INFLUENCE OF NITROGEN LEVEL AND WEEDING ON THE PERFORMANCE OF WHEAT

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REGISTRATION NO. 04-01327

A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGRONOMY

SEMESTER: JULY-DECEMBER, 2009

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This is to certify that the thesis entitled, "***Influence Of Nitrogen Level And Weeding On The Performance Of Wheat***" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in AGRONOMY, embodies the result of a piece of bona fide research work carried out by Shefain Sultana, Registration No. 04-01327 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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To My
Respected Parents

ACKNOWLEDGEMENT

All the gratefulness to the almighty Allah who enabled her to accomplish this thesis paper.

The auther would like to express her heartiest respect, deepest sense of gratitude, profound appreciation to her supervisor, **Prof. Dr.A.K.M.Ruhul Amin.** Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.

The author would like to express her heartiest respect and profound appreciation to her co-supervisor, **Dr.Md.Shahidul Islam ,Associate Professor,** Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.

The author expresses her sincere respect to the Chairman,prof. **Dr. Md. Fazlul Karim** and all the teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.

The author would like to thank Samsul Arifin who has helped her to prepare this thesis paper. She also thank especially to Arif,Tanim, Hira, , Ali, Masud and Lily for helping her in the research work.

Mere diction is not enough to express her profound gratitude and deepest appreciation to her grandmother, mother, husband, elder brother and friends for their ever ending prayer, encouragement, sacrifice and dedicated efforts to educate her to this level.

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LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
^0C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	and others
kg	=	Kilogram
kg ha^{-1}	=	Kilogram per hectare
g	=	gram (s)
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
p^H	=	Hydrogen ion conc.
TSP	=	Triple Super Phosphate
t ha^{-1}	=	ton per hectare
%	=	Percent

INFLUENCE OF NITROGEN LEVEL AND WEEDING ON THE PERFORMANCE OF WHEAT

ABSTRACT

A field experiment was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University, during the period from November, 2008 to March, 2009, to find out the effect of nitrogen level and weeding on the performance of wheat. The treatments comprised five different levels of nitrogen (0 kg ha^{-1}, 69 kg ha^{-1}, 92 kg ha^{-1}, 115 kg ha^{-1} and 138 kg ha^{-1}) and three weedings (no weeding, one weeding at 30 days after sowing and two weedings at 30 and 60 days after sowing). The experiment was laid out in a split plot design with three replications assign nitrogen level in the main plot and weeding in the sub plot. Result showed that increasing nitrogen level upto 115 kg ha^{-1} and increasing number weeding increased grain yield by increasing all the yield contributing parameters. Interaction of 115 kg ha^{-1} and two weedings gave the highest values for the said parameters.

Chapter 1
Introduction

Chapter 1

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INTRODUCTION

Wheat is the second major cereal crop in Bangladesh whereas it ranks first in the world among the grain crops in respect of both area and production among the grain crops of the world. (FAO, 2008). Wheat grain is used as food for men and feed for animals. Bangladesh has been facing acute food shortage for long time due to high population pressure. It is necessary to produce more and more food to achieve the goal of self sufficiency in food. Increasing production per unit area is the only way to minimize the food deficit by applying modem cultivation knowledge and technology in Bangladesh.

It is preferable to rice for its higher seed protein content. About one-third of the world population lives on wheat grains for their subsistence (FAO, 2008). Wheat grain is rich in food value containing 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals (BARI, 2006). Rice is the staple food of Bangladesh but its total production is not sufficient to feed the growing population of the country.

In Bangladesh, the position of wheat is second in respect of total area of land (0.80 million hectares) and production (2.80 million ton) after rice and the average yield of wheat is only 3.44 t ha^{-1} (BBS, 2010) and it can be increased up to 6.8 t ha^{-1} (RARS, 2010). So, there is an ample opportunity to increase production of wheat per unit area through adoption of modern and improved agronomic practices such as optimum grain rate, timely sowing, and judicious application of irrigation, fertilizer and other inputs

Increase in cropping intensity and introduction of high yielding varieties have caused considerable drain of nitrogen and crops showed a positive response to added nitrogen in the soil (Ali *et al.*, 2004). Nitrogen occupies a conspicuous place in a plant metabolism and it also increases the grain yield in cereals. In addition to the formation of proteins, nitrogen is an integral part of chlorophyll, which is the primary absorber of light energy for photosynthesis. An adequate supply of nitrogen is associated with high photosynthetic activity, vigorous vegetative growth and a dark green color, and its supply influences the utilization of carbohydrates. Recent research demonstrates that nitrogen is beneficial at certain growth stages for some genotypes of corn, sorghum, soybeans, wheat and barley, further, its application at postsilking or during grain filling is required to maximize grain yields. Yield and yield components of high yielding varieties are generally increased by increasing level of nitrogen. Therefore, judicious use of nitrogenous fertilizers is of prime importance for farm profitability and environmental protection from pollution.

Weeds often accumulate more nutrients than crops, thus gaining a competitive advantage for other resources, particularly light. Furthermore, the nutrient levels in the soil will likely be depleted more rapidly in the presence of weeds, causing additional losses in crop yield. Thus, it is important to develop fertilization or crop production strategies with three primary objectives in mind: maximize crop competitiveness, minimize weed competitiveness, and lessen the opportunity for nitrate contamination of groundwater. This can include such practices as banding fertilizers in the crop row as opposed to broadcast applications' carefully controlling the timing of nutrient application and using nitrification inhibitors , slow release fertilizers, composts or manures. In addition to manipulating fertilization strategies, nutrient use efficiency can be enhanced through the choice of appropriate cultivars and the employment of cultural practices that maximize nutrient uptake by crops. (Scursoni and Arnold,2004)

Numerous studies have shown that improve the application of nutrients to the soil, particularly nitrogen (N), potassium (K) and phosphorus (P) increased crop yield. However, while nutrients clearly promote crop growth, the application of fertilizers often benefits weeds more than crops. This is usually due to an increase in the innate ability of weeds to accumulate mineral. Increased uptake of minerals in weeds can result in a significant competitive advantage over crop species (shading, moisture depletion). For example, the addition of N fertilizer to wheat infested with wild oat (*Avena fatua*) or green foxtail (*Setaria virids*) increased the weed density and decreased the crop grain yield. Conversely, banding P in the seed row increased the crop's competitiveness, thus increasing grain yields while depressing wild oat.

Competition among weeds and crops for nutrients is not independent of competition for other resources. The ability of a species to better utilize available nutrients can also provide an advantage in competition for water and light. Increasing N in rice benefited purple nutsedge (*Cyperus roundus*) more than the crop. The subsequent increase in nutsedge growth reduced light transmission to the crop, thus reducing rice grain yield. By adopting fertilizer best management practices it is possible to simultaneously reduce the harmful effect of weeds on crop growth and yield, maximize the competitive ability of crops, and reduce the potential for groundwater degradation. This can be accomplished through a number of strategies, including fertilizer banding, use of nitrification inhibitors and alternative nitrogen sources, and fertilizer application timing.

Nitrogen, one of the major essential plant nutrients, which plays an important role in producing higher grain yield of wheat (Ahmed and Hossain, 2002). For increasing nitrogen use efficiency, top dressing, top dressing and split application of nitrogenous fertilizers at critical growth stages of wheat are now being emphasized (Singh, 2003). Randhawa *et al.* (2004) also mentioned that the split application of nitrogenous fertilizer for wheat was more beneficial than its single dose application at sowing. So, both timely irrigation and split application of nitrogen are equally essential as because they similarly and vitally influence the grain yield of wheat. Sufficient nutrient supply ensures higher yield performance due to soil condition by increasing productivity. Among the different plant nutrients, nitrogen has the more effectiveness on growth, which has the great role on higher grain yield and quality seed production (Ashok and Sharma, 2004).

Generally weeds are always considered as harmful plants. Weeds are one of the biggest threats to agriculture (Ross, and Acker, 2005). They use the soil fertility, available nutrients and moisture and compete for space and sunlight with the crop plants. This not only results in yield reduction but also deteriorates the quality of the produce, hence reducing the market value of crops (Heyne, 1987). It has been estimated that crop losses due to weed competition throughout the world as a whole are greater than those resulting from the combined effects of insect pests and diseases. There are thus several reasons for entirely eliminating weeds from the crop environment.

Therefore, the present experiment was conducted with the following objectives:

Objectives:

1. To determine the effect of nitrogen level on growth and yield of wheat,
2. To find out the effect of duration of weed existence on growth and yield of wheat, and
3. To determine the interaction effect of nitrogen level and weed existence duration on growth and yield of wheat.

Chapter 2
Review of literature

Chapter 2

REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief review of researches in relation to the effect of nitrogen level and weeding in the crop field on growth and yield of wheat.

2.1. Effect of nitrogen

Ali (2010) carried out a field study to determine the influence of varying nitrogen levels (0, 70, 140 and 210 kg N ha^{-1}) applied to wheat cultivars i.e. Inqlab-91 and Bakhar-2000. Data for various growth and yield parameters of the crops were collected and analyzed. Bakhar-2000 produced significantly more and taller plants throughout the crop growth and each increment of nitrogen increased plant height significantly. Significantly higher number of tillers and fertile tillers was recorded in Bakhar-2000 and Nitrogen applied at the rate of 210 kg ha^{-1}. This cultivar produced higher 1000-grain weight as well as grain yield than that of Inqlab-91.

Shen *et al.* (2007) conducted a field experiment in China to identify the effects of N application rates (180 and 240 kg ha^{-1}) on grain yield, protein and its components in wheat cv. Ningyan 1. The grain number per spike increased with the increase of N application rate, while the 1000-grain weight decreased. The ear number per unit area, dry matter accumulation, after flowering, leaf area index at heading stage and grain yield increased with the increase of N application rate. When the N rate was 180 kg ha^{-1}, the ear number was increased.

Chaturvedi (2006) conducted a field experiment in India to evaluate the effects of different rates of nitrogen (0, 25, 50, 75, 100 and 125 kg ha^{-1}) applied as urea on the growth, yield, and nutrient uptake of wheat (*Triticum aestivum*) cv. Raj 3077. Various growth, yield and yield parameters of the crop were influenced differently by various nitrogen rates. Nitrogen at 125 kg ha^{-1} was optimum for the growth, yield and nutrient uptake of wheat. Application of 125 kg N ha^{-1} significantly increased plant height (95:2 cm), total number of tillers (1402 m^{-2}), number of green leaves (1067 m^{-2}), dry matter accumulation (14.65 t ha^{-1}), number of grains $spike^{-1}$ (40.5), 1000 grain weight (48.1 g), grain and straw yields (4667 kg ha^{-1} based on pooled data), and uptake of N (102.3 kg ha^{-1}), respectively.

Cerny *et al.* (2005) conducted a field experiments to study the effects of different levels of nitrogen (N) fertilizer application and different forms of N fertilizers on the qualitative and quantitative parameters of the durum wheat cultivars Istrodur and Martondur. Grain yield and technological quality parameters were significantly influenced by fertilizer application. Istrodur produced the highest grain yield (3.85 t ha^{-1}; increased by 4.37%) with the application of 80 kg N ha^{-1}. Martondur yielded the highest (3.96 t ha^{-1}, increased by 16%) at the rate of 120 kg N ha^{-1} Istrodur achieved the highest protein content (13.66%) and glassiness (83.63%) at a rate of 1.20 kg N ha^{-1} and the protein content and glassiness was 16.65 and 85.89% respectively, for Martondur applied with 80 kg N ha^{-1}.

Feng *et al.* (2005) carried out a field experiments in China, wheat cultivars Yumai 66 (large-spike type) and Yumai 49 (mufti-spike type) were supplied with nitrogen fertilizer at 0, 150, 225 and 300 kg N ha^{-1}, of which half was applied as basal fertilizer and the other half added at the , stem-elongation stage of the plant. Noodle-related, quality of Yumai 66 improved with N rate while that of Yumai 49 improved with N rate up to 225 kg N ha^{-1} and deteriorated with 300 kg N ha^{-1}. Both cultivars gave the highest yield due to application of 300 kg N ha^{-1} treatment. Greatest economic efficiency was obtained by the application of 150 kg N ha^{-1} for Yumai 66. Yumai 66 had better quality for all the traits studied except peak viscosity then Yumai 49, but its yield was lower.

Chrzanowska *et al.* (2008) conducted a field experiment in Poland to evaluate the effects of N fertilizer rates and application methods on grain yield and quality of the winter wheat cultivars Kobra. Nitrogen granules influenced the yield and quality of the cultivar. Foliar urea was ineffective. The cultivar on the stand after rape exhibited a significant yield increase with nitrogen rate of 40 kg ha^{-1}, in comparison with the control. A nitrogen rate of 80 kg ha^{-1} (applied in split doses of 40 kg ha^{-1} each at the beginning of the growing season and at the shooting stage), compared to the rate of 40 kg ha^{-1}, proved to be more efficient for Kobra cultivar. Nitrogen rate of 120 kg ha^{-1} did not show any significant effect oil the yield parameters under investigation. Foliar nitrogen application improved the protein content, glassiness and sedimentation index of the wheat grain.

Oad *et al.* (2007) conducted a field experiment in Pakistan to assess the suitable nitrogen (N) levels and placements for the yield and yield traits of wheat cv. Kiran-95. Three N levels (80, 120 and 150 kg ha^{-1}) were incorporated through broadcast, split, pop-up and foliar methods. Split application of 120 kg N ha^{-1} significantly produced lengthy spikes, more grain number $spike^{-1}$, better seed index and maximum grain yield $hectare^{-1}$ followed by broadcast, foliar and pop-up N placements.

Chandurkar *et al.* (2007) carried out a field experiment in India, during Rabi season to determine the response of improved wheat cultivars (GW-322, MACS-2496 and MACS-2846), and their N content and uptake in grain and straw with increasing N fertilizer rates (90, 120 and 150 kg ha^{-1}). The highest grain yield, N content, N uptake and protein content were obtained with 150 kg N ha^{-1} treatment. GW-322 gave the highest gain yield, N content, total N uptake and protein content.

Liaqat *et al.* (2008) conducted an experiment in the Rabi season in Pakistan to evaluate the response of wheat cv. Uqab-2000 to N at 84, 128, 150, 175 and 200 kg ha^{-1}. The number of productive tillers m^{-2} (408), 1000-grain weight (41.2 g) and crop yield (5160 kg ha^{-1}) were highest at a rate of 150 kg N ha^{-1}.N at 175 kg ha^{-1} resulted in the highest number of grains $spike^{-1}$. Maximum plant height was obtained at N at 200 kg ha^{-1}.

Scursoni and Arnold (2004) observed that when wild oat densities were high in wheat (*Triticum aestivum* L.), increasing nitrogen application rates resulted in greater wheat yield loss. Blackshaw *et al.* (2010) found that the method and timing of nitrogen fertilizer application could affect the biomass of wild oat in spring wheat.

2.2. Effect of weeds

Abrar (2009) carried out an investigation to determine the effect of weed competition periods on the growth and yield of black seed (*Kalwanji*) at Faisalabad during 2007-08 growing season. Comprising of seven weed competition periods (no competition, competition for 40, 50, 60, 70 and 80 days after emergence and competition throughout the growing season). The dominant weeds in the experimental area were *Phalaris minor*, *Chenopodium album* and *Convolvulus arvensis*. The results showed that the weed control practices increased the grain yield hectare^{-1} over weedy check by 69.41% by affecting different growth and yield components like number of plants, number of branches, number of capsules, and number of grains capsule^{-1}, 1000-grains weight and total biomass significantly by weed competition periods. All the components were decreased progressively by increasing weed competition periods in black grain.

Iffat (2010) carried out a field study at the Botanical Garden of the University of Punjab, Pakistan, to investigate the yield losses by 6 commonly occurring and most abundant weeds in wheat field viz., *Phalaris minor* Retz., *Rumex dentatus* L., *Coronopus didymus* (L.) Sm., *Medicago denticulate* Willd., *Chenopodium album* L., and *Poa annua* L. These weeds were grown with two commercially grown wheat varieties viz., Inqalab 91 and Punjab 96 in 1:1 weed-crop ratio. Maximum yield losses of 76% in Inqalab 91 were caused by *P. annua* followed by 75% by *C. didymus*, whereas other weeds caused 60-70% yield losses. In case of Punjab 96, maximum yield reduction of 55% was caused by *R. dentatus* followed by *P. minor* (28%), *M. denticulata*, *C. album* (23%), *C. didymus* (10%) and *P. annua* (0%). Punjab 96 proved to be the comparatively resistant against weeds than Inqalab 91.

Weeds are one of the biggest threats to agriculture (Ross, and Acker, 2005). They use the soil fertility, available nutrients and moisture and compete for space and sunlight with the crop plants. This not only results in yield reduction but also deteriorates the quality of the produce, hence reducing the market value of crops. It has been estimated that crop losses due to weed competition throughout the world as a whole are greater than those resulting from the combined effects of insect pests and diseases. There are thus several reasons for entirely eliminating weeds from the crop environment.

Acker (2010) carried out an experiment to determine the effect of weed management practices on yield attributes and yield of wheat. Higher weeding frequency resulting increased plant height (20-30%), dry matter accumulation (12-20%), grains spike^{-1} (8-12%). Unweeded check resulted in least yield attributes number of primary and secondary tillers plant^{-1}, dry weight plant^{-1}, number of spikes plant^{-1}, number of grains spike^{-1} and 1000-grains weight and yield of wheat. Higher results gained with more weeding practices. The highest yield components and yields of wheat were obtained under three weeding at 15, 35 and 60 DAS than two weeding at 15 and 35 DAS. The yield increase was 4.48 and 8.52% higher under three weeding at 15, 35 and 60 DAS.

Several researchers have assessed the effects of different weeds on both spring and winter wheat and they reported that failure to remove weeds reduced wheat yield by 28% and 39% where weeds were at densities of 64 and 188 plants m^{-2}, respectively (Ross, and Acker, 2010) and Dhima *et al.* (2000).

2.3. Interaction effect of nitrogen and weed

Anderson *et al.* (2010) conducted a field experiment to quantify the effect of nitrogen fertilizer on wheat yield loss due to wild oat interference and on crop-weed competition. The experiment was designed as a split plot arrangement with nitrogen fertilizer (N_0, unfertilized control; N_1, 150 N Kg ha^{-1} before wheat seeding and N_2, 50 kg N ha^{-1} before wheat seeding + 100 Kg N ha^{-1} at late tillering stage of wheat) as main plot and wild oat density (D0: weed- free control, D_1: 25, D_2: 50, D_3: 75 and D_4: 100 plants m^{-2}) as subplot with three replications. Initial slope of the rectangular hyperbola model was significantly greater when nitrogen fertilizer was applied. Moreover, for the rectangular hyperbola model, there was significant effect of nitrogen application on estimated maximum wheat yield loss. Application of 150 Kg N ha^{-1} (N_1 treatment) before crop seeding resulted in a greater higher competitive ability of wild oat than other treatments. The slope of the linear model representing the relationship between wild oat density and relative wild oat biomass significantly greater when nitrogen fertilizer applied. Information gained in this study will be utilized to develop a more integrated program for weed management in spring wheat.

Bhat (2006) conducted a field experiment at the research farm of PAU, Ludhiana during 2003-04 and 2004-05 to study the effect of nitrogen levels, irrigation regimes and weed control methods on root density, water use and grain yield of bed planted durum wheat on loamy sand soil, rating low in available nitrogen and medium in phosphorous and potassium. About 60 per cent roots were confined to upper 0-15 cm soil layer. Maximum water use efficiency of 103.0 and 94.01 kg grain ha^{-1} cm^{-1} was recorded during 2003-04 and 2004-05, respectively under application of 150 kg N ha^{-1}. Application of 120 kg N ha^{-1} (though at with 150 kg N ha^{-1}) provided a yield advantage of 9.4 and 6.04 per cent over 90 kg N ha^{-1} during first and second year of experimentation, respectively. Clodinafop 0.06 kg ha^{-1} application effectively controlled Phalaris minor and resulted in significant improvement in grain yield (14.4%) as compared to unweeded check. The two moisture regimes did not produce any significant effects on wheat grain yield.

Brandt *et al.* (2009) showed major advantages of increased crop density and spatial uniformity for competition of wheat with weeds. Field experiments were performed over 3 year to determine whether the effects of crop density and sowing pattern on weed suppression are influenced by nitrogen fertilization. Increased crop density had strong and consistent negative effects on weed biomass and positive effects on crop biomass and yield. At the highest crop density, weed biomass was less than half that at the lowest density. Weed biomass was generally lower, and yield higher, in the uniform pattern, except in one case in which a combination of factors gave one weed species an early size advantage over the crop. When weeds were controlled with herbicide, no effects of crop density or spatial uniformity on crop biomass or yield were observed. Nitrogen fertilization increased weed biomass in 2 of 3 year, and it also increased crop biomass in 2 of 3 year, but there was little evidence that the relative effects of crop density and spatial pattern on weed suppression were influenced by nitrogen fertilization. In the presence of weeds, the highest yields were obtained with high crop density, high spatial uniformity and nitrogen fertilization. The results indicate that increased weed suppression through increased crop density and spatial uniformity will occur over a wide range of nitrogen levels.

Fertilization is an important agronomic strategy used extensively to increase crop yield. Nevertheless, although nutrients clearly promote crop growth, many studies have shown that, in some cases, fertilizers benefit weeds more than crops (Dhima *et al.* 2000). The addition of N fertilizer to wild oat-infested wheat increased the density of wild oat panicles without increasing crop yield. However, Satorre and Snaydon (2007) showed that N fertilizer reduced the severity of competition experienced by wild oat from six spring cereals.

The increase in weed competition at higher N rates has been suggested to be related to an increase in the efficiency of nutrient accumulation and use by weeds. In addition, Brandt *et al.* (2009) reported differences in weed response to soil fertility for wheat and canola (*Brassica napus* L.), suggesting that this may be exploited through the development of agronomic systems that stimulate crop growth over weed growth. Timely weeding and optimum nitrogen dose contribute higher growth and yield of crops (Blackshaw *et al.*, 2010). In addition Acker (2010), stated minimum two weeding not more than three with 200 kg N ha^{-1} resulted higher plant height, tiller number, grains $spike^{-1}$, grain yield and biomass yield and harvest index. Due to crop-weed competition grain also loss its nutritional value and quality.

Knezevic *et al.* (2006) noted that insufficient N can reduce corn (*Zea mays* L.) tolerance to weeds and can lengthen the critical period for weed control. Fertilizer application can have an influence on the composition of the weed community. In this sense, Jornsgard *et al.* (2006) demonstrated an interaction between the growth of individual weed species and the level of N fertilizer in cereal crops. They found that common lambsquarters (*Chenopodium album* L.) in competition with spring barley has a lower N optimum than does the crop, whereas burning nettle (*Urtica urens* L.) has a higher N optimum than does the crop.

Anderson *et al.* (2007) found that in a spring wheat-winter wheat-sunflower (*Helianthus annuus* L.) rotation conducted under a no-till system, N application increased crop competitiveness and reduced weed density. Likewise, the increase in soil fertility as a result of the introduction of subterranean clover (*Trifolium subterraneum* L.) and the application of super phosphate has favored different species of thistles (*Cirsium spp.*) in Australia (Sindel, 2000). However, in long term experiments, found that the effect of crop species on weed flora was more important than the effect of N application. Moreover, N application did not strongly influence the composition of the weed flora.

In small grain cropping systems of the south- western of Iran, wild oat (*Avena fatua* L.) is a weed species of primary concern. As expected, wild oat performance is affected by fertilizer and soil moisture levels. For example, Blackshaw *et al.* (2010) found that greater spring application rates of broadcast nitrogen increased the number of wild oats present in an oat (*Avena sativa* L.) field.

Chapter 3

Materials and Methods

Chapter 3

MATERIALS AND METHODS

In this chapter, the details of different materials used and methodology followed during the experimental period are described below.

3.1 Experimental site

The research work was carried out at the experimental field of Sher-e- Bangla Agricultural University, Dhaka during the period from November 2008 to March 2009 to study the influence of nitrogen level and weeding for the performance of wheat. The soil of the site was well drained and medium high. Weather data (monthly) during the experimental period and physical and chemical properties of soil have been presented in Appendix I and Appendix II, respectively. The average temperature during the experimentation was 20^0 C – 25^0 C. The soil of the experimental plots belonged to the agro ecological zone Madhupur Tract (AEZ-28).

3.2 Planting material

The variety of wheat for the present study was BARI wheat 24 (Prodip). The seeds of this variety were collected from the Bangladesh Agricultural Research Institute (BARI), Gazipur. Before sowing, the seeds were tested for germination in the laboratory and the percentage of germination was found to be over 90%. The important characteristics of these varieties are mentioned below:

3.2.1 BARI wheat 24 (Prodip)

Plants are of average 95 to 100 cm in height. Leaves are darker green and wide. Spikes are long and grains spike^{-1} is 45 – 50; duration of panicle initiation is 64 to 66 days. Weight of 1000 grains is 48 to 55 g. Duration of crop (from sowing to harvest) is 102 – 110 days. Maximum yield is 4300 to 5100 kg ha^{-1}. This variety is susceptible to leaf spot diseases and resistant to leaf rust diseases. Seeds contain strong gluten which is very useful for bread making.

3.3 Land preparation

The land was first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing and harrowing with country plough and ladder. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 9 November and 14 November 2009, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before sowing and the basal dose of fertilizers was applied thoroughly before sowing.

3.4 Fertilizer application The following fertilizer dose were applied for the Crop-

Urea	:	As per treatment
TSP	:	140 kg ha^{-1}
MP	:	40 kg ha^{-1}
Gypsum	:	110 kg ha^{-1}

Two third ($^2/_3$) amount of Urea and whole amount TSP, MP and Gypsum were applied as basal dose. Rest amount of urea ($^1/_3$) were applied as top dressing after first irrigation.

3.5 Treatments of the experiment

The experiment was two factorials with five levels of nitrogen and three levels of weeding treatments.

3.5.1 FactorA: Nitrogen dose (Urea)-5

The following nitrogen doses were applied in the experiment

N_0 = 0 kg ha^{-1}

N_1 = 69 kg ha^{-1}

N_2 = 92 kg ha^{-1}

N_3 = 115 kg ha^{-1}

N_4 = 138 kg ha^{-1}

3.5.2 Factor B: Weeding

The following weeding treatments were imposed in the experiment

W_0 = No weeding
W_1 = One weeding at 30 DAS
W_2 = Two weedings at 30 and 60 DAS

3.5.3 Interaction of Factor A and Factor B

Combining two factors 15 treatment combinations were obtained;

N_0W_0	N_1W_0	N_2W_0	N_3W_0	N_4W_0
N_0W_1	N_1W_1	N_2W_1	N_3W_1	N_4W_1
N_0W_2	N_1W_2	N_2W_2	N_3W_2	N_4W_2

3.6 Experimental design and layout

The experiment was laid out in a split plot design, where urea was applied in main plot and weeding in the sub plots. Each treatment was replicated thrice. The size of a unit plot was 3 m × 2 m. The distance between two adjacent replications (block) was 1m and row-to-row distance was 0.5 m. plot to plot distance was 0.75 m and the inter block and inter row spaces were used as footpath and irrigation drainage^{-1} channels.

3.7 Germination test

Germination test was performed before sowing the seeds in the field. For laboratory test, petridishes were used. Filter papers were placed on petridishes and the papers were softening with water. Seeds were distributed at random in petridish. Data on germination were collected on percentage basis by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedling}}{\text{Number of seed set for germination}} \times 100$$

3.8 Sowing of grains

Seeds were sown in lines continuously on 14 November, 2008. Spacing of this crop in the field was done according to the treatment under the study. Seeds were placed 2 cm depth and then rows were covered with loose soil properly.

3.9 Intercultural operations

3.9.1 Weeding

Weeding was done as per treatment. Demarcation boundaries and drainage channels were kept weed free.

3.9.2 Thinning

Thinning was done once in all the unit plots with care so as to maintain a uniform plant population in each plot. Thinning was done at 15 days after sowing (DAS).

3.9.3 Irrigation

Three levels of irrigations were done. First was done at CRI stage, second was done at maximum tillering stage and third was done at grain filling stage.

3.9.4 Sampling

Ten plants were collected randomly from each plot. These 10 plants were used for taking yield component data.

3.10 Harvesting and threshing

The crop was harvested on 8 March 2009. At maturity, when leaves, stems and pods became yellowish in colors, the plants were harvested. One meter^{-2} area was harvested for yield data and it was converted to tonne hectare^{-1}. The harvested plants were tied into bundles and carried to the threshing floor. The crops were sun dried by spreading on the threshing floor. The seeds were separated from the plants by paddle thresher and thereafter were cleaned, dried and weighed. The weights of the dry straw were also taken from the same demarketed area and were also converted to tonne hectare^{-1}.

3.11 Data collection

The following data on plant characters, yield and yield components were recorded:

3.11.1 Plant parameters

1. Plant height (cm)
2. Spike length (cm)
3. Dry matter weight plant^{-1} (g)
4. Number of effective spikes m^{-2}

3.11.2 Yield and yield contributing parameters

1. Number of spikelets spike^{-1}
2. Number of grains spike^{-1}
3. Weight of 1000 grains(g)
4. Grain yield (t ha^{-1})
5. Straw yield (t ha^{-1})
6. Harvest index (%)

3.12 Procedure of data collection

3.12.1 Plant height

The heights of ten sample plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in centimeter.

3.12.2 Spike length

Spike length was taken from pre selected sample plants with a meter scale from the base level to the top of the spike and the mean length was expressed in centimeter.

3.12.3 Dry matter weight plant^{-1}

For measuring the dry matter weight plant^{-1}, three pants from each plot were uprooted on 30, 60, 90 DAS and at harvest, and then dried in an oven at 60^0C for 72 hours and weight was taken carefully. The weight was then averaged to get the weight per plant.

3.12.4 Effective spikes m^{-2} (no.)

Number of effective spikes m^{-2} of pre selected ten plants from each unit plot was noted and the mean number was recorded. The mean number was expressed in plant^{-1} basis.

3.12.5 Spikelets spikes^{-1} (no.)

Number of spikelets spike^{-1} was counted randomly taking ten spikes from each sample of each plot as per treatment.

3.12.6 Grains spike^{-1} (no.)

Number of grains spike^{-1} was counted randomly taking ten spikes from each sample of each plot as per treatment.

3.12.7 Weight of 1000 grains (g)

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and the mean weight was expressed in gram.

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

Weight of grains of the demarketed area (1 m^2) at the centre of each plot was taken and then yield was converted to tonne hectare^{-1}.

3.12.9 Straw yield

The weight of the plants containing grain was taken. By subtracting the grain weight from the total weight. The biomass weights were calculated after threshing and separation of grain from the sample area and then expressed in t ha^{-1} in dry weight basis.

3.12.10. Harvest index (%)

The harvest index was calculated on the ratio of grain yield to biological yield and expressed in terms of percentage. It was calculated by using the following formula (Donald and Hamblim, 1976):

$$\% \text{ Harvest index} = \frac{\textbf{Grain yield}}{\textbf{Biological yield}} \times 100$$

3.13 Analyzes of data

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT computer package program. Mean difference among the treatments were tested with least significant differences (LSD) at 5% level of significance.

Chapter 4

Results and Discussion

Chapter 4

RESULTS AND DISCUSSION

The results obtained from the present study for different plant characters, yields and other analyzes have been presented and discussed in this chapter.

4 Plant parameters

4.1.1 Plant height

4.1.1.1 Effect of nitrogen

Plant height is an important growth parameter to evaluate effective growth of plant for successful crop production and under the present study and there was a significantly variation with the different doses of nitrogen (Table 1). N_4 (138 kg N ha^{-1}) showed the longest plant (96.461 cm) and gradually decreased plant height was observed with lower doses of nitrogen and finally the smallest plant (75.51 cm) was to end with no nitrogen application, N_0 (0 kg N ha^{-1}). The results obtained from all other treatments showed intermediate value compared to longest and shortest plant height under the present study. These results were in conformity with the findings of Ali (2010), Liaqat *et al.* (2008) and Chaturvedi (2006).

4.1.1.2 Effect of weeding

Weeding operation had significant effect on plant height of wheat (Table 1). Higher number of weeding frequency shows higher plant height and the longest plant height (89.96 cm) at harvest was with W_2 (Two weedings at 30 and 60 DAS) which was statistically similar with W_1 (One weeding at 30 DAS). Higher duration of crop-weed competition resulted lower plant height and the minimum (87.76 cm) was no weeding (W_0).

4.1.1.3 Interaction effect of nitrogen and weeding

Plant height was significant due to the interaction of nitrogen and weeding (Table 1). The tallest plant (97.41 cm) was with N_4W_2 (138 kg N ha^{-1} with Two weeding at 30 and 60 DAS) which was statistically similar with N_4W_1 and closely followed by N_3W_2. The shortest plant (74.97 cm) was with N_0W_0 (0 kg N ha^{-1} with No weeding) which was statistically similar with N_0W_1 and N_0W_2. The results obtained from all other combined treatments showed significantly different results in respect of longest and smallest plant height under the present study. Similar results were found by Blackshaw *et al.* (2010) and Acker (2010).

4.1.2 Spike length

4.1.2.1 Effect of nitrogen

Significant variation was observed on spike length at different levels of nitrogen application (Table 1). The longest spike (11.07 cm) was obtained with N_4 (138 kg N ha^{-1}) which was closely followed by N_2 (92 kg N ha^{-1}) and N_3 (115 kg N ha^{-1}) and the shortest spike length (7.36 cm) was with N_0 (0 kg N ha^{-1}). These results were in conformity with the findings of Oad *et al.* (2007).

4.1.2.2 Effect of weeding

With the technique of weeding, there was a significant effect observed on spike length of wheat (Table 1). Higher duration of crop-weed competition resulted shorter spike where as less duration showed longer spike. The longest spike (10.29 cm) was with W_2 (Two weeding at 30 and 60 DAS) which was closely followed by W_1 (One weeding at 30 DAS) and the shortest spike length (9.45 cm) was record in W_0 (No weeding).

4.1.2.3 Interaction effect of nitrogen and weeding

Significant variation was noticed on spike length as influenced by interaction effect of nitrogen and weeding (Table 1). The longest spike (11.49 cm) was with N_4W_2 (138 kg N ha^{-1} with two weedings at 30 and 60 DAS) which were statistically similar with N_2W_2, N_3W_1, N_3W_2 and closely followed by N_1W_1, N_1W_2, N_2W_0, N_2W_1, N_3W_0 and N_4W_0. On the contrary, the shortest spike (7.42 cm) was with N_0W_0 (0 kg N ha^{-1} with No weeding) which was statistically similar with N_0W_2 and closely followed by N_0W_1.

4.1.3 Effective spikes m^{-2}(no.).

4.1.3.1 Effect of Nitrogen

Effective spikes m^{-2} was significant by different doses of nitrogen (Table 1). The results showed that the highest number of effective spike m^{-2} (242.80) was with N_3 (115 kg N ha^{-1}) which was statistically similar with N_2 (92 kg N ha^{-1}). No nitrogen doses in the crop field represented the lowest effective spike m^{-2} (180.70).

4.1.3.2 Effect of weeding

Different duration of crop weed competition had significant effect on effective spikes m^{-2} of wheat (Table 1). Higher duration of crop-weed competition resulted lower effective spikes m^{-2} where less duration showed higher effectiveness. The highest effective spikes m^{-2} (246.70) was with W_2 (Two weeding at 30 and 60 DAS) and the smallest spikes m^{-2} (185.40) was observed in with W_0 (No weeding).

4.1.3.3 Interaction effect of nitrogen and weeding

Combination of nitrogen and weeding on effective spikes m^{-2} had significant influence on effective spikes m^{-2}, (Table 1). The highest effective spikes m^{-2} (276.00) was obtained with N_2W_2 (92 kg N ha^{-1} and two weeding at 30 and 60 DAS). On the other hand the lowest effective spikes m^{-2} (146.60) was observed with N_0W_0 (no weeding and N dose). All other combined treatments showed significantly different results in respect of highest and lowest effective spikes m^{-2} under the present study.

4.1.4 Spikelets spike^{-1} (no.)

4.1.4.1 Effect of nitrogen

Different nitrogen dose exerted significant difference in number of spikelets spike $^{-1}$(Table 1). The highest number of spikelets spike^{-1} (41.80) was obtained with medium level of nitrogen doses, N_3 (115 kg N ha^{-1}) and the lowest number of spikelets spike^{-1} (19.37) was observed with N_0 (0 kg N ha^{-1}). All other treatments showed intermediate value compared to highest and lowest number of spikelets spike^{-1} under the present study.

4.1.4.2 Effect of weeding

Number of spikelets spike^{-1} varied significantly with the length of crop weed competition (Table 1). It was observed that the highest number of spikelets spike^{-1} (39.19) was with W_2 (Two weeding at 30 and 60 DAS). On the other hand the lowest number of spikelets spike^{-1} (25.81) was observed with W_0 (No weeding).

4.1.4.3 Interaction effect of nitrogen and weeding

Significant variation was observed on the number of spikelets spike^{-1} by interaction effect of nitrogen and duration of crop-weed competition (Table 1). Results showed that the highest number of spikelets spike^{-1} (50.00) was with N_3W_2 (115 kg N ha^{-1} and Two weeding at 30 and 60 DAS). The lowest number of spikelets spike^{-1} (16.00) was with N_0W_0 (0 kg N ha^{-1} and No weeding) which were statistically similar with N_0W_1. The results obtained from all other combined treatments were significantly different in respect of highest and lowest number of spikelets spike^{-1} under the present study.

Table 1: Effect of nitrogen, duration of weed competition and their interaction effect on plant perimeters of wheat

Treatments	Plant height (cm)	Spike length (cm)	Effective spikes m^{-2}	spikelets $spike^{-1}$(no.)
Effect of nitrogen				
N_0	75.51	7.361	180.7	19.37
N_1	86.28	9.927	214.7	29.21
N_2	92.70	10.47	240.8	36.34
N_3	93.66	10.84	242.8	41.80
N_4	96.46	11.07	223.3	38.19
$LSD_{0.05}$	**1.517**	**0.8776**	**5.210**	**1.767**
Effect of weeding				
W_0	87.76	9.446	185.4	25.81
W_1	89.04	10.06	229.3	33.95
W_2	89.96	10.29	246.7	39.19
$LSD_{0.05}$	**1.175**	**0.8007**	**4.036**	**1.560**
Interaction effect of nitrogen and weeding				
N_0W_0	74.97	7.420	146.6	16.00
N_0W_1	75.70	7.647	181.4	19.00
N_0W_2	75.87	7.017	214.0	23.11
N_1W_0	84.48	9.093	180.0	24.10
N_1W_1	86.99	9.957	228.0	29.23
N_1W_2	87.38	10.73	236.2	34.30
N_2W_0	91.82	9.820	194.3	26.01
N_2W_1	92.31	10.71	252.0	40.00
N_2W_2	93.97	10.88	276.0	43.00
N_3W_0	92.06	10.23	204.0	32.40
N_3W_1	93.72	10.97	255.0	43.00
N_3W_2	95.19	11.32	269.5	50.00
N_4W_0	94.76	10.67	202.0	30.51
N_4W_1	97.21	11.04	230.0	38.50
N_4W_2	97.41	11.49	238.0	45.55
$LSD_{0.05}$	**2.627**	**1.520**	**8.213**	**3.488**
CV (%)	**9.56**	**6.26**	**7.64**	**6.64**

N_0 = 0 kg N ha^{-1} W_0 = No weeding
N_1 = 69 kg N ha^{-1} W_1 = One weeding at 30 DAS
N_2 = 92 kg N ha^{-1} W_2 = Two weeding at 30 and 60 DAS
N_3 = 115 kg N ha^{-1}
N_4 = 138 kg N ha^{-1}

4.1.4 Dry weight plant^{-1}

4.1.4.1 Effect of Nitrogen

Significant variation as influenced by different levels of nitrogen application at different days after sowing was found on dry weight plant^{-1} (Fig. 1). Higher rate of dry weight plant^{-1} was achieved with higher doses of nitrogen and with this respect the highest dry weight plant^{-1} (4.70, 9.77, 14.45 and 17.39 g at 30, 60, 90 DAS and at harvest respectively) was found with N_3 (115 kg N ha^{-1}) which was statistically similar with N_4 (138 kg N ha^{-1}) and N_2 (92 kg N ha^{-1}) at 30 DAS and closely followed by N_4 (138 kg N ha^{-1}) at 60, 90 DAS and at harvest. The lowest dry weight plant $^{-1}$(3.60, 5.95, 9.33 and 12.10 g at 30, 60, 90 DAS and at harvest respectively) was observed with N_0 (0 kg N ha^{-1}). The results obtained from all other treatments showed intermediate value compared to highest and lowest dry weight plant^{-1} under the present study. These results were in conformity with the findings of Shen *et al.* (2007) and Chaturvedi (2006).

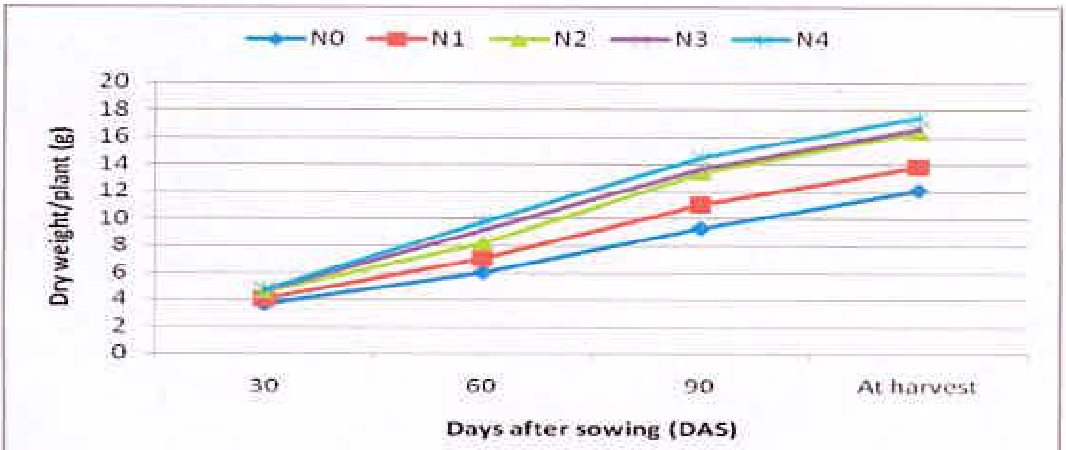

Fig. 1: Effect of different doses of nitrogen on dry weight plant^{-1} at different growth stages of wheat ($LSD_{0.05}$ = 0.7707, 1.036, 0.8523 and 0.8267 for 30, 60 & 90 DAS at harvest, respectfully).

N_0 = 0 kg N ha^{-1}
N_1 = 69 kg N ha^{-1}
N_2 = 92 kg N ha^{-1}
N_3 = 115 kg N ha^{-1}
N_4 = 138 kg N ha^{-1}

4.1.4.2 Effect of weeding

Weeding frequency had significant effect on dry weight plant^{-1} of wheat at different days after sowing (Fig. 2). More weeding operation resulted higher dry weight plant^{-1} and with this respect the highest dry weight plant^{-1} (4.60, 9.06, 14.06 and 16.99 g at 30, 60, 90 DAS and at harvest, respectively) was with W_2 (Two weeding at 30 and 60 DAS) and the lowest dry weight plant^{-1} (3.84, 7.16, 10.77 and 13.60 at 30, 60, 90 DAS and at harvest, respectively) was recorded with W_0 (No weeding).

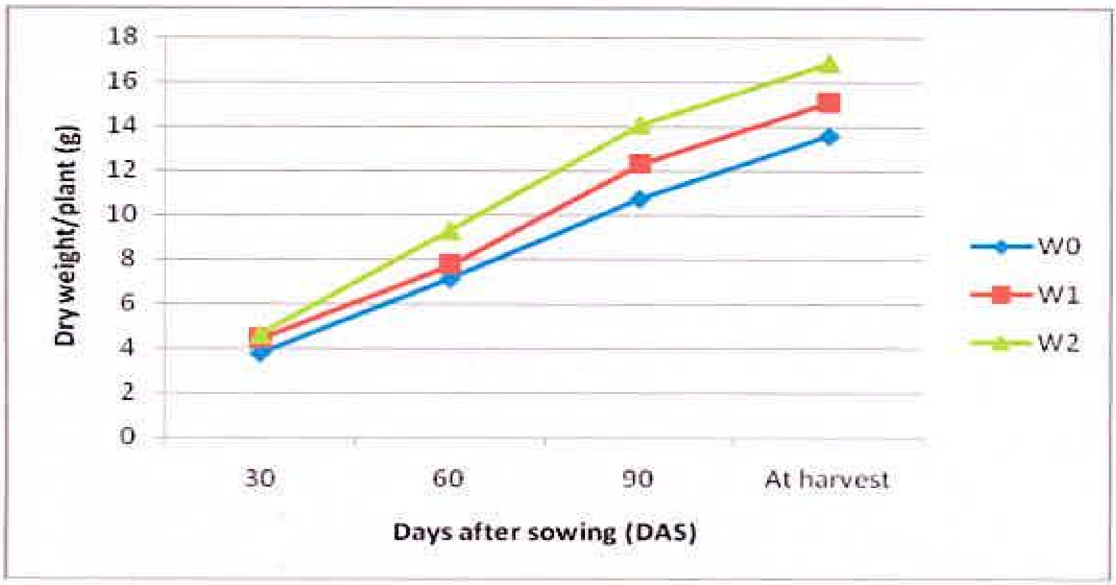

Fig. 2: Effect of weeding on dry weight/plant at different days after sowing ($LSD_{0.05}$ = 0.6843, 0.5018, 0.5177 and 0.4922 for 30, 60 & 90 DAS, at harvest respectively)

W_0 = No weeding
W_1 = One weeding at 30 DAS
W_2 = Two weeding at 30 and 60 DAS

4.1.4.3 Interaction effect of nitrogen and weeding

Significantly different results were found on dry weight plant^{-1} as influenced by nitrogen and weeding combination at different growth stages of wheat (Table 2). It was remarked that the highest dry weight plant^{-1} (4.88, 10.63, 16.59 and 19.64 g at 30, 60, 90 DAS and at harvest, respectively) was with N_3W_2 (115 kg N ha^{-1} with two weeding at 30 and 60 DAS) which was followed by with N_4W_2 (138 kg N ha^{-1} with two weeding at 30 and 60 DAS) for all sampling dates. The lowest dry weight plant^{-1} (3.90, 5.88, 8.64 and 11.41 g at 30, 60, 90 DAS and at harvest, respectively) was with N_0W_0 (no N application with no weeding). All other combined treatments showed significantly different results in respect of highest and lowest dry weight plant^{-1} at all growth stages of wheat under the present study.

Table 2: Interaction effect and duration of weed competition on dry Weight plant^{-1} at different growth stages

Treatments	Dry weight plant $^{-1}$ (g)			
	30 DAS	60 DAS	90 DAS	At harvest
Interaction effect of nitrogen and weeding				
N_0W_0	3.907	5.883	8.643	11.41
N_0W_1	3.977	5.947	9.617	12.37
N_0W_2	4.073	6.023	9.733	12.52
N_1W_0	2.137	6.153	10.57	13.38
N_1W_1	4.217	6.773	10.88	13.67
N_1W_2	4.440	8.090	11.55	14.38
N_2W_0	4.290	7.063	11.01	13.88
N_2W_1	4.637	7.317	13.42	16.30
N_2W_2	4.773	10.03	15.03	18.92
N_3W_0	4.513	8.873	12.36	15.23
N_3W_1	4.707	9.813	14.38	17.30
N_3W_2	4.883	10.63	16.59	19.64
N_4W_0	4.373	7.847	11.26	14.12
N_4W_1	4.587	9.073	13.19	16.17
N_4W_2	4.813	10.50	16.49	19.50
$LSD_{0.05}$	**0.1296**	**1.348**	**0.7076**	**0.6100**
CV (%)	**10.46**	**8.14**	**8.43**	**10.23**

N_0 = 0 kg N ha^{-1} W_0 = No weeding
N_1 = 69 kg N ha^{-1} W_1 = One weeding at 30 DAS
N_2 = 92 kg N ha^{-1} W_2 = Two weeding at 30 and 60 DAS
N_3 = 115 kg N ha^{-1}
N_4 = 138 kg N ha^{-1}

4.2 Yield and yield contributing characters

4.2.1 Grains spike^{-1} (no.)

4.2.1.1 Effect of nitrogen

The number of grains spike^{-1} was significantly influenced by different levels of nitrogen application (Table- 3). The highest number of grains spike^{-1} (36.67) was obtained with N_3 (115 kg N ha^{-1}) which was closely followed by N_4 (138 kg N ha^{-1}) and the lowest (14.54) was observed with N_0 (0 kg N ha^{-1}). These results were in conformity with the findings of Shen *et al.* (2007), Chaturvedi (2006) and Oad *et al.* (2007).

4.2.1.2 Effect of weeding

Significant effect on number of grains spike^{-1} was found with weeding at different days after sowing of wheat (Tab. 4). It was found that the highest number of grains spike^{-1} (32.94) was with W_2 (Two weeding at 30 and 60 DAS) where the lowest (23.98) was with W_0 (no weeding).

4.2.1.3 Interaction effect of nitrogen and weeding

Significant variation was observed on number of grains spike^{-1} as influenced by interaction effect of nitrogen and weeding operation (Table- 3). The highest number of grains spike^{-1} (40.48) was with N_3W_2 (115 kg N ha^{-1} with Two weedings at 30 and 60 DAS) which were closely followed by N_2W_2, N_3W_1, N_4W_1 and N_4W_2. On the other hand the lowest number of grains spike^{-1} (10.58) was with N_0W_0 (0 kg N ha^{-1} with no weeding). All other combined treatments showed significantly different results in respect of highest and lowest number of grains spike^{-1} under the present study. Similar results were bound by Acker (2010).

4.2.2 Weight of 1000 grains

4.2.2.1 Effect of nitrogen

Significant difference was found on weight of 1000 grains as influenced by different levels of nitrogen application (Table- 3). N_3 (115 kg N ha^{-1}) showed the highest 1000 grains weight (45.40 g) which was closely followed by N_4 (138 kg N ha^{-1}) The lowest 1000 grains weight (43.38 g) was observed with N_0 (0 kg N ha^{-1}) which was statistically similar with N_1 (69 kg N ha^{-1}) These results were in conformity with the findings of Ali Hakoomat (2010), Shen *et al.* (2007) and Feng *et al.* (2005).

4.2.2.2 Effect of weeding

Weight of 1000 grains was significantly affected by weeding frequencies (Table- 3). Results showed that the highest 1000 grains weight (45.44 g) was with W_2 (Two weeding at 30 and 60 DAS) which and the lowest 1000 grains weight (43.21 g) was observed with W_0 (no weeding). The results obtained under the present study were similar with Hussain, A. (2009).

4.2.2.3 Interaction effect of nitrogen and weeding

Weight of 1000 grains of wheat under the present study was significantly influenced by the interaction effect of nitrogen and weeding (Table- 3). The result showed that application of two weeding at different growth stages of wheat showed statistically higher level of 1000 grains weight irrespective of nitrogen doses. On the other hand irrespective weeding treatments 115 and 138 kg N ha^{-1} showed the higher level of 1000 grain weight than other nitrogen doses. The highest 1000 grain weight (46.79 g) was with N_3W_2 (115 kg N ha^{-1} with two weedings at 30 and 60 DAS) which were statistically similar with N_4W_2 and closely followed by N_4W_1. The lowest 1000 grain weight (42.33 g) was with N_0W_0 (0 kg N ha^{-1} with no weeding) which was closely followed by N_1W_0. All other combined treatments showed significantly different results in respect of highest and lowest 1000 grains weight under the present study.

4.2.3 Grain yield

4.2.3.1 Effect of Nitrogen

Grain yield was significantly influenced by different levels of nitrogen application (Table 3). The Table shows that grain yield provide a decreasing trend with the increases of nitrogen dose from 115 kg N ha^{-1}. Highest grain yield (4.20 t h^{-1}) was achieved with 115 kg N ha^{-1}. Nitrogen dose lower than 115 kg ha^{-1} showed the second highest grain yield (3.95 t ha^{-1}). It can be inferred from the result that 115 kg N ha^{-1} showed 66.19%, 32.61% and 5.95% and 7.86% higher grain yield than 0, 69 and 92 and 138 kg N ha^{-1}, respectively. These results were in conformity with the findings of Ali (2010), Shen *et al.* (2007) and Feng *et al.* (2005).

4.2.3.2 Effect of weeding

Duration of crop weed competition had significant effect on grain yield of wheat (Table 3). It was observed that the highest grain yield (3.74 t ha^{-1}) was with W_2 (Two weeding at 30 and 60 DAS). On the other hand the lowest grain yield (2.57 t ha^{-1}) was observed with W_0 (no weeding). The results obtained under the present study were similar with Hussain, A. (2009), and Iffat Siddiqui (2010).

4.2.3.3 Interaction effect of nitrogen and weeding

Grain yield was significantly influenced by the interaction effect of nitrogen and weeding (Table 3). Recommended nitrogen dose (115 kg ha^{-1}) gave highest grain yield with all the weeding interaction treatments and that of lowest with no dose of nitrogen (0 kg N ha^{-1}). However, all the weeding with N_2 (115 kg ha^{-1}) treatment combination performed better than other interaction and the interaction N_3W_2 (115kg N $ha^{-1}$with two weedings at 30 and 60 DAS) showed the highest grain yield (4.83 t ha^{-1}) which was closely followed by N_4W_2 and the lowest grain yield (1.02 t ha^{-1}) was with N_0W_0 (0 kg N ha^{-1} with no weeding). Other combined treatments showed significantly different results in respect of highest and lowest grain yield under the present study. This result was in conformity with the findings of Blackshaw *et al.* (2010) and Acker (2010) and Bhat (2006).

4.2.4 Straw yield

4.2.4.1 Effect of nitrogen

Straw yield exerted significant effect due to nitrogen doses (Table 3). The highest straw yield (5.89 t ha^{-1}) was obtained with N_3 (250 kg N/ha) which was statistically identical with N_2 (92 kg N ha^{-1}) and N_4 (138 kg N ha^{-1}). On the other hand the lowest straw yield (2.56 t ha^{-1}) was observed with N_0 (0 kg N ha^{-1}) These results were in conformity with the findings of Chandurkar *et al.* (2007) and Chaturvedi (2006).

4.2.4.2 Effect of weeding

Weeding frequencies at different crop growth stage had significant effect on straw yield of wheat (Table 3). Table represented that the highest straw yield (5.02 t ha^{-1}) at harvest was with W_2 (Two weedings at 30 and 60 DAS). On the other hand the lowest straw yield (4.83 t ha^{-1}) was observed with W_0 (No weeding) which was statistically similar with W_1 (One weeding at 30 DAS). The results obtained under the present study were similar with Hussain, A. (2009).

4.2.4.3 Interaction effect of nitrogen and weeding

Straw yield had significant influenced on straw yield by the by interaction effect of nitrogen and weeding (Table 3). It was observed that the highest straw yield (5.99 t ha^{-1}) was with N_3W_2 (115 kg N ha $^{-1}$ with two weedings at 30 and 60 DAS) which was closely followed by N_2W_2, N_3W_1, and N_4W_2. On the other hand the lowest straw yield (2.37 t ha^{-1}) was with N_0W_0. The combined treatments; N_0W_1, N_0W_2, N_1W_0, N_1W_1 and N_1W_2 were also showed lower straw yield but significantly different from N_0W_0. Similar results were bound by Blackshaw *et al.* (2010) and Acker (2010).

4.2.5 Harvest index

4.2.5.1 Effect of nitrogen

Significant variation was found with different levels of nitrogen application as measured by harvest index (Table 3). It was found that the highest harvest index (41.40%) was obtained with N_3 (115 kg N ha^{-1}) which was statistically similar with N_2 (92 kg N ha^{-1}) and N_4 (138 kg N ha^{-1}) and the lowest harvest index (35.38%) was observed with N_0 (0 kg N ha^{-1}).

4.2.5.2 Effect of weeding

Harvest index showed significant variation as affected by weeding (Table 3). Table showed that the highest harvest index (42.19%) was with W_2 (Two weeding at 30 and 60 DAS) and the lowest harvest index (34.15%) was observed with W_0 (no weeding).

4.2.5.3 Interaction effect of nitrogen and weeding

Harvest index was significantly affected by interaction effect of nitrogen and weeding (Table 3). Results showed that the highest harvest index (44.66 %) was with N_3W_2 (115 kg N ha^{-1} with two weedings at 30 and 60 DAS) which was closely followed by N_2W_1, N_2W_2, N_3W_1 and N_4W_2. Again, the lowest harvest index (30.27%) was with N_0W_0 which was statistically similar with N_0W_1 (0 kg N ha^{-1} with no weeding). The results from all other combined treatments showed significantly different results compared to highest and lowest harvest index under the present study. Similar results were reported by Blackshaw *et al*. (2010) and Acker (2010).

Table 3: Effect of nitrogen, duration of weed competition and their interaction on yield and yield contributing perimeters

Treatments	Grains spike^{-1} (no)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Effect of nitrogen					
N_0	14.54	43.38	1.42	2.56	35.38
N_1	27.96	43.73	2.83	4.78	37.19
N_2	33.42	44.59	3.95	5.68	40.80
N_3	36.67	45.40	4.20	5.89	41.40
N_4	34.90	45.32	3.87	5.66	40.34
$LSD_{0.05}$	**1.788**	**0.7517**	**0.259**	**0.386**	**1.310**
Effect of weeding					
W_0	23.98	43.21	2.573	4.83	34.15
W_1	31.57	44.80	3.449	4.89	40.72
W_2	32.94	45.44	3.740	5.02	42.19
$LSD_{0.05}$	**0.8941**	**0.5823**	**0.2007**	**0.092**	**1.261**
Interaction effect of nitrogen and weeding					
N_0W_0	10.85	42.33	1.02	2.37	30.27
N_0W_1	15.78	43.88	1.50	2.59	36.73
N_0W_2	16.98	43.94	1.75	2.72	39.14
N_1W_0	23.18	42.73	2.31	5.31	30.36
N_1W_1	29.53	44.10	3.01	4.43	40.45
N_1W_2	31.17	44.36	3.17	4.61	40.76
N_2W_0	27.03	43.68	3.07	5.37	36.69
N_2W_1	35.61	44.64	4.31	5.78	42.68
N_2W_2	37.63	45.45	4.45	5.89	43.04
N_3W_0	30.10	43.97	3.36	5.79	36.66
N_3W_1	39.42	45.45	4.42	5.88	42.89
N_3W_2	40.48	46.79	4.83	5.99	44.66
N_4W_0	28.72	43.36	3.10	5.32	36.79
N_4W_1	37.52	45.95	4.00	5.79	40.86
N_4W_2	38.45	46.65	4.50	5.87	43.38
$LSD_{0.05}$	**3.520**	**1.066**	**0.4488**	**0.118**	**4.042**
CV (%)	**10.67**	**7.01**	**8.94**	**8.48**	**6.24**

N_0 = 0 kg N ha^{-1} W_0 = No weeding
N_1 = 69 kg N ha^{-1} W_1 = One weeding at 30 DAS
N_2 = 92 kg N ha^{-1} W_2 = Two weeding at 30 and 60 DAS
N_3 = 115 kg N ha^{-1}
N_4 = 138 kg N ha^{-1}

4.3 Weed biomass

4.3.1 Effect of nitrogen

Application of nitrogen level exerted significant variation on weed biomass yield of wheat for both the weeding dates 30 and 60 DAS (Table 4) for the both weeding date control treatment (no nitrogen application) showed the lowest weed biomass after that weed biomass weight increased steadily with the increases of nitrogen dose. The highest increase was found with the highest dose of nitrogen (138 kg ha^{-1}) for both the dates.

4.3.2 Effect of weeding

Weed biomass weight significantly affect by the weeding treatment (Table 4). The Table shows that the unweeded plot (control) showed significantly highest weed biomass and after that the weight of weed biomass showed a decreasing trend with increased number of weeding treatments for both the weeding treatments. However, two weeding treatment (at 30 and 60 DAS) showed the lowest weed biomass (114.2 and 52.3 g) at 30 and 60 DAS respectively, which was 57.66 and 4.0 g, lower than control and single weeding at 60 DAS weeding dates.

4.3.3 Interaction of nitrogen and weeding

Higher level of nitrogen caused higher weed biomass. For both the sampling dates (30 and 60 DAS). It has also found that higher two doses of nitrogen (115 and 138 kg ha^{-1}) showed the higher weed biomass than lower nitrogen dose, irrespective of weeding treatments. On the other hand two weeding treatment showed the lower weed biomass, irrespective of nitrogen doses, however no nitrogen application with two times of weeding showed the lowest weed biomass for both the sampling dates (30 and 60 DAS).

Table 4: Effect of nitrogen, duration of weed competition and their interaction effect on weed biomass

Treatments	Weed weight (g m^{-2})	
	30 DAS	**60 DAS**
Effect of nitrogen		
N_0	90.30	49.73
N_1	112.0	67.42
N_2	119.5	85.65
N_3	125.8	68.08
N_4	126.2	93.79
$LSD_{0.05}$	**1.193**	**0.9932**
Effect of weeding		
W_0	115.0	110.1
W_1	115.1	56.34
W_2	114.2	52.34
$LSD_{0.05}$	**0.5430**	**2.487**
Interaction effect of nitrogen and weeding		
N_0W_0	90.19	86.91
N_0W_1	91.40	32.01
N_0W_2	89.31	30.27
N_1W_0	112.2	98.87
N_1W_1	111.2	53.27
N_1W_2	112.5	50.12
N_2W_0	120.7	130.8
N_2W_1	119.0	65.78
N_2W_2	118.8	60.34
N_3W_0	125.3	98.23
N_3W_1	126.9	54.71
N_3W_2	125.2	51.30
N_4W_0	126.8	135.8
N_4W_1	126.9	75.91
N_4W_2	125.0	69.68
$LSD_{0.05}$	**2.659**	**5.304**
CV (%)	**8.73**	**10.86**

N_0 = 0 kg N ha^{-1}
N_1 = 69 kg N ha^{-1}
N_2 = 92 kg N ha^{-1}
N_3 = 115 kg N ha^{-1}
N_4 = 138 kg N ha^{-1}

W_0 = No weeding
W_1 = One weeding at 30 DAS
W_2 = Two weeding at 30 and 60 DAS

Chapter 5
Summary and Conclusion

Chapter 5

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka during the period from November 2008 to March, 2009 to study the influence of nitrogen level and weeding on the performance of wheat. The experiment was conducted in a split plot design with three replications.

Two factors were considered for the experiment and that were (A) Nitrogen and (B) Duration of weed competition. The treatment of (A) different nitrogen applications were (i) N_0 (0 kg N ha^{-1}), (ii) N_1 (69 kg N ha^{-1}), (iii) N_2 (92 kg N ha^{-1}), (iv) N_3 (115 kg N ha^{-1}) and (v) N_4 (138 kg N ha^{-1}) and (B) duration of crop-weed competition were (i) W_0 (no weeding), (ii) W_1 (One weeding at 30 DAS) and (iii) W_2 (Two weedings at 30 and 60 DAS).

Results showed that the different levels of nitrogen application and duration of crop-weed competition and their interaction had significant effect on different growth and yield parameters of wheat. The growth and yield parameters were discussed under the present study were plant height, spike length, effective spikes m^{-2}, number of spikelets $spike^{-1}$, dry weight $plant^{-1}$, number of grains $spike^{-1}$, 1000 grains weight, grain yield, straw yield and harvest index.

It was observed that longest plant height (96.46 cm) and spike length (11.07 cm) were with 138 kg N ha^{-1} and the srortest plant height (75.51 cm) and Spike length (7.361 cm) were with 0 kg N ha^{-1}. But increase of highest effective spikes m^{-2} (242.8), number of spikelets $spike^{-1}$ (41.80), dry weight $plant^{-1}$ (17.39 g), number of grains $spike^{-1}$ (36.67), 1000 grains weight (45.40 g), grain yield (4.20 t ha^{-1}), straw yield (5.89 t ha^{-1}) and harvest index (41.40%) were due to 115 kg N ha^{-1} where the lowest were 180.7, 19.37, 12.10g, 14.54, 43.38 g, 1.42 t ha^{-1}, 2.56 t ha^{-1} and 35.38%, respectively with 0 kg N ha^{-1}.

Duration of weed competition had also significant effect on different growth and yield parameters of wheat. The longest plant height (89.96cm), spike length (10.29 cm), effective spikes m^{-2} (246.7), number of spikelets $spike^{-1}$ (39.19), dry weight $plant^{-1}$ (16.99 g), number of grains $spike^{-1}$ (32.94), 1000 grains weight (45.44 g), grain yield (3.740 t ha^{-1}), straw yield (5.02 t ha^{-1}) and harvest index (42.19%) were with two weedings at 30 and 60 DAS where the lowest were 87.76 cm, 9.446 cm, 185.4, 25.81, 13.60 g, 23.98, 43.21 g, 2.573 t ha^{-1}, 4.83 t ha^{-1} and 34.15%, respectively were with no weeding treatment.

Interaction effect of nitrogen and duration of crop-weed competition had also significant effect on the growth and yield parameters of wheat. It was observed that the longest plant height (97.41 cm) and spike length (11.49 cm) were observed with N_4W_2 and the shortest were 74.97 cm and 7.42 cm respectively due to N_0W_0. But incase of the highest effective spike m^{-2} (269.5), number of spikelets $spike^{-1}$ (50.00), dry weight $plant^{-1}$ (19.64 g), number of grains $spike^{-1}$ (40.48), 1000 grains weight (46.79 g), grain yield (4.83 t ha^{-1}), straw yield (5.99 t ha^{-1}) and harvest index (44.66%) were with N_3W_2 where the lowest were 146.6, 16.00, 11.41 g, 10.85, 42.33 g, 1.02 t ha^{-1} 2.37 t ha^{-1} 30.27%, respectively due to N_0W_0 treatment.

Thus the results obtained exhibited that the results from all the treatments were not encouraging in respect of growth, yield and yield contributing characters of wheat. Considering the performance of all nitrogen application rate and duration of crop- weed competition under the present study to achieve the higher performance on yield and yield contributing characters; 115 kg N ha^{-1} and two times of weedings at 30 and 60 DAS is a better approach for wheat production.

However, to reach a specific conclusion and recommendation, more research work on nitrogen level and weeding should be done over different agro-ecological zones in Bangladesh.

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Appendices

APPENDICES

Appendix I. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from November 2009 to March 2010

Month	RH (%)	Max. Temp. (°C)	Min. Temp. (°C)	Rain fall (mm)
November	71.15	26.98	14.88	Terrace
December	68.30	25.78	14.21	Terace
January	69.53	25.00	13.46	0
February	50.31	29.50	18.49	0
March	44.95	33.80	20.28	0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II Physical characteristics and chemical composition of soil of the experimental area.

Soil Characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	5.47 – 5.63
Total N (%)	0.43
Available phosphorous	22 ppm
Exchangeable K	0.42 meq / 100 g soil

Source: Soil Resource Development Institute (SRDI), Khamarbari, Dhaka