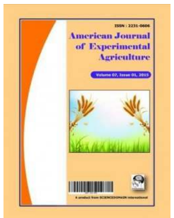

American Journal of Experimental Agriculture
12(2): 1-8, 2016, Article no.AJEA.24286
ISSN: 2231-0606

SCIENCEDOMAIN *international*
www.sciencedomain.org

Effects of Foliar Application of Boron (B) on the Grain Set and Yield of Wheat (*Triticum aestivum* L.)

O. A. Fakir[1*], M. A. Rahman[1] and M. Jahiruddin[2]

[1]ARS, Bangladesh Agricultural Research Institute, Satkhira, Bangladesh.
[2]Department of Soil Science, Bangladesh Agriculture University, Mymensingh, Bangladesh.

Authors' contributions

This work was carried out in collaboration between all authors. Author OAF wrote the protocol, designed the study, executed the field experiment, performed the statistical analyses and wrote the first draft of the manuscript. Author MAR revised the protocol and helped to manage the analyses of the study. Author MJ supervised the experiment, managed the literature searches and revised the manuscript.

Article Information

DOI: 10.9734/AJEA/2016/24286
Editor(s):
(1) Masayuki Fujita, Department of Plant Sciences, Faculty of Agriculture, Kagawa University, Japan.
Reviewers:
(1) A. I. Afe, Kwara State University, Nigeria.
(2) Valeria Santos Cavalcante, Universidade Federal de Vicosa, Brazil.
Complete Peer review History: http://sciencedomain.org/review-history/14183

Original Research Article

Received 12th January 2016
Accepted 24th March 2016
Published 15th April 2016

ABSTRACT

Aims: The objective of this study was to evaluate the effect of foliar application of boron (B) on the grain set and yield of wheat (cv. Shatabdi).
Study Design: The experiment was designed with six boron treatments, arranged in a randomized complete block design (RCBD) with three replications.
Place and Duration of Study: The field trial was conducted at Bangladesh Agricultural University (BAU) farm, Mymensingh during 27 November 2010 to 24 March 2011.
Methodology: The B treatments were (i) B control, (ii) soil application of B, (iii) seed priming into boric acid solution, (iv) foliar spray of B at primordial stage of crop, (v) foliar spray of B at booting stage and (vi) foliar spray of B at primordial and booting stages. The rate of B for soil application was 1.5 kg B ha^{-1} from boric acid (17% B) and the rate for each foliar spray was 0.4% boric acid solution. Seed priming was done by soaking wheat seeds into 0.1% boric acid solution for 10 hours and then seeds were dried before sowing. Every plot received 115 kg N, 25 kg P, 75 kg K and 15 kg S per hectare from urea, TSP, MoP and gypsum, respectively.

**Corresponding author: E-mail: oliahmed317@gmail.com;*

Results: The treatment receiving foliar spray of B at both primordial and booting stages of the crop performed the highest yield (3630 kg ha^{-1}) which was statistically similar with the yield recorded with foliar spray of B at booting or primordial stage of crop and with soil application of B before crop (wheat) was sown; all the yields were significantly higher over the yield noted with seed priming or control treatment. The control treatment (no B application) had the lowest grain yield (2600 kg ha^{-1}) which was significantly lower than the yield observed with the seed priming treatment.

Conclusion: Wheat yield was affected due to grain set failure induced by boron deficiency and it was possible to overcome this element deficiency by soil application at 1.5 kg B ha^{-1} or foliar application of 0.4% boric acid solution at primordial or booting stage of crop.

Keywords: Boric acid; foliar spray; grain set; yield; wheat.

1. INTRODUCTION

Wheat in the world ranks first both in area and production and about the two-thirds people of the globe lives on wheat grains. In Bangladesh, wheat next to rice is the most important cereal crop. Unfortunately the yield of this crop is low in Bangladesh and also in many other Asian countries. Micronutrient deficiency, especially boron deficiency appears to be a major reason for it. Although micronutrients (iron, manganese, zinc, copper, boron, molybdenum, chlorine and nickel) are required in relatively smaller quantities, they are as important as macronutrients for optimal growth and development of plants. Boron deficiency is more common in dry land crops, as in mustard [1], wheat [2], maize [3] and chickpea [4]. This is because of impaired transport of B from soil solution to absorbing root surface during dry season. Boron is involved in flowering, fruiting, and seed formation of crops [5,6]. Boron deficiency can substantially reduce yield of wheat [7], chickpea [8] and lentil [9]. Boron deficiency depresses wheat yield primarily through grain set failure, caused by male sterility which is associated with poorly developed pollen and anthers [7]. Deficiency of boron causes severe reductions in crop yield, due to severe disturbances in B-involving uptake and transport processes [10,11], cell wall synthesis [12], cellular membrane functions [13], and phenol metabolism [14,15].

Cooke [16] suggests as general guidelines for B fertilization that when the hot water soluble B in soil is less than 0.5 mg kg^{-1}, deficiency is likely to occur and all crops are to be treated with B; when it is 0.5-1.0 mg kg^{-1}, deficiency may appear and insurance dressings are to be considered; when it is more than 1.0 mg kg^{-1}, deficiency is unlikely and B treatment is not necessary; and when it is 3-5 mg kg^{-1}, crops may be poisoned from excess B. Thus, boron fertilization needs a careful thought.

In fertilizer schedule an inclusion of B often decides the success and failure of the crops [17]. Efficiency of B application depends on the time and method of B application. Boron can be applied to the soil, foliar sprayed or added as seed treatments. Fertilizer application is usually done to soil before a crop is grown. Foliar application is done at later stages of crop growth when crop stands are already established; this method of B application has been found more effective in yield improvement and grain enrichment [8]. Seed treatment is another option of B application since less amount of nutrient is needed and it is easy to apply and seedling growth is improved [18]. Foliar spray of boron (1%) may produce satisfactory yield of wheat [19]. Tahir et al. [20] have reported a significantly higher wheat yield where boron was applied at booting stage compared to B application at tillering, jointing, and anthesis stages.

With the above understanding, a study was done to evaluate the effect of foliar application of boron on grain set and yield of wheat (*Triticum aestivum* L.).

2. MATERIALS AND METHODS

The experiment was carried out during 2010-2011 wheat season at Bangladesh Agricultural University (BAU) farm, Mymensingh. The experimental field is located at 24.75° N latitude and 90.50° E longitude at a height of 18m above the mean sea level. It was a medium high land and falls under the AEZ 9 (Old Brahmaputra Floodplain). The soil was Sonatala silt loam, a member of Aeric Haplaquept. It belongs to the order Inceptisol having only few horizons, developed under aquatic moisture regime. Physical and chemical characteristics of the soil are presented in Table 1.

Table 1. Physical and chemical characteristics of the soil

Characteristics	Content	Interpretation
Soil texture	Sand–20.4%, Silt – 68.0%, Clay – 11.6%	Silt loam
pH (soil: water = 1:2.5)	7.30	Near neutral
Organic matter (%)	0.81	Very low
Total N (%)	0.06	Low
Available P (mg kg^{-1})	7.29	Low
Available K (c mol kg^{-1})	0.06	Low
Available S (mg kg^{-1})	10.0	Low
Available Zn (mg kg^{-1})	0.84	Low
Available B (mg kg^{-1})	0.15	Low

There were six boron treatments, as follows:

T_1 = Control (no application of B)

T_2 = Soil application of 1.5 kg B ha^{-1} (designated as SA)

T_3 = Seed priming (wheat seed soaked in 0.1% boric acid solution for 10 hours before sowing -designated as SP)

T_4 = Foliar spray of 0.4% boric acid solution at primordial stage of crop growth (designated as FS-p)

T_5 = Foliar spray of 0.4% boric acid solution at booting stage of crop growth (designated as FS-b).

T_6=Foliar spray of 0.4% boric acid solution at primordial and booting stages (designated as FS-pb).

The treatments were distributed to the field following the principle of randomized complete block design (RCBD), with three replications. The crop variety was Shatabdi, developed by the Bangladesh Agricultural Research Institute (BARI). Fertilizers were applied to each plot as per treatments. Besides boron, every treatment received 115 kg N ha^{-1}, 25 kg P ha^{-1}, 75 kg K ha^{-1} and 15 kg S ha^{-1}. Fertilizers such as urea, TSP, MoP, gypsum and boric acid were used as sources for N, P, K, S, and B, respectively. One-third dose of urea and full dose of all other fertilizers were applied as basal to the individual plots during final land preparation. The second dose of urea was applied after 30 days of sowing (crown root stage) and the third split after 55 days (booting stage). For foliar spray treatments, boric acid solution was sprayed at 55 and 75 days after sowing to represent primordial and booting stages of crop, respectively.

Wheat was shown on 27 November 2010 and harvested on 24 March 2011. The cultural practices such as weeding and insecticide spray were done as and when required. Two irrigations were provided after 25 and 55 days of sowing. Weeding was twice done during the whole growth period, the one after 21 days of sowing and another after 50 days. The field was attacked by armyworm (*Mythumna separata*) which was successfully controlled by using Akonazol insecticide.

As evaluation of the treatment effects, data were collected in terms of grain set, grain yield and other plant characters viz. plant height, number of tillers $plant^{-1}$, spike length, number of spikelets $spike^{-1}$, 1000-grain weight and straw yield. These data were taken at harvest of the crop. Due attention was given to recording the grain set data since evaluation of grain set as influenced by boron was a prime objective of the present study. With this point of view, five plants were randomly collected from each plot and the number of grains $spike^{-1}$, 1000- grain weight and the number of spikelets $spike^{-1}$were noted. Other parameters viz. plant height, number of tillers $plant^{-1}$ and spike length were also recorded. The grain and straw yields were recorded on each plot.

The analysis of variance (ANOVA) for all the plant parameters was done following the principle of F-statistics. Mean comparison of the treatments were adjudged by the Duncan's Multiple Range Test [21]. Correlation statistics was performed to examine the interrelationship among the plant characters under study.

3. RESULTS AND DISCUSSION

Application of boron resulted in significant and positive effect on reproductive characters of wheat (cv. Shatabdi). These characters under study included number of spikelets $spike^{-1}$, number of grains $spike^{-1}$, 1000-grain weight and grain yield. There was no significant effect of boron application on other plant characters viz. plant height, number of tillers plant^{-1}, spike length and straw yield. However, the highest value was always observed for any boron treatment and the lowest value was noted for the control treatment (Tables 2 and 3).

Plant height of the crop varied from 90.2 – 97.1 cm over the boron treatments (Table 2). Although boron application had no significant influence on plant height, in value the highest plant height was noted for the T_4 treatment where B was supplied as foliar spray at primordial stage of the crop and the lowest plant height was for the T_1 treatment where B was not used. The number of tillers plant^{-1} varied within a narrow range, 2.83 – 3.60, the maximum tillers observed in T_2 (soil application of boron) and the minimum tillers in T_1 (B control) treatment (Table 2). Spike length of wheat also varied a little, showing a range of 9.10 – 9.84 cm across the treatments. Among the six treatments, the T_5 treatment (foliar spray of B at booting stage) produced the biggest spike and the T_1 (control) did the smallest (Table 2). The results are in agreement with several observations in the past. Mandal and Das [22] in India reported insignificant effect of added boron (10, 15 and 20 kg B ha^{-1} soil) on plant height and spike length of wheat. Abedin et al. [23] in Bangladesh also did not observe significant effect of B on plant height of wheat. It is assumed that boron application could have significant positive effect on these plant characters if the soil would be severely deficient in boron. The experimental field had 0.15 ppm B which is not very low in consideration of the 0.20 ppm B as the critical limit [24].

The number of spikelets spike^{-1} varied significantly with boron treatments, ranging from 15.4 – 17.2 (Table 3). Except T_3 (seed priming), all other treatments of boron application significantly produced higher number of spikelets spike^{-1} over control treatment (T_1). The highest number of spikelets spike^{-1} was observed with the treatment having foliar spray of boron at primordial stage (T_4) which was statistically similar to T_2 treatment (soil applied B).

Application of boron demonstrated a significant improvement in the number of grains spike^{-1} (Table 3). All foliar applied B treatments and also soil treatment of B produced significantly higher number of grains spike^{-1} over seed priming and control treatments. On the other hand, seed priming with boric acid solution produced higher number of grains spike^{-1}, compared to control. Such result, thus, indicates that grain unfilling in wheat occurs due to B deficiency and this problem can be overcome by boron application either to soil or to plant as foliar spray. Although seed soaking into boric acid solution was found to be a weak method of boron application compared to soil or foliar application, still it produced better result than control treatment.

The 1000-grain weight of wheat significantly increased due to boron treatments (Table 3). It varied from 44.5 recorded in control treatment to 54.7 observed in foliar spray of B at primordial and booting stages of the crop. Foliar application of B either at primordial or at booting stage produced statistically similar grain weight. The lowest 1000-grain weight was noted for B control treatment.

Table 2. Effects of different methods of boron application on plant height, tillers plant^{-1} and spike length of wheat (cv. Shatabdi)

Boron treatments	Plant height (cm)	Tillers plant^{-1} (no.)	Spike length (cm)
T_1: Control	90.2 a	2.83 a	9.10 a
T_2: SA	95.9 a	3.60 a	9.83 a
T_3: SP	93.8 a	3.06 a	9.54 a
T_4: FA-p	97.1 a	3.10 a	9.71 a
T_5: FA-b	94.1 a	3.16 a	9.84 a
T_6: FA-pb	93.8 a	3.23 a	9.41 a
Level of significance	NS	NS	NS
CV (%)	3.6	14.0	3.4
S.E. (±)	11.45	0.197	0.103

Values in a column having same letter do not differ significantly at 5% level by DMRT.
NS = Not significant, S.E = Standard error of means, CV = Coefficient of variation, SA = Soil application of 1.5 kg boron ha^{-1}; SP = Seed priming into 0.1% boric acid solution for 10 hours; FS-pb = Foliar spray of 0.4% boric acid solution at primordial and booting stages of crop

Table 3. Effects of different methods of boron application on spikelets spike^{-1}, grains spike^{-1} and 1000-grain weight of wheat (cv. Shatabdi)

Boron treatments	Spikelets spike^{-1} (no.)	Grains spike^{-1} (no.)	1000-grain weight (g)
T_1: Control	15.4 d	15.2 c	44.5 d
T_2: SA	17.0 ab	41.7 a	48.7 bc
T_3: SP	15.7 cd	31.5 b	47.8 c
T_4: FA-p	17.2 a	39.6 a	48.6 bc
T_5: FA-b	16.4 bc	39.6 a	51.6 ab
T_6: FA-pb	16.1 bd	38.2 a	54.7 a
Level of significance	*	**	**
CV (%)	2.7	9.7	3.7
S.E. (±)	0.200	10.94	3.275

Values in a column having same letter do not differ significantly at 5% level by DMRT.
** P <0.05, ** P < 0.01, S.E = Standard error of means, CV = Coefficient of variation,*
SA = Soil application of 1.5 kg boron ha^{-1}; SP = Seed priming into 0.1% boric acid solution for 10 hours; FS-pb = Foliar spray of 0.4% boric acid solution at primordial and booting stages of crop

The grain yield of wheat (cv. Shatabdi) was significantly improved after boron application (Table 4), the yield varied from 2600 - 3625 kg ha^{-1} over the treatments. The yield benefits due to T_2, T_3, T_4, T_5 and T_6 treatments were 37.8%, 18.6%, 35.9%, 39.4% and 39.6% yield increase over control, respectively. The soil and every foliar B treatment gave statistically similar yield which was significantly higher than the yield obtained with seed priming treatment. The yield of seed priming treatment significantly differed from the that of control treatment. The available B content of soil under study was 0.15 mg kg^{-1} which as per National Fertilizer Recommendation Guide [2012] was inadequate to support normal plant growth. Thus, the experiment showed a good correlation between soil test value and crop yield response.

The higher yield of wheat as obtained with B treatment agrees well to the findings, as reported in Bangladesh [2], India [22], Nepal [25], and Thailand [26]. Farooq et al. [27] in their extensive review state that micronutrient (e.g. boron) application through seed treatment can improve crop establishment and yield, but in some cases, seed priming is not beneficial. There was no visible effect of seed priming with B on yields of chickpea, lentil, rice and wheat [8]. Boron requirement for reproductive growth is higher than that for vegetative growth [28]. Impaired formation of pollen cell walls and reduced cell expansion might be the primary consequence of B deficiency during reproduction [29]. Transport of B to floral plant parts is a critical limiting factor and the relative sensitivity of reproductive parts is a consequence of low B transport [10]. So, foliar spray of boron that target reproductive tissues often gives a dramatic yield response [30]. Jolanta Korzenniows [31] from a field trial reported that foliar application of boron resulted in a significant increase of grain yield of four out of ten wheat varieties.

The straw yield did not increase significantly due to B application either to seed, soil or plant (Table 4). In values the lowest yield (5625 kg ha^{-1}) was observed in B control and the highest yield (6388 kg ha^{-1}) noted in foliar B application at primordial and booting stages of crop which was 13.6% increase over control.

Grain yield is a complex character that results from contribution of several plant parameters (Table 5). The grain yield was positively and significantly correlated with plant height ($r= 0.518$; $P< 0.05$), number of tillers per plant ($r=0.543$; $P< 0.05$), spike length ($r=0.485$; $P< 0.05$), spikelets spike^{-1} ($r= 0.580$; $P< 0.05$), grains spike^{-1} ($r= 0.775$; $P< 0.01$) and 1000-grain weight ($r=0.720$; $P< 0.01$), The straw yield was positively correlated with plant height and spike length only. There was no significant relationship between grain and straw yields of wheat ($r= 0.146$). The results indicate that the number of grains spike^{-1} and 1000-grain weight, among the yield contributing characters, had the greatest influence on the grain yield of wheat. Thus, it appears that grain set and grain weight of wheat is affected by boron deficiency and it can be corrected by boron application in the form fertilizer (boric acid).

Table 4. Effects of different methods of boron application on grain and straw yields of wheat (cv. Shatabdi)

Boron treatments	Grain yield (kg ha^{-1})	% yield increase over control	Straw yield (kg ha^{-1})	% yield increase over control
T_1: Control	2600 c	-	5625	-
T_2: SA	3583 a	37.8	5676	0.9
T_3: SP	3083 b	18.6	5870	4.4
T_4: FA-p	3533 a	35.9	6011	6.9
T_5: FA-b	3625 a	39.4	6375	13.3
T_6: FA-pb	3630 a	39.6	6388	13.6
Level of significance	**	-	NS	-
CV (%)	4.15	-	12.64	-
S.E. (±)	0.019	-	0.649	-

Values in a column having same letter do not differ significantly at 5% level by DMRT.
** P <0.05, ** P < 0.01, S.E = Standard error of means, CV = Coefficient of variation,*
SA = Soil application of 1.5 kg boron ha^{-1}; SP = Seed priming into 0.1% boric acid solution for 10 hours; FS-pb = Foliar spray of 0.4% boric acid solution at primordial and booting stages of crop

Table 5. Correlation matrix among the plant characters under study (n=18)

Variables	Plant height	Tillers plant^{-1}	Spike length	Spikelets spike^{-1}	Grains spike^{-1}	1000-grain weight	Grain yield	Straw yield
Plant height	1							
Tillers plant^{-1}	0.374^{ns}	1						
Spike length	0.081^{ns}	0.263^{ns}	1					
Spikelets spike^{-1}	0.124^{ns}	0.388^{ns}	0.777**	1				
Grains spike^{-1}	0.448^{ns}	0.303^{ns}	0.573*	0.608**	1			
1000-grain weight	0.104^{ns}	0.218^{ns}	0.402^{ns}	0.339^{ns}	0.621**	1		
Grain yield	0.518*	0.543*	0.485*	0.580*	0.775**	0.720**	1	
Straw yield	0.076*	0.123^{ns}	0.535*	0.166^{ns}	0.116^{ns}	0.192^{ns}	0.146^{ns}	1

4. CONCLUSION

Wheat yield is markedly affected due to grain set failure and unhealthy grain induced by boron deficiency. This element deficiency can be overcome by boron fertilizer use. Boron fertilizer can be effectively used through foliar spray at booting stage of crop and also through its application to soil before sowing of crop (wheat).

ACKNOWLEDGEMENT

This work was supported by the USDA funded project, "Screening, Selection and Molecular Characterization of Boron Efficient Wheat Genotypes".

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hossain MA, Jahiruddin M, Khatun M. Response of mustard (Brassica) varieties to boron application. Bangladesh J. Agril. Res. 2012;37:137-148.
2. Jahiruddin M. Screening, selection and molecular characterization of boron efficient wheat genotypes. Project completion report. Dept. of Soil Science, BAU, Mymensingh; 2011.

3. Hossain MA, Jahiruddin M, Islam MR, Mian MH. The requirement of zinc for improvement of crop yield and mineral nutrition in the maize-mungbean-rice system. Plant and Soil. 2008;306:13-22.
4. Islam MB. Requirement of Boron for Mustard, Wheat and Chickpea based Rice Cropping Patterns. PhD Thesis, Dept. Soil Sci., BAU, Mymensingh; 2005.
5. Ho SB. Boron deficiency of crops in Taiwan. In: Proceedings of international workshop on micronutrient in crop production held on Nov. 8–13, 1999, National Taiwan University, Taipei, Taiwan ROC; 1999.
6. Rashid A. Boron deficiency in soils and crops of Pakistan – Diagnosis and management. Pak. Agric. Res. Council. Islamabad; 2006.
7. Rerkasem B, Jamjod S. Boron deficiency in wheat: A review. Field Crops Res. 2004;89:173-186.
8. Johnson SE, Lauren JG, Welch RM, Duxbury JM. A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Nepal. Expt. Agric. 2005;41:427–448.
9. Srivastava SP, Bhandari TMS, Yadav CR, Joshi M, Erskine W. Boron defciency in lentil: Yield loss and geographic distribution in a germplasm collection. Plant and Soil. 2000;219:147–151.
10. Brown PH, Bellaloui N, Wimmer MA, Bassil ES, Ruiz J, Hu H, Pfeffer H, Dannel F, Romheld V. Boron in plant biology. Plant Biol. 2002;4:205-223.
11. Miwa K, Tanaka M, Kamiya T, Fujiwara T. Molecular mechanisms of boron transport in plants: Involvement of Arabidopsis NIP5;1 and NIP6; 1. Adv. Expt. Med. Biol. 2010;679:83-96.
12. Roessner U, Patterson JH, Forbes MG, Fincher GB, Langridge P, Bacic A. An investigation of boron toxicity in barley using metabolomics. Plant Physiol. 2006; 142:1087-1101.
13. Goldbach HE, Yu Q, Wingender R, Schulz M, Wimmer M, Findeklee P, Baluska F. Rapid response reactions of roots top boron deprivation. J. Plant Nutr. Soil Sci. 2001;164:173-181.
14. Dell B, Huang L. Physiological response of plants to low boron. Plant and Soil. 1997;193:103-120.
15. Tanaka M, Fujiwar T. Physiological roles and transport mechanisms of boron: Perspectives from plants. Pfügers Arch. European J. Physiol. 2008;456:671–677.
16. Cooke GW. Fertilizing for maximum yield. Granada, UK. 1982;465.
17. Dwivedi GK, Madhu D, Pal SS. Modes of application of micronutrients in acid soil in soybean-wheat crop sequence. J. Indian Soc. Soil Sci. 1990;38:458-463.
18. Singh B, Natesan SKA, Singh BK, Usha K. Improving zinc efficiency of cereals under zinc defciency. Curr. Sci. 2003;88:36–44.
19. Moeinian MR, Zargari K, Hasanpour J. Effect of boron foliar spraying application on quality characteristics and growth parameters of wheat grain under drought stress. Amer. Eur. J. Agric. Environ. Sci. 2011;10:593-599.
20. Tahir M, Tanveer A, Shah TH, Fiaz N, Wasaya A. Yield response of wheat (*Triticum aestivum* L.) to boron application at different growth stages. Pak J. life Soc. Sci. 2009;7:39-42.
21. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd Edt. A Wiley Inter Sci. Publi. John Wiley and Sons., New York; 1984.
22. Mandal AB, Das AD. Response of wheat (*Triticum aestivim*) to boron application. Indian J. Agric. Sci. 1988;58(9):681-852.
23. Abedin MJ, Jahiruddin M, Hoque MS, Islam MR, Ahmed MU. Application of boron for improving grain yield of wheat. Progress, Agric. 1994;6(1):75-79.
24. FRG. Fertilizer recommendation guide, Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215. 2012;274.
25. Sthapit NR. Studies on wheat sterility problems in the hills, tar and tarai of Nepal, Lumple Agric. Centre, Tech. Pap. No. 16/88; 1988.
26. Rerkasem B, Jamjod S. Overcoming wheat sterility problem with boron efficiency. J. Plant Nutr. 2002;92:82-83.
27. Farooq M, Wahid A, Kadambot H. M. Siddique. Micronutrient application through seed treatments – a review. J. Soil Sci. Plant Nutr. 2012;12:125-142.
28. Dell B, Huang L. Physiological response of plants to low boron. Plant Soil. 1997;193: 103-120.
29. Huang L, Pant J, Dell B, Bell R. Effects of boron deficiency on anther development

and floret fertility in wheat (*Triticum aestivum*). Ann. Bot. 2000;85:493-500.
30. Nyomora AMS, Brown PH, Freeman M. Fall foliar-applied boron increases tissue boron concentration and nut set of almond. J. Amer. Soc. Hort. Sci. 1997;122:405-410.
31. Jolanta K. Response of ten winter wheat cultivars to boron foliar application on in a temperature climate. Institute of Soil Science and Plant Cultivation-National Research Ins. Pulawy; 2006.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14183