ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 44(2): 303-310, June 2019

EFFECTS OF BORON APPLICATION ON NEW WHEAT VARIETIES IN BANGLADESH

M. Akter[1], S. Akhter[2], H. M. Naser[3]
S. Sultana[4] and M. A. Hossain[5]

Abstract

A pot experiment was conducted in the Net house of Soil Science Division of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during *rabi* season, 2017-2018 in Tista Meander Floodplain Soils (AEZ-3). The objectives were to evaluate the effect of boron on the yield of wheat, estimate boron use efficiency and to find out suitable variety for maximizing the yield. The experiment was designed in Completely Randomized Design (CRD) with three replications. Three varieties of wheat (BARI Gom-28, BARI Gom-29 and BARI Gom-30) with 5 levels of boron (0, 0.5, 1.0, 1.5 and 2 kg ha^{-1}) along with a blanket dose $N_{120}P_{30}K_{90}S_{15}Zn_3Mg_6$ kg ha^{-1} were used in the study. All the three varieties performed well with application of 1.5 kg B ha^{-1} as compared to the other B treatments. However, the highest yield (39.2 g pot^{-1}) was obtained with BARI Gom-30 variety receiving B at 1.5 kg ha^{-1}.

Keywords: Boron, variety, wheat, uptake and yield.

Introduction

Wheat (*Triticum aestivum* L.) constitutes 15 to 20 per cent of the staple cereal food in Bangladesh and as a cereal crop it ranks second after rice. In 2015-2016 wheat cultivated area was about 4.44 lakh hectares having a total production of 13.48 lakh tons with an average yield of 3.03 t ha^{-1} (BBS, 2016).The grains of wheat have high nutritive value containing 14.70% protein, 2.14% fat, 78.10% starch and 2.10% mineral matter (Kumar *et al.,* 2011). There is a great prospect of wheat cultivation in Bangladesh as it is cultivated in winter season less affected by any climatic hazard and disease. The yield of wheat depends on varieties, location, soil nutrients status and agronomic management. Micronutrients play a vital role for increasing wheat yield in Bangladesh as most of lands are deficient in micronutrients. Among the micronutrients deficiencies for wheat in Bangladesh, B deficiency is common. It is essential for seed production of almost all crops as it plays a vital role in the physiological processes of plants, such as cell elongation, cell maturation, meristematic tissue development and protein synthesis (Mengel and Kirkby, 1982). It influences absorption of N, P, and K. Boron deficiency causes poor seed quality, male

---

[1&4]Scientific Officer, [2&3]Principal Scientific Officer, [5]Chief Scientific Officer, Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur-1701, Bangladesh.

sterility in wheat, increases disease susceptibility like black point of wheat (Jahiruddin, 2011). Farmers of this country do not commonly apply these essential nutrients to soil that leads to low crop productivity and declining soil fertility. Predictably, different varieties of wheat have their own potentials to uptake and assimilate nutrients at divergent rates from the same soil. So along with ensuring balanced fertilizer application, varieties, need to be investigated to find out their nutrient use efficiencies. In AEZ-3, 24% soils have very low B level and 44% soils have low B content level (Jahiruddin and Islam, 2014). Recently, a number of new wheat varieties have been released by Bangladesh Wheat and Maize Research Institute, Dinajpur and information regarding B use efficiency by those varieties is almost looking. BARI Gom-28, BARI Gom-29 and BARI Gom-30 are among the recently released wheat varieties. Considering the above perspectives, the present investigation was undertaken with the following objectives:

- to study the effect of boron on yield and nutrient uptake of different wheat varieties
- to estimate the optimum dose of boron for higher yield of wheat
- to find out the boron efficient varieties of wheat

Materials and Methods

Soil collection sites

Soil samples at a depth of 0-15 cm were collected from Rangpur (AEZ-3) under the same soil series (Gangachara) and used for this study.

Crop

BARI Gom-28, BARI Gom-29 and BARI Gom-30 were considered as test crops for the experiment, which are recently released wheat varieties from Bangladesh Agricultural Research Institute.

Boron treatments

Five rates of boron (B) as 0 (B_0), 0.5 kg ha^{-1} ($B_{0.5}$), 1 kg ha^{-1} (B_1), 1.5 kg ha^{-1} ($B_{1.5}$) and 2 kg ha^{-1} (B_2) were applied from boric acid (17% B). The fertilizers were thoroughly mixed with the soil in individual pot. A sub-sample of about 100 g was collected from each pot for initial chemical analysis.

Experimental works

The total numbers of pots were 45 and these were randomly arranged in the net house of Soil Science Division, BARI, Gazipur. Each of the treatments was replicated thrice in a Completely Randomized Design (CRD) to give a total of 15 (5×3) pots for each variety. Fifteen (15) kg soil was taken in each pot. Pot diameter was 31 cm. Fifteen (15) wheat seeds were sown in each pot and one week after germination 10 healthy plants were selected to grow up to maturity. A basal application was made with 80 kg N ha^{-1}, 30 kg P ha^{-1}, 90 kg K ha^{-1}, 15 kg S ha^{-1}, 3 kg Zn ha^{-1} and 6 kg Mg ha^{-1} in each pot to support normal plant growth. The soils of all pots were kept moist with addition of distilled water periodically. In all pots 40 kg N ha^{-1}as urea was applied after 20 days of planting. Irrigation was given throughout the experiment period to keep the soil moist. At maturity, numbers of tillers $plant^{-1}$ and plant height were recorded and then all plants were harvested by cutting above the soil surface by using a stainless steel scissor. Then spike lengths, Number of spikelets $spike^{-1}$ etc data were recorded. Next, plants were dried in an oven at 70°C for 72 hours to determine dry matter yield. The dries samples were then finely ground in a grinder for laboratory analysis. After harvest, the soil from each pot was thoroughly mixed and approximately 100 g soil was sampled for laboratory analysis.

Chemical analysis

For initial soil analysis, soil pH was measured by a combined glass calomel electrode (Jackson, 1958). Organic carbon determination was done by wet oxidation method (Walkley and Black, 1934). Total N was determined by modified Kjeldahl method. Elements K, Ca and Mg were determined by NH_4OAC extractable method and Cu, Fe, Mn and Zn were determined by DTPA extraction method followed by AAS reading. Boron was determined by $CaCl_2$ extraction method. Phosphorus was determined by Bray and Kurtz method while S by turbidimetric method with $BaCl_2$. The initial soil analysis was an indicative of B deficiency in the areas.

Boron uptake and its use efficiency

Boron uptake was determined by the following formula:

B uptake (kg ha^{-1}) = B % × Dry weight (kg ha^{-1}) /100

Agronomic efficiency was calculated by the following formula:

Agronomic efficiency, (AE) = $(Y_{NA}-Y_{NO})/ N_{RN}$ (FRG, 2012)

Where, AE= Agronomic efficiency

Y_{NA} = Yield due to nutrient addition

$Y_{NO=}$ Yield due to nutrient omission

N_{RN} =Rate of nutrient addition

Recovery efficiency was calculated by the following formula:

Recovery efficiency, (RE) = $(NU_{NA}-NU_{NO})/ N_{RN}$ (FRG, 2012)

Where, RE= Recovery efficiency

NU_{NA} = Nutrient uptake due to nutrient addition

NU_{NO} = Nutrient uptake due to nutrient omission

N_{RN} =Rate of nutrient addition

Table 1. Initial properties of the soil samples of experimental pots

Soil Properties	Texture	pH	OM	Ca	Mg	K	Total N	P	S	B	Cu	Fe	Mn	Zn
			(%)	meq 100g^{-1}			%	µg g^{-1}						
Result	Sandy loam	5.6	1.47	5.6	1.8	0.18	0.07	19.4	26.6	0.18	2.1	22	4.5	3.1
Critical level	-	-	-	2	0.5	0.12	-	7	10	0.2	0.2	4	1	0.6

Results and discussion

Interaction effects of wheat varieties and boron levels on yield

Different parameters were significantly influenced by different varieties and levels of boron application which are shown in Table 2.

Table 2. Interaction effects of different wheat varieties and boron levels on growth and yield attributes of wheat

Treatment		Tillers pot^{-1} (10 plants)	Spike length (cm)	Spikelet spike^{-1}	Grains spike^{-1}	1000 grain Weight (g)
Variety	B levels					
BARI Gom-28	B_0	22.7 g	9.8 bcde	13.4 fg	37.7 d	40.4 de
	$B_{0.5}$	24.7 cdef	10 abcd	14.1 bcdefg	38.6 bcd	40.8 cde
	$B_{1.0}$	24.3 cdefg	10.1 abcd	14.4 abcdef	40.5 abc	41.1 bcde
	$B_{1.5}$	25.7 bc	10.5 ab	15.1 abc	42.6 a	42.8 ab
	B_2	25 bcde	10.4 abc	14.7 abcde	42.1 a	41.3 bcde
BARI Gom-29	B_0	23.3 efg	9 e	13 g	37.4 d	40.3 e
	$B_{0.5}$	25 bcde	9.3 de	13.6 efg	37.6 d	40.5 de
	$B_{1.0}$	25 bcde	9.4 de	13.8 defg	38.3 cd	41.6 bcde
	$B_{1.5}$	26 abc	10.2 abcd	14.8 abcd	39.1 bcd	42.1 abcd
	B_2	25.3 bcd	9.7 bcde	14.1 cdefg	38.6 bcd	41.7 bcde
BARI Gom-30	B_0	23 fg	9.5 cde	13.5 fg	37.2 d	40.8 cde
	$B_{0.5}$	23.6 defg	9.8 bcde	13.9 defg	39 bcd	41.2 bcde
	$B_{1.0}$	26 abc	10.5 ab	14.9 abcd	40.8 ab	42.4 abc
	$B_{1.5}$	27.7a	10.8 a	15.4 a	42.9 a	43.8 a
	B_2	26.7 ab	9.5 de	15.2 ab	42 a	43.6 a
CV (%)		4.7	5.6	4.8	3.7	2.5

Means followed by same letter (s) in a column did not differ significantly at the 5% level of significance by LSD.

Significant variations in yield and yield attributes of wheat varieties were observed due to different rates of boron application. The integrated effects of varieties and boron up to 1.5 kg ha^{-1} significantly increased the number of tillers pot^{-1}; spikelet spike^{-1} and grains spike^{-1} which were declined at higher dose (2 kg B ha^{-1}). Relatively higher number of tillers pot^{-1} was recorded in BARI Gom-30. The highest length of spike (10.8 cm) was recorded in BARI Gom-30 with 1.5 kg B ha^{-1}. Boron application significantly increased the number of spikelets spike^{-1} in all varieties. The highest number of grains spike^{-1} was found with 1.5 kg B ha^{-1} fertilization for all the three varieties. The highest 1000 grain weight was found in BARI Gom-30 (43.8 g) with 1.5 kg ha^{-1} B fertilization.

Table 3. Interaction effects of different wheat varieties and boron levels on the grain and straw yields of wheat

Treatment		Grain yield pot^{-1} (g)	Straw yield pot^{-1} (g)	TDM pot^{-1} (g) (above ground)	Grain yield (t ha^{-1})
Variety	B levels				
BARI Gom 28	B_0	34.2 f	36.2 f	70.4 g	4.6 f
	$B_{0.5}$	34.8 ef	37 ef	71.8 fg	4.6 ef
	$B_{1.0}$	36.3 cde	39.9 cdef	76.1 de	4.8 cde
	$B_{1.5}$	38.8 ab	43.9 ab	82.7 ab	5.2 ab
	B_2	37.5 bc	39.2 def	76.7 cde	5.0 bc
BARI Gom 29	B_0	33.9 f	38.1 def	72.0 fg	4.5 f
	$B_{0.5}$	34.2 ef	39.8 cdef	74.0 efg	4.6 f
	$B_{1.0}$	34.6 ef	40.7 bcd	75.3 def	4.6 ef
	$B_{1.5}$	35.5 def	43.2 abc	78.7 cd	4.7 def
	B_2	34.9 ef	41.7 bcd	76.6 cde	4.7 ef
BARI Gom 30	B_0	34 f	39.1 def	73.1 efg	4.5 f
	$B_{0.5}$	35.2 def	39.8 cdef	75.0 def	4.7 def
	$B_{1.0}$	37 bcd	43.3 abc	80.3 bc	4.9 bcd
	$B_{1.5}$	39.2 a	46.4 a	85.6 a	5.2 a
	B_2	37.5 abc	40.6 bcde	78.0 cd	5.0 abc
CV (%)		3.2	5.4	3.0	3.2

Means followed by same letter (s) in a column do not differ significantly at 5% level of significance by LSD, TDM= Total Dry Matter.

The highest grain yield was obtained in BARI Gom-30 (39.2 g pot^{-1} and 5.2 t ha^{-1}) variety by applying 1.5 kg B ha^{-1} which was significantly higher over the rest of the boron levels in variety BARI Gom-29 and identical to BARI Gom-28 (38.8 g pot^{-1} and 5.2 t ha^{-1}). The highest straw yield was found in BARI Gom-30 (46.4 g pot^{-1}) variety by applying 1.5 kg B ha^{-1}. Significantly higher dry matter yield pot^{-1} was recorded in BARI Gom-30 (85.6 g) with applying 1.5 kg B ha^{-1} which was significantly higher over BARI Gom-29 (78.7 g pot^{-1}) and identical to BARI Gom-28 (82.7 g pot^{-1}). The grain yield increased progressively with the boron levels up to 1.5 kg B ha^{-1} and beyond the dose, the yield declined. All three varieties showed better performances at 1.5 kg B ha^{-1} application since the soils of the study area were B deficient. Rashid *et al*. (2012) recorded significant increase in seed yield of mustard varieties when B was applied with 1.5 kg ha^{-1} rate. It revealed that application of 1.5 kg B ha^{-1} for all the varieties tested successfully contributed to the grain yield over all other treatment combinations. However, BARI Gom-30 showed better performance compared to BARI Gom-28 and BARI Gom-29.

Effects of boron application on the boron content and uptake of wheat
Boron content and uptake by wheat grains were significantly influenced by different rates of boron fertilization (Table 4)

Table 4. Effects of B application on the B content and uptake by wheat

B level (kg ha^{-1})	Boron content (ppm)		Boron uptake (g ha^{-1})		Total uptake (g ha^{-1})
	Grain	Straw	Grain	Straw	
B_0	13.9 c	15.6 e	63 c	79 d	142 d
$B_{0.5}$	14.4 c	17.8 d	67 c	92 c	159 c
$B_{1.0}$	16.7 b	20.0 c	80 b	110 b	190 b
$B_{1.5}$	18.7 a	21.2 b	94 a	126 a	220 a
B_2	18.9 a	22.7 a	92 a	123 a	215 a
CV (%)	6.1	6.1	5.4	6.7	4.4

Means followed by same letter (s) in a column do not differ significantly at the 5% level of significance by LSD.

The highest B concentration (18.9 ppm in grain and 22.7 ppm in straw) were recorded in 2 kg ha^{-1} B rate. In 2 kg ha^{-1} B rate, grain B content (18.9 ppm) was significantly higher over the rest of the boron levels but identical to 1.5 kg ha^{-1} B rate (18.7 ppm).The straw B content (22.7 ppm) obtained with 1.5 kg B ha^{-1} was significantly higher over rest of the boron levels. The lowest B concentrations were found in B control treatment (13.9 ppm in grain and 15.6 ppm in straw). Boron application had significant and positive effect on the B uptake by grain and straw. The lowest B uptake was found in B control (Table 4) and the highest in the treatment having B at 1.5 kg ha^{-1}. The highest B uptake (94 g ha^{-1} in grain and 126 g ha^{-1} in straw) were recorded in 1.5 kg ha^{-1} B rate which were significantly higher over rest of the B levels but identical to 2 kg ha^{-1}B rate. Significantly higher total B uptake (grain+ straw) also found in 1.5 kg ha^{-1} B rate.

Boron use efficiency:

Boron use efficiency was influenced by different treatments (Table 5). The nutrient use efficiency can be expressed as agronomic efficiency, recovery efficiency and physiological efficiency. In this paper, agronomic efficiency and recovery efficiency were shown. Agronomic efficiency refers to the increase in crop yield per unit of an applied nutrient. Recovery efficiency is the increase in nutrient uptake by plants per unit of an applied nutrient. Among the three varieties (Table 5), the highest B use efficiency was recorded in BARI Gom-30 (agronomic efficiency 1108.8 and recovery efficiency 0.029) at 1.5 kg ha^{-1} boron rate and the lowest B use efficiency was found in BARI Gom-28 (agronomic efficiency 358.9 and recovery efficiency 0.014) at 0.5 kg ha^{-1} boron rate. All the three varieties showed the highest boron use efficiency @1.5 kg ha^{-1} B rate.

Table 5. Boron use efficiency by wheat

Treatment		Agronomic efficiency	Recovery efficiency
Variety	Boron levels		
BARI Gom-28	$B_{0.5}$	358.9	0.014
	$B_{1.0}$	760.7	0.026
	$B_{1.5}$	1094.9	0.026
	B_2	419.3	0.018
BARI Gom-29	$B_{0.5}$	555.5	0.017
	$B_{1.0}$	445.9	0.020
	$B_{1.5}$	599.0	0.024
	B_2	311.8	0.018
BARI Gom-30	$B_{0.5}$	501.4	0.022
	$B_{1.0}$	963.5	0.028
	$B_{1.5}$	1108.8	0.029
	B_2	328.2	0.019

Conclusion

All the three wheat varieties as BARI Gom-28, BARI Gom-29 and BARI Gom-30 gave maximum yield with 1.5 kg B ha^{-1} in combination with recommended rates of other fertilizers. Among the varieties, BARI Gom-30 showed the best performances over the other two varieties.

References

BBS, 2016. Year book of Agricultural Statistics-2015, p.78-81, 27thSeries, Statistics and Informatics Division (SID,) Ministry of Planning, Government of the People's Republic of Bangladesh.

FRG. 2012. Fertilizer Recommendation Guide, BARC, Dhaka. 50-51p.

Jahiruddin, M. and Islam, M. R. 2014. Project Report (2011-14). Requirement of Micronutrients for Crops and Cropping Patterns. PIU-BARC (NATP Phase-1) Project. Project ID No. 339.

Jahiruddin, M. 2011. Screening, Selection and Molecular Characterization of Boron Efficient Wheat Genotypes.USDA Project Report, Dept. of Soil Science, BAU, Mymensingh.

Jackson M. L, Soil Chemical Analysis, (Prentice Hall, Inc. Eaglewood Cliffs, N.Y. 1962, pp 219-221). [12]. Jackson M.L, Soil Chemical Analysis, (Prentice Hall India Pvt. Ltd. New Delhi 1967), p-498.

Kumar. P, RK. Yadava, B Gollen, S Kumar, R K Verma, S Yadav. 2011. Nutritional Contents and Medicinal Properties of Wheat. Life Science and Medicine Research. Volume-2011: LSMR-22

Mengel, K. and E. A. Kirkby. 1982. Principles of Plant Nutrition. International Potash Institute. Bern, Switzerland.

Rashid. M. H., M. M. Hasan, M. Ahmed, M.T. Rahman and K. A. M. M. Rahman. 2012. Response of mustard to boron fertilization. *Bangladesh J. Agril. Res.* 37(4):677-682.

Walkley A and Black C. A. 1934. An examination of digestion methods for determining soil organic matter and a proposed modifications of the chromic acid titration method. Soil Sci., 37, 29-38.