

**RESPONSE OF YIELD, NITROGEN USE EFFICIENCY AND GRAIN  
PROTEIN CONTENT OF WHEAT (*TRITICUM AESTIVUM* L.)  
VARIETIES TO DIFFERENT NITROGEN LEVELS**

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**Abstract**

A field experiment was carried out in order to investigate the response of nitrogen use efficiency and yield of two wheat varieties to different nitrogen levels. The wheat varieties, *viz.* Bijoy (V<sub>1</sub>) and Prodig (V<sub>2</sub>) were tested under 4 levels of nitrogen (N<sub>0</sub> = 0 kg N/ha, N<sub>1</sub> = 60 kg N/ha, N<sub>2</sub> = 120 kg N/ha and N<sub>3</sub> = 180 kg N/ha) where wheat varieties assigned in main plot and nitrogen treatments in subplot. Grain yield was increased with increasing rates of nitrogen. Maximum grain yield (3.85 kg/ha) produced by the variety Prodig when N applied @ 180 kg/ha and minimum (1.15 kg/ha) by the variety Bijoy under control treatments. Interactions of two variety and nitrogen levels; N uptake by grain and straw increased with increasing nitrogen levels. Highest N uptake by grain (90.60 kg/ha) and straw (25.53 kg/ha) were observed from the variety Prodig with 180 kg N/ha. Highest (38.66) N use efficiency (NUE) was noticed in Prodig when received 60 kg N/ha. Grain protein (%) also showed maximum value (14.29) when Prodig fertilized with 180 kg N/ha. Between two varieties, Prodig was the best performer with 180 kg N/ha due to maximum nitrogen content and uptake in grain and straw, maximum N use efficiency fertilizer recovery percentage and grain protein.

**Introduction**

Wheat (*Triticum aestivum* L.) is considered as first important cereal crop of the world in view of area and production. It is the second important cereal crop of Bangladesh after rice. Wheat has some special advantages over rice as the food value. It contains carbohydrate (78.1%), protein (14.7%), minerals (2.1%), fat (2.1%) and considerable proportion of vitamins (Mondal *et al.* 2015). Variety has a significant role in yield response of wheat due to its differential genotypic characters, input requirement and growth cycle; as a result farmers of Bangladesh use diverse improved varieties with several yield contributing characters differing from one variety to another (Kumar *et al.* 2011). The growth process of wheat plants under a given agro-climatic condition differs with variety (BARI 2010).

Nitrogen (N) is an essential element for growth, development and biomass production; it also plays important roles in physiological functions (Kaur *et al.* 2016). Boundless use of large amounts of N increases production costs and reduce the economic benefits (Ju *et al.* 2009). Excess use of nitrogen causes environmental pollution by leaching nitrate ion into groundwater and runoff into surface water (Conley *et al.* 2009). The agricultural soils of Bangladesh are grossly N deficient. Crop response depends on soil type, soil fertility, management practices and crop variety also on the dose and method of N application (Rahman *et al.* 2011). Efficient use of N by wheat is needed to sustain or increase yield and quality, while reducing the negative impacts of fertilizer on the environment (Foulkes *et al.* 2009). For economic wheat production and protection

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of ground and surface water, proficient N utilization is of utmost important (Vukovic *et al.* 2008). The genetic variation in both acquisition and internal-use efficiencies indicates that there is potential for increases in efficiency of nitrogen use through proper genotype selection, particularly under nitrogen limiting environments (Giller *et al.* 2004). Considering the above points, the present study was undertaken under field conditions to assess the impact of different levels of N on yield and yield contributing characters of two wheat varieties and to identify variety that possesses high yield, grain protein content and nitrogen use efficiency.

### Material and Methods

The present research work was carried out at farmers field of Siroil village under the Godagari Upazila of Rajshahi (24°28'N latitude and 88°19.8'E longitude), Bangladesh during the period from November 2013 to April 2014. The land belongs to AEZ 26, High Barind Tract and the soil was clay loam in texture, having pH 6.44. The soil contained 1.24% organic carbon, 0.08% N, available P 16 ppm, available K 0.20 meq/100g, available S 12.25 ppm, available Zn 0.42 ppm and water holding capacity of 28.52%. The experimental area was situated under subtropical climate characterized by heavy rainfall during Kharif season (April to September) and scanty rainfall during Rabi season (October to March). The experiment was laid out in a split-plot design with three replications, where two varieties of wheat were assigned in main plots *viz.* V<sub>1</sub>: Bijoy, V<sub>2</sub>: Prodig and four nitrogen levels were assigned in sub-plots *viz.* N<sub>0</sub> = 0 kg N/ha, N<sub>1</sub> = 60 kg N/ha, N<sub>2</sub> = 120 kg N/ha and N<sub>3</sub> = 180 kg N/ha. Seeds were sown continuously in line on 21 November, 2013 with 20 cm distance maintained from line to line. The plots were fertilized with P, K, S and Zn at the rate of 20-50-12-1 kg/ha (BARC 2012), respectively in the form of triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc oxide, accordingly during final land preparation as basal dose. Nitrogen fertilizer applied as granular form of urea into three splits, one third N as basal dose after final land preparation, second 1/3 N as top dressing during crown root initiation stage (CRI) and the rest 1/3 N as top dressing during flowering stage. Irrigation and intercultural operations were done as and when required. At maturity (29 March, 2014), the experimental crops were harvested plot wise. Prior to harvesting 1 m<sup>2</sup> plant samples were selected randomly and uprooted from each plot for data recording. The grain and straw samples were dried in an oven at 65°C for about 48 hrs and then ground by a grinding machine to pass through a 20-mesh sieve. The ground plant materials (grain and straw) were stored in paper bags in a desiccator. The N contents of grain and straw were measured following the Kjeldahl method (Bremner and Mulvaney 1982). Nitrogen use efficiency (NUE) and Apparent Recovery Nitrogen Use Efficiency percentage (ARNE) were calculated according to Moll *et al.* (1982) by using the following formula:

$$\text{NUE} = \text{Grain yield (kg/ha)} / \text{Amount of N applied (kg/ha)}$$

Protein content in grain was calculated by conversion of N content following method of FAO (2002): % protein in grain = % N in grain × 5.83.

All the recorded data were statistically analyzed following the ANOVA techniques and the significance of mean differences were adjudged by DMRT (Gomez and Gomez 1984) with the help of computers software MSTAT.

### Results and Discussion

Yield component like, number of tillers per plant, spike length, grains per spike, and 1000-grain weight responded differently by individual and combined effect of variety and different N treatments. Between two varieties, maximum number of tillers produced by Prodig (4.09) (Table 1). Tiller per plant also varied with different N levels (Table 1), highest tiller per plant (5.05) was

produced when N applied @ 180 kg/ha (N<sub>3</sub>) and lowest (1.78) found from control treatment of nitrogen (N<sub>0</sub>). Kibe and Singh (2003) mentioned that, number of effective tillers per meter significantly and progressively increased with increase in nitrogen application. The interaction of variety and N levels also affected significantly, maximum number of tiller per plant (5.60) produced by the variety Prodip (V<sub>2</sub>) when N applied @ 180 kg/ha which is similar to N<sub>2</sub> (120 kg N/ha) with same variety and minimum number of tillers (1.46) produced by Bijoy (V<sub>1</sub>) from unfertilized plot of nitrogen i.e. N<sub>0</sub> (Table 2). Increases in number of fertile tillers with the progressive rate of nitrogen can be ascribed to the decline in mortality of tillers and enabling the production of more tillers from the main stem (Ali *et al.* 2003). Two varieties of wheat produced significantly different lengths of spike (Table 1). Longer spike (16.79 cm) produced by the variety V<sub>2</sub> compared to V<sub>1</sub> with value 14.77 cm. Differences in length of spike between two varieties of wheat might be due to genetic makeup of the genotypes which was reported by Ashgar *et al.* (2005).

**Table 1. Effect of variety and N level on yield and yield components of wheat.**

Variety	Tillers/ plant (no.)	Spike length (cm)	Grains/spike (No.)	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
V1	3.25 b	14.77 b	29.63 b	43.57 b	2.52 b	3.79
V2	4.09 a	16.79 a	35.73 a	49.25 a	2.74 a	3.77
LS	0.05	0.01	0.01	0.05	0.05	NS
Nitrogen level						
N0	1.78d	12.66 c	22.63 d	39.79 d	1.28 d	2.44 d
N1	3.18 c	15.49 b	29.19 c	45.26 c	2.20 c	3.53 c
N2	4.66 b	16.97 a	37.05 b	49.11 b	3.32 b	4.28 b
N3	5.05 a	18.00 a	41.85 a	51.48 a	3.73 a	4.96 a
LS	0.01	0.01	0.05	0.05	0.01	0.05

In a column, figures having similar letter(s) and without letter(s) do not differ significantly as per DMRT. LS = Level of significance, CV (%) = Coefficient of variation.

Different N levels had significant effect on the spike length (Table 1). Longest spike (18.00 cm) was produced by the treatment N<sub>3</sub> which is similar to the treatment N<sub>2</sub>. The combination of variety Prodip with N<sub>3</sub> produced the longest spike (18.80 cm) and the shortest (11.06 cm) was found from the variety Bijoy under control treatment of N (Table 2). These results are in conformity with the result of Ali *et al.* (2012) regarding the effect of nitrogen on the varietal means of spike length. Aaron *et al.* (2006) reported that, normally the number of grains per spike is ascertained at panicle primordial formation stage which is highly dependent on genetic factors rather than management factors. Grain number per spike of two wheat varieties differ significantly (Table 1), maximum grains in spike (35.73) recorded in the variety Prodip compared to Bijoy (29.63). Regarding main effect of N levels, highest number of grain per spike (41.85) was observed from the treatment N<sub>3</sub> and the lowest (22.63) found from the zero nitrogen treatment (Table 1). Similarly, Khan *et al.* (2010) mentioned that number of grain/panicle of rice increased due to the higher rate of nitrogen. The interaction effect of variety and N levels also influenced grain production (Table 2). Maximum grains per spike (46.50) was produced by V<sub>2</sub> when it received 180 kg N/ha and minimum (20.87) produced by V<sub>1</sub> with zero nitrogen treatment. Islam *et al.* (2011) reported that, grain number per spike of wheat varied significantly due to interaction of variety and urea super granule (USG) levels.

**Table 2. Interaction effect of variety and N level on yield and yield components of wheat.**

Interaction (V × N)	Tillers/ plant (no.)	Spike length (cm)	Grains/ spike (no.)	1000-grain weight (g)	Grain yield t/ha)	Straw yield (t/ha)
V <sub>1</sub> N <sub>0</sub>	1.46 f	11.06 d	20.87 h	37.62 f	1.15 d	2.44 d
V <sub>1</sub> N <sub>1</sub>	2.90 d	14.38 c	27.18 f	41.96 e	2.08 c	3.53 c
V <sub>1</sub> N <sub>2</sub>	4.13 b	16.44 b	33.27 d	45.86 d	3.23 b	4.20 b
V <sub>1</sub> N <sub>3</sub>	4.50 b	17.20 ab	37.20 c	48.83 c	3.60 ab	5.00 a
V <sub>2</sub> N <sub>0</sub>	2.10 e	14.27 c	24.39 g	41.96 e	1.40 d	2.43 d
V <sub>2</sub> N <sub>1</sub>	3.47 c	16.60 b	31.21 e	48.55 c	2.32 c	3.53 c
V <sub>2</sub> N <sub>2</sub>	5.20 a	17.50 ab	40.82 b	52.36 b	3.40 ab	4.23 b
V <sub>2</sub> N <sub>3</sub>	5.60 a	18.80 a	46.50 a	54.12 a	3.85 a	4.92 a
LS	0.05	0.05	0.05	0.05	0.05	0.05

In a column, figures having similar letter(s) and without letter(s) do not differ significantly as per DMRT. LS = Level of significance, CV (%) = Coefficient of variation. Where, V<sub>1</sub>= Bijoy and V<sub>2</sub>= Prodig; are two variety of wheat. N<sub>0</sub>= 0 kg N/ha, N<sub>1</sub> = 60 kg N/ha, N<sub>2</sub> = 120 kg N/ha and N<sub>3</sub> = 180 kg N/ha.

Weight of 1000-grain of two wheat varieties was affected significantly due to genotypic difference (Table 1). Highest 1000-grain weight (49.25 g) was recorded from Prodig compared to Bijoy (43.57 g). Genotypic variation in 1000-grain weight was also observed by other researchers in wheat. Alam *et al.* (2006) and Irfan *et al.* (2005) also found similar result. In case of main effect of nitrogen dose (Table 1), maximum thousand grain weight (51.48 g) was also recorded when the N applied @ 180 kg/ha. Due to interaction the maximum 1000-grain weight (54.12 g) was observed from the variety Prodig when it received 180 kg N/ha and the minimum (37.62 g) was produced by Bijoy under control treatment of nitrogen (Table 2). As observed in our study, reports in the literature also indicate that 1000-grain weight increases with increasing dose of N in wheat (Guarda *et al.* 2004).

Grain yield is a product of an organized interplay of its several components, which are highly susceptible to environmental fluctuations. The individual effect of variety, different N levels and their interactions influenced significantly the grain yield of wheat. Between two varieties, V<sub>2</sub> performed better regarding grain yield with value 2.74 t/ha; on the other hand, variety V<sub>1</sub> produced lower value 2.52 t/ha (Table 1). Grain yield increased with the increasing N levels and maximum grain yield (3.73 t/ha) recorded from the treatment N<sub>3</sub> and lowest (1.28 t/ha) from the N<sub>0</sub> treatment (Table 1). Regarding the interaction of two wheat varieties and four nitrogen levels, highest grain yield i.e. 3.85 t/ha was produced by Prodig when it received N @ 180 kg/ha. The lowest yield produced by Bijoy (1.15 t/ha) under zero nitrogen treatment is also statistically similar to the lowest yield of Prodig (1.40 t/ha) following zero N treatment (Table 2). According to Kazi *et al.* (2012) and Abbas *et al.* (2013) different yield contributing components like number of effective tiller, number of grains per spike, spike length, number of spikelets/spike and 1000 grain weight contribute towards final grains yield and in this study maximum of these value was found from the variety Prodig when it received 180 kg of N/ha. An increase of nitrogen levels up to 180 kg/ha increased grain yield of wheat and its components like number of tillers, spike length, number of grain per spike (Noureldin *et al.* 2013).

Due to the varietal effect straw yield was not influenced significantly but affected by different N levels (Table 1) and its interaction with two varieties. Like grain yield, the maximum straw yield (4.96 t/ha) was also found from the treatment N<sub>3</sub> and the minimum (2.44 t/ha) in the treatment N<sub>0</sub>. In case of interaction effects (Table 2), highest straw yield (5.00 t/ha) produced by

variety Bijoy when fertilized with 180 kg N/ha is statistically identical to the variety Prodip with same nitrogen dose. The minimum straw yield (2.43 t/ha) produced by Prodip with zero nitrogen condition ( $V_2N_0$ ) is also statistically similar to the variety Bijoy with same N levels. According to Haque *et al.* (2015) progressive levels of N significantly increased straw yield of rice. This increase in yield from the supply of N fertilizer may be because of the fact that this nutrient being involves in various metabolic processes which have direct impact on vegetative phases of plants (Chaturvedi 2006).

Nitrogen uptake by grain of two wheat varieties differs significantly. The maximum N uptake by grain (60.51 kg/ha) was recorded from Prodip and the minimum (50.55 kg/ha) was found from Bijoy but the N uptake by straw was insignificant (Table 3). Khaleque *et al.* (2008) reported that, total N uptake varied with different genotypic variations. Different N dose significantly influenced the N uptake of grain and straw. The highest N uptake by grain (86.01 kg/ha) and straw (23.01 kg/ha) observed from the treatment  $N_3$  and the lowest N uptake by grain (23.00 kg/ha) and straw (6.39 kg/ha) was found due to  $N_0$ . This indicated that N uptake increased with progressive rates of N. In case of combined effect of variety and N levels (Table 4), variety Prodip ( $V_2$ ) uptake maximum N by grain (94.60 kg/ha) and straw (25.53 kg/ha) when it received 180 kg N/ha and minimum uptake by grain (19.40 kg/ha) and straw (6.80 kg/ha) observed by Bijoy also under zero N treatment. Pandey *et al.* (2008) reported that the uptake of nitrogen by crop increased significantly with successive increase in nitrogen level. The highest level of nitrogen uptake (81.3 kg/ha) recorded with 120 kg N/ha which was significantly higher than 0 kg N/ha (33.0 kg/ha) on clay loam soil. The combined effect indicated that Prodip is more proficient in uptake of nitrogen under same fertility condition.

**Table 3. Effect of variety and N level on N uptake, N use efficiency and protein content in grain of wheat.**

Variety	N uptake by grain (kg/ha)	N uptake by straw (kg/ha)	N use efficiency	Protein content in grain (%)
$V_1$	50.55 b	12.80	27.18	11.42
$V_2$	60.51 a	15.18	29.46	12.44
LS	0.05	0.05	NS	NS
<b>Nitrogen levels</b>				
$N_0$	23.00 d	6.39 d	-	10.64 c
$N_1$	42.10 c	10.48 c	36.63 a	11.23 bc
$N_2$	71.03 b	16.08 b	26.64 b	12.45 ab
$N_3$	86.01 a	23.01 a	20.69 c	13.41 a
LS	0.01	0.05	0.05	0.05

In a column, figures having similar letter(s) and without letter(s) do not differ significantly as per DMRT.

LS = Level of significance, CV (%) = Coefficient of variation.

Genotypic difference between two wheat varieties singly did not affect the nitrogen use efficiency but different levels of nitrogen influenced significantly (Table 3). Regarding the main effect of nitrogen, maximum value (36.63) when N applied @ 60 kg/ha and minimum (20.69) found when the plot received 180 kg N/ha. The result is in agreement with the work of Li *et al.* (2013) who reported that the NUE of wheat decrease with increasing N fertilization rate.

Considering the interaction of varietal difference and different N levels (Table 4), highest NUE (38.66) observed by the variety Prodip with 60 kg N/ha which had no significant difference from Bijoy with value 34.59 under same nitrogen treatment. The minimum (20.00) NUE was

found from Bijoy with 180 kg N/ha and that found from Prodip (21.39) with the same treatment are not significantly different. This indicates that nitrogen use efficiency of two wheat varieties are more or less similar under same nitrogen treatment. Zhao *et al.* (2006) observed that, decrease in NUE with increasing fertilizer rates is due to less increase in grain yield in comparison to N supply in sorghum. The NUE of barley genotypes grown in the field conditions rely on the level of N applied was also reported by Beatty *et al.* (2010).

**Table 4. Interaction effect of variety and N level on uptake, N use efficiency and protein content in grain of wheat.**

Interaction (V × N)	N uptake by grain (kg/ha)	N uptake by straw (kg/ha)	N use efficiency	Protein content in grain%
V <sub>1</sub> N <sub>0</sub>	19.40 e	6.80 f	-	10.11 c
V <sub>1</sub> N <sub>1</sub>	40.46 d	9.54 ef	34.59 a	11.37 bc
V <sub>1</sub> N <sub>2</sub>	64.92 c	14.35 cd	26.94 bc	11.68 bc
V <sub>1</sub> N <sub>3</sub>	77.42 b	20.50 b	20.00 d	12.54 ab
V <sub>2</sub> N <sub>0</sub>	26.60 e	5.97 f	-	11.17 bc
V <sub>2</sub> N <sub>1</sub>	43.72 d	11.41 de	38.66 a	11.08 bc
V <sub>2</sub> N <sub>2</sub>	77.13 bc	17.80 bc	28.34 b	13.21 ab
V <sub>2</sub> N <sub>3</sub>	94.60 a	25.53 a	21.39 cd	14.29 a
LS	0.05	0.05	0.05	0.05

In a column, figures having similar letter(s) and without letter(s) do not differ significantly as per DMRT. LS = Level of significance, CV (%) = Coefficient of variation. Where, V<sub>1</sub>= Bijoy and V<sub>2</sub>= Prodip; are two variety of wheat. N<sub>0</sub>= 0 kg N/ha, N<sub>1</sub> = 60 kg N/ha, N<sub>2</sub> = 120 kg N/ha and N<sub>3</sub> = 180 kg N/ha.

Due to the main varietal effect, % protein content in the grain of Bijoy (11.42) and Prodip (12.44) was insignificant (Table 3) whereas, main effect of N level and their interaction with variety influenced significantly. Considering single effect of N levels maximum (13.41%) and minimum (10.64%) value found from the treatment N<sub>3</sub> and N<sub>0</sub>, respectively (Table 3). Brian *et al.* (2007) also reported an increase in grain protein concentration with N levels. Table 4 showed that the highest % protein in grain (14.29%) was found when the variety Prodip fertilized with nitrogen @ 180 kg/ha and lowest (10.11%) found from Bijoy under zero nitrogen treatment. Cooper *et al.* (2001) reported wheat grain protein significantly influenced by interaction of different genotypes with various levels of N supply. Due to higher supply of N plant uptake and accumulate more nitrogen in grain which is considered as building blocks in the synthesis of proteins (Khursheed and Mahammad 2015).

It can be concluded from these results that wheat variety Prodip coupled with application of 180 kg N/ha will be a promising practice for high grain yield of wheat with good quality i.e., rich in protein and this variety also performed better considering the nitrogen use efficiency when interact with the same levels of nitrogen compared to the variety Bijoy.

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