INFLUENCE OF METHODS OF NITROGENOUS FERTILIZERS USE AND VARIETIES ON GROWTH AND YEILD OF BORO RICE

A Thesis
By

MIRZA TARIQUL AZAM
Reg. No.: 08-3246

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY,
DHAKA-1207

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INFLUENCE OF METHODS OF NITROGENOUS FERTILIZERS USE AND VARIETIES ON GROWTH AND YEILD OF BORO RICE

BY

MIRZA TARIQUL AZAM
Reg. No.: 08-03246

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Approved by:

………………………………..
(Dr. Md. Hazrat Ali)
Professor
Supervisor

..……………………………..
(Dr. Md. Fazlul Karim)
Professor
Co-supervisor

……………………………………………
(Prof. Dr. A. K. M. Ruhul Amin)
Chairman
Examination Committe

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
PABX: 9110351 & 9144270-79

CERTIFICATE

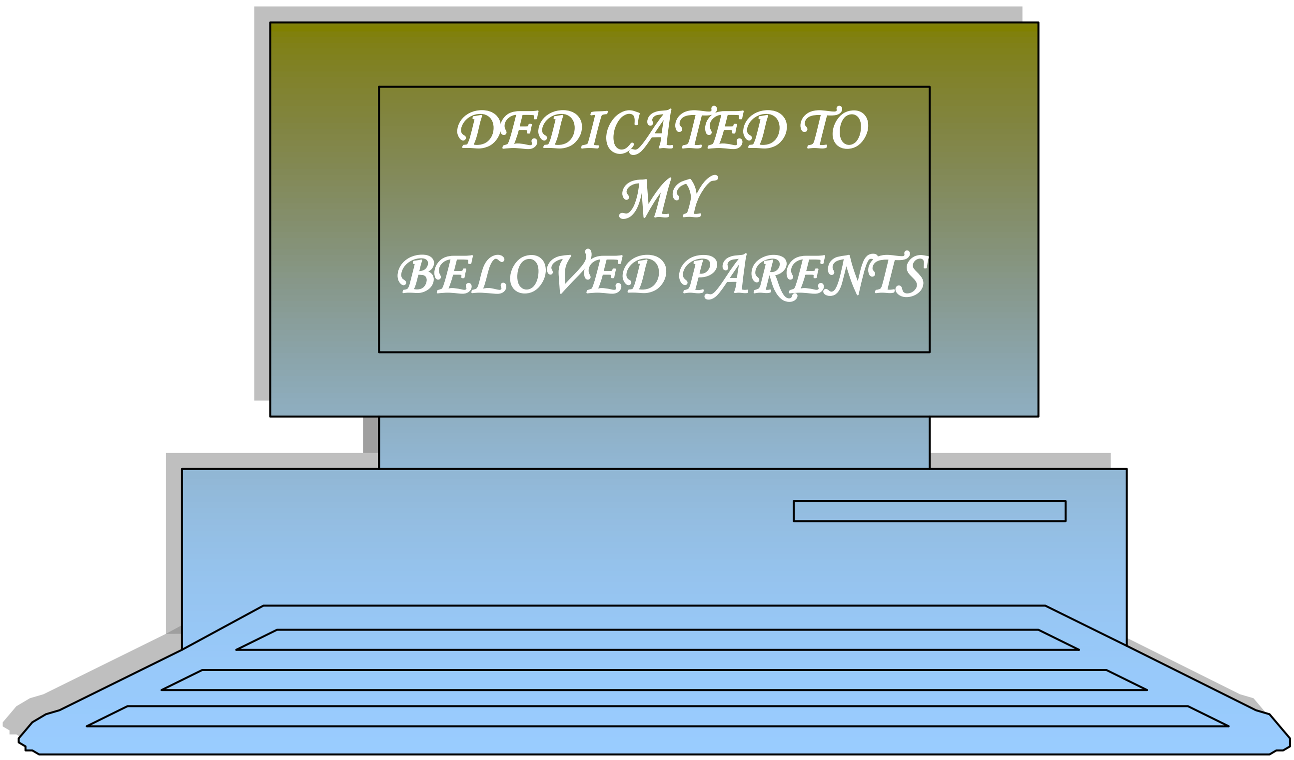
This is to certify that the thesis entitled, **“INFLUENCE OF METHODS OF NITROGENOUS FERTILIZERS USE AND VARIETIES ON GROWTH AND YEILD OF BORO RICE”** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **MIRZA TARIQUL AZAM**, **Registration No. 08-03246** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Place: Dhaka, Bangladesh

(Dr. Md. Hazrat Ali)
Professor
Supervisor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DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2008 to June, 2009 to study the 'Influence of methods of nitrogenous fertilizer use and varieties on growth and yield of boro rice'. The experiment comprised as two factors viz. (1) Factor A – Variety: 3 levels; (i) V_1 = ACI Hybrid dhan 1, (ii) V_2 = BRRI dhan29 and (iii) V_3 = BRRI hybrid dhan2; and (2) Factor B – Methods of urea application: 4 levels; (i) T_1 = 2.7 g size USG placement at 8 DAT, (ii) T_2 = 1.8 g size USG placement at 8 DAT + Prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT, (iii) T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT and (iv) T_4 = 0.9 g size USG placement at 8 DAT + Prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT. The experiment was laid out in Split-plot design with three replications. BRRI hybrid dhan2 (V_3) showed the highest plant height (108 cm), number of tillers hill^{-1} (23.98), number of leaves hill^{-1} (91.09), dry weight hill^{-1} (84.14 g), leaf area index (7.12), panicle length (26.58 cm), number of grains panicle^{-1} (131.20), 1000 seed weight (26.12 g), grain yield (4.79 t ha^{-1}), straw yield (6.80 t ha^{-1}), biological yield (11.6 t ha^{-1}) and harvest index (41.25%) at harvest. With different methods of urea application, the tallest plant was recorded by T_4 (109.80 cm at harvest) but for other parameters; T_1 gave the highest number of tillers hill^{-1} (24.67), number of leaves hill^{-1} (90.41), dry weight hill^{-1} (83.22 g), leaf area index (6.83), panicle length (26.38 cm), number of grains panicle^{-1} (128.2), 1000 seed weight (25.73 g), grain yield (4.67 t ha^{-1}), straw yield (6.72 t ha^{-1}), biological yield (11.39 t ha^{-1}) and harvest index (40.66%). With the combined effect of different boro rice variety and methods of urea application the tallest plant was achieved by V_1T_4 (110.7 cm at harvest), but for other parameters; the highest number of tillers hill^{-1} (28.00 at harvest), number of leaves hill^{-1} (100.20 at harvest), dry weight hill^{-1} (90.59 g at harvest), leaf area index (7.87 at harvest), panicle length (27.06 cm), number of grains panicle^{-1} (146.20), 1000 grain weight (26.79 g), grain yield (5.41 t ha^{-1}), straw yield (7.20 t ha^{-1}), biological yield (12.61 t ha^{-1}) was at V_3T_1. So, V_3T_1 (BRRI hybrid dhan2 × 2.7 g size USG placement at 8 DAT) was the best treatment under the present study.

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LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAT	=	Days after transplanting
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg ha^{-1}	=	Kilogram per hectare
g	=	gram (s)
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
PU	=	Prilled Urea
P^{H}	=	Hydrogen ion conc.
TSP	=	Triple Super Phosphate
T ha^{-1}	=	ton per hectare
USG	=	Urea Super Granule
%	=	Percent

Chapter 1
Introduction

CHAPTER 1
INTRODUCTION

Rice is the main food crop of an estimated 40% of the world's population (Buresh and De Datta 1990). The rice crop removes large amounts of N for its growth and grain production. The estimated amount of N removal ranges from 16 to 17 kg for the production of one ton of rough rice, including straw (Choudhury *et al.,* 1997; Ponnamperuma and Deturck 1993; Sahrawat, 2000). Total N uptake by rice plant per hectare varies among rice varieties. Most of the rice soils of the world are deficient in N, and biological nitrogen fixation by cyanobacteria and diazotrophic bacteria can only meet a fraction of the N requirement (Baldani *et al.,* 2000; Tran Van *et al.,* 2000). Fertilizer N applications are thus necessary to meet the crop's demands. Generally urea is the most convenient N source for rice. The efficiency of the urea-N in rice culture is very low, generally around 30–40%, in some cases even lower (Cao *et al.,* 1984; Choudhury and Khanif, 2004; Choudhury *et al.,* 2002).

Rice is the principal food crop of Bangladesh. That is why food security is directly related to the production of Boro rice. There is no alternative but to increase the production of Boro rice, adopting the advanced technologies as recommended by the agricultural scientists.

Hybrid rice technology is one of the alternative means to meet the challenge of food security for the increasing population in Bangladesh. Hybrid rice has higher seedlings dry matter content, thicker leaves, larger leaf area and longer root system (BRRI, 2000). Hybrid rice can give 10-15% yield advantage over modern inbred varieties through vigorous growth, extensive root system, efficient and greater sink size, higher carbohydrate translocation from vegetative parts to spikelets and larger leaf area index during the grain filling stage (Peng *et al.,* 1998). Again the inbred is normally sink limiting and hybrids are source limiting. For high yield of hybrid rice, sink is not the limiting factor as it is in inbred rice (Yan, 1988). Two-step grain filling is observed in hybrid rice, which means that pollinated spikelets stop development for several days but maintain the ability to fill later (Wen, 1990). During vegetative growth, hybrid rice accumulates more dry matter which results in higher spikelets panicle^{-1}, whereas inbred rice depends basically on the accumulation of assimilates after heading (Yan, 1988). The main reason for higher yield of hybrid rice is vigorous seedlings with tillers. The tillers that emerge in the seedbed produce more spikelets panicle^{-1} than the tillers that emerge after transplanting (Wen, 1990).

The common properties of modern inbred and hybrid rice varieties are, high nitrogen response, erect and thick leaves which remain green till maturity, short statured and high harvest index. Dry matter production at different growth stages shows different patterns for hybrid and inbred rice. While hybrid rice has more dry matter accumulation in the early and middle growth stages, inbred rice has more in the late growth stages (Yan, 1988). High grain yield of hybrid rice is attributed to high vegetative biomass production, high leaf area, large panicles and high tillering capacity in some cases (Peng *et al.,* 1998). The present study was undertaken to evaluate the growth and yield behaviour of a few selected hybrid and inbred rice varieties in boro season under field condition.

Responses of modern rice to applied nitrogen have been studied extensively throughout the country by a series of fertility trials. The average yield increase due to fertilizer N varies from 30 to 75%. In some cases, without applied N modern rice showed almost complete failure, while application of 100 kg N ha^{-1} along with other nutrients resulted in a very successful crop yield of 6-7 t ha^{-1}. The low N-use efficiency is attributed mainly to ammonia volatilization, denitrification, leaching, and runoff losses (Cho, 2003; Singh *et al.,* 1995; Freney *et al.,* 1990). However, the magnitude of N loss by different ways varies depending on environmental conditions and management practices. Volatilization and denitrification cause atmospheric pollution through the emission of gases like nitrous oxide, nitric oxide, and ammonia (Azam *et al.,* 2002; Reeves *et al.,* 2002). Nitrous oxide absorbs infrared radiation contributing to the greenhouse warming and the depletion of the stratospheric ozone layer (Bohlool *et al.,* 1992). Nitric oxide contributes to the formation of tropospheric ozone, a major atmospheric pollutant that affects human health, agricultural crops, and natural ecosystems (Chameides *et al.,* 1994).

Deep placement of N fertilizers into the anaerobic soil zone is an effective method to reduce volatilization loss (Mikkelsen *et al.,* 1978). Field experimental results using the 15N as tracer at IRRI demonstrated that N use efficiency was higher when fertilizer was placed at 10-cm soil depth (De Datta and Craswell, 1980). Urea can be placed deep into the reduced soil layer at 8–10-cm soil depth by an instrument called "pneumatic urea injector" developed in the Netherlands. Field experimental results conducted at Bangladesh Rice Research Institute (BRRI) showed the superiority of this method of urea application over the conventional split broadcast method (Choudhury and Bhuiyan, 1994a).

Nitrogen is the most limiting plant nutrient in Bangladesh agriculture. Its use efficiency from applied urea is very low. For waterlogged rice it is as low as 25% and for upland crops it is not more than 40%. As much as 70% of nitrogen from urea is converted to gas, may contribute to global warming and never reaches to the plant when urea is applied to the surface .The loss of nitrogen drastically reduces the efficiency of urea fertilizer. Thus, there is a great demand to improve N use efficiency for rice as well as high N demanding upland crops. The low level of N recovery by rice is generally caused by large losses from the soil/water/plant complex. N loss processes are ammonia volatilization, denitirfiacation, runoff, seepage and leaching. Nitrogen losses through nitrate leaching can be substantial in sandy soils in drier regions. While $N0_3$ ions are useful for upland crops and also for rice crop at ripening stage, they may pollute underground water if leaching is severe.

The nature and degree of losses depends upon soil and climatic conditions as well as N and floodwater management practices. The major loss processes are dependent upon the concentrations and quantity of ammoniacal N present in floodwater or at the soil-water interface in a flooded situation. Deep placement of N in the reduced zone and proper coverage is the best method that can minimize N losses. Hand placement of urea super granules (USG) of 1-3 g into the reduced zone of the soil has resulted in smaller concentrations of N in the floodwater, less loss of N, higher N recovery and higher yield than the conventional N application practices. It has experimentally been found that minimum 30% more grain yield is possible with basal deep placement (BDP) compared to traditional split broadcast (SB) application at rates of 50-60 kg N ha^{-1}. In other words, it can be inferred that 20-40% fertilizer N savings could occur from BDP compared to SB for production of about 800-1000 kg paddy ha^{-1} yield increase from applied N.

Keeping all the points in mind mentioned above, the present piece of research work was under taken with the following objectives.

Objectives

1. Identify the most appropriate nitrogenous fertilizer management for higher yield of rice
2. Compare the yield performance of HYV and Hybrid varieties of boro rice.
3. Find out the interaction of cultivars and methods of nitrogenous fertilizer applications on growth, yield and yield contributing characters of boro rice.

Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

Rice is the principal food crop for the people of Bangladesh. A good number of research works have been done on various aspects of its growth and yield at different ecological situations. Nitrogen fertilizer plays a significant role on growth and yield of transplant boro rice. Variety of a crop is also an important factor for achieving better yield. During urea use in the crop field by different crop variety, losses of urea is occurred due to different process like leaching loss, volatilization, washes out with water etc. Urea consumption capacity at different forms of urea is also different according to different crop variety. Considering this aspect, in this chapter, some research works relating to the effect of different form of nitrogenous fertilizer and different varieties on growth and yield component of transplanted rice are reviewed and discussed.

2.1 Effect of variety

BRRI (2008a) conducted a comparative study of some promising lines with BRRI modern rice varieties to different nitrogen levels *viz*. 0, 30, 60, 90, 120 and 150 kg N ha^{-1}. It was reported that tiller production with N @ 120 kg ha^{-1} produced significantly higher tiller than those of lower N levels.

Xia *et al.* (2007) found that Shanyou 63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}).

Amin *et al.* (2006) conducted a field experiment to find out the influence of variable doses of N fertilizer on growth, tillering and yield of three traditional rice varieties (*viz.* Jharapajam, Lalmota, Bansful Chikon) was compared with that of a modern variety (*viz.* KK-4) and reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

Bisne *et al.* (2006) conducted an experiment with eight promising varieties using four CMS lines and showed that plant height, tiller number hill^{-1} and grain yield differed significantly among the varieties and Pusa Basmati gave the highest plant height tiller number hill^{-1} and grain yield in each line.

Swain *et al.* (2006) evaluated in a field experiment the performance of rice hybrids NRH1, NRH3, NRH4, NRH5, PA6111, PA6201, DRRH1, IR64, CR749-20-2 and Lalat conducted in Orissa, India during 1999-2000. Among the hybrids tested, PA 6201 recorded the highest leaf area index.

Wang *et al.* (2006) studied the effects of plant density and row spacing (equal row spacing and one seedling hill^{-1}, equal row spacing and 3 seedlings hill^{-1}, wide-narrow row spacing and one seedling hill^{-1}, and wide-narrow row spacing and 3 seedlings hill^{-1}) on the yield and yield components of hybrids and conventional cultivars of rice. Compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti and observed that Mukti (5268 kg ha^{-1}) out yielded the other genotypes and recorded the maximum number of filled grains and had lower spikelet sterility (25.85%) compared to the others.

Sumit *et al.* (2004) worked with newly released four commercial rice hybrids (DRRH 1, PHB 71, Pro-Agro 6201, KHR 2, ADTHR 1, UPHR 1010 and Pant Sankar Dhan 1) and two high yielding cultivars (HYV) as controls (Pant Dhan 4 and Pant Dhan 12) and reported that KHR 2 gave the best yield (7.0 t ha^{-1}) among them.

A field experiment was conducted by Singh and Shivay (2003) at the Research Farm of the Indian Agricultural Research Institute, New Delhi, India to study the effect of coating prilled urea with eco-friendly neem formulations in improving the efficiency of nitrogen use in hybrid rice. Two rice cultivars, hybrid rice (NDHR-3) and Pusa Basmati-1, formed the main plots, with the levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and various forms of urea at 120 kg N ha^{-1}in the subplots. They found that increasing levels of nitrogen significantly increased the number of effective tillers $hill^{-1}$.

Bokyeong *et al.* (2003) reported that applied with same nitrogen dose Sindongjinbyeo and Iksan 467 gave higher primary rachis branches than Sindongjinbyeo and Dongjin No. 1 varieties.

Dongarwar *et al.* (2003) comprised an experiment to investigate the response of hybrid rice KJTRH-1 in comparison with 2 traditional cultivars, Jaya and Swarna, to 4 fertilizer rates, i.e. 100:50:50, 75:37.5:37.5, 125:62.5:62.5 and 150:75:75 kg NPK ha^{-1} and reported that KJTRH-1 produced significantly higher yield (49.24 q ha^{-1}) than Jaya (39.64 q ha^{-1}) and Swarna (46.06 q ha^{-1}).

Hasan *et al.* (2002) determined the response of hybrid (Sonar Bangla-1 and Alok 6201) and inbred (BRRI Dhan 34) rice varieties to the application methods of urea supergranules (USG) and prilled urea (PU) and reported that the effect of application method of USG and PU was not significant in respect of panicle length, number of unfilled grains $panicle^{-1}$ and 1000-grains weight.

Prasad *et al*. (2001) observed that days to flowering are negatively correlated with plant height. Grain yield is negatively correlated with plant height (Amirthadevarathinam, 1983).

Xu and Wang (2001) evaluated ten restorer and ten maintainer lines. They observed that the restorer lines showed more spikelet fertility than maintainer lines. They studied growth duration, number of effective tillers, number of spikelets per panicle and adaptability.

Chen-Liang *et al*. (2000) showed that the cross between Peiai 64s and the new plant type lines had strong heterosis for filled grains per plant, number of spikes per plant and grain weight per plant, but heterosis for spike fertility was low.

Patel (2000) studied that the varietal performance of Kranti and IR36. He observed that Kranti produced significantly higher grain and straw yield than IR36. The mean yield increased with Kranti over IR36 was 7.1 and 10.0% for grain and straw, respectively.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4 m^{-2}) and filled grains $panicle^{-1}$ (111.0) than other varieties, whereas IR36 gave the highest 1000-grain weight (21.07g) and number of panicles m^{-2} than other tested varieties.

Improvement of rice grain yield is the main target of breeding program to develop rice varieties for diverse ecosystems. However, grain yield is a complex trait, controlled by many genes and highly affected by environment (Jennings *et al*., 1979). In addition, grain yield also related with other characters such as plant type, growth duration, and yield components (Yoshida, 1981). Rice yield is a product of number of panicles per unit area, number of spikelets per panicle, percentage of filled grains and weight of 1000 grains (Yoshida, 1981; De Datta and Craswell, 1980). Improving rice (*Oryza sativa* L.) grain yield per unit land area is the only way to achieve increased rice production because of the reduction in area devoted to rice production (Cassman, 1999).

Devaraju *et al.* (1998 a) in a study with hybrid rice cultivar KRH2 and 1R20 as a check variety having different levels of N from 0 to 200 kg N ha^{-1} found that KRH2 out yielded IR20 at all levels of N. The increased grain yield of KRH2 was mainly attributed to the higher number of productive tillers $hill^{-1}$, panicle length, weight and number filled grains $panicle^{-1}$.

Devaraju *et al.* (1998 b) in a study with two rice hybrids such as Karnataka Rice Hybrid 1 (KRH1) and Karnataka Rice Hybrid-2(KRI42) using HYV IR20 as the check variety and found that KRH2 out yielded than IR20. In IR20, the tiller number was higher than that of KRH2

Julfiquar *et al.* (1998) reported that BRRI evaluated 23 hybrids along with three standard checks during *boro* season 1994-95 as preliminary yield trial at Gazipur and it was reported that five hybrids (IR58025A/IR54056, IR54883, PMS8A/IR46R) out yielded the check varieties (BR14 and BR16) with significant yield difference. They also reported that thirteen rice hybrids were evaluated in three locations of BADC farm during the boro season of 1995-96. Two hybrids out yielded the check variety of same duration by more than 1 t ha^{-1}.

Mishra and Pandey (1998) evaluated standard heterosis for seed yield in the range of 44.7 to 230.9% and 42.4 to 81.4%, respectively. Plant height, panicle per plant, grain per panicle and 1000 grain weight increase the yield in modern varieties.

Om *et al.* (1998) in an experiment with hybrid rice cultivars ORI 161 and PMS 2A x IR 31802 found taller plants, more productive tillers, in ORI 161 than in PMS 2A x IR 31802.

Rajendra *et al.* (1998) carried out an experiment with hybrid rice cv. Pusa 834 and Pusa HR3 and observed that mean grain yields of Pusa 834 and Pusa HR3 were 3.3 t ha^{-1} and 5.6 t ha^{-1}, respectively.

Son *et al.* (1998) reported that dry matter production of four inbred lines of rice (low-tillering large panicle type), YR15965ACP33, YR17104ACP5, YR16510-B-B-B-9, and YR16512-B-B-B-10, and cv. Namcheonbyeo and Daesanbyeo, were evaluated at plant densities of 10 to 300 plants m^{-2} and reported that dry matter production of low-tillering large panicle type rice was lower than that of Namcheonbyeo regardless of plant density.

Xu and Li (1998) observed that the maintainer lines were generally shorter than restorer line. He also observed that the plants, which needed more days for 50% flowering generally, gave more yield.

Ahmed *et al.* (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was 60-60-40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

Dwivedi (1997) in a field experiment found that scented genotypes, Kamini and Sugandha gave higher grain and straw yields than four other cultivars RP615, Harban, Basmati and Kasturi with 60 kg N ha^{-1} under midupland sandy loam soil conditions of Agwanpur (Bihar).

Associations of various yield components in rice (Padmavathi *et al.,* 1996) indicate that the plants with large panicles tend to have a high number of fertile grains. Similarly, a positive correlation was observed between number of panicle/plant and panicle length.

Munoz *et al.* (1996) noted that IR8025A hybrid rice cultivar produced an average yield of 7.1 t ha^{-1} which was 16% higher than the commercial variety Oryzica Yacu-9.

BRRI (1995) conducted an experiment with rice cv. BR10, BR22, BR23 and Rajasail (ck.) at three locations in the aman season. It was found that BR23 gave the highest yield (5.71 t ha^{-1}) which was similar to BR22 (5.02 t ha^{-1}) and the check Rajasail yielded the lowest (3.63 t ha^{-1}).

Islam (1995) in an experiment with four rice cultivars *viz.* BR10, BR11, BR22 and BR23 found that the highest number of non bearing tillers $hill^{-1}$ was produced by cultivar BR11 and the lowest number was produced by the cultivar BR10.

BRRI (1994) also reported that among the four varieties viz. BR14, Pajam, BR5 and Tulsimala, BR14 produced the highest tillers $hill^{-1}$ and the lowest number of spikelet $panicle^{-1}$ respectively. They also observed that the finer the grain size, the higher was the number of spikelet $panicle^{-1}$.

BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, BINA13 and BINA19. They found that varieties differed significantly on panicle length and sterile spikelets $panicle^{-1}$. It was also reported that varieties BINA13 and BINA19 each had better morphological characters like more grains $panicle^{-1}$ compared to their better parents which contributed to yield improvement in these hybrid lines of rice.

Chowdhury *et al.* (1993) observed that the cultivar BR23 showed superior performance over cultivar Pajam in respect of number of productive tillers $hill^{-1}$, length of panicle, 1000-grain weight, grain and straw yields but cultivar Pajam produced significantly taller plants, more number of total spikelet $panicle^{-1}$, grain $panicle^{-1}$ and sterile spikelet $panicle^{-1}$. They also observed that the finer the grain size the higher the number of spikelet.

BINA (1992) reported in a field experiment that under transplanting conditions the grain yield of BINA13 and BINA19 were 5.39 and 5.57 t ha^{-1} respectively and maturity of the above strains were 160 days and 166 days, respectively.

Hossain and Alam (1991 a) reported that the growth characters like plant height, total tillers hill^{-1} and the number of grains panicle^{-1} differed significantly among BR3, BRll, BR14 and Pajam varieties in boro season.

Hossain and Alam (1991 b) found that the growth characters like total tillers hill^{-1} differed significantly among BR3, BR11, Pajam and Jaguli varieties in *boro* season.

Miah *et al.* (1990) conducted an experiment where rice cv. Nizersail and mutant lines Mut. NSI and Mut. NSS were planted and found that plant height were greater in Mut. NSI than Nizersail.

Patnaik *et al*. (1990) reported that in hybrids, yield was primarily influenced by effective tillers per plant and fertile grains per panicle, whereas in parents it was panicle length, maturity and effective tillers per plant. Number of effective tillers per plant and fertile grains per panicle remained constant and common in explaining heterosis for yield of most of the hybrids. The heterosis for grain yield was mainly due to the significant heterosis for the number of spikelets/panicle, test weight and total dry matter accumulation.

Saha *et al*. (1989) studied the characteristics of CMS lines V20A, 279A, V41A and P203A with their corresponding maintainer (B) lines and two restorer (R) lines IR50 and IR54. In maintainer lines tiller number were recorded highest in V20B.

Shamsuddin *et al*. (1988) conducted a field trial with nine different rice varieties and observed that plant height differed significantly among varieties.

Sawant *et al.* (1986) conducted an experiment with the new rice cv. R-73-1-1, R-R-711 and the traditional cv. Ratna and reported that the traditional cv. Ratna was the shortest. Dwarfness may be one of the most important agronomic characters, because it is often accompanied by lodging resistance and thereby adapts well to heavy fertilizer application (Futsuhara and Kikuchi, 1984).

2.2 Effect of methods of urea fertilizer application

Masum *et al*. (2010) reported that placement of N fertilizer in the form of USG @ 58 kg N ha^{-1} produced the highest number of effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ which ultimately gave the higher grain yield than split application of urea.

BRRI (2009) conducted an experiment on study of N release pattern from USG and prilled urea under field condition and its effect on grain yield and N nutrition of rice with three doses of N namely 50, 100 and 150 kg N $ha^{-1}$from two types of urea e.g. prilled (PU) and urea super granules (USG) were tested as treatment. Result showed that the highest grain yield was recorded when N applied @ 100 kg N ha^{-1} both from USG and PU and the highest straw yield was obtained in PU @ 150 kg N ha^{-1}.

Hasanuzzaman *et al*. (2009) conducted an experiment to study the economic and effective method of urea application in rice crop. They noted that urea supergranules produced longest panicle (22.3 cm).

Kabir *et al*. (2009) conducted an experiment to find out the effect of urea super granules (USG), prilled urea (PU) and poultry manure (PM) on the yield and yield contributes of transplant *aman* rice. They observed that the highest grain yield (5.17 t ha^{-1}), straw yield (6.13 t ha^{-1}) and harvest index (46.78%) were found from full dose of USG.

Masum *et al*. (2008) conducted an experiment to study the effect of four levels of seedling $hill^{-1}$ *viz*; 1, 2, 3 and 4 and two forms of nitrogen – prilled urea (PU) and urea supergranules (USG) on yield and yield components of modern (BRRI dhan44) and traditional (Nizershail) transplant *aman* rice. They reported that leaf area index significantly higher in USG receiving plant than prilled urea.

BRRI (2008 b) conducted an experiment on the title of response of MVs and hybrid entries to added N in a rice rice cropping pattern. Six N doses 0, 40, 80, 120, 160 and 120 kg N ha^{-1} were tested and resulted that grain yield of hybrid responded up to 120 kg N ha^{-1}.

A field experiment was conducted by Rakesh *et al*. (2005) at Research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India, to determine the response of hybrid rice cv. MPH-501 to different nitrogen (40, 80, 120 and 160 kg N ha^{-1}) and potassium levels (30, 60, and 90 kg K_2O ha^{-1}). The application of 160 kg N and 60 kg K_2O ha^{-1} significantly influenced the growth and yield attributes of hybrid rice and produced higher grain and straw yield.

Edwin and Krishnarajan (2005) reported that N supplied at 7 DAT, 21 DAT, panicle initiation stage and first flowering stage gave the highest grain yield and straw yield and lowest level of spikelet sterility (25.30%).

Miah *et al.* (2004) found that the values of the parameters measured were higher with application of urea super granules compared to application of urea.

A field experiment was conducted by Lang *et al*. (2003) to study the effect of different fertilizer application rates on seedling of Jinyou 207, Guihuanian and Teyou 524 were sown in no-tillage plots situated in 3 different counties in Guangxi, China. At an early stage of growth, the seedlings were subjected to one of three nitrogen fertilizer treatments. Treatment A used a conventional application rate (CAR) of 157-5-172.5 kg

$ha^{-1}N$, treatments B and C used CAR + 10% and CAR + 20%, respectively. They found that the increase in nitrogen fertilizer application rate increased the speed of seedling establishment and tillering peak.

Maitti *et al*. (2003) conducted an experiment to study the effects of nitrogen fertilizer rate (0, 120, and 140 kg ha^{-1}) on the performance of 1 cultivar (IET-4786) and 4 hybrid varieties (ProAgro 6Y213, ProAgro 6Y3024, ProAgro 6111N, and ProAgro 6201) of rice in Mohanpur, West Bengal, India. The nitrogen fertilizer was applied during transplanting (50%) and at the tillering and panicle initiation stages (50%). They reported that the application of 140 kg N ha^{-1} resulted in the highest increase in grain yield (by 76.2%), number of panicles (by 109.00%), number of filled grains per panicle (by 26.2%), and 1000-grain weight (5.80%) over the control, and the highest nitrogen (136.701 kg ha^{-1}), phosphorus (132.029 kg ha^{-1}), and potassium (135.167 kg ha^{-1}) uptake.

Rahman (2003) observed that plant height did not affected by the different level of USG in rice. He carried out an experiment with two levels of urea supergranules (USG) in rice field as 50 and 75 kg N ha^{-1} in *kharif* season. He found that the highest plant height (83cm) was obtained with 75 kg N ha^{-1} as USG. But highest tiller number (14.32), panicle length (20.24 cm), grains $panicle^{-1}$ (91.44), 1000 seed weight (22.58 g), grain yield (3.12 t ha^{-1}) and straw yield (5.34 t ha^{-1})

Alam (2002) found that plant height and tiller number increase significantly with the increased level of USG/4 hill. They also reported that growth and yield parameters were increased with the increased level of nitrogen from 27-87 kg N ha^{-1}. Deep placement of urea supergranules (USG) resulted in the highest plant height, tillers $hill^{-1}$, biological yield, grain yield and harvest index than prilled urea.

Deep placement of urea supergranules (USG) has been proven to improve N fertilizer efficiency. In terms of N recovery, agronomical and physiological efficiency, rice varieties utilized N more efficiently when applied as urea (Miah and Ahmed, 2002).

Hasan *et al.* (2002) determined the response of hybrid (Sonar Bangla-1 and Alok 6201) and inbred (BRRI Dhan 34) rice varieties to the application methods of urea supergranules (USG) and prilled urea (PU) and reported that the effect of application method of USG and PU was not significant in respect of panicle length, number of unfilled grains panicle^{-1} and 1000-grains weight.

Jaiswal and Singh (2001) carried out a field experiment on the comparative efficiency of urea supergranules and prilled urea, both at 60 and 120 kg ha^{-1} on rice cultivation under different planting method during 1996-97 and 1997-98, in Faizabad, Uttar Pradesh, India. They stated that transplanting method with USG placement proved to be best for maximum grain yield (4.53 t ha^{-1}) and deep placement of USG increased N use efficiency (31.7%) compared to conventionally applied urea.

Ahmed *et al.* (2000) conducted a field experiment to study the effect of point placement of urea supergranules (USG) and broadcasting prilled urea (PU) as sources of N in T. *aman* rice. USG and PU were applied @ 40, 80, 120 or 160 Kg N ha^{-1}. A control treatment was also included in the experiment. They reported that USG was more efficient than PU at all respective levels of nitrogen in producing panicle length, filled grains panicle^{-1} and 1000-grain weight.

Mishra *et al.* (2000) conducted a field experiment in 1994-95 in Bhubaneswar, Orissa, India, and reported that rice cv. Lalate was given 76 kg N ha^{-1} as USG at 0, 7, 14 for 21 days after transplanting (DAT), and these treated control and reported that USG application increased plant height.

Mishra *et al*. (1999) conducted a field experiment with urea supergranules (USG) in wet land rice (*Oryza sativa* cv. Lalat) in affine textured soil. USG was applied at 76 kg N ha^{-1} along with prilled urea (PU) split. They found that placement of USG significantly increased both the grain and straw yield of rice compared to PU. Rice showed a greater response to N upon USG placement than split application of PU.

Deeper placement of USG is technologically and agroeconomically advantageous in improving N use efficiency in lowland rice fields (Mohanty et al., 1999). This technology might be effective agronomically for up/dryland cropping systems , but uncertainty prevails with regard to the environmental consequences.

Bhuiyan *et al.* (1998) conducted experiments at BRRI during the period from 1975-1985 on USG and reported that deep placement of urea for rice was superior to split broadcast application during the dry season and the economics of use appeared favorable.

Department of Agricultural Extension conducted 432 demonstrations in 72 Upazilla as of 31 districts in Bangladesh of' *boro* rice. It was reported that USG plots, on an average, produced nearly 5 percent higher yields than the PU treated plots while applying 30-40% less urea in the form of USG (Islam and Black, 1998).

Patel (1997) conducted an experiment and studied the effect of doses, forms of nitrogen fertilizer in rice and he found highest grain yield with 58 kg N ha^{-1} as urea supergranules (USG) applied 7 days after transplanting and were much lower with all rates of prilled urea.

Vijaya and Subbaiah (1997) showed that plant height, number of tillers, root length, number and weight of panicles, dry matter and grain yield of rice increased with the increasing urea super granule size and were greater with the deep placement method of application both N and P compared with broadcasting.

Pandey and Tiwari (1996) carried out a field trial with 87 kg N ha^{-1} as basal application of USG, PU, mussoorie rock phosphate urea (MRPU), large granule urea (LGU) or neem coated urea (NCU) or 66% basal incorporation + 33% top dressing at panicle initiation and found that grain yield and N use efficiency were highest with N given as a basal application of USG or MRPU applied in 2 split applications. Kumar *et al*. (1996) reported that application of urea supergranules in the sub-soil gave 22% higher grain yield than control.

Bastia and Sarker (1995) conducted a field trail in kharif season with rice cv. Jagnnath and observed that grain yield and N content were 4.07 ton ha^{-1} and 1.43% respectively with USG and the lowest 2.66 t ha^{-1} and 1.31% with PU.

Dwivedi and Bajpai (1995) observed through using 0-90 kg N ha^{-1} as urea, USG + urea or urea spray that grain yield net returns increased with the increased rate of N application and the yield was highest with USG and lowest with urea spray.

Swain *et al*. (1995) evaluated the performance of USG application methods in low land transplanted rice. They have reported that USG gave higher grain and straw yield.

Urea supergranules gave 14.9% higher yield, than applying 3 split applications of prilled urea (Mahalle and Throat, 1995). The same also observed by Patel and Mishra (1994), they placed urea supergranules 5-10 cm deep a week after transplanting. Choudhury and Bhuiyan (1994) reported that 87 kg N ha^{-1} as urea supergranules gave highest yields compared with prilled urea applied as 3 equal splits. USG placed by hand at 8-10 cm depth after seedling establishment. Grain yield was highest when 112 kg N ha^{-1} was applied as large granular urea in 3 split dressing than prilled urea applied in 3 splits (Raja *et al*., 1994).

Azollon, a slow-release nitrogen fertilizer, has been developed in Germany. It is a urea-formaldehyde condensation product containing 38% N. The relative performances of PU, ULG, USG, and Azollon in wetland rice culture were evaluated in a field experiment at BRRI (Choudhury *et al.*, 1994 a). Considering grain yield, USG was significantly superior to PU and azollon, whereas ULG had a slight edge over PU but was not statistically different. Total N uptake increased significantly in ULG- and USG-treated plots compared to the conventional PU-treated plots. Agronomic efficiency and apparent recovery of added N were considerably higher with USG and ULG compared to PU (Choudhury *et al*. 1994 b).

Harun *et al*. (1993) compared the benefits of USG application over PU and they found that USG produces at least 25% higher yield than PU and the marginal rate of return was highest for USG at 58kg N ha^{-1}.

Zaman *et al*. (1993) found that USG consistently produces significantly higher grain yield than PU. Also the total N uptake, apparent N recovery and agronomic efficiency N were higher with USG than PU.

An experiment was carried out at the Agronomy Field Laboratory, BAU, Mymensingh to investigate the effect of cultivar, depth of transplanting and sources of N fertilizer on the growth and yield of transplant *aman* rice and Kabir (1992) found that the grain yield of transplant *aman* rice can be maximized by maintaining a transplanting depth of 3 cm and applying USG instead of conventional PU.

Singh and Singh (1992) studied about the nitrogen economy through modified forms of urea application in rice and found that the grain yield increased with increasing nitrogen rates. Urea super granule produced significantly higher yields than the other sources.

Johnkutty and Mathew (1992) conducted an experiment with different forms of nitrogen on rice cv. Jyothy during rainy season and reported that 84 kg N ha^{-1} USG gave higher yield than PU.

Sahu *et al.* (1991) worked on the method of application of USG in low land rice soil and showed that USG gave higher yields than PU when USG was placed at midway between every alternate 4 hills.

Kamal *et al.* (1991) conducted a field experiment in *kharif* season of 1985 and 1986 on rice cv. Joya with different level of nitrogen @ 29, 58, 87, kg ha^{-1} as urea super granules (USG). Among the three doses of nitrogen, total tillers was the highest when 87 kg N ha^{-1} was applied, productive tillers also followed a similar trend.

Thakur (1991) studied the influence of levels, forms and method of application of urea in rice during *kharif* season. He observed that grain yield differed significantly due to the levels and sources of applied. Placement of nitrogen at 60 kg ha^{-1} through urea super granules produced the highest number of panicle $unit^{-1}$ area, panicle weight, number of grains $panicle^{-1}$ and 1000-grain weight which ultimately gave the grain yield 4.77 t ha^{-1} in 1987 and 4.94 t ha^{-1} in 1988.

Idris and Matin (1990) noted that plant height increased up to 120 kg N ha^{-1} compared to the control and there after the height declined at 140 kg N ha^{-1}. They also noted that the length of panicle was highly related with the application of increased level of nitrogen. They also stated that panicle formation and elongation is directly related with the contribution of nitrogen. The maximum number of tiller $hill^{-1}$ 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 tiller $hill^{-1}$ was obtained from the control treatment (0 kg ha^{-1}).

Sahu and Mitra (1989) reported that higher grain yields were obtained with large granular urea @ 60 or 90 kg N ha^{-1} applied in two splits (7 days after transplanting and panicle initiation stage) than with PU. USG gave higher yields than large granular urea or PU.

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

Rama *et al.* (1989) mentioned that the number of panicles m^{-2} increased significantly when nitrogen level increased from 40 to 120 kg N ha^{-1} as urea super granule (USG).

Patel and Desai (1987) found that rate of 58 kg N ha^{-1} as urea super granules placed at 10-12 cm depth gave the highest yield (4.34 t ha^{-1}) compared to any other rate.

Setty *et al.* (1987) reported that the grain yield increased significantly with increase N rate up to 87 kg ha^{-1} as urea super granules (USG).

Raja *et al.* (1987) conducted an experiment with rice cv. Pravath and urea super granules (USG). The USG at 75 kg N ha^{-1} gave the highest yield of 7.2 t ha^{-1}.

Reddy *et al.* (1986) reported that increasing N rates from 30 to 60 and 90 kg ha^{-1} increased paddy yields of wet land rice from 2.89 to 3.77 and 4.39 t ha^{-1}, respectively when N applied as urea super granules (USG) and placed in the root zone in soil.

Ali (1985) carried out an experiment with PU, USG on rice *cv.* BR3 and found that deep placement of USG was superior to 2 or 3 split application of PU. He had also found that USG was superior at all N rates where 62 kg N ha^{-1} gave the highest grain yield and it was increased with increasing N application up to 124 or 155 kg N ha^{-1} regardless of management.

Kumar and Singh (1983) carried out an experiment with rice cv. Hindham grown by applying 29-116 kg N ha^{-1} under flooded condition and stated that 87 kg N ha^{-1} in the form of USG gave the highest yield.

Juang (1980) stated that the performance of USG was superior in rice yields and fertilizer N efficiency had shown the new product to be highly suitable for rice in many Asian countries, where urea is already a common fertilizer for rice. This product is to 40 to 50% more efficient than conventional urea.

De Datta and Crasswell (1980) showed that evaluation of rice program during 1975 to 1978 and he found that deep placement of USG is an effective means of increasing rice yields compared with traditional split application of PU.

From an international trial in eight countries under INPUTS project Yoshida *et al.* (1978) found that deep placement of USG was superior both for yield and nitrogen recovery to the conventional method of urea application. They achieved 1 tha^{-1} increased yield by 41 kg N ha^{-1} in USG but the rate was 60 kg N ha^{-1} of increased yield case of urea.

Juang and Tann (1978) studied that the effect of form and rate of nitrogen fertilizer on yield and nitrogen content of rice under subtropical conditions using urea and USG at 44, 66, 88, and 132 kg N ha^{-1} and found that USG was very effective for increasing grain yield of rice than urea in the subtropics, but the optimum rate of this fertilizer might vary with the nitrogen fertility of the rice soils.

Chapter 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2008 to June, 2009. This chapter deals with a brief description on experimental site, climate, soil, land preparation, methods, experimental design, intercultural operations, data recording and their analysis.

3.1 Site description

The present study was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level (Appendix I).

3.2 Climate and weather

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Meterological Station of Bangladesh, Sher-e Bangla Nagar, presented in Appendix III.

3.3 Soil

The soil belongs to “The Modhupur Tract”, AEZ – 28. Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land.

3.4 Plant materials and features

ACI hybrid dhan 1, BRRI dhan29 and BRRI hybrid dhan2 were used as plant materials for the present study. These three varieties are recommended for boro season. The features of these three varieties are presented below:

ACI hybrid dhan 1: ACI hybrid dhan 1 variety is grown in boro season. This variety is recommended for cultivation in medium high land and medium low land. The cultivar matures at 140-145 days of planting. It attains a plant height 115-120 cm. The cultivar gives an average yield of 10-12 t ha^{-1}.

BRRI dhan29: Average plant height of the BRRI dhan29 variety is 100 cm at the ripening stage. The grains are medium fine and white. It requires about 155-160 days for completing its life cycle with an average grain yield of 6.5 t ha^{-1}.

BRRI hybrid dhan2: BRRI hybrid hybrid dhan2 variety is grown in boro season. This variety is recommended for cultivation in medium high land and medium low land. The cultivar matures at 145-150 days of planting. It attains a plant height 120-125 cm. The cultivar gives an average yield of 12-14 t ha^{-1}.

3.5 Experimental details

3.5.1 Treatments

Factor A: Variety

i. ACI hybrid dhan 1:V_1
ii. BRRI dhan29 :V_2
iii. BRRI hybrid dhan2 : V_3

Factor B: Different methods of urea application

i. T_1 = 2.7 g size USG placement at 8 DAT
ii. T_2 = 1.8 g size USG placement at 8 DAT + 75 g prilled urea for V_1 and V_3 and 45 g prilled urea for V_2 per plot at 30 DAT
iii. T_3 = 1.8 g size USG placement at 8 DAT + 75 g urea foliar spray for V_1 and V_3 and 45 g urea foliar spray for V_2 per plot at 30 DAT
iv. T_4 = 0.9 g size USG placement at 8 DAT + 37.5 g prilled urea for V_1 and V_3 and 22.5 g prilled urea for V_2 per plot at 30 DAT + 37.5 g urea foliar spray for V_1 and V_3 and 22.5 g urea foliar spray for V_2 per plot at 50 DAT.

3.5.2 Experimental design

The experiment was laid out in a split-plot design with three replications having variety in the main plots and different methods of urea application in the sub-plot. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 3 m × 2.5 m (7.5 m^2). The distances between plot to plot and replication to replication were 1 m.

3.6 Growing of crops

3.6.1 Raising seedlings

3.6.1.1 Seed collection

The seeds of the test crop i.e. BRRI dhan29 and BRRI hybrid dhan2 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur and ACI hybrid dhan 1 was collected from Local market**.**

3.6.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method and then immersed in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown in nursery bed after 72 hours.

3.6.1.3 Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed on November 20, 2008 in order to transplant the seedlings in the main field.

3.6.2 Preparation of the main field

The selected plot for the experiment was opened in 22 December 2008 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good puddle condition. Weeds and stubble were removed, and finally obtained a desirable puddled condition of soil for transplanting of seedlings.

3.6.3 Fertilizers and manure application

The fertilizers P, K, S and Zn in the form of TSP, MoP, Gypsum and $ZnSO_4$, respectively were applied. The entire amount of TSP, MoP, Gypsum and Zinc sulphate at rate of 165 kg ha^{-1}, 180 kg ha^{-1}, 90 kg ha^{-1} and 15 kg ha^{-1} respectively were applied during the final land preparation. Nitrogenous fertilizer was applied as per treatment.

Eight days after transplanting (DAT) one 2.7g mega granule, 1.8 g and 0.9 g granule were placed as per treatment in the centre of four hills at two alternate rows at a depth of 6-8 cm. During USG application 2-3 cm standing water were maintained in the field. After USG application the water level were raised to 4-5 cm. After USG application no disturbance was done in the field following one month. Foliar spray formulation was prepared by 1 kg urea into 10 liter of water and sprayed by spray machine as per treatment. According to treatment prilled urea was applied at broadcasting method.

3.6.4 Uprooting seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on December 30, 2008 without causing much mechanical injury to the roots.

3.6.5 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on Decembar 30, 2008 and the rice seedlings were transplanted in lines each having a line to line distance of 20 cm and plant to plant distance was 20 cm for all treat varieties in the well prepared plot.

3.6.6 Cultural operations

The details of different cultural operations performed during the course of experimentation are given below:

3.6.6.1 Irrigation and drainage

Flood irrigation was given to maintain a constant level of standing water upto 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering. The field was finally dried out at 15 days before harvesting.

3.6.6.2 Gap filling

Gap filling was done for all of the plots at 7-10 days after transplanting (DAT) by planting same aged seedlings.

3.6.6.3 Weeding

Weeding was done from each plot at 40 and 65 DAT. Hand weeding was done from each plot.

3.6.6.4 Plant protection

Furadan 57 EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

3.7 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80-90% of the grains become golden yellow in colour. ACI hybrid dhan 1 and BRRI hybrid dhan2 were harvested on 30th May, 2009 and BRRI dhan29 on 8th June, 2009. Ten pre-selected hills per plot from which different data were collected and 3 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. Finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.8 Data recording

The following data were collected during the study period:

3.8.1 Data on growth parameters

1. Plant height (cm)
2. Number of tillers $hill^{-1}$
3. Number of leaves $hill^{-1}$
4. Dry weight $hill^{-1}$ (g)
5. Leaf area index

3.8.2 Data on yield and yield contributing parameters

1. Panicle length (cm)
2. Grains $panicle^{-1}$
3. Weight of 1000 seed (g)
4. Grain yield (t ha^{-1})
5. Straw yield (t ha^{-1})
6. Biological yield (t ha^{-1})
7. Harvest index (%)

3.8.3 Procedure of recording data

3.8.3.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 25, 50, 75 DAT (days after transplanting) and at harvest. Data were recorded as the average of same 10 plants pre selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.8.3.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} was recorded at 25, 50, 75 DAT and at harvest by counting total tillers as the average of same 5 hills selected at random from the inner rows of each plot.

3.8.3.3 Number of leaves hill^{-1}

The number of leaves hill^{-1} was recorded at 25, 50, 75 DAT and at harvest by counting total tillers as the average of same 5 hills selected at random from the inner rows of each plot.

3.8.3.4 Dry weight hill^{-1}

Total dry matter hill^{-1} was recorded at the time of 25, 50, 75 DAT and at harvest by drying the plant samples. Data were recorded as the average of 3 sample hill plot^{-1} selected at random from the outer rows of each plot leaving the boarder line and expressed in gram.

3.8.3.5 Leaf area index

Leaf area index was estimated manually measuring the length and width of leaf and multiplying by a factor 0.75 as suggested by Yoshida (1981).

3.8.3.6 Length of panicle

The length of panicle was measured with a meter scale from 10 selected panicles and the average value was recorded.

3.8.3.7 Number of grains panicle^{-1}

The total number of grains was collected randomly from selected 10 plants of panicle of a plot and then average number of grains panicle^{-1} was calculated.

3.8.3.8 Weight of 1000 grains

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.8.3.9 Grain yield

Grains obtained from demarked area of each unit plot were sun-dried and weighed carefully and finally converted to t ha^{-1} basis. The central 3 m^2 from each plot were harvested, threshed, dried, and cleaned, weighed.

3.8.3.10 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully and finally converted to t ha^{-1} basis. The dry weight of straw of central 3 m^2 were harvested, threshed, dried and weighed

3.8.3.11 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.8.3.12 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$\text{HI (\%)} = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.9 Statistical Analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques using MSTAT-C package and the mean values were separated using least significant differences (LSD) test at 5% level of significance.

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

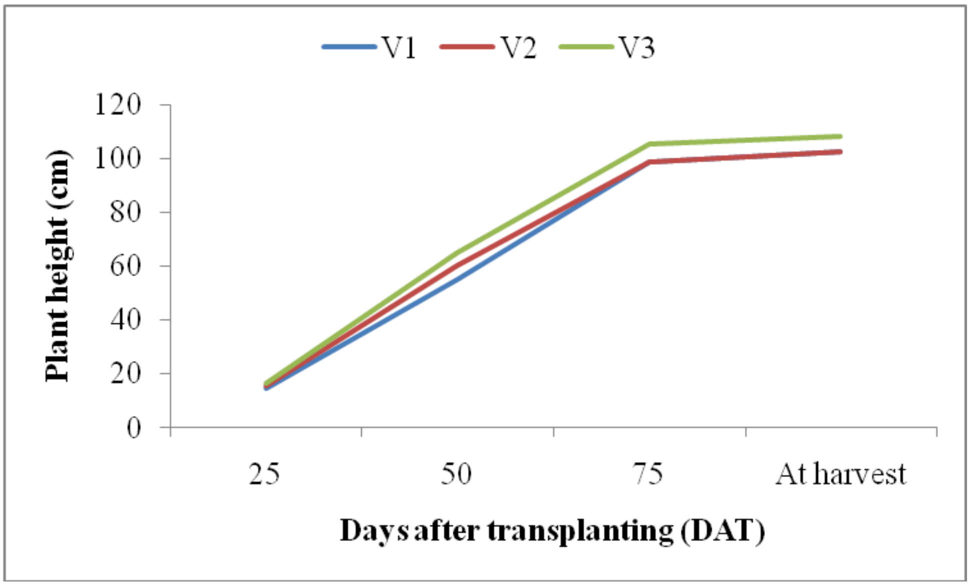
The experimental results regarding the '**INFLUENCE OF METHODS OF NITROGENOUS FERTILIZERS USE AND VARIETIES ON GROWTH AND YEILD OF BORO RICE**' have been presented and discussed in this chapter. The effects of variety and different methods of urea application and their interaction on growth, yield and yield contributing characters have been presented below.

4.1 Growth parameters

4.1.1 Plant height

4.1.1.1 Effect of variety

Significant influenced was remarked in terms of plant height under the present study as influenced by different varieties at different growth stages (Fig. 1 and Appendix IV). Results showed that BRRI Hybrid dhan2 (V_3) showed the highest plant height (16.42, 64.96, 105.30 and 108.00 cm at 25, 50, 75 DAT and at harvest, respectively). The competition on plant height among the varieties, ACI Hybrid dhan 1 (V_1) showed the shorter plant (14.6, 55.04, 98.92 and 102.50 cm at 25, 50, 75 DAT and at harvest, respectively) which was statistically simillar with V_2 (BRRI dhan29) at 75 DAT and at harvest. The results obtained from other findings by Bisne *et al.* (2006), BINA (1993) and Hossain and Alam (1991 a) was similar and they stated that plant height significantly differed among different varieties.

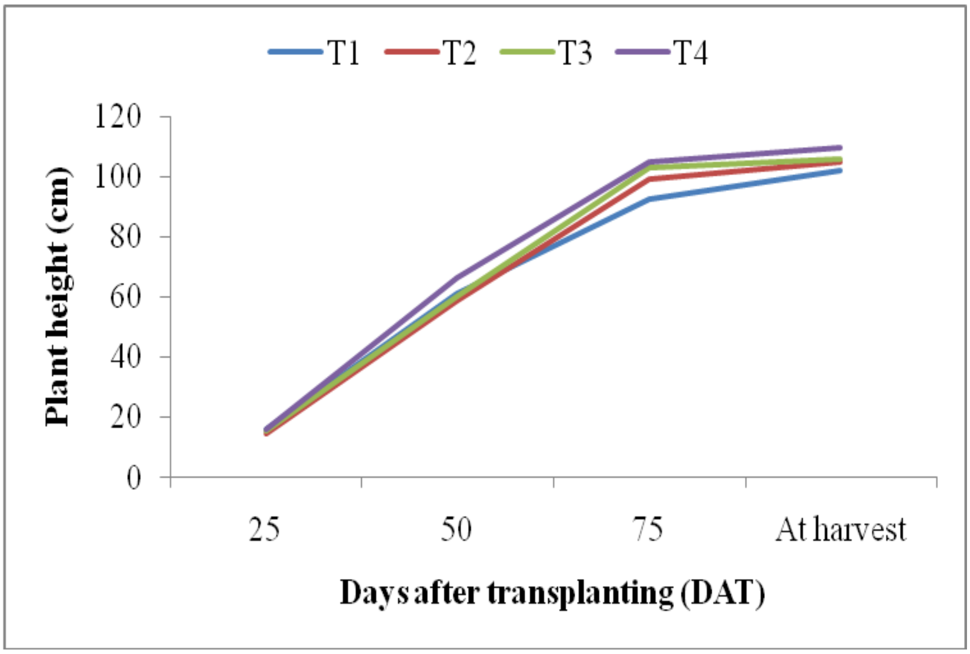


V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan2

Fig. 1: Plant height of rice as influenced by different varieties
($LSD_{0.05}$= 0.6475, 2.4583, 2.3894 and 1.2362 at 25, 50, 75 DAT and at harvest, respectively)

4.1.1.2 Effect of different methods of urea application

Plant height as influenced by different methods of urea application on different varieties of boro rice was significant at different growth stages (Fig. 2 and Appendix IV). Results showed that at 25 DAT, the tallest plant was recorded by T_1 (16.11 cm) which was statistically similar with T_4 (15.83 cm) but at 50, 75 DAT and at harvest the tallest plant was recorded by T_4 (66.50, 105.1 and 109.8 cm, respectively). The results obtained from T_2 showed the shortest plant (14.72 and 58.83 cm at 25 and 50 DAT respectively). But later on the shortest plant was recorded from T_1 (92.56 and 102.20 cm at 75 DAT and harvest respectively). The result under the present study was similar with the findings of Rahman (2003), Alam (2002) and Vijaya and Subbaiah (1997).



T_1 = 2.7 g size USG placement at 8 DAT
T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g V_1 and V_3 and 22.5 g V_2) at 50 DAT

Fig. 2: Plant height of rice as influenced by different methods of nitrogenous fertilizers application ($LSD_{0.05}$ = 0.4894, 1.1145, 2.3654 and 1.3472 at 25, 50, 75 DAT and at harvest, respectively)

4.1.1.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application significantly influenced the plant height at different growth stages of boro rice (Table 1 and Appendix IV). Results indicated that the longest plant (17.50, 67.50, 106.00 and 110.70 cm at 25, 50, 75 DAT and at harvest, respectively) was with V_3T_4. The results from V_3T_1 at 25 DAT and V_3T_2 at harvest showed same result but V_1T_4, V_3T_2 and V_3T_3 at 50 DAT; V_3T_2 at 75 DAT and V_1T_3 at harvest showed statistically similar result. On the other hand, V_1T_2 showed the lowest plant height (13.50 and 55.83 cm at 25 and 50 DAT respectively) which was statistically similar with V_2T_3 at 25 and 50 DAT. But at 75 DAT and at harvest, the shortest plant was achieved by

V_1T_1 (93.67 and 101.5 cm respectively) which was statistically similar with V_1T_2 and V_2T_2 at harvest. The results obtained from all other treatments at different growth stages on plant height gave significantly different results.

Table 1: Plant height of rice as influenced by different varieties and methods of nitrogenous fertilizers use

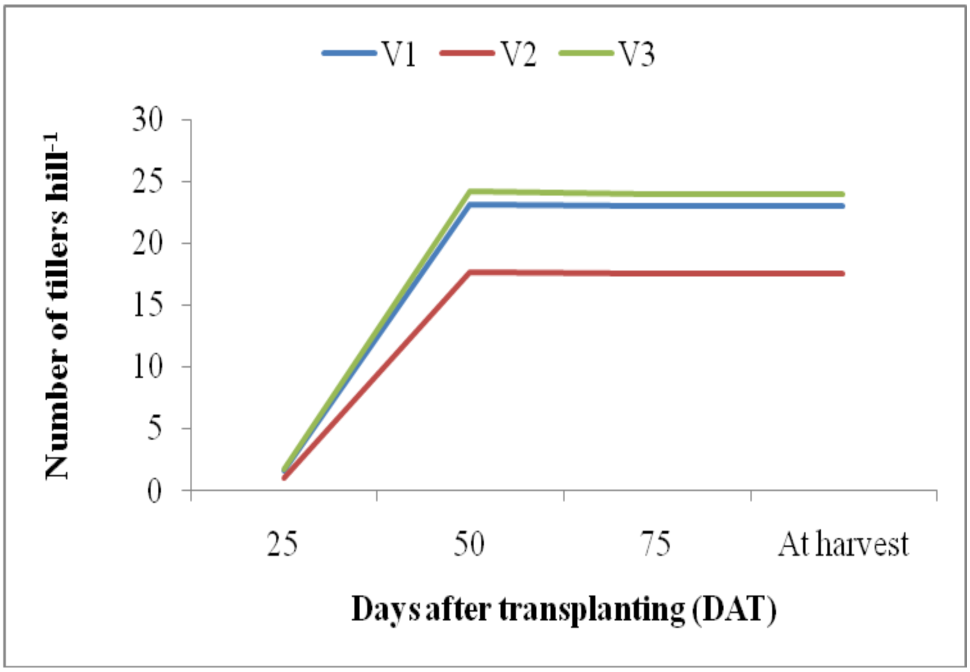
Treatments	Plant height (cm)			
	25 DAT	50 DAT	75 DAT	At harvest
V_1T_1	15.17 cd	59.67 c	93.67 f	101.50 e
V_1T_2	13.50 e	55.83 e	95.33 e	101.70 e
V_1T_3	16.33 b	60.00 c	100.70 bc	107.80 ab
V_1T_4	14.47 d	65.67 ab	96.00 e	105.80 c
V_2T_1	15.83 bc	59.00 c	99.33 cd	103.80 d
V_2T_2	16.17 b	59.00 c	95.00 e	101.80 e
V_2T_3	13.67 e	56.00 e	99.33 d	105.20 c
V_2T_4	16.33 b	57.33 d	99.33 d	103.80 d
V_3T_1	17.33 a	59.33 c	95.67 de	103.30 d
V_3T_2	14.50 d	65.67 ab	104.30 ab	109.20 a
V_3T_3	16.33 b	65.67 ab	99.00 de	105.80 c
V_3T_4	17.50 a	67.50 a	106.00 a	110.70 a
$LSD_{0.05}$	0.7614	1.162	1.237	1.831
CV (%)	8.44	6.24	8.49	9.40

V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan2
T_1 = 2.7 g size USG placement at 8 DAT
T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT

4.1.2 Number of tillers hill^{-1}

4.1.2.1 Effect of variety

Number of tillers hill^{-1} was significantly influenced by different varieties used in the present study (Fig. 3 and Appendix V). Results showed that BRRI hybrid dhan2 (V_3) showed the highest number of tillers hill^{-1} (1.73, 24.16, 23.98 and 23.98 at 25, 50, 75 DAT and at harvest, respectively). ACI Hybrid dhan 1 (V_1) also showed significantly same result compared to the variety of BRRI hybrid dhan2 (V_3) at 25 DAT. Comparing tiller producing capacity of tillers hill^{-1} among the three varieties, BRRI dhan29 (inbred) (V_2) showed the lowest number of tillers hill^{-1} (1.02, 17.68, 17.56 and 17.54 at 25, 50, 75 DAT and at harvest, respectively). ACI Hybrid dhan 1 gave intermediate result which was statistically similar with V_2 (BRRI dhan29) at 50, 75 DAT and at harvest, respectively. The other findings by Bisne *et al.* (2006), Devaraju *et al.* (1998 b), BRRI (1994), BINA (1993), Chowdhury *et al.* (1993) and Hossain and Alam (1991) were similar with the present finding.

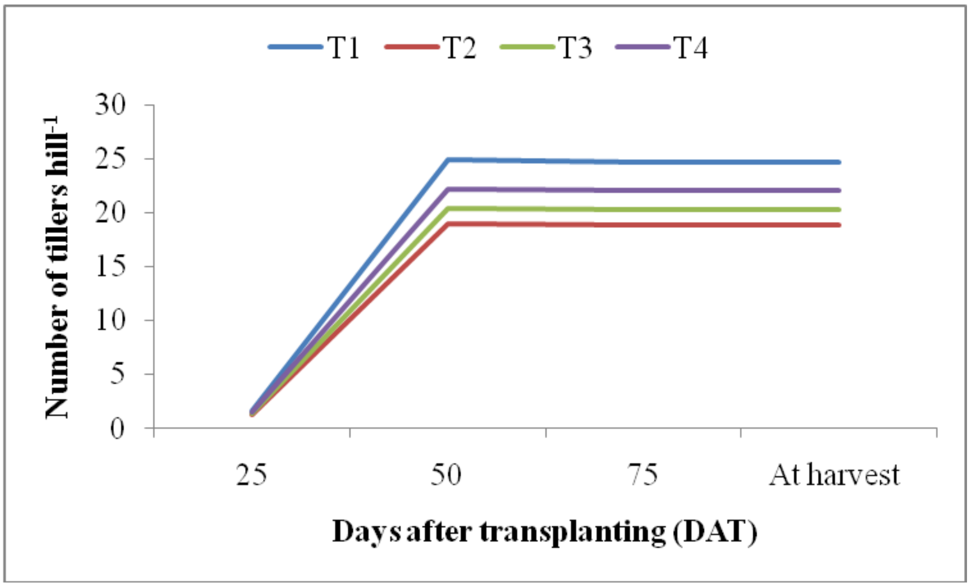


V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan2

Fig. 3: Number of tillers hill^{-1} of rice as influenced by different varieties ($LSD_{0.05}$ = 0.4237, 0.9182, 0.9142 and 0.9000 at 25, 50, 75 DAT and at harvest, respectively)

4.1.2.2 Effect of different methods of urea application

Significantly varied result was observed in case of number of tillers hill^{-1} as influenced by different methods of urea application on three varieties of boro rice at different growth stages (Fig. 4 and Appendix V). Results showed that at all growth stage the highest number of tillers hill^{-1} was recorded by T_1 (1.65, 24.94, 24.67 and 24.67 at 25, 50, 75 DAT and at harvest respectively) which was closely followed by T_4 at 25 DAT. The results obtained from T_2 showed the lowest number of tillers hill^{-1} (1.29, 18.98, 18.90 and 18.88 at 25, 50, 75 DAT and at harvest, respectively) which was closely followed by T_3 at 25 DAT. The result under the present study was similar with the findings of Rahman (2003) and Alam (2002).



T_1 = 2.7 g size USG placement at 8 DAT
T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g V_1 and V_3 and 22.5 g V_2) at 50 DAT

Fig. 4: Number of tillers hill^{-1} of rice as influenced by different methods of nitrogenous fertilizers use ($LSD_{0.05}$ = 0.2124, 1.045, 1.056 and 1.039 at 25, 50, 75 DAT and at harvest, respectively)

4.1.2.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application significantly influenced the number of tillers hill^{-1} at different growth stages of the three varieties of boro rice (Table 2 and Appendix V). Results indicated that the highest number of tillers hill^{-1} (1.97, 28.39, 28.00 and 28.00 at 25, 50, 75 DAT and at harvest, respectively) was with V_3T_1 which was closely followed by V_1T_1 at 25, 75 DAT and at harvest, respectively. The results recorded from V_2T_2 showed the lowest number of tillers hill^{-1} (1.00, 16.59, 16.49 and 16.51 at

25, 50, 75 DAT and at harvest, respectively) which was statistically identical with V_2T_3 and V_2T_4 at 25 DAT but similar at 50and 75 DAT and at harvest, respectively. The results obtained from all other treatments showed significantly different results compared to the highest and the lowest result of number of tillers hill^{-1}.

Table 2: Number of tillers hill^{-1} of rice as influenced by different varieties and methods of nitrogenous fertilizers use

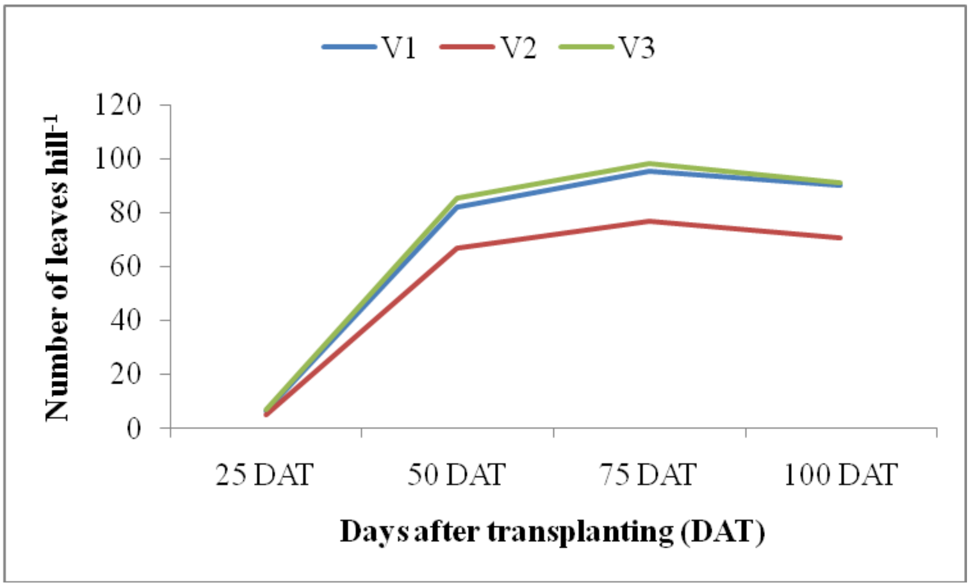
Treatments	Number of tillers hill^{-1}			
	25 DAT	50 DAT	75 DAT	At harvest
V_1T_1	1.87 ab	26.54 b	26.30 ab	26.29 ab
V_1T_2	1.41 c	20.11 f	20.04 f	20.00 f
V_1T_3	1.59 bc	21.59 ef	21.49 ef	21.49 ef
V_1T_4	1.76 ab	24.11 cd	24.00 cd	24.00 cd
V_2T_1	1.10 d	19.89 f	19.70 f	19.70 f
V_2T_2	1.00 d	16.59 g	16.49 g	16.51 g
V_2T_3	1.00 d	17.01 g	16.94 g	16.91 g
V_2T_4	1.00 d	17.21 g	17.09 g	17.06 g
V_3T_1	1.97 a	28.39 a	28.00 a	28.00 a
V_3T_2	1.46 c	20.24 f	20.16 f	20.15 f
V_3T_3	1.66 bc	22.69 de	22.49 de	22.49 de
V_3T_4	1.81 ab	25.31 bc	25.29 bc	25.29 bc
$LSD_{0.05}$	0.2657	1.828	2.048	2.022
CV (%)	6.33	8.14	5.04	9.26

V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan2
T_1 = 2.7 g size USG placement at 8 DAT
T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT

4.1.3 Number of leaves hill^{-1}

4.1.3.1 Effect of variety

Significant variation was observed by different varieties used in the present study in respect of number of leaves hill^{-1} (Fig. 5 and Appendix VI). Results indicated that BRRI hybrid dhan 2 (V_3) showed the highest number of leaves hill^{-1} (6.75, 85.24, 97.99 and 91.09 at 25, 50, 75 DAT and at harvest, respectively). ACI Hybrid dhan 1 (V_1) also showed significantly similar result compared to the variety of BRRI hybrid dhan 2 (V_3) at 25 DAT and at harvest. Among the three varieties, BRRI dhan 29 (inbred) (V_2) showed the lowest number of leaves hill^{-1} (5.06, 67.03, 76.82 and 70.48 at 25, 50, 75 DAT and at harvest respectively). These results might be due to cause of genotypic characters of varieties and proper nutrient availability from soil.



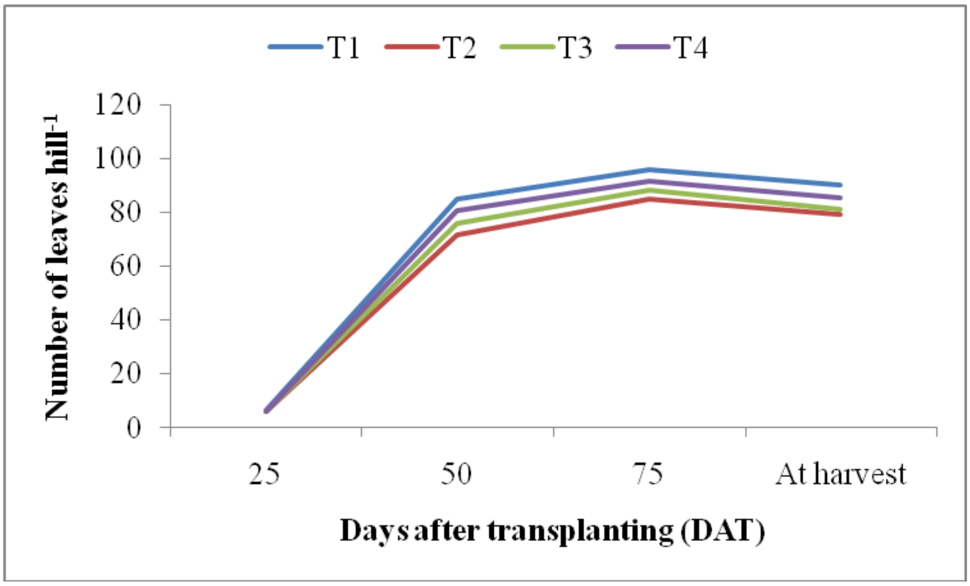
V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan2

Fig. 5: Number of leaves hill^{-1} of rice as influenced by different varieties ($LSD_{0.05}$ = 0.8064, 1.277, 1.214 and 1.282 at 25, 50, 75 DAT and at harvest, respectively)

4.1.3.2 Effect of different methods of urea application

Significantly different variation was observed in case of number of leaves hill^{-1} as influenced by different methods of urea application on three varieties of boro rice at different growth stages (Fig. 6 and Appendix VI). Results showed that at all growth stage the highest number of leaves hill^{-1} was recorded by T_1 (6.40, 84.96, 95.94 and 90.41 at 25, 50, 75 DAT and at harvest, respectively) which was closely followed by T_4 at 25 DAT. The results obtained from T_2 showed the lowest number of leaves hill^{-1} (5.94, 71.43, 84.92 and 79.42 at 25, 50, 75 DAT and at harvest, respectively) which was statistically similar with T_3 at 25

DAT and at harvest. These results might be due to proper nutrient availability from soil.



T_1 = 2.7 g size USG placement at 8 DAT
T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT

Fig. 6: Number of leaves hill^{-1} of rice as influenced by different methods of nitrogenous fertilizers use ($LSD_{0.05}$ = 0.2870, 1.474, 1.401 and 1.480 at 25, 50, 75 DAT and at harvest, respectively)

4.1.3.3 Interaction of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on number of leaves hill^{-1} at different growth stages of the three varieties of boro rice (Table 3 and Appendix V). Results indicated that the highest number of leaves hill^{-1} (7.00, 95.24, 105.4 and 100.2 at 25, 50, 75 DAT and at harvest, respectively) was with V_3T_1 which was closely followed by V_1T_1 at 25 DAT and at harvest and by V_3T_4 at 25 DAT. The results recorded from V_2T_2 showed the lowest number of leaves hill^{-1} (5.00, 66.03, 72.29 and 68.32 at 25, 50, 75 DAT and at harvest, respectively) which was statistically identical with V_2T_3 and V_2T_4 at 25 DAT but similar at 50, 75 DAT and at harvest and with V_2T_1 at 25 and 50 DAT. The results obtained from all other treatments showed significantly different results compared to the highest and the lowest result of number of leaves hill^{-1}.

Table 3: Number of leaves hill^{-1} of rice as influenced by different varieties and methods of nitrogenous fertilizers use

Treatments	Number of leaves hill^{-1}			
	25 DAT	50 DAT	75 DAT	At harvest
V_1T_1	6.94 ab	91.14 b	101.2 b	97.26 ab
V_1T_2	6.39 c	72.87 f	90.59 f	89.54 c
V_1T_3	6.60 bc	78.46 e	93.27 def	84.46 d
V_1T_4	6.76 a-c	85.26 c	96.36 cd	90.16 c
V_2T_1	5.26 d	68.51 g	81.21 g	73.75 f
V_2T	5.00 d	66.03 g	72.29 i	68.32 g
V_2T_3	5.00 d	66.39 g	75.64 hi	69.59 g
V_2T_4	5.00 d	67.19 g	78.15 gh	70.24 g
V_3T_1	7.00 a	95.24 a	105.4 a	100.2 a
V_3T_2	6.44 c	75.39 f	91.89 ef	80.39 e
V_3T_3	6.69 a-c	81.59 d	95.11 de	88.31 c
V_3T_4	6.87 ab	88.75 b	99.59 bc	95.41 b
SE	0.0049	0.0075	0.0153	0.0117
$LSD_{0.05}$	0.3516	3.051	3.509	3.364
CV (%)	6.27	7.02	9.13	8.22

V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan2

T_1 = 2.7 g size USG placement at 8 DAT

T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT

T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT

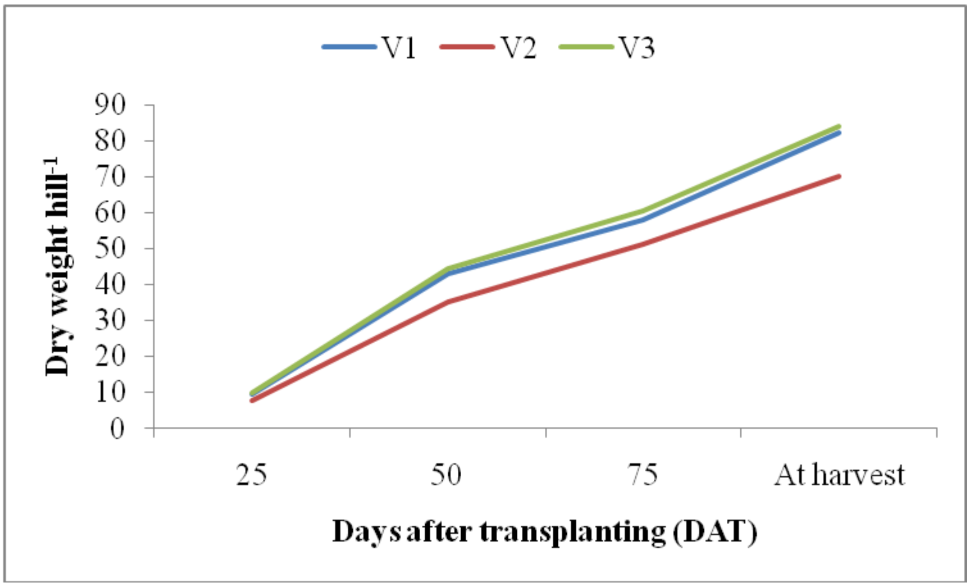
T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT

4.1.4 Dry weight hill^{-1}

4.1.4.1 Effect of variety

Significant variation was observed by different varieties used in the present study in terms of dry weight hill^{-1} (Fig. 7 and Appendix VII). Results showed that BRRI hybrid dhan2 (V_3) showed the highest dry weight hill^{-1} (9.71, 44.35, 60.41 and 84.14 g at 25, 50, 75 DAT and at harvest, respectively). ACI Hybrid dhan 1 (V_1) also showed significantly similar result compared to the variety of BRRI hybrid dhan2 (V_3) at 25 DAT. Among the three varieties, BRRI dhan29 (inbrid) (V_2) showed the lowest number dry weight hill^{-1} (7.639, 35.24, 51.21

and 70.20 g at 25, 50, 75 DAT and at harvest, respectively). ACI Hybrid dhan 1 (V_1) gave intermediate level result at 50, 75 DAT and at harvest, respectively compared to highest and lowest dry weight hill^{-1}. Similar result was found by Amin *et al.* (2006), Son *et al.* (1998) and Patnaik *et al*. (1990).

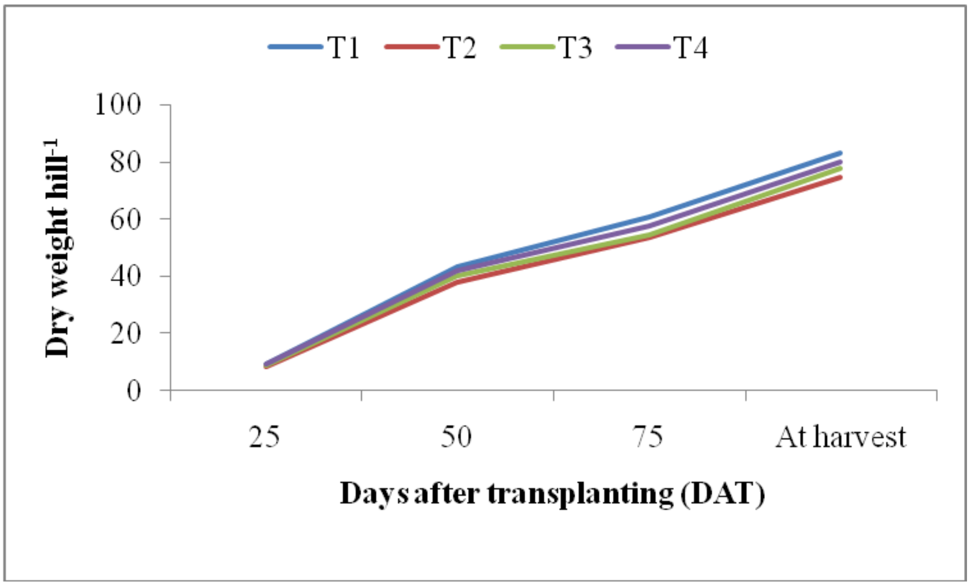


V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3= BRRI hybrid dhan1

Fig. 7: Dry weight hill^{-1} of rice as influenced by different varieties ($LSD_{0.05}$ = 0.9477, 0.9254, 1.400 and 0.9309 at 25, 50, 75 DAT and at harvest, respectively)

4.1.4.2 Effect of different methods of urea application

Significantly varied results were observed in terms of dry weight hill^{-1} as influenced by different methods of urea application among the three varieties of boro rice at different growth stages (Fig. 8 and Appendix VII). Results showed that at all growth stage the highest dry weight hill^{-1} was recorded by T_1 (9.41, 43.58, 60.74 and 83.22 g at 25, 50, 75 DAT and at harvest, respectively). The results obtained from T_2 showed the lowest dry weight hill^{-1} (8.45, 38.05, 53.65 and 74.66 g at 25, 50, 75 DAT and at harvest, respectively). The results obtained from all other treatments showed significantly different results compared to the highest and the lowest result of dry weight hill^{-1}. The result under the present study was similar with the findings of Vijaya and Subbaiah (1997).



T_1 = 2.7 g size USG placement at 8 DAT
T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT

Fig. 8: Dry weight hill^{-1} of rice as influenced by different methods of nitrogenous fertilizers use ($LSD_{0.05}$ = 0.1435, 1.069, 1.616 and 1.075 at 25, 50, 75 DAT and at harvest, respectively)

4.1.4.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on dry weight hill^{-1} at different growth stages of the three varieties of boro rice (Table 3 and Appendix V). Results indicated that the highest dry weight hill^{-1} (10.13, 48.39, 66.79 and 90.59 g at 25, 50, 75 DAT and at harvest, respectively) was with V_3T_1 which was closely followed by V_1T_1 at 25 DAT and at harvest and by V_3T_4 at 25 DAT. The result of dry weight hill^{-1} from V_1T_1, V_1T_3, V_1T_4, V_3T_3, and V_3T_4 also gave higher results but significantly different from V_3T_1. The results recorded from V_2T_2 showed the lowest dry weight hill^{-1} (7.05, 34.19, 50.22 and 68.94 g at 25, 50, 75 DAT and at harvest, respectively) which was statistically similar with V_2T_1, V_2T_3 and V_2T_4 at the time of harvest. The treatment combination of V_1T_2 and V_3T_2 also gave lower dry weight hill^{-1} but significantly higher than V_2T_2. The results obtained from all other treatments at different growth stages showed significantly different results compared to the highest and the lowest result of dry weight $hill^{-1}$.

Table 4: Dry weight $hill^{-1}$ of rice as influenced by different varieties and methods of nitrogenous fertilizers use

Treatments	Dry weight $hill^{-1}$ (g)			
	25 DAT	50 DAT	75 DAT	At harvest
V_1T_1	9.96 ab	46.15 b	63.14 b	87.67 ab
V_1T_2	9.04 d	39.31 g	54.32 fg	76.64 f
V_1T_3	9.45 b-d	41.99 ef	55.67 ef	80.11 de
V_1T_4	9.71 a-c	44.16 cd	58.89 cd	83.77 c
V_2T_1	8.15 e	36.21 h	52.29 gh	71.39 g
V_2T	7.05 f	34.19 i	50.22 h	68.94 g
V_2T_3	7.41 f	34.89 hi	50.64 h	70.01 g
V_2T_4	7.95 e	35.69 hi	51.71 gh	70.44 g
V_3T_1	10.13 a	48.39 a	66.79 a	90.59 a
V_3T_2	9.26 cd	40.66 fg	56.41 def	78.39 ef
V_3T_3	9.61 bc	43.06 de	57.20 de	82.45 cd
V_3T_4	9.84 ab	45.29 bc	61.26 bc	85.11 bc
$LSD_{0.05}$	0.4698	1.836	2.497	3.053
CV (%)	7.21	10.02	9.82	10.14

V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan1

T_1 = 2.7 g size USG placement at 8 DAT

T_2 = 1.8 g size USG placement at 8 DAT + prilled urea $plot^{-1}$ (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT

T_3 = 1.8 g size USG placement at 8 DAT + foliar spray $plot^{-1}$ (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT

T_4 = 0.9 g size USG placement at 8 DAT + prilled urea $plot^{-1}$ (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray $plot^{-1}$ (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT

4.1.5 Leaf area index

4.1.5.1 Effect of variety

Leaf area index was significantly influenced by different varieties used in the present study (Table 5 and Appendix VIII). Results indicated that BRRI hybrid dhan2 (V_3) showed the highest leaf area index (7.36, 7.19 and 7.12 at 50, 75 DAT and at harvest, respectively) which was statistically similar with ACI Hybrid dhan 1 (V_1) at 50, 75 DAT and at harvest, respectively. But at 25 DAT there was significant variation observed. Among the three varieties, BRRI dhan 29 (V_2) showed the lowest leaf area index (4.65, 4.53 and 4.43 at 50, 75 DAT and at harvest, respectively). These results might be due to cause of proper nutrient supply mechanism from soil to the plants, light intensity and light holding capacity of a variety and above all phenotypic characters of the varieties.

4.1.5.2 Effect of different methods of urea application

Different methods of urea application had significant effect on leaf area index among the three varieties of boro rice at different growth stages (Table 5 and Appendix VIII). Results showed that at all growth stage the highest leaf area index was recorded by T_1 (2.16, 7.08, 6.92 and 6.83 at 25, 50, 75 DAT and at harvest, respectively) which was closely followed at 25 DAT and statistically similar at 50, 75 DAT and at harvest with T_4. Treatment T_3 also gave statistically similar result at 75 DAT and at harvest compared to T_1. The results obtained from T_2 showed the lowest leaf area index (1.88, 5.49, 5.37 and 5.31 at 25, 50, 75 DAT and at harvest, respectively) which was closely followed by T_3 at 25 DAT. The result under the present study might be due to cause of balance fertilizer use in the crop field.

4.1.5.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on leaf area index at different growth stages of the three varieties of boro rice (Table 5 and Appendix VIII). Results indicated that the highest leaf area index (2.37, 8.11, 7.94 and 7.87 at 25, 50, 75 DAT and at harvest, respectively) was with V_3T_1 which was statistically similar with V_1T_1, V_1T_4 and V_3T_4 and closely followed by V_1T_3 and V_3T_3 at the time of harvest. These treatment combinations (V_1T_1, V_1T_3, V_1T_4, V_3T_3 and V_3T_4) also gave higher leaf area index value at different growth stages. The results recorded from V_2T_2 showed the lowest leaf area index (1.59, 4.11, 4.01 and 3.98 cm^2 at 25, 50, 75 DAT and at harvest respectively) which was statistically identical with V_2T_3 and V_2T_4 at all growth stages. The treatment combination of V_1T_2

and V_2T_1 also gave lower leaf area index but significantly higher than V_2T_2. The results obtained from all other treatments combinations at different growth stages showed significantly different results compared to the highest and the lowest result of leaf area index.

Table 5: Leaf area index of rice as influenced by different varieties and methods of nitrogenous fertilizers use

Treatments	Leaf area index			
	25 DAT	50 DAT	75 DAT	At harvest
	Effect of variety			
V_1	2.16 a	7.12 a	6.98 a	6.93 a
V_2	1.68 a	4.65 b	4.53 b	4.43 b
V_3	2.22 a	7.36 a	7.19 a	7.12 a
$LSD_{0.05}$	0.5585	0.9582	0.9723	0.9178
	Effect of different methods of urea application			
T_1	2.16 a	7.08 a	6.92 a	6.83 a
T_2	1.88 c	5.49 c	5.37 b	5.31 b
T_3	1.97 bc	6.15 b	6.01 ab	5.95 ab
T_4	2.07 ab	6.79 a	6.63 a	6.56 a
$LSD_{0.05}$	0.1469	0.3758	1.123	1.060
	Combined effect of variety and different methods of urea application			
V_1T_1	2.31 ab	7.97 a	7.81 ab	7.79 a
V_1T_2	2.01 cd	6.04 b-d	5.94 cd	5.84 bc
V_1T_3	2.11 bc	6.85 ab	6.71 bc	6.69 ab
V_1T_4	2.21 a-c	7.64 a	7.45 ab	7.39 a
V_2T_1	1.79 de	5.16 c-e	5.01 de	4.84 cd
V_2T	1.59 e	4.11 e	4.01 e	3.98 d
V_2T_3	1.65 e	4.44 e	4.34 e	4.25 d
V_2T_4	1.71 e	4.89 de	4.75 e	4.67 d
V_3T_1	2.37 a	8.11 a	7.94 a	7.87 a
V_3T_2	2.06 bc	6.31 bc	6.17 c	6.11 b
V_3T_3	2.16 a-c	7.16 ab	6.97 a-c	6.89 ab
V_3T_4	2.28 ab	7.84 a	7.68 ab	7.61 a
$LSD_{0.05}$	0.2301	1.149	1.064	1.064
CV (%)	5.28	7.16	5.13	7.11

V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan2

T_1 = 2.7 g size USG placement at 8 DAT

T_2 = 1.8 g size USG placement at 8 DAT + prilled urea $plot^{-1}$ (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT

T_3 = 1.8 g size USG placement at 8 DAT + foliar spray $plot^{-1}$ (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT

T_4 = 0.9 gm size USG placement at 8 DAT + prilled urea $plot^{-1}$ (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray $plot^{-1}$ (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT

4.2 Yield contributing characters

4.2.1 Panicle length

4.2.1.1 Effect of variety

Panicle length was significantly influenced by different varieties used in the present study (Table 6 and Appendix IX). Results showed that BRRI hybrid dhan2 (V_3) showed the highest panicle length (26.58 cm) which was statistically similar with ACI Hybrid dhan 1 (V_1). Among the three varieties, BRRI dhan29 (V_2) showed the lowest panicle length (24.73 cm). Devaraju *et al.* (1998 b), BINA (1993) and Chowdhury *et al.* (1993) achieved similar results from different experiment with different rice varieties.

4.2.1.2 Effect of different methods of urea application

Different methods of urea application had significantly effect on panicle length among the three varieties of boro rice (Table 6 and Appendix IX). Results showed that the highest panicle length was recorded by T_1 (26.38 cm). The results obtained from T_2 showed the lowest panicle length (25.40 cm). Treatment T_3 and T_4 showed medium result compared to the highest and the lowest panicle length. The result under the present study was similar with the findings of Rahman (2003) and Vijaya and Subbaiah (1997).

4.2.1.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on panicle length among the three varieties of boro rice (Table 6 and Appendix IX). Results indicated that the highest panicle length (27.06 cm) was with V_3T_1 which was statistically similar with V_1T_1 and closely followed by V_3T_4 at the time of harvest. The treatment combination of V_1T_3 and V_3T_3 gave comparatively higher panicle length but significantly different from V_3T_1. The results recorded from V_2T_2 showed the lowest panicle length (24.29 cm) which was closely followed by V_2T_3 and V_2T_4 at the time of harvest. Again, V_1T_2, V_2T_1 and V_3T_2 showed comparatively lower panicle length but significantly higher than V_2T_2. The results obtained from all other treatments combinations was significantly different compared to the highest and the lowest panicle length.

4.2.2 Number of grains panicle^{-1}

4.2.2.1 Effect of variety

Number of grains panicle^{-1} was **s**ignificantly influenced by different varieties used in the present study (Table 6 and Appendix IX). Results showed that BRRI hybrid dhan2 (V_3) showed the highest number of grains panicle^{-1} (131.2) and BRRI dhan29 (V_2) showed the lowest number of grains panicle^{-1} (94.93). The variety, ACI Hybrid dhan 1 used for the study showed intermediate result. Supporting results were achieved by Bhowmick and Nayak (2000), Chowdhury *et al.* (1993) and Hossain and Alam (1991).

4.2.2.2 Effect of different methods of urea application

Different methods of urea application had significant effect on number of grains panicle^{-1} among the three varieties of boro rice (Table 6 and Appendix IX). Results showed that the highest number of grains panicle^{-1} was recorded by T_1 (128.20) where the lowest (106.70) was obtained from T_2. The results obtained from T_3 and T_4 showed medium result compared to the highest and the lowest number of grains panicle^{-1}. The result under the present study was similar with the findings of Rahman (2003).

4.2.2.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on number of grains panicle^{-1} among the three varieties of boro rice (Table 6 and Appendix IX). Results indicated that the highest number of grains panicle^{-1} (146.20) was with V_3T_1 which was significantly different from all other treatment combinations. The results from V_1T_1, V_1T_4, V_3T_3 and V_3T_4 gave comparatively higher number of grains panicle^{-1} but significantly different from V_3T_1. On the other hand the lowest result was recorded from V_2T_2 (89.68) which were also significantly different from all other treatment combinations. Again, V_1T_2, V_2T_1, V_2T_3, and V_2T_4 also gave lower number of grains panicle^{-1} but comparatively higher than V_2T_2. The results obtained from all other treatments combinations was significantly different compared to the highest and the lowest number of grains panicle^{-1}.

4.2.3 Weight of 1000 grains

4.2.3.1 Effect of variety

Weight of 1000 grains was significantly influenced by different varieties used in the present study (Table 6 and Appendix IX). Results showed that BRRI hybrid dhan2 (V_3) showed the highest 1000 grain weight (26.12 g) where BRRI dhan29 (V_2) showed the lowest 1000 grain weight (23.36 g). Another variety, ACI Hybrid dhan 1 used for the study showed intermediate result regarding 1000 grain weight. Bhowmick and Nayak (2000), Mishra and Pandey (1998) and Chowdhury *et al.* (1993) found almost similar results in respect of 1000 grain weight at different varieties of rice.

4.2.3.2 Effect of different methods of urea application

Different methods of urea application had significant effect on 1000 grain weight among the three varieties of boro rice (Table 6 and Appendix IX). Results showed that the highest 1000 grain weight was recorded by T_1 (25.73 g) where the lowest (24.61 g) was obtained from T_2. The results obtained from T_3 and T_4 showed medium result compared to the highest and the lowest 1000 grain weight. The result under the present study was in agreement with the findings of Rahman (2003) and Thakur (1991).

4.2.3.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on 1000 grain weight among the three varieties of boro rice (Table 6 and Appendix IX). Results indicated that the highest 1000 grain weight (26.79 g) was with V_3T_1 which was closely followed by V_1T_1. The results from V_1T_4, V_3T_2 and V_3T_4 gave comparatively higher 1000 grain weight but significantly different from V_3T_1. On the other hand the lowest result was recorded from V_2T_2 (22.91 g) which was closely followed by V_2T_3. Again, V_1T_3, V_2T_1 and V_2T_4 also gave lower 1000 grain weight but comparatively higher than V_2T_2. The results obtained from all other treatments combinations was significantly different compared to the highest and the lowest 1000 grain weight.

Table 6: Yield contributing characters of rice as influenced by different varieties and methods of nitrogenous fertilizers use

Treatments	Panicle length	Grains panicle^{-1}	1000 grain weight
Effect of variety			
V_1	26.44 a	125.3 b	25.75 b
V_2	24.73 b	94.93 c	23.36 c
V_3	26.58 a	131.2 a	26.12 a
$LSD_{0.05}$	0.9190	1.741	0.1329
Effect of different methods of urea application			
T_1	26.38 a	128.2 a	25.73 a
T_2	25.40 d	106.7 d	24.61 d
T_3	25.78 c	113.8 c	24.76 c
T_4	26.12 b	119.9 b	25.19 b
$LSD_{0.05}$	0.2170	2.010	0.1534
Combined effect of variety and different methods of urea application			
V_1T_1	26.94 a	138.1 b	26.55 ab
V_1T_2	25.89 c	112.3 f	25.44 de
V_1T_3	26.24 bc	121.6 e	25.11 e
V_1T_4	26.69 ab	129.3 d	25.89 cd
V_2T_1	25.14 d	100.2 g	23.86 f
V_2T_2	24.29 e	89.68 i	22.91 h
V_2T_3	24.64 de	93.59 h	23.16 gh
V_2T_4	24.86 de	96.26 h	23.51 fg
V_3T_1	27.06 a	146.2 a	26.79 a
V_3T_2	26.01 c	118.1 e	25.94 cd
V_3T_3	26.44 abc	126.3 d	25.56 de
V_3T_4	26.81 ab	134.1 c	26.19 bc
$LSD_{0.05}$	0.5842	3.664	0.5479
CV (%)	8.03	7.04	7.84

V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dha 2
T_1 = 2.7 g size USG placement at 8 DAT
T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT
T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g V_1 and V_3 and 22.5 g V_2) at 50 DAT

4.2.4 Grain yield

4.2.4.1 Effect of variety

Grain yield was significantly influenced by different varieties used in the present study (Table 7 and Appendix X). Results showed that BRRI hybrid dhan2 (V_3) showed the highest grain yield (4.79 t ha^{-1}) where BRRI dhan29 (V_2) showed the lowest grain yield (3.27 t ha^{-1}). Another variety, ACI Hybrid dhan 1 used for the study showed intermediate result regarding grain yield. The present finding was conformity with Bisne *et al.* (2006), Patel (2000), Devaraju *et al.* (1998 b), Dwivedi (1997) and Chowdhury *et al.* (1993).

4.2.4.2 Effect of different methods of urea application

Different methods of urea application had significant effect on grain yield among the three varieties of boro rice (Table 7 and Appendix X). Results showed that the highest grain yield was recorded by T_1 (4.67 t ha^{-1}) where the lowest (3.84 t ha^{-1}) was obtained from T_2. The results obtained from T_3 and T_4 showed medium result compared to the highest and the lowest grain yield. The result under the present study was similar with the findings of Rahman (2003), Alam (2002), Patel (1997) and Choudhury *et al*. (1994).

4.2.4.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on grain yield among the three varieties of boro rice (Table 7 and Appendix X). Results indicated that the highest grain yield (5.41 t ha^{-1}) was with V_3T_1. The results from other treatment combinations like V_1T_1, V_1T_4 and V_3T_4 gave comparatively higher grain yield but significantly different from V_3T_1. Again, the lowest result was recorded from V_2T_2 (3.04 t ha^{-1}) which closely followed by V_2T_3. The treatment combination of V_2T_1 and V_2T_4 also gave lower grain yield but comparatively higher than V_2T_2. The results obtained from the rest of the treatment combinations showed intermediate level of grain yield compared to the highest and the lowest grain yield.

4.2.5 Straw yield

4.2.5.1 Effect of variety

Straw yield was significantly influenced by different varieties used in the present study (Table 7 and Appendix X). Results showed that BRRI hybrid dhan2 (V_3) showed the highest straw yield (6.80 t ha^{-1}) which was statistically similar with ACI Hybrid dhan 1. Again, the lowest straw yield (5.69 t ha^{-1}) was achieved by BRRI dhan29 (V_2). These results are in agreement with the findings of by Patel (2000), Dwivedi (1997) and Chowdhury *et al.* (1993).

4.2.5.2 Effect of different methods of urea application

Different methods of urea application had significantly effect on straw yield among the three varieties of boro rice (Table 7 and Appendix X). Results showed that the highest straw yield was recorded by T_1 (6.72 t ha^{-1}) where the lowest (6.09 t ha^{-1}) was obtained from T_2. The results obtained from T_3 and T_4 showed medium result compared to the highest and the lowest straw yield. The result under the present study was similar with the findings of Rahman (2003), Mishra *et al*. (1999) and Swain *et al*. (1995).

4.2.5.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on straw yield among the three varieties of boro rice (Table 7 and Appendix X). Results indicated that the highest straw yield (7.20 t ha^{-1}) was with V_3T_1 which was closely followed by V_1T_1. The results from other treatment combinations like V_1T_4 and V_3T_4 gave comparatively higher straw yield but significantly different from V_3T_1. Again, the lowest result was recorded from V_2T_2 (5.46 t ha^{-1}) which was significantly different from all other treatments but V_2T_1, V_2T_3 and V_2T_4 gave lower straw yield but higher than that of V_2T_2. The results obtained from the rest of the treatment combinations showed intermediate level of straw yield compared to highest and lowest straw yield.

4.2.6 Biological yield

4.2.6.1 Effect of variety

Biological yield was significantly influenced by different varieties used in the present study (Table 7 and Appendix X). Results showed that BRRI hybrid dhan2 (V_3) showed the highest biological yield (11.60 t ha^{-1}) where the lowest biological yield (8.96 t ha^{-1}) was achieved by BRRI dhan29 (V_2). Again, ACI Hybrid dhan 1 gave medium biological yield. This result was shown due to cause of higher grain and straw yield of BRRI hybrid dhan2 than other test variety under the present study.

4.2.6.2 Effect of different methods of urea application

Different methods of urea application had significantly effect on straw yield among the three varieties of boro rice (Table 7 and Appendix X). Results showed that the highest biological yield was recorded by T_1 (11.39 t ha^{-1}) where the lowest (9.92 t ha^{-1}) was obtained from T_2. The results obtained from T_3 and T_4 showed medium result compared to the highest and the lowest biological yield. The findings was obtained from Alam (2002) was similar with the present finding.

4.2.6.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on biological yield among the three varieties of boro rice (Table 7 and Appendix X). Results indicated that the highest biological yield (12.61 t ha^{-1}) was with V_3T_1 which was significantly different from all other treatments. The results from other treatment combinations like V_1T_1, V_1T_4, V_3T_3 and V_3T_4 gave comparatively higher biological yield but lower than that of V_3T_1. Again, the lowest result was recorded from V_2T_2 (8.50 t ha^{-1}) which was significantly different from all other treatments but V_2T_1, V_2T_3 and V_2T_4 gave lower biological yield but significantly higher than that of V_2T_2. The results obtained from the rest of the treatment combinations showed intermediate level of biological yield compared to the highest and the lowest biological yield.

4.2.7 Harvest index

4.2.7.1 Effect of variety

Harvest index was significantly influenced by different varieties used in the present study (Table 7 and Appendix X). Results showed that BRRI hybrid dhan2 (V_3) showed the highest Harvest index (41.25%) where the lowest harvest index (36.51%) was achieved by BRRI dhan29 (V_2). Again, ACI Hybrid dhan 1 gave medium value of harvest index. The harvest index value of BRRI hybrid dhan2 was higher due to cause of higher grain and straw yield.

4.2.7.2 Effect of different methods of urea application

Different methods of urea application had significant effect on harvest index among the three varieties of boro rice (Table 7 and Appendix X). Results showed that the highest harvest index was recorded by T_1 (40.66%) where the lowest (38.48%) was obtained from T_2. The results obtained from T_3 and T_4 showed medium result compared to the highest and the lowest harvest index. This result was conformity with the findings of Alam (2002).

4.2.7.3 Interaction effect of variety and different methods of urea application

Interaction effect of variety and different methods of urea application had significant influence on harvest index among the treatment combinations (Table 7 and Appendix X). Results indicated that the highest harvest index (42.85%) was with V_3T_1 which was closely followed by V_1T_1. The results from other treatment combinations like, V_1T_3, V_1T_4, V_3T_2, V_3T_3 and V_3T_4 gave comparatively higher harvest index but lower than that of V_3T_1. Again, the lowest result was recorded from V_2T_2 (35.76%) which was closely followed by V_2T_3. The treatment combination of V_1T_4 and V_2T_4 gave lower harvest index but significantly higher than that of V_2T_2. The results obtained from the rest of the treatment combinations showed intermediate level of harvest index value compared to the highest and the lowest harvest index result.

Table 7: Yield parameters of rice as influenced by different varieties and methods of nitrogenous fertilizers use

Treatments	Grain yield	Straw yield	Biological yield	Harvest index
Effect of variety				
V_1	4.61 b	6.69 a	11.29 b	40.76 b
V_2	3.27 c	5.69 b	8.96 c	36.51 c
V_3	4.79 a	6.80 a	11.60 a	41.25 a
$LSD_{0.05}$	0.09396	0.1151	0.1534	0.3092
Effect of different methods of urea application				
T_1	4.67 a	6.72 a	11.39 a	40.66 a
T_2	3.84 d	6.09 d	9.92 d	38.48 d
T_3	4.07 c	6.27 c	10.34 c	39.15 c
T_4	4.32 b	6.50 b	10.81 b	39.73 b
$LSD_{0.05}$	0.1085	0.1329	0.1772	0.3571
Combined effect of variety and different methods of urea application				
V_1T_1	5.11 b	7.10 ab	12.21 b	41.89 ab
V_1T_2	4.16 f	6.36 f	10.51 g	39.54 d
V_1T_3	4.44 def	6.51 ef	10.95 ef	40.54 cd
V_1T_4	4.71 cd	6.79 cd	11.50 cd	41.04 bc
V_2T_1	3.49 g	5.86 g	9.34 h	37.25 e
V_2T_2	3.04 h	5.46 h	8.50 j	35.76 f
V_2T_3	3.21 gh	5.69 g	8.89 i	36.11 ef
V_2T_4	3.36 g	5.74 g	9.10 hi	36.92 e
V_3T_1	5.41 a	7.20 a	12.61 a	42.85 a
V_3T_2	4.31 ef	6.44 ef	10.76 fg	40.15 cd
V_3T_3	4.56 de	6.61 de	11.19 de	40.79 bc
V_3T_4	4.89 bc	6.96 bc	11.83 c	41.21 bc
$LSD_{0.05}$	0.2766	0.2170	0.3598	1.101
CV (%)	7.62	8.13	9.08	9.33

V_1 = ACI hybrid dhan 1, V_2 = BRRI dhan29, V_3 = BRRI hybrid dhan2

T_1 = 2.7 g size USG placement at 8 DAT

T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT

T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT

T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g for V_2) at 50 DAT

Chapter 5
Summary and Conclusion

CHAPTER 5

Summary and Conclusion

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2008 to May, 2009 to study the ‘influence of methods of nitrogenous fertilizers use and varieties on growth and yeild of boro rice’. The experiment comprised as two factors viz. (1) Factor A – Variety: 3 levels; (i) V_1 = ACI Hybrid dhan 1, (ii) V_2 = BRRI dhan29 and (iii) V_3 = BRRI hybrid dhan2 and (2) Factor B – Methods of urea application: 4 levels; (i) T_1 = 2.7 gm size USG placement at 8 DAT, (ii) T_2 = 1.8 g size USG placement at 8 DAT + prilled urea plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT, (iii) T_3 = 1.8 g size USG placement at 8 DAT + foliar spray plot^{-1} (75 g for V_1 and V_3 and 45 g for V_2) at 30 DAT and (iv) T_4 = 0.9 g size USG placement at 8 DAT + prilled urea plot^{-1} (37.5 g for V_1 and V_3 and 22.5 g V_2) at 30 DAT + foliar spray plot^{-1} (37.5 g V_1 and V_3 and 22.5 g V_2) at 50 DAT. The size of the unit plot was 7.5 m^2. There are 12 treatment combinations were used for the present study with three replications. The experiment was laid out in Split-plot design. Significant variation was recorded for data on growth, yield and yield contributing parameters of experimental materials.

Data was collected on plant height (cm), number of tillers hill^{-1}, number of leaves hill^{-1}, dry weight hill^{-1} (g), leaf area index, panicle length (cm), number of grains panicle^{-1}, 1000 seed weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%).

Three effects were considered for analyzing data viz. effect of variety, different methods of urea use and their combinations. Different variety showed dissimilar plant height at different growth stage. BRRI hybrid dhan 2 (V_3) showed the highest plant height (16.42, 60.96, 100.30 and 104 cm at 25, 50, 75 DAT and at harvest respectively) where ACI Hybrid dhan 1 (V_1)

showed the shortest plant height (14.6, 57.04, 98.92 and 102.7 cm at 25, 50, 75 DAT and at harvest respectively). But in terms of other growth parameters, the highest number of tillers hill^{-1} (1.73, 24.16, 23.98 and 23.98 at 25, 50, 75 DAT and at harvest respectively), number of leaves hill^{-1} (6.75, 85.24, 97.99 and 91.09 at 25, 50, 75 DAT and at harvest respectively), dry weight hill^{-1} (9.71, 44.35, 60.41 and 84.14 g at 25, 50, 75 DAT and at harvest respectively) and leaf area index (2.22, 7.36, 7.19 and 7.12 at 25, 50, 75 DAT and at harvest respectively) were achieved by BRRI hybrid dhan2 (V_3) where the lowest number of tillers hill^{-1} (1.02, 17.68, 17.56 and 17.54 at 25, 50, 75 DAT and at harvest respectively), number of leaves hill^{-1} (5.06, 67.03, 76.82 and 70.48 at 25, 50, 75 DAT and at harvest respectively), dry weight hill^{-1} (7.639, 35.24, 51.21 and 70.20 g at 25, 50, 75 DAT and at harvest respectively) and leaf area index (1.68, 4.65, 4.53 and 4.43 at 25, 50, 75 DAT and at harvest respectively) were obtained by BRRI dhan29 (V_2). Again, for yield and yield contributing characters BRRI hybrid dhan2 (V_3) showed the best perfomance where BRRI dhan29 (V_2) showed the lowest performance. The highest panicle length (26.58 cm), number of grains panicle^{-1} (131.20), 1000 seed weight (26.12 g), grain yield (4.79 t ha^{-1}), straw yield (6.80 t ha^{-1}), biological yield (11.6 t ha^{-1}) and harvest index (41.25%) were gained by BRRI hybrid dhan2 (V_3) where the lowest panicle length (24.73 cm), number of grains panicle^{-1} (94.93), 1000 seed weight (23.36 g), grain yield (3.27 t ha^{-1}), straw yield (5.69 t ha^{-1}), biological yield (8.96 t ha^{-1}) and harvest index (36.51%) were given by BRRI dhan29 (V_2).

Different methods of urea application during the study had significant influence on growth, yield and yield contributing parameters. At 50, 75 DAT and at harvest the tallest plant was recorded by T_4 (60.50, 100.1 and 103.8 cm respectively) whereas at later stage the lowest was with T_1 (98.56 and 102.2 cm at 75 DAT and harvest respectively). But in terms of other growth parameters; the highest number of tillers hill^{-1} (1.65, 24.94, 24.67 and 24.67 at 25, 50, 75 DAT and at harvest respectively), number of leaves hill^{-1} (6.40, 84.96, 95.94 and 90.41 at 25, 50, 75 DAT and at harvest respectively), dry weight hill^{-1} (9.41, 43.58, 60.74 and 83.22 g at 25, 50, 75 DAT and at harvest respectively) and leaf area index (2.16, 7.08, 6.92 and 6.83 at 25, 50, 75 DAT and at harvest respectively) were found from T_1 where the lowest number of tillers hill^{-1} (1.29, 18.98, 18.90 and 18.88 at 25, 50, 75 DAT and at harvest respectively), number of leaves hill^{-1} (5.94, 71.43, 84.92 and 79.42 at 25, 50, 75 DAT and at harvest respectively), dry weight hill^{-1} (8.45, 38.05, 53.65 and 74.66 g at 25, 50, 75 DAT and at harvest respectively), leaf area index (1.88, 5.49, 5.37 and 5.31 at 25, 50, 75 DAT and at harvest respectively) were observed by T_2. For yield and yield contributing parameters; the highest panicle length (26.38 cm), number of grains panicle^{-1} (128.2), 1000 seed weight (25.73 g), grain yield (4.67 t ha^{-1}), straw yield (6.72 t ha^{-1}), biological yield (11.39 t ha^{-1}) and harvest index (40.66%) was accomplished with T_1 where the lowest panicle length (25.40 cm), number of grains panicle^{-1} (106.70), 1000 seed weight (24.61 g), grain yield (3.84 t ha^{-1}), straw yield (6.09 t ha^{-1}), biological yield (9.92 t ha^{-1}) and harvest index (38.48%) attained with T_2.

Different boro rice variety and methods of urea application during the study period had also significant effect on growth, yield and yield contributing parameters. It was revealed that the highest result on plant height was achieve by V_3T_4 (17.50, 62.50, 102.0 and 105.7 cm at 25, 50, 75 DAT and at harvest respectively) but at final stage to maturity, the shortest plant was achieved by V_1T_1 (97.67 and 101.5 cm at 75 DAT and at harvest respectively). In terms of other growth parameters; the highest number of tillers hill^{-1} (1.97, 28.39, 28.00 and 28.00 at 25, 50, 75 DAT and at harvest respectively), number of leaves hill^{-1} (7.00, 95.24, 105.4 and 100.2 at 25, 50, 75 DAT and at harvest respectively), dry weight hill^{-1} (10.13, 48.39, 66.79 and 90.59 g at 25, 50, 75 DAT and at harvest respectively) and leaf area index (2.37, 8.11, 7.94 and 7.87 at 25, 50, 75 DAT and at harvest respectively) were gained from V_3T_1 where the lowest number of tillers hill^{-1}

(1.00, 16.59, 16.49 and 16.51 at 25, 50, 75 DAT and at harvest respectively), number of leaves hill^{-1} (5.00, 66.03, 72.29 and 68.32 at 25, 50, 75 DAT and at harvest respectively), dry weight hill^{-1} (7.05, 34.19, 50.22 and 68.94 g at 25, 50, 75 DAT and at harvest respectively) and leaf area index (1.59, 4.11, 4.01 and 3.98 at 25, 50, 75 DAT and at harvest respectively) were gained from V_2T_2. For yield and yield contributing parameters; the highest panicle length (27.06 cm), number of grains panicle^{-1} (146.20), 1000 seed weight (26.79 g), grain yield (5.41 t ha^{-1}), straw yield (7.20 t ha^{-1}), biological yield (12.61 t ha^{-1}) and harvest index (42.85%) was accomplished with V_3T_1 where the lowest panicle length (24.29 cm), number of grains panicle^{-1} (89.68), 1000 seed weight (22.91 g), grain yield (3.04 t ha^{-1}), straw yield (5.46 t ha^{-1}), biological yield (8.50 t ha^{-1}) and harvest index (35.76%) attained with V_2T_2.

From the above discussion it can be concluded that among the three varieties for the present study, BRRI hybrid dhan2 demonstrated the best performance where BRRI dhan29 showed lower efficiency regarding different growth, yield and yield contributing characters. Again, among the different four urea application method, T_1 (2.7 g size USG placement at 8 DAT) showed the best performance where the T_2 (1.8 g size USG placement at 8 DAT + field urea plot^{-1} at 30 DAT) gave the lowest efficiency considering growth, yield and yield contributing characters. As combined effect of the present study V_3T_1 (BRRI hybrid dhan2 × 2.7 g size USG placement at 8 DAT) showed the best performance regarding growth, yield and yield contributing characters of boro rice varieties. So, V_3T_1 (BRRI hybrid dhan2 × 2.7 g size USG placement at 8 DAT) was the best treatment for the present study.

Limited research work done yet before in the world. Many other research works can be done at any other location combining any other treatments. To justify the result further experiment can be done at here or any other places.

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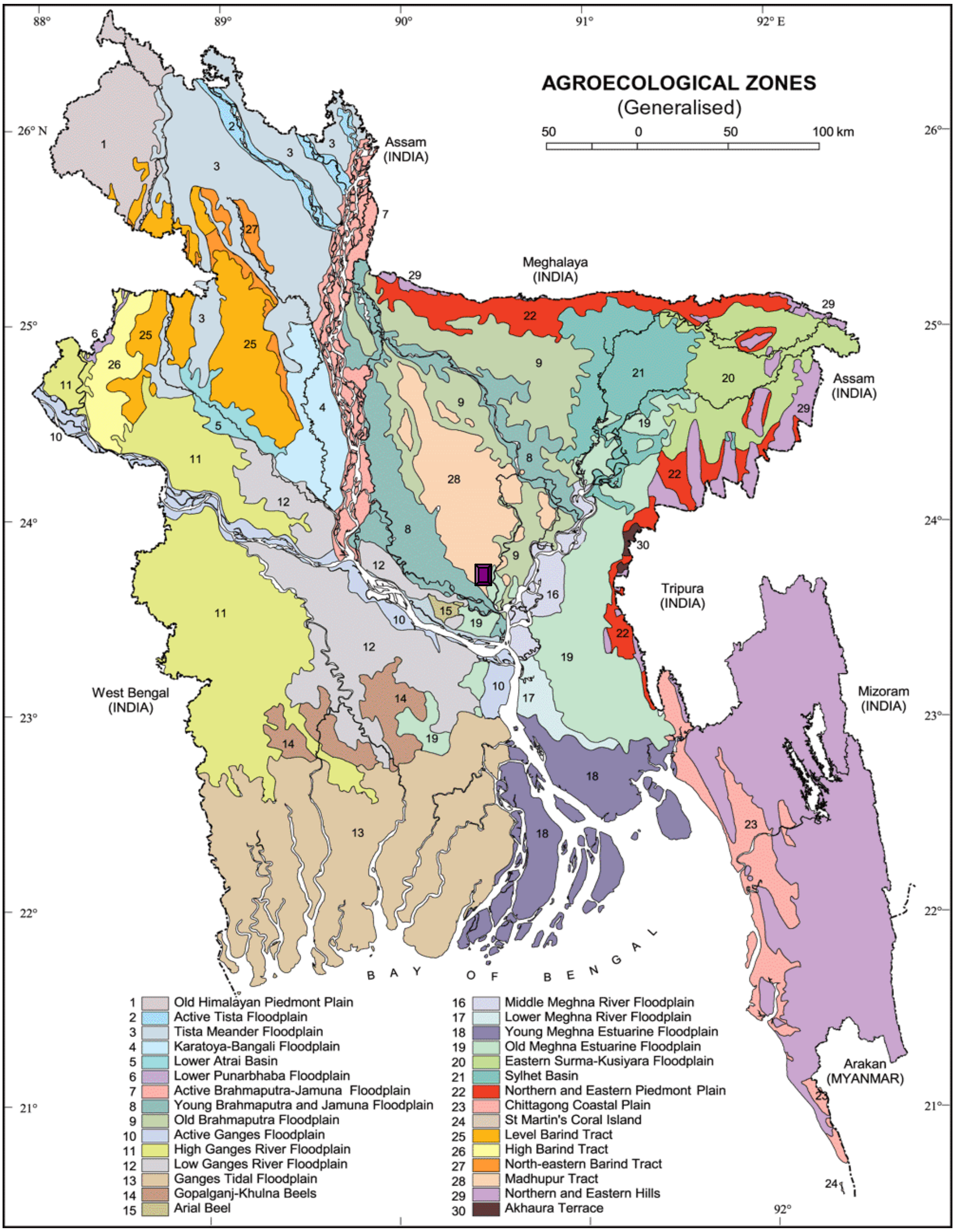
Appendices

APPENDICES

Appendix I: Map showing the experimental sites under study



The experimental site under study

Appendix II: Characteristics of soil of experimental is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Field laboratory, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium hHigh land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI)

Appendix III: Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from January to May 2009

Month (Year 2009)	*Air temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
January	24.5	12.4	68	00	5.7
February	27.1	16.7	67	30	6.7
March	31.4	19.6	54	11	8.2
April	33.6	23.6	69	163	6.4
May	32.4	27.2	71	134	7.1

* Monthly average,

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

Appendix IV: Effect on plant height as influenced by different varieties and methods of nitrogenous fertilizers use

Source	Degrees of freedom	Mean square of plant height			
		25 DAT	50 DAT	75 DAT	At harvest
Replication	2	0.84	1.11	1.86	2.58
Factor A	2	1.19**	4.05*	6.69*	6.89*
Error	4	2.69	2.57	8.36	13.17*
Factor B	3	3.26*	4.64*	3.96*	4.60
AB	6	6.21*	6.80*	5.32*	5.87*
Error	18	1.28	1.76	2.12	3.13

** 1% level of significance

* 5% level of significance

Appendix V: Effect on number of tillers hill^{-1} as influenced by different varieties and methods of nitrogenous fertilizers use

Source	Degrees of freedom	Mean square of number of tillers hill^{-1}			
		25 DAT	50 DAT	75 DAT	At harvest
Replication	2	0.01	0.01	1.14	0.04
Factor A	2	1.79**	4.87*	3.11*	3.36*
Error	4	1.01	2.32	1.04	0.32
Factor B	3	1.21**	9.26*	5.83*	5.08*
AB	6	2.03*	4.15*	4.05*	4.11*
Error	18	0.026	0.148	1.16	2.023

** 1% level of significance
* 5% level of significance

Appendix VI: Effect on number of leaves hill^{-1} as influenced by different varieties and methods of nitrogenous fertilizers use

Source	Degrees of freedom	Mean square of number of leaves hill^{-1}			
		25 DAT	50 DAT	75 DAT	At harvest
Replication	2	0.02	0.01	0.00	0.18
Factor A	2	4.86*	9.00*	7.34*	14.06
Error	4	0.07	1.01	1.00	1.03
Factor B	3	4.33**	11.28*	20.51*	12.10
AB	6	6.03**	15.53*	3.75**	15.80
Error	18	0.13	2.03	1.04	2.03

** 1% level of significance
* 5% level of significance

Appendix VII: Effect on number of dry weight hill^{-1} as influenced by different varieties and methods of nitrogenous fertilizers use

Source	Degrees of freedom	Mean square of dry weight hill^{-1} (g)			
		25 DAT	50 DAT	75 DAT	At harvest
Replication	2	0.04	0.02	0.08	0.07
Factor A	2	5.88*	12.34*	13.07*	8.09*
Error	4	1.01	1.02	1.03	1.08
Factor B	3	1.58**	9.33*	9.07*	17.75*
AB	6	0.02**	5.16*	12.29*	15.69*
Error	18	0.048	1.044	1.065	2.326

** 1% level of significance
* 5% level of significance

Appendix VIII: Effect on leaf area index as influenced by different varieties and methods of nitrogenous fertilizers use

Source	Degrees of freedom	Mean square of leaf area index			
		25 DAT	50 DAT	75 DAT	At harvest
Replication	2	0.01	0.02	0.011	0.08
Factor A	2	1.04**	9.96*	16.25*	12.97*
Error	4	0.04	0.04	2.01	1.00
Factor B	3	0.13**	4.51**	4.24**	4.12*
AB	6	0.02**	6.15*	10.14*	10.19*
Error	18	0.044	1.032	2.014	2.038

** 1% level of significance
* 5% level of significance

Appendix IX: Effect on yield parameters as influenced by different varieties and methods of nitrogenous fertilizers use

Source	Degrees of freedom	Panicle length	Grains/panicle	1000 seed weight
Replication	2	0.02	0.03	0.00
Factor A	2	12.68*	11.48*	26.91*
Error	4	0.04	0.09	2.04
Factor B	3	1.64*	8.88*	12.28*
AB	6	4.01*	5.65*	4.09*
Error	18	2.034	3.033	3.06

** 1% level of significance
* 5% level of significance

Appendix X: Effect on yield contributing characters as influenced by different varieties and methods of nitrogenous fertilizers use

Source	Degrees of freedom	Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	0.02	0.03	0.04	0.00
Factor A	2	8.24*	14.53*	24.98*	1.44*
Error	4	1.04	0.42	1.12	0.02
Factor B	3	1.15**	12.68*	13.57*	7.70*
AB	6	2.07*	6.04*	8.19*	1.31*
Error	18	1.088	3.088	4.036	3.116

** 1% level of significance
* 5% level of significance