COMPARABLE EFFECT OF PRILLED AND GRANULAR UREA ON BORO RICE CULTIVATION

SHAMIMA YESMIN

DEPARTMENT OF SOIL SCIENCE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

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SHAMIMA YESMIN

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Approved by:

Prof. Dr. Alok Kumar Paul Supervisor	**Prof. Mst. Afrose Jahan** Co-Supervisor

Dr. Mohammad Mosharraf Hossain
Professor
Chairman
Examination Committee

DEPARTMENT OF SOIL SCIENCE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **'COMPARABLE EFFECT OF PRILLED AND GRANULAR UREA ON BORO RICE CULTIVATION'** submitted to the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in SOIL SCIENCE**, embodies the results of a piece of bonafide research work carried out by **SHAMIMA YESMIN**, Registration No. **15-06923** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated:
Dhaka, Bangladesh

Prof. Dr. Alok Kumar Paul
Department of Soil Science
Sher-e-Bangla Agricultural University
Dhaka-1207

Supervisor

Dedicated To

My Beloved Parents

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ABSTRACT

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from December, 2015 to May, 2016 to evaluate the comparable effect of prilled and granular urea on boro rice cultivation. The experiment comprises eight treatments laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were; T_1: 140kg N ha^{-1} from prilled urea, T_2: 100 Kg Nha^1 from prilled urea, T_3:1 USG in between 4 hills , T_4: 2 USG in between 4 hills, T_5:1 USG in between 4 hills + 40 kg Nha^{-1} from prilled urea, T_6: 1 USG in between 4 hills + 60 kg N ha^{-1} from prilled urea, T_7: 1 USG in between 4 hills + 80 kg Nha^{-1} from prilled urea and T_8: Control (No nitrogen fertilizer). The recommended fertilizer doses used for P, K, S, and Zn were 20, 80, 16 and 2 kg ha^{-1}, respectively. The N fertilizers were used in two forms namely prilled urea and granular urea or Urea Super Granule (USG). Applications of different forms of N significantly increased the yield components and grain and straw yields of BRRI dhan63. The performance of granular urea was superior to prilled urea. The treatment T_3 (1 USG in between 4 hills) produced the highest grain yield of 6.60 t/ha and straw yield of 7.43t/ha. The lowest grain yield 4.07t/ha and straw yield 4.53t/ha were found in control (T_8: No nitrogen fertilizer) treatment. The overall results indicate that application of 1urea super granule in between 4 hills can be more efficient and economic for boro rice production. However, further investigation is necessary to make concrete recommendation.

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LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
Adv.	Advanced
Agric.	Agricultural
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
CV	Coefficient of Variation
cv.	Cultivar
df	Degrees of Freedom
LSD	Least Significant Difference
DAT	Days After Transplanting
et al.	and others
etc.	etcetera
MOP	Muriate of Potash
ns	Non Significant
Res.	Research
RH	Relative humidity
Sci.	Science 's

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Rice is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice) belongs to the family Poaceae. As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the agricultural commodity with third-highest worldwide production (rice, 741.5 milion tones in 2014), after sugarcane (1.9 bilion tones) and maize (1.0 bilion tones) (FAOSTAT, 2017). Rice is grown in more than ten countries with a total harvested area of nearly 1.60 billion hectares, producing more than 7 billion tons every year (IRRI, 2010).

Bangladesh is an agro-based country where Agriculture is the single most important sector of its economy. Agriculture in Bangladesh is dominated by rice. It is one of the most densely populated countries in the world with a population of about 158.9 milion and having an area of 147,570 square kilometers. In recent years, the country has earned self-sufficiency in rice production, but also gradually entering into the export regime (BER, 2015). Since dependence, there has been a three-fold increase in rice production in Bangladesh, which jumped from nearly 11 MT in 1971-72 to about 34.86 MT in 2014-15 (AIS, 2016). In the last few years (2009-10 to 2013-14) rice production has increased by 0.34 MT per year (BBS, 2014).

In Bangladesh, about 75% of the total cropped area and over 80% of the total irrigated area is covered by rice. Thus, rice plays a vital role in the livelihood of the people of our country. Rice provides about 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average per person in our country. The population of Bangladesh is growing by 2 million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020 to feed the nation (BRRI, 2011).

Rice is also the main staple food crop of Bangladesh and it covers about 80% of the total cropped area of the country (AIS, 2013). Among the crops grown in Bangladesh rice is covering the area of 11.45 million hectares and 34.60 million tons, respectively where boro covers the area 48 lac hectare and production of 192 lac million tons (BBS, 2016). But compared to other major rice growing countries of the world, the grain yield per hectare is still low.

Yield of rice can be increased in many ways like developing new high yielding variety and by adopting proper management practices to the existing varieties to achieve their potential yield.

Proper fertilization is one of the important management practice which can increase the yield of rice. Judicious and proper use of fertilizers can increase the yield and improve the quality of rice (Youshida, 1981). Among the fertilizers, nitrogenous fertilizer has massive effect on the yield of rice. Proper application of Urea Super Granule (USG) and prilled urea is an important step towards expansion of rice yields. Nitrogen is the top most important nutrient and it is a main input for rice production in the rice growing countries as well in Bangladesh (Hasan *et al.*, 2002). Total N uptake by rice plant per hectares varies among rice varieties. Nitrogen is applied in adequate amount in 3 split application at early, at mid-tillering and panicle initiation stage for better grain development (Ahmed *et al.*, 2005).

The soil nitrogen content of the country is also very low due to warm climatic condition accompanied by extensive cultivation practices with little addition of manures in the crop fields. As a result, most of the flooded rice fields face a shortage of nitrogen, so the addition of costly nitrogen fertilizers should always be done to maintain its availability in the field. The nitrogen efficiency especially of urea fertilizer is very low (about 30-35%) in rice cultivation (IFDC, 2007). Nitrogen is one of the major elements in plant growth where urea has been found to be a very effective nitrogenous fertilizer in rice production. But the efficiency of applied nitrogen in rice is very low, generally it ranging from 15 to 25% in wet land condition (Prasad and Datta, 1979) with the highest absorption rate of 30 to 50% (De Datta, 1978).

Nitrogen has a positive influence on the production of effective tillers (BRRI, 1990). However, huge application of nitrogen does not always give higher yield. In spite of that, during cultivation most of the farmers use urea fertilizer by broadcast method and most of the applied fertilizers are lost through volatilization, denitrification, run-off and leaching.

According to Craswell *et al*. (1980) broadcast application of urea on the surface soil causes losses up to 50% but point placement of USG in 10 cm depth reduce negligible loss. Application of urea super granule increases the effectiveness of urea fertilizer up to 25%. It can save 30% nitrogen than prilled urea, increases nutrient absorption, improves soil health and ultimately increases the yield.

Hence, this study was undertaken to evaluate the response of prilled urea and USG for optimum yield of rice. So, the present experiment has been taken with the following objectives:

OBJECTIVES:

1. To compare the effect of prilled and granular urea on growth and yield of boro Rice.
2. To find out the optimum dose of USG for maximum yield of boro rice.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

High production of any crops depends on manipulation of basic ingredients of agriculture. Growth and yield of rice is greatly influenced by environmental factors like day length or photoperiod, temperature, humidity, variety and agronomic practices such as transplanting time, spacing and number of seedlings hill^{-1}, fertilization and irrigation. Among the factors level of nitrogen fertilizer application are important especially for the production of boro rice.

Nitrogen is one of the macro-nutrients used in Bangladesh in the form of urea. There is different form of urea. Granular urea as USG (urea super granule) is one of them which greatly influences crop yield. Prilled urea is another form of urea. Many experiments were conducted by national and international institutions. A number of studies were conducted in Bangladesh on different forms of urea as the source of nitrogen especially prilled urea dose and dose of granular urea as USG (urea super granule) also an important factor in research farms and farmers filed under different agro-ecological conditions. An attempt has been made in this chapter to review the literatures and research finding on the level of prilled urea and granular urea as USG (urea super granule) application as the source of nitrogen in boro rice production.

2.1 Effect of N-fertilizer

2.1.1 Plant height

Zohra (2012) conducted an experiment with 3 different T. *aman* varieties and highest plant height was recorded when 3 pellets of USG/4 adjacent hills were applied.

Razib (2010) observed the highest plant height (100.2 cm) of rice when 120 kg N ha^{-1} was applied.

Mizan (2010) reported that the highest plant height (98.32 cm) was obtained from 160 kg N ha^{-1} followed by 120 kg N ha^{-1}.

Ahammed (2008) observed that leaf area increased with increasing level of nitrogen application from 40 kg N ha^{-1} up to 120 kg N ha^{-1}.

Rahman (2007) found that effect of depth of placement of USG as granular urea significantly influenced all growth characters and the yield attributes except plant height.

Salem (2006) reported that the nitrogen levels had a positive and significant effect on growth parameters of rice plants in boro season. Increasing nitrogen levels up to 70 kg ha^{-1} significantly increased leaf area index and plant height. The highest plant height at harvest was recorded about 92.81 cm when rice plants were fertilized with the highest nitrogen level of 70 kg ha^{-1}. On the contrary, the lowest value of the height was recorded about 80.21 cm when rice plants received no nitrogen fertilizer.

Meena *et al.* (2003) reported that between two levels of N 100 and 200 kg ha^{-1}, application of 200 kg ha^{-1} significantly increased the plant height (127.9 cm) of rice and total number of tillers $hill^{-1}$(16.3).

Ahmed *et al.* (2002) observed that among 5 levels, 80 kg N ha $^{-1}$gave the highest plant height (155.86 cm) and the height decreased gradually with decreased levels of nitrogen fertilizer application. Plants receiving no nitrogenous fertilizers were significantly shorter than other treatments. They also stated that nitrogen influences cell division and cell enlargement and ultimately increases plant height.

Alam (2002) found that plant height increased significantly with the increase of level of USG/4 hills as granular urea. Rahman (2003) also observed that different level of USG did not affect the plant height.

Mishra *et al.* (2000) reported that the application of 76 kg N ha^{-1} USG as granular urea at 14 DAT increased plant height, panicle length, N uptake and consequently the grain and straw yields of lowland rice.

Sahrawat *et al.* (1999) found that nitrogen level significantly influenced plant height of rice. Increasing levels of nitrogen increased the plant height significantly up to 120 kg N ha^{-1}.

Chowdhury *et al.* (1998) noted that the longest plant height of 112.1 cm was produced by nitrogen application at 100 kg ha^{-1} and was followed by 75 kg ha^{-1} due to the excellent vegetative growth of rice.

Thakur (1993) observed that the highest plant height of rice was obtained from 120 kg N ha^{-1} and the lowest one from the control.

Rekhi *et al.* (1989) conducted an experiment on a loamy sand soil with rice cv. PR 106 providing 0, 37.5, 75.0 or 112.5 kg N ha^{-1} as prilled urea (PU) or USG. PU was applied in three equal splits at transplanting, tillering, and panicle initiation and USG was placed 8-10 cm deep in alternate rows, equidistant from 4 hills. They found that PU produced the longest plant, higher number of panicles and higher amount of nitrogen uptake.

Singh and Singh (1986) reported that the plant height increased significantly with the increase in the levels of nitrogen from 27 to 87 kg N ha^{-1}. Deep placement of USG as granular form of urea resulted in the highest plant height than pilled urea.

The varieties differing in plant type markedly differ in their response to added nitrogen levels (Evant *et al*, 1960; Tanaka *et al*, 1964). Nitrogen fertilization also influenced the plant height (Talukdar, 1973; Hoque *et al.*, 1977; BRRI, 1989).

2.1.2 Number of effective tillers $hill^{-1}$

Azam (2009) conducted an experiment with 3 varieties and observed, in general, the number of total tillers $hill^{-1}$ was increased as the USG level increased but highest no. of total tillers $hill^{-1}$ was produced when 55 kg N ha^{-1} applied as USG.

Hasan (2007) conducted an experiment during the *aman* season of 2006 and recorded the increased number of tillers $hill^{-1}$ with increased nitrogen level as USG.

Singh and Shivay (2003) evaluated that the effective tillers $hill^{-1}$ was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tillers $hill^{-1}$.

Alam (2002) observed that total tillers $hill^{-1}$ and effective tillers $hill^{-1}$ increased significantly with the increase of level of granular form of USG , when USG was applied as one, two, three and four granules/4 hills during the boro season.

Krishnan and Nayak (2000) found that increasing levels of N application resulted in more secondary tillers which contributed little to grain resulting in low harvest index.

Ahsan (1996) stated that tillering is strongly correlated with nitrogen content of the plant. The incremental level of nitrogen increase the number of tiller $hill^{-1}$. Results showed that the highest number of tiller $hill^{-1}$ (31) was obtained at 150 kg N ha^{-1} and declined with the lower level of nitrogen.

Kumar *et al* (1995) stated that an increase in N level from 80 to 120 kg N ha^{-1} significantly increased total tillers $hill^{-1}$.

Thakur (1991b) concluded that the yield attributes of rice like number of productive tillers m^{-2} and grain weight $panicle^{-1}$ increased with increasing levels of nitrogen.

Idris and Matin (1990) noticed that the maximum number of tillers $hill^{-1}$ was produced with 140 kg N ha^{-1} which was statistically similar to 60, 80, 100 and 120 kg N ha^{-1}. The minimum number of tillers $hill^{-1}$ was obtained from the control treatment (0 kg N ha^{-1}).

Mirzeo and Reddy (1989) worked with different modified urea materials and levels of N (30, 60 and 90 kg N ha^{-1}). They reported that root zone placement of USG of granular form produced the highest number of tillers at 30 or 60 days after transplanting.

Tillering of rice plant is strongly influenced by nitrogen supply (IRRI, 1968; BRRI, 1989) and adequate nitrogen is necessary during tillering stage to ensure sufficient number of panicle bearing tillers (Hall and Tacket, 1964)

Tanaka *et al.* (1964) reported that at a higher N level, rice plants have vigorous growth, high maximum tillers $plant^{-1}$ but lower percentage of effective tillers $hill^{-1}$.

2.1.3 Number of Grains $panicle^{-1}$

Zohra *et al. (*2012) observed that the number of grains $panicle^{-1}$ was varied significantly due to different level of USG.

Rajarathinam and Balasubramaniyan (1999) indicated that there was no appreciable change in grains $panicle^{-1}$ due to higher dose of N above 150 kg ha^{-1}. They also noticed an appreciable reduction in grains $panicle^{-1}$ at 250 kg N ha^{-1}.

Idris and Matin (1990) noted that the length of panicle of rice was highly related with the application of increased level of nitrogen. They also stated that panicle formation and elongation was directly related with the contribution of nitrogen.

Jee and Mahapatra (1989) observed that number of panicles m^{-2} were significantly higher with 90 kg N ha^{-1} as deep placed USG than split application of urea.

Singh and Kumar (1983) stated that grain yield increased consistently with increasing N application up to 87 kg ha^{-1} USG of granular urea produced the higher grain yield of than ordinary urea applied in three equal split dressings and other N sources.

Lal *et al.* (1983) studied the effects of deep placement of USG (granular form) or PU on yields of cv. Jaya and Govind revealed that with random transplanting, deep placement of USG increased yield of cv. Jaya and Govind by 0.4 and 1.1 t ha^{-1} respectively over yields with broadcast application of PU

Yosida and Parao (1976) reported that in rice at higher nitrogen level the number of grain become decreased due to lodging.

2.1.4 Weight of 1000-grain (g)

Azam *et al.* (2009) conducted an experiment during the *aman* season with 3 different T. *aman* varieties by using both USG (granular form) and prilled urea as a source of N. He observed that source and dose of nitrogen did not show significant effect on 1000-grain weight. The highest 1000-grain weight (24.70 g) was obtained with USG applied at 55 kg N ha^{-1} and lowest (24.09 g) 1000-grain weight was observed at 110 kg N ha^{-1} as PU.

Chopra and Chopra (2004) showed that N had significant effects on yield attributes such as plant height, panicle plant $^{-1}$ and 1000-grain weight. Cumulative effect of yield attributing and nutrient characters resulted in significant increase in seed yield at 120 kg N ha^{-1} over 60 kg N ha^{-1} and the control.

A field experiment was conducted by Maiti *et al.* (2003) during the boro season with the nitrogen fertilizer applied during transplanting, at the tillering and panicle initiation stages. They found increased number of higher number of panicles, number of filled grains panicle $^{-1}$, 1000-grain weight and grain yield.

Chopra and Sinha (2003) conducted an experiment with the treatments comprised of 4 N levels (0, 60, 120 and 180 kg N ha^{-1}) and results showed that N had significant effects on yield attributes such as plant height, panicles $plant^{-1}$ and 1000-seed weight. Cumulative effects of yield attributing characters resulted in significant increase and seed yield at 120 kg N ha^{-1} over 60 kg N ha^{-1}.

Alam (2002) observed that 1000-grain weight was not influenced by level of USG (granular form).

Garcia and Azevedo (2000) conducted an experiment with 5 doses of nitrogen fertilizer (0, 50, 100, 150 and 200 kg N ha^{-1}) and concluded that weight of 1000-grains increased with increase in nitrogen fertilizer up to 150 kg N ha^{-1}.

Naseem *et al.* (1995) recorded lower 1000-grain weight in the control treatment than in the plots received fertilizer nitrogen.

Ali *et al.* (1993) showed that weight of 1000 grains was higher when 100 kg nitrogen ha^{-1} was applied in three equal splits at basal 30 days and 60 days after transplanting.

Rahman *et al.* (1985) noted that there was a little relationship between nitrogen and weight of 1000 grains of rice.

Tanaka *et al.* (1964) noted that increasing rate of N decreased 1000-grain weight in the traditional varieties of rice.

2.1.5 Grain and straw yield

Zohra *et al*. (2012) conducted an experiment with different level of USG (granular form) on 3 different varieties of T. *aman* rice. Among the 6 doses of USG, highest grain yield was produced when the crop was fertilized with 2 pellets of USG/4 hills and lowest grain yield was recorded in the control treatment.

Das (2011) found the highest grain yield (4.28 t ha^{-1}) of rice using the 240 kg prilled urea ha^{-1} and the lowest grain yield (3.06 t ha^{-1}) using the no nitrogen application in a field trial with prilled urea.

Islam *et al.* (2011) carried out an experiment on the effectiveness of NPK briquette on rice in tidal flooded soil condition. They found that NPK briquettes, USG (granular form) and prilled urea (PU) produced statistically similar grain yield but gave significantly higher grain yield than N control.

Azam (2009) conducted a field experiment during *aman* season involving 5 rates of N (0, two as prilled urea and two as USG) found that, highest straw yield (6.11 t ha^{-1}) was produced by 110 kg N ha^{-1} as USG (granular form).

Singh and Gangwer (2009) claimed each incremental dose of nitrogen gave significantly higher straw yield.

In a field experiment on agronomy field laboratory, BAU, Hussain (2008), evaluated that maximum utilization of N was possible due to proper application of N as USG (granular form) placement or crop N demand. If the doses of N are higher or lower than demand, it will be overdose or deficiency of N and then yield will be reduced.

Hasan (2007) found the effect of level of USG (granular form) significantly influences all the yield attributes except 1000 grain weight. In his experiment, the highest grain and straw yields were found (5.20 and 7.45 t ha^{-1}, respectively) from the level of USG @ 3 pellets/4 hill or 90 kg N ha^{-1} as USG.

Xie *et al.* (2007) in his experiment found that the level of nitrogen application depends on the variety for obtaining the highest grain yield.

Dwivedi *et al.* (2006) conducted a field experiments to evaluate the effects of nitrogen levels on growth and yield of hybrid rice. They found 184.07 kg N ha^{-1} was the optimum rate for highest yield.

Rahman (2005) determined the nitrogen level and found that the grain yield of rice was increased with increasing nitrogen levels and the highest yield (4.19 t ha^{-1}) was attained with 150 kg N ha^{-1} while further increase in nitrogen level decreased the grain yield. It was estimated that the grain yield with 150 kg N ha^{-1} was 35.8, 18.9, 5.0 and 6.0% higher than those obtained with 0, 50, 100 and 200 kg N ha^{-1}, respectively.

Mashkar and Thorat (2005) conducted a field experiment during the 1994 kharif season in Konkan, Maharashtra, India, to study the effects of different nitrogen levels (0, 40, 80 and 120 kg N ha^{-1}) on the N, P and K uptake and grain yield of scented rice cultivars (Pula Basmati 1, Kasturi, Indrayani and Sugandha). The different levels of N had significant effect in augmenting the uptake of N, P and K nutrients and grains as well as straw yield of rice. Application of 120 kg N ha^{-1} recorded significantly higher N, P and K uptake in rice compared to the rest of the N levels. Every increment of 40 kg N ha^{-1} from 0 to 120 kg N ha^{-1} increased the total N uptake by 49.55, 34.30 and 27.17% total P uptake by 40.33, 27.06 and 20.32% and total K uptake by 32.43, 20.70 and 17.25%, respectively.

Salam *et al.* (2004) conducted an experiment to determine the level of nitrogen (0, 40, 80 and 120 kg N ha^{-1}) and the highest grain yield was recorded from the application of 80 kg N ha^{-1}.

Miah *et al.* (2004) carried out an experiment with transplanted rice cv. BINA dhan 4. They found that the values of the parameters measured were higher with application of USG compared to application of urea.

Elbadry *et al.* (2004) in pot and lysimeter experiment showed that the increasing level of N had statistically significant difference on growth parameters and yield attributes like dry weight, number of productive tillers, grain and straw yields of rice .

Rahman (2003) found that two USG (granular form) per 4 hills produced the higher grain and straw yields (5.22 and 6.09 t ha^{-1}, respectively).

Dongarwar *et al.* (2003) conducted a field experiment in Shandara, Maharashtra, India to investigate the response of the rice (KJTRH-1), Jaya and Sawarna to 4 fertilizer rates i.e.75, 100, 125 and 150 kg N ha^{-1}. There was a significant increase in grain yield with successive increase in fertilizer rate. The highest grain yield (53.05 q ha^{-1}) was obtained with 150 kg N ha^{-1} and KJSTRH-1 produced a significant higher yield than Jaya (39.64 q ha^{-1}) and Sawarna (46.06 q ha^{-1}).

Singh and Kumar (2003) conducted a field experiment and recorded the application of slow release fertilizers (USG- granular form), biogas slurry and blue green algae + prilled urea (PU) significantly increased grain and straw yield, nitrogen uptake, nitrogen use efficiency, and nitrogen recovery in rice. The highest grain yield, nitrogen recovery was recorded with the application of USG.

Ahmed *et al.* (2002) revealed that USG was more efficient than PU at all levels of nitrogen in producing all yield components and in turn, grain and straw yields. Placement of 160 kg N ha^{-1} as USG (granular form) produced the highest grain yield (4.32 t ha^{-1}) which was statistically identical to that obtained from 120 kg N ha^{-1} as USG and significantly superior to that obtained from any other level and source of nitrogen.

Nayak and Panda (2002) carried out a field experiment on transformation of applied urea and its efficient utilization in rainfed lowland rice (*Oryza sativa* L.) and observed that management practices on grain and straw yields was good. The treatments included surface broadcasting of prilled urea (PU) with partial or thorough incorporation at sowing, basal banding of PU in solid, solution or suspension form with or without SSP and MoP, deep placement of USG or urea mudlumps (UML) with or without SSP or MoP in submerged soil and surface broadcasting of PU onto submerged land at tillering state.

Wopereis *et al.* (2002) stated that rice yields increased significantly as a result of N application on two N dressing (applied at the onset of tillering and at panicle initiation) with a total of approximately 120 kg N ha^{-1} in farmer's fields.

Sarkar *et al.* (2001) reported that application of nitrogen increased straw yield significantly up to 120 kg N ha^{-1}.

Nitrogen fertilizer was applied to the rice crop at the of 0, 96 and 144 kg N ha^{-1} in urea form and the main results indicated that increasing nitrogen levels up to 144 kg ha^{-1} significantly increased straw yield (Ebaid and Ghanem, 2000).

Pandey and Tiwari (1996) evaluated the rate of 87 kg N ha^{-1} as a basal application of USG and to dressing as PU and observed that grain yield and N use efficiency were the highest with N applied as a basal application of USG (granular form).

Surendra *et al*. (1995) applied N @ 0, 40, 80, 120 kg ha^{-1} from USG (granular form) and urea dicyandiamide @ 80 kg N ha^{-1}. They observed that USG (granular form) and urea dicyandiamide produced significantly more panicle $hill^{-1}$, grains $panicle^{-1}$, panicle weight and grain yield than PU @ 80 kg N ha^{-1}.

Quayum and Prasad (1994) conducted field trial during *Kharif* season involving 5 rates of N (0, 35.5, 75, 112.5 and 120 kg N ha^{-1}) as USG (granular form) with rice cv. Sita found that application up to 112.5 kg N ha^{-1} increased grain (4.37 t ha^{-1}) and straw yields (5.49 t ha^{-1}). It is concluded that the slow release of fertilizers were effective for rainfed lowland rice.

Singh *et al.* (1993) pointed out that application of 30 or 60 kg N ha^{-1} as PU or USG (granular form) gave the highest grain yield and N uptake increased with the rate of N application and was highest with deep placed USG.

Zaman *et al.* (1993) found that USG (granular form) consistently produced significantly higher grain yield than PU.

Bhale and Salunke (1993) conducted a field trial to study the response of upland irrigated rice to nitrogen applied through urea and USG (granular form). They found that grain yield increased with up to 120 kg N ha^{-1} as urea and 100 kg N ha^{-1} as USG.

Kamal *et al.* (1991) used different forms of urea and level of nitrogen @ 29, 58, 87 kg N ha^{-1} in rice. They reported that total tiller varied significantly due to forms in 1985, but during 1986 there was no significant variation. PU was significantly inferior to the other forms. The highest number of tillers was produced in treatment where USG were applied. 1000-grain weight was not significantly influenced by the forms of urea. Among the three doses of nitrogen, total tiller was the highest when 87 kg N ha^{-1} was applied. Productive tillers also followed a similar trend.

Rama *et al.* (1989) carried out an experiment with different modified urea materials @ 27, 54, 87 kg N ha^{-1}. They observed that spikelets $panicle^{-1}$, % sterility and 1000-grain weight did not differ significantly due to different modified urea materials viz., prilled urea, sulphur coated urea, urea super granules.

Das (1989) reported that the dry matter yield, concentration of NH_4^+-N content in soil, N uptake and grain and straw yields of rice were higher with application of USG than PU.

Mohanty *et al.* (1989) observed that placement of USG (granular form) in rice gave significantly higher grain and straw yields of 36% and 39% in dry and 17% and 18% in wet season, respectively than split application of PU.

Dalai and Dixit, (1987) reported that nitrogen had marked effect both on yield and yield attributes of rice. They observed that grain and straw yields increased significantly at each successive level of N due to increase in the number of panicles , length of panicle, spikelet panicle^{-1} and weight of 1000-grain.

2.1.6 Biological yield

Gaudin (2012) carried out an experiment on the kinetics of ammonia disappearance from deep-placed urea supergranules (USG) (granular form) in transplanted rice: the effects of deep placement USG application and PU fertilizer. He found that ammonia disappearance from the placement site is faster for the second application, and it appears that the rice roots took up ammonia at a higher concentration: 20 mM for the second application versus 10 mM for the first application.

Iqbal (2011) carried out an experiment on determination of the effects of five fertilizer application rates on vertical leaching from 30 cm and 60 cm soil layers and) found that during paddy growth, nitrogen losses from different nitrogen treatments varied 2.82-5.07% application of the urea compared to USG.

Mishra *et al.* (1999) reported that apparent N recovery in rice also increased from 21% for PU to 40% for USG (granular form). Here Rice showed a greater response to N upon USG placement than split application of PU.

2.1.7 Harvest index

Sarker *et al.* (2001) obtained the nitrogen response of a Japonica and an Indica rice variety with different nitrogen levels viz. 0, 40, 80 and 120 kg N ha^{-1}. They observed that application of nitrogen increased grain and straw yields significantly but harvest index was not increased significantly.

Dwivedi (1997) noticed that application of nitrogen significantly increased the growth yield and yield components grain yield, straw yield as well as harvest index with 60 kg N ha^{-1}.

Chapter III

Materials & Methods

CHAPTER III

MATERIALS AND METHODS

This chapter deals with a brief description on experimental period, experimental site, climate, soil, and land preparation, layout of the experimental design, intercultural operations, data recording and their analyses. Details materials and methods used in this experiment.

3.1 Experimental period

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the boro season of December 2015 to May 2016 to study the effect of prilled and granular urea on boro rice cultivation.

3.2 Site Description

3.2.1 Geographical Location

The experimental area was situated at 23^{0}77'N latitude and $90^{0}33^{'}$E longitude at an altitude of 8.2 meter above the sea level (Anon., 2004).

3.2.2 Agro–Ecological Region

The experimental field belongs to the Agro–ecological zone of "The Modhupur Tract", AEZ–28 (Anon., 1998a). 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., 1998b). The experimental site was shown in the map of AEZ of Bangladesh (Fig. 3.1).

3.2.3 Climate

The experimental site under the sub-tropical climate that is characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during rabi season (October-March). The weather data during the study period at the experimental site are shown in Appendix II

3.2.4 Soil

The soil of the experimental field belongs to the general soil type, ‘‘Shallow Red Brown Terrace Soils” under Tejgaon soil series. Soil pH was 5.8. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from the experimental field. The details have been presented in Table 3.1 and 3.2.

Table 3.1 Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher–e–Bangla Agricultural University Farm, Dhaka
AEZ	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Table 3.2 Physical and chemical properties of the initial soil sample

Properties	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	18.70%
% Silt (0.02-0.002 mm)	45.34%
% Clay (<0.002 mm)	36.56%
Textural class	Silty-clay
pH (1: 2.5 soil- water)	5.8
Organic Matter (%)	1.38
Total N (%)	0.06
Available P (mg kg^{-1})	19.32
Available S (mg kg^{-1})	16.0

3.3 Experimental details

3.3.1 Treatments

This experiment composed of 8 treatments which are given below:

T_1: 140 kg N ha^{-1} from prilled urea

T_2: 100 kg N ha^{-1} from prilled urea

T_3: 1 USG in between 4 hills

T_4: 2 USG in between 4 hills

T_5: 1 USG in between 4 hills + 40 kg N ha^{-1} from prilled urea

T_6: 1 USG in between 4 hills+ 60 kg N ha^{-1} from prilled urea

T_7: 1 USG in between 4 hills + 80 kg N ha^{-1} from prilled urea

T_8: Control (No nitrogen fertilizer)

3.4 Description of the sources of nitrogen

Ordinary or prilled urea and granular urea or urea super granule were used as the source of nitrogen.

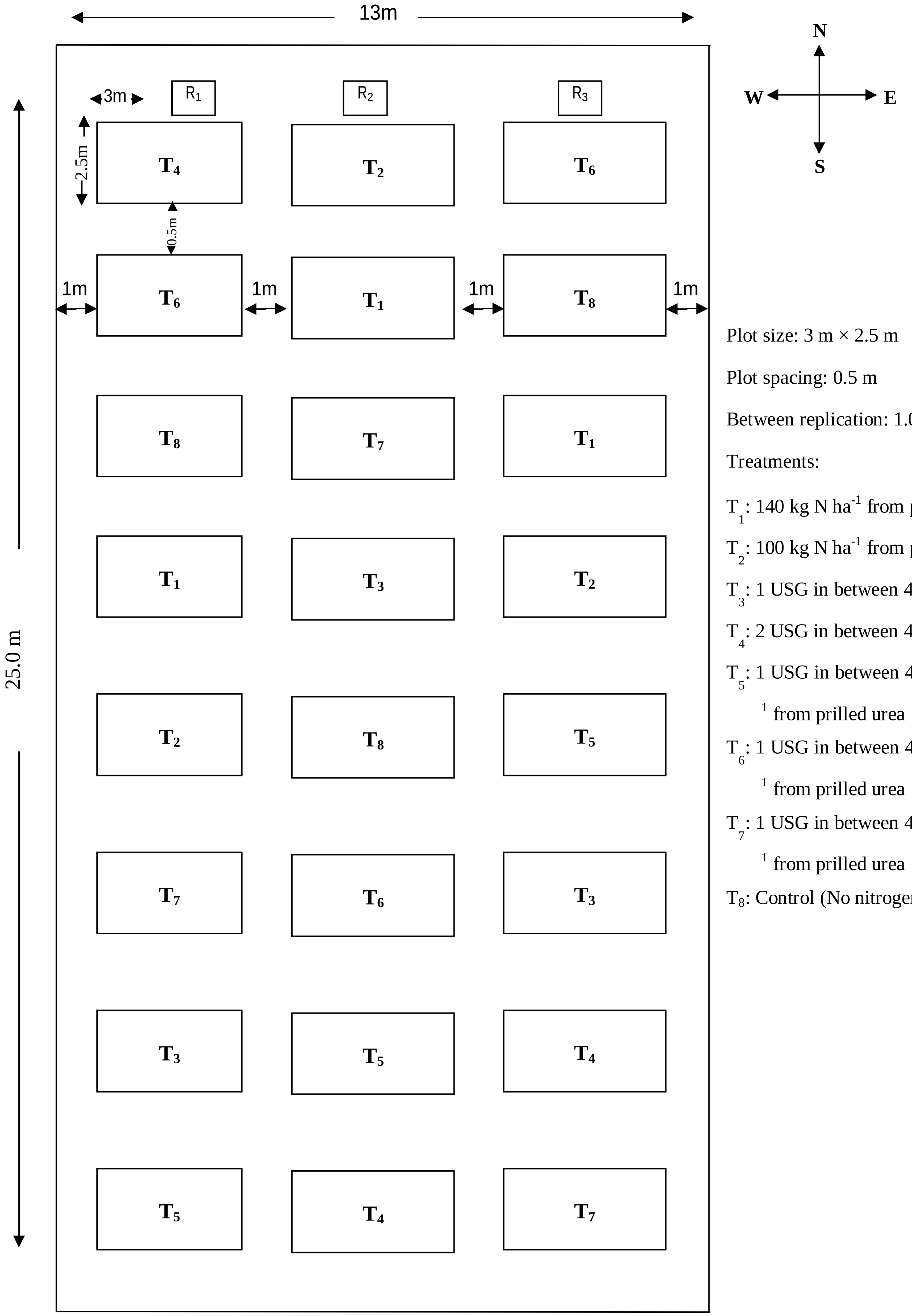
Prilled urea: Ordinary or prilled urea is the most common form of urea available in the market. It contains 46% N.

Granular urea: Granular urea or Urea Super Granule (USG) fertilizer is manufactured from a physical modification of ordinary urea fertilizer. It has been developed by the International Fertilizer Development (IFDC), Muscle Shoals, Alabama, 35660, USA. It consists of approximately 0.9, 1.8, 2.7 g discreate urea particles. Here we use 1.8g size granular urea. It properties are similar to that of urea. But its granule size is bigger and condensed with some conditions for slow hydrolysis. It also contains 46% N which is similar to that of prilled urea.

the variety is 90-95 cm at the ripening stage. It requires about 148-150 days completing its life cycle with an average grain yield of around 6.5-7 ton per ha (BRRI, 2015). It is very popular for its extra length and fineness.

3.6.1 Layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications to reduce the heterogenetic effects of soil. Each block was sub–divided into eight unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 24. The unit plot size was 3 m ×2.5. There was 1 m width drains between the blocks and plot to plot distance was 0.5 m. The layout of the experiment has been shown in Figure 1.



Plot size: 3 m × 2.5 m

Plot spacing: 0.5 m

Between replication: 1.0 m

Treatments:

T_1: 140 kg N ha^{-1} from prilled urea

T_2: 100 kg N ha^{-1} from prilled urea

T_3: 1 USG in between 4 hills

T_4: 2 USG in between 4 hills

T_5: 1 USG in between 4 hills + 40 kg N ha^{-1} from prilled urea

T_6: 1 USG in between 4 hills + 60 kg N ha^{-1} from prilled urea

T_7: 1 USG in between 4 hills + 80 kg N ha^{-1} from prilled urea

T_8: Control (No nitrogen fertilizer)

Figure 1. Layout of the experimental plot

3.7 Crop Management

3.7.1. Seed Collection

Healthy and vigorous seeds of BRRI dhan63 was collected from the Breeding Division, BRRI, Joydebpur, Gazipur.

3.7.2 Sprouting of seed

The seeds were soaked in water in bucket for 24 hours. Then seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and became suitable for sowing after 72 hours

3.7.3 Preparation of seedling nursery and seed sowing

A piece of high land was selected in the Soil Science Field Laboratory, SAU, Dhaka for raising seedlings. The land was puddled well with country plough followed by cleaning and leveling with ladder. Sprouted seeds were sown in the wet nursery bed on 21 december 2015. Irrigation was gently provided to the bed as and when needed. Proper care was taken to raise seedlings in the nursery bed. The beds were kept weed free throughout the period of seedling raised.

3.7.4 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the sample was air-dried and sieved through a sieve and stored in a clean plastic container for physical and chemical analysis.

3.7.5 Preparation of experimental land

The experimental field was first ploughed on January 21, 2016 with the help of a tractor drawn rotary plough, late on January 23, 2016 the land was irrigated and prepared by three successive ploughing and cross ploughing with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on January 25, 2016 according to experimental specification.

3.7.6. Fertilizer Application

The fertilizers P, K, S and Zn in the form of TSP, MoP, Gypsum and Zinc sulphate, respectively were applied @ 20 kg, 80 kg, 16 kg and 2.0 kg ha^{-1} (BRRI, 2015). Full dose of TSP, MoP, gypsum and zinc sulphate were applied as basal dose at final land preparation of individual plots. Prilled urea was applied to T_1, T_2, $T_{5,}$ T_6 and T_7treatment plot in three equal installments at 15, 35 and 60 days after transplanting (DAT) BRRI dhan63 .USG was applied for treatment $T_{3,}$ T_4, T_5, T_6 and T_7 at 10 DAT.

3.7.7 The uprooting of seedlings

For nursery seedlings 40 days old seedlings were uprooted carefully on January 30, 2016 and were kept in soft mud in shade. The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots.

3.7.8 Transplanting of seedlings

Seedlings were transplanted on January 30, 2016 in the well-puddled experimental plots. Spacing were given 25 cm × 20 cm the variety. Soil of the plots was kept moist without allowing standing water at the time of transplanting.

3.7.9 Inter-cultural operations

3.7.9.1 Gap filling

After one week of transplanting gap filling were done to maintain the constant population number. After transplanting the nursery seedlings gap filling was done whenever it was necessary using the seedling from the previous source.

3.7.9.2 Weeding

Weed infestation was a severe problem during the early stage of crop establishment. The experimental plots were infested with some common weeds. To minimize weed infestation, manual weeding through hand pulling was done three times during entire growing season.

3.7.9.3 Irrigation and drainage

Irrigation was done by alternate wetting and drying from transplanting to maximum tillering stage. From panicle initiation (PI) to hard dough stage, a thin layer of water (2-3 cm) was kept on the plots. Water was removed from the plots during ripening stage.

3.7.9.4 Plant protection measures

Plants were infested with rice stem borer (*Scirphophaga incertolus*) and leaf hopper (*Nephotettix nigropictus*) to some extent which were successfully controlled by applying Diazinon @ 10 ml/10 liter of water for 5 decimal lands on March 02, 2016. Ripcord was applied on March 09 and March 20, 20165G @ 10 kg/ha on March 09, 2016 @ 10 ml/10 litre of water for 5 decimal lands. Crop was protected from birds during the grain filling period. For controlling the birds watching was done properly.

3.7.10 Harvesting and post harvest processing

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting of BRRI dhan63 on May 07, 2016. Hills from the central $1m^2$ area of each plot were harvested for collecting data on crop yield. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The crops were threshed by pedal thresher and then grains were cleaned. The grain and straw weights for each plot were recorded after proper sun drying and then converted into ton $hectare^{-1}$. The grain yield was adjusted at 14% moisture level.

3.8 Recording of data

Data were collected on the following parameters-

3.8.1 Plant and yield components

1. Plant height at harvest
2. Panicle length
3. Tillers $hill^{-1}$(no.) at harvest
4. Effective tillers $hill^{-1}$(no.)
5. Filled grains $panicle^{-1}$(no.)
6. Weight of 1000-grains (g)
7. Grain yield
8. Straw yield
9. Biological yield
10. Harvest index

3.9 Procedure of recording data

A brief outline on data recording procedure followed during the study is given below:

3.9.1 Growth characters

3.9.1.1 Plant height

The plant height was measured from the ground level to the top of the panicle. Plants of 10 hills (1 m^2) were measured and average for each plot.

3.9.1.2 Panicle length

The measurement of panicle length was taken from basal node of the rachis to apex of each panicle and expressed in centimeter (cm). Each observation was an average 5 panicle

3.9.1.3 Total no. tillers hill^{-1}

Tillers with at least one visible leaf were counted. It included both effective and non-effective tillers.

3.9.1.4 Number of effective tillers hill^{-1}

Ten hills were taken at random from each plot and the number of tillers hill $^{-1}$ was counted and thereafter the numbers of effective tillers hill^{-1} was determined.

3.9.1.5 Number of filled Grains panicle^{-1}

Presence of any kernel in the spikelet was considered as grain and total number of filled grain on each panicle was counted. Ten panicles were taken at random to count grains and averaged.

3.9.1.6 1000–grain weight

One thousand clean dried grains were counted from the seed stock per plot and weighed by using an electric balance.

3.9.1.7 Grain yield

Grains obtained from the central $1m^2$ areas of each plot were sun dried, cleaned, weighed carefully and adjusted at 14% moisture level. Dry weight of grams of each plot was converted into t ha^{-1}.

3.9.1.8 Straw yield

Straw obtained from the central $1m^2$ area of each plot were sun dried, cleaned, weighed separately and finally converted into t ha^{-1}.

3.9.1.9 Biological yield

Grain yield and straw yield were together regarded as biological yield. Biological yield was calculated with the following formula:

3.9.1.10 Harvest index (%)

It is the ratio of economic yield to biological yield and was calculated with the following formula:

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \text{x } 100$$

3.10 Analyses of Soil Samples

Soil samples were analyzed for both physical and chemical properties such as pH, total nitrogen, available P and exchangeable K contents. The soil samples were analyzed following standard methods as follows:

3.10.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter using soil: water ratio of 1: 2.5 as described by Jackson (1962).

3.10.2 Total nitrogen

One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 g catalyst mixture (K_2SO_4:$CuSO_4$:$5H_2O$: Se=100:10:1), 2 mL 30% H_2O_2 and 5 mL H_2SO_4 were added. The flasks were swirled and allowed to stand for about 10 minutes. Then heating was continued until the digest was clear and colorless. After cooling, the content was taken into 100 mL volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digest was used for nitrogen determination. After completion of digestion, 40% NaOH was added with the digest for distillation. The evolved ammonia was trapped into 4% H_3BO_3 solution and 5 drops of mixed indicator of bromocressol green ($C_{21}H_{14}O_5Br_4S$) and methyl red ($C_{10}H_{10}N_3O_3$) solution. Finally the distillate was titrated with standard 0.01 NH_2SO_4until the color changed from green to pink (Bremner and Mulvaney, 1982). The amount of N was calculated using the following formula.

$$\% N = (T-B) \times N \times 0.014 \times 100/S$$

Where, T= Sample Titration value (mL) of Standard H_2SO_4

B= Blank titration value (mL) of standard H_2SO_4

N = Strength of H_2SO_4

S= Sample volume in milileter

3.10.3 Available phosphorus

Available phosphorus was extracted from the soil samples by shaking with 0.5 M $NaHCO_3$ solution at pH 8.5 following Olsen method (Olsen *et al.*, 1954). The extracted phosphorus was determined by developing blue color by $SnCl_2$reduction of phosphomolybdate complex and measuring the intensity of color colorimetrically at 660 nm wavelength and the readings were calibrated to the standard P curve.

3.10.4 Exchangeable potassium

Exchangeable potassium was extracted from the soil samples with 1.0 N NH_4OAc (pH 7) and K was determined from the extract by flame photometer and calibrated with a standard curve (Black, 1965).

3.11 Statistical analysis of the data

The analysis of variance for different crop characters as well as for different nutrient concentrations of the treatments were made and the mean differences were judged at 5% level of probability by using Duncan’s Multiple Range Test (DMRT) with a computer operated program named MSTAT-C.

Chapter IV

Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

Results obtained from the study of nitrogen sources on growth and yield of boro rice have been presented and discussed in this chapter. Treatments effect of nitrogen on all the studied parameters have been presented in various tables and figures and discussed below under the following sub-headings.

4.1 Plant height

Plant height was found to be statistically significant in all of the treatments used in the experiment. Effect of nitrogen source showed a significant variation on plant height (Table 3). At harvest, the tallest plant (92.33 cm) was recorded from T_6 treatment (1 USG in between 4 hills+ 60 kg N/ha from prilled urea) which was significantly greater than that obtained from the rest of the treatments used in the experiment and the shortest plant (70.33 cm) was recorded from the control (T_8) treatment (no nitrogen fertilizer).

The results were similar with the findings of Meena *et al.* (2003), Sahrawat *et al.* (1999) and Thakur (1993) who observed higher plant height with the higher doses of nitrogen.

4.2 Panicle length

Panicle length was found to be statistically significant in all of the treatments used in the experiment. Effect of nitrogen source showed a significant variation on panicle length (Table 3). At harvest, the highest panicle length (24.67 cm) was recorded from T_6 treatment (1 USG in between 4 hills + 60 kg N/ha from prilled urea) which was significantly greater than that obtained from the rest of the treatments used in the experiment and the shortest panicle length (21.67 cm) was recorded from the T_4 treatment (2 USG in between 4 hills).

Table: 3. Effects of different nitrogen sources on plant height and panicle length of boro rice (BRRI dhan63). Mean was calculated from three replicates for each treatment.

Treatments	Plant height (cm)	Panicle length (cm)
T_1	87ab	24.33ab
T_2	87ab	23.0abc
T_3	90.33ab	23.67abc
T_4	86ab	21.67c
T_5	85.33b	22.33abc
T_6	92.33a	24.67a
T_7	89.33ab	22.0bc
T_8	70.33c	23.0abc
LSD (0.05)	6.62	2.53
CV (%)	4.40	6.26
Level of significance	*	*

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

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

T_1= 140 kg N/ha from prilled urea, T_2= 100 kg N/ha from prilled urea, T_3= 1 USG in between 4 hills,

T_4= 2 USG in between 4 hills, T_5=1 USG in between 4 hills + 40 kg N/ha from prilled urea,

T_6=1 USG in between 4 hills + 60 kg N/ha from prilled urea,

T_7= 1 USG in between 4 hills + 80 kg N/ha from prilled urea,

T_8= control (no nitrogen fertilizer)

4.3 Total tillers/hill

The effect of different treatments on total tillers/hill was statistically significant (Figure 2). The maximum number of total tillers/hill (24.67) was obtained in the T_3 (1 USG in between 4 hills) treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment. The second highest total tillers/hill (22.67) was obtained in the T_7 (1 USG in between 4 hills + 80 kg N/ha from prilled urea) treatment. However, the total tillers/hill did not differ significantly in T_1 (140 kg N/ha from prilled urea), T_3 (1 USG in between 4 hills), T_5 (1 USG in between 4 hills + 40 kg N/ha from prilled urea) treatments. The minimum number of total tillers/hill (15.33) was obtained in the T_8 control (no nitrogen fertilizer) treatment. It was observed that total tillers/hill increased with increasing doses of nitrogen.

BRRI (2006), Ahsan (1996), Kumar *et al.* (1995) and ldris and Matin (1990) reported similar result that supports the present findings.

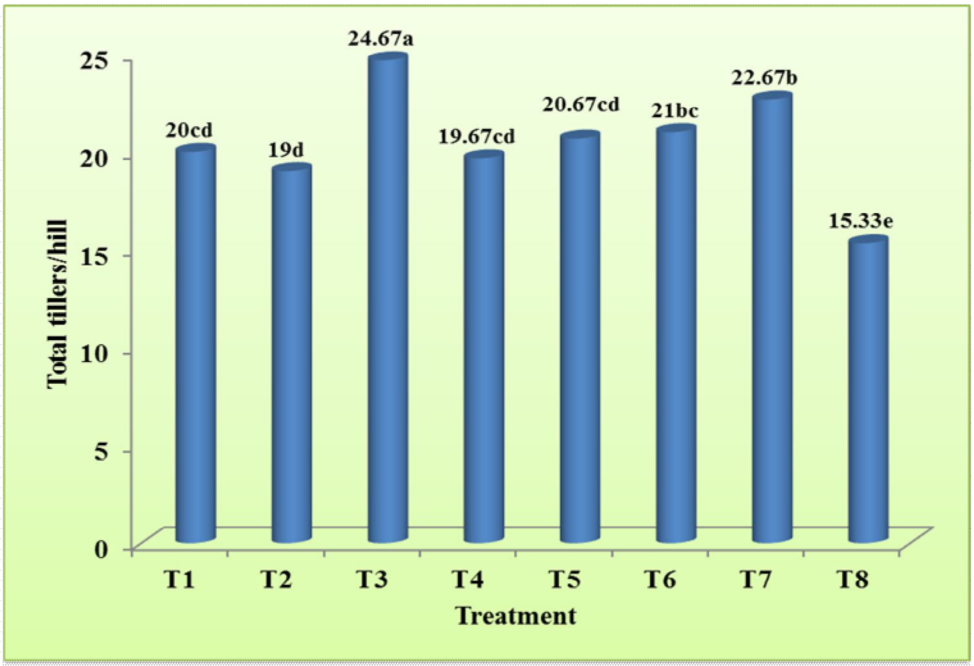


Figure 2: Effects of different nitrogen sources on Total tillers/hill of boro rice (BRRI dhan63). Mean was calculated from three replicates for each treatment.

T_1= 140 kg N/ha from prilled urea, T_2= 100 kg N/ha from prilled urea, T_3= 1 USG in between 4 hills

T_4= 1 USG in between 4 hills, T_5= 1 USG in between 4 hills + 40 kg N/ha from prilled urea,

T_6= 1 USG in between 4 hills + 60 kg N/ha from prilled urea,

T_7=1 USG in between 4 hills + 80 kg N/ha from prilled urea,

T_8= control (no nitrogen fertilizer)

4.4 Effective tillers/hill

Figure 3 shows the effects of different treatments on effective tillers/hill. It was found that effective tillers/hill statistically significant. The maximum number of effective tillers/hill (23.33) was obtained in the T_3 (1 USG in between 4 hills) treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment. The second highest effective tillers/hill (20) was obtained in the T_7 (1 USG in between 4 hills + 80 kg N/ha from prilled urea) treatment. However, the effective tillers/hill did not differ significantly in T_1 (140 kg N/ha from prilled urea), T_2 (100 kg N/ha from prilled urea), T_4 (2 USG in between 4 hills), T_5 (1 USG in between 4 hills + 40 kg N/ha from prilled urea) treatments. The minimum number of effective tillers/hill (13.67) was obtained in the T_8 control (no nitrogen fertilizer) treatment. It was observed that the number of effective tillers/hill increased with increasing levels of nitrogen.

Hari *et al.* (2000), Thakur (1991a) and Tanaka *et al.* (1964) also found similar result that increasing levels of nitrogen increased the number of effective tillers.

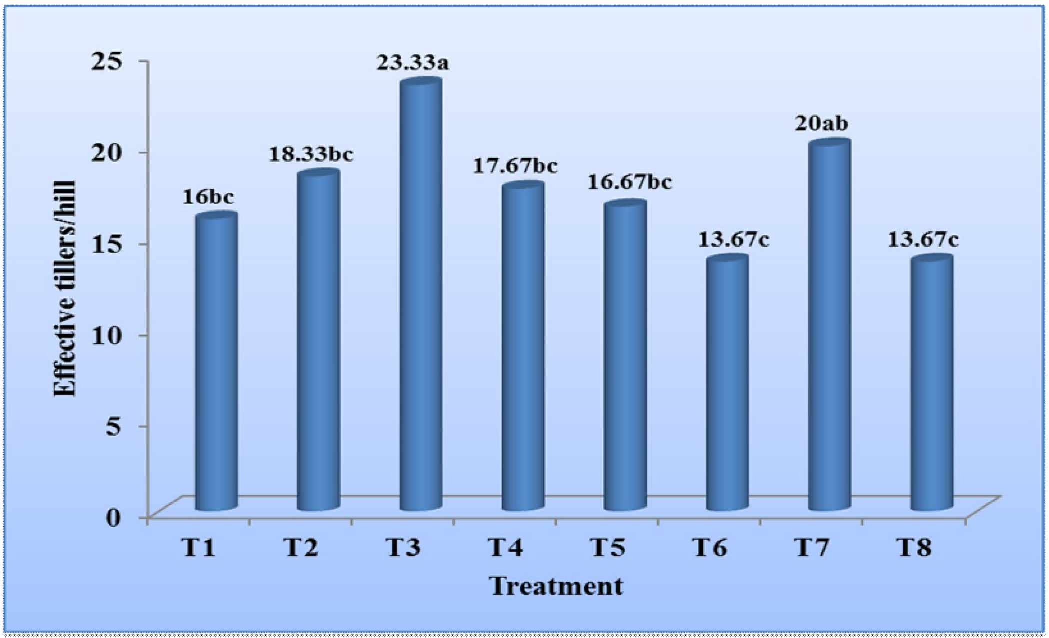


Figure 3: Effects of different nitrogen sources on effective tillers/hill of boro rice (BRRI dhan63). Mean was calculated from three replicates for each treatment.

T_1= 140 kg N/ha from prilled urea, T_2= 100 kg N/ha from prilled urea, T_3= 1 USG in between 4 hills,

T_4=2 USG in between 4 hills, T_5=1 USG in between 4 hills + 40 kg N/ha from prilled urea,

T_6= 1 USG in between 4 hills + 60 kg N/ha from prilled urea,

T_7= 1 USG in between 4 hills + 80 kg N/ha from prilled urea,

T_8= control (no nitrogen fertilizer)

4.5 Number of total grains/panicle

Table 4 shows the effects of different treatments on total grains/panicle. It was found that total grains/panicle statistically significant. The maximum number of total grains/panicle (119.67) was obtained in the T_3 (1 USG in between 4 hills) treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment and statistically similar with the treatment T_6 (1 USG in between 4 hills + 60 kg N/ha from prilled urea). The second highest total grains/panicle (113.33) was obtained in the T_7 (1 USG in between 4 hills + 80 kg N/ha from prilled urea) treatment. However total grains/panicle did not differ significantly in T_1 (140 kg N/ha from prilled urea), T_4 (2 USG in between 4 hills), T_2 (100 kg N/ha from prilled urea), T_5 (1 USG in between 4 hills + 40 kg N/ha from prilled urea) and T_8 control treatments. The minimum number of total grains/panicle (84.33) was obtained in the T_8 control (no nitrogen fertilizer) treatment.

4.6 Number of filled grains/panicle

Nitrogen sources showed significant variation on production of filled grains/panicle (Table 4). It was found that filled grains/panicle statistically significant. The maximum number of filled grains/panicle (105.0) was obtained in the T_3 (1 USG in between 4 hills) treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment. The second highest filled grains/panicle (99.67) was obtained in the T_6 (1 USG in between 4 hills + 60 kg N/ha from prilled urea) treatment which was statistically similar with the T_7 (97.0) treatment (1 USG in between 4 hills + 80 kg N/ha from prilled urea). However, filled grains/panicle did not differ significantly in T_1 (140 kg N/ha from prilled urea), T_2 (100 kg N/ha from prilled urea), T_4 (2 USG in between 4 hills) treatments. The minimum number of filled grains/panicle (76.67) was obtained in the T_8 control (no nitrogen fertilizer) treatment.

The result agreed with the findings of Kumar *et al.* (1986) and Thakur *et al.* (1995) in that increasing level of nitrogen significantly increased the number of filled grains panicle^{-1}.

Table: 4. Effects of different nitrogen sources on no of grains/panicle and no of filled grains/panicle of boro rice (BRRI dhan63). Mean was calculated from three replicates for each treatment.

Treatments	No of grains/panicle	No of filled grains/panicle
T_1	107.0ab	91.0bcd
T_2	98.33ab	85.33cde
T_3	119.67a	105.0a
T_4	104.0ab	90.0bcd
T_5	94.67ab	80.33de
T_6	115.0a	99.67ab
T_7	113.33ab	97.0abc
T_8	84.33b	76.67e
LSD (0.05)	29.99	13.86
CV (%)	12.70	6.55
Level of significance	*	

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

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

T1= 140 kg N/ha from prilled urea, T2= 100 kg N/ha from prilled urea, T3= 1USG in between 4 hills,

T4= 2 USG in between 4 hills, T5=1USG in between 4 hills + 40 kg N/ha from prilled urea,

T_6=1 USG in between 4 hills + 60 kg N/ha from prilled urea,

T_7= 1 USG in between 4 hills + 80 kg N/ha from prilled urea,

T_8= control (no nitrogen fertilizer)

4.7 1000-grain weight

1000-grain weight was found to be statistically insignificant in all of the treatments used in the experiment (Table 5). The maximum 1000-grain weight (21.67) was obtained from the T_6 (1 USG in between 4 hills + 60 kg N/ha from prilled urea) treatment and minimum 1000-grain weight (18.67) was obtained in the T_7 (1 USG in between 4 hills + 80 kg N/ha from prilled urea) treatment (Table 1).

The result fairly agreed with the findings of Rahman (2003) and Azad *et al.* (1995) who found that the level of nitrogen didn't influence the weight of 1000-grain weight significantly which is dissimilar with the findings of Mohaddesi *et al*. (2011) that 1000 grain weight had significant effect with increasing nitrogen levels.

4.8 Grain yield

Figure 4 shows the effects of different treatments on grain yield (t/ha). Grain yield was significantly influenced by different sources of nitrogen. The highest grain yield (6.60 t/ha) was obtained in the T_3 (1 USG in between 4 hills) treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment followed by statistically similar with the T_7 (6.20 t/ha) treatment (100 kg N/ha from prilled urea). However, Grain yield did not differ significantly in T_1 (140 kg N/ha from prilled urea), T_4 (2 USG in between 4 hills), T_6 ((1 USG in between 4 hills + 60 kg N/ha from prilled urea) treatments. The lowest grain yield (4.07) was obtained in the T_8 control (no nitrogen fertilizer) treatment. Numerical value indicated that treatment T_3 out yielded by 0.87, 0.1, 0.6, 1.43, 1.2, 0.4 and 2.53 t ha^{-1} over T_1, T_2, T_4, T_5, T_6, T_7 and T_8 treatment, respectively. Improvement of yield component such as number of effective tillers $hill^{-1}$ and number of grains $panicle^{-1}$ in T_3 treatments ultimately resulted in high yield of grains. Idris and Matin (1990) reported that application of nitrogen increased the yield of rice which supports the results.

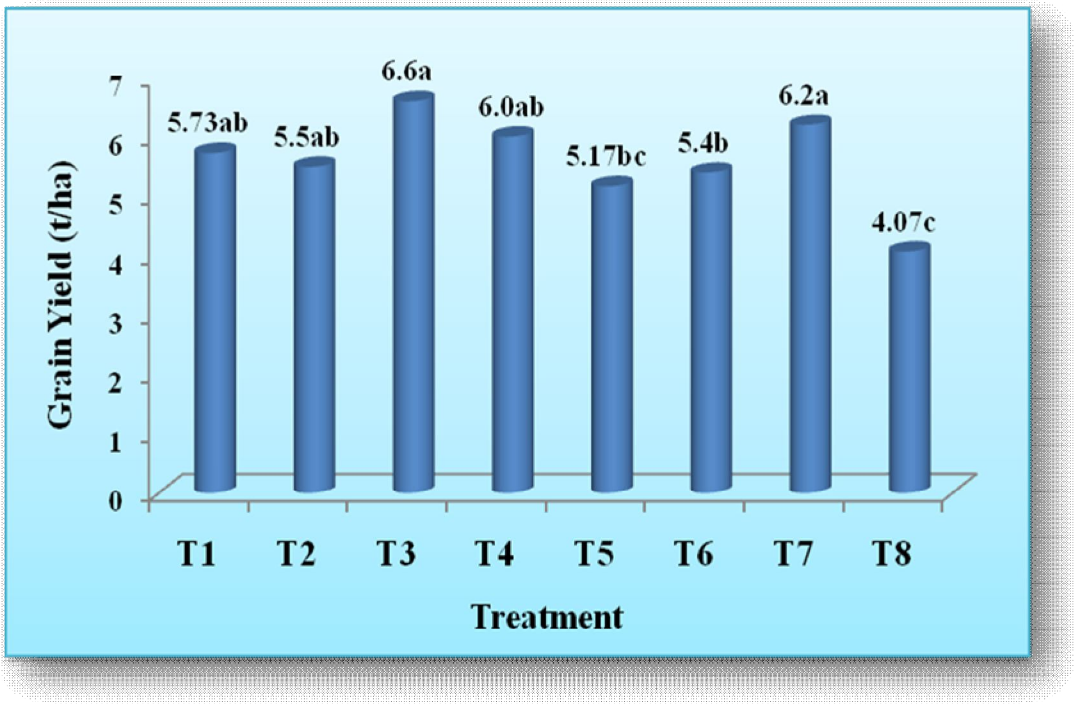


Figure 4: Effects of different nitrogen sources on grain yield of boro rice (BRRI dhan63). Mean was calculated from three replicates for each treatment.

T_1= 140 kg N/ha from prilled urea, T_2= 100 kg N/ha from prilled urea, T_3= 1 USG in between 4 hills

T_4= 2 USG in between 4 hills, T_5= 1 USG in between 4 hills + 40 kg N/ha from prilled urea,

T_6= 1 USG in between 4 hills + 60 kg N/ha from prilled urea,

T_7=1 USG in between 4 hills + 80 kg N/ha from prilled urea,

T_8= control (no nitrogen fertilizer)

4.9 Straw yield (t/ha)

Figure 5 shows the effects of different treatments on straw yield (t/ha). Straw yield was significantly influenced by different sources of nitrogen. The highest straw yield (7.43 t/ha) was obtained in the T_3 (1 USG in between 4 hills) treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment followed by statistically similar with the T_7 (1 USG in between 4 hills + 80kg N/ha from prilled urea), T_4 (2 USG in between 4 hills), T_1 (140 kg N/ha from prilled urea), T_6 (1 USG in between 4 hills + 60 kg N/ha from prilled urea) treatment. The lowest grain yield (4.53) was obtained in the T_8 control (no nitrogen fertilizer) treatment.

Elbadry *et al.* (2004), Meena *et al.* (2003) and El-Rewainy (2002) observed similar view on straw yield due to nitrogen application

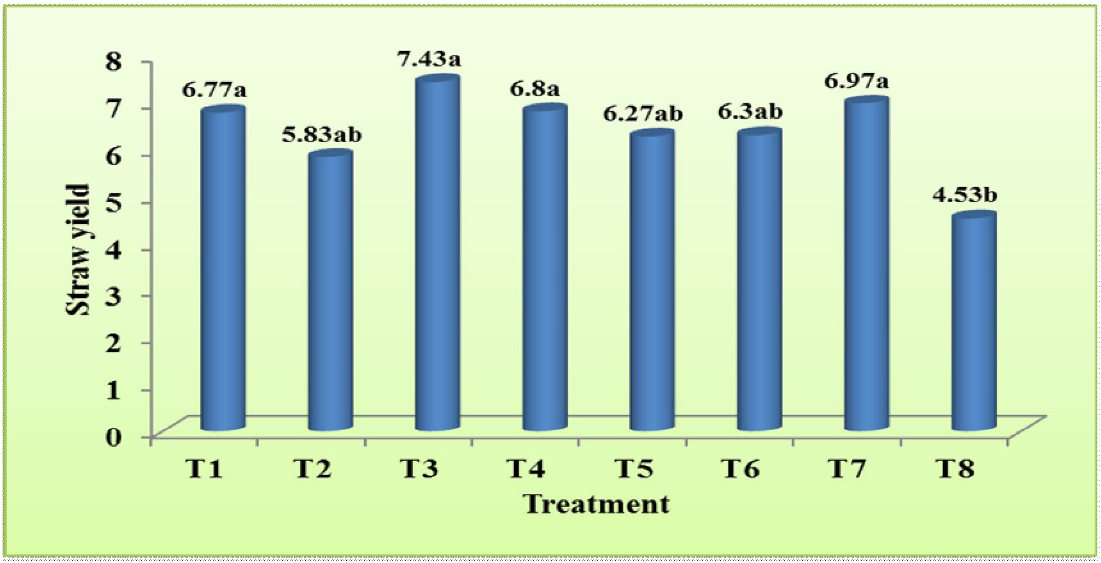


Figure 5: Effects of different nitrogen sources on straw yield of boro rice (BRRI dhan63). Mean was calculated from three replicates for each treatment

T_1= 140 kg N/ha from prilled urea, T_2= 100 kg N/ha from prilled urea, T_3= 1 USG in between 4 hills

T_4= 2 USG in between 4 hills, T_5= 1 USG in between 4 hills + 40 kg N/ha from prilled urea,

T_6= 1 USG in between 4 hills + 60 kg N/ha from prilled urea, T_7=1 USG in between 4 hills + 80 kg N/ha from prilled urea, T_8= control (no nitrogen fertilizer)

4.10 Biological yield (t/ha)

Table 5 shows the effects of different treatments on biological yield. Biological yield was significantly influenced by different sources of nitrogen. The highest biological yield (14.03 t/ha) was obtained in the T_3 ((1 USG in between 4 hills) treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment followed by T_7 (1 USG in between 4 hills + 80 kg N/ha from prilled urea), T_4 (2 USG in between 4 hills),T_1 (140 kg N/ha from prilled urea), and T_2 (100 kg N/ha from prilled urea) treatment.. The lowest biological yield (8.6 t/ha) was obtained in the T_8 control (no nitrogen fertilizer) treatment. The result agreed with the findings of Ahmed *et al.* (2005) who observed the significant effect of nitrogen on biological yield (t ha^{-1}) of rice.

4.11 Harvest Index

Harvest index (HI) is the ratio of seed yield to total above ground plant yield. Effect of nitrogen sources exerted significant variation on harvest index (Table 5). Harvest index was highest at T_2 (100 kg N/ha from prilled urea) treatment (48.54%) which was not only statistically similar with the T_3 (1 USG in between 4 hills) but also similar with T_7 (1 USG in between 4 hills + 80 kg N/ha from prilled urea), T_4 (2 USG in between 4 hills), T_1 (140 kg N/ha from prilled urea), and T_6 (1 USG in between 4 hills + 60 kg N/ha from prilled urea) streatment and the lowest harvest index (45.19%) was obtained from treatment (T_5).

Table: 5. Effects of different nitrogen sources on 1000 grain weight, biological yield and harvest index (%) of boro rice (BRRI dhan63). Mean was calculated from three replicates for each treatment.

Treatments	1000 grain weight (gm)	Biological yield (t/ha)	Harvest index (%)
T_1	21.00	12.50ab	45.84ab
T_2	21.33	11.33ab	48.54a
T_3	20.00	14.03a	47.04a
T_4	20.00	12.08ab	46.87ab
T_5	20.67	11.44bc	45.19ab
T_6	21.67	11.07bc	46.15ab
T_7	18.67	13.17b	47.07ab
T_8	21.33	8.6c	47.32b
LSD (0.05)	3.38	1.98	2.58
CV (%)	9.21	12.07	11.05
Level of significance	NS	*	*

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

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

T1= 140 kg N/ha from prilled urea, T2= 100 kg N/ha from prilled urea, T3= 1 USG in between 4 hills,

T_4= 2 USG in between 4 hills, T_5=1 USG in between 4 hills + 40 kg N/ha from prilled urea,

T_6= 1 USG in between 4 hills + 60 kg N/ha from prilled urea,

T_7=1 USG in between 4 hills + 80 kg N/ha from prilled urea,T_8= control (no nitrogen fertilizer)

Chapter V

Summary and Conclusion

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SUMMARY AND CONCLUSION

The experiment was carried out at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from December 2015 to May 2016 to determine the suitable nitrogen sources to growth performance and to increase the yield of boro rice. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. There are all together eight treatments consists of: T_1:140 kg N ha^{-1} from prilled urea, T_2: 100 Kg N ha^{-1} from prilled urea, T_3: 1 USG in between 4 hills, T_4: 2 USG in between 4 hills , T_5: 1 USG in between 4 hills + 40 kg Nha^{-1} from prilled urea, T_6: 1 USG in between 4 hills + 60 kg N ha^{-1} from prilled urea, T_7: 1 USG in between 4 hills + 80 kg Nha^{-1} from prilled urea and T_8: Control (No nitrogen fertilizer). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total numbers of unit plots were 24 and the size of unit plot was $7.5m^2$ (3 m × 2.5 m). The recommended fertilizer doses used for P, K, S, and Zn were 20, 80, 10 and 2 kg ha^{-1} respectively at final land preparation of individual plots. Prilled urea was applied in 3 equal splits and granular urea was applied at 10 DAT. Intercultural operations were done as and whenever required. At maturity, the crop was harvested. Grain and straw yields were recorded at 14% moisture. All the data are statistically analyzed and the mean differences were calculated using Duncan's Multiple Range Test (DMRT). The results of the experiment are summarized below:

Results revealed that nitrogen sources had significant effect on plant height. The tallest (92.33 cm) plant was recorded from T_6 treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment and the shortest plant (70.33 cm) was recorded from the control (T_8) treatment (no nitrogen fertilizer).

The maximum number of total tillers/hill (24.67) was obtained in the T_3 treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment. The second highest total tillers/hill (22.67) was obtained in the T_7 treatment. The minimum number of total tillers/hill (15.33) was obtained in the T_8 control treatment.

The maximum number of effective tillers/hill (23.33) was obtained in the T_3 treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment. The second highest effective tillers/hill (20) was obtained in the T_7 and the minimum number of effective tillers/hill (13.67) was obtained in the T_8 control treatment. It was observed that the number of effective tillers/hill increased with increasing levels of nitrogen.
At harvest, the highest panicle length (24.67 cm) was recorded from T_6 treatment and the shortest panicle length (21.67 cm) was recorded from the T_3 treatment.

The maximum number of total grains/panicle (119.67) was obtained in the T_3 treatment and the minimum number of total grains/panicle (84.33) was obtained in the T_8 control.

The maximum number of filled grains/panicle (105.0) was obtained in the T_3 treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment. The second highest filled grains/panicle (115.0) was obtained in the T_6 treatment which was statistically similar with the T_7 (113.33) treatment. However filled grains/panicle did not differ significantly in T_1, T_2, T_4 treatments. The minimum number of filled grains/panicle (76.67) was obtained in the T_8 control treatment.

The 1000-grain weight was not influenced significantly by the treatments. The maximum 1000-grain weight (21.67) was obtained from the T_6 treatment and minimum 1000-grain weight (18.67) was obtained in the T_7 treatment.

Application of 1 urea super granules in between 4 hills increased the grain and straw yield. The highest grain yield (6.60 t/ha) was obtained in the T_3 (1 USG in between 4 hills) and the lowest grain yield (4.07t/ha) was obtained in the T_8 control (no nitrogen fertilizer) treatment. The treatment T_3 gave the maximum straw yield of (7.43 t/ha) and the lowest grain yield (4.53t/ha) was obtained in the T_8 control treatment.

From the present study finally it can be concluded that the sources and application methods of nitrogen as USG showed the superiority over prilled urea. The above result also suggested that the application of 1 USG in between 4 hills performed the best compare to other treatments of the study in aspect of yield and yield contributing characters of *boro* rice. The above result also suggested that the application of urea super granule increases the effectiveness of urea fertilizer up to 25%.Use of USG as a nitrogen source also reduced the environmental and soil pollution. USG release nutrient at slow rate than prilled urea that can help to uptake nutrient for plant longer time. So I strongly recommended that the farmer of our country can use urea super granule as a source of N for increasing the rice production with higher nutrient capability. Considering the above observation of the present study, the following recommendation may be suggested :

i. Further study may be needed to ensuring the performance of urea super granule

ii. More varieties may be needed to include for further study to make sure the performance of genotype and fertilizer for rice production.

iii. Such study is also needed in different agro–ecological zones (AEZ) of Bangladesh for regional adaptability and other performances.

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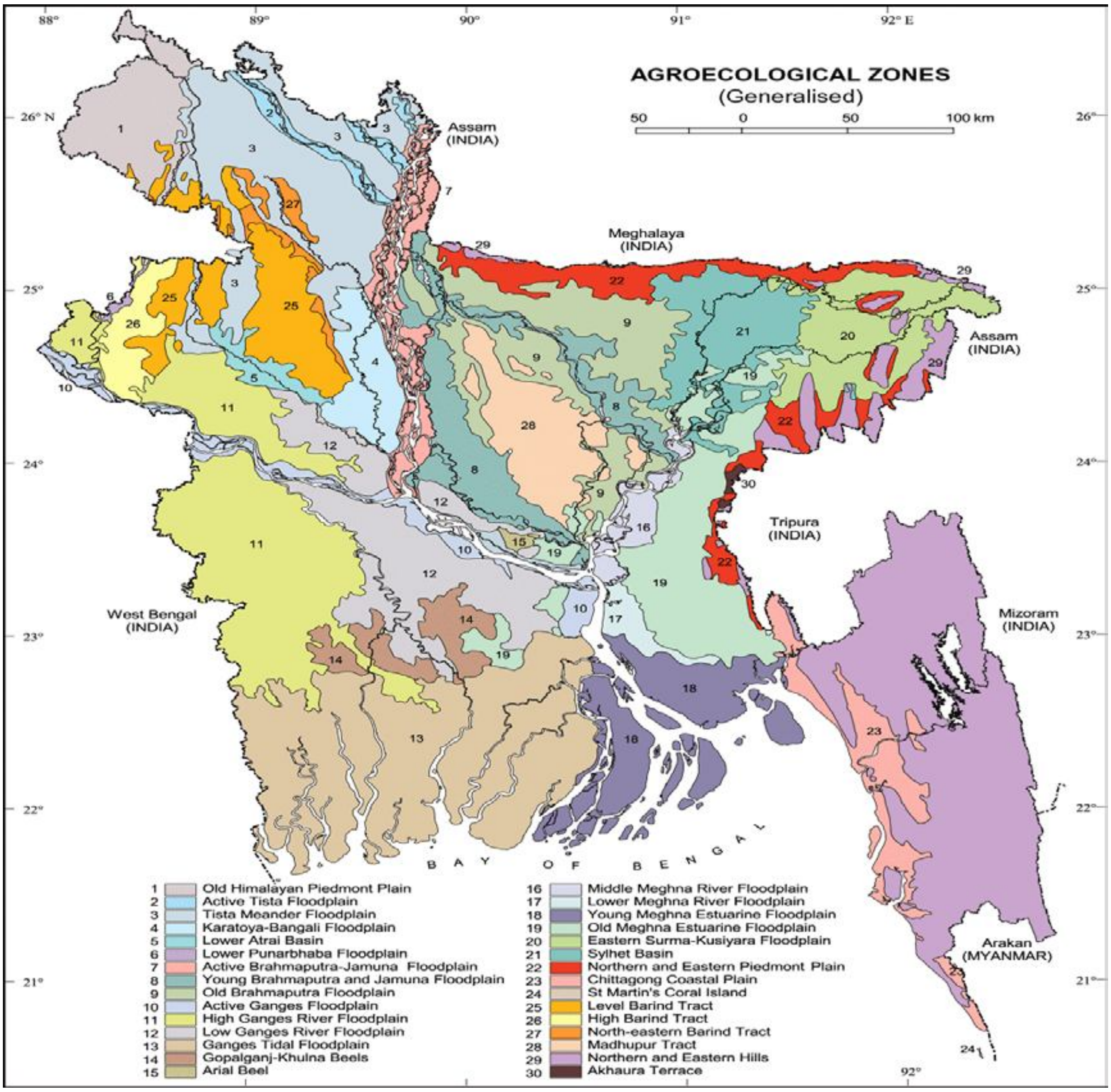
Appendices

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from November 2015 to March 2016

Month	*Air temperature (ºc)		*Relative humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
December, 2015	22.4	13.5	74	00	6.3
January, 2016	24.5	12.4	68	00	5.7
February, 2016	27.1	16.7	67	30	6.7
March, 2016	29.4	19.6	68	00	6.8
April, 2016	34.3	24.5	67	78	6.9
May,2016	33.5	25.5	70	185	7.8

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka –1207