GROWTH AND YIELD OF BORO RICE AS AFFECTED BY DIFFERENT METHODS OF UREA APPLICATION

AMRIT LAL DAS

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2015

GROWTH AND YIELD OF BORO RICE AS AFFECTED BY DIFFERENT METHODS OF UREA APPLICATION

By

AMRIT LAL DAS

REGISTRATION NO. 09-03634

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

MASTER OF SCIENCE

IN

AGRONOMY

SEMESTER: JANUARY-JUNE, 2015

Approved by:

(Prof. Dr. Parimal Kanti Biswas) **Supervisor**	**(Prof. Dr. Md. Shahidul Islam)** **Co-supervisor**

(Prof. Dr. Md. Fazlul Karim)
Chairman
Examination Committee

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207
Phone: 9134789

CERTIFICATE

This is to certify that the thesis entitled **" GROWTH AND YIELD OF BORO RICE AS AFFECTED BY DIFFERENT METHODS OF UREA APPLICATION"** submitted to the Faculty of Agriculture**,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGRONOMY,** embodies the results of a piece of bona fide research work carried out by **AMRIT LAL DAS,** Registration. No. **09-03634** under my supervision and guidance. No part of this 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:

Dhaka, Bangladesh

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

ACKNOWLEDGEMENTS

First of all, the author is indebted to "Almighty God" to complete the research work.

The author would like to express his heartfelt gratitude to his research supervisor, Dr. Parimal Kanti Biswas, Dean, Post Graduate Studies and Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, for his constant supervision, valuable suggestions, scholastic guidance, continuous inspiration, constructive comments, extending generous help and encouragement during his research work and guidance in preparation of manuscript of the thesis.

The author sincerely express his heartiest respect, deepest sence of gratitude and profound appreciation to his co-supervisor Dr. Md. Shahidul Islam, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, for constant encouragement, cordial suggestions, constructive criticisms and valuable advice during the research period and preparing the thesis.

The author would like to express his deepest respect and boundless gratitude to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, for the valuable teaching, sympathetic co-operation and inspirations throughout the course of this study and suggestions and encouragement to research work. The author would like to express his cordial thanks to the departmental and field staffs for their active help during the experimental period.

The author expresses his unfathomable tributes, sincere gratitude and heartfelt indebtedness from his core of heart to his father Hara Lal Das , mother Basanti Rani Das, whose blessing, inspiration, sacrifice, and moral support opened the gate and paved to way of his higher study, and also pleasant to his brothers and sisters.

The author feels much pleasure to convoy the profound thanks to his senior Mominul Haque Rabin, student of Sher-e-Bangla Agricultural University and all of his fellow friends for their help in research work.

The Author

GROWTH AND YIELD OF BORO RICE AS AFFECTED BY DIFFERENT METHODS OF UREA APPLICATION

ABSTRACT

A field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka from December 2013 to July 2014. The experiment consisted of two factors: Factor A: Variety viz. BRRI dhan28 (V_1) and BRRI hybrid dhan2 (V_2) and Factor B: Methods of urea application viz. 100% Urea of the recommended dose (RD) was applied as 3 top dressing (**T_1**), 100% Urea of RD was applied as 3 foliar spray (**T_2**), 100% Urea of RD was applied as 1 top dressing and 2 foliar spray (**T_3**), 75% Urea of RD was applied as 1 top dressing and 2 foliar spray (**T_4**), 75% Urea of RD was applied as 3 foliar spray (**T_5**) and 50% Urea of RD was applied as 3 foliar spray (**T_6)**, following split-plot design with three replications. The maximum number of filled, unfilled and total grains panicle^{-1} (155.2, 21.63 and 176.8 cm, respectively) were obtained from BRRI hybrid dhan2 while the minimum (114.4, 19.31 and 133.7, respectively) were recorded from BRRI dhan28. The maximum 1000-grain weight (23.77 g) was obtained from hybrid variety and the minimum (21.35 g) was found from the inbred variety. The highest grain yield (6.19 t ha^{-1}), straw yield (7.74 t ha^{-1}) and biological yield (13.93 t ha^{-1}) were recorded from BBRI hybrid dhan2 whereas the lowest (4.17, 3.53 and 7.70 t ha^{-1}) were from BRRI dhan28. BRRI hybrid dhan2 has better yield potential than BRRI dhan28 in *boro* season. Grain yield and biological yield were not significantly influenced by methods of urea application. In the case of interactions, the highest grain yield (6.50 t ha^{-1}) was observed in 100% Urea of the recommended dose (RD) was applied as 3 top dressing in BRRI hybrid dhan2.

LIST OF CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	Agro- Ecological Zone
Anon.	Anonymous
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BRRI	Bangladesh Rice Research Institute
cm	Centi-meter
CV	Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
^0C	Degree Celsius
et al.	And others
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
IRRI	International Rice Research Institute
hr	Hour(s)
K_2O	Potassium Oxide
Kg	Kilogram (s)
LSD	Least Significant Difference
LAI	Leaf area Index
m	Meter
m^2	Meter squares
mm	Millimeter
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percentage
P_2O_5	Phosphorus Penta Oxide
S	Sulphur
SAU	Sher-e- Bangla Agricultural University
t ha^{-1}	Ton per hectare
TSP	Triple Super Phosphate
var.	Variety
Wt.	Weight
Zn	Zinc

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa L.*) belongs to cereal crops under Poaceae family. Nearly half of the population of the world use rice as their main food. Millions of people in Asia subsist entirely on rice and over 90% of the world's rice is grown and eaten in Asia (BBS, 2013). It plays a vital role in the economy of Bangladesh providing significant contribution to the GDP, employment generation and food availability. In Bangladesh, rice is the most extensively cultivated cereal crop. It provides about 75% of the calories and 55% of the protein in the average daily diet of the people of our country (Bhuiyan *et al.,* 2002). The climatic and edaphic conditions of Bangldesh are favorable for rice cultivation throughout the year. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country (BBS, 2013). About 75% of the total cropped area and over 80% of the total irrigated area is planted to rice. Thus, rice plays a vital role in the livelihood of the people of Bangladesh. Among the rice growing countries, Bangladesh occupies third position in rice area and fourth position in rice production (BRRI, 2012). But the average yield is quite low compared to that in other leading rice growing countries.

The area and production of total rice in Bangladesh is about 11.35 million hectares and 31.98 million metric tonnes, respectively where *boro* covers the largest part of about 4.70 million hectares with the production of 18.06 million metric tons. In *boro* season than hybrid rice covers about 6.86 lac hectares area with production of 32.2 lac metric tons, respectively (BBS, 2010). Among the three rice crops, *boro* rice covers about 35.72% of total rice and it contributes to 44.13% of the total rice production (BBS, 2003). In Bangladesh total cultivable land is 10 million hectare and near about 70 per cent of this land is occupied by rice cultivation. In the year 2011, the total production of rice was 33.5 million metric ton. Hybrid rice varieties was cultivated in 0.653 million hectare of land and total production is 2.9 million metric ton in the year of 2010-2011. On the other hand, HYV (High Yielding Varieties) was cultivated in 4.06 million hectare land and the total production of rice was 15.6 million metric ton. The average rice production of hybrid varieties was 4.41 metric ton and HYV varieties were 3.84 metric ton in the year 2010 – 2011 (BBS, 2011). Variety is the key component to produce higher yield of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season. The growth process of rice plants under a given agro-climatic condition differs with variety. Variety is the most important factor in rice production. Selection of potential variety, planting in appropriate method and application of optimum amount of nutrient elements, can play an important role in increasing yield and national income. Variety itself is a genetic factor which contributes a lot in producing yield and yield components of a particular crop. Yield components are directly related to the variety and neighboring environments in which it grows. It was the farmers who have gradually replaced the local indigenous low yielding rice varieties by HYV of rice developed by BRRI only because of getting 20% to 30 % more yield $unit^{-1}$ land area (Shahjahan, 2007). The population of Bangladesh is still growing and will require about 27.26 million tons of rice for the year 2020. But the average yield of rice is poor (4.34 t ha^{-1}) in Bangladesh (BRRI, 2011). On the other hand, rice production area is decreasing day by day due to high population pressure. The possibility of horizontal expansion of rice production area has come to stand still (Hamid, 1991). Therefore, attempts should be taken to increase the yield per unit area through use of comparatively high yielding varieties along with judicial fertilizer management. Introduction of hybrid rice is an important step towards augmentation of rice yields. Hybrid rice out yielded the existing conventional High Yielding Varieties (HYVs) by 15-20% in India, Bangladesh and Vietnam (Janaiah *et al.,* 2002).

Food scarcity has been and will remain as a major concern for Bangladesh. Although the soil and climatic conditions of Bangladesh are favourable for rice cultivation throughout the year, the unit area yield is much below to those of other leading rice growing countries of the world. Therefore, emphasis should be given to increase the yield of rice (specially *boro* rice) through adaptation of proper and intensive fertilizer management along with other improved technology and management practices. Nitrogen plays a key role in rice production and it is required in large amount. Nitrogen is the most important limiting nutrient in rice production and has heavy system losses when applied as inorganic sources in puddle field (Fillery *et al.*, 1984). Nitrogen has a positive influence on the production of effective tiller per plant, yield and yield attributes (Jashim *et al.*, 1984, BRRI, 1990). It is necessary to find out the suitable rate of nitrogen fertilizer for efficient management and better yield of rice. A suitable combination of variety and rate of nitrogen is necessary for better yield (BRRI, 1990). Rice plant cannot produce higher grain yield without addition of fertilizer in the crop field (BRRI, 2011). Among the nutrients, nitrogen is the kingpin in rice farming (Alam *et al*., 2012a) for crop growth and development. Nitrogen is an essential constituent of chlorophyll and well-supplied nitrogen which enhanced crop growth vigorously (Dobermann and Fairhurst, 2000). On the contrary, nitrogen deficiency results reduced tillering, grains panicle^{-1} and ultimately decreases grain yield of rice (Peng *et al*., 2003). However, only optimum dose of N applied can play a vital role on the growth and development of rice plant (Hasanuzzaman *et al*., 2009). The absorption patterns of applied nitrogen vary with growth stages. About 52 to 60 % of total plant nitrogen in the high yielding plants has been absorbed by early panicle formation stage, and 70 to 80 % by heading stage; 20- 30 % nitrogen is absorbed during the ripening period (De Datta, 1981). Generally, the nitrogenous fertilizer (urea) is applied as basal and as top dressed at different growth stages for rice cultivation (BRRI, 2011). Unfortunately, N use efficiency in the wetland rice culture is very low, rarely exceeding 30-40 % (Alam *et al*., 2000) and more than 50 % of the applied nitrogen is lost through denitrification, volatilization, leaching and runoff (Khan *et al*., 2009) and ultimately affect on cash loss of farmers and sometimes causes environmental as well as ground water pollution (De Datta, 1981; IRRI, 1997). High price of urea fertilizer and its availability at the right time jeopardize rice production occasionally (BRRI, 2009). So, it is necessary to improve the efficiency of applied nitrogenous fertilizer utilization by rice plant (Miah and Panaullah, 1999). All the factors provide an indication of searching an effective alternate N application method for rice cultivation (BRRI, 2011). However, foliar application can improve nutrient utilization and lower environment pollution through reducing amount of fertilizers added to soil (Abou-EI-Nour, 2002). In many cases aerial spray of nutrients is preferred and give quicker and better results than the soil application (Jamal *et al.*, 2006) which minimizes N losses to the environment without affecting rice yield (Millard and Robinson, 1990). Most plants absorb foliar applied urea rapidly and hydrolyze the urea in the cytosol (Nicoulaud and Bloom, 1996). The NH_3 released may be transported into the chloroplast and be assimilated by the chloroplastidic Glutamine synthetase (Lam *et al*., 1996). Recently foliar application of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants (Alam *et al.*, 2012b).

Many factors determine the fertilizer use efficiency for rice crop during cultivation such as soil, cultivar, season, environment, planting time, water management, weed control, cropping pattern, source, form, rate, time of application and method of application (De Datta, 1978). Therefore, there is an imperative need to provide the required nutrients over and above the regular soil application through foliar application as well. Foliar application is well recognized and is being practiced in agriculturally advanced countries. In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application (Jamal *et al*., 2006). Recently foliar application of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants. Foliar feeding is an effective method for overcoming the flooded soil special condition. In case of foliar feeding, nutrients are absorbed directly where they are needed, the rate of the photosynthesis in the leaves is increased, nutrient absorption by plant roots is stimulated and foliar nutrition applied at critical times. Other advantages are low application rates, uniform distribution of fertilizer, reduction in plant stress, plant's natural defense mechanisms to resist plant disease and insect infestations, improvement of plant health and yield (Finck, 1982). Nitrogen fertilizer is more urgent for security rice production. Liquid fertilization might reduce the use of chemical fertilizer specially the nitrogenous fertilizer in soil. Recently foliar application of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants. In this aspect, the present study was, therefore, undertaken to find out the role of variety and urea fertilizer application method on growth and yield of boro rice.

In the light of the above discussion, the present study was under taken with the following objectives:

(I) To compare the yield and yield component of the two rice varieties under different urea fertilizer application methods,

(II) To observe the effect of foliar application of urea fertilizer in the rice field and

(III) To select the suitable combination of urea fertilizer application method with varieties grown in boro rice season.

CHAPTER 2
REVIEW OF LITERATURE

Growth and development of rice plants are greatly influenced by the environmental factors i.e. air, day length or photoperiod, temperature, variety and agronomic practices like transplanting time, spacing, number of seedlings, depth of planting, fertilizer management etc. Among the factors, which are responsible for the yield of rice, fertilizer management of boro rice is one of them. Yield and yield contributing characters of rice are considerably influenced by different doses of NPKS fertilizers and their combined application. Cultivar plays an important role in rice production by affecting the growth, yield and yield components of rice. Research works related to the growth and yield of *boro* rice as affected by method of urea application have been reviewed in this chapter.

2.1 Effect of variety

The successful production of any crop depends on manipulation of basic ingredients of crop culture. The variety of crop is one of the basic ingredients. Variation of yield and other crop growth characters due to different varieties. Variety itself is the genetic factor which contributes a lot in improving yield and yield components. Different scientists reported on the effect of rice varieties on grain yields. Some available information and literature related to the effect of variety on the yield and yield contributing characters of rice are furnished here.

An experiment was carried out by Alam *et al. (*2012b) to study the effect of variety, spacing and number of seedlings hill^{-1} on the yield potentials of transplant aman rice. Variety had significant effects on almost all the yield component characters and yield. Among the varieties BRRI dhan33 gave significantly the tallest plant (113.17 cm), which is statistically identical with BR11 (111.25 cm). The highest number of total tillers hill^{-1} (12.23) was produced by BR11 and the lowest number of total tillers hill^{-1} (10.17) was produced by BRRI dhan32. All the yield components characters (tillers hill^{-1}, effective tillers hill^{-1}, panicle length, weight of 1000-grain and grain yield) except number of fertile spikelets panicle^{-1} were highest in case of variety BR11 and hence it produced the highest grain yield (5.92 t ha^{-1}).

Nahar *et al.* (2009) was carried a field experiment studied the effect of low temperature stress influenced by date of transplanting on yield attributes and yields of two rice varieties. The experiment consisted of two varieties (BRRI dhan46 and BRRI dhan31) and 4 transplanting dates (01, 10, 20 and 30 September, 2008). BRRI dhan46 had significantly higher values of yield attributes (effective tillers hill^{-1}, panicles hill^{-1}, panicle length, spikelets panicle^{-1}, filled grains panicle^{-1} and 1000-grain weight) and yields than the BRRI dhan31 in late transplanted conditions. There were significant reductions in yield attributes and yields after delayed transplanting. Spikelet sterility was increased by late transplanting due to low temperature at panicle emergence stage. Yield reduction of BRRI dhan46 due to late transplanting at 10 September, 20 September and 30 September were 4.44, 8.88 and 15.55%, respectively compared to 01 September transplanting. In case of BRRI dhan31 the reduction was more significant which were 6.12, 20.48 and 36.73%, respectively.

A study was undertaken to evaluate the growth performance and grain quality of six aromatic rice varieties BRRI dhan34, BRRI dhan38, Kalizira, Chiniatop, Kataribhog and Basmati grown under rainfed conditions by Ashrafuzzaman *et al.* (2009). They found that Kalizira was the tallest (107.90 cm) of all the studied varieties. It had shown no significant difference with BRRI dhan38 (107.80 cm) and BRRI dhan34 (106.70 cm). BRRI dhan34 showed the highest number of panicles per hill (11.67) followed by Kalizira (11.33). The rice varieties differed significantly ($P<0.05$) with respect to leaf chlorophyll content, plant height, internode length, thousand grain weight and grain and straw yields. Varieties differed in morphological and yield and yield contributing traits. Thousand grain weight and grain yield both were highest in BRRI dhan38. Basmati required shorter days to maturity and Kalizira longest days to maturity.

Islam *et al.* (2013) was conducted a field experiment during July- December, 2010 with a view to find out the varietal performance of *aman* rice as affected by different methods of urea application. The experimental treatments included four varieties i.e. BR11, BRRI dhan33, BRRI dhan39, BRRI dhan46 and four urea application methods. The results showed that urea fertilizer application method significantly influenced plant height, tillering production, leaf area index, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, total grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, and biological yield. Application of USG N as at 7 DAT gave highest yield (7.82 t ha-1) while application of 15 kg N ha^{-1} as PU 30 DAT+ 15 kg N ha^{-1} as PU at 50 DAT gave lowest yield (4.88 t ha^{-1}). Varietal influence were significant on tillering pattern, leaf area index, effective tillers $hill^{-1}$, filled grains $panicle^{-1}$,1000-grain weight, grain yield, straw yield and biological yield. BR11 gave the highest yield (8.17 t ha^{-1}) which was statistically similar with BRRI dhan46 (7.3 t ha^{-1}) while the lowest yield obtained from BRRI dhan33 (2.87 t ha^{-1}).

A field experiment was conducted by Roy *et al.* (2014) to evaluate the growth, yield and yield attributing characteristics of 12 indigenous *Boro* rice varieties collected from South-Western regions of Bangladesh namely; Nayon moni, Tere bale, Bere ratna, Ashan boro, Kajol lata, Koijore, Kali boro, Bapoy, Latai balam, Choite boro, GS one and Sylhety boro. The plant height and number of tillers $hill^{-1}$ at different days after transplanting varied significantly among the varieties up to harvest. At harvest, the tallest plant (123.80 cm) was recorded in Bapoy and the shortest (81.13 cm) was found in GS one. The maximum number of tillers $hill^{-1}$ (46.00) was observed in Sylhety boro and the minimum (19.80) in Bere ratna. The maximum number of effective tillers $hill^{-1}$ (43.87) was recorded in the variety Sylhety boro while Bere ratna produced the lowest effective tillers $hill^{-1}$ (17.73). The highest (110.57) and the lowest (42.13) number of filled grains $panicle^{-1}$ was observed in the variety Koijore and Sylhety boro, respectively. Thousand grain weight was the highest (26.35 g) in Kali boro and the lowest (17.83 g) in GS one. Grain did not differ significantly among the varieties but numerically the highest grain yield (5.01 t ha^{-1}) was found in the variety Koijore and the lowest in GS one (3.17 t ha^{-1}).

Leenakumari *et al.* (1993) found higher grain yield from the hybrid varieties over the modern varieties. They evaluated eleven hybrids of varying duration against controls Jaya, Rasi, 1R20 and Margala, and concluded that hybrid OR 1002 gave the highest yield (7.9 t ha^{-1}) followed by IR 1000 (6.2 t ha^{-1}).

BRRI (1991) reported that the number of effective tillers produced by some transplant *aman* rice ranged from 7 to 14 tillers $hill^{-1}$ and it significantly differed from variety.

Main *et al.* (2007) reported that there was no significant variation of effective tillers hill^{-1}, total grains panicle^{-1}, filled grains panicle, straw yield and harvest index observed between the two varieties but hybrid variety showed higher panicle length, grain weight and grain yield compared to inbred variety. The variety Sonarbangla-1 gave the longer panicle (26.40 cm) compared to that of BR11 (25.66 cm). The higher weight of 1000 grains (28.32 g) was obtained from the hybrid variety and the lower (27.08 g) was obtained from the inbred variety. The higher grain yield (4.70 t ha^{-1}) was obtained from the hybrid variety Sonar bangla-1 and from inbred variety BR11 (4.43 t ha^{-1}).

WenXiong *et al.* (1996) reported that Shnyou 63 (Zhenshan 97A x Minhui 63) and Teyou 63 (Longtepu A x Minhui 63) showed significant grain yield increase over Minhui 63 of 35.2 and 48%, respectively, in China in 1993. The higher number of productive tillers plant^{-1} had the largest direct effect on grain yield, resulting in increased sink capability. The higher tiller number and number of grains panicle^{-1} were attributable to higher leaf areas, higher net photosynthesis in individual leaves (particularly in the later stages) and favorable partitioning of photosynthesis to plant organs. Compared with Minhui 63, hybrids showed slight heterosis in relative growth rate but significant heterosis in crop growth rate, especially at later growth stages, with increases of 160.52 and 97.62% in shanyou 63 and Teyou 63, respectively.

B1NA (1993) evaluated the performance of four varieties- IRATOM 24, BR 14, Binadhan-13 and Binadhan-9. It was found that the varieties differed significantly in respect of plant height, number of unproductive tillers hill^{-1}, panicle length and sterile spikelets panicle^{-1}.

Number of panicles was the result of the number of tillers produced and the proportion of effective tillers, which survived to produce panicle (Hossain *et al.*, 2008).

Zohra *et al.* (2013) was carried a field experiment during July- December, 2011 with a view to find out the yield performance of three transplant *aman* rice namely, Binadhan-7, BRRI dhan46 and Kalizira were evaluated under five levels of urea super granules (USG) viz. control (no USG), one, two, three and four pellet(s) of USG/4 hills providing 0, 30, 60, 90 and 120 kg N ha^{-1}, respectively, and recommended dose of prilled urea were evaluated. Variety exerted significant influence on yield of transplant *aman* rice. Grain yield was highest (5.46 t ha^{-1}) in BRRI dhan46 and straw yield was highest (6.58 t ha^{-1}) in Kalizira. It was observed that in most of the cases, all the varieties performed better for their yield contributing characters with 2 pellets of USG/4 hills compared to any other levels. The findings suggest that BRRI dhan46 can be cultivated to obtain high rice yield in transplant *aman* season.

Idris and Matin (1990) reported that number of total tillers hill^{-1} was identical among the varieties studied. BRRI (2006) studied the performance of BR14, Pajam, BR5 and Tulsimala and reported that Tulsimala produced the highest number of filled grains panicle^{-1} and BR14 produced the lowest number of filled grains panicle^{-1}.

Kabir *et al.* (2009) was carried an experiment in transplant *Aman* season 2008 to find out the effect of urea super granules (USG), prilled urea (PU) and poultry manure (PM) on the yield and yield attributes of transplant *Aman* rice varieties. Two transplant *Aman* rice varieties viz. BRRI dhan41 and BRRI dhan46 and ten levels of integrated nutrient management encompassing USG, PU and PM were tested. In case of varietal effect plant height, total tillers hill^{-1}, effective tillers hill^{-1}, length of panicle, grains panicle^{-1}, unfilled spikelets panicle^{-1}, grain yield, straw yield and harvest index were significantly influenced at different levels of significance. Variety BRRI dhan41 produced higher grain and straw yield and harvest index than that of BRRI dhan46. Higher grain yield in BRRI dhan41was due mainly to higher of effective tillers hill^{-1}and grains panicle^{-1}.

BRRI (2004) reported that the filled grains panicle^{-1} of different modern varieties were 95-100 in BR3, 125 in BR4, 120-130 in BR22 and 110-120 in BR23 when they were cultivated in transplant *Aus* season. They reported that three modern upland rice varieties namely, BR20, BR21 and BR24 were suitable for high rainfall belts of Bangladesh. Under proper management, the grain yield was 3.5 ton for BR 20, 3.0 ton for BR21 and 3.5 ton for BR24 ha^{-1}. They also reported that grain yields of the modern rice varieties in *Aus* season under transplant condition ranged from 4.0-4.5 t ha^{-1} for BR3, 5.5 - 6.5 t ha^{-1} for BR4, 2.5-5.5 t ha^{-1} for BR23 and 4.0-4.5 t ha^{-1} for IR20.

Obaidullah (2007) stated that variety significantly influenced panicle length, number of total grains panicle', filled grains panicle1, 1000 grains weight, grain yield and straw yield but not for effective tillers hill' and harvest index. The varietial effects on yield and other yield attributes where hybrid variety gave numerically maximum tillers hill^{-1} (10.08), and significantly highest panicle length (27.36 cm), grains panicle^{-1} (196.75), filled grains panicle^{-1} (156.84), 1000 grain weight (27.40 g) which eventually elevated the grain yield (5.58 t ha^{-1}). These parameters were 9.8, 25.17 cm, 112.83, 86.77, 20.09 g and 3.88 t ha^{-1}, respectively as lowest measurements from inbred varieties.

Bhuiya (2000) reported that plant height varied variety to variety *viz.* Binasail, Binadhan 4 and Binadhan 19 with different plant spacing *viz.* 20 cm x 10 cm, 20 cm x 15 cm and 20 cm x 20 cm.

BRRI (1985) concluded that BR4 and BR10 were higher yielders than Rajasail and Kajalsail. Kamal *et al.* (1988) observed that among three rice varieties BR3 produced the highest the grain yield and pajam yielded the lowest. The superiority of promising line over the high yielding varieties in respect of grain yield was recorded.

Miller (1978) from a study of 14 rice cultivars observed that grain yields ranged from 5.6 to 7.7 t ha^{-1}. He also reported that grain yield was significantly influenced by rice cultivars.

Sultana (2008) observed that number total of tillers hill^{-1} was not significantly affected by variety. Apparently more number (11.07) of total tillers was produced by the variety BR14 than BR26 (10.90).

Akbar (2004) stated that variety, seedling age and their interaction exerted significant influence on almost all the studied crop characters of rice. Among the varieties, BRRI dhan4l performed the best in respect of number of bearing tillers hill^{-1}, panicle length, total spikelets panicle^{-1}, and number of grains panicle^{-1}. BRRI dhan41 also produced the maximum grain and straw yields, Sonarbangla-1 ranked first in respect of total tillers hill^{-1} and 1000 grain weight but produced the highest number of non-bearing tillers hill and sterile spikelets panicle^{-1}. Grain, straw and biological yields were found highest in the combination of BRRI dhan41 x 15 day-old seedlings. Therefore, BRRI dhan4l may be cultivated using 15 day-old seedlings in *aman* season following the SRI technique to better grain and straw yields.

Takita (2009) reported that Nerica rice has erect panicles even after maturity which can favor high canopy photosynthesis with less light interception by these panicles than droopy panicles.

Debnath *et al.* (2012) observed that variety had significant effect on all the agronomic parameters except number of effective tillers, ineffective tillers, total tillers, grain straw ratio and biological yield. BRRI hybrid dhan2 produced the highest dry grain yield (5.92 t ha^{-1}) and the lowest straw yield (4.97 t ha^{-1}), whereas, BRRI dhan29 produced the lowest grain yield (4.16 t ha^{-1}) and the highest straw yield (6.70 t ha^{-1}).

Jesy (2007) observed that weight of 1000-grains was not significantly affected by variety. Apparently BRRI dhan4l produced the higher weight of 1000-grains (23.42 g) than BRRI dhan40 (23.39 g).

Hasanuzzaman *et al.* (2009) in a study found that the length of panicle in late transplanted Aman rice ranged from 23.59 to 21.30 cm. Refey *et al.* (1989) reported that weight of 1000-grains differed among the cultivars studied.

Hossan (2005) observed that grain yield was significantly differed due to variety. It was evident from the result that BRRI dhan4l produced the higher grain yield (5.02 t ha^{-1}) than BRRI dhan31. Ahmed *et al.* (2007) conducted a field experiment at Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during December 2005 to May 2006 to study the influence of cultivation methods on inbred and hybrid rice in *boro* season. The experiment consisted of two levels of treatment viz, variety and cultivation method and was laid out in a split plot design with four replications. Interaction of variety and cultivation method revealed that nursery seedlings of the inbred variety produced the highest grain yield (8.88 t ha^{-1}) and sprouted broadcasted seeds of the inbred variety gave the lowest grain yield (6.35 t ha^{-1}).

In a trial, varietal differences in harvest index and yield were examined using 60 Japanese varieties bred in Asian countries. It was reported that harvest index varied from 36.8% to 53.4%. Mean values of harvest index were 43.5% in the Japanese group and 48.8% in high yielding group. Yield ranged from 22.6 g plant^{-1}. The mean value of yield in Japanese group was 22.8 g plant^{-1}, and that in high yielding group was 34.1 g plant^{-1}. They also reported that a positive correlation was found between harvest index and yield in the yielding group (Cui *et al.*, 2000).

Om *et al.* (1999) conducted a field experiment with four varieties (3 hybrids: ORI 161, PMS 2A, PMS 10A and one inbred variety HKR 126) during rainy season and observed that hybrid ORI 161 exhibited superiority to other varieties in grain yield and straw yield.

Tac *et al.* (1998) conducted an experiment with two varieties, Akitakomachi and Hitombore in tohoku region of Japan. It was found that Hitombore yielded the higher (710 g m^{-2}) and Akitakomachi the lowest (660 g m^{-2}).

Miah *et al.* (1993) reported that plant height differed significantly among BR 3, BR 11, BR 22, Nizershail, Pajam, and Badshabhog varieties in Aman season (Jul-Dec). Tiller number varied widely among the varieties and the number of tillers/plant at the maximum tiller number stage ranged between 14.3 and 39.5 in 1995 and 12.2 and 34.6 in 1996.

Mahato *et al.* (2014). was carried a field experiment during July-December, 2010 to find out the allelopathic effect on growth and yield of three aman rice varieties. Aman rice varieties were viz. BRRI dhan 46, Guti Swarna and Ranzit. Results showed significantly higher in grain yield of ranzit with ariach (6.5 t ha^{-1}). Araiach and Razit also exhibited the higher number of tillers hill^{-1} (13.6), filled grains panicle^{-1} (256.0) and 1000-grain weight (23.8 g). As a result, BARI- 46 and Ranzit considered as the most important variety and the most effective plant residue was ariach for growth and yield of aman rice.

Chang and Vergara (1972) stated that the tillering pattern of rice varied with the varieties. In general tall cultivars showed a tendency to have small number of tillers and shorts on showed a large number. Tiller number and panicle number were positively correlated. *Japonica* cultivars that produced few tillers under tropical conditions were vigorous and produced more tillers when grown under temperate conditions. *Indica* cultivars, which were vigorous under tropical conditions, showed few tillers under temperate conditions.

2.2 Effect of application methods of urea fertilizer

Shafiee *et al.* (2013) conducted an experiment of during off-seasons of 2007 through 2009 in Sungai Besar, Selangor's North West Project, Malaysia to assess the enhancing effect of SBAJATM (formerly known as BIPOMIXTM) on the growth and yields of rice (*Oryza sativa* L. var. MR 220). The clonal growth of SBAJATM -treated rice crop based on plant height and tiller numbers plant^{-1}, albeit temporal inconsistencies, did not register any significant difference from each other at $p<0.05$, save for those in the control plots at 45, 75 DAT, and at harvest with measurably lower tiller numbers plant^{-1}. The mean panicle length plant^{-1} and mean number of panicles m^{-2} were significantly ($p<0.05$) longer and higher, respectively in plots treated with SBAJATM *vis-à-vis* the control. While no significant differences were recorded in the 1000 grain weight, the percentage of filled grains panicle^{-1} and the number of grains panicle^{-1} were higher among rice plants in plots receiving the SBAJATM treatments. Invariably, the Crop Cutting Tests (CCT) in plots subjected to foliar applications of SBAJATM registered measurable increase in rice yields from 15 to 29% *vis-à-vis* the equivalent foliar-applied fertilizer subsidy from the government, and the conventional NPK fertilizer applications of 100:30:20 (here served as the control), respectively. The SBAJATM treated plots registered a mean yield of 9.66 tons ha^{-1} compared with 7.49 tons ha^{-1} in the control plots. The parallel average yield from the equivalent foliar-applied fertilizer subsidy from the government was 8.38 tons ha^{-1}. In monetary terms, a yield increase of 1 ton ha^{-1} is translated as an extra net profit of RM 1,000 ha^{-1} season^{-1}.

Parvin *et al.* (2013). was conducted an experiment to investigate the effect of weeding and foliar application of urea on the yield and yield components of *Boro* rice *cv*. BRRI dhan 29. The experiment included four weedings e.g. no weeding (W_0), one weeding (W_1), two weedings (W_2) and three weedings (W_3) and six methods of urea application viz. foliar spray @ 0, 60, 80,100 and120 kg ha^{-1} and soil application @ 220 kg ha^{-1} . Yield and yield contributing characters of *Boro* rice *cv*. BRRI dhan 29 were significantly influenced by foliar application of urea. The highest grain yield was obtained from five times foliar urea spray @ 100 kg ha^{-1}. This highest grain yield was the resultant effect of highest number of effective tillers hill^{-1} and grains panicle^{-1}

in this treatment. The interaction of weeding and foliar application of urea also influenced grain yield of *Boro* rice *cv*. BRRI dhan29. The highest grain yield was obtained from the five times foliar spray of urea @ 100 kg ha^{-1} with three weedings regime.

Alam *et al.* (2010) was conducted An experiment during Boro season of 2008 with a view to examining the effect of soil and foliar application of urea on the yield and nutrient uptake of BRRIdhan 29 and to evaluate whether urea foliar application (FA) could replace its soil application (SA) in the rice cultivation. The treatments were: T_1 (control), T_2 (282 kg urea ha^{-1} SA), T_3 (1% urea solution FA), T_4 (2% urea solution FA), T_5 (3% urea solution FA), T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA), T_7 (94 kg urea ha^{-1} SA + 2% urea solution FA) and T_8 (94 kg urea ha^{-1} SA + 3% urea solution FA). The results showed that soil and foliar application of nitrogen significantly influenced the growth and yield of crop. The treatment T_2 (282 kg urea ha^{-1}) produced the highest grain yield (5.34 t ha^{-1}). The T_6 (94 kg urea ha^{-1} + 1% urea solution FA) produced the highest straw yield (6.58 t ha^{-1}) of the crop.

Sarandon and Asborno (1996) was carried a field trial to study the effect of foliar urea spraying on biomass production, harvest index, grain yield and grain protein content on three rice cultivars. Nitrogen (30 kg/ha), was applied as foliar urea spraying at the end of tillering, heading or postanthesis. Spraying N at heading increased grain yield due to higher grain number/m^2 and a more efficient dry matter partition to the grain (harvest index), without changes in the biomass production. The effect of urea sprayings on grain N content and protein percentage varied according to the cultivars and time of application (positive interaction cultivar x time). Both grain N content and grain protein percentage increased significantly with postanthesis spraying in two of the three cultivars studied but it had no effect on the grain yield. The efficiency of N fertilization for grain yield was higher when applied at heading. No apparent N recovery in the grain was observed when urea spraying was done at tillering; but it rises to 70% when applied at heading and to 47% when applied at postanthesis. In all cultivars N spraying at heading increased grain protein production per ha due to an increase of both grain yield and grain protein percentage. It has been concluded that N spraying in rice, even at low doses, could be effective to increase grain yield and grain protein content depending on rice cultivars and time of application.

Alam *et al.* (2015) conducted an experiment during the period of August 2013 to January 2014 to find out the efficacy of liquid fertilization (Magic Growth) on the performance of Kataribhog rice and to calculate how much urea can be saved without the reduction of grain yield. The experiment was accommodated with the split plot design with two levels of liquid fertilization viz., no liquid fertilization (Lo), Liquid fertilization with Magic Growth applied at 30, 45 and 60 DAT (L_1), and four levels of nitrogen fertilizer viz., no nitrogen fertilizer (N_0), 50% recommended nitrogen fertilizer (N_{50}), 75% recommended nitrogen fertilizer (N_{75}) and 100% recommended fertilizer (N_{100}). The liquid fertilizer and nitrogen fertilizer doses were assigned to the main plot and sub-plot, respectively. Liquid fertilization (L_1) treatment provided greater grain yield compared to no liquid fertilization treatment (L_0) in all nitrogen levels. Furthermore, with the increment of nitrogen level the grain yield was increased up to N_{100} compared to no liquid fertilization treatment (L_0), but in the application of liquid fertilization treatment (L_1), grain yield was increased up to N_{75} and thereafter decreased in N_{100} dose application. Moreover, Liquid fertilization with Magic Growth along with 75% of the recommended nitrogen fertilizer increased 10.5% grain yield with a saving of 25% of the recommended nitrogen fertilizer compared to recommended practice.

Bhuyan *et al.* (2012) was observed that bed planting with foliar nitrogen fertilizer application of rice production systems is very new, and research on it is still at introductory phase. Influence of foliar application of nitrogen fertilizer on growth and yield of transplanted aman rice and evaluation of water and fertilizer application efficiency of rice-fallow-rice cropping system were investigated under raised bed cultivation method. Results showed that foliar spray in bed planting method increased grain yield of transplanted aman rice up to 9.33% over conventional method. Foliar nitrogen fertilizer application in bed planting method increased the number of panicle m^{-2}, number of grains $panicle^{-1}$, and 1000-grain weight of rice than the conventional method. Sterility percentage and weed infestation were lower at foliar nitrogen fertilizer application in bed planting method than the conventional method. Thirty-nine percent of irrigation water and time for application could be saved through foliar nitrogen spray in bed planting than conventional method.Water use efficiency for grain and biomass production was higher by foliar nitrogen fertilizer application in bed planting than conventional method. Likewise, agronomic efficiency of foliar nitrogen fertilizer application in bed planting method was higher than the conventional method. This study concluded that foliar nitrogen spray in bed planting method is a new approach to get fertilizer and water use efficiency as well as higher yield compared to existing agronomic practice in Bangladesh.

Akhand *et al.* (2013) was conducted an experiment at the Bangladesh Rice Research Institute Farm, Gazipur, during aman and boro seasons of 2009-2012. One observational and two replicated trials were conducted to find out the suitability of urea spraying of nitrogen management for rice cultivation. One observational trial, urea solution was sprayed at different concentration levels with or without addition of prilled urea. In this trial, 12 treatments were applied. Two replicated where applied treatments were; Urea at 266 kg ha^{-1} in boro and 175 kg ha^{-1} in aman, urea top dressed at 20, 30 DAT (date after transplanting) and at panicle initiation stage, 2/3rd of recommended N, top dressed at 20, 30 DAT along with 3.5% urea spraying at PI stage, 2/3rd of recommended N, top dressed at 20, 30 DAT along with 3.5% urea solution spraying at PI and booting stage, 2/3rd of recommended N along with 3.5% urea spraying at maximum tillering, PI and booting stage, and compared with without N. It was found that urea could be saved by 22% in aman and 27% in boro seasons without scarifying grain yield when 2/3rd of recommended N, top dressed at 20 and 30 DAT along with urea solution spraying with 3.5% concentration at tillering, panicle initiation and booting stages.

Rahman *et al.* (2007) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during T. Aman season, 2002 to study the effect of different level of nitrogen on growth and yield of transplant Aman rice. The experiment included four treatments viz. 0, 60, 80 and 100 kg N/ha. Nitrogen level significantly influenced growth and yield components. The highest number of effective tillers/hill (9.20), maximum grains/panicle (100.80) and the highest grain yield (5.34 t/ha) were obtained with 80 kg N/ha. The highest straw yield (6.98 t/ha) was obtained at the highest nitrogen level (100 kg N/ha). The highest harvest index (44.50%) was observed at 80 kg N/ha. Results showed that 80 kg N/ha was optimum to produce maximum yield of transplant Aman rice cv. BRRI dhan32.

Saha *et al.* (2004) conducted an experiment in 2002-2003 to create and compare a suitable fertilizer recommendation model for lowland rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results show that the application of different packages estimated by different fertilizer models significantly influence panicle length, panicle numbers, spikelet number per panicle, total grains panicle^{-1}, number of filled grain and unfilled grain per panicle. The combination of NPK that gives the height result was 120-13-70-20 kg/ha NPKS.

Haq *et al.* (2002) conducted an experiment with twelve treatments combination of N, P, K, S, Zn and Diazinon. They found that all the treatments significantly increase the grain and straw yield of BRRI dhan30 rice over control. 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} + diazinon gave the height grain and straw yield.

Asif *et al.* (2000) reported that NPK levels significantly increased the panicle length, number of primary and secondary branches panicle^{-1} when NPK fertilizers were applied at the dose of 180-90-90 kg ha^{-1}.This might be attributed due to the adequate supply of NPK.

Amin *et al.* (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. They found that increased fertilizer dose of NPK increase plant height.

Islam *et al.* (2008a) conducted an experiment in 2001-2002, 2002-2003 and 2003-2004 to determine the response and the optimum rate of nutrients (NPK) for Chili- Fallow-T. *aman* cropping pattern. He found that grain yield influenced significantly due to application of different rates of nutrients and 60-19-36 kg/ha NPK maximized the yield of T. *aman* rice varieties in respect of yield and economics.

Ahmed *et al*. (2005) was carried a field experiment during aman season, 2003 at the experimental field of Agrotechnology Discipline, Khulna University, Khulna to study the effect of nitrogen on different characteristics of transplanted local aman rice variety, Jatai .The levels of nitrogen used in this study were 0, 20, 40, 60 and 80 kg ha^{-1}. Results of this study reveled that different agronomic characteristics varied significantly among the treatments. Higher N dose produced higher plant height. The highest effective tiller hill^{-1}, panicle length, filled grains panicle^{-1}, 1000-grain weight and grain yield was obtained with 40 kg N ha^{-1}. The highest and lowest biological yield was produced with 40 kg N ha^{-1}and 0-kg N ha^{-1} respectively.

Ndaeyo *et al.* (2008) conducted an experiment in Nigeria with five rice varieties (WAB340- 8-8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB) and four rates of NPK (15:15:15) fertilizer (0, 200, 400 and 600kg/ha). The results showed that 600kg/ha NPK (15:15:15) fertilizer rate significantly ($P < 0.05$) increased plant height, number of leaves and tillers per plant in two years. The 400kg/ha rate increased the number of panicles per plant, length of central panicle per plant and the overall grain yields, straw yield over other rates by 4-32% and 2-21% in 2005 and 2006, respectively.

Islam *et al.* (2008b) conducted a field experiment to find out the effect of nitrogen levels and transplanting dates on the yield and yield components of aromatic rice cv. Kalizira. The experiment was laid out in a randomized complete block design with three replications using four (0, 50, 100, and 150 kg N/ha) levels of nitrogen and three transplanting dates (10 August, 22 August and 04 September, 2007) along with the basal doses of triple super phosphate (TSP), muriate of potash (M_OP) and gypsum. The study revealed that most of the yield and yield contributing characters with few exceptions were significantly influenced by nitrogen levels and transplanting dates. They had significant positive effect on tillers, grains/panicle and straw yield. The highest grain yield (2.63 t/ha) was observed in 100 kg N/ha with 10 August transplanting treatment and straw yield (6.43 t/ha) was found highest in 150 kg N/ha with same date of transplanting and the lowest grain (1.83 t/ha) and straw yields (5.14 t/ha) were found in N control treatment with transplanting date of 04 September. The highest grain length (4.68 mm), grain breadth (2.49 mm) and imbibition ratio (6.93) were observed with 100 kg/ha N rate coupled with 10 August transplanting, and for length-breadth ratio, the same rate recorded the highest result, but with different transplanting date i.e. 22 August.

Rasheed *et al.* (2003) reported that the effect of different NP levels i.e., 0-0, 25-0, 50-25, 75-50, 100-75 and 125-100 kg ha^{-1} on yield and yield attributes of rice Bas-385. Yield attributes (No. of effective tillers per hill, spikelet per panicle, normal kernels per panicle, 1000-grain weight) were improved linearly with increasing NP levels up to 100-75 kg/ha. The NP level of 100-75 kg/ha resulted in the highest grain yield of 4.53 t/ha with minimum kernel abnormalities (Sterility, abortive kernels and opaque kernels) as against the minimum of 2.356 t/ha in the control (0-0) followed by 25-0 kg NP/ha with maximum kernel abnormalities.

Bahmanyar and Mashaee (2010) conducted this research to investigate the effects of topdressing of different rates of nitrogen (N) and potassium (K) on grain yield and yield components of rice (*Oryza sativa cv. Tarrom*) and to observe N and K content of upper leaves analyzed at ten different times. A pot experiment was carried out on a completely randomized design with seven replications under greenhouse conditions at the Experiment Station of Sari Agricultural Sciences and Natural Resources University, Iran, during the growing season in 2008. Nitrogen was applied in the form of urea (46% N) at the rates of 0, 23 and 46 kg N/ha and potassium in the form of potassium chloride (60% K_2O) at the rates of 0, 30 and 60 kg/ha K_2O. Results indicated that panicle length, plant height, number of tiller, number of grain per panicle, hollow grain percentage, grain and biological yield were significantly affected by N and K fertilization. Maximum grain yield (75.46 g/pot) occurred at 23 kg N/ha and 30 kg/ha K_2O. At flowering stage, K content of stems were higher than leaves, and N content in flag leaves was higher than other plant parts.

Singh *et al.* (2003) also reported that crop growth rate and relative growth rate such as total dry matter production was significantly influenced by NPK. The tiller number and total dry matter production are closely correlated with yield depending on the rice cultivar which can be greatly enhanced by applying proper nutrient.

Mishra *et al.* (1994) carried out a field experiment with rice cv. Sita giving 0 or 80 kg N ha^{-1} as urea, USG and neem, lac, rock phosphate or karanj coated urea and showed that the highest grain yield was (3.39 t ha^{-1}) obtained by urea in three split applications.

2.3 Combined effect of variety and urea fertilization method on the growth and yield of rice

Russo (1996) was carried an experiments in order to compare the effects from slow-release N-fertilizers (ISODUR) and pro-ducts integrated with diciandiamide (DCD), a nitrification inhibitor, with the N splitting method applied in two or three times on the rice growth and yield. The effect of increasing N rate at preplant time compared with the top-dressing application was also determined. Fertilizers treatments were applied on two commercial rice cultivars, Baldo and Panda. Different types of N fertilizers were compared with N split applications based on two or three times. Plant growth (height), plant development (days to heading and ripening), rice yield, yield components, and quality were monitored. Results showed that split fertilization with N topdressed at panicle initiation stage was more effective in rice yielding than preplant only application, independently from the N rate. Commercial "slow-release" fertilizer and ammonium sulphate were less effective in rice production. Compared to urea, inhibitor of nitrification, Diciandiammide (DCD) was the top yielding treatment, when applied with the split method. The fertilization method, based on three split N applications, showed no significant yielding differences compared to the two times method. Application of slow-release fertilizers (110 kg/ha N) produced a significant decrease of rice yield. Thus, the effect on rice production of the Isodur N release pattern appears insufficient due mainly to the lack of synchronism with the peaks of plant nitrogen demand. The interaction between varieties and treatments resulted statistically insignificant ($p<0.05$).

Perez *et al.* (1996) was observed that Rice yields of 10 and 6 t/ha can be achieved in the humid tropics during the dry and wet seasons, respectively. At these high yield levels, late nitrogen (N) fertilizer application at flowering at the International Rice Research Institute (IRRI) farm often results in increased rough rice yield of IR cultivars and is accompanied by higher milled rice protein and increased total and head-milled rice contents. The combined effects of N application at flowering resulted in a 30-60% increase in head-rice protein yield in three field experiments. In general, milled rice translucency improved, but Kett whiteness decreased with late N fertilizer application.Brown-rice weight was not affected by late N application. In most cases, there was a significant positive correlation between head rice content, milled rice protein and translucency. Thus, when crop management seeks to achieve yields that approach yield potential levels, late N fertilizer application provides an option to improve milling and nutritional quality of rice grain.

Honjyo *et al.* (1980) was observed that using the 5 varieties grown on the field with sufficient nitrogen fertilizer as the basal dressing, to investigated the effect of nitrogen topdressing and foliar application of urea at full heading time on the translocation of nitrogen from the leaves and culms to the ears and the protein content of brown rice. 1. The amount of dry matter production increased 40% by topdressing and 36% by foliar application compared with non-topdressing on the average of 5 varieties. 2. The recovery rates of nitrogen applied at full heading time were 53~73% on the topdressing plots and 74~84% on the foliar application plots. The recovery rates of nitrogen on the foliar application plots were higher than those of the topdressing plots. 3. The distribution ratio of nitrogen to ears was about 50% of the nitrogen recovered on the topdressing plots and about 60% of the nitrogen recovered on the foliar application plots. 4. On the topdressing plots, 9~17% of the nitrogen of the ears at harvest time was translocated from the leaf blades and little or nothing from the leaf sheaths or the culms, and the nitrogen absorbed from the soil was 68~76%. On the foliar application plots, the translocation of nitrogen from the other organs and the soil to the ears showed almost the same tendency as the topdressing plots. 5. The protein content of brown rice increased 23% by nitrogen topdressing and 48% by foliar application of urea at full heading tinle on the average of 5 varieties compared with the non-topdressing plots. The foliar application of urea was more effective than the nitrogen topdressing on the increase of protein of brown rice when the same amount of nitrogen was applied.

Ghaley (2012) was observed that the uptake of urea fertilizer (NDFF), applied with 150 kg nitrogen (N) ha^{-1}, topdressed in five splits of 30 kg N ha^{-1} (30 N) each at 7, 26, 45, 70 and 83 days after transplanting (DAT) of rice (Oryza sativa L.), was investigated in an improved (Khangma Maap, KM) and a traditional (Janam, JN) cultivar in Bhutan highlands, using enriched 15N stable isotope. Although cultivar differences were not recorded in soil N accumulation and in total dry matter N, KM produced 21% higher grain yields compared to JN due to higher grain harvest index and partial factor productivity of N. Irrespective of the cultivars, topdressing timing had significant effects on NDFF, with highest mean N recovery (REN) of 29% of applied 30 N at 45 DAT during active tillering stage, resulting in mean NDFF total (grain + straw) uptake of 8.71 kg N ha^{-1} compared to least effective topdressing timing at 7 DAT with mean REN of 12% and NDFF total of 3.51 kg N ha^{-1}. In similarity to topdressing at 45 DAT, topdressing at 70 DAT (panicle initiation stage) was equally effective with mean REN of 27% across the cultivars. Hence, fertilizer N topdressing recommendations that combine use of improved cultivars with N applications timed to coincide with maximum crop demand at 45 and

70 DAT, could enhance N fertilizer use efficiency for increased rice yields as well as reduce N losses downstream, which can cause adverse off-site environmental effects.

Pal *et al.* (2008) were carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during July to December 2006 to study the root growth of four Transplant Aman rice varieties as influenced by NPKS fertilization. The experiment was laid out in a split-plot design with three replications. The experiment consisted of four varieties viz. BRRI dhan 30, BRRI dhan 3l, BRRI dhan 40 and BRRI dhan 4l; and four levels of fertilizers viz. 0, 50%, 100% and 150% of the recommended dose of NPKS. BRRI dhan 4l had better performance in all root parameters. All root parameters except number of roots/hill performed better at high level of fertilizer. The interaction effect between variety and fertilizer level was significant in respect of number of roots/hill, fresh weight of root (except at 30 days after transplanting (DAT) and 90 DAT), dry weight of root, fresh weight of above ground plant part (except at 30 DAT and 90 DAT) and dry weight of above ground plant part (except at 90 DAT).

Azam *et al.* (2012) was conducted a field experiment at the agronomy field of Sher-e-Bangla Agricultural University, Dhaka during with the objectives to find out the influence of variety and different urea fertilizer application method on growth and yield of *boro* rice. Result showed that variety and urea fertilizer application method had significant effect on plant height, tillers hill^{-1}, dry weight hill^{-1}, leaf area index, grain panicle^{-1}, 1000-grain weight, grain yield, straw yield and harvest index. BRRI hybrid dhan2 showed the highest plant height (108 cm), number of tillers hill^{-1} (23.98), dry weight hill^{-1} (84.14 g), leaf area index (7.12), grains panicle^{-1} (131.20), 1000-grain weight (26.12 g), grain yield (4.79 t ha^{-1}), straw yield (6.80 t ha^{-1}) and harvest index (41.25%) at harvest. With the combined effect of different boro rice variety and methods of urea application the highest number of tillers hill^{-1} (28.00 at harvest), dry weight hill^{-1} (90.59 g at harvest), leaf area index (7.87 at harvest), grains panicle^{-1} (146.20), 1000-grain weight (26.79 g), grain yield (5.41 t ha^{-1}) and straw yield (7.20 t ha^{-1}) was at V_3 T_1 . So, V_3 T_1 (BRRI hybrid dhan2 × 2.7 g size USG placement at 8 DAT) was the best treatment.

Alim (2012) was carried an experiment was conducted to study the effect of different sources and doses of nitrogen application on the yield formation of *boro* rice. Two *indica* modern *boro* rice varieties (BRRI dhan28 and BRRI dhan36) and 21 nitrogen fertilizer combinations were used in the experiment. Among the two varieties BRRI dhan28 produced higher grain and straw yield. Grain and straw yields were increased with the increase of nitrogen rate up to 120 kg ha^{-1} at all the sources. In general, organic manures alone could not produce higher grain yield but the combination of organic and inorganic fertilizers produced higher yield. The application of 60 kg N ha^{-1} as urea with 60 kg N ha^{-1} as mustard oil cake (MOC) produced maximum grain and straw yield which was statistically similar to the yield of 50 kg N ha-1 as urea with 50 kg N ha-1 as MOC. The lowest values were found in control nitrogen application. The results suggest that replacement of 50% urea N by MOC was the best source of nitrogen considering higher yield of *boro* rice. Therefore, fertilization of BRRI dhan28 and BRRI dhan36 varieties of rice with 60 kg N ha^{-1} as urea and 60 kg N ha^{-1} as MOC or 50 kg N ha^{-1} as urea with 50 kg N ha^{-1} as MOC was found to be the best nitrogen rate among all the treatment combinations in respect of grain and straw yields.

Haque (1988) reported that spikelet sterility induced by low temperature at the reproductive stage of rice increased further with the increase of nitrogen supply. Spikelet sterility in Fujisaka-5 did not increase due to low temperature when nitrogen supply was increased from 10 to 40 ppm and at 80 ppm nitrogen supply it was less affected than IR36. Total nitrogen content in the leaves increased with the increase of nitrogen supply and was forced to be associated with the spikelet sterility induced by low temperature. Based on auricle distance between the last two leaves, the most sensitive stage to low temperature damage differed in Fujisaka-5 and IR36. Spikelet sterility induced by low temperature for 10 days was very high in both the varieties and the effect of nitrogen was not clear. The effect of phosphorus on the spikelet sterility induced by low temperature at reproductive stage was not clear except that at the highest phosphorus (p) level (10 ppm) the spikelet sterility increased both in Fujisaka-5 and IR 36. Spikelet sterility induced by low temperature at the reproductive stage of rice decreased with the increase of potassium (K) supply in both Fujisaka-5 and IR36. With an increase of potassium supply, nitrogen (N) content decreased in the leaves and panicles and spikelet sterility induced by low temperature decreased with an increase of the K to N ratio in the leaves and panicles. The results suggest that potassium might play a major role to counteract the low temperature damage at the reproductive stage of rice.

From the above reviews it is cleared that method of urea application has profound influence on the yield and yield contributing characters of *Boro* rice. Thus there may have enough scope investigating the method of urea application in favour of yield improvement of *Boro* rice cv. BRRI dhan28 and BRRI hybrid dhan2.

CHAPTER 3
MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December 2013 to July 2014. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout of the experimental design, intercultural operations, data recording and their analyses.

3.1 Site Description

3.1.1 Geographical Location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The area had sub tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March).

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranges from 5.4-5.6 and had organic carbon 0.82%. The experimental area was flat having available irrigation and drainage system and above flood level.

3.2 Details of the Experiment

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

A. Variety (2):

1. BRRI dhan28 (inbred)-V_1 and
2. BRRI hybrid dhan2 (hybrid)-V_2

B. Methods of urea application (6):

1. 100% Urea of the recommended dose (RD) applied as 3 top dressing (T_1)
2. 100% Urea of RD applied as 3 foliar spray (T_2)
3. 100% Urea of RD applied as 1 top dressing and 2 foliar spray (T_3)
4. 75% Urea of RD applied as 1 top dressing and 2 foliar spray (T_4)
5. 75% Urea of RD applied as 3 foliar spray (T_5)
6. 50% Urea of RD applied as 3 foliar spray (T_6)

3.2.2 Experimental design

The experiment was laid in a split-plot design with three replications having variety in the main plots and methods of urea application in the sub-plots. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 4.0 m by 2.0 m. The distances between plot to plot and replication to replication were 1 m and 0.5 m respectively. The layout of the experiment has been shown in Appendix II.

3.3 Description of Variety

Two rice varieties (BRRI dhan28 and BRRI hybrid dhan2) were used as variety.

3.3.1 BRRI dhan28

BRRI dhan28, a high yielding variety of *boro* rice was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. It was released in 1994. The plant grows up to 90 cm height. Seed to seed duration is 140 days. The appropriate time for seed sowing is mid December to 1st week of January and transplanting should be done within 20 January to 25 January. The variety is harvested from 1-25 May and approximate yield is 5.5-6.0 t ha^{-1} (BRRI, 2010).

3.3.2 BRRI hybrid dhan2

BRRI hybrid dhan2, a hybrid variety suitable for the *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. The pedigree line of the variety is BR10H, and NSB released the variety for mass cultivation in Dhaka, Comilla, Jessore and Rajshahi in 2008. It takes about 140 to145 days to mature. It attains a plant height of 105 cm at maturity and the flag leaf remains green and erect. The grains are medium bold with light golden husks and kernels are white in color. This genotype is known for its medium bold grains and the cultivar gives an average grain yield of 8.0 t ha^{-1}(BRRI, 2010).

3.4 Crop Management

3.4.1 Raising of Seedling

3.4.1.1 Seed collection

Seeds of BRRI dhan28 and the hybrid rice seed BRRI hybrid dhan2 were collected from Genetic Resource and Seed Division, BRRI, Joydebpur, Gazipur, Bangladesh.

3.4.1.2 Seed sprouting

Healthy seeds were selected by following specific gravity method. Seeds were immersed into water in a bucket for 24 hours. These were then taken out of water and kept tightly in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.4.1.3 Preparation of seedling nursery

A common procedure was followed in raising of seedlings in the seedbed. The nursery bed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.4.1.4 Seed sowing

Seeds were sown on the seedbed on December 1, 2013 for raising nursery seedlings.

3.4.2 Preparation of experimental land

The experimental field was first opened on December 24, 2013 with the help of a tractor drawn disc plough, later on January 7, 2014 the land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor plough and subsequently leveled by laddering. All kinds of weeds and residues of previous crop were removed from the field. After the final land preparation the field layout was made on January 8, 2014 according to experimental plan. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

3.4.3 Fertilizer application

The experimental plots were fertilized with recommended doses of 220, 80, 120, 100 and 5 kg ha^{-1} N, P_2O_5, K_2O, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at final land preparation. Urea was applied as per the treatments in three equal installments. The first dose of urea was applied after seedling recovery, second during the vegetation stage and third at 7 days before panicle initiation (BRRI, 2010).

3.4.4 Uprooting and transplanting of seedlings

The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. The 37 days old nursery seedlings were uprooted carefully on January 8, 2014 and were kept in soft mud in shade**.** The seedlings were then transplanted with 25 cm × 15 cm spacing on the well-puddled plots.

3.4.5 Intercultural operations

3.4.5.1 Thinning and gap filling

A minor gap filling was done as and where necessary using the seedling or separated clonal tillers from the previous source as per treatment. No thinning was done for any treatment.

3.4.5.2 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Two hand weedings were done for each treatment; first weeding was done at 20 days after transplanting followed by second weeding at 15 days after first weeding.

3.4.5.3 Application of irrigation water

Irrigation water was added to each plot according to the need. All the plots were kept irrigated maintaining 3-5 cm stagnant water throughout the entire period upto 15 days before harvesting.

3.4.5.4 Plant protection measures

Plants were infested with rice stem borer (*Scirphophaga incertolus*) and leaf hopper (*Nephotettix nigropictus*) to some extent which were successfully controlled by applying Diazinon @ 10 ml/10 liter of water for 5 decimal lands and by Ripcord @ 10 ml/10 liter of water for 5 decimal lands as and when needed. Crop was protected from birds during the grain filling period. For controlling the birds watching was done properly, especially during morning and afternoon.

3.4.5.5 General observation of the experimental field

The field was investigated time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable losses by pest could be minimized. The field looked nice with normal green color plants. Incidence of stem borer, green leaf hopper, leaf roller and rice hispa was observed during tillering stage that controlled properly. No bacterial and fungal disease was observed in the field.

3.4.5.6 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. Ten pre-selected hills plot^{-1} from which different crop growth data were collected and 5 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done using by pedal thresher. The grains were cleaned and sun dried to moisture content of about 12%. Straw was also sun dried properly. Finally grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}.

3.4.6 Recording of data

Experimental data were recorded from 25 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of hills at different dates from the inner rows leaving border rows and harvest area for grain. The followings data were recorded during the experiment.

A. Crop growth characters

i. Plant height (cm) at 25 days interval from 25 DAT to harvest
ii. Number of tillers hill^{-1} at 25 days interval from 25 DAT to harvest
iii. Leaf area index at 25 days interval from 25 DAT to harvest
iv. Dry weight of plant at 25 days interval from 25 DAT to harvest

B. Yield and other crop characters

i. Number of effective tillers hill^{-1}
ii. Number of ineffective tillers hill^{-1}
iii. Length of panicle (cm)
iv. Number of rachis branches panicle^{-1}
v. Number of filled grains panicle^{-1}
vi. Number of unfilled grains panicle^{-1}
vii. Number of total grains panicle^{-1}
viii. Weight of 1000 grains (g)
ix. Grain yield (t ha^{-1})
x. Straw yield (t ha^{-1})
xi. Biological yield (t ha^{-1})
xii. Harvest index (%)

3.4.7 Detailed procedures of recording data

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

A. Crop growth characters

i. Plant height (cm)

Plant height was measured at 25, 50, 75 DAT and at harvest. The height of the randomly pre-selected 5 hills plot^{-1} was determined by measuring the distance from the soil surface to the tip of the leaf height before heading, and to the tip of panicle after heading. The collected data were finally averaged.

ii. Number of tillers hill^{-1}

Number of tillers hiil^{-1} were counted at 25, 50, 75 DAT and at harvest from five randomly pre-selected hills and averaged as their number hill^{-1}. Only those tillers having three or more leaves were considered for counting.

iii. Leaf Area Index (LAI)

Leaf area index were estimated measuring the length and width of leaf and multiplying by a factor of 0.75 followed by Yoshida (1981).

iv. Dry weight of plant (g)

Two hills plot^{-1} was uprooted from second line and oven dried (sub-sample) until a constant level from which the average weights of dry matter were recorded.

B. Yield and other crop characters

i. Effective tillers hill^{-1} (no.)

The panicles which had at least one grain was considered as effective tillers. The number of effective tillers 5 hill^{-1} was recorded and finally averaged for counting effective tillers number hill^{-1}.

ii. Ineffective tillers hill^{-1} (no.)

The tiller having no panicle was regarded as ineffective tillers. The number of ineffective tillers 5 hill^{-1} was recorded and finally averaged for counting ineffective tillers number hill^{-1}.

iii. Panicle length (cm)

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 10 panicles.

iv. Rachis branches panicle^{-1} (no.)

Primary branches of panicle that contains a number of spikelet termed as rachis branches. The number of total rachis branches present on ten panicles were recorded and finally averaged.

v. Filled grains panicle^{-1} (no.)

Grain was considered to be filled if any kernel was present there in. The number of total filled grains present on ten panicles were recorded and finally averaged.

vi. Unfilled grains panicle^{-1} (no.)

Unfilled grains means the absence of any kernel inside in and such grains present on each of ten panicles were counted and finally averaged.

vii. Total grains panicle^{-1} (no.)

The number of filled grains panicle^{-1} plus the number of unfilled grains panicle^{-1} gave the total number of grains panicle^{-1}.

viii. Weight of 1000 grains (g)

One thousand cleaned dried grains were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained about 12% moisture and the mean weight were expressed in gram.

ix. Grain yield (t ha^{-1})

Grain yield was determined from the central 5 m^2 area of each plot and expressed as t ha^{-1} on about 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

x. Straw yield (t ha^{-1})

Straw yield was determined from the central 5 m^2 area of each plot. After separating of grains, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1}.

xi. Biological yield (t ha^{-1})

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

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})

xii. Harvest Index (%)

It denotes the ratio of economic yield to biological yield and was calculated with following formula (Donald, 1963; Gardner *et al*., 1985).

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

3.4.8 Statistical Analyses

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5 % level of significance. (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

The results of the study regarding the growth and yield of *boro* rice as affected by method of urea application have been presented with possible interpretations under the following headings:

4.1 Plant height at different days after transplantation

4.1.1 Effect of variety

The plant height of *boro* rice was not significantly influenced by different varieties at 25, 50 and 75 days after transplanting (DAT) and at harvest (Appendix III and Table 1). Numerically the result revealed that at 25 DAT, hybrid variety BRRI hybrid dhan2 produced taller plant (25.59 cm) and the inbred variety BRRI dhan28 gave the shorter plant (22.11 cm) and the same trend of plant height for hybrid variety over inbred variety was obtained at 50 and 75 DAT and at harvest.

In the initial stage of growth, the increase of plant height was very slow and the crop remained in vegetative stage. The rapid increase of plant height was observed from 25 to 75 DAT. After reaching the maximum vegetative stage, the growth of plant became slow. Probably the genetic makeup of varieties was responsible for the variation in plant height. This confirms the reports of Shamsuddin *et al.* (1988) that plant height differed due to varietal variation. Main (2006) observed highest plant height in hybrid variety and the lowest in inbred variety. This finding disagreed with Debnath (2010) who observed highest plant height in inbred variety and the lowest in hybrid variety.

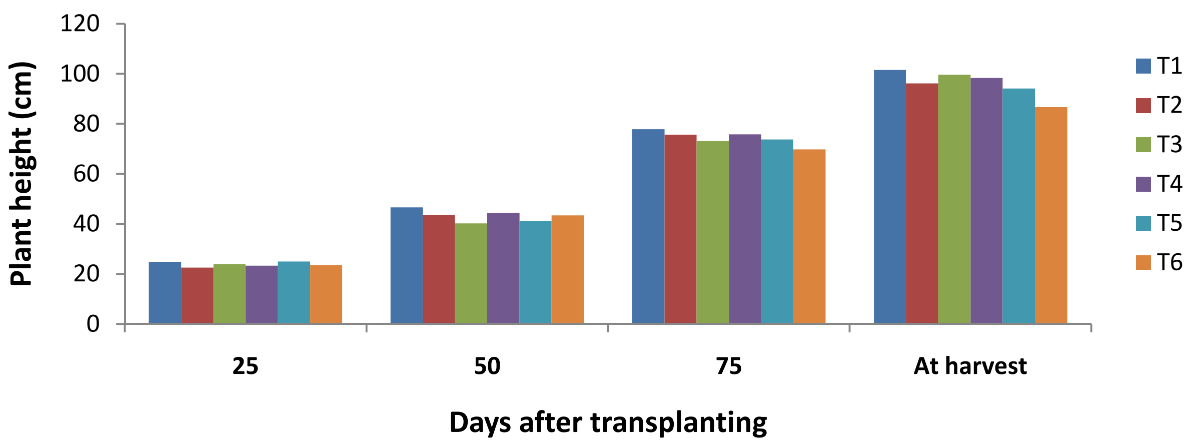
Table 1. Effect of variety on plant height at different growth duration of inbred and hybrid *boro* rice

Treatments	Plant height (cm) at different DAT			
	25	50	75	At harvest
V_1 (BRRI dhan28)	22.11	39.92	70.97	92.40
V_2 (BRRI hybrid dhan2)	25.59	42.50	77.68	99.71
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	24.67	13.46	14.72	7.92

NS = Not significant

4.1.2 Effect of N-Management

Significant variation of plant height was found due to nitrogen fertilizer doses and application methods at 50, 75 DAT and at harvest (Appendix III and Figure 1). At 25 DAT the plant height was statistically insignificant but numerically the maximum plant height (24.97 cm) was obtained from the T_5 and the minimum plant height (22.49 cm) was obtained from the T_2 treatment. At 50 DAT, the tallest plant (46.68 cm) was recorded from T_1 followed by T_2 (43.63 cm), T_4 (44.44 cm) and T_6 (43.41 cm) and the shortest plant was obtained from T_3 (40.23 cm) which was statistically similar with T_5 (41.14 cm). At 75 DAT, the tallest plant (77.90 cm) was recorded from T_1 followed by T_2 (75.65 cm) and T_4 (75.78 cm) and the shortest plant was obtained from T_6 (69.75 cm) which was statistically similar with T_3 (73.17 cm) and T_5 (73.72 cm). At harvest, the tallest plant (101.5 cm) was found from T_1 followed by T_3 (99.62 cm) and T_4 (98.30 cm) and the shortest plant was obtained from T_6 (86.73 cm) which was statistically similar with T_2 (96.15 cm) and T_5 (94.07 cm). Chopra and Chopra (2004) reported that nitrogen had significantly effects on plant height. These findings are in agreement with the findings of Singh and Singh (1986) who reported that plant height increased with the increase of nitrogen level.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray

Figure 1. Effect of different doses of nitrogen fertilizer and application methods on plant height (cm) at different days after transplanting ($LSD_{0.05}$ = NS, 5.075, 6.901 and 10.850 at 25, 50 and 75 DAT and at harvest, respectively).

4.1.3 Interaction effect of variety and N-management

Significant interaction effect between the variety and N-management on plant height was observed at 25, 50 and 75 DAT (Appendix III and Table 2). The results revealed that at 25 DAT, the tallest plant (28.45 cm) was obtained from the T_1 of the hybrid variety (V_2) which was statistically similar with the T_5 of the hybrid variety V_2 (27.43 cm) and the shortest plant (19.95 cm) was obtained from the T_6 of the inbred variety (V_1) which was statistically similar with the T_1 (21.21 cm) of the inbred variety (V_1). At 50 DAT, the tallest plant (47.99 cm) was obtained from the T_1 of the hybrid variety (V_2) which was statistically similar with the T_1 (45.37 cm) and T_2 (45.17 cm) of the inbred variety (V_1) and the shortest plant (37.87 cm) was obtained from the T_6 of the inbred variety (V_1). At 75 DAT, the tallest plant (80.97 cm) was obtained from the T_2 of the inbred variety (V_1) which was statistically similar with the T_1 (79.27 cm) and T_4 (79.10 cm) of the inbred variety (V_1) and the shortest plant (68.37 cm) was obtained from the T_3 of the hybrid variety (V_2) which was statistically similar with the T_5 (68.90 cm) and T_6 (69.23 cm) of the hybrid variety (V_2). Interaction effect between the variety and N-management on plant height was statistically insignificant at harvest, numerically the tallest plant (104.6 cm) was obtained from the T_1 of the hybrid variety (V_2) and the shortest plant (73.67 cm) was obtained from the T_6 of the inbred variety (V_1). This may be due to higher nutrient use efficiency through foliar application. Sarandon and Asborno (1996) carried out a field trial to study the effect of foliar urea spraying on three rice cultivars and found that biomass production was not varied due to foliar application. But Amin *et al.* (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. They found that increased fertilizer dose of NPK increase plant height.

Table 2. Interaction effect of variety and N-management on plant height at different growth duration of inbred and hybrid *boro* rice

Treatments		Plant height (cm) at different DAT			
		25	50	75	At harvest
V_1	T_1	21.21 de	45.37 a	79.27 ab	98.33
	T_2	22.95 b-e	45.17 a	80.97 a	92.90
	T_3	22.75 b-e	44.77 ab	77.97 a-d	99.70
	T_4	23.32 a-e	44.89 ab	79.10 ab	96.60
	T_5	22.50 b-e	41.17 ab	78.53 abc	93.20
	T_6	19.95 e	37.87 b	70.27 bcd	73.67
V_2	T_1	28.45 a	47.99 a	76.53 a-d	104.6
	T_2	22.03 cde	42.09 ab	70.33 bcd	99.40
	T_3	25.17 a-d	42.05 ab	68.37 d	99.53
	T_4	23.38 a-e	44.00 ab	72.47 a-d	100.0
	T_5	27.43 ab	41.11 ab	68.90 cd	94.93
	T_6	27.07 abc	42.59 ab	69.23 cd	99.80
$LSD_{(0.05)}$		5.163	7.178	9.760	NS
CV (%)		12.71	9.74	7.71	9.38

V_1 - (BRRI dhan28), V_2 – (BRRI hybrid dhan2), NS – Not Significant

T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

4.2 Number of tillers hill^{-1} at different days after transplantation

4.2.1 Effect of variety

The production of total number of tillers hill^{-1} of *boro* rice was statistically insignificant and was not influenced by different varieties (Appendix IV and Table 3). Numerically higher number of tillers hill^{-1} at 25 and 50 DAT was observed in the hybrid variety V_2 (BRRI hybrid dhan2) and the lower number of tillers hill^{-1} was obtained from the inbred variety V_1 (BRRI dhan28). At 75 DAT and at harvest higher number of tillers hill^{-1} was observed in the inbred variety V_1 (BRRI dhan28) and the lower number of tillers hill^{-1} was obtained from the hybrid variety V_2 (BRRI hybrid dhan2). Number of tillers hill^{-1} can be different in different varieties due to genetical build-up. Roy *et al.* (2014) found that, number of tillers hill^{-1} at different days after transplanting varied significantly among the varieties up to harvest where maximum number of tillers $hill^{-1}$ was observed in Sylhety boro and minimum in Bere ratna. Ashrafuzzaman (2006) observed that varieties differed significantly in respect of varietal variation. On the other hand it was observed by Debnath (2010) that BRRI dhan29 produced higher number of tillers $hill^{-1}$ compared to BRRI hybrid dhan2 insignificantly.

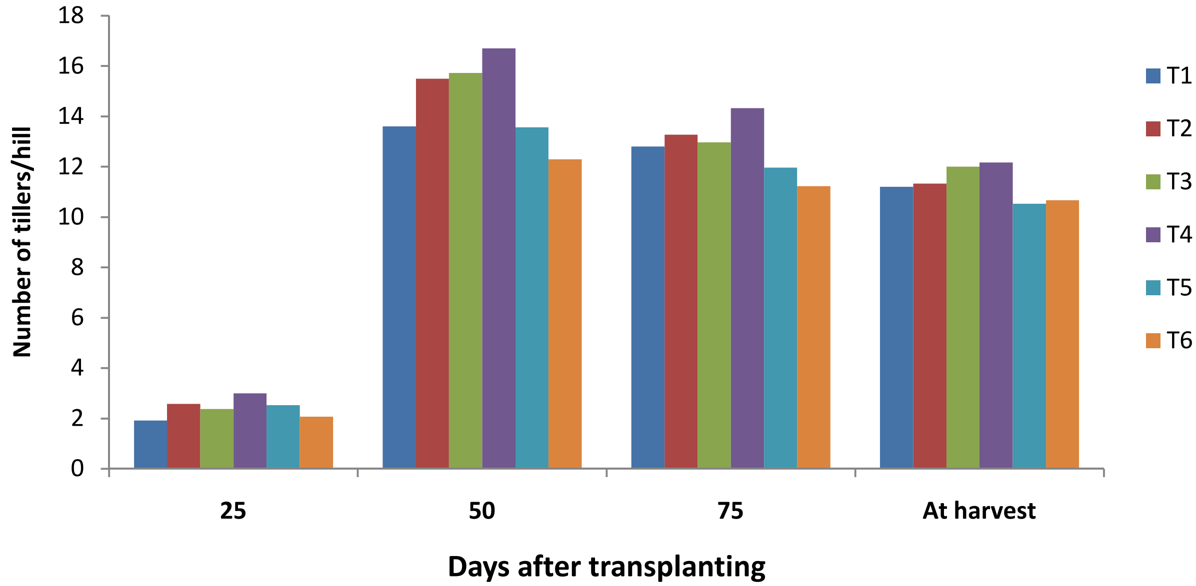
Table 3. Effect of variety on number of tillers $hill^{-1}$ at different growth duration of inbred and hybrid *boro* rice

Treatments	Number of tillers $hill^{-1}$ at different DAT			
	25	50	75	At harvest
V_1 (BRRI dhan28)	2.30	13.82	12.86	12.17
V_2 (BRRI hybrid dhan2)	2.52	15.31	12.67	10.47
LSD $_{(0.05)}$	NS	NS	NS	NS
CV (%)	12.78	4.95	13.57	10.54

NS = Not significant

4.2.2 Effect of N-management

The total number of tillers $hill^{-1}$ was significantly influenced by different nitrogen fertilizer doses and application methods at 25, 50 and 75 DAT but insignificant at harvest (Appendix IV and Figure 2). At 25 DAT the highest numbers of tillers $hill^{-1}$ was observed in T_4 (3.00) whereas the lowest numbers of tillers $hill^{-1}$ was observed in T_1 (1.92) which was statistically similar with T_6 (2.07). At 50 DAT and 75 DAT the highest number of tillers $hill^{-1}$ (16.70 and 14.33 respectively) was observed in T_4 which was statistically similar with T_1 (13.60 and 12.80 respectively), T_2 (15.50 and 13.27 respectively), and T_3 (15.73 and 12.97 respectively), and the lowest numbers of tillers $hill^{-1}$ was obtained from T_6 (12.30 and 11.23 respectively) which was statistically similar with T_5 (13.57 and 11.97 respectively). At harvest numerically the highest numbers of tillers $hill^{-1}$ was obtained from T_6 (12.17) and the lowest numbers of tillers $hill^{-1}$ was obtained from T_5 (10.53). Foliar application of Urea gave higher performances than soil application. Bayan and Kandasamy (2002) reported that tillers $hill^{-1}$ increased with the application of nitrogen fertilizer. Ndaeyo *et al.* (2008) conducted an experiment where they found that higher rates of NPK resulted higher number of tillers per plant.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray

Figure 2. Effect of different doses of nitrogen fertilizer and application methods on number of tillers hill^{-1} at different days after transplanting ($LSD_{0.05}$ = 1.122, 3.571, 2.107 and NS at 25, 50 and 75 DAT and at harvest, respectively).

4.2.3 Interaction effect of variety and N-management

Significant interaction effect between the variety and N-management on number of tillers hill^{-1} was observed at 25, 50 and 75 DAT and at harvest (Appendix IV and Table 4). The results revealed that at 25 DAT, the highest numbers of tillers hill^{-1} was observed in T_3 (3.07) of the hybrid variety (V_2) which was statistically similar with T_4 (3.00) of the hybrid variety (V_2) and T_4 (3.00) of the inbred variety (V_1) followed by T_3 (1.67) of the inbred variety (V_1) which was statistically similar with T_1 (1.90) of the inbred variety (V_1) and T_1 (1.90) of the hybrid variety (V_2). At 50 DAT highest number of tillers hill^{-1} were obtained from T_4 (18.53) of the hybrid variety (V_2) which was statistically similar with T_4 (16.80) of the inbred variety (V_1) followed by T_6 (12.07) of the inbred variety (V_1) which was statistically similar with the T_5 (12.53) of the hybrid variety (V_2). Highest numbers of tiller hill^{-1} at 75 DAT was observed T_4 (15.33) of the inbred variety (V_1) which was statistically similar with T_3 (13.93) of the hybrid variety (V_2) and the lowest numbers of tillers hill^{-1} was obtained from T_6 (10.20) of the hybrid variety (V_2) which was statistically similar with T_5 (11.60) of the inbred variety (V_1). At harvest highest number of tillers hill^{-1} were obtained from T_4 (14.00) of the inbred variety (V_1) which was statistically similar with T_3 (12.80) of the hybrid variety (V_2) and the lowest number of tillers hill^{-1} was obtained from T_6 (8.73) of the hybrid variety (V_2) which was statistically similar with T_5 (10.00) of the hybrid variety (V_2). Ahmed *et al*. (2005) found that higher N dose produced highest effective tillers hill^{-1} which ultimately leads to achieve higher total tillers per hill. Nitrogen is an essential plant nutrient and involves in enzymatic reactions, protein synthesis and is a major component of amino and nucleic acids but it is the most widely lost nutrients while applied in soil. Many studies showed that foliar urea application can reduce the nitrogen dose and increase the nutrient use efficiency.

Table 4. Interaction effect of variety and N-management on number of tillers hill^{-1} at different growth duration of inbred and hybrid *boro* rice

Treatments		Number of tillers hill^{-1} at different DAT			
		25	50	75	At harvest
V_1	T_1	1.90 fg	12.87 b	13.20 ab	12.27 a-d
	T_2	2.77 abc	15.07 ab	12.73 abc	11.87 a-d
	T_3	1.67 g	12.93 b	12.00 bc	11.20 bcd
	T_4	3.00 ab	16.80 ab	15.33 a	14.00 a
	T_5	2.47 cd	13.20 b	11.60 bc	11.07 b-e
	T_6	2.00 efg	12.07 b	12.27 bc	12.60 abc
V_2	T_1	1.93 fg	14.33 ab	12.40 abc	10.13 de
	T_2	2.40 cde	15.93 ab	13.80 ab	10.80 b-e
	T_3	3.07 a	16.60 ab	13.93 ab	12.80 ab
	T_4	3.00 ab	18.53 a	13.33 ab	10.33 cde
	T_5	2.60 bc	12.53 b	12.33 bc	10.00 de
	T_6	2.13 def	13.93 ab	10.20 c	8.73 e
LSD $_{(0.05)}$		1.587	5.050	2.979	2.368
CV (%)		10.38	7.85	13.71	12.29

V_1 - (BRRI dhan28), V_2 – (BRRI hybrid dhan2)

T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

4.3 Leaf area index at different days after transplantation

4.3.1 Effect of variety

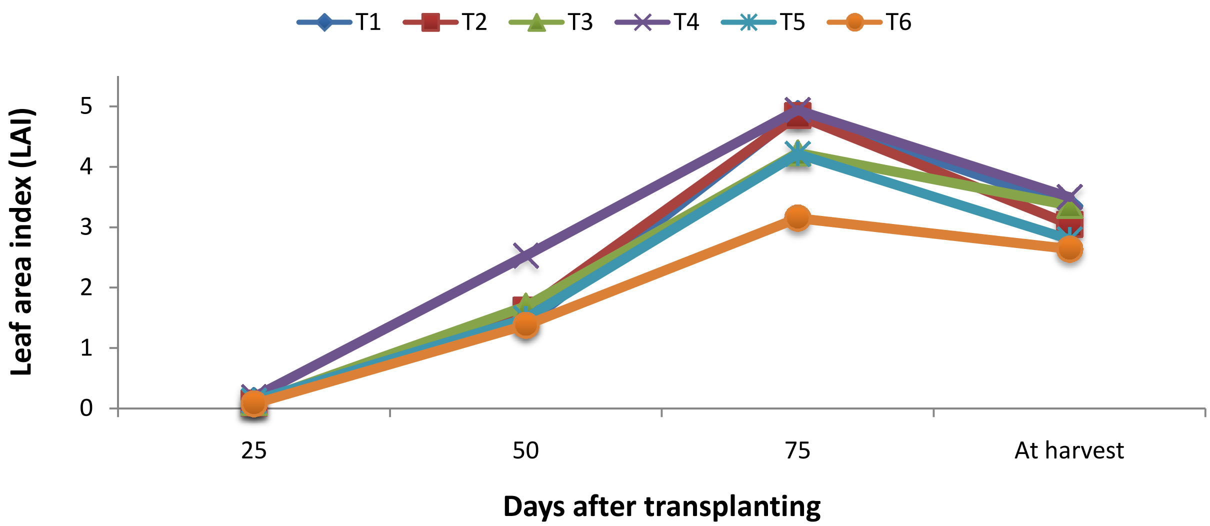
Varietal effect significantly influenced leaf area index (LAI) of *boro* rice at 25 DAT, 50 DAT and 75 DAT and at harvest (Appendix V and Table 5). At 25 DAT, 50 DAT, 75 DAT and at harvest, the higher leaf area index (0.15, 1.99, 4.71 and 3.78 respectively) was found in the hybrid variety V_2 (BRRI hybrid dhan2) and the lower leaf area index (0.10, 1.37, 4.04 and 2.46, respectively) was found in the inbred variety V_1 (BRRI dhan28). This might be due to the production of comparatively lower tillers of the inbred variety than the hybrid variety which consequently decreased the number of leaves plant^{-1} and leaf area index. This finding disagreed with Ahmed (2006) who observed highest leaf area index in BRRI dhan29 than hybrid variety.

Table 5. Effect of variety on leaf area index at different growth duration of inbred and hybrid *boro* rice

Treatments	Leaf area index at different DAT			
	25	50	75	At harvest
V_1 (BRRI dhan28)	0.10 b	1.37 b	4.04 b	2.46 b
V_2 (BRRI hybrid dhan2)	0.15 a	1.99 a	4.71 a	3.78 a
LSD $_{(0.05)}$	0.045	0.523	0.281	1.074
CV (%)	8.26	21.65	19.96	18.63

4.3.2 Effect of N-management

Nitrogen fertilizer doses and application methods significantly influenced leaf area index (LAI) of *boro* rice was at 25, 50 and 75 DAT and at harvest (Appendix V and Figure 3). At 25 DAT, T_4 produced the highest leaf area index (0.19) and T_6 treatment produced the lowest leaf area index (0.08) which was statistically similar with T_2 (0.09) and T_3 (0.10). At 50 DAT highest leaf area index (2.53) was observed in T_4 and the lowest was observed in T_6 (1.38) which was statistically similar with T_1 (1.39) and T_5 (1.49). The highest leaf area index (4.94) at 75 DAT was obtained from T_4 which was statistically similar with T_1 (4.88), T_2 (4.85), T_3 (4.23) and T_5 (4.21) and the lowest leaf area index (3.15) was observed in $T_{6.}$ At harvest T_4 produced the highest leaf area index (3.50) which was statistically similar with all treatments except T_6 (2.64) that showed the lowest leaf area index which was statistically similar with all treatments except T_4 (3.50). Ndaeyo *et al.* (2008) conducted an experiment where they found that higher rates of NPK resulted higher number of leaves per plant.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray

Figure 3. Effect of different doses of nitrogen fertilizer and application methods on leaf area index at different days after transplanting ($LSD_{0.05}$ = 0.038, 0.170, 1.052 and 0.812 at 25, 50 and 75 DAT and at harvest, respectively).

4.3.3 Interaction effect of variety and N-management

Interaction effect of variety and N-management significantly influenced leaf area index (LAI) of *boro* rice at 25, 50 and 75 DAT and at harvest (Appendix V and Table 6). At 25 DAT, V_2T_4 produced the highest leaf area index (0.22) and the lowest LAI was observed in V_1T_3 (0.06) which was statistically similar with V_1T_1 (0.10), V_1T_2 (0.08), V_1T_5 (0.11) and V_1T_6 (0.08). At 50 DAT the highest LAI was obtained from V_2T_4 (2.78) and the lowest LAI was observed in V_1T_1 (0.99) which was statistically similar with V_1T_2 (1.08) and V_1T_3 (1.05). Highest LAI at 75 DAT was observed in V_2T_4 (5.29) which was statistically similar with V_2T_1 (5.30), V_2T_2 (5.03) and V_2T_5 (4.79) and the lowest LAI was observed in V_1T_6 (3.08) which was statistically similar with V_1T_5 (3.62) and V_2T_6 (3.2). At harvest the highest LAI (4.61) was obtained from V_2T_3 which was statistically similar with V_2T_1 (4.24), V_2T_2 (3.61), V_2T_4 (3.84) and V_2T_5 (3.56) and the lowest LAI (2.03) was obtained from V_1T_5 which was statistically similar with V_1T_1 (2.45), V_1T_2 (2.50), V_1T_3 (2.10), V_1T_4 (3.17), V_1T_6 (2.49) and V_2T_6 (2.79). Many studies have been showed that soil urea application cannot be fully replaced by foliar spray but combination of both can surely reduce the dose. Islam *et al.* (2008b) conducted a field experiment to find out the effect of nitrogen levels and transplanting dates on Kalizira (aromatic rice) and the results revealed that most of the yield and yield contributing characters with few exceptions were significantly influenced by nitrogen levels.

Table 6. Interaction effect of variety and N-management on leaf area index at different growth duration of inbred and hybrid *boro* rice

Treatments		Leaf area index at different DAT			
		25	50	75	At harvest
V_1	T_1	0.10 bcd	0.99 e	4.46 a-d	2.45 ef
	T_2	0.08 d	1.08 e	4.66 abc	2.50 def
	T_3	0.06 d	1.05 e	3.82 a-d	2.10 f
	T_4	0.15 bc	2.29 b	4.59 abc	3.17 b-f
	T_5	0.11 bcd	1.45 d	3.62 bcd	2.04 f
	T_6	0.08 d	1.37 d	3.08 d	2.49 def
V_2	T_1	0.16 b	1.79 c	5.30 a	4.24 ab
	T_2	0.11 bcd	2.17 b	5.03 ab	3.61 a-d
	T_3	0.13 bc	2.32 b	4.63 abc	4.61 a
	T_4	0.22 a	2.78 a	5.29 a	3.84 abc
	T_5	0.16 b	1.52 d	4.79 ab	3.56 a-e
	T_6	0.10 cd	1.39 d	3.21 cd	2.79 c-f
LSD $_{(0.05)}$		0.054	0.241	1.488	1.148
CV (%)		14.39	8.38	19.96	18.63

V_1 - (BRRI dhan28), V_2 – (BRRI hybrid dhan2)

$\mathbf{T_1}$ = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, $\mathbf{T_2}$ = 100% Urea of RD was applied as 3 foliar spray, $\mathbf{T_3}$ = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, $\mathbf{T_4}$ = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, $\mathbf{T_5}$ = 75% Urea of RD was applied as 3 foliar spray, $\mathbf{T_6}$ = 50% Urea of RD was applied as 3 foliar spray.

4.4 Total dry weight at different days after transplantation

4.4.1 Effect of variety

Varietal effect significantly influenced total dry weight of *boro* rice at 25 DAT, 50 DAT and 75 DAT however; it was not significantly influenced at harvest (Appendix VI and Table 7). At 25 DAT, 50 DAT and 75 DAT, the higher total dry weight (1.05 g, 9.79 g and 37.32 g plant^{-1} respectively) was found in the hybrid variety V_2 (BRRI hybrid dhan2) and the lower total dry weight (0.42 g, 6.77 g and 33.39 g plant^{-1} respectively) was found in the inbred variety V_1 (BRRI dhan28). At harvest, inbred variety V_1 (BRRI dhan28) gave the numerically higher (30.31 g plant^{-1}) total dry weight whereas V_2 (BRRI hybrid dhan2) gave the lower (27.48 g plant^{-1}) total dry weight. Ahmed (2006) also observed higher dry weight in BRRI dhan29 compared to hybrid variety. This finding disagreed with Ahmed (2006) who observed higher dry weight in BRRI dhan29 compared to hybrid variety.

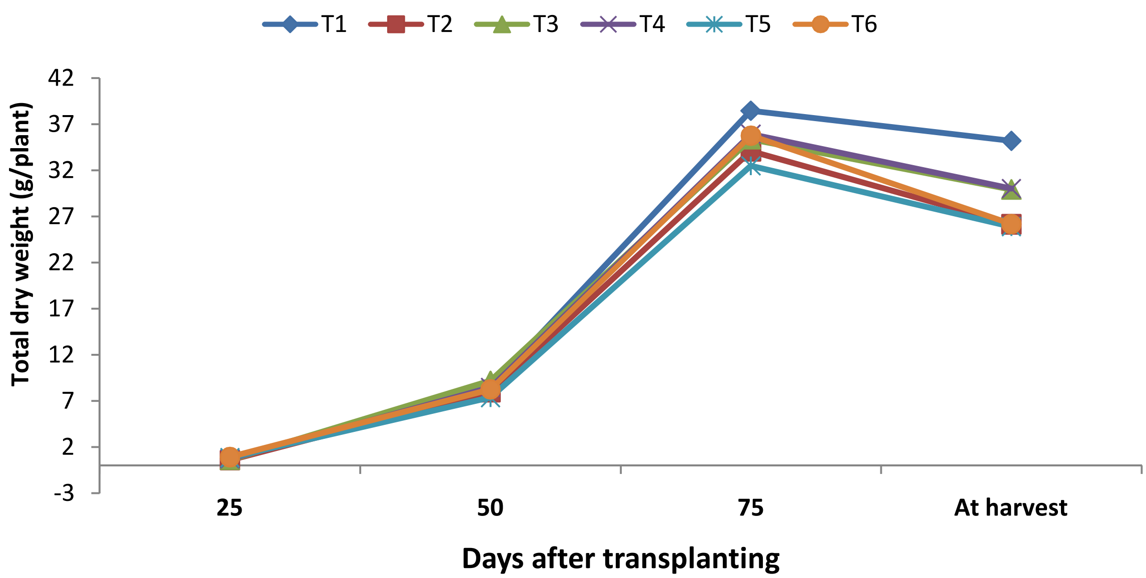
Table 7. Effect of variety on total dry weight at different growth duration of inbred and hybrid *boro* rice

Treatments	Total dry weight (g plant^{-1}) at different DAT			
	25	50	75	At harvest
V_1 (BRRI dhan28)	0.42 b	6.77 b	33.39 b	30.31
V_2 (BRRI hybrid dhan2)	1.05 a	9.79 a	37.32 a	27.48
LSD $_{(0.05)}$	0.079	1.173	3.043	NS
CV (%)	7.46	9.88	6.00	8.86

NS = Not significant

4.4.2 Effect of N-management

The total dry matter production of plant was significantly influenced by nitrogen fertilizer doses and application methods at 25, 50, 75 DAT and at harvest (Appendix VI and Figure 4). At 25 DAT, the highest dry weight (0.91 g plant^{-1}) was recorded in T_6 and the lowest dry weight (0.57 g plant^{-1}) was recorded in T_2 which was statistically similar with T_3 (0.62 g plant^{-1}). At 50 DAT, the highest dry weight (9.19 g plant^{-1}) was recorded in T_3 which was statistically similar with T_1 (8.48 g plant^{-1}) and T_4 (8.45 g plant^{-1}) whereas the lowest dry weight (7.36 g plant^{-1}) was recorded in T_5 which was statistically similar with T_2 (7.96 g $plant^{-1}$). At 75 DAT, the highest dry weight (38.48 g $plant^{-1}$) was found in T_1 which was statistically similar with T_3 (35.37 g $plant^{-1}$), T_4 (35.94 g $plant^{-1}$) and T_6 (35.75 g $plant^{-1}$) whereas the lowest dry weight (32.50 g $plant^{-1}$) was found in T_5 which was statistically similar with T_2 (34.08 g $plant^{-1}$). At harvest, the highest dry weight (35.20 g $plant^{-1}$) was found in T_1 whereas the lowest dry weight (25.89 g $plant^{-1}$) was found in T_5 which was statistically similar with T_2 (26.16 g $plant^{-1}$) and T_6 (26.17 g $plant^{-1}$).



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray

Figure 4. Effect of different doses of nitrogen fertilizer and application methods on total dry weight (g $plant^{-1}$) at different days after transplanting ($LSD_{0.05}$ = 0.054, 0.791, 3.820 and 3.942 at 25, 50 and 75 DAT and at harvest, respectively).

4.4.3 Interaction effect of variety and N-management

Significant interaction effect between the variety and N-management on dry matter production (g plant^{-1}) was observed at 25, 50 and 75 DAT and at harvest (Appendix VI and Table 8). At 25 DAT, the highest (1.53 g) total dry weight was recorded from V_2T_6 while the lowest (0.30 g) total dry weight was recorded from V_1T_6 which was statistically similar with V_1T_1 (0.35 g), V_1T_2 (0.31 g) and V_1T_3 (0.37 g). At 50 DAT, the highest (11.93 g) total dry weight was recorded from V_2T_3 which was statistically similar with V_2T_1 (11.40 g) whereas the lowest (5.55 g) total dry weight was recorded from V_1T_1 which was statistically similar with V_1T_2 (6.31 g), V_1T_3 (6.44 g) and V_1T_6 (6.13 g). At 75 DAT, the highest (42.33 g) total dry weight was observed from V_1T_1 which was statistically similar with V_2T_2 (39.00 g), V_2T_4 (37.72 g) and V_2T_6 (41.67 g) whereas the lowest (29.17 g) total dry weight was recorded from V_1T_2 which was statistically similar with V_1T_3 (34.17 g), V_1T_4 (34.17 g), V_1T_5 (30.67), V_1T_6 (29.83 g) and V_2T_5 (34.33 g). At harvest, the highest (38.24 g) total dry weight was observed from V_2T_1 whereas the lowest (21.26 g) total dry weight was recorded from V_1T_2 which was statistically similar with V_1T_6 (25.94 g), V_2T_5 (23.21 g) and V_2T_6 (26.41 g).

Table 8. Interaction effect of variety and N-management on total dry weight at different growth duration of inbred and hybrid *boro* rice

Treatments		Total dry weight (g $plant^{-1}$) at different DAT			
		25	50	75	At harvest
V_1	T_1	0.35 f	5.55 g	42.33 a	32.15 b
	T_2	0.31 f	6.31 fg	29.17 e	21.26 e
	T_3	0.37 f	6.44 fg	34.17 cde	28.36 bcd
	T_4	0.60 e	9.07 d	34.17 cde	28.59 bcd
	T_5	0.59 e	7.11 ef	30.67 de	28.58 bcd
	T_6	0.30 f	6.13 fg	29.83 de	25.94 cde
V_2	T_1	1.15 b	11.40 ab	34.63 cd	38.24 a
	T_2	0.83 d	9.60 cd	39.00 abc	31.05 bc
	T_3	0.86 d	11.93 a	36.57 bc	31.45 bc
	T_4	0.84 d	7.83 e	37.72 abc	31.49 bc
	T_5	1.07 c	7.62 e	34.33 cde	23.21 de
	T_6	1.53 a	10.34 bc	41.67 ab	26.41 cde
$LSD_{(0.05)}$		0.076	1.118	5.402	5.575
CV (%)		5.45	7.93	8.97	11.33

V_1 - (BRRI dhan28), V_2 – (BRRI hybrid dhan2)

T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

4.5. Number of effective tillers hill^{-1}

4.5.1 Effect of variety

The number of effective tillers hill^{-1} was not significantly influenced by variety (Appendix VII and Table 9). Numerically the higher number of effective tillers hill^{-1} (11.99) was obtained from inbred variety BRRI dhan28 and the lower number of effective tillers hill^{-1} (10.39) observed in hybrid variety BRRI hybrid dhan2. Debnath (2010) and Ashrafuzzman (2006) also observed that varieties differed insignificantly in respect of number of effective tillers m^{-2} though Ahmed (2006) found significant effect between inbred and hybrid varieties in respect of number of effective tillers m^{-2}.

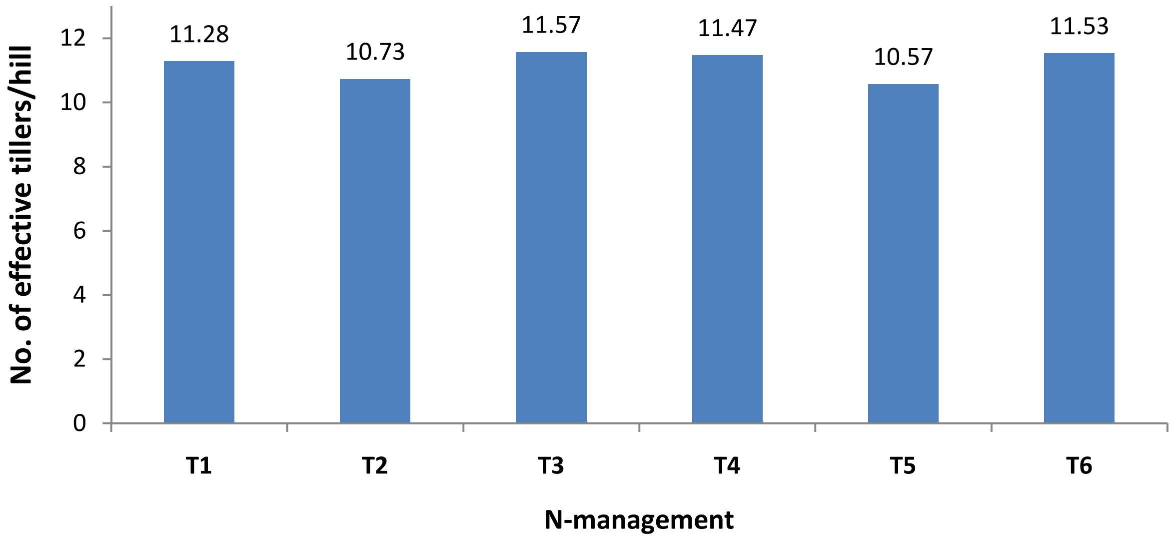
Table 9. Effect of variety on number of effective and ineffective tillers hill^{-1} of inbred and hybrid *boro* rice

Treatments	No. of effective tillers hill^{-1}	No. of ineffective tillers hill^{-1}
V_1 (BRRI dhan28)	11.99	2.00 a
V_2 (BRRI hybrid dhan2)	10.39	0.37 b
LSD $_{(0.05)}$	NS	0.7185
CV (%)	12.45	19.08

NS = Not significant

4.5.2 Effect of N-management

The number of effective tillers hill^{-1} was not significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 5). Numerically the highest (11.57) number of effective tillers hill^{-1} was observed from T_3 and the lowest (10.57) number of effective tillers hill^{-1} was observed in T_5. Rasheed *et al.* (2003) reported that the number of effective tillers hill was increased when NP levels were increased. Chopra and Chopra (2004) reported that nitrogen had significantly effects on yield attributes of effective tillers hill^{-1} with increasing levels of N up to 120 kg N ha^{-1} in rice.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 5. Effect of different doses of nitrogen fertilizer and application methods on the number of effective tillers hill^{-1}.

4.5.3 Interaction effect of variety and N-management

Interaction effect of variety and N-management significantly influenced the number of effective tillers hill^{-1} (Appendix VII and Table 10). The highest number of effective tillers hill^{-1} (14.17) was observed in T_6 of the inbred variety (V_1) which was statistically similar with T_1 (12.23) of the inbred variety (V_1) and the lowest number of effective tillers hill^{-1} (8.90) was obtained from T_6 of the hybrid variety (V_2) which was statistically similar with T_1 (10.33), T_2 (10.33) and T_5 (9.66) of the hybrid variety (V_2). Number of effective tillers hill^{-1} can vary from cultivar to cultivar. Parvin *et al.* (2013) conducted an experiment to investigate the effect of foliar application of urea on BRRI dhan29 and found that yield and yield contributing characters (i.e. highest number of effective tillers hill^{-1}) of *Boro* rice *cv*. BRRI dhan29 were significantly influenced by foliar application of urea.

Table 10. Interaction effect of variety and N-management on number of effective and ineffective tillers hill^{-1} of inbred and hybrid *boro* rice

Treatments		No. of effective tillers hill^{-1}	No. of ineffective tillers hill^{-1}
V_1	T_1	12.23 ab	2.07 ab
	T_2	11.13 bc	1.87 b
	T_3	11.33 bc	2.33 a
	T_4	11.60 bc	2.33 a
	T_5	11.47 bc	1.86 b
	T_6	14.17 a	1.53 c
V_2	T_1	10.33 bcd	0.27 ef
	T_2	10.33 bcd	0.47 de
	T_3	11.80 bc	0.33 ef
	T_4	11.33 bc	0.33 ef
	T_5	9.66 cd	0.66 d
	T_6	8.90 d	0.13 f
LSD $_{(0.05)}$		2.221	0.309
CV (%)		11.65	15.27

V_1 - (BRRI dhan28), V_2 – (BRRI hybrid dhan2)

T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

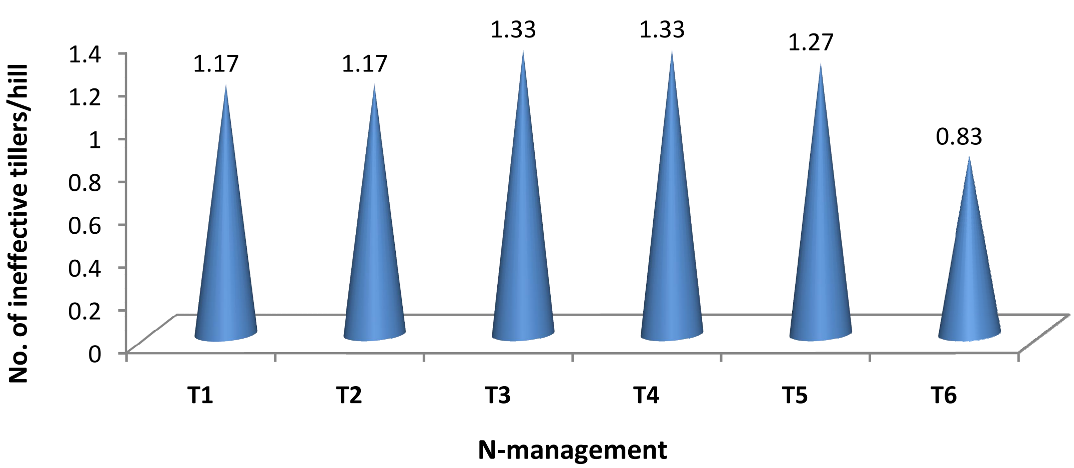
4.6 Number of ineffective tillers hill^{-1}

4.6.1 Effect of variety

The number of ineffective tillers hill^{-1} was significantly influenced by variety (Appendix VII and Table 9). The higher number of ineffective tillers hill^{-1} (2.00) was obtained from inbred variety V_1 (BRRI dhan28) and the lower number of ineffective tillers hill^{-1} (0.37) observed in hybrid variety V_2 (BRRI hybrid dhan2). Ahmed (2006) found significant effect between inbred and hybrid varieties in respect of number of effective tillers m^{-2} though Debnath (2010) and Ashrafuzzman (2006) also observed that varieties differed insignificantly in respect of number of effective tillers m^{-2}.

4.6.2 Effect of N-management

The number of ineffective tillers hill^{-1} was significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 6). The highest number of ineffective tillers hill^{-1} (1.33) was obtained from T_3 which was statistically similar with all except T_6 (0.83) whereas the lowest number of ineffective tillers hill^{-1} (0.83) was observed in T_6 treatment.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 6. Effect of different doses of nitrogen fertilizer and application methods on the number of ineffective tillers hill^{-1} ($LSD_{0.05}$ = 0.219).

4.6.3 Interaction effect of variety and N-management

Interaction effect of variety and N-management significantly influenced the number of ineffective tillers hill^{-1} (Appendix VII and Table 10). The highest number of ineffective tillers hill^{-1} (2.33) was observed in T_3 and T_4 of the inbred variety (V_1) which was statistically similar with T_1 (2.07) of the inbred variety (V_1) and the lowest number of ineffective tillers hill^{-1} (0.13) was obtained from T_6 of the hybrid variety (V_2) which was statistically similar with T_1 (0.27), T_3 and T_4 (0.33) of the hybrid variety (V_2).

4.7 Panicle length (cm)

4.7.1 Effect of variety

The panicle length was not varied significantly due to the variation of variety (Appendix VII and Table 11). Numerically the higher (24.81 cm) and lower (23.55 cm) panicle length was obtained from BRRI hybrid dhan2 (V_2) and BRRI dhan28 (V_1) respectively. Such findings might be due to the genetic make-up of the varieties though Babiker (1986) observed that panicle length differed due to the varietal variation. Ashrafuzzaman (2006) and Main (2006) who observed that varieties differed insignificantly in respect of panicle length. This finding disagreed with Ahmed (2006) also observed maximum panicle length in inbred than hybrid variety and Debnath (2012) found the highest panicle length in BRRI dhan29 and lowest in BRRI hybrid dhan2 among other varieties.

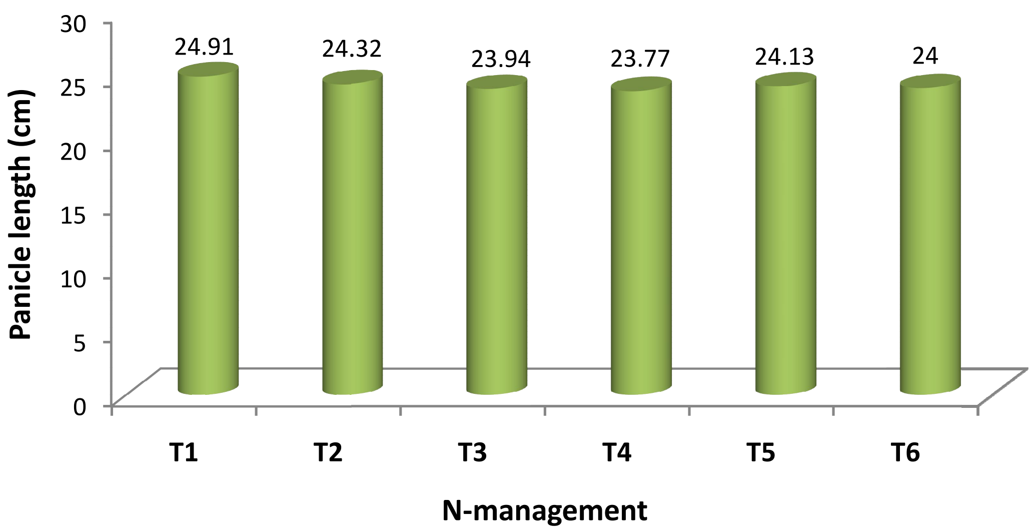
Table 11. Effect of variety on different crop characters of inbred and hybrid *boro* rice

Treatments	Panicle length (cm)	No. of rachis branches panicle^{-1}	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	No. of total grains panicle^{-1}	1000-grains weight (g)
V_1 (BRRI dhan28)	23.55	7.48 b	114.4 b	19.31 b	133.7 b	21.35 b
V_2 (BRRI hybrid dhan2)	24.81	9.04 a	155.2 a	21.63 a	176.8 a	23.77 a
LSD $_{(0.05)}$	NS	1.238	31.27	1.822	32.53	1.608
CV (%)	4.28	10.45	16.17	6.21	14.61	4.97

NS = Not significant

4.7.2 Effect of N-management

There was significant difference in panicle length observed between different doses of nitrogen fertilizer and application methods (Appendix VII and Figure 7). The highest panicle length (24.91 cm) was recorded from T_1 which was statistically similar with T_2 (24.32 cm), T_5 (24.13 cm) and T_6 (24.00 cm) and the lowest panicle length (23.77 cm) was obtained from T_4 which was statistically similar with T_3 (23.94 cm). Ahmed *et al*. (2005) found that higher N dose produced higher panicle length. Shafiee *et al.* (2013) who conducted an experiment using liquid fertilizer SBAJATM (formerly known as BIPOMIXTM) and found the mean panicle lengths were significantly longer and higher, respectively in plots treated with SBAJATM *vis-à-vis* the control.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 7. Effect of different doses of nitrogen fertilizer and application methods on panicle length.

4.7.3 Interaction effect of variety and N-management

Panicle length was significantly influenced by the interaction effect of variety and N-management (Appendix VII and Table 12). The highest panicle length (25.37 cm) was observed in T_1 of the hybrid variety (V_2) which was statistically similar with T_2 (25.04 cm), T_3 (24.17 cm), T_4 (24.15 cm), T_5 (25.34 cm), T_6 (24.78 cm) of the hybrid variety (V_2) and T_1 (24.44 cm) of the inbred variety whereas the lowest panicle length was observed in T_5 (22.92 cm) of the inbred variety (V_1) which was statistically similar with all except T_1 (25.37 cm), T_2 (25.04 cm), T_5 (25.34 cm) and T_6 (24.78 cm) of the hybrid variety (V_2) and T_1 (24.44 cm) of the inbred variety. It is very obvious that panicle length can vary from variety to variety. Topdressing of urea along with foliar spray gave better results. Ndaeyo *et al.* (2008) conducted an experiment in Nigeria with five rice varieties and found that higher N doses increased length of central panicle per plant. This was conformed to Sarder *et al.* (1988) who have observed that the panicle length increased up to 120 kg N ha^{-1}.

Table 12. Interaction effect of variety and N-management on different crop characters of inbred and hybrid *boro* rice

Treatments		Panicle length (cm)	No. of rachis branches panicle^{-1}	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	No. of total grains panicle^{-1}	1000-grains weight (g)
V_1	T_1	24.44 abc	8.07 de	125.5 bc	21.17 bc	146.7 bc	21.20 c
	T_2	23.61 bcd	8.20 cde	118.8 bc	18.63 bcde	137.4 bc	21.20 c
	T_3	23.71 bcd	6.90 f	111.1 c	25.90 a	137.0 bc	21.73 c
	T_4	23.39 cd	7.47 ef	120.4 bc	21.47 bc	141.9 bc	21.30 c
	T_5	22.92 d	6.77 f	104.7 c	10.77 f	115.5 c	21.67 c
	T_6	23.23 cd	7.50 ef	106.1 c	17.90 cde	124.0 c	21.00 c
V_2	T_1	25.37 a	9.33 ab	195.2 a	25.67 a	220.9 a	23.33 b
	T_2	25.04 a	9.67 a	138.0 bc	21.87 b	159.9 bc	23.52 ab
	T_3	24.17 a-d	8.60 a-d	138.0 bc	20.37 bcd	158.4 bc	23.55 ab
	T_4	24.15 a-d	8.90 a-d	163.6 ab	28.47 a	192.0 ab	24.43 a
	T_5	25.34 a	8.53 b-e	146.6 abc	16.67 e	163.3 bc	23.52 ab
	T_6	24.78 ab	9.20 abc	149.5 abc	16.77 de	166.3 abc	24.25 ab
$LSD_{(0.05)}$		1.321	1.092	52.07	3.639	55.29	0.936
CV (%)		3.21	7.76	22.68	10.44	20.91	2.44

V_1 - (BRRI dhan28), V_2 – (BRRI hybrid dhan2)

T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

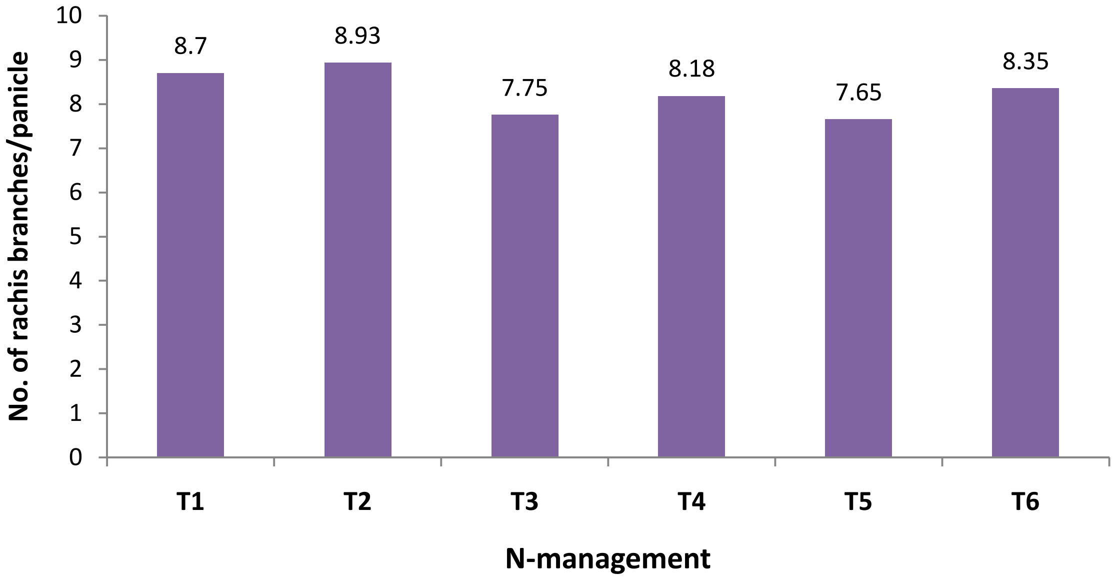
4.8 Number of rachis branches panicle^{-1}

4.8.1 Effect of variety

The number of rachis branches panicle^{-1} was significantly influenced by the variety (Appendix VII and Table 11). The maximum number of rachis branches panicle^{-1} (9.04) was observed in BRRI hybrid dhan2 and the minimum number of rachis branches panicle^{-1} (7.48) was observed in BRRI dhan28. Main (2006) and Obaidullah (2007) who observed the maximum number of rachis branches panicle^{-1} in hybrid variety and the minimum number of rachis branches panicle^{-1} in inbred variety.

4.8.2 Effect of N-management

The number of rachis branches panicle^{-1} was significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 8). The highest number of rachis branches panicle^{-1} (8.93) was obtained from T_2 which was statistically similar with all treatments except T_3 (7.75) and T_5 (7.65) whereas the lowest number of rachis branches panicle^{-1} (7.65) was obtained from T_5 which was statistically similar with T_3 (7.75), T_4 (8.18) and T_6 (8.35).



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 8. Effect of different doses of nitrogen fertilizer and application methods on the number of rachis branches panicle^{-1} ($LSD_{0.05}$ = 0.772).

4.8.3 Interaction effect of variety and N-management

The number of rachis branches panicle^{-1} was significantly influenced by the interaction of variety and N-management (Appendix VII and Table 12). The highest number of rachis branches panicle^{-1} (9.67) was obtained from T_2 of the hybrid variety (V_2) which was statistically similar with T_1 (9.33), T_3 (8.60), T_4 (8.90) and T_6 (9.20) of the hybrid variety (V_2). The lowest number of rachis branches panicle^{-1} was observed in T_5 (6.77) of the inbred variety (V_1) which was statistically similar with T_3 (6.90), T_4 (7.47) and T_6 (7.50) of the inbred variety (V_1).

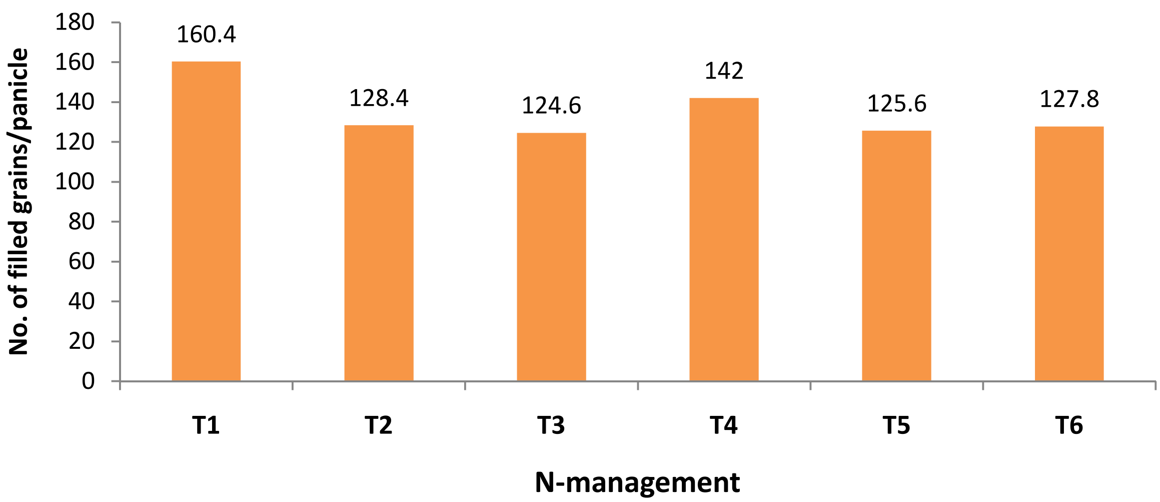
4.9 Number of filled grains panicle^{-1}

4.9.1 Effect of variety

The number of filled grains panicle^{-1} differed significantly for variation of the variety (Appendix VII and Table 11). The higher number of filled grains panicle^{-1} (155.2) was found in the hybrid variety BRRI hybrid dhan2 and the lower number of filled grains panicle^{-1} (114.4) was obtained from the inbred variety BRRI dhan28. Debnath (2010) who obtained the highest number of filled grains panicle^{-1} from the hybrid variety BRRI hybrid dhan2 and the lowest number of filled grains panicle^{-1} from the inbred variety BRRI dhan29.

4.9.2 Effect of N-management

The number of filled grains panicle^{-1} was not significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 9). Numerically the maximum number of filled grains panicle^{-1} (160.4) was observed in T_1 while the minimum number of filled grains panicle^{-1} (124.6) was obtained from T_3. Parvin *et al.* (2013) found that highest grains panicle^{-1} was obtained from five times foliar urea spray @ 100 kg ha^{-1} in BRRI dhan29.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 9. Effect of different doses of nitrogen fertilizer and application methods on the number of filled grains panicle^{-1}.

4.9.3 Interaction effect of variety and N-management

The number of filled grains panicle^{-1} was significantly influenced by the interaction of variety and **N**-management (Appendix VII and Table 12). The highest number of filled grains panicle^{-1} (195.2) was observed in T_1 of the hybrid variety (V_2) which was statistically similar with T_4 (163.6), T_5 (146.60) and T_6 (149.5) of the hybrid variety (V_2). The lowest number of filled grains panicle^{-1} (104.7) was obtained from T_5 of the inbred variety (V_1) which was statistically similar with all treatments except T_1 (195.2) and T_4 (163.6) of the hybrid variety (V_2). Bhuyan *et al.* (2012) observed that bed planting with foliar nitrogen fertilizer produced higher number of grains panicle^{-1}. Filled grains panicle^{-1} is one of the most important yields contributing parameter in case of grain crops. In this study it was observed that hybrid variety BRRI hybrid dhan2 gave higher filled grains panicle^{-1} between the two varieties. On the other hand, 100% Urea of the recommended dose (RD) was applied as 3 top dressing performed better than other urea application methods and doses.

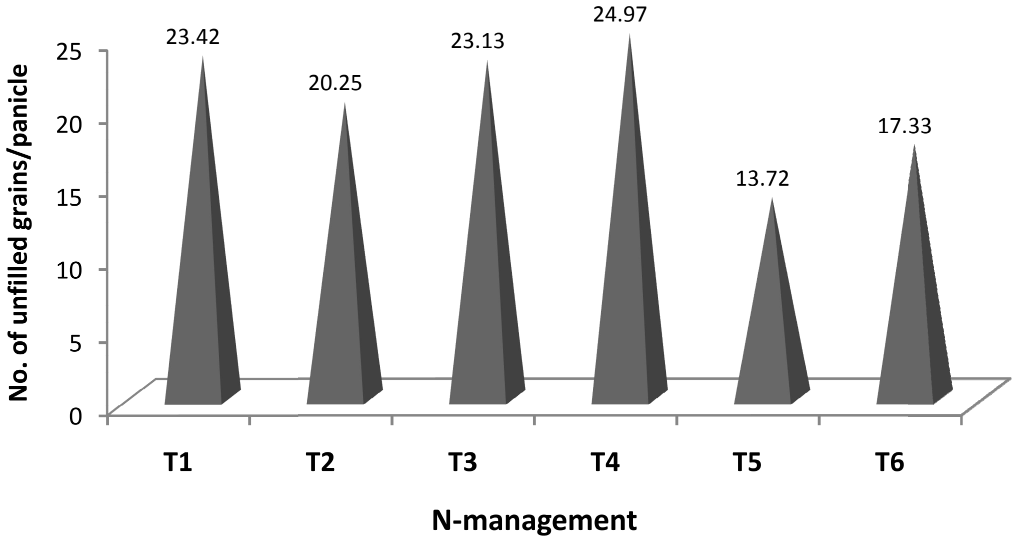
4.10 Number of unfilled grains panicle^{-1}

4.10.1 Effect of variety

The number of unfilled grains panicle^{-1} differed significantly for variation of the variety (Appendix VII and Table 11). The higher number of unfilled grains panicle^{-1} (21.63) was found in the hybrid variety BRRI hybrid dhan2 and the lower number of unfilled grains panicle^{-1} (19.31) was obtained from the inbred variety BRRI dhan28. This finding agreed with Obaidullah (2007) who observed the highest number of unfilled grains panicle^{-1} in the hybrid variety and the lowest number of unfilled grains panicle^{-1} in the inbred variety though Debnath (2010) who obtained the highest number of unfilled grains panicle^{-1} from the inbred variety BRRI dhan29 than hybrid variety BRRI hybrid dhan2.

4.10.2 Effect of N-management

The number of unfilled grains panicle^{-1} was significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 10). The highest number of unfilled grains panicle^{-1} (24.97) was recorded in T_4 which was statistically similar with T_1 (23.42) and T_3 (23.13) whereas the lowest number of unfilled grains panicle^{-1} (13.72) was obtained from T_5.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, T_2 = 100% Urea of RD was applied as 3 foliar spray, T_3 = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, T_4 = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, T_5 = 75% Urea of RD was applied as 3 foliar spray, T_6 = 50% Urea of RD was applied as 3 foliar spray.

Figure 10. Effect of different doses of nitrogen fertilizer and application methods on the number of unfilled grains panicle^{-1} ($LSD_{0.05}$ = 2.573).

4.10.3 Interaction effect of variety and N-management

The number of unfilled grains panicle^{-1} was significantly influenced by the interaction of variety and N-management (Appendix VII and Table 12). The maximum number of unfilled grains panicle^{-1} (28.47) was observed in T_4 of the hybrid variety (V_2) which was statistically similar with T_1 (25.67) of the hybrid variety (V_2) and T_3 (25.90) of the inbred variety (V_1). The minimum number of unfilled grains panicle^{-1} (10.77) was obtained from T_5 of the inbred variety (V_1). This may be due to better nutrient use efficiency and better genetic characters.

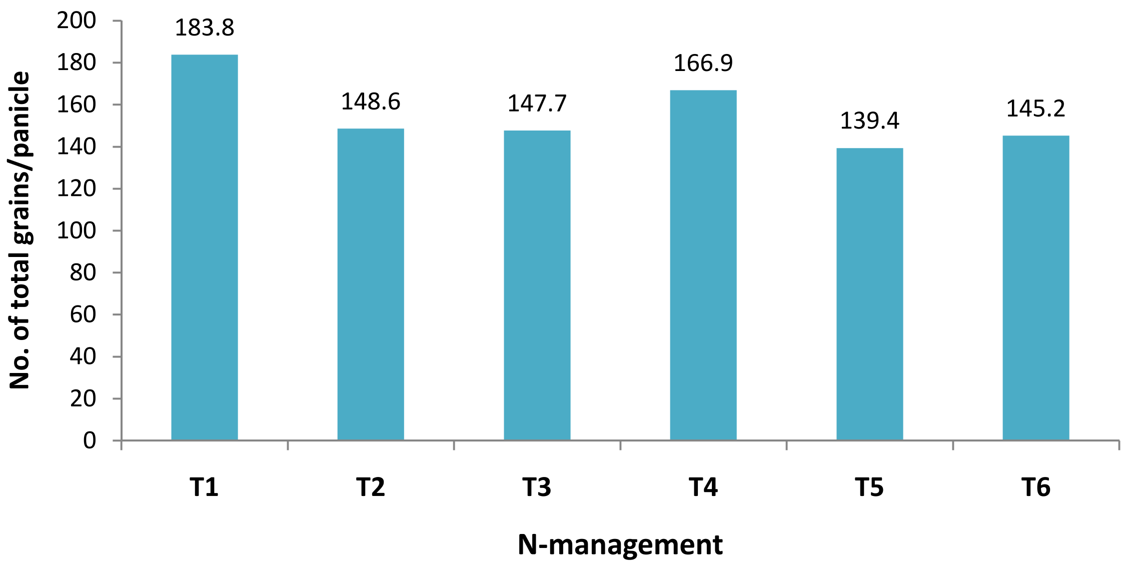
4.11 Number of total grains panicle^{-1}

4.11.1 Effect of variety

The number of total grains panicle^{-1} was significantly influenced by the variety (Appendix VII and Table 11). The higher number of total grains panicle^{-1} (176.8) was observed in BRRI hybrid dhan2 and the lower number of total grains panicle^{-1} (133.7) was obtained from BRRI dhan28. This finding agreed with Obaidullah (2007) and Main (2006) who observed maximum number of total grains panicle^{-1} in hybrid variety than inbred variety that of though Ashrafuzzaman (2006) was observed dissimilar findings where the number of total grains panicle^{-1} in inbred variety was higher than that of hybrid variety.

4.11.2 Effect of N-management

The number of total grains panicle^{-1} was significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 11). The highest number of total grains panicle^{-1} (183.8) was recorded in T_1 which was statistically similar with all treatments except T_5 (139.4) that showed the lowest number of unfilled grains panicle^{-1} (139.4) which was statistically similar with all treatments except T_1 (183.8). Bhuyan *et al.* (2012) observed that bed planting with foliar nitrogen fertilizer produced higher number of grains panicle^{-1}.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 11. Effect of different doses of nitrogen fertilizer and application methods on the number of total grains panicle^{-1} ($LSD_{0.05}$ = 39.10).

4.11.3 Interaction effect of variety and N-management

The total number of grains panicle^{-1} was significantly influenced by the interaction of variety and N-management (Appendix VII and Figure 12). The highest number of total grains panicle^{-1} (220.9) was observed in T_1 of the hybrid variety (V_2) which was statistically similar with T_4 (192.0) and T_6 (166.3) of the hybrid variety (V_2). The lowest number of total grains panicle^{-1} (115.5) was obtained from T_5 of the inbred variety (V_1) which was statistically similar with all except T_1 (220.9) and T_4 (192.0) of the hybrid variety (V_2). Rahman *et al.* (2007) conducted an experiment where the results showed that nitrogen level significantly influenced growth and yield components and maximum grains panicle^{-1} was found from 80 kg N/ha.

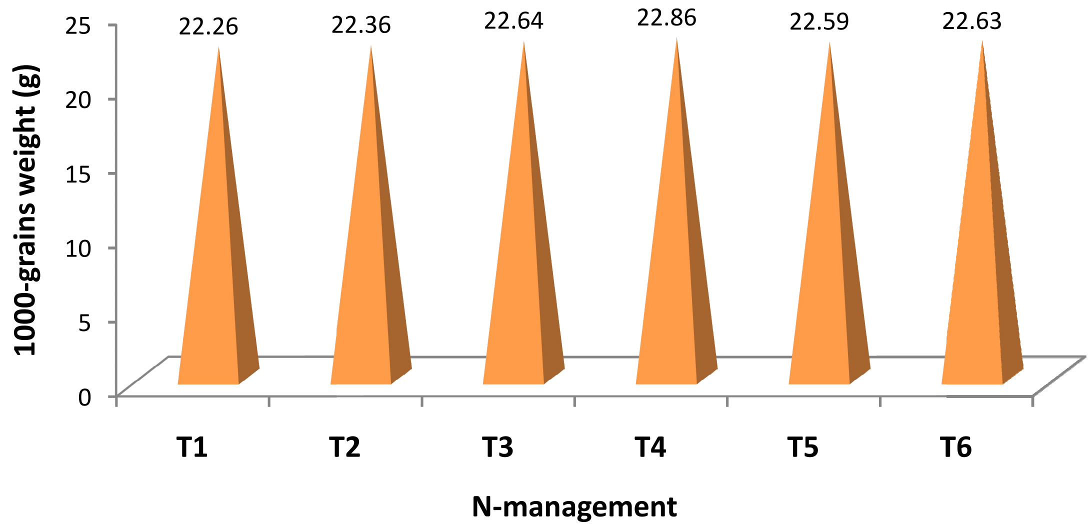
4.12 Weight of 1000 grains

4.12.1 Effect of variety

The weight of 1000 grains was significantly influenced by the variety (Appendix VII and Table 11). The maximum weight of 1000 grains (23.77 g) was obtained from the hybrid variety BRRI hybrid dhan2 and the minimum weight (21.35 g) was obtained from the inbred variety BRRI dhan28. The variation of 1000 grains weight between varieties might be due to the difference in their genetic makeup. The result supports the findings of Obaidullah (2007), Ashrafuzzaman (2006) and Debnath (2010) who found the highest weight of 1000 grains in hybrid variety than the inbred variety.

4.12.2 Effect of N-management

The weight of 1000-grain (g) was not significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 12). But numerically the maximum weight of 1000-grain (22.86 g) was obtained from T_4 and the minimum weight of 1000-grain (22.26 g) was obtained from T_1 treatment. These results were in agreed with Shafiee *et al.* (2013) who conducted an experiment using liquid fertilizer SBAJATM (formerly known as BIPOMIXTM) and found no significant differences in the 1000 grain weight.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 12. Effect of different doses of nitrogen fertilizer and application methods on the weight of 1000 grains.

4.12.3 Interaction effect of variety and N-management

Interaction effect of variety and N-management was found significant in respect of weight of 1000 grains (Appendix VII and Table 12). The highest weight of 1000 grains (24.43 g) was obtained from T_4 of the hybrid variety (V_2) which was statistically similar with T_2 (23.52 g), T_3 (23.55 g), T_5 (23.52 g) and T_6 (24.25 g) of the hybrid variety (V_2) and the lowest weight of 1000 grains (21.00 g) was obtained from T_6 of the inbred variety (V_1) which was statistically similar with T_1 (21.20 g), T_2 (21.20 g), T_3 (21.73 g), T_4 (21.30 g) and T_5 (21.67 g) of the inbred variety (V_1). Azam *et al.* (2012) conducted an experiment to find out the influence of variety and different urea fertilizer application method on growth and yield of *boro* rice and result showed that variety and urea fertilizer application method had significant effect on 1000 grains weight.

4.13 Grain yield

4.13.1 Effect of variety

Grain yield was significantly influenced by the variety (Appendix VII and Table 13). The higher grain yield (6.19 t ha^{-1}) was obtained from the hybrid variety BRRI hybrid dhan2 and lower (4.17 t ha^{-1}) from the inbred variety BRRI dhan28. Debnath (2010) also observed similar result where BRRI hybrid dhan2 produced significantly higher yield (5.92 t ha^{-1}) than BRRI dhan29 (4.97 t ha^{-1}) and Ahmed (2006) found higher grain yield in hybrid variety than inbred variety.

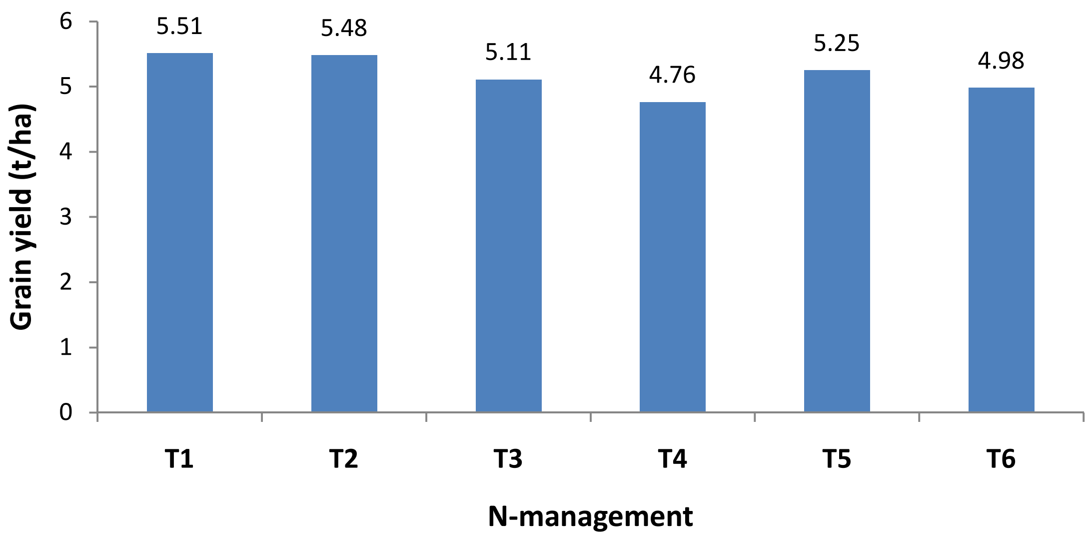
Table 13. Effect of variety on yield and other crop characters of inbred and hybrid *boro* rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1 (BRRI dhan28)	4.17 b	3.53 b	7.70 b	54.16 a
V_2 (BRRI hybrid dhan2)	6.19 a	7.74 a	13.93 a	44.76 b
LSD $_{(0.05)}$	0.905	2.112	2.745	3.726
CV (%)	12.17	26.14	17.67	5.25

4.13.2 Effect of N-management

Grain yield was not significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 13). Numerically the maximum grain yield (5.51 t ha^{-1}) was obtained from T_1 that is 100% recommended dose of urea (RD) applied as 3 top dressing and the manimum grain yield (4.76 t ha^{-1}) was observed in T_4 that is 75% Urea of RD applied as 1 top dressing and 2 foliar spray .

It has been reported that a small amount of nutrients (nitrogen, potash or phosphate) by foliar spraying increases yield of crops (Asenjo *et al*. 2000). Alam *et al.* (2015) reported that with the increment of nitrogen level the grain yield was increased up to N_{100} compared to no liquid fertilization treatment, but in the application of liquid fertilization treatment, grain yield was increased up to N_{75} and also observed that, liquid fertilization with Magic Growth along with 75% of the recommended nitrogen fertilizer increased 10.5% grain yield with a saving of 25% of the recommended nitrogen fertilizer compared to recommended practice. Parvin *et al.* (2013) found that highest grain yield was obtained from five times foliar urea spray @ 100 kg ha^{-1} in BRRI dhan29.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 13. Effect of different doses of nitrogen fertilizer and application methods on the grain yield.

4.13.3 Interaction effect of variety and N-management

Interaction between variety and N-management played an important role for promoting the yield. Grain yield was significantly influenced by the interaction effect of variety and N-management (Appendix VII and Table 14). Among the treatments, the highest grain yield (6.50 t ha^{-1}) was observed in T_1 of the hybrid variety (V_2), which was statistically similar with T_2 (6.34 t ha^{-1}), T_3 (6.32 t ha^{-1}), T_4 (6.28 t ha^{-1}), T_5 (6.34 t ha^{-1}) and T_6 (5.38 t ha^{-1}) of the hybrid variety (V_2).

Alam *et al.* (2015) observed that, liquid fertilization with Magic Growth along with 75% of the recommended nitrogen fertilizer increased 10.5% grain yield with a saving of 25% of the recommended nitrogen fertilizer compared to recommended practice. Shafiee *et al.* (2013) conducted an experiment using liquid fertilizer SBAJATM (formerly known as BIPOMIXTM) and found the highest yield of grains (9.66 tons ha^{-1}) compared with (7.49 tons ha^{-1}) in the control plots. Islam *et al.* (2008a) observed that grain yield influenced significantly due to application of different rates of nutrients and 60-19-36 kg/ha NPK maximized the yield of T. *aman* rice varieties in respect of yield and economics.

Table 14. Interaction effect of variety and N-management on yield and other crop characters of inbred and hybrid *boro* rice

Treatments		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1	T_1	4.52 bc	3.26 d	7.78 d	58.14 ab
	T_2	4.62 bc	3.28 d	7.90 d	58.72 a
	T_3	3.91 c	3.70 d	7.61 d	51.25 b-e
	T_4	3.25 c	3.35 d	6.60 d	49.39 cde
	T_5	4.16 bc	3.29 d	7.45 d	55.71 abc
	T_6	4.57 bc	4.29 d	8.86 cd	51.74 a-d
V_2	T_1	6.50 a	8.11 ab	14.60 a	44.34 ef
	T_2	6.34 a	7.41 bc	13.75 ab	46.17 def
	T_3	6.32 a	7.49 bc	13.81 ab	45.88 def
	T_4	6.28 a	9.79 a	16.07 a	39.87 f
	T_5	6.34 a	7.57 bc	13.91 ab	45.49 def
	T_6	5.38 ab	6.08 c	11.46 bc	46.78 def
$LSD_{(0.05)}$		1.454	1.737	2.734	7.027
CV (%)		16.48	18.10	14.84	8.34

V_1 - (BRRI dhan28), V_2 – (BRRI hybrid dhan2)

T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

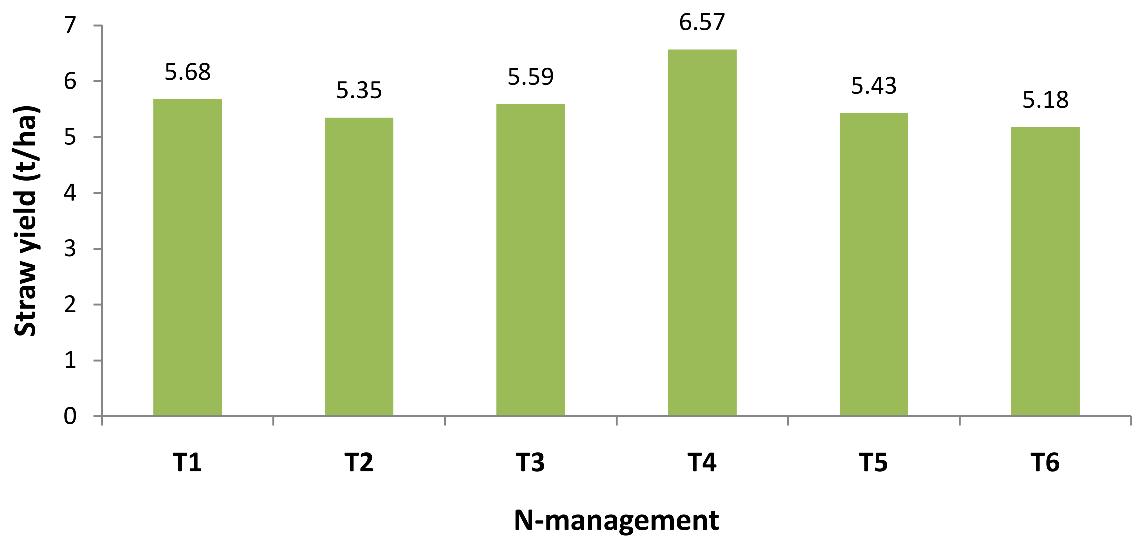
4.14 Straw yield

4.14.1 Effect of variety

Straw yield was significantly influenced by the variety (Appendix VII and Table 13). The maximum straw yield (7.74 t ha^{-1}) was obtained from the hybrid variety BRRI hybrid dhan2 and lower (3.53 t ha^{-1}) from the inbred variety BRRI dhan28. Debnath *et al.* (2012) and Ahmed (2006) also observed dissimilar result where inbred variety produced higher straw yield than hybrid variety. This result was in agreement with the finding of Patel (2000) who reported that straw yield performance varied with variety.

4.14.2 Effect of N-management

Straw yield was significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 14). The highest straw yield (6.57 t ha^{-1}) was obtained from T_4 which was statistically similar with all treatments except T_6 (5.18 t ha^{-1}) that showed the lowest straw yield (5.18 t ha^{-1}) which was statistically similar with all except T_4 (6.57 t ha^{-1}). Haq *et al.* (2002) conducted an experiment with twelve treatments combination of N, P, K, S, Zn and Diazinon and they found that all the treatments significantly increased the straw yield of BRRI dhan30 over control. Islam *et al.* (2008b) conducted a field experiment to find out the effect of nitrogen levels and transplanting dates on the yield and yield components of aromatic rice cv. Kalizira and found that straw yield significantly influenced by nitrogen levels. This result was in an agreement with the findings of Dhane *et al.* (1989) who reported that straw yield increases with increasing nitrogen level.



$\mathbf{T_1}$ = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, $\mathbf{T_2}$ = 100% Urea of RD was applied as 3 foliar spray, $\mathbf{T_3}$ = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, $\mathbf{T_4}$ = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, $\mathbf{T_5}$ = 75% Urea of RD was applied as 3 foliar spray, $\mathbf{T_6}$ = 50% Urea of RD was applied as 3 foliar spray.

Figure 14. Effect of different doses of nitrogen fertilizer and application methods on the straw yield.

4.14.3 Interaction effect of variety and N-management

Straw yield was significantly influenced by the interaction effect of variety and N-management (Appendix VII and Table 14). Among the treatments, the highest straw yield (9.79 t ha^{-1}) was observed in T_4 of the hybrid variety (V_2) which was statistically similar with T_1 (8.11 t ha^{-1}) of the hybrid variety (V_2). The lowest straw yield (3.26 t ha^{-1}) was observed in T_1 of the inbred variety (V_1) which was statistically similar with T_2 (3.28 t ha^{-1}), T_3 (3.70 t ha^{-1}), T_4 (3.35 t ha^{-1}), T_5 (3.29 t ha^{-1}) and T_6 (4.29 t ha^{-1}) of the inbred variety (V_1). Ndaeyo *et al.* (2008) conducted an experiment in Nigeria with five rice varieties where they found that higher rates of NPK resulted higher straw yield of rice. Azam *et al.* (2012) conducted an experiment to find out the influence of variety and different urea fertilizer application method on growth and yield of *boro* rice and result showed that variety and urea fertilizer application method had significant effect on straw yield.

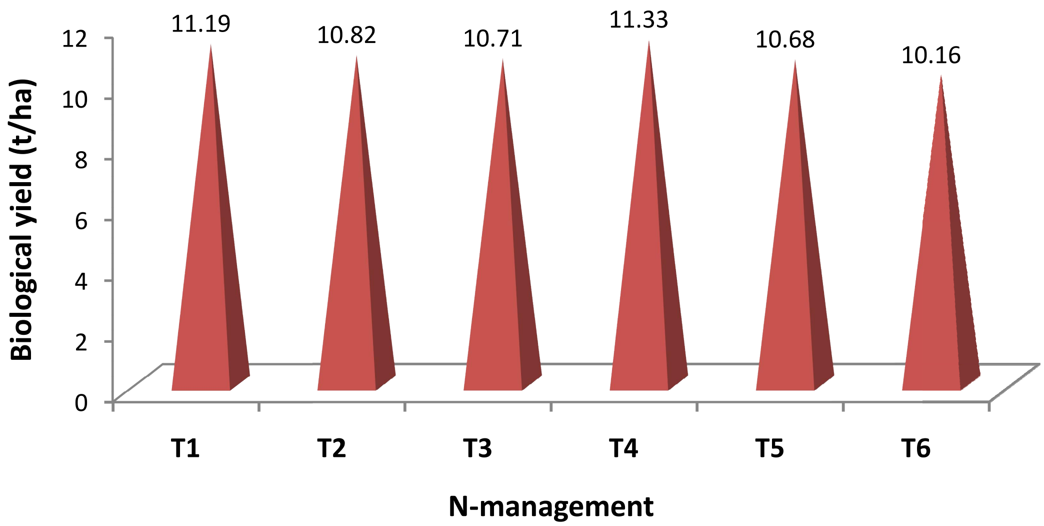
4.15. Biological yield

4.15.1 Effect of variety

Biological yield was significantly influenced by the variety (Appendix VII and Table 13). The highest biological yield (13.93 t ha^{-1}) was obtained from the hybrid variety BRRI hybrid dhan2 and lowest (7.70 t ha^{-1}) from the inbred variety BRRI dhan28. Rahman (2001) reported that hybrid variety produced higher biological yield compared to inbred variety. Debnath (2010) and Ahmed (2006) also observed dissimilar result where BRRI dhan29 produced higher biological yield than BRRI hybrid dhan2.

4.15.2 Effect of N-management

Biological yield was not significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 15). Numerically the maximum biological yield (11.33 t ha^{-1}) was obtained from the T_4 treatment (75% Urea of RD was applied as 1 top dressing and 2 foliar spray). The T_4 treatment produced the highest grain yield and straw yield which resulted in the maximum biological yield. The minimum biological yield (10.16 t ha^{-1}) was found from T_6. This was due to the lowest amount of grain and straw yield in $T_{6.}$ Vegetative growth was influenced due to the higher dose of urea and for the reason the grain and straw yield was also increased with the increased dose of nitrogenous fertilizer. Singh and Lallu (2005) stated that each increment dose of N significantly increased grain and straw yields (biological yield) over its preceding dose.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 15. Effect of different doses of nitrogen fertilizer and application methods on the biological yield.

4.15.3 Interaction effect of variety and N-management

Interaction effect between variety and N-management was significant in respect of biological yield (Appendix VII and Table 14). The highest biological yield (16.07 t ha^{-1}) was observed in T_4 of the hybrid variety (V_2) which was statistically similar with T_1 (14.60 t ha^{-1}), T_2 (13.75 t ha^{-1}), T_3 (13.81 t ha^{-1}) and T_5 (13.91 t ha^{-1}) of the hybrid variety (V_2). The lowest biological yield was observed in T_4 (6.60 t ha^{-1}) of the inbred variety (V_1) which was statistically similar with T_1 (7.78 t ha^{-1}), T_2 (7.90 t ha^{-1}), T_3 (7.61 t ha^{-1}), T_5 (7.45 t ha^{-1}) and T_6 (8.86 t ha^{-1}) of the inbred variety (V_1). The result agreed with the findings of Ahmed et al. (2005) who observed the effect of nitrogen dose on biological yield (15 t ha^{-1}) of rice.

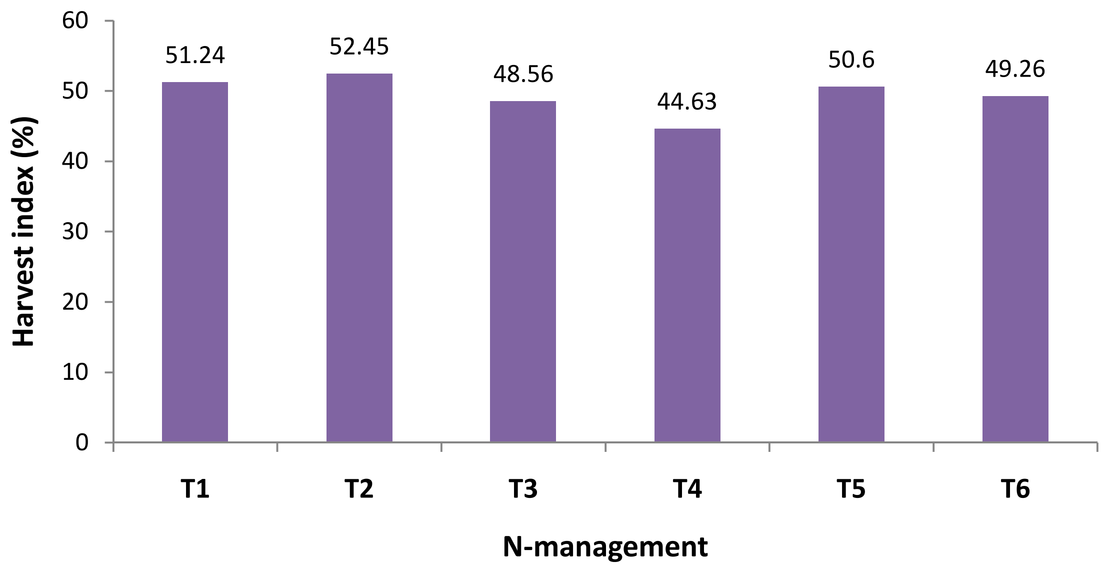
4.16 Harvest index

4.16.1 Effect of variety

Harvest index was significantly influenced by the variety (Appendix VII and Table 13). The higher harvest index (54.16 %) was obtained from the inbred variety BRRI dhan28 and the lower (44.76 %) from the hybrid variety BRRI hybrid dhan2. However this finding disagreed with Debnath (2010) and Ahmed (2006) who observed significant difference between inbred and hybrid variety in respect of harvest index where the higher harvest index was obtained from the hybrid variety than that of inbred variety. Rahman (2001) also observed the highest harvest index in hybrid variety than the inbred varieties.

4.16.2 Effect of N-management

Harvest index was significantly influenced by nitrogen fertilizer doses and application methods (Appendix VII and Figure 16). The highest harvest index (52.45 %) was obtained from T_2 treatment which was statistically similar with all treatment except T_4 (44.63 %) whereas the lowest harvest index (44.63 %) was found from T_4 which was statistically similar with T_3 (48.56 %) and T_6 (49.26 %). Awan et al. (2011) reported the highest harvest index with 156 kg N ha^{-1}.



T_1 = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Figure 16. Effect of different doses of nitrogen fertilizer and application methods on the harvest index.

4.16.3 Interaction effect of variety and N-management

Interaction effect between variety and N-management was significant in respect of harvest index (Appendix VII and Table 14). The highest harvest index (58.72 %) was observed in T_2 of the inbred variety (V_1) which was statistically similar with T_1 (58.14 %), T_5 (55.71 %) and T_6 (51.74 %) of the inbred variety (V_1). The lowest harvest index (39.87 %) was observed in T_4 of the hybrid variety (V_2) which was statistically similar with T_1 (44.34), T_2 (46.17 %), T_3 (45.88 %), T_5 (45.49 %) and T_6 (46.78 %) of the hybrid variety (V_2).

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from December 2013 to July 2014 to study on the growth and yield of *boro* rice as affected by different methods of urea application in *boro* season under the Modhupur Tract (AEZ-28). The experiment was comprised of two sets of treatments viz. Factor-A. Variety: (BRRI dhan28 and BRRI hybrid dhan2) and Factor-B. Method of urea application : 100% Urea of the recommended dose (RD) was applied as 3 top dressing (T_1), 100% Urea of RD was applied as 3 foliar spray (T_2), 100% Urea of RD was applied as 1 top dressing and 2 foliar spray (T_3), 75% Urea of RD was applied as 1 top dressing and 2 foliar spray (T_4), 75% Urea of RD was applied as 3 foliar spray (T_5) and 50% Urea of RD was applied as 3 foliar spray (T_6). The experiment was laid out in split-plot design with three replications assigning variety in the main plots and different methods of urea application in the sub plots. The data on crop growth characters (plant height, number of tillers hill^{-1}, leaf area index (LAI) and total dry weight) were recorded in the field and yield as well as yield contributing characters (number of effective and ineffective tillers hill^{-1}, panicle length, rachis branches panicle^{-1}, number of filled grains panicle^{-1}, unfilled grains panicle^{-1} and number of total grains panicle^{-1}, 1000 grains weight, grain and straw yield, biological yield and harvest index) were recorded after harvest and analyzed using the MSTAT-C package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

Different growth and yield parameters varied significantly due to varietal difference. Plant height (cm) was not significantly influenced at different growth stage. BRRI hybrid dhan2 gave taller plant height than that of BRRI dhan28 throughout the growing period at 25, 50 and 75 DAT and at harvest. The number of tillers hill^{-1} was not significantly influenced at different growth stage. But numerically at 25 DAT, the variety BRRI hybrid dhan2 produced the highest number of tillers hill^{-1} (2.52) and the variety BRRI dhan28 gave the lowest number of tillers hill^{-1} (2.30) and the same trend was observed for variety BRRI hybrid dhan2 (15.31) over BRRI dhan28 (13.82) at 50 DAT though finally at 75 DAT and at harvest comparatively BRRI dhan28 gave better results. The leaf area index (LAI) of *boro* rice showed statistically significant variation among the two varieties. Maximum leaf area index (LAI) at 25, 50, 75 DAT and at harvest was observed in the V_2 (BRRI hybrid dhan2). Total dry weight (g plant^{-1}) was significantly influenced at 25, 50 and 75 DAT but insignificant at harvest. At 25 DAT, the variety BRRI hybrid dhan2 produced the highest total dry weight (1.05 g) and the variety BRRI dhan28 gave the lowest total dry weight (0.42 g). At 50 DAT and 75 DAT BRRI hybrid dhan2 gave the maximum total dry weight (respectively 9.79 g and 37.32 g) than BRRI dhan28 (respectively 6.77 g and 33.39 g). But numerically higher total dry weight (30.31 g) was recorded from BRRI dhan28 than BRRI hybrid dhan2 (27.48 g) at harvest. The variety showed significant effect on all the yield parameters except number of effective tillers hill^{-1} and panicle length (cm). Numerically maximum number of effective tillers hill^{-1} (11.99) was observed in the V_1 (BRRI dhan28). BRRI dhan28 showed significantly maximum number of ineffective tillers hill^{-1}. The higher (24.81 cm) and lower (23.55 cm) panicle length was obtained from BRRI hybrid dhan2 and BRRI dhan28 respectively. The higher number of rachis branches panicle^{-1} (9.04) was observed in BRRI hybrid dhan2 and the lower number of branches panicle^{-1} (7.48) was observed in BRRI dhan28. The higher number of filled grains, unfilled grains and total grains panicle^{-1} (155.2, 21.63 and 176.8 cm respectively) were obtained from the hybrid variety and the lower number of filled grains, unfilled grains and total grains panicle^{-1} (114.4, 19.31 and 133.7 respectively) were obtained from the inbred variety. The higher weight of 1000-grain (23.77 g) was obtained from the hybrid variety and the lower weight of 1000-grain (21.35 g) was obtained from the inbred variety. The maximum grain yield (6.19 t ha^{-1}), straw yield (7.74 t ha^{-1}) and biological yield (13.93 t ha^{-1}) was recorded from BBRI hybrid dhan2 whereas minimum from (4.17, 3.53 and 7.70 t ha^{-1}) BRRI dhan28. The higher (54.16 %) harvest index was observed from BRRI dhan28 whereas the lower (44.76 %) from BBRI hybrid dhan2.

Application methods of urea fertilizer also significantly influenced the growth and yield attributes except number of effective tillers m^{-2}, number of filled grains panicle^{-1}, 1000-grain weight, grain yield and biological yield. At 50 DAT, T_1 treatment produced significantly tallest plant height (46.68 cm) and T_3 gave the shortest plant height (40.23 cm). The same trend was observed for T_1 (77.90 cm and 101.5 cm respectively) whereas the shorter plant height (69.75 cm and 86.73 cm respectively) was observed from T_6 at 75 DAT and at harvest. At 25 DAT, T_5 treatment produced insignificantly maximum plant height (24.97 cm) and T_2 gave the minimum plant height (22.49 cm). At 25, 50 and 75 DAT, the highest number of tillers hill^{-1} (3.00, 16.70

and 14.33 respectively) was found from T_4 whereas the lowest (1.92) from T_1 at 25 DAT and (12.30 and 11.23 respectively) from T_6 at 50 and 75 DAT. At harvest number of tillers hill^{-1} was statistically insignificant. But numerically maximum (12.17) number of tillers hill^{-1} was found from T_4 while minimum (10.53) from T_4. Significantly the highest leaf area index (LAI) at 25, 50, 75 DAT and at harvest was recorded (0.19, 2.53, 4.94 and 4.00 respectively) from T_4 and the lowest (0.09, 1.38, 3.15 and 3.14 respectively) leaf area index produced by T_6. The total dry weight (g plant^{-1}) was significantly influenced by nitrogen fertilizer doses and application methods whereas T_5 produced the lowest dry weight at 50, 75 DAT, at harvest and T_2 and T_6 produced the lowest (0.57 g) and highest (0.91 g) dry weight respectively at 25 DAT. T_3 gave the highest (9.19 g) total dry weight plant^{-1} at 50 DAT. T_1 gave maximum (38.48g and 35.20g respectively) total dry weight at 75 DAT and at harvest. The highest panicle length (24.91 cm) was observed in T_1 and the lowest panicle length (23.77 cm) in T_4. The highest number of rachis branches panicle^{-1} (8.93) was obtained from T_2 and the lowest number of rachis branches panicle^{-1} (7.65) was obtained from T_5. Number of filled grains panicle^{-1} and 1000-grain weight (g) was statistically insignificant. But numerically the maximum number of filled grains panicle^{-1} and 1000-grain weight (142.0 and 22.86 g respectively) was observed in T_4 and the lowest (124.6 and 22.26 g respectively) from T_3 and T_1. Significantly the highest number of unfilled grains panicle^{-1} (24.97) and total grains panicle^{-1} (166.9) was observed in T_4 and the lowest number of unfilled grains panicle^{-1} (13.72) and total grains panicle^{-1} (139.4) was obtained from T_5. The highest grain yield and straw yield (5.51 t ha^{-1} and 6.57 t ha^{-1} respectively) were obtained from T_1 and T_4 whereas the lowest grain yield and straw yield (4.76 t ha^{-1} and 5.18 t ha^{-1} respectively) were observed in T_4 and T_6.

Interaction effect of variety and N-management also significantly influenced all the growth as well as yield and other crop characters. The results revealed that at 25, 50 DAT and at harvest the tallest plant (28.45 cm, 47.99 cm and 104.6 cm respectively) was obtained from the V_2T_1 and the shortest plant (19.95 cm, 37.87 cm and 73.67 cm respectively) was obtained from the V_1T_6. The tallest plant (80.97 cm) was recorded at 75 DAT from V_1T_2 and the shortest plant (68.37 cm) was obtained from V_2T_3. The highest numbers of tillers hill^{-1} was observed at 25 DAT in V_2T_3 (3.07) followed by V_1T_3 (1.67). At 50 DAT, the highest number of tillers hill^{-1} were obtained from V_1T_4 (18.53) followed by V_1T_6 (12.07). The highest numbers of tillers hill^{-1} at 75 DAT and at harvest was observed in V_1T_4 (15.33 and 14.00 respectively) and the lowest numbers of tillers hill^{-1} was obtained from V_2T_6 (10.20 and 8.73, respectively). The highest leaf area index (LAI) at 25, 50 and 75 DAT was observed in V_2T_4 (0.22, 2.78 and 5.29 respectively) whereas the lowest LAI at 25 and 50 DAT was observed in V_1T_3 (1.05 and 0.06 respectively) and the lowest LAI at 75 DAT was observed in V_1T_6 (3.08). At harvest, the highest LAI was obtained from V_2T_3 (5.61) and the lowest LAI was observed in V_1T_5 (2.03). At 25 DAT the highest dry weight was observed in V_1T_6 (1.53 g plant^{-1}) and the lowest in V_1T_6 (0.30 g plant^{-1}). At 50 DAT the highest dry weight was obtained from V_2T_3 (11.93 g plant^{-}1) and the lowest from V_1T_1 (5.55 g plant^{-1}). At 75 DAT the highest dry weight was observed in V_1T_1 (42.33 g plant^{-1}) and the lowest in V_2T_2 (29.17 g plant^{-1}). At harvest the highest dry weight was obtained from V_2T_1 (38.24 g plant^{-1}) and the lowest from V_1T_2 (21.26 g plant^{-1}). The highest number of effective tillers hill^{-1} (14.17) was observed in V_1T_6 and the lowest number of effective tillers hill^{-1} (8.90) was obtained from V_2T_6. The highest panicle length, number of filled grains panicle^{-1} and total grains panicle^{-1} was observed in V_2T_1 (25.37 cm, 195.2 and 220.9 respectively) whereas the lowest from V_1T_5 (22.92 cm, 104.7 and 115.5 respectively). The highest number of rachis branches panicle^{-1} was observed in V_2T_2 (9.67) and the lowest from V_1T_5 (6.77). The highest weight of 1000-grain (24.43 g) was obtained from V_2T_4 and the lowest weight of 1000-grain (21.00 g) was obtained from V_1T_6. The highest grain yield (6.50 t ha^{-1}) was observed in V_2T_1 and the lowest grain yield was observed in V_1T_4 (3.25 t ha^{-1}).The maximum straw and biological yield was recorded from V_2T_4 (9.79 t ha^{-1} and 16.07 t ha^{-1}) whereas the minimum straw yield from V_1T_1 (3.26 t ha^{-1}) and biological yield V_1T_4 (6.60 t ha^{-1}). The highest harvest index (58.72 %) was obtained from V_1T_2 the lowest harvest index (39.87 %) was obtained from V_2T_4.

From the above results it can be concluded that,

- ❖ BRRI hybrid dhan2 has better yield potential than BRRI dhan28 in *boro* season.
- ❖ Among the methods of urea application grain yield showed the statistically similar results but 100% Urea of the recommended dose (RD) was applied as 3 top dressing gave the better results.

However, to reach a specific conclusion and recommendation the experiments with different application methods of urea need to be repeated with more varieties and in different agro-ecological zones.

REFERENCES

Abou El-Nour, E. A. A. (2002). Can supplemented potassium foliar feeding reduce the recommended soil potassium. *Pak. J. Biol. Sci*., **5**(3): 259-262.

Ahmed, M., Islam, M. and Paul, S. K. (2005). Effect of nitrogen on yield and other plant characters of Local T. Aman Rice, Var. Jatai. *Res. J. Agric. Biol. Sci.* **1**(2): 158-161.

Ahmed, Q. N. (2006). Influence of different cultivation methods on growth and yield of hybrid and inbred rice. M.S. Thesis. Dept. of Agronomy, Sher-e-Bangla Agricultural University, Dhaka.

Ahmed, Q. N., Biswas, P. K. and Ali, M. H. (2007). Influence of cultivation methods on the yield of inbred and hybrid rice. *Bangladesh J. Agri.* **32**(2): 65-70.

Akbar, M. K. (2004). Response of hybrid and inbred rice varieties to different seedlings ages under system of rice intensification in transplant aman season. M. S. (Ag.) Thesis. Dept. Agron. BAU, Mymensingh.

Akhand, M. I. M., Roy, B. C., Biswas, J. C., Parvin, N. and Paul, S. (2013). Urea spraying as an effective alternate method of nitrogen management. *Eco-friendly Agril. J.* **6**(09): 188-192.

Alam, A. K. M. A., Rahman, M. M., Islam, M. M. and Anwar, M. N. (2000). Effect of azolla, farmyard manure (FYM) and fertilizer-N on yield and nutrient uptake of BR2 rice. *Bangladesh J. Life Sci.,* **12**(1&2): 91-98.

Alam, S. S., Moslehuddin, A. Z. M., Islam, M. R. and Kamal, A. M. (2012a). Soil and foliar application of nitrogenfor Boro rice (BRRI dhan29). *J. Bangladesh Agril. Univ*., **8**(2): 199-202.

Alam, M. S., Baki, M. A., Sultana, M. S., Ali, K. J. and Islam, M. S. (2012b). Effect of variety, spacing and number of seedlings per hill on the yield potentials of transplant aman rice. *Intl. J. Agron. Agric. Res. (IJAAR)*. **2**(12): 10-15.

Alam, M. Z., Sadekuzzaman, M., Sarker, S. and Hafiz, M. H. R. (2015). Reducing soil application of nitrogenous fertilizer as influenced by liquid fertilization on yield and yield traits of kataribhog rice. *Intl. J. Agron. Agric. Res. (IJAAR)*. **6**(1): p. 63-69.

Alam, S. S., Moslehuddin, A. Z. M., Islam, M. R. and Kamal, A. M. (2010). Soil and foliar application of nitrogen for Boro rice (BRRI dhan29*). J. Bangladesh Agril. Univ.,* **8**(2): 199–202.

Alim, M. A. (2012). Effect of different sources and doses of nitrogen application on the yield formation of boro rice. *J. Environ. Sci. Nat. Res*. **5**(1): 273- 282.

Amin, M., Khan, M. A., Khan, E. A. and Ramzan, M. (2004). Effect of increased plant density and fertilizer dose on the yield of rice variety Ir-6. *J. Res. Sci*. **15**(1): 09-16.

Anonymous. (1988a). The Year Book of Production. FAO, Rome, Italy.

Anonymous. (1988b). Land Resources Appraisal of Bangladesh for Agricultural Development. Report No. 2. Agroecological Regions of Bangladesh, UNDP and FAO. pp. 472-496.

Anonymous. (2004). Annual Internal Review for 2000-2001. Effect of seedling throwing on the grain yield of wart land rice compared to other planting methods. Crop Soil Water Management Program, Agronomy Division, BRRI, Gazipur-1710.

Asenjo, M. C., Gonzalez, J. L., and Maldonado, J. M. (2000). Influence of humic extracts on germination and growth of ryegrass. *Comm. Soil Sci. Pl. Anal.* **31**: 101–114.

Ashrafuzzaman, M. (2006). Influence of tiller separation days on yield and yield attributes of inbred and hybrid rice. M.S. Thesis. Dept. of Agronomy, Sher-e-Bangla Agricultural University, Dhaka.

Ashrafuzzaman, M., Islam, M. R., Ismail, M. R., Shahidullah, S. M. and Hanafi, M. M. (2009). Evaluation of six aromatic rice varieties for yield and yield contributing characters. *Intl. J. Agric. Biol.* **11**: 616–620.

Asif, M., Aslam, M., Jabbar, A., Rafique, K., Babar, M. R. and Ehsanullah. (2000). Panicle Structure, Kernel Quality and Yield of Fine Rice as Influenced by NPK Rates and Split Nitrogen application. *Intl. J. Agri. Biol.,* **2**(4): 306-308.

Awan, T. H., Ali, R. I., Manzoor, Z., Ahmed, M. and Akhtar, M. (2011). Effect of different nitrogen levels and row spacing on the performance of newly evolted medium grain rice variety, KSK-133. *J. Anim. and Pl. Sci.* **21**(2): 231-234.

Azam, M. T., Ali, M. H., Karim, M. F., Rahman, A., Jalal, M. J. and Mamun, A. F. M. (2012). Growth and yield of boro rice as affected by different urea fertilizer application methods. *Intl. J. Sustain. Agric*. **4**(3): 45-51.

Babiker, F. S. H. (1986). The effect of zinc sulphate levels on rice growth and productivity. *Alexandria J. Agril. Res.* **31**(2): 480-481.

Bahmanyar, M. A. and Mashaee, S. S. (2010). Influences of Nitrogen and Potassium Top Dressing on Yield and Yield Components as Well as Their Accumulation in Rice (*Oryza sativa*). *African J. Biotech*. **9**(18): 2648-2653.

Bayan, H.C. and Kandasamy, O.S. (2002). Effect of weed control methods application of nitrogen on weed and crop in direct seeded puddle rice. *Res. Hisar.* **24** (2): 200-272.

BBS (Bangladesh Bureau of Statistics). (2003). Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Govt. People's Republic of Bangladesh. pp. l98- 199.

BBS (Bangladesh Bureau of Statistics). (2010). Agriculture crop cutting. Estimation of boro rice 2009-2010. Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). (2011). Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. pp. 81-128.

BBS (Bangladesh Bureau of Statistics). (2013). Statistical Yearbook of Bangladesh Statistics Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh. pp. 189-258.

Bhuiya, A. K. M. A. (2000). Effect of variety and spacing on the performance of transplant aman rice. M.S Thesis. Agronomy Dept. Bangladesh Agril. Univ., Mymensingh. pp. 43-45.

Bhuiyan, M. S. U., Hossain, S. M. A. and Kabir, S. K. G. (2002). Nitrogen fertilization in rice cv. BR10 after green manuring. *Bangladesh J. Agril. Sci.* **16**(1): 89-92.

Bhuyan, M. H. M., Ferdousi, Mst. R. and Iqbal, M. T. (2012). Foliar spray of nitrogen fertilizer on raised bed increases yield of transplanted aman rice over conventionalmethod. International Scholarly Research Network, ID 184953.

BINA (Bangladesh Institute of Nuclear Agriculture). (1993). Annual Report for 1992- 1993. Bangladesh Inst. Nuclear Agric. P.O. Box No. 4. Mymensingh. pp. 52-143.

BRRI (Bangladesh Rice Research Institute). (1985). Annual Report for 1982. BRRI Pub. No.79. Bangladesh Rice Res. Inst. Joydehpur, Gazipur, Dhaka. p. 237.

BRRI (Bangladesh Rice Research Institute). (1990). Nitrogen response of promising variety. Annual Rep. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, p. 95.

BRRI (Bangladesh Rice Research Institute). (1991). Annual Report for 1988, Joydehpur, Gazipur. pp. 40-42.

BRRI (Bangladesh Rice Research Institute). (2004). Adhunic Dhaner Chash Pub. No. 5. Bangladesh Rice Res. Inst. Joydebpur, Gazipur. pp. 140-158.

BRRI (Bangladesh Rice Research Institute). (2006). Annual Report for 2004 Joydebpur, Gazipur, Bangladesh. pp.8-320.

BRRI (Bangladesh Rice Research Institute). (2009). Annual Research Review Workshop 2008-2009, BRRI, Agronomy Division, Gazipur, pp. 490-492.

BRRI (Bangladesh Rice Research Institute). (2010). Adhunik Dhaner Chash (In Bengali). 15th Edition. Bangladesh Rice Research Institure, Gazipur, pp. 10-11, 17-18.

BRRI (Bangladesh Rice Research Institute). (2011). Adhunik Dhaner Chash (in bengali). Bangladesh Rice Research Institute, Joydebpur, Gazipur, pp: 5.

BRRI (Bangladesh Rice Research Institute). (2011). BRRI Annual Report 2008-2009. Publication no.187. pp.79-83.

BRRI (Bangladesh Rice Research Institute). (2012). Annual Report for 2011. Bangladesh Rice Res. Inst. Joydebpur, Gazipur, Bangladesh, pp. 9-13.

Chang, T. T. and Vergara, B.S. (1972). Rice Breeding, IRRI, Philippines. p.727.

Chopra, N.K. and Chopra, N. (2004). Seed yield and quality of "Pusa 44" rice (*Oryza sativa*) as influenced by nitrogen fertilizer and raw spacing. *Indian. J. Agril. Sci.* **74**(3): 144-146.

Cui, J., Kusutani A., Toyota, M. and Asanuma, K. (2000). Stadies on the varietal differences of harvest index in rice. *Japanese J. Crop Sci.* **69(**3): 357-358.

De Datta, S. K. (1978). Fertilizer Management for Efficient Use in Wetland Rice Soils.In F.N. Ponnamperuma, ed. Soil and Rice. pp. 671-670. Intl. Rice Res. Inst. Los Banos, Philippines.

De Datta, S K. (1981). Principles and practices of rice production. Intl. Rice Res. Inst. Los Banos, Philippines. pp. 9-535.

Debnath, A. (2010). Influence of planting material and variety on yield of boro rice. M.S. Thesis. Dept. of Agronomy, Sher-e-Bangla Agricultural University, Dhaka.

Debnath, A., Biswas, P. K., Sardar, M. S. A. and Rahman, A. (2012). Influence of mother and clonal tillers on yield and performance of inbred and hybrid *boro* rice. *Bangladesh Agron. J.* **15**(1): 1-7.

Dhane, S. S., Khadse, R. R., Patil, V. H. and Sauant, N. K. (1989). Effect of deep placed USG with limited green manure on transplanted rice yield. *Intl. Rice Res. Newsl.* **14**(4): 31.

Dobermann, A. and Fairhurst, T. (2000). Rice; Nutrient Disorders and Nutrient Management. and book Series. pp 41-157.

Donald, C. M. (1963). Competition among crops and pasture plants. *Adv. Agon.* **15**: 11-18.

Fillery, I. R. P., Simpson, J. R. and De Datta, S. K. (1984). Influence of field environment and fertilizer management on ammonia loss from flooded rice. *J. Soil Sci. Soc. Am*. **48**: 914-920.

Finck, A. (1982). Fertilizers and Fertilization.VerlagChimie GmbH, Weinheim, Germany.

Gardner, F. P., Pearce, R. B. and Mistechell, R. L. (1985). Physiology of Crop Plants. Iowa State Univ. Press, Powa. p. 66.

Ghaley, B. B. (2012). Uptake and utilization of 5-split nitrogen topdressing in an improved and a traditional rice cultivar in the bhutan highlands. Environmental Agriculture, **48**(04).

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedure for agricultural research. Second Edn. Intl. Rice Res. Inst., John Wiley and Sons. New York. pp. 1-340.

Hamid, M. A., (1991). A data base on agricultural and food grains in Bangladesh. Ayesha Akhtar, 606 North Shahjahanpur, Dhaka, Bangladesh. pp: 30-35.

Haq, M. T., Sattar, M. A., Hossain, M. M. and Hasan, M. M. (2002). Effects of Fertilizers and Pesticides on Growth and yield of Rice. *Online J. Biol. Sci.* **2**(2): 84-88.

Haque, M. Z. (1988). Effect of Nitrogen, Phosphorus and Potassium on Spikelet Sterility Induced by Low Temperature at the Reproductive Stage of Rice. *Pl. Soil.* **109**: 31-36.

Hasanuzzaman M., Nahar, K., Alam, M. M., Hossain, M. Z. and Islam, M. R. (2009). Response of transplanted rice to different application methods of urea fertilizer. *Intl. J. Sust. Agric*. **1**(1): 01-05.

Honjyo, K., Harano, M. and Fujise, K. (1980). Studies of Protein Content in Rice Grain : V. Effects of topdressing of ammonium sulfate and foliar application at full heading time on the translocation of nitrogen to ears and the protein content of brown rice. *Japan J. Crop Sci.* **49**(3): 467-474.

Hossain, M. B., Islam, M. O. and Hasanuzzaman, M. (2008). Influence of different nitrogen levels on the performance of four aromatic rice varieties. *Intl. J. Agric. Biol.,* **10**: 693–696.

Hossan, M. D. (2005). Effect of variety and spacing on the growth and yield of transplant Aman rice.M.S. Thesis. Agronomy Dept. Bangladesh Agril. Univ., Mymensingh. pp. 54.

Idris, M. and Matin, M.A. (1990). Response of four exotic strains of Aman rice to urea. *Bangladesh J. Agril. Sci.* **17**(2): 271-275.

IRRI (International Rice Research Institute). (1997). Rice Almanac, 2nd Ed.; IRRI in association with the West Africa Rice Development Association and the Centro Internacional de Agricultura Tropical: Manila, Philippines.

Islam, M. B., Ali, M. H., Masum, S. M., Hasanuzzaman, M., Rahman, A., Hosain, M. T., Islam, M. S., Chowdhury, M. P. and Khalil, M. I. (2013). Performance of Aman varieties as affected by urea application methods. *App. Sci. Rep.* **2**(3) : 55-62.

Islam, M. S., Howlader, M. I. A., Rafiquzzaman, S., Bashar ,H. M. K. and Al-Mamun, M. H. (2008a). Yield Response of Chili and T. Aman Rice to NPK Fertilizers in Ganges Tidal Floodplain. *J. Soil. Nat*. **2**(1): 07-13.

Islam, M. S., Hossain, M. A., Chowdhury, M. A. H. and Hannan, M. A. (2008b). Effect of Nitrogen and Transplanting Date on Yield and Yield Components of Aromatic Rice. *J. Bangladesh Agril. Univ.* **6**(2):291-296.

Jamal, Z., Hamayun, M., Ahmad, N. and Chaudhary, M. F. (2006). Effect of soil and foliar application of different concentrations of NPK and foliar application of $(NH_4)_2SO_4$ on different parameters in wheat. *J. Agron*. **5**(2): 251-256.

Janaiah, A., Hossain, M. and Husain, M. (2002). Hybrid Rice for Tomorrow's Food Security: Can the Chinese Miracle be Replicated in other Countries? *Outlook Agric.* **31**(1): 23-33.

Jashim, C., Ahmed, U. and Ahmed, K. U. (1984). Response of rice varieties to applied N in saline soils. *Intl. Rice Res. Newsl*. **9**(5): 22.

Jesy, A. J. (2007). Effect of variety and spacing on the performance of transplant Aman rice. M.S. Thesis. Agronomy Dept. Bangladesh Agril. Univ., Mymensingh. p. 27.

Kabir, M. H., Sarkar, M. A. R. and Chowdhury, A. K. M. S. H. (2009). Effect of urea super granules, prilled urea and poultry manure on the yield of transplant *Aman* rice varieties. *J. Bangladesh Agril. Univ.* **7**(2): 259–263.

Kamal, A. M. A., Azam, M. A. and Islam, M. A. (1988). Effect of cultivars and NPK combination on the yield contributing characters of rice. *Bangladesh J. Agril. Sci.* **15**(1): 105-110.

Khan, P, Memon, M. Y, Imtiaz, M. and Aslam. M. (2009). Respone of wheat to foliar and soil application of urea at different growth stage. *Pak. J. Bot*. **41**(3): 1197-1204.

Lam, H. M., Coschigano, K. T., Oliveira, I. C., Melo- Oliveira, R. and Coruzzi, G. M. (1996). The molecular-genetics of nitrogen assimilation into amino acids in higher plants. Plant Physiol. *Pl. Mol. Biol.* **47**: 569-593.

Leenakumari, S., Mahadevappa, M., Vidyachandra, B. B. and Krishnamurthy, R. A. (1993). Performance of experimental rice hybrids in Bangalore, Karnataka, India. *Intl. Rice Res. Notes*. **18**(1): 16.

Mahato, S. K., Poddar, K. K., Roni, M. Z. K., Biswas, P. K. and Jamal Uddin, A. F. M. (2014). Allelopathic effect of different plant residues on growth and yield of three aman rice varieties. *Bangladesh Res. Pub. J*. **10**(3): 270-274.

Main, M. A. (2006). Influence of planting material and planting methods on yield and yield attributes of inbred and hybrid rice. M.S. Thesis. Dept. of Agronomy, Sher-e-Bangla Agricultural University, Dhaka.

Main, M. A., Biswas, P. K. and Ali, M. H. (2007). Influence of planting material and planting methods on yield and yield attributes of inbred and hybrid rice. *J. Sher-e-Bangla Agric. Univ*. **1**(1): 72-79.

Miah, M. A. B., Alam, M. M., Hossain, M. Z. and Islam, M. R. (1993). Morpho-physiological Studies of Some Rice Cultivars. MS in Crop Botany. Department of Crop Botany. Bangladesh Agricultural University. Mymensingh, Bangladesh: p 111.

Miah, M. A. M. and Panaullah, G. M. (1999). Effect of water regimes and N-levels on soil available N, its uptake and use efficiency by transplanted rice. *Bangladesh J. Agril. Res.* **24**(2):343-353.

Millard, P. and Robinson, D. (1990). Effect of the timing and rate of nitrogen-fertilization on the growth and recovery of fertilizer nitrogen within the potato (*Solanum tuberosum* L.). *Crop. Fert. Res*. **21**: 133-140.

Miller, T. L. (1978). Rice performance trails, sixteen varieties tested at Datta Branch Station. *MAFFS Res. Highlight.* **41**(2): 6.

Mishra, P. C., Sarker, A. K. and Mishra, B. (1994). Relative efficiency of different nitrogen sources in transplanted rice of Chotanagpur region. *J. Indian Soc. Soil Sci.* **42**(2): 333-335.

Nahar, K., Zaman, M. H. and Majumder, R. R. (2009). Effect of low temperature stress transplanted Aman rice varieties mediated by different transplanting dates. *Academic J. Plant Sci.* **2**(3): 132-138.

Ndaeyo, N. U., Iboko, K. U., Harry, G. I. and Edem, S. O. (2008). Growth and yield performances of some upland rice (*Oryza sativa* L.) cultivars as influenced by varied rates of NPK (15:15:15) fertilizer on an ultisol. *J. Trop. Agric. Food. Env. Ext.* **7**(3): 249 – 255.

Nicoulaud, B. A. L. and Bloom, A. J. (1996). Absorption and assimilation of foliarly applied urea in tomato. *J. Am. Soc. Hortic. Sci*. **121**: 1117.

Obaidullah, M. (2007). Influence of clonal tiller age on growth and yield of aman rice varieties. M.S. Thesis. Dept. of Agronomy, Sher-e-Bangla Agricultural University, Dhaka.

Om, H., Katal, S. K., Dhiman, S. D. and Sheoran, O. P. (1999). Physiological parameters and grain yield as influence by time of transplanting and rice (*Oryza sativa*) hybrids. *Indian J. Agron.* **44**(4): 696-700.

Pal, N. C., Sarkar, M. A. R., Hossain, M. Z. and Barman, S. C. (2008). Root Growth of Four Transplant Aman Rice Varieties as Influenced by NPKS Fertilizer. *J. Bangladesh Agril. Univ*. **6**(2): 235-238.

Parvin, S., Uddin, S., Khanum, S. and Bhuiya, M. S. U. (2013). Effect of weeding and foliar urea spray on the yield and yield components of boro rice. *Am-Euras. J. Agric. & Environ. Sci.* **13**(6): 866-871.

Patel, J. R. (2000). Effect of water regime, variety and blue green algae on rice (*Oryza sativa*). *Indian J. Agron.* **45**(1): 103-106.

Peng, S., Buresh, R., Huang, J., Yang, J., Wang, G., Zhong, X. and Zou, Y. (2003). Principles and practices of real time nitrogen management: a care study on irrigated rice in China. Rice Science: Innovations and Impact for Livelihood. Intl. Rice Res. Inst. Los Banos, Philippines, p. 433.

Perez, C. M., Juliano, B. O., Liboon, S. P., Alcantara, J. M. and Cassman,K. G. (1996). Effects of late nitrogen fertilizer application on head rice yield, protein content and grain quality of rice. *American Ass. Cereal Chemists Inc.* **73**(5): 556-560.

Rahman, M. H., Khatun, M. M., Mamun, M. A. A., Islam, M. Z. and Islam, M. R. (2007). Effect of number of seedling hill^{-1} and nitrogen level on growth and yield of BRRI dhan32. *J. Soil Nat.* **1**(2): 01-07.

Rahman, M. S. (2001). Effect of tiller plantation on the performance of transplant *aman* rice. MS Thesis. Dept. of Agronomy, Baangladesh Agricultural University, Mymensingh.

Rasheed, M., Asif, M. and Ghafoor, A. (2003). Yield and yield attributes of fine rice BAS-385 as affected by different NP levels on farmer's field. *Pak. J. Agric. Sci.* **40:** 1-2.

Refey, A., Khan P. A. and Srivastava, V. C. (1989). Effect of nitrogen on growth, yield and nutrition uptake of upland rice. *Indian J. Agron*. **34**(2): 133-135.

Roy, S. K., Ali, M. Y., Jahan, M. S., Saha, U. K., Ahmad-Hamdani, M. S., Hasan, M. M. and Alam, M. A. (2014). Evaluation of growth and yield attributing characteristics of indigenous Boro rice varieties. *Life Sci. J.* **11**(4): 122-126.

Russo, S. (1996). Rice yield as affected by the split method of 'N' application and nitrification inhibitor DCD. In : Chataigner J. (ed.). Perspectives agronomiques de la culture du riz en Mediterranee : reduire la consommation de leau et des engrais . Montpellier : CIHEAM,. pp. 43-52 (Cahiers Options Méditerranéennes; n. **15**(1)).

Saha, P. K., Saleque, M. A., Panaullah, G. M. and Mazid Miah, M. A. (2004). Comparison of the fertilizer recommendation Models for low land rice. *Bangladesh J. Soil Sci*. **30** (1-2): 31-37.

Sarandon, S. J. and Asborno, M. D. (1996). Foliar urea spraying in rice (*Oryza sativa* L.). effects of time of application on grain yield and protein content. *Cereal Res. Comm.* **24** (4): 507-514.

Sarder, N. A., Shamsuddin, A. M. and Khan, N. H. (1988). Yield and yield components of wetland rice under various sources and levels of nitrogen. *Philippine J. Crop Sci*. **l3**(3): 155-158.

Shafiee, M. I., Boyce, A. N., Khandaker, M. M., Saad, J. M., Aziz, T. A., Mispan, M. S., Anuar, M. S. M. and Bakar, B. H. (2013). Pilot Studies on Rice. Yield Enhancement with Foliar Application of SBAJA in Sungai Besar, Selangor, Malaysia. *Life Sci* . **10**(1): 329-335.

Shahjahan, M. (2007). Modern rice in Asia: Role in food security and poverty alleviation. Financial Express. htm. p.1589.

Shamsuddin, A. M., Islam, M. A. and Hossain, A. (1988). Comparative study on the yield and agronomie characters of nine cultivars of Aus rice. *Bangladesh J. Agril. Sci.* **15**(1): 121-124.

Singh, B.K. and Singh, R.P. (1986). Effect of modified urea materials on rainfed lowland transplanted rice and their 62 residual effect successding wheat crop. *Indian J. Agron*. **3l** (2): 198-200.

Singh, S. N. and Lallu. (2005). Influence of different levels of nitrogen on its uptake and productive efficiency of paddy varieties. *Indian J. Pl. Physiol.* **10**(1): 94-96.

Singh, V. K., Dwivedi, B. S., Shukla, A. K. and Yadav, R. L. (2003). Effects of nitrogen and phosphorus fertilization on the growth and yield of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) as influenced by the inclusion of forage cowpea (*Vigna unguiculata*) in rice-wheat system. *Indian J. Agril. Sci.* **73** (9): 482-489.

Sultana, M. (2008). Effect of variety, method of planting and weeding on the yield and yield components of transplant *Aus* rice. M.S. Thesis. Agronomy Dept. Bangladesh Agril. Univ., Mymensingh. p. 28.

Tac, T. H., Hirano, M., Iwamoto, S., Kuroda, E. and Murata, T. (1998). Effect on topdressing and planting density on the number of spikelets and yield of rice cultivated with nitrogen-free basal dressing. *Pl. Prod. Sci.* **1**(3): 191-198.

Takita, T. (2009). Yield and canopy structure of a super high yielding rice variety recently developed. *Nogyo Gijutsu.* **64**: 136-139.

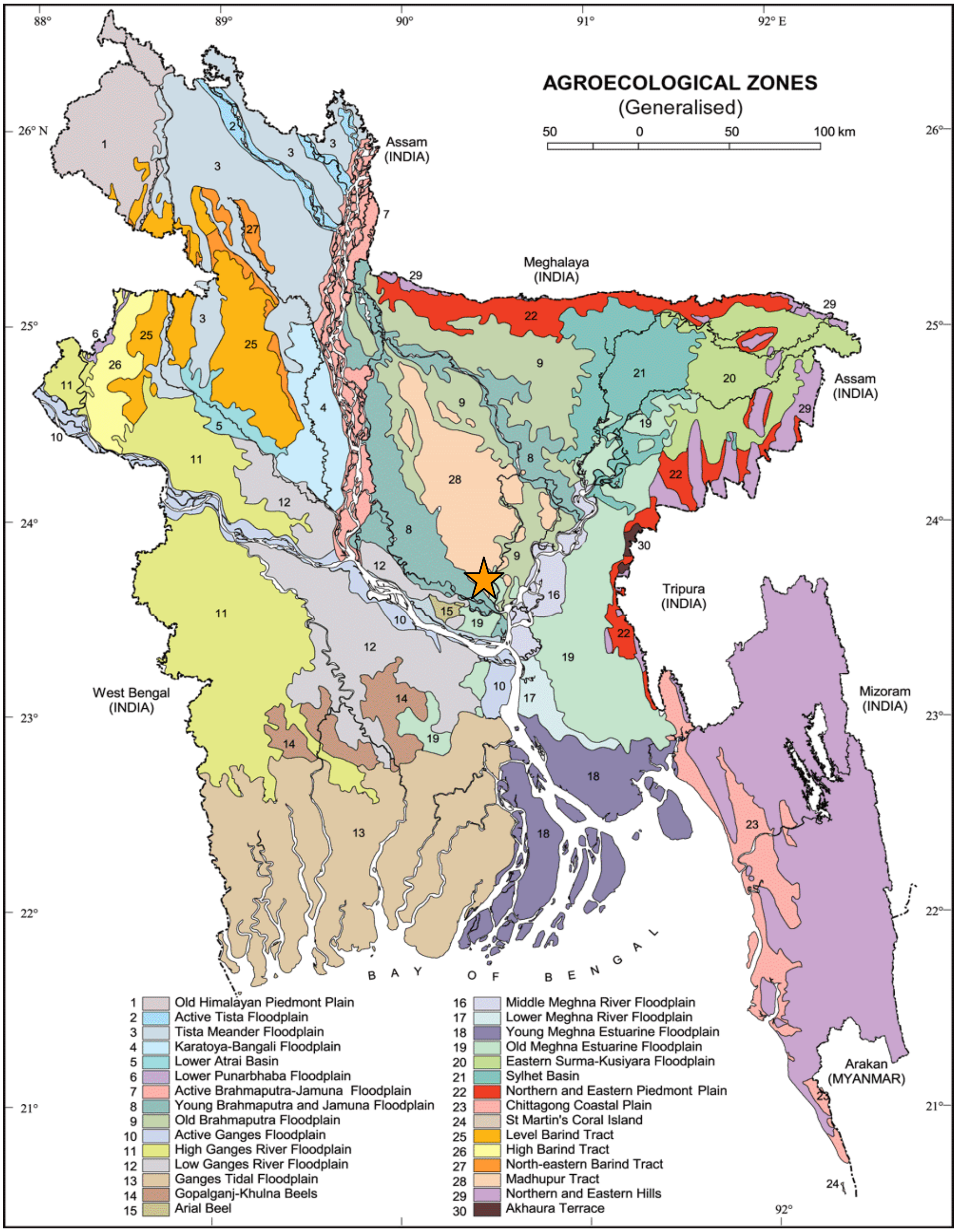
WenXiong, L., Yiyuan, L. and TingChat, W. (1996). The heterotic effects on dry matter production and grain yield formation in hybrid rice. *J. Fujian Agric. Uni.* **25**(23): 260-265.

Yoshida, S. (1981). Fundamentals of Rice Crop Science, IRRI, Philippines. pp. 1-41.

Zohra, F. T., Ali, M., Salimand, R. and Kader, M. A. (2013). Effect of urea super granules on the performance of transplant aman rice. *J. Agrofor. Environ*. **7**(1): 49-52.

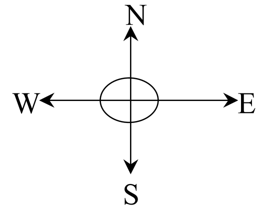
APPENDICES

Appendix I. Map showing the experimental sites under study

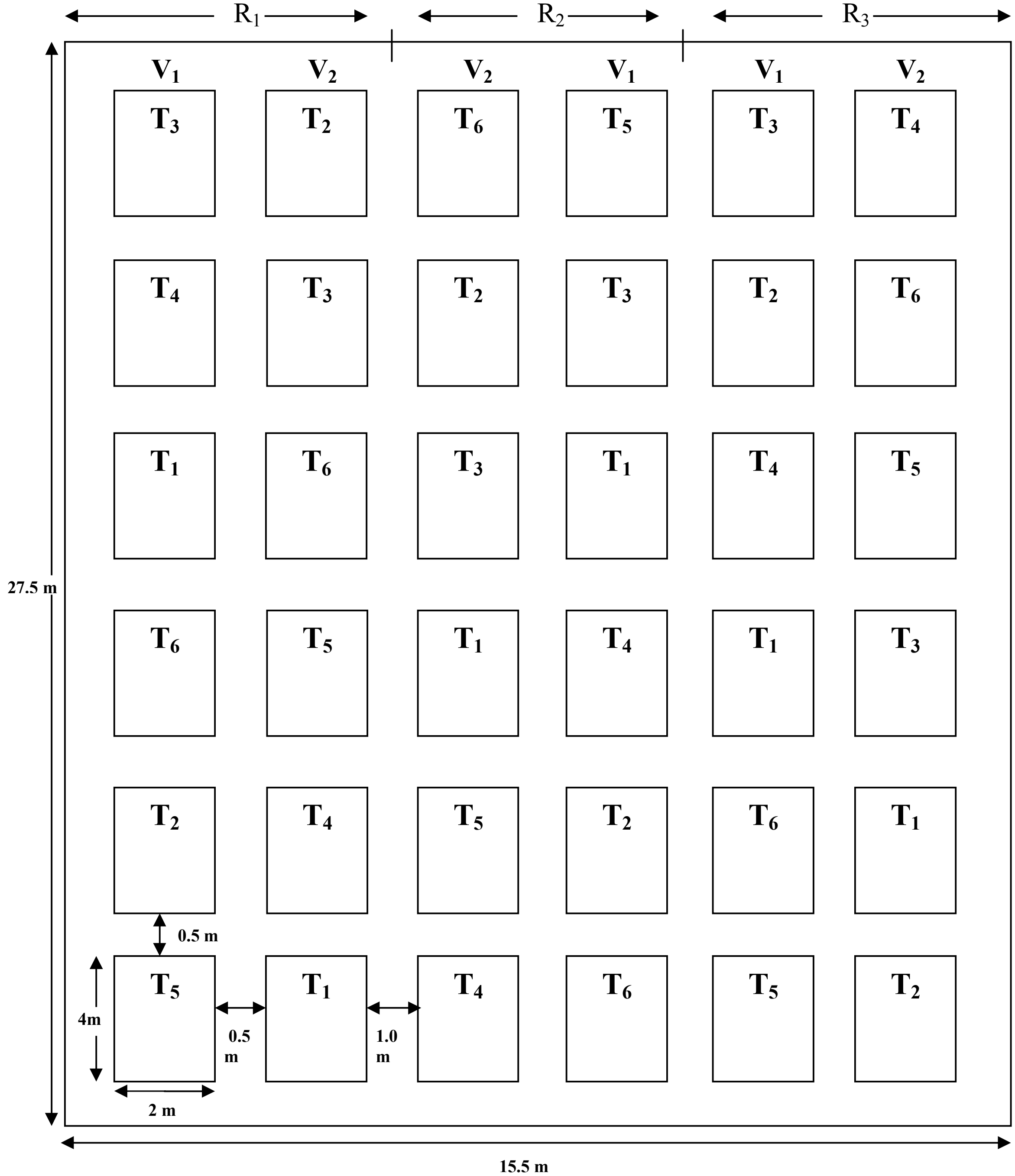


★ **The experimental site under study**

V_2



Appendix II. Layout of the experimental field



V_1 - (BRRI dhan28), **V_2** – (BRRI hybrid dhan2), **T_1** = 100% Urea of the recommended dose (RD) was applied as 3 top dressing, **T_2** = 100% Urea of RD was applied as 3 foliar spray, **T_3** = 100% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_4** = 75% Urea of RD was applied as 1 top dressing and 2 foliar spray, **T_5** = 75% Urea of RD was applied as 3 foliar spray, **T_6** = 50% Urea of RD was applied as 3 foliar spray.

Appendix III. Mean square values for plant height at different days after transplanting *boro* rice

Sources of Variation	Degrees of freedom	Mean square values for plant height at different days after transplanting			
		25	50	75	At harvest
Replication	2	70.880	53.278	67.929	64.148
Variety	1	108.646	0.094	405.351	481.071
Error (a)	2	34.649	33.910	119.764	57.908
N-management	5	5.329	32.292*	47.166*	165.441*
Variety × N-management	5	18.489*	14.024*	24.100*	137.505
Error (b)	20	9.191	17.760	32.837	81.136

* Significant at 5% level

Appendix IV. Mean square values for tiller numbers hill^{-1} at different days after transplanting of *boro* rice

Sources of Variation	Degrees of freedom	Mean square values for tiller numbers hill^{-1} at different days after transplanting			
		25	50	75	At harvest
Replication	2	0.039	1.843	8.801	5.163
Variety	1	0.444	19.951	0.321	26.010
Error (a)	2	0.095	0.521	3.060	1.423
N-management	5	0.908*	16.627*	6.884*	2.687
Variety × N-management	5	0.550*	6.527*	4.233*	6.133*
Error (b)	20	0.063	1.308	3.001	1.933

* Significant at 5% level

Appendix V. Mean square values for leaf area index at different days after transplanting of *boro* rice

Sources of Variation	Degrees of freedom	Mean square values at different days after transplanting			
		25	50	75	At harvest
Replication	2	0.001	0.052	32.688	23.623
Variety	1	0.024*	3.503*	22.404*	470.890*
Error (a)	2	0.001	0.133	880.375	203.470
N-management	5	0.008*	1.131*	259.340*	59.501*
Variety × N-management	5	0.001*	0.404*	136.407*	170.114*
Error (b)	20	0.001	0.020	100.271	42.984

* Significant at 5% level

Appendix VI. Mean square values for total dry weight at different days after transplanting of *boro* rice

Sources of Variation	Degrees of freedom	Mean square values at different days after transplanting			
		25	50	75	At harvest
Replication	2	0.002	0.218	22.886	18.753
Variety	1	3.497*	82.053*	139.122*	71.995
Error (a)	2	0.003	0.669	4.503	6.559
N-management	5	0.099*	2.204*	24.071*	79.136*
Variety × N-management	5	0.180*	12.018*	70.536*	39.618*
Error (b)	20	0.002	0.431	10.061	10.716

* Significant at 5% level

Appendix VII. Mean square values for crop growth characters, yield and other crop characters of BRRI dhan28 and BRRI hybrid dhan2 at harvest

Sources of Variation	Degrees of freedom	Mean square values											
		Effective tillers hill^{-1}	Ineffective tillers hill^{-1}	Panicle length	Rachis branches panicle^{-1}	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Total grains panicle^{-1}	1000-grains weight	Grain yield	Straw yield	Biolo-gical yield	Harvest index
Replication	2	12.343	0.142	2.754	0.764	485.989	1.008	1027.051	1.124	0.430	4.935	8.197	27.462
Variety	1	22.880	24.010*	14.288	21.778*	14920.62*	48.767*	16675.41*	52.538*	36.703*	159.85*	349.752*	795.710*
Error (a)	2	1.941	0.251	1.071	0.745	475.396	1.614	514.602	1.257	0.398	2.169	3.662	6.748
N-management	5	1.130	0.210*	0.967*	1.552*	1178.809	109.789*	1685.526 *	0.280	0.507	1.453*	1.048*	45.081*
Variety × N-management	5	6.079*	0.178*	0.739 *	0.058*	451.969*	34.172*	581.418*	0.591*	0.823*	3.436*	7.273*	19.776*
Error (b)	20	1.701	0.033	0.602	0.411	934.777	4.566	1053.787	0.302	0.729	1.040	2.577	17.023

* Significant at 5% level