RESPONSE OF WHEAT VARIETIES TO DIFFERENT LEVELS OF NITROGEN FERTILIZER

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ABSTRACT

A field experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207 during November 2012 to March 2013 to evaluate the response of wheat variety by different levels of nitrogen. The experiment included three varieties viz., BARI Gom-23 (V_1), BARI Gom-24 (V_2) and BARI Gom-25 (V_3) and four levels of nitrogen viz., N_1 = 75 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 125 kg N ha^{-1} and N_4= 150 kg N ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results revealed that nitrogen had significant effect on growth, yield and quality and other parameters. The value of all parameters studied in this experiment increased with increasing nitrogen levels up to 125 kg ha^{-1} and thereafter decreased with fertilizer increasing level. Significant variation was recorded for plant height, number of leaves $plant^{-1}$, leaf length and dry matter content due to varieties and/or nitrogen levels. Grains ear^{-1}, number of fertile grains $plant^{-1}$, 1000- grain weight, grain yield and harvest index were also significantly influenced by varieties and/or nitrogen levels. Results demonstrated that the variety BARI Gom-24 with application of 125 kg N ha^{-1} produced the maximum grain yield (4.71 t ha^{-1}), harvest index (49.37 %) and protein content (10.88 %). Among the twelve treatment combinations, the variety BARI Gom-24 showed the best performance when fertilized with 125 kg N ha^{-1} along with recommended amount of other nutrients.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

%	:	Percentage
@	:	At the Rate of
Abstr.	:	Abstract
AEZ	:	Agro-ecological Zone
Agric.	:	Agriculture
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ratio
cm.	:	Centimeter
cv.	:	Cultivar
DAS	:	Day After Sowing
et al.	:	et alii (and others)
FAO	:	Food and Agriculture Organization of the United Nations
Fig.	:	Figure
FW	:	Fresh weight
FYM	:	Farm Yard Manure
G	:	Gram
Hort.	:	Horticulture
i.e.	:	That is
J.	:	Journal

K	:	Potassium
kg	:	Kilogram
LSD	:	Least Significant Difference
M	:	Meter
MP	:	Murate of Potash
N	:	Nitrogen
NS	:	Non-significant
^{O}C	:	Degree Celsius
P	:	Phosphorus
RCBD	:	Randomized Complete Block Design
Sci.	:	Science
Soc.	:	Society
T	:	Tonne
ton/ha	:	Ton per hectare
Tk.	:	Taka
TSP	:	Triple Super Phosphate
UK	:	United Kingdom
UNDP	:	United Nations Development Program
Viz.	:	Namely

CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the first important cereal crop throughout the world and second in Bangladesh. It is the leading cereal crop which ranks first both in area (21,360 thousand hectares) and production (5,76,317 thousand metric ton) of the world (FAO, 2014). Wheat is grown across a wide range of environments around the world. More lands are devoted world-wide to the production of wheat than to any other commercial crop. Wheat is cool-loving crop and adopted for cultivation in regions with cooler climatic conditions. Its production is concentrated between latitudes 30^0 and 60^0 N and 27^0 and 40^0 S (Nuttonson, 1955). But wheat flourishes in many different agro-climatic zones. Bangladesh lies in the warmer part of the world and wheat is grown in the winter or cold season of the country. In consideration of the facts that growing of wheat in a location is decided by the temperature limits of 20^0 and 25^0C (Ray and Nathan, 1986). Its grain growth and development depend on temperature range of $15^0/10^0$ to $18^0/15^0$C (Thorne *et al.*, 1968), the best time of sowing of wheat in Bangladesh is the second half of November that needed around 105 days to complete its life cycle. About one-third people of the world live on wheat. It is a staple food for about one billion in as many as 43 countries and provides about 205 of total food calories. It contains carbohydrate (78.1%), protein (14.7%), minerals (2.1%), fat (2.1%) and considerable proportion of vitamins (Peterson, 1965).

Wheat contains about 12.1% protein on an average which is only 8.79% in rice (Mattem *et al.*, 1970). In the rice based cropping systems like Bangladesh, wheat is considered as the second most important cereal crop (Razzaque and Hossain, 1990). Wheat is terribly under populated in our country. The low yield of wheat may be due to various factors such as lack of varieties, good quality seed, untimely seedling, low fertilization, seed rate, sowing techniques etc.

Balanced fertilization and better cultural practices are needed to obtain higher yield as the potential of crops increase. This lead to the necessity of better methods of soil fertility diagnosis, when fertilizer is applied, the plant response is reflected by tissue composition although the relationship with the yield is not necessarily direct, moreover in the semi arid region, response to fertilizers depends on the amount and distribution of precipitation. Nitrogen is one of the basic elements required for obtaining higher wheat yield. It is largely used in the synthesis of protein, chlorophyll and other vital compounds which are attributed to all physiological and biochemical processes of plants. The response to N fertilization varies according to location, climate, crops and their varieties, characteristics of the soil, type, rate, time of fertilizer application and its placement (Mengel and Kirkby, 1978). An efficient use of fertilizers management seems to be important under Bangladesh conditions to increase wheat yield. The effect of nitrogen is more prominent and significant over other fertilizers, as because nitrogen is the integral part of protoplasm, protein and chlorophyll and results in larger cell size in turn increases plant height and crop yields (Hutchision and Talbot, 1983). Increasing crop yield through adequate nitrogen fertilization is a pertinent farm management tool. The basic requirement for high yield and quality of wheat ids that the plant receives optimum amount of nitrogen through the growing season (Dorsheimer and Issac, 1982). Unlike the other major plant nutrient elements, nitrogen is the most limiting one in most of the soils of Bangladesh for sustenance of optimum plant growth. Therefore, this nutrient is mostly added extraneously in order to supplement their deficiencies in soil for successful crop production.

But the addition of nitrogen beyond optimum level affects plant performance adversely. On the other hand, nitrogen either as nitrate or ammonium froms is very unstable in soil in its natural cycle. It is reported that split application of nitrogen is better than singles application in increasing the yield of wheat (Gravelle *et al.*, 1989). Rajput and Verma (1994) have shown that yield of wheat increased significantly by splitting the nitrogen applied at the critical crop growth stages. It is reported that top dressing and split application of nitrogen fertilizers at critical crop growth stages of wheat are now emphasized (Singh, 1988) as it is more beneficial than applying as single dose at sowing (Randhawa *et al.*, 1976). However, the yield response varies with number of split and time/stage of nitrogen application. Hence, it would be a good effort to develop an effective schedule for nitrogen management for wheat crop by the way of quantity split and time of application on a particular set of environmental situation.

Protein is an important quality component of cereal grain. The quality of wheat is directly related to protein content. High grain protein level in wheat is an important consideration for human nutrition in advanced countries of the world. But the varieties grown in the country are of low to medium protein content (Warsthorn, 1988). High grain quality required a steady nutrient supply. Many author have found that most of the nitrogen uptake wheat plants occur before an thesis (Dhugga and Waines, 1989; Frank *et al.*, 1989). However, it is a common practice in cultivation of cereal crops to split the total amount of fertilizer. In Bangladesh, very little research work has been done on wheat grain protein content and to acknowledge no work seems to have been reported on its relation with grain yield, as regards of in view of the limited information on the aforesaid problems a study was therefore, undertaken to determine the response of wheat varieties to different levels of nitrogen and protein content of wheat.

The following experiment has these objectives:

1. To find out the yield performance of three wheat varieties as influenced by nitrogen levels.
2. To find out the suitable variety and optimum N level for maximizing grain yield and protein content.

CHAPTER II

REVIEW OF LITERATURE

A large number of research works on yield and quality of wheat and its response to variety and nitrogen have been carried out in different wheat growing countries of the world. Research activities on the effect of variety and fertilization are few in Bangladesh. Some of the literatures pertinent to this study are reviewed below:

2.1 Effect of varieties

2.1.1 Effect on plant characters, yield components and grain yield

2.1.1.1Plant height

Anonymous (1972) observed that varieties differed significantly for plant height. Amin *et al*. (1993) reported that plant height of Aghrani and Kanchan were 90.13 and 93.38 cm, respectively. Sarker *et al.* (1996) found that plant height of Kanchan was 89.3 cm. Hossain *et al.* (1996) reported that plant height of Akbar was 85.1 cm with the fertilizer rate 160 N; 100 P; 80 K kg/ha. Shrestha (1988) reported that plant height was variable for different wheat varieties, namely. Lerma 52, RR – 21, UP – 262, Tribeni, Lumbini, Bhaskar, Siddhortha and Vindyak.

Anonymous (1972) reported that varieties differed significantly in producing total tillers and fertile per plant. He also reported that all these characters were highest in penjamo – 62 variety.

2.1.1.2 Grains ear^{-1}

Kratzsch (1982) reported that varietal differences were observed for number of ears per unit area, number of grains per ear. Ceapoiu *et al.* (1982) found that winter wheat cv. Fundulea 29 produced 33.9 grains per ear which was higher than in the other three cultivars. Tripathi (1978) reported that of 12 Wheat cultivars given NPK, the high yielding cultivars were characterized by greater number of grains per ear. Malik (1981) obserbed that increasing N rates from 0 to 120 kg/ha applied to two irrigated wheat cultivars increased grains per ear. Shrestha (1988) reported that grains per ear was variable for different wheat varieties, namely, Lerma 52, RR – 21, UP -262, Tribeni, Lumbini, Bhaskar, Siddhartha, and Ninayak. Hossain *et al.* (1996) peported that grains per ear was 28.6 in Akbar variety.

2.1.1.3 1000 – grain weight

Anonymous (1972) reported that varieties differed significantly for 1000 – grain weight. Norteo 67 produced the highest weight of 1000 grains which was significantly higher than those of the other varieties. Sarkar *et al.* (1996) reported that 1000 – grain weight was variable for different wheat varieties, namely Lerma – 52, RR – 21, UP – 262, Tribeni, Lumbini, Bhaskar, Siddhartha, and Binayak.

Bengtsson (1985) reported that 1000 – grain weight ranged from 41.2 g in cv. WW 28182 to 52.0 g in LP 468971. Amin *et al.* (1993) reported that 1000 – grain weight of Aghrani was 42.59 g. Kratzsch (1982) reported that varietal differences were obserbed for 1000 – grain weight. Tripathi (1978) reported that 12 wheat cultivars given NPK, the high yielding cultivars were characterized by higher 1000 – grain weight.

2.1.1.4 Grain yield

Bostal *et al.* (1989) reported that wheat cv. Slavia was given 150 kg N as N, 42 kg P and 100 kg K/ha. N was applied at various growth stages which increased grain yield by 48 – 82%. Ali *et al.* (1984) reported that Sonalika gave maximum average grain yields due to the highest treatment N 160, P 80, K 60, S 30 and Zn 8 which were 3.2, 3.3, 2.6 and 4.1 t/ha, respectively, for Mymensingh, Jamalpur, Madhupur and Ishurdi. They reported that addition of 40 kg S/ha in Madhupur soil significantly increased the grain yield of cv. Sonalika with a record of 2.4 t/ha in S added plot and 1.96 t/ha in the control.

Gandapur and Bhatti (1983) reported that highest yield was obtained with 180 kg N and 65 kg P_2O_5, cv. Khasal – 69 yielded highest followed by cv. Mexi – pak – 69. All cultivars produced higher yields at higher N rates when applied in combination with P. Islam *et al.* (1987) reported that nitrogen fertilizer increased average grain yield of Sonalika from 1.3 t/ha in the unfertilized control to 3.54 t/ha with 180 kg/ha nitrogen. The unfertilized control to 3.54 t/ha with 180 kg/ha nitrogen. The maximum of 3.82 t/ha of grain was obtained from 180 kg/ha nitrogen and 80 kg/ha P_2O_5application. Malik (1981) observed that increasing N rates from 0 to 120 kg/ha applied to two irrigated wheat cultivars increased average grain yield from 1.34 to 4.57 t/ha. Sarkar *et al.* (1996) conducted an experiment with 13 varieties of wheat. Among the varieties highest yield (2.21 t/ha) was given by HI – 784 and lowest by UP – 1008 (0.99 t/ha).

Das and Kashyapi (1988) studied nine wheat cultivars given four NPK rates. Application of 120 kg N + 60 kg P_2O_5+ 40 kg K_2O/ha gave the highest grain yield of 3.16 t/ha compared with 1.16 t/ha without NPK. At this NPK rate CPAN – 1998 gave the highest yield of 3.67 t/ha followed by HI – 1114 with 3.31 t/ha; other cultivars yielded 3.01 – 3.16 t/ha. Anonymous (1972) reported that Aghrani and Kanchan were found responsive to high dose of N level and gave increased yield with increased rate of N. But Akbar showed positive response up to 60 kg/ha N application.

Sarkar *et al.* (1996) observed Kanchan produced 2.7 t/ha grain yield. Malik (1981) reported that without fertilizer application average yield of dwarf and tall cultivars were 2.09 t/ha and 1.63 t/ha, respectively. Yield increase of 528 and 328 to fertilizer application were recorded in the semidwarf and tall groups, respectively.

2.1.1.5 Straw yield

Anonymous (1972) is a study with some varieties of wheat observed that varieties differed significantly in producing straw yield. He also reported that straw yield and other characters were highest in Penjamo – 62 variety. Bengtsson (1985) reported that average straw yield ranged from 6.8 t/ha in cv. Brigand to 10.8 t/ha in cv. WW 28204.

Hossain *et al.* (1996) noticed that straw yield of cv. Akbar was 5.18 t/ha at the fertilizer rates 160 N: 100 P: 80 k kg/ha. Malik (1981) reported that the four varieties studied varied significantly in grain and straw yields. The mean grain and straw yields followed the order: Enkoy>Cocorit>DZ – 14 – 118 and Boohai.

2.2 Effect of Nitrogen

2.2.1 Effect of plant characters, yield components and grain yield

2.2.1.1 Plant height

Islam *et al.* (1987) found that N had the highest effect on plant height. Ahmed and Hossain (1992) observed that plant heights were 79.9 cm, 82.3 cm and 84.4 cm with 45, 90 and 135 kg N ha^{-1}, respectively. Plant height increased with increased nitrogenous fertilizer doses. Patel and Upadhyay (1993) reported that plant height was increased with increased N up to 150 kg/ha.

2.2.1.2 Length of ear

Patel and Upadhyay (1993) reported that length of ear increased up to 150 kg N/ha. Length of ear was 8.58 cm from 150 kg N/ha. Singh and Singh (1987) noticed that length of ear was affected favourablly up to the highest N rate of 120 kg/ha. Fuchs *et al.* (1969) reported that application of 34, 45 and 59 kg N ha^{-1} markedly increased the ear length.

2.2.1.3 Grains ear^{-1}

Andrascik *et al.* (1986) reported that the number of grains per ear was best at the highest NPK rates (170 kg N + 61.04 kg P + 116.20 kg K/ha). Stock *et al.* (1996) observed that number of grains per ear was not affected by N rate. Singh and Singh (1987) noticed that the number of grains per ear was affected favourably up to the highest N rate of 120 kg/ha.

Fuchs *et al.* (1969) reported that application of 34, 45 and 59 kg N/ha markedly increased the number of grains per ear. Patel and Upadhyay (1993) reported that organic manuring benefitted number grains per ear. Malik (1981) reported that increasing nitrogen from 0 to 120 kg/ha increased number of grains per ear.

2.2.1.4 1000 – grain weight

Patel and Upadhyay (1993) reported that 1000 – weight increased up to 150 kg N/ha. Stock *et al.* (1995) observed that 1000 grain weight was not affected by N rate. Singh and Singh (1987) noticed that yield attributes were affected favourably up to the highest N rate of 120 kg/ha except 1000 – grain weight. Kirallov and Pavolv (1989) found that application of N markedly increased 1000 grain weight. Patra (1990) reported that yield contributing characters except 1000 grain weight were not significantly influenced by doses up to the highest level of 120 kg N + 60 kg P_2O_5+ 60 kg K_2O/ha.

Ahmed and Hossain (1992) observed that increased N rate increased 1000 – grain weight. 1000 – grain weights were 39.5, 39.7 and 40.0 with 45, 90 and 135 kg N/ha respectively.

2.2.1.5 Grain yield

Knonv *et al.* (1985) reported that application of NPK was most effective in increasing grain yield farmyard manure (FYM) + NPK was best and its efficiency increased with increasing proportion of NPK. Curic (1988) carried out an experiment on cherozem soil at Rimski with 0, 50, 100 or 150 kg/ha each of N, $P_2O_5$and K_2O in 20 combinations. Grain yield ranged from 2.06 t/ha with 100 kg K_2O/ha to 6 t/ha with the highest rates of NPK. N and the greatest effect on yield. Patel and Upadhyay (1993) reported that the effect of inorganic fertilizer alone and its combined application with organic manures on grain yield was not significant. But all N (120 kg/ha) applied through N, 90 kg N/ha through N + 30 k g N/ha through castor cake produced significantly higher grain yield.

Curic (1988) reported that grain yield was most dependent on N than P and very little on K. Mamedov (1981) found that application of NPK and 0 – 40 kg S/ha gave the highest grain yield of 4.02 t/ha with 40 kg S/ha compared with 3.38 t/ha without Hossain *et al.* (1996) reported that grain yield was increased significantly by fertilizer. Highest grain yield was obtained by 120 N: 60 K kg/ha, the yield of grain being 3.72 t/ha. Canko and Bano (1986) reported that average grain yield of soft wheat CV. LBZ given N. P and K in various combination in the ranges 66 – 330, 36 – 90 and 50 or 100 kg/ha, respectively, was 4.65 – 6.22 t/ha compared with 2.48 t/ha when no NPK was applied. P and K rates had little effect on yield, which increased with increasing N rate up to 132 kg/ha. Naphade *et al.* (1975) reported that application of 25 t FYM/ha + NPK gave highest grain yield of 2.45 t/ha compared with 1.1 t/ha without FYM or NPK.

Naphade *et al.* (1975) noticed that grain yields were 1.34 and 1.74 t/ha for treatments given manure and manure + NPK, respectively, on light soils. Sarkar *et al.* (1996) found that the application of 60 or 120 kg N/ha to wheat at sowing or in two split dressings at sowing and before or after the first irrigation gave grain yields of 1.16 – 1.17 and 1.32 – 1.49 t/ha, respectively compared with 0.26 ton without N. The date of N application had no significant effect on yields. Randhawa *et al.* (1976) found that grain yield was highest when half the N was applied at sowing and rest at the start of flowering. Generally splitting the fertilizer dose was more beneficial than applying a single dose at sowing.

Ali *et al.* (1984) reported that the maximum average grain yields obtained due to the highest treatment of N 160, P 80, K 60, S 30, Zn 8 were 3.2, 3.3, 2.6 and 4.1 t/ha from Mymensingh, Jamalpur, Modhupur that application of 67.3 kg N + 67.3 kgP_2O_5/ha gave the highest yield of 3.18 t/ha was given by 128 kg N + 64 kg P_2O_5/ha + 40 t FYM/ha. Malik (1981) found that increasing nitrogen from 0 to 120 kg/ha increased grain yield from 1.34 to 5.47 t/ha. Yields did not increase further with addition of 160 kg N/ha. Duffera (1991) reported that all the varieties exhibited a significant grain yield response to increase N rate (0, 30, 60 and 90 kg/ha) having significant linear and quadratic components. The mean grain yields of the varieties followed the order: Enkoy>Cocorit>DZ – 04 – 118 and Boohai.

Islam *et al.* (1987) reported that grain yield of wheat progressively increased with higher rates of nitrogen but rates over 60 kg N/ha were not economically sound. Nitrogen at the rate of 120 kg N/ha gave the highest yield of 1.86 t/ha while 60 kg N/ha gave the highest return: Mathur *et al.* (1987) reported that FYM significantly affect yields. Curic (1988) carried out an experiment with 0, 50, 100 or 150 kg each N, P_2O_5 and K_2O in 20 combinations. Grain yields ranged from 2.06 t/ha with 100 kg K_2O/ha to 6 t/ha with the highest rate of NPK. N had the greatest effect on yield while P increased yields in the presence of N. Arora and Takkar (1989) reported that grain yield was increased by the manures and by the Mg, S, Zn, Cu and Mn treatment and increased with increasing NPK concentration. Highest yields were obtained with poultry manure and caused higher nutrient uptake at all NPK levels.

Ahmed and Hossain (1992) observed application of N at the rate of 135 kg/ha produced the highest seed yield ranging from 2.2 to 2.6 t/ha. Singh *et al.* (1992) reported that no significant variation in grain yield was observed due to methods of fertilizer placement.

Sekhon *et al.* (1994) observed grain yield in wheat was highest after FYM application. Andrascik *et al.* (1986) reported that grain yield was best at the highest NPK rate (170 kg N + 61.04 kg P + 116.20 kg K/ha). Stock *et al.* (1995) observed that with 19 kg N/ha wheat yield significantly increased. Dokic (1988) observed that N increased grain yields when applied at early stem elongation. Rajput and Verma (1994) found that grain yield was highest with 100 kg N and 60 kg P_2O_5/ha.

2.2.1.6 Straw yield

Hossain *et al.* (1996) reported that straw yield increased significantly by fertilizer. Straw yield was 5.18 t/ha at N 160: P 100: K 80 kg/ha. Singh *et al.* (1992) reported that no significant variation straw yield was observed due to methods of fertilizer placement.

Splitting the nitrogen application increases flour protein content and bread loaf volume according to Ayoub *et al.* (1994); Djoke and Denic (1985) observed that the crude protein increase by 35% on average for all vrieties when nitrogen is fed to the leaves at anthesis stage.

Phiri and Mwale (1995) suggested that a continuous and adequate supply of nitrogen which can be achieved by split applications of the top dressing fertilizer. The first done may be applied at about 6 weeks (full tiller stage) and the second at anthesis. The proportion of split application of top dressing should be about 75% of the recommended rate as the first and 25% as the second dose at anthesis for higher protein content.

Other studies by Olson e*t al.* (1964) showed that the later the vegetative stage at which nitrogen in applied up to bloom stage the less the effect on the vegetative growth weight and the greater the increase in grain protein. Liu *et al.* (1997) concluded that late nitrogen application was only useful at high soil fertility, and most of the nitrogen translocatedwas used for the synthesis of residual proteins. Grignani and Reyneri (1990) also found that grain protein content was higher with the later than earlier nitrogen application and increased with increase in nitrogen rate.

Protein content in wheat can be manipulated to some extent by the amount of fertilizer applied and the timing of application. Applying nitrogen to the soil early during crop development will generally result in high grain yield and applying nitrogen at flowering time or a little effect upon yield (Dampney and Salmon, 1990; Haldore *et al.*, 1982). Pelton (1992) found that nitrogen added at pollination mainly incrased the kernel weight and bread making quality.

2.3 Effect on quality of wheat

Basibekov and Umbetov (1984) reported that grain protein and gluten contents increased with increasing fertilizer rate, but slightly decreased the quality. Stock *et al.* (1995) found that increasing NPK rate increased true protein contents. Pelton (1992) reported that grain crude protein (CP) contents increased from 11.8 – 12.58 without N to 12.9 – 13.78 with 120 kg N, and 13.7 – 148 with 160 kg N/ha. The high rate of N reduced the contents of essential amino acids, non-essential amino acid in the gluten increased.

Pelton (1992) observed that increasing the N rate from 0 to 200 kg/ha increased the amino acid. N particularly improved proline and phenylalanine contents but had no effect on the proportion of essential amino acid. N fertilizer benefitted total amino acid contents especially on wet sites. Liu *et al.* (1997) observed that NPK fertilizer increased grain N, P, Mg, Fe and Mn concentration. But decreased K, Ca and Zn. Fertilizer application increased straw N and Cu concentration and decreased P, Mg and Zn concentration.

Konov *et al.* (1985) reported that application of NPK was most effective in increasing grain quality. FYM + NPK was the best, its efficiency increased with increasing proportion of NPK, and FYM alone had little effect on the quality of wheat. Dokic (1988) observed that N increased grain protein content when applied between stem elongation and anthesis. Manchenkov and Platonov (1971) reported that application of dung + NPK gave the highest yield of grain of good quality. The contents of cysteine, aspartic acid, glutamic acid, serine, tyrosine, phenylalanine and leucine in protein increased with increasing protein content, but the contents of lysine, histidine, threonine and glycine decreased.

Salomonsson *et al.* (1995) obserbed that there was no consistent difference in protein content with organic fertilizer and N treatment. The protein content was as high after a single early N application as after a split application. Konov *et al.* (1985) found that the wheat quality indicatorr were affected positively by the application of nitrogen. Morova *et al.* (1992) reported that protein production was lower at the maximum nitrogen done (200 kg/ha).

Konov *et al.* (1985) reported that nitrogen fertilizer increased the grain protein content from 30.3 to 40.98. Garmashov *et al.* (1985) observed that CP content of the grain of wheat increased with increasing N rates and benefited from split dressing.

Singh *et al.* (1992) reported that protein content of grain was significantly higher with increasing the level of nitrogen (120 kg/ha). Curic (1988) reported that P content was fairly stable and was decreased slightly by N. Plant N content was greatly affected by applied N. Patel and Upadhyay (1993) reported that protein content increased up to 150 kg N/ha.

Wheat compares well with other cereals in nutrient values. Its protein content is higher than that of rice, maize, sorghum and is about equal to that of other cereals like oats, barley and rye (Hossain *et al.*, 1996). The protein content of commercial wheat ranges from 6-16%. The composition of wheat protein provides an efficient source of protein if balanced by other foods that supply certain amino acids such as lysine which are low in wheat protein and therefore important in determining the nutritional status of millions of human beings. Grain protein content is a major contributor to nutritional quality of wheat (Hutchision and Stalbot, 1983; Konov *et al.*, 1985).

In general, grains of higher protein content have more economic value for bread making purposes. In other areas, grain of low protein content may be preferable for use in cakes and cookies. Beyond the quantitative aspect, however, protein has two major areas of interest. When flour is mixed with water and sufficiently blended, a gluten matrix will form. This is the unique characteristic of wheat flour that most people associate with the ability of dough to form envelopes that enclose the gas liberated by yeast during baking process. This is responsible for making yeast-leavened bread, particularly attractive to those people who like the texture of open grained, relatively light bread types (Gandapur and Bhatti, 1989).

According to Curic (1988), correlation coefficients confirmed that sedimentation value and protein content are good preliminary indicators of baking quality which can be utilized in selection of materials, particularly at the early stages of breeding programmes. Hubik (1995), found a positive correlation between protein content and wet gluten content with nitrogen fertilizer rate.

Gaur (1982) reported that grain protein content of Sonalika variety increased from 8.78 without N to 14.58 with 240 kg N/ha using equal split applications at sowing and first irrigation. Increasing N rate increased straw N and K content but decreased straw P content. Sarker *et al.* (1996) reported that protein percentage was higher in durum wheat than in bread wheat, ranging from 138 in Marrocos 8 and Kahla to 13.68 in PulawskaTwarda, compared with 10.88 and 11.48 in the bread wheat Alfa and Kolibri, respectively. Arora and Singh (1987) found that cv. HD 4530 was superior to HD 2236 and WH 147 for protein, P and S contents of grain.

Singh and Singh (1987) reported that at 120 kg N/ha, split doses in spring gave best grain amino acid composition. N gave a more favourable grain essential amino acid composition than DAM 390 (308 N). Brown earth (pernolec) positively influenced the essential amino acid composition compared with grey-brown Podjol. Ahmad and Hossain (1992) found that Khushal – 69 and Mexi – pak -69 with increased applied N increased protein. Patra (1990) observed that increasing N rates from 0 to 100 kg/ha increased grain protein and amino acid contents of wheat cv. Sonalika, 150 kg N/ha decreased it. Bengtsson (1985) reported that protein content was significantly higher for cv. Heta in all fertilization conditions. Protein content increased with increasing nitrogen supply for all varieties. The effect of nitrogen fertilization on protein content was highest for cultivars Heta, Setu and Polkka.

From the above reviews it is clear that nitrogen is an important nutrient for wheat for increasing its yield and protein content.

CHAPTER III

MATERIALS AND METHODS

A field experiment was conducted in robi season to study Response of wheat varieties to different levels of nitrogen fertilizer. This chapter presents a brief description of the experimental site, soil, climate, experimental design, treatments, cultural operations, collection and analysis of different parameters.

3.1 Location

The experiment was conducted at the agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2012 to March 2013.

3.2 Geographical location

The experimental area was situated at $23^{0}77'$N latitude and $90^{0}33'$E longitude at an altitude of 8.6 meter above the sea level. The experimental site belongs to the agro-ecological zone of “Modhupur Tract”, AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.3 Soil

Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood levels. The selected plot was medium high land. The details were presented in Appendix II.

3.4 Climate of the experimental site

Experimental site was located in the sub-tropical monsoon climatic zone, set aparted by winter during the months from mid November to mid March (Rabi season). Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for wheat growing in Bangladesh. The weather data during the study period at the experimental site are shown in Appendix III.

3.5 Variety

Three modern varieties of wheat were tested in the experiment.

3.5.1 BARI Gom-23 (Bijoy)

Bijoy (BARI Gom-23) was released by BARI in 2005 for cultivation throughout Bangladesh. The height ranges from 95-105 cm. It produces 5-6 tillers/ Plant. Leaves are broad and deep green in color. Seeds are big and white in color. It needs about 60-65 DAS for the emergence of spikes. Weight of 1000 grains is 35-40 g. It takes about 103-112 DAS to harvest. It is resistant against leaf spot and rust. The average yield is 4.3-5.0 t ha^{-1}.

3.5.2 BARI Gom-24 (Prodip)

BARI Gom-24 (Prodip) was released by BARI in 2005 for cultivation throughout Bangladesh. The height ranges from 95-100 cm. It produces 5-6 tillers/ Plant. Leaves are broad and deep green in color. Seeds are big and white in color. It needs about 64-66 DAS for the emergence of spikes. Weight of 1000 grains is 45-55 g. It takes about 102-110 DAS to harvest. It is resistant against leaf spot and rust. The average yield is 3.5-5.1 t ha^{-1}.

3.5.3 BARI Gom-25

BARI Gom-25 was released by BARI in 2005 for cultivation throughout Bangladesh. The height ranges from 95-100 cm. It produces 5-6 tillers/ Plant. Leaves are broad and deep green in color. Seeds are big and white in color. It needs about 57-61 DAS for the emergence of spikes. Weight of 1000 grains is 54-58 g. It takes about 102-110 DAS to harvest. It is resistant against leaf spot and rust. The average yield is 3.6-4.6 t ha^{-1}.

3.6 Experimental treatments

There are two sets of treatments in the experiment. The treatments were variety which is considers as Factor A and different nitrogen levels considers as Factor B.

The level of Factor A and B are as follows:

Factor A: Variety (3)

V_1 = BARI Gom-23 (Bijoy)

V_2 = BARI Gom-24 (Prodip)

V_3 = BARI Gom-25

Factor B: Nitrogen levels (4)

$\mathbf{N_1}$ **=** 75 kg N ha^{-1}

$\mathbf{N_2}$ **=** 100 kg N ha^{-1}

$\mathbf{N_3}$ **=** 125 kg N ha^{-1}

$\mathbf{N_4}$ **=** 150 kg N ha^{-1}

These two factors were consisted the 12 treatment combination. The treatment combinations are:

V_1N_1, V_1N_2, V_1N_3, V_1N_4, V_2N_1, V_2N_2, V_2N_3, V_2N_4, V_3N_1, V_3N_2, V_3N_3 and V_3N_4.

3.7 Layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replication. The experimental unit was divided into three blocks. Blocks represented the replication. So, the total number of unit plant in the entire experiment was 3x12= 36. Size of each unit plot was $5x2=10m^2$. The distance between block was 1m.

3.8 Details of the field operations

The particular of the cultural operations carried out during the experimentation are presented below:

3.8.1 Land preparation

The land is ploughed with a rotary plough and power tiller. Ploughed soil was then brought desirable fine tilth condition and leveled by repeated laddering. The larger visible clods were hammered to break into small pieces. After removing of weeds, stubbles and crop residues were cleaned from the land. The final ploughing and land preparation were done before mid November. The layout was done as per experimental design on mid November.

3.8.2 Fertilizer application

The field was fertilized with P, K, Gypsum and Boric acid at the rate of 26-50-20-1 kg respectively. Nitrogen was applied as per treatment. The whole amount of TSP, MOP, Gypsum and Boric acid and one third of N were incorporated in the soil at the time of final land preparation. The remaining amount of N was applied in two split doses at crown root initiation stage (20 DAS) and prior to spike initiation stage (55 DAS) as top dressing.

3.8.3 Collection and sowing of seeds

The wheat seeds were collected from the wheat reseach centre, Bangladesh Agricultural Institute (BARI), Joydebpur, Gazipur. At good tilth condition, furrows were made with hand rakes for sowing. Seed were sown continuously in line 19 November, 2012 as per experimental treatment. The line to line distance was maintained 20cm. After sowing, seed were covered with the soil and slightly pressed by hand.

3.8.4 Weeding

Weed infested the experimental plots. So two weedings were done manually at 25 and 45 DAS. During weeding the weeds identified were kakpaya ghash (*Dactlyoctenium aegyptium* L.), Durba (*Cynodon dactylon* L.), Arail (*Leersia hexandra*), Chelaghash (*Parapholis incurve* L.), Mutha (*Chenopodium album* L.), Foskabegun (*Physalis beterophylls*) and Titabegun (*Solanum torvum*).

3.8.5 Irrigation

Two irrigations were applied at crown root initiation stage and heading stage at 20 and 55 DAS respectively. Excess water was drained out from the field.

3.8.6 Pest management

At 20 DAS the experimental plots were sprayed with Melethion 57 EC @ 2m/L to control aphid. No infestation of diseases was found. A gourd was appointed to protect the wheat grain from bird especially parrots from mid February to harvest.

3.8.7 Harvesting and sampling

The crop was harvested at maturity on March 18, 2013. Samples were collected from different places of each plot leaving undisturbed middle three rows in the centre and border rows. The selected sample plants were then tagged and carefully carried to the agronomy field laboratory in order to collect data. Plants of central $5m^2$ were harvested plot wise, bundled and tagged. The crop bundles were sun dried by spreading those on threshing floor. The grains were separated from the plants by beating the bundles with wooden sticks. The grain and straw were dried again to constant moisture and the weight were recorded and converted into t ha^{-1} basis.

3.9 Data collection

1. Plant height (cm) at 30 DAS, 60 DAS and 90 DAS
2. Number of leaves $plant^{-1}$ at 30 DAS, 60 DAS and 90 DAS
3. Leaf length (cm) at 30 DAS, 60 DAS and 90 DAS
4. Dry weight (g $plant^{-1}$) of plant at 30 DAS, 60 DAS, and 90 DAS
5. Grains ear^{-1}
6. Number of fertile grains $plant^{-1}$
7. Number of unfertile grains $plant^{-1}$
8. 1000-grain weight (g)
9. Grain yield (t ha^{-1})
10. Straw yield (t ha^{-1})
11. Harvest index (%)
12. Protein content (%)

3.9.1 Plant height

Three plants per plot were randomly selected during earlier growth stage of the crop15 cm linear rows measured at 30, 60 and 90 DAS. The height was measured taking base to the leaf/ spike and the mean height was recorded.

3.9.2 No. of leaves $plant^{-1}$

The total leaves of three plant randomly selected per plot was counted at 30, 60 and 90 DAS and the mean values were recorded.

3.9.3 Leaf length (cm)

Three leaves per plant were randomly selected from where length from the base of the spike to the tip of the leaflet was measured at 30, 60 and 90 DAS and the mean values were recorded.

3.9.4 Dry matter (g plant^{-1})

The plants within 15 linear centimeters in a row were uprooted with the help of hand and cleaned with water. Plants were oven dried at 80^{0}C until a constant weight was obtained. The dry weight of plants were recorded in gram and converted into per hectare basis. Data were collected at 30, 60 and 90 DAS.

3.9.5. Grains ear^{-1}

The grains per ear collected from three spikes were randomly selected from where grain from the base of the ear to the tip of the spike was counted and the mean values were recorded.

3.9.6 Number of fertile grains plant^{-1}

The grain, which had at least one fertile grain, was considered as effective tiller.

3.9.7 Number of unfertile grains plant^{-1}

The grains, which had no fertile was regarded as non effective tiller.

3.9.8 Weight of 1000-grain (g)

One thousand clean and sun-dried grains were counted from the seed stock and weighed by an electronic balance.

3.9.9 Grain yield (t ha^{-1})

The yield of each sample plot was measured after threshing, proper drying (12% moisture level). Cleaning and values were converted into ton ha^{-1}.

3.9.10 Straw yield (t ha^{-1})

Straw weight of each sample plot was measured after threshing, drying and converted into ton ha^{-1}.

3.9.11 Harvest index (%)

Harvest index (%) was determined by dividing the economic (Grain) yield from the harvest area by the total biological yield (grain+ straw) of the same area

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (t/ha)}}{\text{Biological Yield (t/ha)}} \times \mathbf{100}$$

3.9.12 Protein content (%)

Protein content (%) of the samples was chemically analyzed and values were recorded correctly.

3.10 Statistical analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using MSTAT-C computer package programme. The significant differences among the treatment means were compared by Least Significant Different (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to find out the response of wheat variety as influenced by different levels of nitrogen fertilization. The analysis of variance (ANOVA) of the data on different growth parameter and yield parameter are presented in Appendix IV-VIII. The results have been presented and discussed, and possible interpretations given under the following headings:

4.1 Plant height

Significant variation was recorded for plant height of wheat due to varieties at 30, 60 and 90 DAS (Appendix IV). At 30, 60 and 90 DAS, the tallest plants (37.17, 69.14 and 95.85 cm) were observed from V_2, while the shortest plants (30.58, 61.33 and 90.79 cm) were found in V_1 at same days after sowing (Table 1).

Plant height of wheat at 60 and 90 DAS varied significantly due to nitrogen except 30 DAS (Appendix IV). At 30 DAS, numerically tallest plant (38.33 cm) was recorded from N_3, whereas shortest plant was (35.33 cm) recorded from N_1. At 60 and 90 DAS, the tallest plants (72.78 and 98.77 cm) were observed from N_3 and the shortest plants (63.37 and 89.17 cm) were found in N_1 at same days after sowing (Table 2).

Significant differences were also recorded for the interaction effect of varieties and nitrogen on plant height of wheat at 30, 60 and 90 DAS (Appendix IV). At 30, 60 and 90 DAS, the tallest plants (42.00, 72.45 and 99.85 cm) were observed from V_2N_3 and the shortest plants (22.67, 57.78 and 82.18 cm) were found in V_1N_1 at same days after sowing (Table 3).

Table 1. Effect of varieties on plant height of wheat

Variety	Plant height (cm) at		
	30 DAS	60 DAS	90 DAS
V_1	30.58 c	61.33 c	90.79 c
V_2	37.17 a	69.14 a	95.85 a
V_3	33.72 b	65.39 b	93.05 b
$LSD_{(0.05)}$	2.865	3.864	2.864
CV (%)	7.59	4.32	5.94

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25.

Table 2. Effect of nitrogen on plant height of wheat

Nitrogen level	Plant height (cm) at		
	30 DAS	60 DAS	90 DAS
N_1	35.33	63.37 d	89.17 d
N_2	34.89	66.61 c	92.15 c
N_3	38.33	72.78 a	98.77 a
N_4	36.33	69.70 b	95.20 b
$LSD_{(0.05)}$	NS	NS	NS
CV (%)	7.59	4.32	5.94

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

Table 3: Interaction effect of varieties and nitrogen on plant height of wheat

Treatments	Plant height (cm) at		
	30 DAS	60 DAS	90 DAS
V_1N_1	22.67 h	57.78 i	82.18 g
V_1N_2	32.67 f	60.89 h	92.14 ef
V_1N_3	32.67 f	65.45 e	93.18 de
V_1N_4	33.33 e	63.00 g	91.76 f
V_2N_1	34.67 d	68.33 c	93.17 de
V_2N_2	40.67 b	67.55 d	96.04 b
V_2N_3	42.00 a	72.45 a	99.85 a
V_2N_4	34.33 d	70.22 b	94.12 d
V_3N_1	38.67 c	67.67 d	92.14 ef
V_3N_2	31.67 g	67.22 de	95.41 c
V_3N_3	32.67 f	63.00 g	93.74 d
V_3N_4	32.67 f	63.89 f	93.43 d
$LSD_{(0.05)}$	NS	0.285	1.485
CV (%)	7.59	4.32	5.94

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

4.2 Number of leaves per plant

Statistically significant differences were recorded for number of leaves $plant^{-1}$ of wheat application of different nitrogen levels at 30, 60 and 90 DAS (Appendix V). At 30, 60 and 90 DAS, the maximum number of leaves $plant^{-1}$ (5.03, 5.14 and 5.17) was found from V_2. At the same DAS, the minimum number of leaves $plant^{-1}$ (3.03, 3.08 and 3.11) was observed from V_1 (Table 4).

Different nitrogen levels were significantly on number of leaves $plant^{-1}$ of wheat at 30, 60 and 90 DAS (Appendix V). At 30, 60 and 90 DAS, the highest number of leaves $plant^{-1}$ (5.00, 5.11 and 5.15) was recorded from N_3 whereas, the lowest number of leaves $plant^{-1}$ (3.11, 3.56 and 4.00) was found from N_1 for the same DAS, respectively (Table 5).

Significant variation was recorded due to combined effect of varieties and different nitrogen levels in terms of number of leaves plant^{-1} of wheat at 30, 60 and 90 DAS (Appendix V). At 30, 60 and 90 DAS, the maximum number of leaves plant^{-1} (5.31, 5.35 and 5.45, respectively) was attained from V_2N_3 whereas, the lowest number of leaves plant^{-1} (2.67, 3.00 and 3.02) was found from V_1N_1 at same DAS, respectively (Table 6).

Table 4: Effect of varieties on number of leaves plant^{-1} of wheat

Variety	Number of leaves at		
	30 DAS	60 DAS	90 DAS
V_1	3.03 c	3.08 c	3.11 c
V_2	5.03 a	5.14 a	5.17 a
V_3	4.08 b	4.09 b	4.22 b
$LSD_{(0.05)}$	0.38	0.28	0.43
CV (%)	2.49	5.93	3.20

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25.

Table 5: Effect of nitrogen on number of leaves plant^{-1} of wheat

Nitrogen level	Number of leaves at		
	30 DAS	60 DAS	90 DAS
N_1	3.11 c	3.56 d	4.00 d
N_2	4.01 b	4.40 b	4.62 b
N_3	5.00 a	5.11 a	5.15 a
N_4	4.03 b	4.07 c	4.15 c
$LSD_{(0.05)}$	0.82	0.94	0.42
CV (%)	2.49	5.93	3.20

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

Table 6: Interaction effect of varieties and nitrogen on number of leaves plant^{-1} of wheat

Treatments	Number of leaves at		
	30 DAS	60 DAS	90 DAS
V_1N_1	2.67 j	3.00 f	3.02 i
V_1N_2	3.00 i	3.l1 e	3.21 g
V_1N_3	3.34 g	3.11 e	3.20 g
V_1N_4	3.11 h	3.11 e	3.11 h
V_2N_1	4.64 d	5.04 b	5.11 c
V_2N_2	5.20 b	5.05 b	5.22 b
V_2N_3	5.31 a	5.35 a	5.45 a
V_2N_4	4.97 c	5.05 b	5.11 c
V_3N_1	4.05 f	4.11 c	4.11 e
V_3N_2	4.05 f	4.11 c	4.00 f
V_3N_3	4.16 e	4.00 d	4.11 e
V_3N_4	4.15 e	4.11 c	4.33 d
$LSD_{(0.05)}$	0.203	0.392	0.425
CV (%)	2.49	5.93	3.20

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

4.3 Leaf length (cm)

Statistically significant differences were recorded for leaf length of wheat varieties by application of different nitrogen levels at 30, 60 and 90 DAS (Appendix VI). At 30, 60 and 90 DAS, the tallest leaf length (23.72, 30.25 and 31.22 cm, respectively) was found from V_2 and the shortest leaf length (19.96, 26.24 and 28.43 cm, respectively) was observed from V_1 (Table 7).

Different nitrogen levels were significantly on leaf length of wheat at 30, 60 and 90 DAS (Appendix VI). At 30, 60 and 90 DAS, the tallest leaf length (24.30, 29.92 and 31.44 cm, respectively) was recorded from N_3 whereas, the shortest leaf length (21.82, 26.92 and 27.13 cm, respectively) was found from N_1 (Table 8).

Significant variation was recorded due to combined effect of varieties and nitrogen in terms of leaf length of wheat at 30, 60 and 90 DAS (Appendix VI). At 30, 60 and 90 DAS, the maximum leaf length (24.78, 32.33 and 32.51 cm, respectively) was attained from V_2N_3 whereas, the lowest was (17.06, 25.67 and 26.71 cm) found from V_1N_1 at same DAS, respectively (Table 9).

Table 7: Effect of varieties on leaf length of wheat

Variety	Leaf length (cm) at		
	30 DAS	60 DAS	90 DAS
V_1	19.96 c	26.24 c	28.43 c
V_2	23.72 a	30.25 a	31.22 a
V_3	21.53 b	28.33 b	30.03 b
$LSD_{(0.05)}$	1.384	1.472	2.483
CV (%)	7.49	7.03	3.40

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25.

Table 8: Effect of nitrogen on leaf length of wheat

Nitrogen level	Leaf length (cm) at		
	30 DAS	60 DAS	90 DAS
N_1	21.82 c	26.92 c	27.13 c
N_2	23.20 b	28.52 b	29.44 b
N_3	24.30 a	29.92 a	31.44 a
N_4	23.04 b	28.55 b	29.22 b
$LSD_{(0.05)}$	0.045	1.073	2.060
CV (%)	7.49	7.03	3.40

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

Table 9: Interaction effect of varieties and nitrogen on leaf length of wheat

Treatments	Leaf length (cm) at		
	30 DAS	60 DAS	90 DAS
V_1N_1	17.06 j	25.67 i	26.71 h
V_1N_2	20.11 h	27.33 f	28.52 f
V_1N_3	21.45 f	28.22 e	29.84 d
V_1N_4	21.11g	26.22 g	27.29 g
V_2N_1	22.78 c	31.11 b	31.90 b
V_2N_2	24.22 b	28.78 d	29.26 d
V_2N_3	24.78 a	32.33 a	32.51 a
V_2N_4	21.89 e	31.00 b	31.11 c
V_3N_1	22.56 c	28.22 e	28.45 f
V_3N_2	22.22 d	27.00 f	29.23 e
V_3N_3	17.89 i	29.55 c	31.73 b
V_3N_4	21.00 g	29.11 c	30.71 c
$LSD_{(0.05)}$	0.683	0.732	0.593
CV (%)	7.49	7.03	3.40

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

4.4 Dry matter content (g plant^{-1})

Significant differences were recorded for dry matter content in plant of wheat due to different varieties at 30, 60 and 90 DAS (Appendix VII). The maximum total dry matter in wheat plant (3.98, 12.14 and 17.85 g plant^{-1}) was recorded from V_2, whereas the lowest dry matter content in plant (2.04, 9.33 and 12.79 g plant^{-1}) were found in V_1 at same days after sowing (Table 10).

Total dry matter in plant of wheat varied significantly due to different nitrogen levels at 30, 60 and 90 DAS (Appendix VII). At 30, 60 and 90 DAS, the highest dry matter in plant (4.33, 11.78 and 17.77 g plant^{-1}) were recorded from N_3, whereas the lowest dry matter content in plant (2.33, 7.37 and 13.17 g plant^{-1}) were found in N_1 at same days after sowing (Table 11).

Interaction effect of varieties and nitrogen varied significant by total dry matter of wheat at 30, 60 and 90 DAS (Appendix VII). At 30, 60 and 90 DAS, the highest dry matter (4.98, 14.04 and 19.49 g plant^{-1}) were observed from V_2N_3, whereas the lowest dry matter (1.75, 8.56 and 10.38 g plant^{-1}) were found in V_1N_1 at same days after sowing (Table 12).

Table 10: Effect of varieties on weight of dry matter (g plant^{-1}) of wheat

Variety	Dry matter (g plant^{-1}) at		
	30 DAS	60 DAS	90 DAS
V_1	2.04 c	9.33 c	12.79 c
V_2	3.98 a	12.14 a	17.85 a
V_3	2.79 b	10.39 b	14.05 b
$LSD_{(0.05)}$	0.473	1.384	1.853
CV (%)	1.94	1.20	1.38

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25.

Table 11: Effect of nitrogen on dry matter (g plant^{-1}) of wheat

Nitrogen Level(kg ha^{-1})	Dry matter (g plant^{-1}) at		
	30 DAS	60 DAS	90 DAS
N_1	2.33 d	7.37 d	13.17 d
N_2	2.89 c	9.31 c	14.15 c
N_3	4.33 a	11.78 a	17.77 a
N_4	3.33 b	10.60 b	15.20 b
$LSD_{(0.05)}$	0.294	1.045	2.174
CV (%)	1.94	1.20	1.38

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

Table 12: Interaction effect of varieties and nitrogen on dry matter ($g\ plant^{-1}$) of wheat

Treatments	Dry matter ($g\ plant^{-1}$) at		
	30 DAS	60 DAS	90 DAS
V_1N_1	1.75 i	8.56 i	10.38 j
V_1N_2	2.01h	9.19 g	11.39 i
V_1N_3	2.04 h	10.38 e	15.20 e
V_1N_4	2.34 gh	9.20 g	13.79 g
V_2N_1	2.77ef	10.27 e	15.70 e
V_2N_2	3.59 c	11.39 e	17.49 c
V_2N_3	4.98 a	14.04 a	19.49 a
V_2N_4	3.74 b	13.09 b	18.67 b
V_3N_1	2.37 g	8.97 h	11.99 h
V_3N_2	2.79 ef	9.59 f	14.30 f
V_3N_3	3.04 d	12.03 c	16.59 d
V_3N_4	2.85 e	10.99 d	13.29 g
$LSD_{(0.05)}$	0.458	0.863	0.295
CV (%)	1.94	1.20	1.38

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

4.5 Grains ear^{-1}

Number of grains ear^{-1} was significantly influenced by varieties (Appendix VIII). The maximum grains ear^{-1} in wheat plant (17.47) was recorded from V_2, whereas the minimum (16.17) were found in V_1 (Table 13).

Significant differences were recorded for number of grain ear^{-1} in plant of wheat due to different levels of nitrogen (Appendix VIII). The maximum grains ear^{-1} in wheat plant (17.60) was recorded from N_3, whereas the minimum (16.29) were found in N_1 (Table 14).

Varieties and nitrogen interact significant differences on number of grains ear^{-1} of wheat (Appendix VIII).The highest grains ear^{-1} (18.24) were observed from V_2N_3, whereas the lowest (15.57) were found in V_1N_1 (Table 15).

4.6 Number of fertile grains plant^{-1}

Variation in fertile grains plant^{-1} among the studied varieties was statistically significant (Appendix VIII and Table 13). The highest number of fertile grains plant^{-1} was observed in V_2 (54.69) whereas, the lowest was V_1 (45.55).

The effect of nitrogen on number of fertile grains plant^{-1} was statistically significant (Appendix VIII and Table 14). Results showed that number of fertile grains plant^{-1} increased with increasing nitrogen levels and thereafter decreased by gradually increased the nitrogen levels. The highest number of fertile grains plant^{-1} was recorded at N_3 (52.85) whereas, the lowest was N_1 (48.63).

The interaction effect of variety and nitrogen levels in relation to number of fertile grains plant^{-1} was also statistically significant (Appendix VIII and Table 15). The highest number of fertile grains plant^{-1} was observed in V_2N_3 (59.67) and the lowest was recorded in V_1N_1 (40.33).

4.7 Number of unfertile grains plant^{-1}

Variation in number of unfertile grains plant^{-1} among the studied varieties was statistically significant (Appendix VIII and Table 13). The highest number of unfertile grains plant $^{-1}$ was observed in V_1 (7.36) whereas, the lowest was recorded in V_2 (3.00).

Nitrogen had significant influence on unfertile grains plant^{-1} production in wheat (Appendix VIII and Table 14). Results revealed that unfertile grains plant $^{-1}$ decreased with increasing nitrogen and thereafter increased by gradually increased the nitrogen levels. The higher unfertile grains plant^{-1} was observed

N_1 (6.45). In contrast, the lowest number of unfertile grains plant $^{-1}$ was recorded in N_3 (5.63).

The interaction effect of different variety and nitrogen levels in relation to number of unfertile grains plant $^{-1}$ was also statistically significant (Appendix VIII and Table 15). The highest number of unfertile grains plant $^{-1}$ was observed in V_1N_1 (7.89) and the lowest was recorded in V_2N_3 (2.05).

4.8 1000-grain weight

A significant difference in 1000-grain weight was also observed in studied varieties of wheat (Appendix VIII and Table 13). The highest 1000-grain weight was recorded in V_2 (54.95 g). In contrast, the lowest 1000-grain weight was recorded in V_1 (50.91 g). Genotypic variation in 1000-grain weight was also observed by many workers in wheat (Ghosh *et al.*, 1991; Bisht *et al.*, 1999; Hassan, 2006; Chowdhury, 2008) that also supported the present experimental result.

The effect of nitrogen on 1000-grain weight was significant (Appendix VIII and Table 14). The highest 1000-grain weight was recorded in N_3 (53.92 g) whereas, the lowest 1000-grain weight was recorded in N_1 (49.82 g).

The interaction effect of different variety and nitrogen levels for 1000-grain weight was significant (Appendix VIII and Table 15). The highest 1000-grain weight was recorded in V_2N_3 (57.60 g) whereas, the lowest 1000-grain weight was recorded in V_1N_1 (48.97 g).

4.9 Grain yield (t ha^{-1})

Variety had significant effect on grain yield ha^{-1} area basis (Appendix VIII and Table 13). The highest grain yield ha^{-1} area (4.61 t ha^{-1}) was recorded in V_2 whereas, the lowest was recorded from V_1 (3.45 t ha^{-1}).

Nitrogen had significant effect on grain yield hectare^{-1} (Appendix VIII and Table 14). Results revealed that seed yield ha^{-1} increased with increasing nitrogen and thereafter decreased by gradually increased the nitrogen levels in wheat. The highest grain yield ha^{-1} area (4.77 t ha^{-1}) was recorded in N_3 whereas, the lowest were recorded from N_1 (3.20 t ha^{-1}).

The interaction effect of variety and nitrogen on seed yield hectare^{-1} was significant (Appendix VIII and Table 15). In case of unit area, V_2N_3 produced the highest grain yield (4.71 t ha^{-1}). In the interaction effect, V_1N_1 was produced the lowest grain yield (3.23 t ha^{-1}).

4.10 Straw yield (t ha^{-1})

The straw yield showed significant differences among the studied varieties (Appendix VIII and Table 13). BARI gom-23 produced the highest straw yield (5.92 t ha^{-1}). On the other hand, BARI gom-24 produced the lowest straw yield (5.02 t ha^{-1}).

The effect of nitrogen on straw yield was statistically significant (Appendix VIII and Table 14). The higher straw yield were recorded in N_1 (6.03 t ha^{-1}) whereas, the lowest was recorded in (4.83 t ha^{-1}).

The interaction effect of variety and nitrogen in relation to straw yield was significant (Appendix VIII and Table 15). The highest straw yield was observed in V_1N_1 (6.11 t ha^{-1}) and the lowest was recorded in V_2N_3 (4.83 t ha^{-1}).

4.11 Harvest index (%)

Variation in HI among the studied varieties was statistically significant (Appendix VIII and Table 13). The highest HI was recorded in BARI gom-24 (47.87 %) whereas, the lowest harvest index was observed in BARI gom-23 (36.82 %).

The effect of nitrogen on harvest index (HI) was statistically significant (Appendix VIII and Table 14).Result revealed that the highest HI recorded in N_3 (49.68 %) whereas, the lowest harvest index was observed in N_1 (34.67 %).

The interaction effect of variety and nitrogen in relation to HI was also statistically significant (Appendix VIII and Table 15). Results showed that highest HI was found in V_2N_3 (49.37%) and HI was the lowest in V_1N_1 (34.58 %) for wheat cultivation under Bangladesh environmental condition.

Table 13: Effect of varieties on yields and yield components of wheat

Variety	Grains ear^{-1}	No. of fertile grainsplant^{-1}	No. of unfertile grainsplant^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1	16.17 c	45.55 c	7.36 a	50.91 c	3.45c	5.92 a	36.82 c
V_2	17.47 a	54.69 a	3.00c	54.95 a	4.61 a	5.02 c	47.87 a
V_3	16.88 b	49.83 b	5.89 b	52.47 b	4.00 b	5.32 b	42.92 b
$LSD_{(0.05)}$	0.4941	3.994	1.488	1.529	0.5271	0.2798	3.945
CV (%)	3.74	2.09	5.40	4.03	9.47	7.29	5.40

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
V_1–BARI Gom-23, V_2–BARI Gom-24 and V_3–BARI Gom-25.

Table 14: Effect of nitrogen on yields and yield components of wheat

Nitrogen level	Grains ear^{-1}	No. of fertile grains $plant^{-1}$	No. of unfertile grains $plant^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
N_1	16.29 d	48.63 c	6.45 a	49.82 d	3.20 d	6.03 a	34.67 d
N_2	16.81 c	51.89 b	6.37 b	51.59 c	4.10 c	5.67 b	41.97 c
N_3	17.60 a	52.85 a	5.63 d	53.92 a	4.77 a	4.83 d	49.68 a
N_4	17.20 b	52.07 b	5.89 c	52.90 b	4.40 b	5.24 c	45.64 b
$LSD_{(0.05)}$	0.2390	0.627	0.079	0.943	0.2703	0.3378	2.849
CV (%)	3.74	2.09	5.40	4.03	9.47	7.29	5.40

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability .
N_1–75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N $ha^{-1}$and N_4 - 150 kg N ha^{-1}.

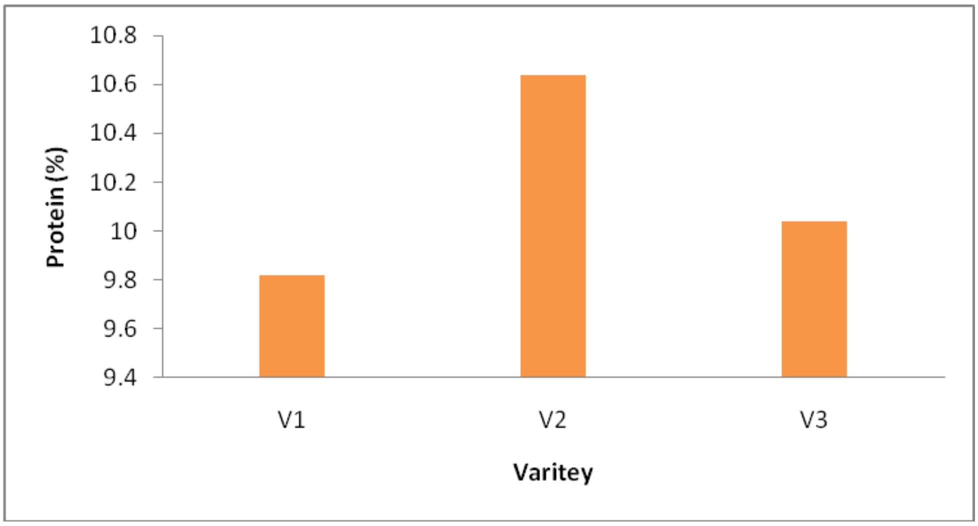
Table 15: Interaction effect of varieties and nitrogen on yield and yield components of wheat

Treatments	Grains ear^{-1}	No. of fertile grains $plant^{-1}$	No. of unfertile grains $plant^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1N_1	15.57 h	40.33 j	7.89 a	48.97 j	3.23 j	6.11 a	34.58 j
V_1N_2	17.22 d	51.78 e	7.11 b	52.55 e	3.53 i	5.39 f	39.57 f
V_1N_3	16.15 f	43.33 i	7.11 b	49.90 i	3.32 g	5.84 c	36.25 h
V_1N_4	15.81gh	45.44 h	7.11 b	50.00 h	3.76 h	5.91 b	38.88 g
V_2N_1	16.74 e	53.55 cd	2.89 g	56.84 b	4.66 b	5.61 e	45.38 c
V_2N_2	17.13 d	54.00 b	4.33 e	53.20 d	4.46 d	4.95 h	47.39 b
V_2N_3	17.75 bc	59.67 a	2.05 h	57.60 a	4.71 a	4.83 j	49.37 a
V_2N_4	18.24 a	52.55 d	3.00 f	52.59 e	4.01 f	4.90 i	45.00 c
V_3N_1	17.58 c	49.44 f	6.22 c	50.93 g	4.39 e	5.80 c	43.08 d
V_3N_2	16.07 fg	49.89 f	5.11 d	51.57 f	4.58 c	5.78 d	43.08 d
V_3N_3	17.95 b	53.78 c	6.00 c	53.82 c	3.30 g	5.73 d	35.48 i
V_3N_4	15.90 fg	46.55 g	5.78 c	53.37 d	3.81 g	5.19 h	42.33 e
$LSD_{(0.05)}$	0.288	0.988	0.575	0.557	0.054	0.060	1.03
CV (%)	3.74	2.09	5.40	4.03	9.47	7.29	5.40

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability .
V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25, N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1},N_4 - 150 kg N ha^{-1}.

4.12 Protein content (%)

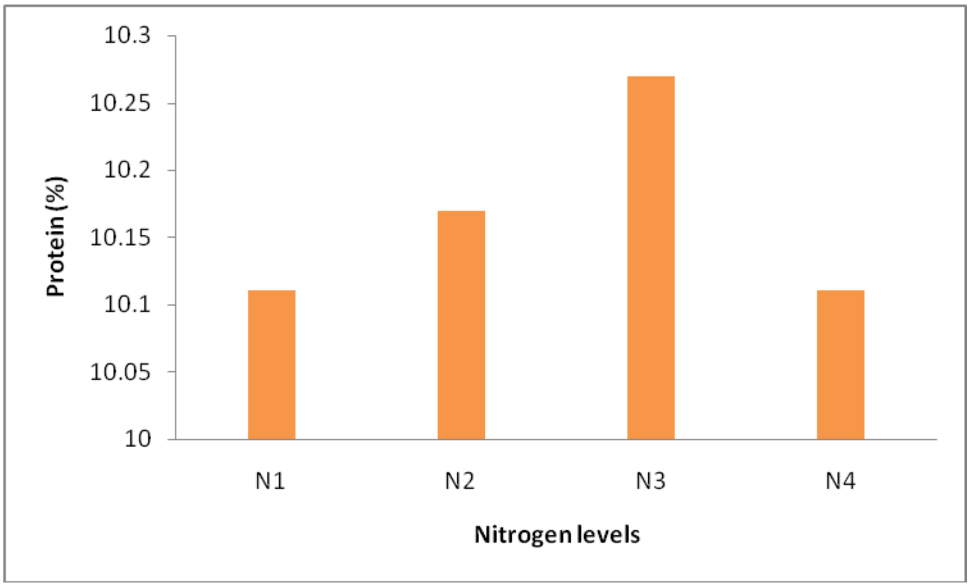
Variation in Protein (%) among the studied varieties was statistically significant (Appendix VIII). The highest Protein was recorded in BARI gom-24 (10.64 %) whereas, the lowest Protein was observed in BARI gom23 (9.82 %) (Figure 1).



V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25.

Figure 1: Effect of varieties on Protein (%) of wheat ($LSD_{0.05}$ = 0.0045)

The effect of nitrogen on Protein (%) was statistically significant (Appendix VIII and Figure 2). Result revealed that the highest protein content recorded in N_3 (10.27 %) whereas, the lowest protein was observed in N_1 (10.11 %.



V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25.

Figure 2: Effect of nitrogen on Protein (%) of wheat ($LSD_{0.05}$ = 0.0072)

The interaction effect of variety and nitrogen in relation to protein (%) was also statistically significant (Appendix VIII and Table 16). Results showed that the highest protein was recorded in V_2N_3 (10.88 %) and the lowest was in V_1N_1 (9.53 %) for wheat cultivation under Bangladesh environmental condition.

Table 16: Interaction effect of varieties and nitrogen on protein (%) of wheat

Treatments	Protein (%)
V_1N_1	9.53 e
V_1N_2	10.05 c
V_1N_3	10.54 b
V_1N_4	9.85 de
V_2N_1	10.05 c
V_2N_2	10.62 b
V_2N_3	10.88 a
V_2N_4	10.04 c
V_3N_1	9.89 cd
V_3N_2	9.81 e
V_3N_3	10.02 cd
V_3N_4	10.52 b
$LSD_{(0.05)}$	0.1713
CV (%)	4.38

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

V_1 – BARI Gom-23, V_2 – BARI Gom-24 and V_3 – BARI Gom-25
N_1 – 75 kg N ha^{-1}, N_2 - 100 kg N ha^{-1}, N_3 - 125 kg N ha^{-1} and N_4 - 150 kg N ha^{-1}.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2012 to March 2013 to study the response of wheat variety as influenced by different levels of nitrogen fertilization. The experiment comprised three varieties viz., V_1 (BARI Gom-23), V_2 (BARI Gom-24), V_3 (BARI Gom-25) and four nitrogen levels viz., N_1 (75 kg N ha^{-1}), N_2 (100 kg N ha^{-1}), N_3 (125 kg N ha^{-1}), N_4 (150 kg N ha^{-1}). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

The result indicated significant variations in plant height, number of leaves plant^{-1}, leaf length, dry matter content, number of fertile grain plant^{-1}, number of unfertile grain plant^{-1}, grain ear^{-1}, weight of 1000 seed, grain yield, straw yield, harvest index and Protein percentage due to varieties. At 30, 60 and 90 DAS, the tallest plants (37.17, 69.14 and 95.85 cm), the maximum number of leaves plant^{-1} (5.03, 5.14 and 5.17), leaf length (23.72, 30.25 and 31.22 cm), dry matter in wheat plant (3.98, 12.14 and 17.85 g plant^{-1}) was recorded from BARI Gom-24. The maximum grains ear^{-1} (17.47 cm), number of fertile grains plant^{-1} (54.69), number of unfertile grains plant $^{-1}$ (7.36), highest 1000-grain weight (54.95 g), grain yield (4.61 t ha^{-1}), straw yield (5.92 t ha^{-1}), Harvest index (47.87 %) and Protein (10.64 %) was recorded form in BARI Gom-24.

The result indicated significant variations in plant height, number of leaves plant^{-1}, leaf length, dry matter content, number of fertile grain plant^{-1}, number of unfertile grain plant^{-1}, grain ear^{-1}, weight of 1000 seed, grain yield, straw yield, harvest index and Protein percentage due to varieties. At 30, 60 and 90 DAS, the tallest plants (72.78 and 63.37 cm), highest number of leaves per plant (5.00, 5.11 and 5.15), leaf length (24.30, 29.92 and 31.44 cm), highest dry matter in plant (4.33, 11.78 and 17.77 g plant^{-1}) were recorded from 125 kg N ha^{-1} application. The maximum grains ear^{-1} (17.60 cm), highest number of fertile grains plant^{-1} (52.85), number of unfertile grains plant^{-1} (6.45), 1000-grain weight (53.92 g), grain yield (4.77 t ha^{-1}), straw yield (6.03 t ha^{-1}), Harvest index (49.68 %) and, Protein content (10.27 %) was revealed that the application of 125 kg N ha^{-1}.

The result indicated significant variations in plant height, number of leaves plant^{-1}, leaf length, and dry matter content, number of fertile grain plant-1, number of unfertile grain plant^{-1}, grain ear^{-1}, and weight of 1000 seed, grain yield, straw yield, harvest index and Protein percentage due to treatments. At 30, 60 and 90 DAS, the tallest plants (42.00, 72.45 and 99.85 cm), maximum number of leaves per plant (5.31, 5.35 and 5.45), maximum leaf length (24.78, 32.33 and 32.51 cm), dry matter content (4.98, 14.04 and 19.49 g plant^{-1}) were observed from V_2N_3. The highest grains ear^{-1} (18.24 cm), number of fertile grains plant^{-1} (59.67), number of unfertile grains plant $^{-1}$ (7.89), 1000-grain weight (57.60 g), grain yield (4.71 t ha^{-1}), straw yield (6.11 t ha^{-1}), harvest index (49.37%) and Protein content (10.88 %) was found in V_2N_3. When wheat variety was cultivated BARI Gom-24 with application of 125 kg N ha^{-1} then this combination given the best result.

From the above discussion it may be concluded that BARI Gom 24 showed the best result performance on the basis of yield and protein content when fertilized with 125 kg N ha^{-1} along with recommended rate of others nutrients compare to those of other varieties studied in this experiment.

Recommendations

Considering the above observation of the present study and further investigation in the following areas may be suggested.

1. Ensuring the application of different nitrogen levels in relation to growth and yield performance in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
2. More wheat varieties may be included future study in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.

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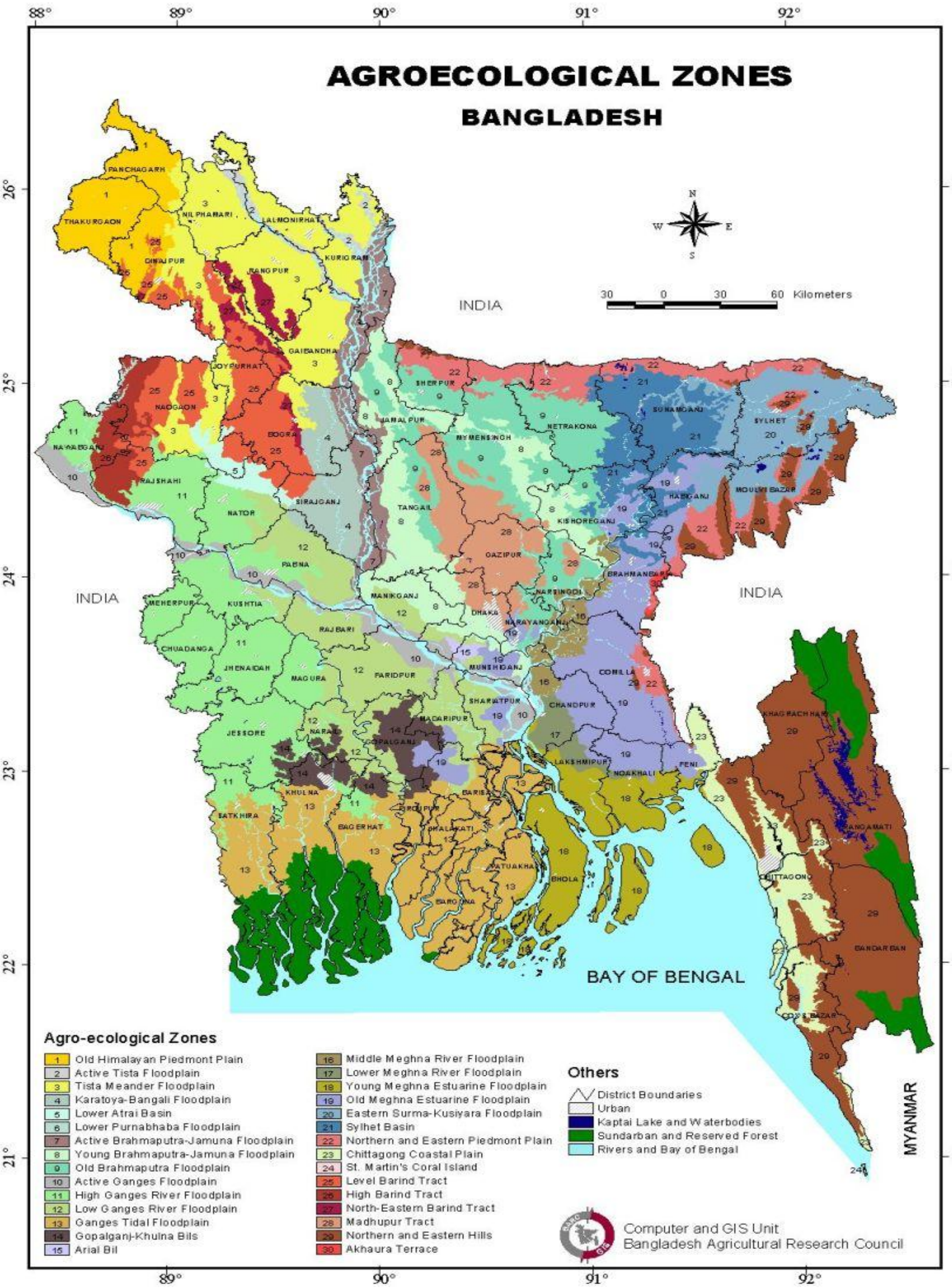
APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh



Appendix II. Characteristics of Aronomy Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Ferm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Fallow-wheat

B. Physical and chemical properties of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
pH	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20.00
Exchangeable K (mel 1 00 g soil)	0.10
Available S (ppm)	45

Source : SRDI, 2013

Appendix III. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from November 2012 to March 2013

Month	Average air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)	Total Sunshine per day (hrs)
	Maximum	Minimum	Mean			
November, 2012	29.7	20.1	24.9	65	5	6.4
December, 2012	26.9	15.8	21.35	68	0	7.0
January, 2013	24.6	12.5	18.7	66	0	5.5
February, 2013	36.0	24.6	30.3	83	37	4.1
March, 2013	36.0	23.6	29.8	81	45	3.9

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan. Dhaka – 1212

Appendix IV: Error mean square values for plant height of wheat

Source of variation	Degrees of freedom	Plant height		
		30 DAS	60 DAS	90 DAS
Replication	2	0.477	1.293	2.566
Variety (A)	2	3.260*	8.767*	13.342*
Nitrogen level (B)	3	26.337**	217.063**	115.873**
A × B	6	3.820**	13.072**	15.437**
Error	22	1.009	2.985	3.278

*Significant at 5% level of probability

** Significant at 1% level of probability

Appendix V: Error mean square values for number of leaves per plant of wheat

Source of variation	Degrees of freedom	Number of leaves per plant		
		30 DAS	**60 DAS**	**90 DAS**
Replication	2	0.0001	0.141	0.023
Variety (A)	2	0.012*	0.776*	1.254*
Nitrogen level (B)	3	0.411**	7.440**	45.312**
A × B	6	0.009**	0.984**	4.178**
Error	22	0.003	0.207	0.398

*Significant at 5% level of probability

** Significant at 1% level of probability

Appendix VI: Error mean square values for leaf length of wheat

Source of variation	Degrees of freedom	Leaf length		
		30 DAS	**60 DAS**	**90 DAS**
Replication	2	0.477	1.293	2.566
Variety (A)	2	3.260*	8.767*	13.342*
Nitrogen level (B)	3	26.337**	217.063**	115.873**
A × B	6	3.820**	13.072**	15.437**
Error	22	1.009	2.985	3.278

*Significant at 5% level of probability

** Significant at 1% level of probability

Appendix VII: Error mean square values for total dry matter of wheat

Source of variation	Degrees of freedom	Dry matter content		
		30 DAS	60 DAS	90 DAS
Replication	2	0.087	0.378	0.089
Variety (A)	2	2.854**	1.718**	2.290*
Nitrogen level (B)	3	2.317**	1.905**	6.442**
A × B	6	1.286**	2.347**	2.043**
Error	22	0.118	0.334	0.599

*Significant at 5% level of probability

** Significant at 1% level of probability

Appendix VIII: Error mean square values for weight of 1000 seed, grain yield, straw yield, harvest index and protean content of wheat

Source of variation	Degrees of freedom	Weight of 1000 seed	Grain yield	Straw yield	Harvest index	Protein content
Replication	2	27.709	16506.667	28666.667	184349.683	1.067
Variety (A)	2	207.177**	119286.133**	429715.702**	675581.729**	1.295**
Nitrogen level (B)	3	446.009**	750176.859**	2042626.627**	5230420.753**	4.318**
A × B	6	379.101**	39221.130**	122100.501**	225033.308**	2.601**
Error	22	17.447	4592.381	7952.381	86146.457	0.210

*Significant at 5% level of probability
** Significant at 1% level of probability

PLATES

Plate 1: Field management of wheat at ripening stage

Plate 2: Harvesting time of wheat