5	0.5	0.03	0.05	0.2	0.4	0.2	0.2	0.09
	LSD	2.2	1.4	1.5	0.09	0.12	0.7	1.3	0.5	0.5	0.3

Figure.1 Harvest index (%) of crops under seed treatment and soil treatment. Error bars indicate the standard deviation (S.D.) at 5% level of significance



It was observed that (Table 3), there were variations in the agronomic parameters of wheat with the treatment combination. The maximum plant height (103.1 cm), the number of grains per spikelet (52) and test weight (24.93 g) were at the treatment T_9 where the seed was treated with a full dose of boron. This was again reflected by the maximum (5.37 tha^{-1}) of grain and straw (7.10 t ha^{-1}) yield at T_9 where there was a full application of nutrients.

The similar trend was observed in the biometric observation of wheat under soil-treated plots. The maximum straw yield (6.60 t ha^{-1}) and grains yield (4.78 t ha^{-1}) were observed at T_9 and the least at T_1 (3.85t ha^{-1}) (untreated control).

It was also observed that boron application along with basal dose of NPK significantly increased the wheat yield. The harvest index (Figure 1) varied from 35.85 to 43.05 under the seed- treated plots while that from 34.10 – 42 in the soil- treated plots. In both the cases, the maximum harvest index was at the treatment T_9 and least and T_1.

Kamaruzzaman *et al.*, (2013) studied that the application of 0.5 t lime ha^{-1} significantly increased most of the growth parameters of wheat compared to that without any lime application It was found that highest yield and yield components of wheat were recorded from recommended fertilizers+ lime + B + Mg treated plots and the lowest was recorded in control plot. Saric and Saciragic, (1969) reported that in oats (*Avena sativa L.*) seed priming with B (0.02% solution of H_3BO_3) had no marked effect on seed germination, yet tillering, panicle length and grain weight were increased by seed priming with B contributing to a grain yield increase of 8.42% compared with untreated seeds. Mandal *et al.,* (2007) observed that the use of boron produced the highest grain yield due to maximum number of grains spike while significant positive interaction between fertilizer treatments and physiological stages of wheat growth. During one of the experiment by Osundwa *et al.,* (2013), it was revealed that different characters of wheat viz. plant height, tillers plant^{-1}, spike length, grains sipke^{-1} and grain yield were significantly increased by the application of lime. In a study, it was found that amendment of soil acidity with lime addition, increased grain yield significantly (p=0.05) in Chepkoilel and Kipsangui area of Kenya and the lowest grain yield were found on control treatment. Mc Donald (2000) observed that the performance of the seeds was relatively better to the soil application, might be due to the faster germination for the partially hydrated seed allowing metabolic events and less imbibition time which might have some effects as reported by Farooq *et al.,* (2012) for an improved nutrient supply. Significant yield differences were there in between the treatments (Table 3). It was apparent both under the seed- treated and soil-treated plots that higher doses of boron and lime had their role to play in increasing the biometric parameters of wheat, resulting in the higher yield of the crop under the acidic soil condition.

From the harvest index (Figure 1), it was apparent that the application of lime and boron had the significant role to play in maximizing the yield of wheat under acid soils. This was also reported by Nardim *et al.,* (2011) that the requirement of B in wheat during the vegetative stage leading to a high response to the grain yield. Since boron is responsible for the translocation of food materials in plants therefore it played vital role in grain setting as well as higher number of grains in wheat. Biswas *et al.,* (2015) also found that there was significant effect of boron on grain and straw yield of wheat. Tahir *et al.,* (2009) in a study observed that Harvest Index was significantly affected by the application of Boron. Hence, application of lime and boron had the significant role to play in maximizing the yield of wheat under acid soils.

The maximum grain yield was observed in the treatment T_9 (NPK+ full lime+ full boron)while minimum at the untreated control T_1under seed treatment of boron over that of the soil application of boron in which maximum yield was also observed in the treatment T_9 (NPK+ full lime+ full boron) while minimum at the untreated control. This may be due to some interaction between Lime and Boron for nutrient uptake by seeds. Hence, absorption of the Boron by the wheat seed at a definite concentration may play a significant role towards the yield. Liming in acid soil can facilitate the process of establishing the crops for the better effect of the application of boron in soils.

Acknowledgements

We especially thank Uttar Banga Krishi Vishwavidalya (UBKV), Pundibari, West Bengal, India, for providing the logistics for this work and Mr. Anarul Hoque, RRS, Terai zone, UBKV, for assistance during field trial and laboratory analysis.

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How to cite this article:

Princy Thakur and Dibyendu Mukhopadhyay. 2018. Effect of Boron and Lime on Yield assessment of Wheat (*Triticum aestivum L*.). *Int.J.Curr.Microbiol.App.Sci.* 7(12): 1133-1140.
doi: https://doi.org/10.20546/ijcmas.2018.712.139