J. Environ. Sci. & Natural Resources, **6(1): 41 - 45, 2013** ISSN 1999-7361

Effects of Boron Fertilization and Sowing Date on the Grain Protein Content of Wheat Varieties

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Abstract: Wheat is the most important cereal crop and staple food of about two billion people around the world and contributes more calories and proteins to the world diet than any other cereal crop. Wheat grain quality is a function of grain composition, principally in proteins, which depends on the genotype and the environment. Protein content is a key quality factor that determines the suitability of wheat for a particular type of product as it affects other factors including mixing tolerance, loaf volume and water absorption capacity. The experiment was conducted at the Bangladesh Agricultural University farm during 2007 to 2010 to study the effects of boron fertilization and sowing dates on the Black point disease of wheat genotypes. The soil was silty loam in texture having pH 6.7, cation exchange capacity 12.6 me/100g soil, organic matter 1.9%, total N 0.09%, available P 7.3 ppm, exchangeable K 0.09 cmol kg^{-1}, available S 12.4 ppm, available Zn 0.8 ppm and available B 0.19 ppm. The wheat varieties used in the experiment were Prodip, Shatabdi and Sourav. Boron was applied @ 0 and 1 kg ha-1 and sowing dates were 18 November, 28 November, 08 December and 18 December. The experiment was laid out in a split-split plot design with a distribution of sowing dates to the main plots, varieties to the sub-plots and boron treatment to the sub-sub plots. All the factors were replicated three times. The total amount TSP, MoP, gypsum and zinc oxide were applied during final land preparation. Nitrogen was applied @ 120 kg ha^{-1} from urea (46 % N), P @ 20 kg ha^{-1} from TSP (20 % P), K @ 60 kg ha^{-1} from MoP (50 % K), S @ 10 kg ha^{-1} from gypsum (18 % S) and Zn @ 1.5 kg ha^{-1} from ZnO (78 % Zn). Urea was applied in three equal splits - final land preparation and 30 and 45 days after sowing. Boric acid (17%B) was applied to the B treatment plots prior to sowing. The crop was irrigated 2 times- 21 days (crown root initiation) and 47 days (heading stage) of sowing. Soil samples were analyzed for texture, pH, OM, total N and available P, K, S, Zn, S and B contents. The data were analyzed statistically (Gomez and Gomez, 1984). Boron application exerted a significant increasing effect on the protein content of wheat grain. A. significant variation in the N and protein content of wheat grains was observed among the wheat varieties in both the years. The 28 November sowing recorded the maximum protein content in wheat grains while the minimum value was noted with the 18 December sowing in both the years.

Key words: Boron, Protein, Sowing date, Wheat

Introduction

Wheat is the most important cereal crop and staple food of about two billion people around the world and is grown on more than 240 million hectares which is larger than for any other crop (Safdar *et al.*, 2009). World trade in wheat is greater than for all other crops combined. Wheat provides more nourishment for humans than any other food source. It is a major diet component because of the wheat plant's agronomic adaptability with the ability to grow from near arctic regions to equator, from sea level to plains of Tibet, approximately 4,000 m above sea level. In addition to agronomic adaptability, wheat offers ease of grain storage and ease of converting grain into flour for making edible, palatable, interesting and satisfying foods. Wheat protein is easily digested by nearly 99% of human population as is its starch. It also contains a diversity of minerals, vitamins and fats (lipids). With a small amount of animal or legume protein added, a wheat-based meal is highly nutritious.

Wheat grain quality is a function of grain composition, principally in proteins, which depends on the genotype and the environment. The genetic effect is mainly reflected by qualitative variation such as protein polymorphism and secondly by quantitative variation of total protein or of different units and subunits. In contrast, the environmental effect was mainly reflected by the quantitative variation, such as in total protein or protein unit and subunit contents. (Triboi *et al.*, 2000).Protein composition is a key component of the end-use value for wheat grain. Although the qualitative composition of the grain is genetically determined, the quantitative composition is significantly modified by the growing conditions, and there are significant genotype × environment interactions (Jamieson *et al.*, 2004)

The accumulation of the different protein fractions is highly asynchronous, inferring that the protein composition of the grain changes during grain development. One consequence is that conditions that shorten grain filling, such as high temperature or drought, affect the balance of protein fractions (Jamieson et al., 2001; Triboi *et al.*, 2003). Protein content is a key quality factor that determines the suitability of wheat for a particular type of product as it affects other factors including mixing tolerance, loaf volume and water absorption capacity (Shah *et al.*, 2008). Both protein quantity and quality are considered important in estimating the potential of flour for its end use quality (Farooq *et al.*, 2001).

The problem for growers is to improve grain yield while at the same time maintaining or improving grain protein content. Nitrogen is the key nutrient in the problem, since it is the nutrient used in greatest quantity by the growing wheat crop. It is central to the production of high yields and protein. The total protein content of wheat ranges from 6 to 22 percent, depending on soil, weather conditions, and variety. A protein content of 12 to 12.5 percent (on a moisture-free basis) can be considered as intermediate. The protein value will influence the grain's inclusion level in the diet and its value. In the international market place buyers are now demanding for wheat with higher protein content. Low yields and a decline in grain protein are a problem and a challenge for wheat growers today. Protein is an important component when selling wheat on a global market. Wheat is one of the world's most widely grown (and consumed) grains; Prices for wheat less than 11% protein may decline while process for wheat with relatively high protein may maintain current levels. Wheat cultivation in Bangladesh ranks next to rice. Its life cycle is shorter than to rice and is widely adapted to different agro-climatic conditions. Wheat is the most important stable food crop for more than one third of the world population and contributes more calories and proteins to the world diet than any other cereal crop (Abd-El-Haleem *et al*. 1998; Shewry, 2009). In addition to agronomic adaptability, wheat offers ease of grain storage and ease of converting grain into flour for making edible, palatable, interesting and satisfying foods.

Numerous studies on the response of wheat to B fertilizer have been reported in recent years including those from Bangladesh (Nyomora *et al*., 1997; Wang *et al*., 1999; Yan *et al*., 2003; Subedi *et al*., 1997; Rashid *et al*., 1997a, 1997b). Boron has a positive effect on the number of grains spike^{-1} and grain yield of wheat (Hossain *et al.* 1994), number of spikelets on the main stem, leaf area, photosynthesis, 1000-grain weight and N, P and K content of wheat (Weo and Zuo, 1996).Wheat genotypes differ significantly in producing plant height, tillers plant $^{-1}$, spikelets spike^{-1}, grains spike^{-1}, weight of 1000-grain and straw yield under a given agro-climatic condition (Hasan,1995).

In Bangladesh, the maximum grain yield is obtained from 15 November to 05 December sowing (Siddiqui *et al.*, 2004; Shah *et al*., 2006)) and such a variation might be due to interaction of sowing date with local climatic variation (BARI, 1989). Late sowing leads to early maturity and reduction in yield attributes with resultant decrease in yield (Razzaque, 1982; BARI, 1986). Delay in seeding after 1 December resulted in yield loss @1% per day in Bangladesh (BARI, 1986). Over 50% of the wheat grown in Bangladesh is planted in December (December 07-31) following delayed harvest of transplant aman paddy (Razzaque *et al*., 1994). Such late-sown wheat becomes affected by temperature during anthesis and / or grain filling period, resulting in low yields. The wheat yield would be highly affected if sowing is delayed after 01 December (Guler *et al*., 1986; Razzaque and Hossain,1991). Sowing date affect initiation of spike primordia (22-28 days after emergence), booting (30-45 DAE), heading (40-58 DAE), grain filling and maturity of wheat (BARI, 1990).

Materials and Methods

The experiment was conducted at the Bangladesh Agricultural University farm, Mymensingh belonging to the Sonatola soil series of Non-calcareous Dark Gray Floodplain Soils under the AEZ-9: Old Brahmaputra Floodplain during 2007 to 2010. The soil was silty loam in texture having pH 6.7, cation exchange capacity 12.6 me/100g soil, organic matter 1.9%, total N 0.09%, available P 7.3 ppm, exchangeable K 0.09 cmol kg^{-1}, available S 12.4 ppm, available Zn 0.8 ppm and available B 0.19 ppm. The wheat varieties used in the experiment were Prodip, Shatabdi and Sourav . Boron was applied @ 0 and 1 kg ha^{-1} and sowing dates were 18 November, 28 November, 08 December and 18 December. The experiment was laid out in a split-split plot design with a distribution of sowing dates to the main plots, varieties to the sub-plots and boron treatment to the sub-sub plots. All the factors were replicated three times. There were altogether 72 (4×3×2×3) unit plots, each plot measuring 5m× 4m. The total amount TSP, MoP, gypsum and zinc oxide were applied during final land preparation. Nitrogen was applied @ 120 kg ha^{-1} from urea (46 % N), P @ 20 kg ha^{-1} from TSP (20 % P), K @ 60 kg ha^{-1} from MoP (50 % K), S @ 10 kg ha^{-1} from gypsum (18 % S) and Zn @ 1.5 kg ha^{-1} from ZnO (78 % Zn). Urea was applied in three equal splits - final land preparation and 30 and 45 days after sowing. Boric acid (17%B) was applied to the B treatment plots prior to sowing. The crop was irrigated 2 times- 21 days (crown root initiation) and 47 days (heading stage) of sowing. The crop was harvested at maturity after about four months of sowing and the grains were analyzed for N treatment wise. Then the protein content of the wheat grains was calculated. The data were analyzed statistically (Gomez and Gomez, 1984). Soil samples were analyzed for texture, pH, OM, total N and available P, K, S, Zn, S and B contents.

Results and Discussion

The results in the Table 1 indicate that the application of boron significantly increased the grain nitrogen and protein content of wheat both in 2007-08 and

2008-09. Protein content of the wheat grain in the boron treated plot was 13.45% in 2007-08 and 14.31% in 2008-09 while the corresponding values of untreated plot was 10.20% and 10.55%, respectively. The N content of the wheat grain in 2007-08 and 2008-09 were 2.26% and 2.51% in the B treated plots while the corresponding values in the control plots were 1.79% and 1.85%, respectively.A significant variation in the nitrogen and protein content of wheat grains was observed among the wheat varieties in both the years. The protein content of wheat grains in 2007-08 ranged from 12.26% to 11.40% and that in 2008-09 ranged from 12.94% to 11.74%.The variety Prodip recorded the maximum grain protein (12.26%) in 2007-08 while the highest value in 2008-09 was noted with the variety Sourav (12.94%).The variety Shatabdi recorded minimum grain protein in both the years. The N content in the grains of wheat varieties Pradip, Shatabdi and Sourav ranged from 2.00 % to 2.15 % in 2007-08 and 2.06% to 2.27% in 2008-09.

Table 1. Effects of boron, variety and sowing date on N and protein content of wheat grain

Boron /Variety /Sowing date	Grain N (%)		Protein content (%)	
	2007-08	2008-09	2007-08	2008-09
Boron dose				
B_0	1.79	1.85	10.20	10.55
B_1	2.36	2.51	13.45	14.31
LSD (P = 0.05)	0.06	0.08		
Variety				
Prodip (V_1)	2.15	2.21	12.26	12.60
Shatabdi (V_2)	2.00	2.06	11.40	11.74
Sourav (V_3)	2.08	2.27	11.86	12.94
LSD (P = 0.05)	0.01	0.02		
Sowing date				
November 18 (S_1)	2.09	2.22	11.91	12.65
November 28 (S_2)	2.18	2.34	12.43	13.34
December 08 (S_3)	2.09	2.09	11.91	11.91
December 18 (S_4)	1.95	2.06	11.12	11.74
LSD (P = 0.05)	0.02	0.03		

LSD=Least significant difference

Sowing date of wheat seed also influenced considerably the grain N and protein content of wheat in both the years. The grain protein content of wheat for 18 November, 28 November , 08 December and 18 December sowing ranged from 12.43% to 11.12% in 2007-08 and 13.34% to 11.74% in 2008-09.The 28 November sowing recorded the maximum protein content in wheat grains while the minimum value was noted with the 18 December sowing in both the years. The protein content in wheat grains may be ranked in the order of 28 November > 18 November > 08 December >18 December sowing. The N content in wheat grains due to different sowing dates ranged from 1.95% to 2.18% in 2007-08 and 2.06% to 2.34% in 2008-09. In both the years, the 28 November sowing recorded the maximum N content in wheat grains and the minimum value was noted with the 18 December sowing.

Table 2. Interaction effects of boron × variety and boron × sowing date on N and protein content of wheat grain

Interactions	Grain N (%)		Protein content (%)	
	2007-08	2008-09	2007-08	2008-09
Boron × Variety				
V_1B_0	1.89	1.83	10.77	10.43
V_1B_1	2.40	2.58	13.68	14.71
V_2B_0	1.71	1.74	9.75	9.92
V_2B_1	2.29	2.38	13.05	13.57
V_3B_0	1.78	1.97	10.15	11.23
V_3B_1	2.39	2.56	13.62	14.59
LSD (P = 0.05)	NS	NS		
Boron × Sowing date				
S_1B_0	1.70	2.07	9.69	11.80
S_1B_1	2.47	2.38	14.08	13.57
S_2B_0	1.88	2.03	10.72	11.57
S_2B_1	2.48	2.65	14.14	15.11
S_3B_0	1.89	1.67	10.77	9.519
S_3B_1	2.29	2.52	13.05	14.36
S_4B_0	1.70	1.62	9.69	9.23
S_4B_1	2.20	2.49	12.54	14.19
LSD (P = 0.05)	0.05	0.05		

LSD=Least significant difference

The interaction effects of boron x variety and boron x sowing date of wheat on the N and protein content of wheat grains were studied and a considerable variation was observed (Table 2). The grain N content due to boron x variety interactions in 2007-08 ranged from 1.71% to 2.39% and that in 2008-09 ranged from 1.74% to 2.58%.The corresponding protein contents in wheat grains ranged from 9.75% to 13.68% and 9.92% to 14.71%, respectively. The N content in the wheat grains due to boron x sowing date interactions ranged from 1.70% to 2.48% in 2007-08 and 1.62% to 2.65% in 2008-09 while the corresponding protein content in wheat grains ranged from 9.69% to 14.14% and 9.23% to 15.11%, respectively.

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