RESPONSE OF COWDUNG AND UREA ON TWO *BORO* RICE VARIETIES UNDER WETLAND CULTIVATION

M. S. MUKTADIR

DEPARTMENT OF SOIL SCIENCE
SHER–E–BANGLA AGRICULTURAL UNIVERSITY
DHAKA –1207

JUNE, 2014

RESPONSE OF COWDUNG AND UREA ON TWO *BORO* RICE VARIETIES UNDER WETLAND CULTIVATION

By

M.S. MUKTADIR

Reg. No.: 07–02526

A Thesis

Submitted to the Department of Soil Science
Sher–e–Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (M.S.)

IN

SOIL SCIENCE

SEMESTER: JANUARY–JUNE, 2014

Approved By:

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

....

Dr. Mohammad Issak
Chairman
Examination Committee

JUNE, 2014

Department of Soil Science

Sher-e-Bangla Agricultural University

Sher-e -Bangla Nagar, Dhaka-1207, Bangladesh

Ref. SAU/SOIL/ **Date:** ……………………

CERTIFICATE

*This is to certify that thesis entitled, "**RESPONSE OF COWDUNG AND UREA ON TWO BORO RICE VARIETIES UNDER WETLAND CULTIVATION**" 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 **SOIL SCIENCE,** embodies the result of a piece of bona fide research work carried out by **M. S. MUKTADIR, Registration No. 07-02526** under my supervision and guidance. No of part of the thesis has been submitted for any other degree of 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

Professor Mst. Afrose Jahan

Department of Soil Science

Supervisor

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENT

All praises to the Almighty ***Allah*** *who enable me to complete a piece of research work and prepare this thesis for the degree of Master of Science (M.S.) in Soil Science.*

I feel much pleasure to express my gratitude, sincere appreciation and heartfelt indebtedness to my reverend research supervisor ***Prof. Mst. Afrose Jahan****, Department of Soil Science, Sher–e–Bangla Agricultural University (SAU), Dhaka–1207, Bangladesh for his scholastic guidance, support, encouragement, valuable suggestions and constructive criticism throughout the study period.*

I also express my gratefulness to respected co–supervisor, ***Prof. Dr. Alok Kumar Paul****, Department of Soil Science, Sher–e–Bangla Agricultural University (SAU), Dhaka–1207 for her constant inspiration, valuable suggestions, cordial help, heartiest co–operation, providing all facilities and supports which were needed to completing the study.*

I would like to express my deepest respect and thanks to all my honorable teachers of the Department of Soil Science, Sher–e–Bangla Agricultural University (SAU) for their valuable suggestions, instructions, cordial help and encouragement.

I am extremely thankful to all MS student of Jan-June/2012 and July- Dec/2012 semester, all officers and staffs of the Department of Soil Science, Sher–e–Bangla Agricultural University (SAU), Dhaka–1207 for their kind support and sincere co–operation during my study.

Finally, I express my deepest sense of gratitude to my beloved parents, brothers, sisters, other family members, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

Dhaka, Bangladesh ***The Author***
June, 2014

RESPONSE OF COWDUNG AND UREA ON TWO *BORO* RICE VARIETIES UNDER WETLAND CULTIVATION

ABSTRACT

A field experiment was conducted to evaluate the response of Cowdung and Urea on rice under wetland condition at the research farm of Sher–e–Bangla Agricultural University, Dhaka, Bangladesh during the *Boro* season (Mid November–March) of 2012–13. Two rice varieties namely BRRI dhan29 (V_1) and Heera 4 (V_2) and seven treatments including control *viz.* T_0: controlled or no fertilizer, T_1: 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea), T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea), T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea), T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea), T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea) and T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea) were used for the present study. The experiment was laid out in RCBD method with three replications and analysis was done by the MSTAT–C package program and means were adjudged by DMRT at 5% level of probability. Effect of variety was significantly affected the whole characters of the study except harvest index and K content in postharvest soil where the HYV variety Heera 4 had highly significant than BRRI dhan29. Similarly, whole studied traits of the study were also influenced significantly due to the effect of cowdung + Urea as a source of N where the treatment T_4 (3.84 t ha^{-1} cowdung + 196.0 kg ha^{-1} Urea) showed understanding superiority for getting the better growth, higher yield and greater significant effect on nutrient management practices. Most of the studied traits were also influenced significantly due to the effect of interaction of variety and cowdung + Urea fertilizer where harvest index, P and K content in grain and N and P content in straw showed numerically similar performance among the interaction treatments due to non significant variation. Rest of the characters had highest in variety Heera 4 receiving of 3.84 ton cowdung ha^{-1} + 196.0 kg Urea ha^{-1} (V_2T_4) as well as the tallest plant (101.40 cm), more effective tillers hill^{-1} (23.90), longest panicle (33.14 cm), more grains panicle^{-1} (219.30), highest 1000–grain weight (33.10 g), highest yield of grain, straw and biological (6.53, 7.96 and 14.49 t ha^{-1}) were recorded. Only N content in grain had highest (1.190%) in Heera 4 receiving of 5.12 ton cowdung ha^{-1} + 168.0 kg Urea ha^{-1} (V_2T_5) while K content in straw had highest (1.475%) in Heera 4 treated by T_4 (V_2T_4). NPK uptake in grain (75.38, 21.73 and 20.97 kg ha^{-1}, respectively) and straw (59.28, 14.66 and 117.50 kg ha^{-1}, respectively) were found in V_2T_4 while same treatment also recorded the highest NPK content in postharvest soil (0.0960 ppm, 34.70 ppm and 0.0467 meq 100 g^{-1}, respectively). The overall results indicate that the variety Heera 4 and 3.84 ton cowdung ha^{-1} (30%) along with 196.0 kg Urea ha^{-1} (70%) as singly or their interaction was the most selective variety and optimum Nitrogen levels for getting the superior yield under wetland condition and higher capability to increase nutrient ability in grain and straw as well as increase the sustenance capacity of the soil. The above results also indicated that the organic fertilizer as cowdung can be reduced 30% use of inorganic fertilizer which also reduced the soil pollution by chemical fertilizer.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

ABBREVIATIONS

μM	=	Micro mol
AEZ	=	Agro–Ecological Zone
ANOVA	=	Analysis of variance
BARC	=	Bangladesh Agricultural Researcher Council
BARI	=	Bangladesh Agricultural Research Institute
SAU	=	Sher–E–Bangla Agricultural University
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
BRRI	=	Bangladesh Rice Research Institute
BSMRAU	=	Bangabandhu Sheikh Mujibur Rahman Agricultural University
CRD	=	Completely randomized design
DAS	=	Days after sowing
DAT	=	Days after transplanting
DMRT	=	Duncan's Multiple Range Test
e.g.	=	Exempli gratia (by way of example)
et al.	=	And others
FAO	=	Food and Agriculture Organization
HI	=	Harvest index
HRC	=	Horticulture research center
i.e.	=	edest (means That is)
IRRI	=	International Rice Research Institute
LSD	=	Least significant difference
mgL^{-1}	=	Milligram per litre
NICS	=	National Institute of Crop Science
RDF	=	Recommended dose of fertilizer
RD	=	Recommended dose
RFD	=	Recommended fertilizer dose
RCBD	=	Randomized Complete Block Design
SA	=	Soil application
spp	=	Species (plural number)
var.	=	Variety
Viz.	=	Namely

CHAPTER 1

INTRODUCTION

CHAPTER 1
INTRODUCTION

Rice belongs to the Poaceae family with the genus *Oryza* which contains about 22 different species (Wopereis *et al*., 2009). It is the dominant staple food for many countries of the world (Mobasser *et al*., 2007). It is also the most important food crop and a major food grain for more than a third of the world population and 50% of the global population (Zhao *et al*., 2011). Among the most cultivated cereals in the world, rice ranks as second to wheat (Abodolereza and Racionzer, 2009). Rice is grown in more than 10 countries with a total harvested area of nearly 160 million hectares, producing more than 700 million tons every year (IRRI, 2010). According to the FAO of the UN, 80% of the world rice production comes from 7 countries (UAE/FAO, 2012).

In Bangladesh, rice covered an area of 28.49 million acres with a production of 33.54 million M tons while the average yield of rice in Bangladesh is around 1.18 T tons acres^{-1}. In case of *Boro* rice, it covers the largest area of 11788 (41.38% of total rice cultivation area) T acre (local 195 + HYV 9968 + HYB 1625 T acre) with a production of 1.86 million tons (55.50%) and the average yield is about 1177 kg acre^{-1} during 2010–11 (BBS, 2012). Besides, based on the rice cultivation, Bangladesh is the 5th largest country of the world (BBS, 2012). Alam (2012) also reported that rice covers about 82% of the total cropped land of Bangladesh. It accounts for 92% of the total food grain production in the country and provides more than 50% of the agricultural value addition employing about 44% of total labour forces. According to the latest estimation made by BBS, per capita rice consumption is about 166 kg year^{-1}. Rice alone provides 76% of the calorie intake and 66% of total protein requirement and shares about 95% of the total cereal food supply (Alam, 2012). The population of Bangladesh is growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020 (BRRI, 2011). During this time total rice area will also shrink to 10.28 million hectares. Rice yield therefore, needs to be increased by 53.3% (Mahamud *et al*., 2013). On the other hand, agricultural land is decreasing day by day. About 220 hectares agricultural lands are decreased per year due to urbanization, industrialization, housing and road construction purposes. Fifty lakh acres of agricultural land decreased during last 20 years. Food deficit has been also increasing in Bangladesh at an alarming rate due to increase in population growth and low yield of food crops achieved per unit area.

Use of local cultivars is also one of the most important reasons for low yield. So, we have to think how to solve the food problem of the country. Since there is little scope of horizontal expansion of the rice area in the country attempt should be made to increase the yield per unit area. However, the potential for increasing rice production strongly depends on various factors like as cultivar, fertilizer application, planting methods, sowing time, seed rate etc. Among them, selection of a better cultivar concerning the regional condition of the cultivated area and proper doses of fertilizer are the most important features for maximizing the rice yield. Use of high yielding cultivar (HYV) has been increased remarkably in recent years and the country has almost reached a level of self sufficiency in food. Hence, the cultivar itself is a genetic factor which contributes a lot in producing yield and yield components of a particular crop which are directly related to the cultivar. BRRI as the designated organization for carrying out research and development of high yielding modern rice technology has so far successfully developed and released as many as 59 modern rice cultivars suitable for growing in different seasons (Alam, 2012). Despite this impressive achievements made by BRRI, the Bangladesh Institute of Nuclear Agriculture (BINA) has also developed few high yielding rice cultivars. BRAC, the biggest non–government development organization has so far developed six high yielding hybrid rice cultivars to boost rice production through adoption of high yielding modern rice cultivars (MVs) along with improved production technologies (Alam, 2012).

Depletion of soil fertility is a major constraint for higher crop production in Bangladesh. Most of the cultivated soils have organic matter content of below 1.5% and on the other hand, addition of organic matter is very low. However, nitrogen is one of the major elements in plant growth and urea has been found to be a very effective nitrogenous fertilizer in rice production. But the efficiency of applied nitrogen in rice is very low, generally ranging from 15 to 25% in wet land condition (Prasad and Datta, 1979) with the highest absorption rate of 30 to 50% (De Datta, 1978). Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Continuous use of inorganic fertilizer like Urea deteriorates some soil properties and causes a nutrient imbalance of soil in addition to causing micronutrient deficiency (Rahman *et al*, 2009). Furthermore, chemical fertilizers pollute soil and water making our environment harmful while soil organic matter plays a vital role to improve the physical chemical and biological properties of soil. So it is worthwhile to proceed for an integrated use of inorganic fertilizers and manures for sustainable crop production. So, a suitable combination of organic and inorganic sources of nutrients is very necessary for sustainable crop yield (Shaha, 2014). Application of cowdung and poultry manure alone or in combination with Urea can play an important role in rice cultivation (Rahman *et al*, 2009). A great deal of work has also been conducted with Urea, cowdung and poultry manure in many countries of the world but the information on the relative contribution with chemical fertilizers in rice production is scarce in Bangladesh. Such the related researches in Bangladesh were conducted by Rahman *et al*., 2007; Parvez *et al*., 2008. In Bangladesh, Tasnin (2012) also reported that the organic fertilizer such as cowdung may play a vital role in soil fertility improvement as well as supplying primary and secondary and micro nutrients for crop production. In addition, it can improve the physical, chemical and biological properties of soil and helps increase and conserve the soil productivity. Besides, application of organic fertilizers such as cowdung is more profitable and economic than other inorganic fertilizers to avoid attack of insects, pests and disease. So, the use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility by maintaining the eco–friendly environment in reducing the use of inorganic fertilizer.

From the above aspect, the present study was conducted to investigate the effects of cowdung and Urea alone or in combination on the yield and nutrient uptake of BRRI dhan29 and Heera 4. Considering the above facts, the present research study was therefore undertaken to find out following objectives:

i. To determine the role of organic fertilizer (cowdung) and inorganic fertilizer (Urea) on the production of Boro rice;
ii. To identify the suitable cultivar on the aspect of better growth, higher yield and superior nutrient uptake of BRRI dhan29 and Heera 4;
iii. To find out the optimum level of cowdung + Urea concerning better response on various agronomical studied traits;
iv. To select the most advantageous interaction, if any, between cultivars and cowdung + Urea relating to above aspect;
v. To maintain eco –friendly environment by reducing the use of inorganic fertilizer (Urea); and
vi. To enhance rice yield with implementing sustainable agriculture

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2
REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief and relevant review of many researchers in relation to the effects of *Boro* rice varieties and different rates of cowdung (%) along with Urea (%) on the aspect of growth, yield of rice in Bangladesh perspective and also in the other parts of the world. Related review regarding nutrient content and uptake in grain and straw along with nutrient status in postharvest soil was also reviewed in this chapter under the following headings:

2.1 Effect of varieties on growth, yield and nutrient attributes of *Boro* rice

Wirnas *et al*. (2015) reported that the genotypes evaluated Mekongga, and IPB 3S have higher yield potential and significantly different from IR 64, Situ Patenggang, and Kalimutu. All of the varieties evaluated had lower total grain number due to high temperature stress, but only significantly different for Inpari 13, IPB 4S, IPB 5R, and IPB 7R. The Inpari 13, IPB 3S, IPB 4S, IPB 5R, and IPB 7R varieties had lower grain weight and 1000 grain weight due to high temperature stress. Varieties IR 64 and Situ Patenggang were able to sustain the grain weight under high temperature stress, but have a lower grain weight than other varieties.

Wiangsamut *et al*. (2015) found that the plant height of RD14 rice genotype was significantly taller than San–pah–tawng1 rice genotype. Grain yield of RD14 rice genotype was significantly higher than San–pah–tawng1 rice genotype; mainly due to RD14 rice genotype having had higher filled grain number panicle^{-1} and harvest index.

Roy *et al*. (2014) evaluated 12 indigenous *Boro* rice varieties where the plant height and tillers hill^{-1} at different DAT 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) in GS. The maximum tillers hill^{-1} (46.00) was observed in Sylhety *Boro* and the minimum (19.80) in Bere Ratna. All of the parameters of yield and yield contributing characters differed significantly at 1% level except grain yield, biological yield and harvest index. The maximum 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) 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}).

Haque *et al*. (2015) evaluated the two popular indica hybrids (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrid varieties out yielded the inbred. However, the hybrids and inbred varieties exhibited statistically identical yield in late planting. Filled grain (%) declined significantly at delayed planting in the hybrids compared to elite inbred due to increased temperature impaired–inefficient transport of assimilates. Results suggest that greater remobilization of shoot reserves to the grain rendered higher yield of hybrid rice varieties.

Hossain *et al*. (2014b) conducted an experiment at the research farm of SAU on the yield and yield attributes of exotic hybrid rice varieties. Significantly longer panicle was recorded from Heera2 (24.70 cm) which was statistically identical with Aloron (24.52 cm). Both hybrid rice varieties Heera2 (119.8) and Aloron (111.8) produced the highest spikelets $panicle^{-1}$ than that of BRRI dhan48 (105.5). In BRRI dhan48, the highest filled spikelets $panicle^{-1}$ (79.53) was recorded. This was may be due to lower sensitiveness of BRRI dhan48 to high temperature and low sunshine hour at grain filling stage compared to test hybrid varieties. The highest spikelet filling percent was recorded from BRRI dhan48 (74.43%) due to favorable environmental condition at grain filling stage. Aloron produced heavier grain size than that of Heera2 and BRRI dhan48. BRRI dhan48 gave significantly higher grain yield 3.51 t ha^{-1} over the tested hybrid varieties Heera2 (3.03 t ha^{-1}) and Aloron (2.77 t ha^{-1}). Biological yield did not varied significantly among studied hybrid and inbred rice varieties. The highest HI was obtained from BRRI dhan48 while it was lowest in Aloron.

Hossain *et al*. (2014a) evaluated the five rice cultivars (one hybrid: WR96, three modern: BR16, BR26, and BRRI Dhan27 and one local: Pari). Most of the yield–contributing characters examined and showed wide variations among the cultivars whereas modern cultivar BR16 produced the highest panicle length, number of grain $panicle^{-1}$ and grain yield ha^{-1}. At the same time as local cultivar Pari generated the lowest number of tiller $plant^{-1}$, panicle length, grain number $panicle^{-1}$ and grain yield ha^{-1}. Moreover, hybrid cultivar WR96 produced the highest percentage of spotted grain $panicle^{-1}$.

Sokoto and Muhammad (2014) conducted a pot experiment to determine the effect of water stress and variety on productivity of rice. The results indicated significant ($P < 0.05$) differences among genotypes. Faro 44 differed significantly from others in plant height, number of leaves plant^{-1}, harvest index and grain yield. FARO 44 differed significantly from NERICA 2 and FARO 15 at all the parameters under study.

Shiyam *et al*. (2014) conducted an experiment to evaluate the performance of four Chinese hybrid rice varieties where it was showed comparative superiority of FARO 15 to the hybrids in all growth and yield components assessed. FARO 15 was taller (140 cm) with more productive tillers (11.0), higher spikelets plant^{-1} (166.0), higher filled grains panicle^{-1} (156.17), higher filled grains (92.17%), highest 100–grain weight of 2.63 g and the higher paddy yield (5.021 t ha^{-1}) than others. Despite the comparative poor performance of the hybrids, Xudao151came close to FARO 15 with grain yield of 2.987 t ha^{-1}.

Akter (2014) investigated the growth, yield and nutrient content of 15 *Boro* rice cultivars. BR 15, BRRI dhan29 and BRRI dhan28 were the three rice cultivars having high potentials for grain and straw production during *Boro* season. The highest yield was recorded 5.26 t ha^{-1} which is still very low compared to other rice growing countries of the world. Chola *Boro* and Sada bore are two local land races having potentials for producing higher number of effective tillers and higher 1000 grain weight. Sada *Boro* and Chola *Boro*, two local cultivars were found very high in grain nitrogen content compared to other test cultivars.

Sarker *et al*. (2013) found that the BRRIdhan 28 was shorter in plant height, having more tillering capacity, higher leaf number which in turn showed superior growth character and yielded more than those of the local cultivars. The HYV BRRIdhan 28 produced higher grains panicle^{-1} and bolder grains resulted in higher grain yield over the local cultivars. The BRRIdhan 28 produced higher grain yield (7.41 t ha^{-1}) and Bashful, Poshurshail and Gosi yielded ha^{-1}, respectively. Among the local rice cultivars, Gosi showed the higher yielding ability than Bashful and Poshursail.

Islam *et al*. (2013) found that the highest plant height (116.00 cm) was found in the variety Morichsail and the lowest in the variety Khaskani. Filled grains panicle^{-1} was found highest (100) with the variety Khaskani and the lowest was recorded in the variety Raniselute. Raniselute produced the highest 1000–grain weight (32.09 g) and the lowest (13.32 g) was recorded from the variety Kalijira. The variety Morichsail produced the highest grain yield (2.53 t ha^{-1}) followed by Kachra (2.41 t ha^{-1}), Raniselute (2.13 t ha^{-1}) and Badshabhog (2.09 t ha^{-1}) and the lowest grain yield (1.80 t ha^{-1}) was obtained from Kalijira.

Hossaina *et al*. (2013) reported that the evaluated five rice cultivars showed wide variations regarding most of the yield–contributing characters. Modern cultivar BR16 produced the highest panicle length, number of grain $panicle^{-1}$ and grain yield ha^{-1}. At the same time as local cultivar Pari generated the lowest number of tiller $plant^{-1}$, panicle length, grain number $panicle^{-1}$ and grain yield ha^{-1}.

Garba *et al*. (2013) studied on the effects of variety, seeding rate and row spacing on growth and yield of rice. Variety Ex–China produced significantly ($P<0.05$) higher numbers of tillers $plant^{-1}$ and spikes $hill^{-1}$. However, NERICA–1 produced significantly ($P<0.05$) higher numbers of spikelets $spike^{-1}$, seeds $spike^{-1}$, weight of seed $spike^{-1}$, weight of seed $hill^{-1}$, 1000 grain weight and yield in kg ha^{-1} than Ex–China.

Yao *et al*. (2012) found insignificant difference in grain yield between the cv. AWD and CF. On average, YLY6 produced 21.5% higher yield than HY3 under AWD conditions. Like grain yield, YLY6 showed consistently higher water productivity and physiological nitrogen use efficiency than HY3. Both total dry weight and harvest index contributed to higher grain yield of YLY6.

Sritharan and Vijayalakshmi (2012) evaluated the physiological traits and yield potential of six rice cultivars *viz.*, PMK 3, ASD 16, MDU 3, MDU 5, CO 47 and RM 96019. The plant height, total dry matter production and the growth attributes like leaf area index, crop growth rate and R:S ratio were found to be higher in the rice cultivar PMK 3 that showed significant correlation with yield. Yield and yield components like number of productive tillers, fertility co–efficient, panicle harvest index, grain weight and harvest index were found to be higher in PMK 3.

Panwar *et al*. (2012) studied to evaluate the performance of rice varieties. Growth parameters viz plant height (cm), No. of tillers m^{-2}, leaf area index and dry matter accumulation (g) was highest in JGL–3844 over rest of varieties. The effective tillers m^{-2} (331.6), panicle length (25.63), grains $panicle^{-1}$ (68.23), sterility per cent (12.1), grain yield (60.9 q ha^{-1}) and straw yield (92.58 q ha^{-1}) yield were also highest in variety JGL–3844.

Oka *et al*. (2012) assessed the agronomic characteristics of 15 selected indigenous and newly introduced hybrid rice varieties in Ebonyi State, Nigeria. Significant variation ($P<0.05$) was detected among the 20 rice varieties for all the traits evaluated. The results showed that plant height ranged between 144.01 cm in "Mass (I)" and 76.00 cm in "Chinyeugo". Cv. "E4197" had the highest value of 38±0.02 cm for panicle length and "Chinyereugo" had the highest value of 6.3g ± 0.03 for panicle weight. Leaf area showed the highest value of 63.8cm^2 ± 0.01 in "Mass (I)". Cv. "Co–operative" had high number of seeds panicle^{-1} (139 ± 0.19). "Chinyereugo" had the highest value of 25.9g ±1.4 for 1000–grains weight. The grain of "E4314" was the longest (8.00 mm ± 0.89) of the varieties studied.

Mannan *et al.* (2012) reported that the Badshabhog and Kalijira showed taller plants and Chinigura was shorter while Chinigura produced the greatest tillers at early, mid and at later growth stages and the lower tillers was observed in Badshabhog. Chinigura produced the highest amount of DM and while least amount of DM was observed in Kataribhog. The Chinigura produced significantly the highest panicles but it was statistically identical with Kalijira, while, Kataribhog exhibited lower number of panicles but number of grains panicle^{-1} was found more in Badshabhog. The heaviest grain was found in Kataribhog while the light grain was observed in Badshabhog. The grain yield of Chinigura and Kalijira was almost identical. Lower grain yield was found in Kataribhog which may be attributed to the lower number of panicles and grain panicle^{-1}.

Alam *et al*. (2012) found that the cultivar BRRI dhan33 gave significantly the tallest plant (113.17 cm), while the shortest plant was found in BRRI dhan32 cultivar (105.07 cm). Among the cultivars, BR11 produced the maximum total tillers hill^{-1} (12.33), maximum fertile spikelets panicle^{-1} (103.83) while lowest fertile spikelets panicle^{-1} (102.10) and minimum total tillers hill^{-1} (10.17) were found in BRRI dhan32. BR11 also produced the highest 1000–grain weight (23.79g) and highest grain yield (5.92 t ha^{-1}) while BRRI dhan33 produced the lowest 1000–grain weight (21.69 g) and grain yield. The cultivar BR11 produced the highest grain yield, it might be due to the highest number of total tillers hill^{-1}, number of effective tillers hill^{-1} and 1000–grain weight and lowest number of sterile spikelets panicle^{-1}.

Mahamud *et al*. (2013) showed that rice cultivars differed significantly in all growth characters, such as plant height, tillers number, chlorophyll content and dry matter weight of different plant parts, panicle length, filled grain, unfilled grain, filled grain percentage, 1000–grain weight, grain yield and straw yield.

Khushik *et al*. (2011) studied to assess the performance of rice hybrid and other varieties planted in rice growing areas of Sindh and Balochistan. The results revealed that average yield of hybrid rice was 195 mds ha^{-1}, followed by IRRI–6 (151 mds ha^{-1}), B–2000 (91 mds ha^{-1}) and Rosi (94 mds ha^{-1}). This indicates that the yield of hybrid rice was higher by 29% than the major variety IRRI–6.

Islam (2011) conducted a field experiment at BINA, Mymensingh on five aromatic rice genotypes viz., BRRIdhan34, Ukunimadhu, RM–100/16, KD5 18–150 and Kalozira by at BINA, Mymensingh. Among the varieties, KD5 18–150 showed higher grain yield, total dry matter $plant^{-1}$ and harvest index under temperature stress.

Baset Mia and Shamsuddin (2011) reported that the aromatic rice cultivars showed tallest plant stature, profuse tillers $hill^{-1}$, panicle $hill^{-1}$ and larger panicle but smaller grain, higher grain yield, lowest straw yield and harvest index compare modern rice. Modern rice cultivars generally had higher TDM, LAI, LAR, CGR, RGR whereas aromatic cultivars resulted in higher NAR. The highest grain yield of modern rice cultivars was due to the higher harvest index. Poor yield in aromatic rice cultivars was due to lower translocation of assimilates.

Akinwale *et al*. (2011) evaluated 14 rice varieties (10 commercial hybrids, 2 inbred and 2 lowland NERICAs) at the Africa Rice Center to compare the grain yield performance. The number of panicles m^{-2}, number of grains $panicle^{-1}$ were significantly higher in the hybrids than in the inbred and inter–specific varieties. The hybrids had the highest grain yield compared to the inbred and the inter–specific lowland NERICA varieties. The results indicated that hybrids exhibited significant yield increase of 13.44% over the best lowland NERICAs and 15.17% over the best inbred variety WITA 4.

Islam *et al*. (2010) found that the rice cultivar 1R76712H produced the highest grain yield (7.7 t ha^{-1}) followed by 1R75217H and Magat (7.6 t ha^{-1}) in WS; in DS, 1R79118H produced the highest grain yield (9.17 t ha^{-1}) followed by 1R73855H (8.9 t ha^{-1}) and SL–8H (8.8 t ha^{-1}) due to high harvest index. Hybrid produced higher spikelets panicle^{-1} and 1000–grain weight than inbred rice. Spikelet filling percent was higher in inbred than hybrid rice.

Islam *et al*. (2009b) reported that the genotype BINAdhan 5 and BINAdhan 6 showed similar performance in respect of most of the parameters but BINA dhan 6 produced the highest grain yield (40.26 g hill^{-1}) compared to BINA dhan 5 (35.54 g hill^{-1}) and Tainan 3 (33.90 g hill^{-1}).

Islam *et al*. (2009a) reported that BRRI dhan–3l had about 10–15% higher plant height, very similar tillers plant^{-1}, 15–25% higher LA at all DAT compared to Sonarbangla–1 in 2001. Sonarbangla– 1 had about 40% higher DM production at 25 DAT but had very similar DM production at 50 and 75 DA. BRRI dhan–3l had higher panicles plant^{-1} than Sonarbangla–1, but Sonarbangla–1 had higher grains panicle^{-1}, 1000–grain weight and grain yield than BRRI dhan–31. In 2002, BRRI dhan–31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhan–l had the highest plant height. Sonarbangla–1 had the largest LA at 25 and 50 DAT while BRRI dhan–31 had the largest LA.

Sohel *et al*. (2009) found that BRRI dhan41 produced higher grain yield (4.7 t ha^{-1}) which was the contribution of higher number of grains panicle and heavier grain weight. Lower yield (4.51 t ha^{-1}) was recorded in BRRI dhan 40.

Razzaque *et al*. (2009) studied on salt tolerant genotypes PVSB9, PVSB19, PNR381, PNR519, Iratom24 and salt sensitive genotype NS15 along with one standard check salt tolerant rice cultivar Pokkali. The different morphological characters studied include plant height, total number of tillers, Root Dry Weight (RDW), Shoot Dry Weight (SDW) and Total Dry Matter (TDM) content of the selected rice genotypes in view to evaluate their response at different salinity levels. The genotypes Pokkali, PVSB9, PVSB19 showed significantly higher values and the lowest value of all these characters were recorded in NS15.

Jeng *et al*. (2009) found that the cultivar Tainung 67 had greater yield (7.2 mg ha^{-1}) than SA419 (6.2 mg ha^{-1}). The greater yield of SA419 than Tainung 67 in autumn was due to its higher net assimilation rate and better dry matter partitioning during grain filling. Significant panicle branch effects on the distribution pattern of grain weight were also found between Tainung 67 and SA419 with greater variation for the former than the latter.

Ashrafuzzaman *et al*. (2009) reported that the Kalizira was the tallest (107.90 cm) while it was shortest (93.40 cm) in Chiniatop and was identical to Kataribhog (95.30 cm) due to genetic makeup of the cultivar, but the environmental factors also influence it. There was also significant difference on 1000–grains weight among the cultivars whereas the highest 1000–grains weight was recorded in BR38 (20.13 g) and the lowest was recorded in BR34 (12.17 g). BR34 produced the maximum grain yield and Basmati produced the lowest. The highest harvest index was recorded from BR34 (34.94%) and the lowest harvest index was obtained from Basmati (31.51%).

Alam *et al*. (2009) reported that the tallest plant was observed with BRRI dhan 29 due to its genetic characters while numerically the highest DM of plant was found in Hira 2 and lowest in BRRI dhan 29 at all the growth stages except 25 DAT. They also found that the CGR values increased progressively with time reaching the highest at 75–100 DAT regardless of variety while CGR was maximum in Hira–2 (33.24 g m^{-2} d^{-1}) at 75–100 DAT and it was identical with Aloron (31.79 g m^{-2} d^{-1}), while CGR was lowest in BRRI dhan 29 during the whole growth period.

Masum *et al*. (2008) reported that that Nizershail produced the taller plant height than BRRI dhan44 at different DAT. Total tillers $hill^{-1}$ was significantly influenced by variety at all stages. At 30 and 60 DAT, Nizershail had significant by higher amount of DM (35.46% higher at 30 DAT and 18.01% higher at 60 DAT) than BRRI dhan44 but at harvest BRRI dhan44 had significantly higher amount of DM (39.85 g $hill^{-1}$) that was 18.42% higher than Nizershail. BRRI dhan44 produced higher (4.85 t ha^{-1}) grain yield than Nizershail (2.46 t ha^{-1}). Nizershail produced higher (7. 22 t ha^{-1}) straw yield compared to BRRI dhan44 (6.34 t ha^{-1}).

Hossain *et al*. (2008) reported that all the yield contributing characters differed significantly due to cultivar. The tallest plant was observed in Chinigura (162.8 cm) which statistically similar to Kataribhog. Kalizira produced the maximum number of grains $panicle^{-1}$ (135.90). Among the cultivars, BRRI dhan 38 gave the maximum grain yield (4.00 t ha^{-1}). Five varieties were evaluated by Ndaeyo *et al*. (2008). Among the varieties, the variety WAB224–8–HB produced the highest grain yield (4.73 and 4.40 t ha^{-1}) followed by WAB189–B–B–B–8–HB (4.37 and 4.20 t ha^{-1}) for both years.

Akram *et al*. (2007) studied on fifteen rice hybrids where two hybrids viz., MK Hybrid 111 and 27P72 produced more productive tillers than KS 282. All most all the hybrids produced more number of grains $panicle^{-1}$ and higher 1000–grain weight. Yield advantage of the hybrids over the commercially grown rice variety ranges between 4.59–21.33% except RH–257 and GNY–40. These two hybrids were low yielder by 4.20 % and 14.95%, respectively, than the check variety.

A pot experiment was conducted by Islam *et al*. (2007) at the BINA, Mymensingh, to find out the growth and yield attributes of mutant rice under varied saline levels. Three rice genotypes viz. Q–31, Y–1281 and MR–219 were used as tests materials. Among the genotypes, MR–219 showed best performance in respect of yield and yield contributing characters such as plant height, number of tiller $hill^{-1}$, effective tillers $hill^{-1}$, panicle length, filled grain $panicle^{-1}$, 1000–grain weight (g), grain yield $hill^{-1}$ (g). The genotypes Q–31 and Y–1281 showed its susceptibility to salinity stress. Thus MR–219 was found best salt tolerant genotype than others.

Khan *et al*. (2006) reported that the variety Rachna showed the highest yield of 4009.590 kg ha^{-1} followed by Basmati–385, Shaheen and Super with the production of 3678.983, 2939.257 and 2175.303 kg ha^{-1}, respectively. However, the plant height (cm) of Rachna was at 2^{nd} position (125.400 cm) after Basmati–385 at 129.767 cm. The maximum tiller $plant^{-1}$ (18) was obtained by variety Rachna, which significantly differ from variety Super that produced 10 tillers $plant^{-1}$. The maximum spike $plant^{-1}$ 18 were shown by variety Rachna and the number of tiller $plant^{-1}$ produced by Rice variety Basmati–385 i.e., 17. The highest yield of Rachna variety was due to the best performance in terms of tillers $plant^{-1}$, spike $plant^{-1}$ and weight of 1000 grains.

Amin *et al*. (2006) studied on traditional and modern rice cultivars at BSMRAU, Salna, Gazipur. Cultivar KK–4, a high yielding variety out yielded (4772 kg ha^{-1}) the indigenous varieties Jharapajam (4150 kg ha^{-1}), Lalmota (3628 kg ha^{-1}) and Bansful Chikon (3575 kg ha^{-1}).

George *et al*. (2005) evaluated the 12 aromatic rice varieties/cultivars where pooled analysis of the yield data indicates that 'Pusa Basmati–1' had the highest grain yield of 2777 kg ha^{-1}. But it was statistically at par with that of 'Jeerakasala' (2743 kg ha^{-1}) and IET–12606 (2610 kg ha^{-1}), implying the suitability of these three varieties for cultivation in Wayanad district.

2.2 Effect of N /Urea on growth, yield and nutrient attributes of *Boro* rice

Azarpour *et al*. (2014) studied on yield and physiological traits of three rice cultivars (Khazar, Ali Kazemi and Hashemi) due to the effect of N fertilizer (0, 30, 60, and 90 Kg N ha^{-1}). Results of growth analysis indicated that, nitrogen increasing rates of fertilizer caused the increment of growth indexes and yield of rice.

Zhaowen Mo *et al*. (2013) reported that yield formation and growth of "super" rice (*Oryza sativa* L.) was affected by nitrogen application. The results showed that, N 187.5 kg ha^{-1} had the highest LAI at full heading, CGR from full heading to maturity as well as TDW at maturity, which resulted in a significantly high increase in grain yield from 24.19–29.84% and 5.01–6.26% as compared to N 0 and 225 kg ha^{-1}, respectively.

Yoseftabar (2013) reported that N fertilizer is a major essential plant nutrient and key input for in increasing crop yield. The results showed that panicle number, panicle length, panicle dry matter, number of primary branches, total grain and grain yield increased significantly with nitrogen fertilizer. Application 300 kg N ha^{-1} observed high rate of this parameter.

Uddin *et al*. (2013) found that application of nitrogen at 80 kg ha^{-1} produced the highest total spikelets and maximum grains $panicle^{-1}$ resulted in the highest grain yield. Based on the results it may be recommend that nitrogen should be applied at 80 kg for obtaining the higher grain yield of NERICA 1 rice.

Naidu *et al*. (2013) reported that the highest growth, yield attributes, lesser spikelet sterility and higher grain yield were obtained with the application of 100–50–50 kg ha^{-1} N, P_2O_5, K_2O and these parameters were at their minimum with the supply of 60–30–30 kg ha^{-1} of N, P_2O_5, K_2O. The increase in yield with supply of 100–50– 50 kg ha^{-1} N, P_2O_5, K_2O (N_3), compared to supply of 60–30–30 kg ha^{-1} N, P_2O_5, K_2O (N_1) was 15.1 and 15.4% respectively during 2006 and 2007 respectively.

Maqsood *et al*. (2013) reported that the nitrogen application at 100 kg N ha^{-1} provided a maximum paddy yield (4.39 and 4.67 t ha^{-1}) in both years under the climatic conditions of Faisalabad, Pakistan, higher paddy yield and yield components, as well as greater economic benefits, can be obtained at 100 kg N ha^{-1} nitrogen application.

Haque (2013) conducted an experiment to investigate the effect of five nitrogen levels viz. 0, 40, 80, 100 and 140 kg N ha^{-1} and he found the longest plant, highest number of total, effective tillers hill^{-1}, grains panicle^{-1}, grain and straw yields were observed with 100 kg N ha^{-1} followed by 140 kg N ha^{-1}.

Yoseftabar *et al*. (2012) showed that yield and yield components increased significantly with nitrogen fertilizer. Interesting in comparison to 100 and 200 kg ha^{-1} level application of higher N–fertilizer 300 kg ha^{-1} showed a positive respond to application of high nitrogen on hybrid cultivar. Effect of different split application N–fertilizer was significantly on parameter of above. Sharma *et al*. (2012) found that the highest grain yield of 70.60 q ha^{-1} was attained with an application of 180 kg N ha^{-1}. The lowest yield (44.12 q ha^{-1}) was recorded in the control plot.

Hasanuzzaman *et al*. (2012) conducted an experiment on growth and yield of rice due to evaluat the effect of N–fertilizer (0, 80, 120, 160, 200 kg N ha^{-1}, USG @ 75 kg N ha^{-1}). Results indicated that N had a significant effect on effective tillers hill^{-1}, filled grains panicle^{-1} and 1000–grain weight. USG gave the highest effective tillers hill^{-1} (13.63) followed by 120 kg N ha^{-1} (12.11). The highest filled grains panicle^{-1} (154.7) was found from N_2 (USG) which was at par with 160 kg N ha^{-1} (145.8), 120 kg N ha^{-1} (145.4) and 200 kg N ha^{-1} (144.1). Application of N created significantly variation in grain yield, straw yield, biological yield and harvest index. USG gave the highest yield (9.42 t ha^{-1}) which was followed by 160 kg N ha^{-1} (8.58 t ha^{-1}). The increase in yield by the use of USG and 160 kg N ha^{-1} was 76.74% and 60.98%, respectively over the N_0.

Alim (2012) reported that the grain and straw yields were increased with the increase of nitrogen rate up to 120 kg ha^{-1} at all the sources. 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.

Abou–Khalifa (2012) evaluated the 5 rice varieties under different N levels (0, 55, 111, 165 and 220 Kg ha^{-1}). Main results induced that maximum tillering, panicle initiation, roots length, heading dates, grains filling rates (GFR) at five stages, LAI chlorophyll content, number of tillers m^{-2}, 1000– grains weight, number of grains $panicle^{-1}$, panicle length (cm) and grain yield (t ha^{-1}) were the highest value at 220 kg N ha^{-1}.

Salem *et al*. (2011) found that the number of tillers $hill^{-1}$, days from sowing up to panicle initiation, heading dates, leaf area index, leaf area ratio, chlorophyll content, 1000–grain weight, panicles length, agronomic efficiency, utilization efficiency and grain yield (t ha^{-1}) were increased by increasing nitrogen levels up to 165 kg N ha^{-1}.

Salem *et al.* (2011) reported that the number of tillers $hill^{-1}$, days from sowing up to panicle initiation, heading dates, leaf area index, leaf area ratio, chlorophyll content, 1000–grain weight, panicles length, agronomic efficiency, utilization efficiency and grain yield (t ha^{-1}) were increased by increasing nitrogen levels up to 165 kg N ha^{-1}.

Salem *et al*. (2011) reported that the number of tillers $hill^{-1}$, days from sowing up to panicle initiation, heading dates, LAI, LAR, chlorophyll content, days 1000–grain weight, panicle length, agronomic efficient, utilization efficiency and grain yield (ton ha^{-1}) were increased by increasing nitrogen levels up to 165 kg N ha^{-1}.

Mohaddesi *et al*. (2011) found that the effect of nitrogen fertilizer rates had not significant effects on traits except 1000–grain weight in both seasons. Increasing N fertilizer levels up to 300 kg N ha^{-1} resulted in increases in plant height, grain yield, biological yield but these increases were not significant.

Metwally *et al*. (2011) studied to evaluate the response of Egyptian hybrid rice 1 'H1' to nitrogen fertilizer. Nitrogen levels were 0, 50, 100, 150, 200, 250, 300, 350, and 400 kg N ha^{-1}. Nitrogen fertilization significantly increased grain yield. The maximum grain yield was obtained with the application of 200 kg N ha^{-1}. Yield components were also significantly affected by N treatments.

Khorshidi *et al*. (2011) reported that the effect of nitrogen fertilizer had no significant difference on 1000 seeds weight and number of grains $panicle^{-1}$. The effect of fertilizers on rice yield showed that application of 100 kg of nitrogen had the highest yield of 5733 kg ha^{-1}. Data also indicated that yield had the highest positive correlation with panicle and harvest index.

Karim (2011) studied on the effect of nitrogen fertilizer (0, 20, 40, 60, 80.100 120 kg N ha^{-1}) in respect to high yield and better seed quality. Growth parameters like plant height (114.37 cm) and tillers hill^{-1} (15.1) had higher at higher level of nitrogen. However, plants with moderate level of applied nitrogen showed better yield component of the variety where the highest panicle hill^{-1} (11.8), grains panicle^{-1} (140.5) and filled grains panicle^{-1} (130.33) were recorded with 60 kg N ha^{-1}. Better yield components of the variety obtained at 60 kg N ha^{-1} attributed to the highest yield (4.43 t ha^{-1}) of the variety.

Jun *et al*. (2011) conducted an experiment in a rice field with different crop rotation systems and nitrogen application rates, surface water nitrogen content, nitrogen loss via runoff, soil fertility and rice yield were determined. Alfalfa–rice and rye–rice rotation systems enhanced soil nitrogen content, promoted rice nitrogen absorption and significantly improved rice yield.

Fageria *et al*. (2011) reported that yield and yield components were significantly increased in a quadratic fashion with increasing N rate. Based on regression equation, maximum grain yield was achieved with the application of 380 mg N kg^{-1} by ammonium sulfate and 271 mg N kg^{-1} by urea. Grain yield and yield components were reduced at higher rates of urea (>300 mg kg N) but these plant parameters' responses to ammonium sulfate at higher rates was constant. In the intermediate N rate range (125 to 275 mg kg^{-1}), urea was slightly better compared to ammonium sulfate for grain yield.

Awan *et al.* (2011) carried out an experiment to study the effect of different nitrogen levels (110, 133 and 156 kg ha^{-1}) in combination with different row spacing (15 cm, 22.5 cm and 30 cm). Treatment RS2N3, where 156 kg N ha^{-1} were applied with 22.5 cm row to row and plant to plant spacing had maximum values of plant height (79.07 cm), tillers m^{-2} (594), panicle length (25.40cm), number of grains panicle^{-1} (132.97), grain yield (5.46 t ha^{-1}), straw yield (9.66 t ha^{-1}) and least value of sterility percentage (5.7 %).

Mizan (2010) reported that the highest plant height (983.32 cm) was obtained form 160 kg N ha^{-1} followed by 120 kg N ha^{-1}.

Mannan *et al.* (2010) studied to determine the optimum N level as well as to find out the genotype having high yield potential. The plant height, tiller number, number of panicles, panicle length, spikelet sterility and straw yield increased with the increase of nitrogen levels up to 75 kg N ha^{-1}. Maximum plant growth at the highest level of N caused lodging of plant which increased spikelet sterility and lower grains panicle^{-1} and ultimately decreased grain yield.

Kandil *et al*. (2010) found that the increasing nitrogen fertilizer levels up to 80 kg N ha^{-1} resulted in marked increases in number of tillers m^{-2}, panicle length, panicle weight, filled grains panicles^{-1}, 1000–grain weight, grain and straw yields ha^{-2} and harvest index in both seasons. The addition of 144 or 192 kg N ha^{-1} recorded the tallest plants and the highest number of panicles m^{-2} without significant differences. The increase in plant height and straw yield ha^{-2} with the heaviest 1000–grains weight, highest grain yield ha^{-2} and HI in both seasons.

Hoshain (2010) observed that no. of effective tiller, no. of grains panicle^{-1}, grain yield and straw yield were significantly increased with the increasing rates of N 120 Kg ha^{-1} as urea where harvest index increased from up to N 80 Kg ha^{-1} application. Salahuddin *et al.* (2009) found gradual increase in panicle length (24.50 cm), grains panicle^{-1} (110) and grain yield (4.91 t ha^{-1}) due to the increase in nitrogen levels up to 150 kg ha^{-1} and declined thereafter. Thousand–grain weight was not significantly influenced by application of different levels of nitrogen.

Hossain *et al.* (2008) reported that different nitrogen rates also significantly affected the aromatic rice cultivars. All the yield components were significantly increased up to 90 kg N ha^{-1}. Nonetheless, maximum grain yield (3.62 t ha^{-1}) was observed from 60 kg N ha^{-1}.

Islam *et al*. (2009b) found significant variation on morpho–physiological attributes of BINAdhan 5, Tainan 3 and BINAdhan 6 due to four N levels. Plant height, tillers hill^{-1}, leaves hill^{-1}, LA hill^{-1} (cm2), DM of root, stem and leaves hill^{-1}, TDM hill^{-1} and chlorophyll content in leaves (at 74 DAT), were increased with the split application of N. Among the treatments, T_4 showed the best performance and grain yield (45.25 g hill^{-1}) compared to control (30.61 g hill^{-1}). Full dose of urea (215 kg urea ha^{-1}) applied at three equal split at 15, 30 and 55 DAT was found to be the most beneficial one for the all the rice genotypes.

Nori *et al*. (2008) studied to assess the grain yield and straw nutritive quality of MR 211 and MR 219 rice varieties due to five nitrogen rates (0, 120, 160, 200 and 240 kg

N ha^{-1}). Increases in nitrogen application was found to increase ($P<0.01$) the grain yield, total spikelets m^{-2}, spikelets panicle^{-1} and straw crude protein from 4.56% to a maximum level of 8.45%.

Islam *et al*. (2008) conducted a field experiment found that the application of N fertilizer significantly influenced the plant height, number of tillers, effective tillers, panicle length, grains panicle^{-1} and grain yield. The highest grain yield 4.27 t ha^{-1} was recorded with the N_4 (100 kg N ha^{-1}).

Hossain *et al.* (2007b) reported that the N levels also exerted significant effect on all the yield parameters, except for panicle length and 1000–grain weight. The highest grain yield was obtained from the application of 75 kg ha^{-1} of the recommended dose of N and the lowest from the control treatment (0 kg ha^{-1}) of rice cv. BRRI dhan32.

Hossain *et al.* (2007a) reported that the greatest plant height and highest number of tillers hill^{-1} were observed with the application of 69 kg N ha^{-1}, which was significantly followed by 51.75, 34.5 and 17.25 kg N ha^{-1}, respectively and the lowest was observed in control treatment (0 kg N ha^{-1}).

Abbasi *et al.* (2007) found that the highest number of fertile tiller was obtained in the fifty and sixth treatments with double and triple split application of 120 kg N ha^{-1}. They suggested that triple split application of 80 kg N ha^{-1} could be best for rice production.

Manzoor *et al*. (2006) evaluated the nine different nitrogen levels i.e. 0, 50, 75, 100, 125, 150, 175, 200 and 225 kg ha^{-1} for observing the field performance of rice. Plant height, productive tillers hill^{-1}, panicle length, grains panicle^{-1}, 1000 grain weight and paddy yield showed increasing trend from 0 kg N ha^{-1} up to 175 kg N ha^{-1}. The yield parameters including paddy yield, grains panicle^{-1} and 1000 grain weight started declining at 200 kg N ha^{-1} level and above. Maximum paddy yield (4.24 t ha^{-1}) was obtained from 175 kg ha^{-1} nitrogen application treatment which also produced highest values of grains panicle^{-1} (130.2) along with a maximum 1000 grain weight (22.92 gm). The plant height (139.8 cm) along with productive tillers hill^{-1} (23.42) and panicle length (29.75 cm) was the maximum at 225 kg N ha^{-1}.

Dwivedi *et al*. (2006) conducted a field experiment on growth and yield of rice to evaluate the effect of N level. They found that 184.07 kg ha^{-1} N (urea) was the optimum rate for highest yield.

Amin *et al*. (2006) found significant variation on growth, tillering and yield of three traditional rice varieties due to variable doses of N fertilizer compared with that of a modern variety at BSMRAU, Salna, Gazipur. Application of 60 kg N ha^{-1} produced more TDM and lesser ineffective tillers. Application of 30 kg N ha^{-1} appropriate for low responsive traditional varieties produced the highest yield (4451 kg ha^{-1})

Rahman *et al*. (2005) reported that recommended 100% dose of N increasing the highest grain yield (4.80 t ha^{-1}) which was as par with 75% recommended dose of N producing 4.75 t grain ha^{-1}.

Naik and Paryani (2005) reported that the plant height and grain yield were increased with application of N up to 150 kg ha^{-1}. The highest number of grains $panicle^{-1}$ (157.9), yield of grains (64.4 q ha^{-1}) and straw (94.4 q ha^{-1}) were produced significantly from rice hybrids PHB –71.

Muhammad *et al*. (2005) reported that the highest number of plant height (116.55 cm), number of spikelet $panicle^{-1}$ (118.85) and straw yield (11.00 t ha^{-1}) were obtained from 150 $kgha^{-1}$ urea.

Mashkar and Thorat (2005) conducted a field experiment to study the effects of different nitrogen levels (0, 40, 80 and 120 kg N ha^{-1}, respectively) on N, P and K uptake and grain yield of scented rice cultivars (Pula Basmati 1, Kasturi, Indrayani and Sugandha). The different levels of N had significant effect in augmenting the uptake of N, P and K nutrients and grains as well as straw yield of rice. Application of 120 kg N ha^{-1} recorded significantly higher N, P and K uptake in rice compared to the rest of the N levels. Every increment of 40 kg N ha^{-1} from 0 to120 kg N ha^{-1} increased the nutrient content and uptakes.

Sidhu *et al*. (2004) reported that nitrogen fertilizers substantially increased the mean grain yield of Basmati up to 40 kg N ha^{-1} in the fallow Basmati–wheat Sequence while 60 kg N ha^{-1} reduced Basmati yield. Compared to the treatment No, the mean grain yield of Basmati was increased by 0.31, 0.40 t ha^{-1} at doses of 20 and 40 kg N ha^{-1}. Subhendu *et al*. (2003) conducted a field experiment during kharif season at Hyderabad, India. They found that application of N 120 kg ha^{-1} as urea in equal splits during transplanting, tillering, panicle initiation and 50% of flowering resulted in the highest 1000 grain weight (22.57 g).

Singh and Shivay (2003) evaluated that increasing level of N significantly increased the number of tiller hill^{-1}. Mondal and Swamy (2003) observed that highest harvest index by applying N (120 kg ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and flowering. Lawal and Lawal (2002) found that grain yield of rice significantly increased by 80 kg ha^{-1} N (urea) application.

Bayan and kandasamy (2002) observed that effective tiller hill^{-1} was significantly affected by the level of N and recommended doses of N (Urea) in four splits at 10 days after sowing, active tillering, panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz., effective tillers m^{-2}.

2.3 Effect of varieties and N levels on various characteristics of rice

The experiment of Bekere *et al*. (2014) was to investigate the effect of split application of nitrogen on growth and yield of NERICA 1 and NERICA 4 rice varieties at Tsukuba International Center, Japan. The result showed that NERICA 1 had significantly greater establishment percentage, SDM, panicle length and 1000–grain weight than NERICA 4, but its leaves were significantly ($p<0.05$) less green than the latter after 55 days of sowing. It also produced significantly longer panicles than the other two modes of N applications.

Malik *et al*. (2014) studied on three different fertility levels of N *viz.* 100, 120 and 140 where varietal trial indicates that Pusa Basmati–1 at N 120 level was significantly different from all the parameters measured which include plant height number of tillers hill^{-1}, dry weight, length of panicle, filled grains panicle^{-1}, straw yield, biological yield, harvest index, benefit cost ratio and grain yield of 4.66 t ha^{-1} at nitrogen 120, 3.10 t ha^{-1} at nitrogen level 120 were maximum and minimum in Pusa basmati–1 and Basmati–370, respectively .

Alim (2012) reported that the 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.

Abou–Khalifa (2012) evaluated two field experiment on five rice varieties under different nitrogen levels (0, 55, 111, 165 and 220 Kg ha^{-1}). Main results induced that maximum number of tillers m^{-2}, 1000– grains weight, number of grains $panicle^{-1}$, panicle length (cm) and grain yield (t ha^{-1}) were the highest value at 220 (Kg N ha^{-1}) with the cultivar Sakha 106. While zero nitrogen with GZ.9362 gave the lowest value with all traits under study.

Razzaque *et al*. (2011) reported that the cultivars BRRIdhan 39 gave the highest yield (50.82 g $plant^{-1}$) at supra optimum N level and elevated CO_2. Local varieties gave similar results under elevated CO2 in optimum and supra optimum N level. The lowest yield was produced by the local variety Shakkorkhora (15.09 g) under ambient CO_2 with no nitrogen application.

Mannan *et al.* (2010) studied to determine the optimum N level as well as to find out the genotype having high yield potential. Genotype Basmati PNR having dwarf plant characteristics performed well at higher level of nitrogen (100 kg N ha^{-1}), while other genotypes having medium plant height responded well at lower level of nitrogen (52–56 kg N ha^{-1}). Similar effects were also obtained on among other all studied traits.

Hach and Nam (2006) found that the application of nitrogen fertilizer at 60 kg N ha obtained the highest economical efficiency in the Wet season for all tested rice varieties. Further increase in the rate of nitrogen fertilizer beyond 90 kg N ha^{-1} gave a negative EENA value. In the Dry season, at 80 kg N ha^{-1}, EENA obtained the highest for all tested rice varieties. At higher nitrogen rates (120–160 kg N ha^{-1}), EENA values were lowest.

2.4 Effect of variety, cowdung and N levels on morpho–physiological, yield and yield attributes of rice

Shaha (2014) reported that the different rates of cowdung with inorganic fertilizers showed significant effect on all growth parameters viz. plant height and tillers $hill^{-1}$. Among the cowdung levels with BRRI RD of inorganic fertilizers, highest grain yield (5.62 t ha^{-1}) was obtained from cowdung 7.5 t ha^{-1} with inorganic fertilizers and lowest (5.07 t ha^{-1}) was recorded in control. Similarly, the highest grain yield (6.25 t ha^{-1}) was obtained from the treatment combination of BR11 and cowdung 7.5 t ha^{-1} with inorganic fertilizers which was statistically identical with all BR11 in cowdung treated plot.

Sarkar (2014) found that the application of 75% RD of inorganic fertilizers + 50% cowdung showed superiority in terms of plant height (123.3 cm) and total tillers hill^{-1} (13.87) where those were also highest in combination of BRRI dhan34 × 75% RD of inorganic fertilizers + 50% cowdung. Nutrient management of 75% RD of inorganic fertilizers + 50% cowdung (5 t ha^{-1}) gave the highest grain yield (3.97 t ha^{-1}) and the lowest grain yield (2.87 t ha^{-1}) was found in control. The highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 coupled with 75% RD of inorganic fertilizers + 50% cowdung and the lowest grain yield (2.7 t ha^{-1}) was found in BRRI dhan37 in control.

Liza *et al*. (2014) found that the treatment T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}) produced the highest grain yield (6.87 t ha^{-1}) and straw yield (7.24 t ha^{-1}). The lowest grain yield (3.22 t ha^{-1}) and straw yield (4.55 t ha^{-1}) were found in T_0. Treatment T_6 receiving 50% RFD along with the residual effect of 2.5 t ha^{-1} cowdung, 1.5 t ha^{-1} poultry manure and 2.5 t ha^{-1} compost was found to be the best combination of organic and inorganic nitrogens for obtaining the maximum yield of BRRI dhan29 and nutrient content and uptake by grain and straw.

Islam *et al*. (2014) found that the yield contributing characters like plant height, effective tillers hill^{-1}, panicle length and grains panicle^{-1} of BRRI dhan49 were significantly influenced by the application of manures and fertilizers. The highest grain yield of 4.87 t ha^{-1} was observed in the treatment T_3 [PM + STB–CF (HYG)] and the lowest value of 3.61 t ha^{-1} was found in T_0. The straw yield ranged from 4.10 to 5.51 t ha^{-1} in different treatments. The NPKS uptake by BRRI dhan49 was markedly influenced by manures and fertilizers. Based on overall results, the treatment T_3 [PM + STB–CF (HYG)] was found to be the best combination of manures and fertilizers for obtaining the maximum yield and quality of rice.

Hasan (2014) showed that the treatment T_6 (5t CD + USG@78kg N ha^{-1}) produced the highest grain yield of 5.56 t ha^{-1} and straw yield was highest (5.95 t ha^{-1}) in treatment T_1. The treatment T_6 also showed highest (23 kg grain kg^{-1} N applied) N use efficiency. The N, P and K uptake by BRRI dhan32 rice were influenced profoundly due to the application of USG alone or in combination with cowdung. USG application generated available NH4–N and NO3–N slowly over the entire growth period; indicating a beneficial role of USG. The overall results indicate that application of USG in combination with cowdung could be considered more effective in rice production for reducing N–losses, conserving–N and increasing the efficiency of applied N.

Islam *et al*. (2013) studied to evaluate the effect of nitrogen supplied from organic sources (cowdung, poultry manure and compost) and inorganic source (urea) on the yield and nitrogen use efficiency of BRRI dhan28. The treatments were T_0 (Control), T_1 (100% N from RFD), T_2 (70% N from RFD, RFD + 30% N from CD), T_3 (70% N from RFD + 30% N from PM), T_4 (70% N from RFD + 30% N from CoM), T_5 [70% N from RFD + 30% N from (CD + PM + CoM)], T_6 [100% N from (CD + PM + CoM), T_7 [100% N from RFD + 30% N from (CD + PM + CoM)]. The highest grain yield of 5847 kg ha^{-1} was observed in the treatment T_7 and the lowest grain yield of 2426 kg ha^{-1} was found in T_0. The highest N uptake (138.9 kg ha^{-1}) was found in T_7 followed by T_1 (119.8 kg ha^{-1}). The highest nitrogen use efficiency was observed in T_6 and the lowest value was noted in T_5.

Rifat–E–Mahbuba (2013) found that the Application of N as PU, USG alone or in combination with cowdung significantly increased yield components, grain and straw yields of BRRI dhan28 rice. The treatment T_3 (78 kg N ha^{-1} from USG) produced the highest grain yield of 5.85 t ha^{-1} and straw yield of 5.50 t ha^{-1} due to the treatment T_6. The treatment T_2 (104 kg N ha^{-1} from USG) performed better than T_1 and T_4, indicating the superiority of USG over PU. The N, P and K uptake by BRRI dhan28 rice were influenced profoundly due to the application of USG alone or in combination with cowdung. The overall results indicate that application of USG in combination with cowdung could be considered more effective in rice production.

Haque (2013) evaluated the use of manures and fertilizers for maximizing the growth and yield of BRRI dhan28. The maximum grain yield of 5651 kg ha^{-1} and straw yield of 6572 kg ha^{-1} were recorded in T_3 [(PM) + STB–CF]. The lowest grain and straw yields were found for T_0. The NPKS content and uptake by BRRI dhan28 were also influenced significantly due to integrated use of manures and fertilizers.

Fakhrul Islam *et al*., (2013) studied the fertilizer and manure effect on the growth, yield and nutrient concentration of BRRI dhan28 at Sher–e–Bangla Agricultural University research farm, Dhaka. The T_5 (50% RDCF + 4 ton PM ha^{-1}) showed the highest effective tillers hill^{-1}, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg plot^{-1}) and straw yield (5.91 kg plot^{-1}). The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure.

AL Fakhrul Islam *et al*. (2013) studied on the effect of fertilizer and manure with different water management on the growth, yield and nutrient concentration of BRRI dhan28. The yield contributing characters and yields were significantly influenced by applied fertilizer and manure. The T_5 (50% RDCF + 4 ton PM ha^{-1}) showed the highest effective tillers $hill^{-1}$, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg $plot^{-1}$) and straw yield (5.91 kg $plot^{-1}$). The higher grain and straw yields were obtained organic manure + inorganic fertilizers than full dose of chemical fertilizer and manure. The highest concentrations of grain and straw N, P, K, S were recorded in T_5 treatment. The levels of organic matter and nutrient concentration were increased in the post harvest soils due to added manure plus inorganic fertilizer.

Dey (2012) found that the highest grain (6.20 t ha^{-1}) and straw yields (7.75 t ha^{-1}) were produced by the T_7 (USG at transplanting + 50% PKS at transplanting + 50% PKS at maximum tillering) treatment. The P, K and S uptake by BRRI dhan29 significantly increased due to split fertilization. So, split application of P, K and S fertilizers along with USG exerted a beneficial effect on yield contributing characters, resulting in higher grain and straw yields for BRRI dhan29 as compared to their single application.

Basu *et al*. (2012) conducted a field experiment to study the quality aspect of rice (cv. BRRI dhan28) as response to chemical fertilizers and organic manure (cowdung) treatments comprised of four doses of chemical fertilizers (0, 0.5, 0.75 and full recommended dose) and four cowdung doses (0, 1.0, 1.5, two times of full recommended dose). The grain yield ranged from 1.92 to 4.58 t ha^{-1}. The highest grain yield was observed in treatment containing the full recommended dose of chemical fertilizers along with the double dose of cowdung (F1M3) and it was the lowest in without chemical fertilizers and recommended dose of cowdung (F0M1). Application of cowdung and chemical fertilizers had significant effect on the content of N, P, K, S, Ca, Mg, B, Zn, protein, starch and amylose in rice grain. Grain yield of rice was increased by application of half the recommended dose of chemical fertilizers along with recommended dose of cowdung.

Rashid *et al*. (2011) examine the effect of urea– nitrogen, cowdung, poultry manure and urban wastes on growth and yield of transplant *Boro* rice, cv. BRRI Dhan 29. Among the treatments, T_6 (N_{50} + PM_{50}) produced 43.39% higher number of effective tiller $hill^{-1}$ than control treatment. Application of 47.5 kg N along with 9.5 t poultry manure ha^{-1} produced the maximum panicle length (27.03 cm) with an increase of 18.03 percent over control treatment. Treatment T_6 further produced the maximum number of filled grains panicle^{-1} (121), highest weight of 1000–grains (29.30 g), maximum grain yield (5.54 t ha^{-1}) and maximum straw yield (5.89 t ha^{-1}). The lowest number of filled grains panicle^{-1} (89), lowest weight of 1000–grains (21.17 g), lowest grain yield (3.06 t ha^{-1}) and the lowest straw yield (3.39 t ha^{-1}) was noted in control treatment.

Qian *et al*. (2011) conducted an experiment to see the effects of organic manure application on rice yield and soil fertility. Results revealed that organic manure application combined with chemical fertilizers treatments were 65.4%–71.5% ($P<0.05$) higher than CK, and 3.9%–7.8% ($P<0.05$) higher than NPK treatment in yield. Rice yield of 30F + 70M treatment was the highest in all treatments.

Hossaen *et al*. (2011) studied on the yield and yield attributes of *Boro* Rice due different organic manure and inorganic fertilizer. At 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tiller hill^{-1} (5.43, 11.64, 21.01 and 17.90) at same DAT was recorded from T_5 (70% NPKS + 2.4 t PM ha^{-1}) and the lowest was observed from T_0 (control) in every aspect. The maximum number of effective tillers hill^{-1} (13.52), the longest panicle (24.59 cm), maximum number of total grain plant^{-1} (97.45), the highest weight of 1000 seeds (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) was recorded from T_5 treatment whereas the lowest number of effective tillers hill^{-1} (6.07), the shortest panicle (16.45 cm) , the minimum total grain plant^{-1} (69.13) , the lowest weight of 1000 seeds (16.73 g), the lowest grain yield (2.06 t ha^{-1}) and straw yield (4.63 t ha^{-1}) was observed from T_0. Treatment T_5 also showed the highest biological yield and HI.

Akter (2011) found that the treatment T_4 (75% Urea + 25% N from poultry manure, 2.9 t ha^{-1}) produced the highest grain yield of 6334 kg ha^{-1} and straw yield of 8175 kg ha^{-1}. The lowest grain and straw yields (3112 and 3489 kg ha^{-1}, respectively) were found in control when no nitrogen was not applied from either fertilizers or manures Further, the treatment T_7 (100% Urea +2.0 t ha^{-1} poultry manure) performed better than T_2, T_3,T_5 and T_6 indicating the superiority of poultry manure over cowdung and compost. The N, P, K and S contents and uptake by BRRI dhan29 were profoundly influenced due to application of Urea in combination with cowdung, compost and poultry manure.

Yaqub *et al*. (2010) conducted an experiment on a traditional approach to deal with the declining yields of rice–wheat system. Results showed that averaged across Urea treatments, manuring significantly increased the number of tillers plant^{-1} (11% increase), rice grain yield (6% increase), grain N content (4% increase) and grain N uptake (9% increase).

Kumari *et al*. (2010) reported that the Birsamati rice grown with RD of inorganic fertilizer produced 20.09% higher grain yield when compared with the best organic source combination of green manuring (GM) @ 5 t ha^{-1} + FYM @ 10 t ha^{-1} (3.3 t ha^{-1}). The yield attributing characters also followed the trend of grain yield. Similarly, the uptake of N, P and K by rice grown with fertilizers was 31.69%, 25.98%, and 23.74% higher than GM + FYM. The maximum available N (277 kg ha^{-1}) and minimum N loss (3 kg ha^{-1}) was recorded from the plots that received GM 5 t ha^{-1} + BGA 10 kg ha^{-1} + Azotobacter @ 500 g ha^{-1}. Similarly maximum available P (24.7 kg ha^{-1}) and maximum gain in soil P (0.7 kg ha^{-1}), was recorded with the application of Karanjcake (KC) 2.5 t ha^{-1}. However, maximum available K (202 kg ha^{-1}) and maximum gain in soil K (2.0 kg ha^{-1}) was recorded from the plot receiving GM 5 t ha^{-1} + PS 10 t ha^{-1}. Among organic sources, GM + FYM fetched significantly higher B:C (2.61) when compared with rest of the organic sources under test.

Hossain *et al*. (2010) conducted an experiment to evaluate the effect of Urea, poultry manure (PM) and cowdung (CD) on the nutrient content and uptake by BRRI dhan 29. The experiment was laid out in a RCBD with eight treatments in three replications. Application of poultry manure, cowdung and Urea significantly influenced the yield and yield components of BRRI dhan 29 and N, P, K and S contents and uptake. The overall results indicate that application of PM @ 3 t ha^{-1} in combination with N 100 kg ha^{-1} can reduce the use of N fertilizer at a substantial level. The findings of the study suggest that integrated use of manure and fertilizer is more important for sustainable production of BRRI dhan 29.

Hoshain (2010) conducted an experiment to investigate the effect of cowdung and nitrogen on rice cv. BRRI dhan50. He showed that highest number of effective tillers hill^{-1}, number of grain panicle^{-1}, grain yield (6.13 t ha^{-1}) and biological yield were obtained from the combination of 6 t ha^{-1} cowdung with 120 kg N ha^{-1}.

Saha *et al*. (2009) conducted a field trial to validate some fertilizer application approaches for *Boro*–Green manure (GM). Application of cowdung (CD) @ 6 t ha^{-1} (at 15 % moisture) along with integrated plant nutrient system (IPNS) based chemical fertilizer with reduced doses of chemical fertilizer (60% N, 50% P, 50% K, and 50% S) substantially increased grain yield .The N uptake was in excess of the N added as fertilizer with an improved balance of P, S, and Zn was observed.

Rahman *et al*. (2009) reported that the Chola *Boro* and Sada *Boro* are two local land races having potentials for producing higher effective tillers and higher 1000–GW. Sada *Boro* and Chola *Boro*, two local cultivars were found very high in grain N content compared to other test cultivars. These two cultivars could be a nice tool for rice breeder to develop high nitrogen content rice. Chola *Boro*, IRATOM 24 and BR 14 are three high straw–K containing varieties having breeding potentials to make our future rice plant strong.

Rahman *et al* (2009) conducted an experiment at the Soil Science field laboratory, Bangladesh Agricultural University, Mymensingh during *Boro* season of 2007 to evaluate the effect of Urea in combination with poultry manure and cowdung on BRRI Dhan29. Application of manures and different doses of Urea fertilizers significantly increased the yield components and grain and straw yields of BRRI Dhan29. The treatment receiving N 80 kg ha^{-1} and PM 3 t ha^{-1} produced the highest grain yield of 5567.29 kg ha^{-1} and straw yield of 6991.78 kg ha^{-1}.

Nyalemegbe *et al*. (2009) reported that the cow dung (CD) and poultry manure (PM) were separately applied to the soil at 20 t ha^{-1} solely and also 5, 10 and 15 t ha^{-1}, in combination with Urea fertilizer at 90, 60 and 30 kg ha^{-1}, respectively. Other treatments included a control and Urea fertilizer at 30, 60, 90 and 120 kg ha^{-1}. The application of 10 t ha^{-1} CD and urea fertilizer (at 45 kg N ha^{-1}) and 10 t ha^{-1} PM and urea (at 60 kg N ha^{-1}) both gave paddy yields of 4.7 t ha^{-1}, which did not differ significantly from the yield of 5.3 t ha^{-1}, obtained under the recommended inorganic nitrogen fertilizer application of 90 kg N ha^{-1}.

Islam (2008) showed that the highest plant height (109.49 cm), number of effective tillers $hill^{-1}$ (9.43), number of total tiller $hill^{-1}$ (13.33), grain yield (6.13 t ha^{-1}) and harvest index(46.04%) were obtained from the combination of 50% recommended fertilizer with 5 t ha^{-1} cowdung.

Aziz (2008) reported that effective tillers hill^{-1}, panicle length, 1000–grain weight and grain yield were highest in 15 t ha^{-1} cowdung application. Ali *et al*. (2007) was conducted an experiment to study the combined effect of cowdung with USG on yield of rice and showed that combination of cowdung 1.3 t ha^{-1} with USG at 58 kg N ha^{-1} produced highest grain yield.

Singh *et al*. (2006) conducted an experiment to evaluate the effects of chemical fertilizer (urea), cowdung and biofertilizer (Azospirillum) on the yield of rice and physicochemical properties of the soil. Application of chemical fertilizer, cowdung and Azospirilluni, individually or in combinations, significantly increased the yield attributes (plant height, number of tillers, panicle length, grain yield and straw yield) over the control. The treatment comprising 80 kg N ha^{-1} + Azospirillum + 2.5 t cowdung ha^{-1} was superior over all other treatments in terms of rice yield.

Mobasser *et al*. (2005) reported that plant height, number of panicle m^{-2}, grain yield were significantly higher in cowdung treated plots compared with the unfertilized control.

Brahmacharrii *et al*. (2005) conducted a field experiment to evaluate the productivity and quality development of rice (cv. IET–4094) under irrigated condition on Entisol type of new alluvial soil. They reported that the productivity of rice was maximum when this crop in sequence received bo organic and inorganic sources of nutrients ($N_{40}P_{20}K_{30}$ + FYM at 10 t ha^{-1}). In the experiment the relationship of K content of rice plants with hulling percentage, milling percentage of grain was significantly positive.

Saleque *et al*. (2004) studied with six treatments viz. absolute control (T_1), 1/3 of RFD (T_2), 2/3 of RD (T_3), full doses of RF (T_4), T_2 + 5 t cowdung and 2.5 t ash ha^{-1} (T_5) and T_3 + 5 t cowdung ha^{-1} + 2.5 t ash ha^{-1} (T_6) were compared. The results showed that application of cowdung and ash (T_5 and T_6) increased rice yield by about 1 t ha^{-1} year^{-1} over that obtained with chemical fertilizer alone.

Jha *et al*. (2004) observed that 50: 40:30 kg NPK ha^{-1} + 3 t cowdung and urea mixture ha^{-1} produced significantly higher plant height, number of effective tiller hill^{-1} and grain yield. Gowda *et al*. (2004) reported that plant height of Phalguna variety was maximum due to application of 10 t ha^{-1} and 15 t ha^{-1} cowdung than Jaya variety of rice.

Yaduvanshi (2003) reported that the application of NPK and its combination with green manuring and FYM increased the rice yield significantly. Fertilizers (120 kg N, 26 kg P, 42 kg K ha^{-1}) and it's combined use with green manure or 10 t ha^{-1} FYM and 150% significantly higher(3119 and 3956kg ha^{-1}, respectively) to other treatments which received NPK fertilizers.

Usman *et al*. (2003) reported that rice produced maximum number of tillers $hill^{-1}$ and grain yield from application of organic fertilizer 10 t ha^{-1} + manure 20 t ha^{-1}.

Mishra *et al*. (2003) recorded data for number of effective tillers $hill^{-1}$, panicle length, panicle weight, number of spikelets $panicle^{-1}$, number of fertile spikelets $panicle^{-1}$, sterility percentage, 1000–grain weight, grain yield and straw yield. Among the treatments, 75% recommended N blended within cowdung urine and 1000 ppm Cycocel [chormequat] gave the highest pooled grain yield (85.24 and 76.54 q ha^{-1}, respectively). While 75% recommended N+25%farmyard manure and 1000 ppm Cycocel [chormequat] gave the highest straw yield (117.28 and 107.95 q ha^{-1}, respectively).

Vanaja and Raju (2002) conducted a field experiment for one year during 1996–97, in sandy loam soil having pH of 8.4 at Student's Farm College of Agriculture, Hyderabad. Organic manures (FYM, poultry manure) and biofertilizers (BGA, Azospirillum) alone and in combination with inorganic fertilizer nitrogen were studied on rice crop. The relationship between total dry matter production at maturity and total uptake of nutrients (N, P and K) was highly significant.

Lawal and Lawal (2002) conducted an experiment to evaluate the growth and yield of low land rice during rainy season in Nigeria to varying cowdung rates and placement method of fertilizer and showed that 1000– grain weight was significantly increased.

Chettri *et al*. (2002) conducted a field experiment in a sandy clay loam soil of netrual reaction having 0.067, 17, 19.3 and 17.2 kg ha^{-1} available N, P, K and S, respectively, in Nadia, West Bengal, India during 1994–95 and 1995–96. The highest number of effective tillers $hill^{-1}$, grains $panicle^{-1}$, percentage of filled grains, 1000–grain weight, grain yield (44.05 q ha^{-1}) of rice were obtained with the application of 60 kg N, 30 kg P_2O_5 and 30kg K_2O ha^{-1} with 10 t FYM ha^{-1}.

Abro *et al*. (2002) carried out an experiment and showed that highest plant height and highest number of tiller hill^{-1} were produced from 15 t ha^{-1} cowdung + green manure with rice and lowest from the control.

Saitoh *et al*. (2001) conducted an experiment on the growth and yield of rice to evaluate the effect of organic fertilizer (cowdung and chicken manure) and pesticide. They found that yield of organic manure and pesticide treated free plots were 10% lower than that of chemical fertilizer and pesticide treated plots due to a decrease in the number of panicle.

Raju and Reddy (2000) was carried out a field experiment in both rainy and winter seasons at Maruteru, Andhra Pradesh, India to determine the effect of integrated nutrient supply system in rice (Oryza sativa)–rice system of coastal ecosystems. There were 12 treatments used in the experiment, 4 treatments of different levels of recommended fertilizers in rainy and winter seasons, 6 treatments of integration of chemical fertilizers with organic sources. They found that application of organic matter along with chemical N to rainy season rice reduced the 25% N fertilizer.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3
MATERIALS AND METHODS

An experiment was conducted at the research field in Sher–e–Bangla Agricultural University (SAU), Dhaka–1207, during the *Boro* season of 2012–13 to study on the performance of growth variability, yield potentialities and nutrient management practices of rice as influenced by varieties and the combinations of organic (cowdung) and inorganic (Urea) fertilizer. This chapter presents a brief description of the soil, crop, experimental design, treatments, cultural operations, collection of soil and plant samples and analytic methods followed in the experiment. This chapter has been divided into a number of sub–heads describe as below:

3.1 Site Description

3.1.1 Geographical Location

The experimental area was situated at $23^{0}77^{0}$N latitude and $90\ ^{0}33^{0}$E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004e).

3.1.2 Agro–Ecological Region

The experimental field belongs to the Agro–ecological zone of “The Modhupur Tract”, AEZ–28 (Anon., 1998a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1998b). The experimental site was shown in the map of AEZ of Bangladesh (Fig. 3.1).

3.1.3 Soil

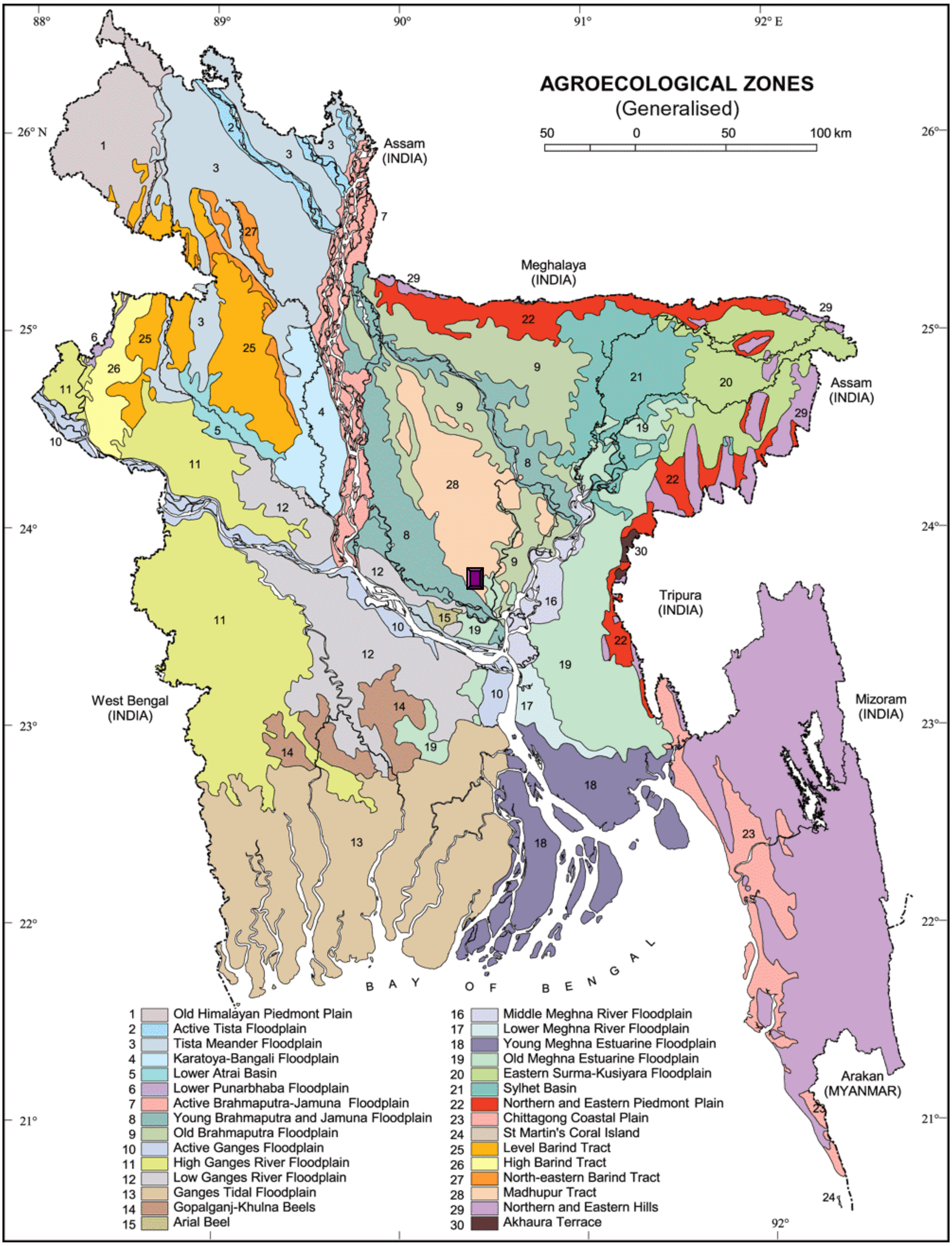
The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive–gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic matter 0.81%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0–15 cm depths were collected from experimental field. Soil samples were analyzed for both physical and chemical properties in the laboratory of the SRDI, Farmgate, Bangladesh. The properties studied included pH, organic matter, total N, available P and exchangeable K. The soil was analyzed following standard methods. Particle–size analysis of soil was done by Hydrometer method and soil pH was measured with the help of a glass electrode pH meter using soil water suspension of 1:2.5. The morphological, physical and chemical characteristics of initial soil are presented in Tables 3.1 and 3.2.

Table 3.1 Morphological characteristics of the experimental field

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

Table 3.2 Physical and chemical properties of the initial soil sample

Characteristics	6Value
Particle size analysis	
% Sand	28.2
% Silt	41.2
% Clay	30.6
Textural class	Silty–clay
pH	5.6
Bulk Density (g/cc)	1.45
Particle Density (g/cc)	2.52
Organic carbon (%)	0.47
Organic matter (%)	0.81
Total N (%)	0.05
Available P (ppm)	18.1
Exchangeable K (meq/100g soil)	0.10
Available S (ppm)	40



Indicated the location of the experiment

Fig. 3.1 Map showing the experimental site under study

3.1.4 Climate

The area has 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). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Table 3.3.

Table 3.3 Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from November 2012 to March 2013

Months	Air temperature		Relative humidity (%)	Rainfall (mm) (Total)
	Maximum	Minimum		
November, 2012	25.82	16.04	78	00
December, 2013	22.40	13.50	74	00
January, 2013	24.50	12.40	68	00
February, 2013	27.10	16.70	67	30
March, 2013	31.40	19.60	54	21

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

3.2 Details of the experimental materials

Two sets of the experimental materials included in the experiment were as follows:

3.2.1 Variety (2)

The following two varieties were selected for the experiment.

V_1: BRRI dhan29 and V_2: Heera 4

The characteristics of the above two varieites are as follows:

BRRI Dhan 29: BRRI dhan 29, a high yielding variety of boro season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. The pedigree line (BR802-118-4-2) of the variety was derived from a cross (BG902/BR51-46-5) and was released in 1994. It takes about 155 to 160 days to mature. It attains at a plant height of 95-100 cm and at maturity the flag leaf remains green and erect. The grains are medium slender with light golden husks and kernels are white in color. This genotype is known for its bold grains, with a 1000-grains weight of about 29 g, grain length of 5.9 mm, and grain width of 2.5 mm. The cultivar gives an average grain yield of 7.5 t ha^{-1}. The milled rice is medium fine and white. It is resistant to damping off and moderately resistant to blast (Pyricularia oryzae) and bacterial blight (Xanthomonas oryzae) in terms of yield, this is the best variety so far released by BRRI (Anon., 2003; Anon., 1991).

Heera 4: Heera 4 also known as HSQ–1 which was introduced in Bangladesh by Supreme Seed Company Ltd. from the China. The year of notification/registration is 67^{th} NSB in 2008 (17/9/2008) and 70^{th} NSB in 2009 (4/11/2009). It is mainly cultivated in Comilla, Jessore, Rajshahi and Mymensingh and some other region of Bangladesh during the *Boro* season. The grains of Heera 4 are medium, thick with light golden husks. It takes about 150 days to mature.

Nutrient status of decomposed cowdung:

Moisture, Nitrogen (N), Phosphours (P) and Potassium (K) were 35±3.5%, **1±0.1%,** 0.3±0.03% and 0.46±0.05%, respectively (BARC, 2012).

3.2.2 Organic and inorganic treatment combinations (7)

The following seven treatments including control treatment were included in the present experiment where the treatments were the combinations of organic (Cowdung) and inorganic (Urea) fertilizer(s).

T_0 = Controlled (No Fertilizer)

T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)

T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)

T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)

T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)

T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)

T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

There were on the whole 14 (2×7) treatments combination as V_1T_0, V_1T_1, V_1T_2, V_1T_3, V_1T_4, V_1T_5, V_1T_6, V_2T_0, V_2T_1, V_2T_2, V_2T_3, V_2T_4, V_2T_5 and V_1T_6.

3.3 Growing of crops

3.3.1 Seed collection

Healthy and vigorous seeds of BRRI dhan29 and Heera 4 were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur and Research Laboratory of the Department of Soil Science, SAU, Dhaka.

3.3.2 Seed sprouting

Healthy seeds were collected by specific gravity method. The selected seeds were soaked for 24 hours and then these were kept in gunny bags. The seed started sprouting after 48 hours and almost all seeds were sprouted after 72 hours.

3.3.3 Preparation of seedling nursery and seed sowing

A piece of high land was selected in the Soil Science Field Laboratory, SAU, Dhaka for raising seedlings. The land was puddled well with country plough followed by cleaning and leveling with ladder. Sprouted seeds were sown in the wet nursery bed on 7 Novemberr 2012. Proper care was taken to raise the seedlings in the nursery bed. Weeds were removed and irrigation was given in the seedbed as and when necessary.

3.4 Experimental design

Design: Randomized Complete Block (RCB)

Factor A: Variety (2)

Factor B: Organic + inorganic fertilizer treatments (7)

Treatment combinations: 14

Replication: 3

Total number of plots: 42

Plot size: 3 m × 1.5 m

Block to block distance: 2 m

Plot to plot distance: 1 m

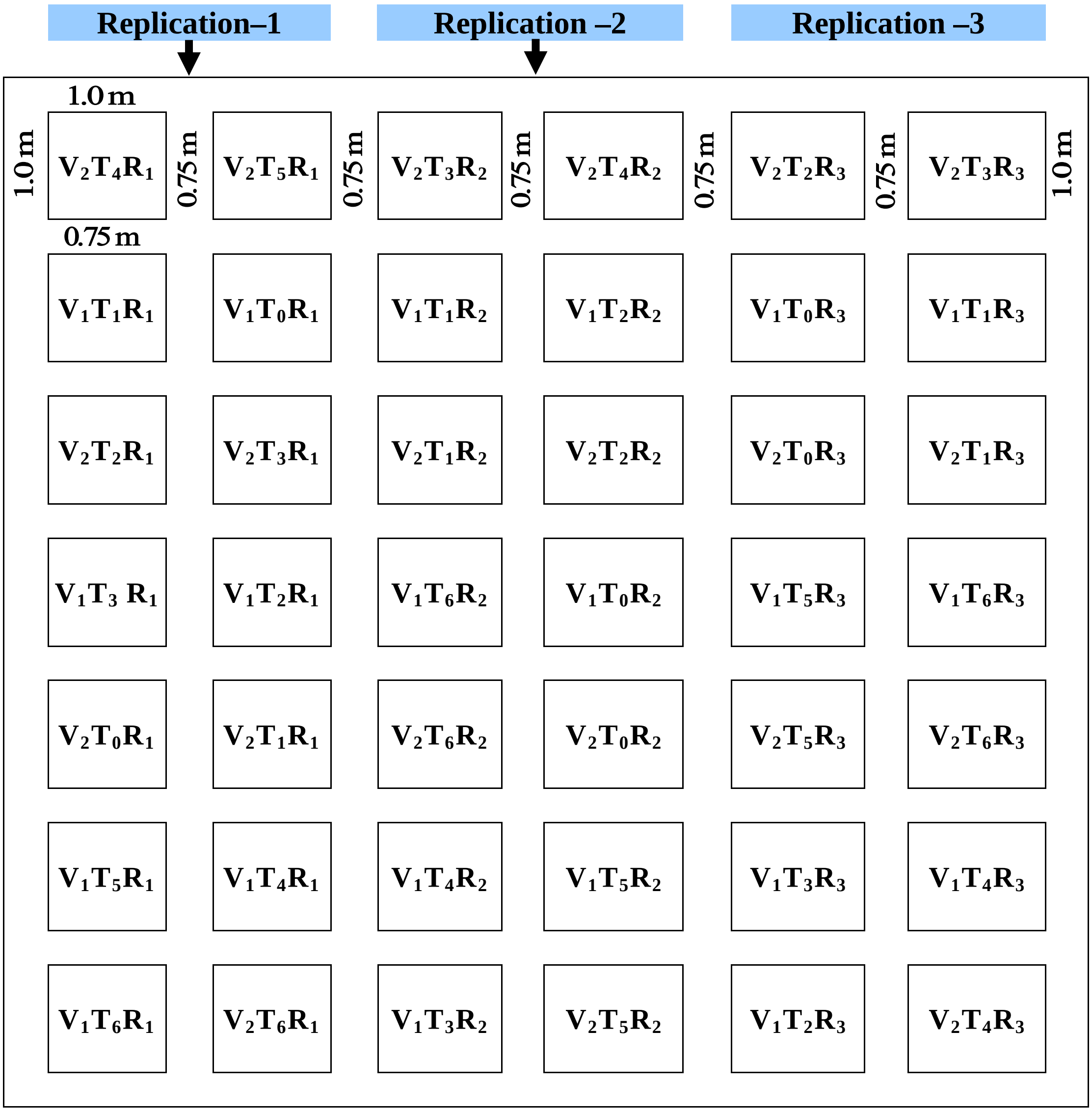
3.4.1 Layout of the experiment

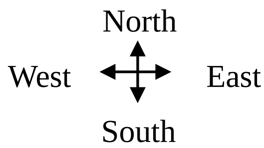
The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each block was sub–divided into fourteen unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 42 (14×3). The unit plot size was 3 m × 1.5m. Block to block distance was 2 m and plot to plot distance was 1 m. The layout of the experiment has been shown in Fig. 3.2.

3.5 Preparation of experimental land

The experimental field was first opened on December 01, 2012 with the help of a tractor drawn disc plough, later on December 13, 2012 the land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on December 14, 2012 according to experimental specification. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

Fig. 3.2 Lay out of the experimental field





Legend
Total number of plot: **42**; Total number of varieties: **2**; Total number of Treatment: **7**
Plot length: **3 m**; Plot width: **1.5 m**; Plot area: 3 m× 1.5 m (**4.5 m²**)
Peripheral drain: 1m (each side);

Internal Drain: Replication to Replication: **1 m** and Plot to plot: **0.75 m**

Total Width: (1.5 m× 6) + (1 m × 4) + (0.75m × 3) = 15.25 m
Total Length: (3 m × 7) + (1 m × 2) + (0.75 m × 6) = 27.5 m
Total area: 15.25 m × 27.5 m)= 419.38 m²

3.6 Uprooting of seedlings

The seedbeds were made wet by application of water on the previous day of uprooting the seedlings. The seedlings were uprooted carefully without causing dry injury to the roots. The uprooted seedlings were kept on soft mud under shade.

3.7 Transplanting of seedlings

On 17 December, 2012, 39 day–old seedlings were transplanted in the experiment field keeping plant to plant distance 20 cm and row to row distance 25 cm. Gap filling was made up to 7 days after transplanting to maintain proper treatment and similar plant population density for every plot.

3.8 Application of fertilizers

The triple super phosphate (TSP), muriate of potash (MoP), gypsum and $ZnSO_4$ fertilizers were applied in the experimental plots @ 120, 180, 110 and 10 kg ha^{-1}, respectively as basal dose (BARC, 2012). Cowdung was also applied as basal dose as per treatment. Urea was applied as per treatment in three equal splits. The first split was applied after 15 days of transplanting, the second split was applied after 35 days of transplanting i.e. at active vegetative stage and the third split was applied after 60 days of transplanting i.e. at panicle initiation stage. The recommended dose of urea was 280 kg ha^{-1}.

The following chart showing the amount of studied cowuding and urea levels as per treatments regarding ha^{-1} and $plot^{-1}$.

Treatments	Amount (ha^{-1})		Amount ($plot^{-1}$)	
	Cowdung (tons)	Urea (kg)	Cowdung (kg)	Urea (g)
T_0	0	0	0	0
T_1	0	280	0	126.0
T_2	1.28	252	0.58	113.4
T_3	2.56	224	1.15	100.8
T_4	3.84	196	1.72	88.20
T_5	5.12	168	2.30	75.60
T_6	6.40	140	2.88	63.00

3.9 Intercultural Operations

3.9.1 Thinning and Gap Filling

After one week of direct seed sowing thinning was done to maintain the constant population number. After transplanting the seedlings of the research field, gap filling was done whenever it was necessary using the seedling.

3.9.2 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Two hand weeding were done for every method, first weeding was done at 15 days after transplanting followed by second weeding at 15 days after first weeding. Weeds were removed mechanically with the help of Japanese rice wider.

3.9.3 Application of Irrigation Water

Irrigation water was added to each plot according to the recommended treatments of inbred and hybrid cultivar by their originated characteristics. Partial amount of water was applied to keep the soil moist, and it was even allowed to dry out for 2 to 4 days during tillering. This was done to keep the soil well aerated, to allow better root growth. From panicle initiation (PI) to hard dough stage, a thin layer of water (2–3 cm) was kept on the plots. Again water was drained from the plots during ripening stage.

3.9.4 Plant Protection Measures

Plants were infested with rice stem borer (Scirphophaga incertolus) and leaf hopper (Nephotettix nigropictus) to some extent which were successfully controlled by applying Diazinone @ 10 ml/10 liter of water for 5 decimal lands on February 03 and by Ripcord @ 10 ml/10 liter of water for 5 decimal lands on February 20 and February 25, 2013. Crop was protected from birds and rats during the grain filling period. Field trap and foxtoxin poisonous bait was used to control the rat. For controlling the birds watching was done properly, especially during morning and afternoon.

3.10 Plant sampling at harvest

Plants from 1 m^2 were randomly selected from each plot to record the yield contributing characters like plant height (cm), number of tillers $hill^{-1}$, panicle length (cm), number of grains $panicle^{-1}$, and 1000–grain weight (g). The selected hills were collected before harvesting. Grain and straw yields were recorded plot–wise and expressed at t ha^{-1} on sun dry basis.

3.11 Harvesting

The crop was harvested at maturity on 22 March, 2013. The harvested crop was threshed plot–wise. Grain and straw yields were recorded separately plot–wise and moisture percentage was calculated after sun drying. Dry weight for both grain and straw were also recorded.

3.12 Data collection

The data on the following growth and yield contributing characters of the crop were recorded:

i) Plant height (cm)
ii) Number of effective tillers $hill^{-1}$
iii) Panicle length (cm)
iv) Number of grains $panicle^{-1}$
v) 1000–grain weight (g)
vi) Grain yields (t ha^{-1})
vii) Straw yields (t ha^{-1})
viii) Biological yields (t ha^{-1})
ix) Harvest index (%)

3.12.1 Plant height (cm)

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

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

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

3.12.3 Panicle length

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

3.12.4 Number of grains panicle^{-1}

Presence of any food material in the spikelet was considered as grain and numbers of grains present in each panicle were counted. Ten panicles were taken at random to count grains and averaged.

3.12.5 1000–grain weight

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

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

Grains obtained from the harvest area of 1m x lm from the middle of each unit plot were sun dried and weighed carefully and converted to t ha^{-1}.

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

The collected straw from each plot was sun dried properly to record the final straw yield plot^{-1} and finally converted to t ha^{-1}.

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

Grain and straw yields are altogether regarded as biological yield. The biological yield was calculated with the following formula:

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

3.12.9 Harvest index (%)

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

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

Where,

Economic yield = Grain yield and Biological yield = Grain yield + Straw yield

3.13 Chemical analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in the laboratory of Soil Resource Development Institute (SRDI), Farmgate, Dhaka. The properties studied included total N, available P and exchangeable K. The chemical properties (NPK) of the initial soil have been presented in Table 3.2. The soil was analyzed by standard methods:

3.13.1 Total nitrogen (N)

Total nitrogen of soil was determined by Micro Kjeldahl method where soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se powder in the ratio of 100:10:1). Nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01N H_2SO_4 (Bremner and Mulvaney, 1982).

3.13.2 Available phosphorus (P)

Available phosphorus was extracted from soil by shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 (Olsen *et al.*, 1954). The phosphorus in the extract was then determined by developing blue colour using ascorbic acid of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 *n*m wave length by Spectrophotometer and available P was calculated with the help of standard curve.

3.13.3 Exchangeable potassium (K)

Exchangeable potassium was determined by 1N NH_4OAc (pH 7.0) extract of the soil by using Flame photometer (Black, 1965).

3.14 Chemical analyses of grain and straw

3.14.1 Preparation of samples

The plant samples (grain and straw) were dried in an oven at 65^0C for about 48 hrs before they were ground by a grinding machine. Then the ground samples were passed through a 20–mesh sieve and stored in paper bags and finally they were kept into desiccators. The grain and straw samples were analyzed for determination of N, P, K and S.

3.14.2 Digestion of samples

Exactly, 1g of finally ground plant material was taken into a 250mLconical flask and 10mL of di–acid mixture (HNO_3: $HClO_4$=2:1) was added to it, then it was placed into the electric hot plate for heating at 180–200^0C until the solid particles was disappeared and white fumes were evolved from the flask (Jackson, 1962). It was then cooled at room temperature, washed with distilled water repeatedly and filtered into a

100mL volumetric flask through Whatman No.42 filter paper and the volume was made up to the mark with distilled water. The grain and straw extracts were preserved separately in plastic bottles for the analysis of different elements.

3.14.3 Nitrogen content (%)

The N concentration was determined by Semi–micro Kjeldahl method as described in section 3.16.4.

3.14.4 Phosphorus content (%)

P concentration is digested grain and straw were determined from the extract by adding ammonium molybdate and ascorbic acid solution and measuring the colour with the help of spectrophotometer at 660 nm wavelength (Olsen *et al*. 1954).

3.14.5 Potassium content (%)

Potassium concentration in digested grain and straw were determined directly with the help of flame photometer (Black, 1965).

3.14.7 Nutrient uptake

The uptake of N, P and K were calculated by multiplying the concentration of the nutrient in the grain and straw samples with the corresponding yields of grain and straw of crop. So, the uptake was calculated by the following formula:

Nutrient uptake (kg ha^{-1}) = Nutrient Content (%) x Yield (kg ha^{-1})

3.15 Statistical Analysis

Data recorded for yield and yield contributing characters including the nutrient content and uptake were compiled and tabulated in proper form for statistical analyses. Analysis of variance was done with the help of MSTAT–C computer package programme developed by Russel (1986). The mean differences among the treatments were evaluated with DMRT test (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4
RESULTS AND DISCUSSION

Results obtained from the present study regarding the influence of cultivar and various treatment combinations of organic (cowdung) and inorganic (Urea) fertilizers on growth, yield and yield attributes of *Boro* rice under wetland condition are presented and discussed in this chapter. The results have been presented in Tables 1 through 13 and Figures 1 to 8. All ANOVA are presented in Appendices I and V. The morpho–physiological parameters and grain yield with yield contributing characters of the rice cultivars have been presented and discussed under separate heads and sub–heads as follows:

4.1 Morpho–physiological, yield and yield attributes of rice

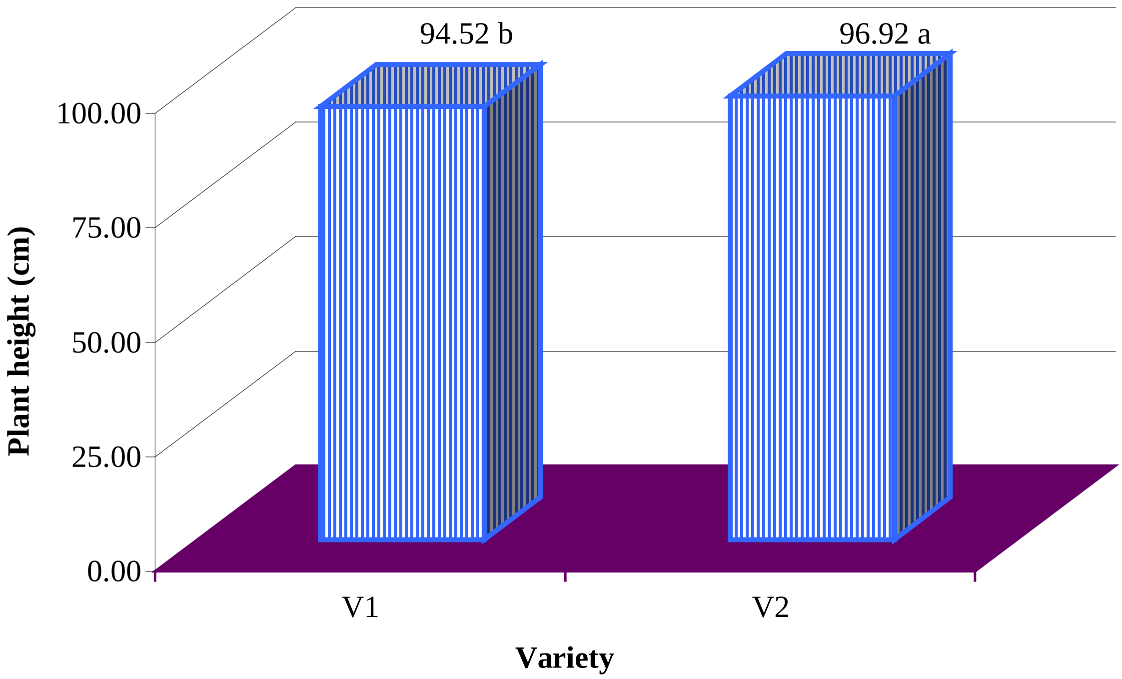
4.1.1 Plant height

4.1.1.1 Effect of variety

Plant height is one of the most efficient trait for greater yield of rice which was also directly related to straw yield incase of the tallest plant produce the higher yield of straw. Plant height is a vertical spatial distribution of plant. Plant height was recorded at harvest whereas plant height was significantly influenced due to the effect of variety (Appendix I and Fig. 4.1). Between the varieties, Heera-4 was taller (96.92 cm) than BRRI dhan29 (94.52 cm) under wetland condition during the *Boro* season. The above variation in plant height was observed due to the variation in genetic variability and adaptability in studied area. Similar findings were also obtained by Islam *et al*. (2013) who found also significant and genetic variation among the varieties regarding plant height. Mahamud *et al*. (2013), who found that the variation in plant height was indicated by the differentiation of genotypic characters and their genetic makeup also. Similar findings were also obtained by Panwar *et al*. (2012); Oka *et al*. (2012); Sritharan and Vijayalakshmi (2012); Uddin *et al*. (2010), Hossain *et al*. (2005), Ashrafuzzaman *et al*. (2009) and many other scientists. Besides, the climatic and soil condition of the studied area were farvourable for better growth of Heera 4 which ultimately showed highest plant height than BRRI dhan29.

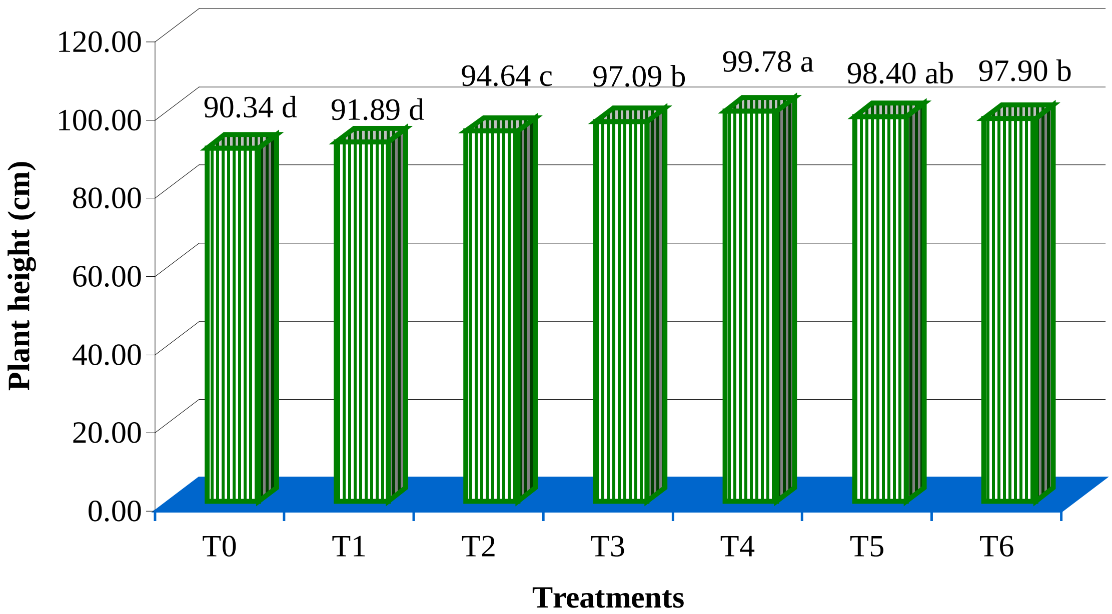
4.1.1.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

Plant height varied significantly due to the effect of cowdung and Urea treatments at harvest while plant height ranges from 90.34 cm to 99.78 cm (Appendix I and Fig. 4.2).



V_1: BRRI dhan29 and V_2: Heera–4

Fig. 4.1 Effect of variety on plant height at harvest



T_0 = Controlled (No Fertilizer)
T_1 = 0 Ton ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 Ton ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 Ton ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 Ton ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 Ton ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 Ton ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

Fig. 4.2 Effect of cowdung and Urea on plant height at harvest

Fig. 4.2 revealed that all the treatment was recorded significantly higher plant height over the control (T_0). Obtained result from the Fig. 4.2 revealed that the tallest plant of 99.78 cm was found from the treatment T_4 receiving cowdung 3.84 t ha^{-1} (30%) + Urea 196 kg ha^{-1} (70%) followed by T_5: Cowdung 5.12 t ha^{-1} (40%) + Urea 168.0 kg ha^{-1} (60%) of 98.40 cm. The shortest plant height of 90.34 cm was found in T_0 (no fertilizer) treatment having no cowdung or Urea. These result revealed that the plant height of rice progressively increased up to 3.84 t ha^{-1} cowdung (30%) + urea 196 kg ha^{-1} (70%). Such effect of cowdung along with Urea on plant height might be associated with the stimulating effect of cowdung and Urea on various physiological processes including cell division and cell elongation of the plant. These findings are in agreement with that of Shaha (2014) who reported that the different rates of cowdung with inorganic fertilizers showed significant effect on all the growth parameters viz. plant height. Similarly, Yoseftabar (2013) reported that the plant height increased significantly with nitrogen fertilizer. Similarly, Pramanik and Bera (2013) also found higher plant height in N 150 kg ha^{-1}. Besides, Islam (2008) showed that the highest plant height (109.49 cm) was obtained from the combination of 50% recommended fertilizer with 5 t ha^{-1} cowdung which result more or less similar with the present study. Jha *et al*. (2004); Gowda *et al*. (2004) and many scientists were also found significant variation in plant height due to the effect of inorganic N fertilizer along with cowdung.

4.1.1.3 Interaction effect of variety and cowdung along with Urea

Analysis of variance data on plant height at harvest varied significantly due to the effect of interaction of variety and cowdung along with Urea fertilizers where plant height varied significantly from 89.83 cm to 101.40 cm (Appendix I and Table 4.1). The highest plant height of 101.40 cm was produced from the variety Heera 4 receiving of 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) (V_2T_4) which was statistically differed from other interactions. The shortest plant of 89.83 cm was found from the variety BRRI dhan29 while it did not received any levels of cowdung and Urea which was statistically close (90.85 cm) to Heera 4 under having no fertilizers (V_2T_0). A regular trend of increase in the plant height was observed with cowdung @ 3.84 t ha^{-1} (30%) + Urea @ 196.0 kg ha^{-1} (70%) due to each variety (Table 4.1).

Table 4.1 Interaction effect of varieties and cowdung mixed with Urea fertilizer on plant height, number of effective tillers, length of panicle and number of grains panicle^{-1} of *Boro* rice at harvest

Variety × treatments		Plant height (cm)	No. of effective tillers hill^{-1}	Length of panicle (cm)	No. of grains panicle^{-1}
BRRI dhan29	T_0	89.83 h	17.73 f	24.17 i	166.60 f
	T_1	91.19 gh	18.80 ef	24.69 hi	187.70 d
	T_2	94.00 ef	19.30 e	25.71 gh	200.60 c
	T_3	95.39 de	20.70 d	27.14 ef	204.70 c
	T_4	98.12 bc	22.90 ab	28.57 cd	215.30 ab
	T_5	96.74 cd	21.40 cd	28.07 cde	213.20 ab
	T_6	96.37 cde	21.33 cd	27.60 def	210.90 b
Heera 4	T_0	90.85 gh	18.73 ef	26.80 fg	176.40 e
	T_1	92.59 fg	19.20 e	27.92 def	192.50 d
	T_2	95.28 de	20.40 d	29.22 c	204.20 c
	T_3	98.79 bc	21.37 cd	30.65 b	210.70 b
	T_4	101.4 a	23.90 a	33.14 a	219.30 a
	T_5	100.1 ab	22.30 bc	31.58 b	216.50 ab
	T_6	99.42 ab	22.70 b	31.11 b	213.90 ab
CV (%)		**1.46**	**3.03**	**2.33**	**1.64**
Level of significance		*	*	*	*

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*= significant at 5% level of probability

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

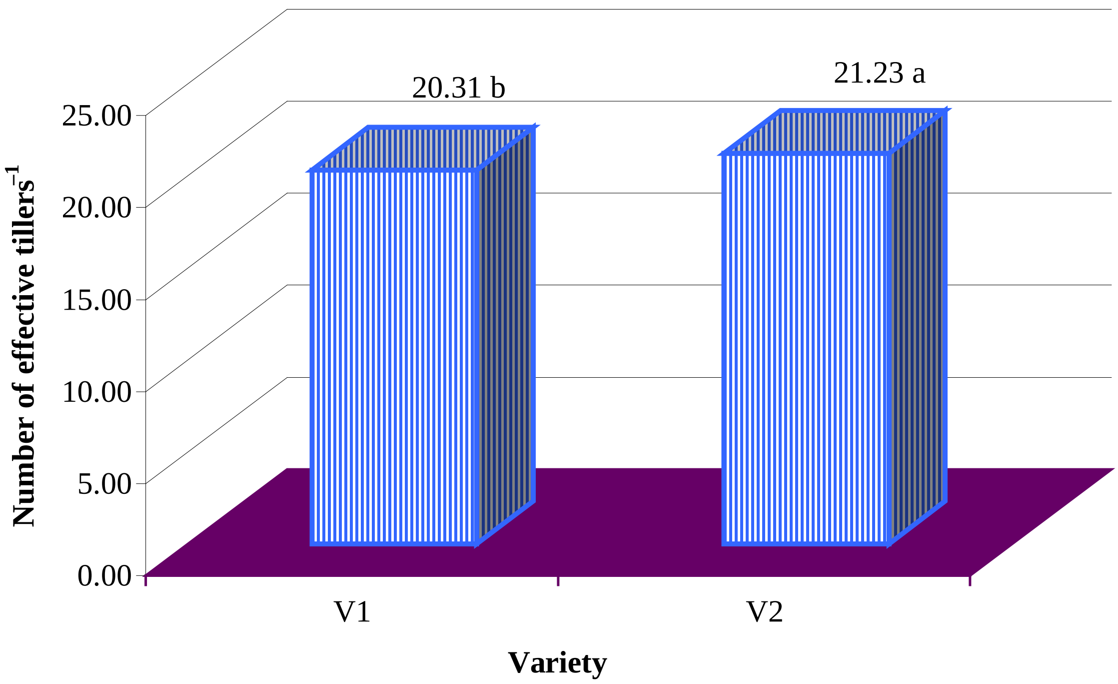
4.1.2 Number of effective tillers hill^{-1}

4.1.2.1 Effect of variety

The effective tillers i.e. ear bearing tillers is an important parameter which affect the yield of rice. A rice plant may produce a number of tillers during its early growth stages but not all of them become effective i.e., they do not bear panicles. So, this character is directly related to yield of rice. Number of effective tillers hill^{-1} had shown significant difference amongst the studied varieties (Appendix IX). The number of effective tillers hill^{-1} had maximum (21.23) in Heera 4 compare BRRI dhan29 (20.31) at harvest (Fig. 4.3). Result revealed that Heera 4 produced greater number of effective tillers hill^{-1} than BRRI dhan29 due to variation in their genetic characteristics or genetic make up. Similarly, significant variation among the rice varieties regarding tillers hill^{-1} were also found by Panwar *et al*. (2012); Alam *et al*. (2012); Islam *et al*. (2007) while Sohel *et al*. (2009) reported that the significantly higher number of bearing tillers hill^{-1} was recorded from BARI dhan41 than BRRI dhan40.

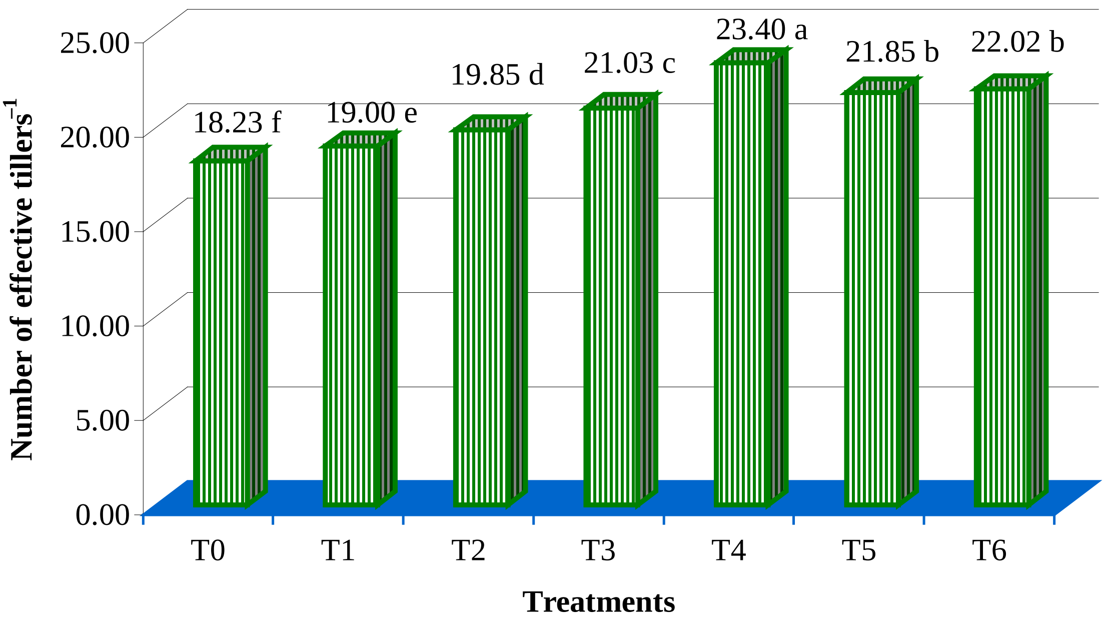
4.1.2.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

The levels of cowdung along with Urea had significant influence on number of effective tillers hill^{-1} (Appendix IX). The maximum number of effective tillers hill^{-1} (17.22) was recorded in treatment T_4 having 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} followed (22.02) by the treatments T_6 (higher levels of cowdung @ 6.40 t ha^{-1} and lower levels of Urea @ 140.0 kg ha^{-1}). The minimum number of effective tillers hill^{-1} (18.23) was produced in T_0 having no fertilizers. So, the number of effective tillers hill^{-1} significantly varied from 18.23 to 23.40 (Fig. 4.4). These result revealed that 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} was the adequate level for producing the more productive tillers which might be due to the rice plant can be utilize more nutrient from the soil by this application treatment. Such above the same performance were also obtained by Shaha (2014) who found that the cowdung levels along with BRRI RD of inorganic fertilizer showed the more tillers hill^{-1} which might be due to the combination of cowdung and inorganic fertilizer increase the soil nutrient and enhance the tillering capacity. Rashid *et al*. (2011) also found that the effect of urea– nitrogen + cowdung + poultry manure + urban wastes single or their interaction influence the growth and yield of transplant *Boro* rice where N_{50} + PM_{50} produced 43.39% higher number of effective tiller hill^{-1} than control treatment.



V_1: BRRI dhan29 and V_2: Heera–4

Fig. 4.3 Effect of variety on number of effective tillers hill^{-1} at harvest



T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

Fig. 4.4 Effect of cowdung and Urea on number of effective tillers hill^{-1} at harvest

Hoshain (2010) also found that the highest number of effective tillers hill^{-1} was obtained from the combination of 6 t ha^{-1} cowdung + 120 kg N ha^{-1}. Islam (2008); Jha *et al*. (2004); Gowda *et al*. (2004) and other scientists of the home and abroad also conducted their study with the effect of organic (cowdung) and inorganic fertilizer which ultimately agreed the present findings.

4.1.2.3 Interaction effect of varieties and Cowdung along with Urea fertilizer

The effect of interaction between cultivars and Cowdung with Urea fertilizer was significant in respect of number of effective tillers hill^{-1} (Appendix IX). The significant variation result in Table 4.1 revealed that the productive tillers varied from 17.73 to 23.90 where the maximum number of effective tillers hill^{-1} (23.90) was produced from the variety Heera 4 receiving of 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} (V_2T_4) followed by the variety BRRI dhan29 receiving same treatment (22.90) and the variety Heera 4 receiving 6.40 t cowdung ha^{-1} + 140.0 kg Urea ha^{-1} (22.70). Similarly, the minimum number of effective tillers hill^{-1} (17.73) was produced in the treatment combination of the cultivar BRRI dhan29 having no fertilizer treatment (Table 4.1).

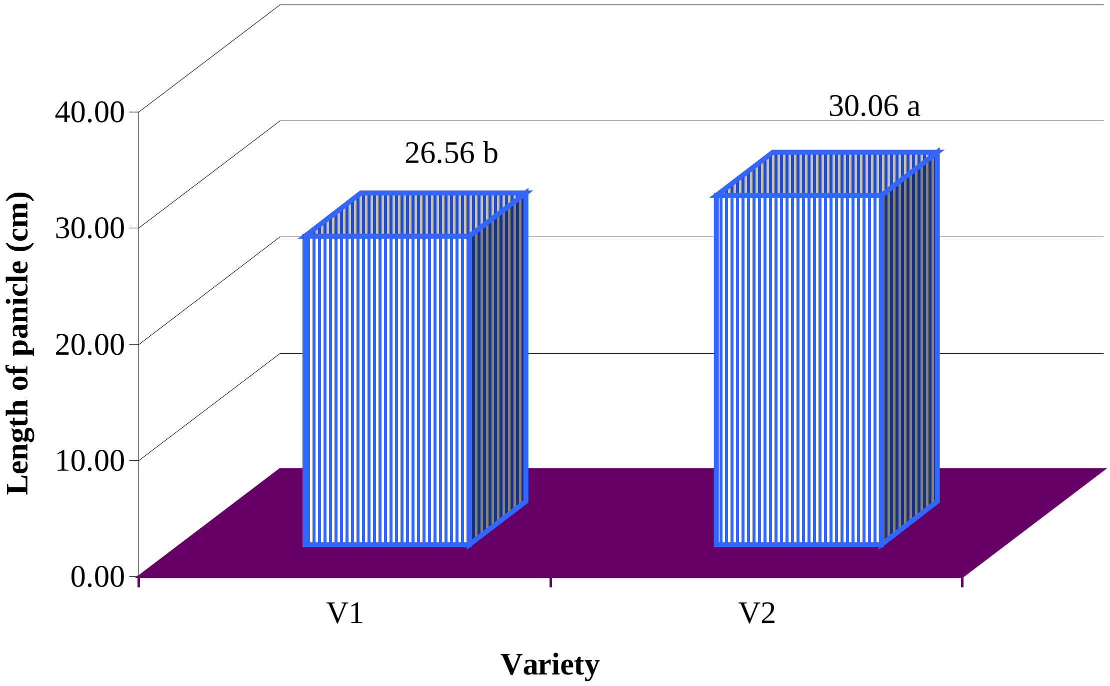
4.1.3 Panicle length

4.1.3.1 Effect of variety

Analysis of variance data on panicle length was significantly influenced by the variety (Appendix IX and Fig. 4.5). From the Fig. 4.5, it was found that the longest panicle (30.06 cm) was observed from the cultivar Heera 4 than BRRI dhan29 (26.56 cm). These results showed that there was significant difference among the cultivar might be due to its genetic variation. This result is in agreement with the findings Ali *et al*. (2014); Hossain *et al*. (2014a and b); Shiyam *et al*. (2014); Sarker *et al*. (2013); Baset Mia and Shamsuddin (2011); Jeng *et al*. (2009); Bakul *et al*. (2009) and many other scientists. They also found variation in panicle length due to the variation in genetic make up of the varieties of rice.

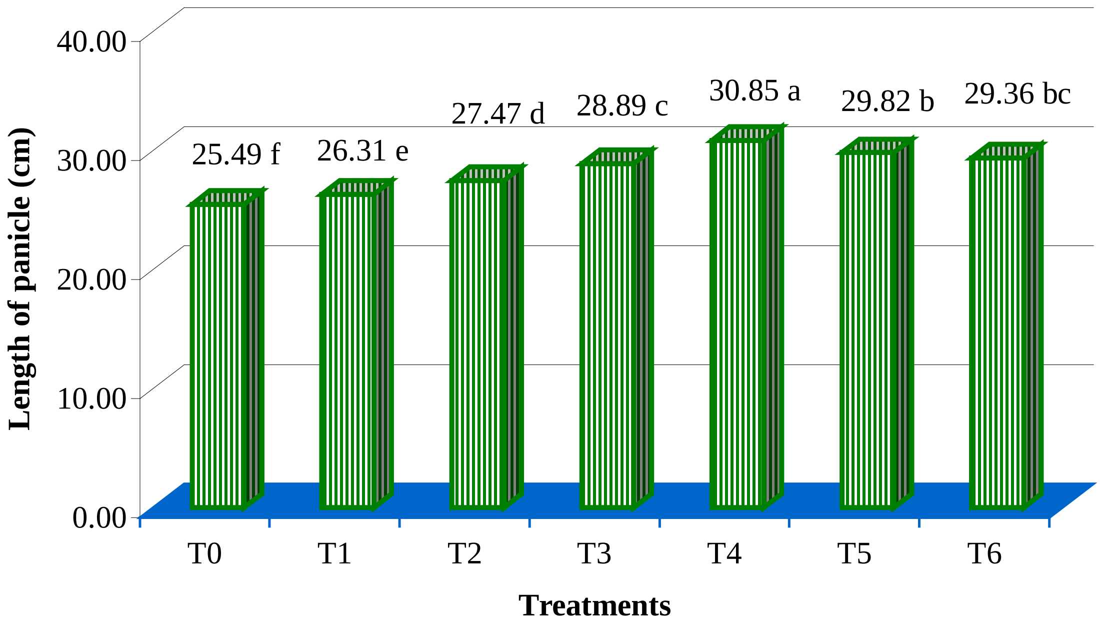
4.1.3.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

Analysis of variance data on panicle length showed significant variation among the cowdung and Urea treatments (Appendix IX and Fig. 4.6). The longest panicle (30.85 cm) was obtained from the treatment T_4 having 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} which was significantly differed from other treatments. Similarly, without fertilizer (T_0: control) showed the shortest panicle (25.49 cm) and significantly differed from other treatments (Fig. 4.6).



V_1: BRRI dhan29 and V_2: Heera–4

Fig. 4.5 Effect of variety on panicle length at harvest



T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

Fig. 4.6 Effect of cowdung and Urea on panicle length at harvest

These result reveled that 3.84 t ha^{-1} cowdung + 196 kg Urea ha^{-1} had highly effective than other higher levels of cowdung + Urea to produced longest panicle. Similarly, Rashid *et al*. (2011) found that the Urea, cowdung, poultry manure and urban wastes was significantly influenced the panicle length where application of 47.5 kg N along with 9.5 t poultry manure ha^{-1} produced the maximum panicle length (27.03 cm) with an increase of 18.03 percent over control treatment. So, the above findings fully agreed the present findings while this was also agreed by the research work of Hoshain (2010); Islam (2008) and other researchers of the home and abroad.

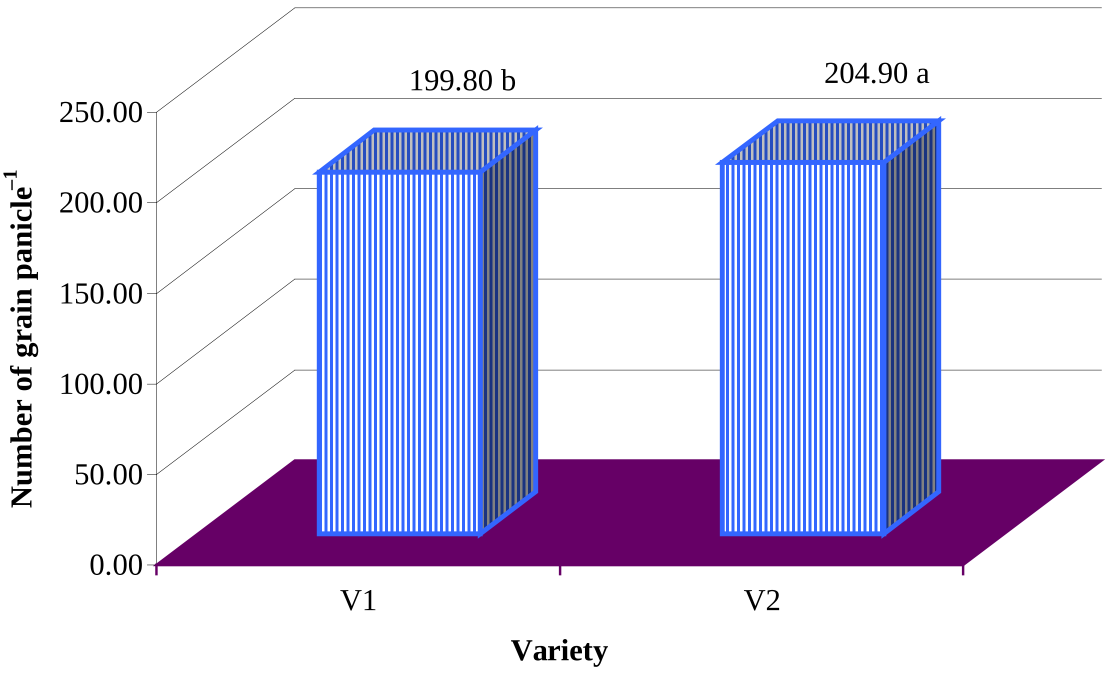
4.1.3.3 Interaction effect of varieties and Cowdung along with Urea fertilizer

The analysis of variance data of the Appendix I showed that there was a significant variation for panicle length at harvest due to the interaction effect of varieties and Cowdung with Urea fertilizer ha^{-1}. From the obtained result in Table 4.1 also found that the length of panicle significantly varied from 24.17 to 33.14 cm. The longest panicle (33.14 cm) was recorded from the variety Heera 4 containing 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} (V_2T_4) while shortest panicle (24.17 cm) was obtained from the variety BRRI dhan29 having no fertilizer (V_1T_0) (Table 4.1).

4.1.4 Number of grains panicle^{-1}

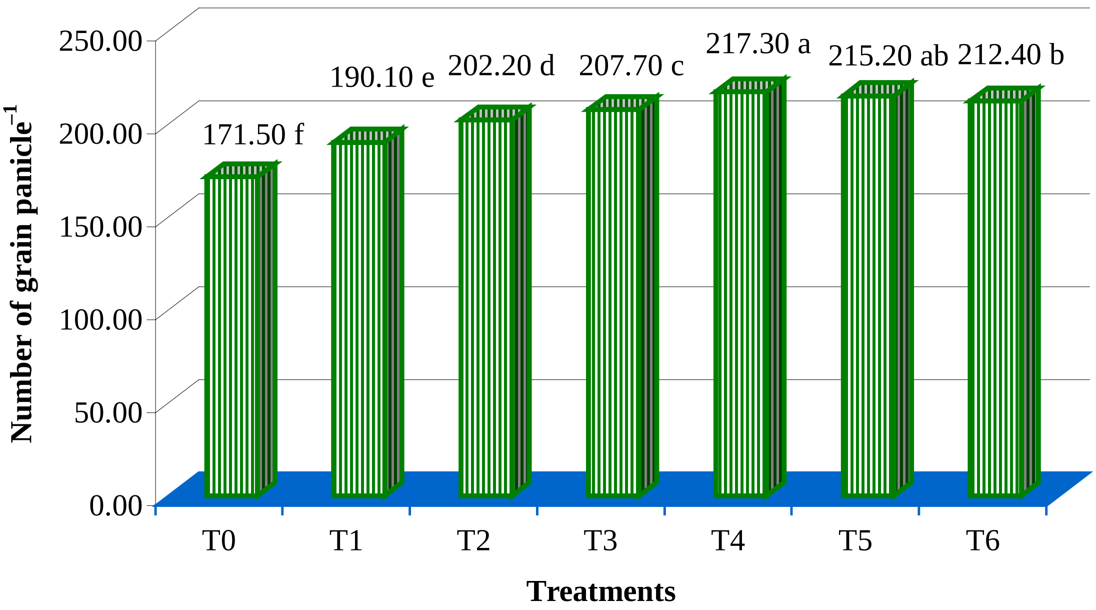
4.1.4.1 Effect of variety

Analysis of variance on number of grains panicle^{-1} was significantly influenced by the effect of variety (Appendix I). The significant variation data of Fig. 4.7 showed that the variety Heera 4 produced more number of grains panicle^{-1} (204.90) than BRRI dhan29 (199.80) (Fig. 4.7). Filled grains hill^{-1} is the most imperative yield attribute which might be due to the increasing grains hill^{-1} significantly increased the grain yield for any crops. These result also revealed that the different variety observed the variation in grains hill^{-1} due to their genetic make up and also the variation in panicle length. Such the similar above findings of the present study was also found by Uddin *et al*. (2011) who reported the significant differences were found in grains panicle^{-1} while BRRI dhan 44 excelled significantly and Lalchicon produced the lowest. Similarly, Shiyam *et al*. (2014); Sarker *et al*. (2013); Islam *et al*. (2013); Mahamud *et al*. (2013); Alam *et al*. (2012); Uddin *et al*. (2010); Bakul *et al*. (2009) and many other scientist of the country and abroad also agreed the present findings.



V_1: BRRI dhan29 and V_2: Heera–4

Fig. 4.7 Effect of variety on number of grains panicle^{-1} at harvest



T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

Fig. 4.8 Effect of cowdung and Urea on number of grains panicle^{-1} at harvest

4.1.4.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

Number of grains panicle^{-1} varied significantly due to the effect of cowding and Urea fertilizer levels (Appendix I). Number of grains panicle^{-1} increased significantly with the increasing levels of cowdung up to 3.84 t ha^{-1} + Urea up to 196 kg ha^{-1} (T_4) and thereafter it decreased. So, the maximum number of grains panicle^{-1} (217.30) was recorded in treatment T_4 followed (215.20) by the treatment T_5 having 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1}. On the other hand, the minimum number of grains panicle^{-1} (171.50) was produced from the treatment T_0 having no fertilizer. Similarly, Rashid *et al*. (2011) also found significant variation on the production of grains panicle^{-1} due to the effect of urea– nitrogen, cowdung, poultry manure and urban wastes where T_6 (N_{50} + PM_{50}) produced the maximum number of filled grains panicle^{-1}. This was also supported by the findings of Hoshain (2010) who also found significant variation due to the effect of organic (cowdung) and inorganic (nitrogen) fertilizer where the highest number of grain panicle^{-1} was obtained from the combination of 6 t ha^{-1} cowdung + 120 kg N ha^{-1}. Therefore, both the researchers agreed the present study.

4.1.4.3 Interaction effect of varieties and Cowdung with Urea fertilizer

Number of grains panicle^{-1} was significantly influenced by the effect of interaction of varieties and Cowdung with Urea fertilizer levels (Appendix I). The number of grains panicle^{-1} significantly varied from 166.6 to 219.30 (Table 4.1). From the Table 4.1, it was found that the maximum number of grains panicle^{-1} was produced from the cultivar Heera 4 receiving of 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} (V_2T_4) which was closely followed (172.20) by the same variety receiving of 5.12 t cowdung ha^{-1} + 168.0 kg Urea ha^{-1} (V_2T_5). On the other hand, the minimum number of grains panicle^{-1} (166.60) was obtained from the cultivar BRRI dhan29 while any doses of N was absent (Table 4.1).

4.1.5 1000–grain weight

4.1.5.1 Effect of variety

Thousand grains weight represents grain size and it was ultimately related to the grain yield. The effect of rice varieties on 1000–grains weight was significant (Appendix II). The variety Heera 4 showed the highest 1000–grains weight (30.93 g) compared to BRRI dhan29 (27.26 g) due to lighter grain (Table 4.2).

Table 4.2 Effect of varieties on yield and yield attributes of *Boro* rice at harvest

Variety	Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
BRRI dhan29	27.26 b	5.430 b	7.070 b	12.50 b	43.37
Heera 4	30.93 a	5.748 a	7.350 a	13.10 a	43.82
CV (%)	**2.47**	**1.50**	**1.99**	**1.08**	**1.66**
Level of significance	**	**	**	**	**ns**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
**= significant at 1% level of probability and ns= non significant

Table 4.3 Effect of cowdung and Urea mixed fertilizer on yield and yield attributes of *Boro* rice at harvest

Treatments	Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_0	26.06 e	4.660 g	6.472 e	11.13 g	41.86 d
T_1	28.23 d	5.057 f	6.687 d	11.74 f	43.06 c
T_2	28.96 cd	5.465 e	7.057 c	12.52 e	43.64 bc
T_3	29.33 c	5.727 d	7.327 b	13.05 d	43.86 abc
T_4	30.93 a	6.297 a	7.807 a	14.10 a	44.63 a
T_5	30.48 ab	6.067 b	7.668 a	13.73 b	44.17 ab
T_6	29.67 bc	5.848 c	7.453 b	13.30 c	43.96 abc
CV (%)	**2.47**	**1.50**	**1.99**	**1.08**	**1.66**
Level of significance	**	**	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation and **= significant at 1% level of probability

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)

T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

The variation in 1000–grain weight might be due to genetic makeup of particular genotype and sink strength. Ali *et al*. (2014) found similar result and they reported that 1000–grain weight differed significantly among the cultivars, which was also supported by Hossain *et al*. (2005 and 2008). Shiyam *et al*. (2014); Islam *et al*. (2013); and many scientists of the home and abroad were also found significant variation in 1000–grain weight due to the variation in genetic make up of the variety. These results also revealed that the variety Heera 4 had more efficient to produce bigger sizes grain than BRRI dhan29 due to the maximum tillers, filled and total grain were achieved. The findings of the present study are also agreed to the findings of Oka *et al*. (2012); Alam *et al*. (2012).

4.1.5.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

The levels of Cowdung and Urea fertilizer showed significant effect on 1000–grain weight (Appendix II). Among the treatments, treatment T_4 (3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1}) showed significantly the maximum 1000–grain weight (30.93 g) closely followed (30.48 g) by the treatment T_5 having 5.12 t cowdung ha^{-1} + 168.0 kg Urea ha^{-1}. On the other hand, control treatment or without fertilizer levels (T_0) produced the lowest (26.06 g) weight of 1000–grain (Table 4.3). These result indicated that grain size increase significantly with the increasing amount of cowdung and decreasing rate of Urea (3.84 t cowdung ha^{-1} and 196 kg Urea ha^{-1}) which might be due to the adequate soil nutrient supply by this certain levels of cowdung and Urea. Similarly, such the variation in 1000–grain weight were also found by Fakhrul Islam *et al*., (2013) who also conducted their study with the application of inorganic (RDF) + organic (PM) manures where T_5 (50% RDCF + 4 ton PM ha^{-1}) showed the highest 1000 grain weight. The present study was mainly on the effect of organic + inorganic fertilizer on *Boro* rice and the similar type of study were also obtained by Rashid *et al*. (2011) who studied on the effect of urea– nitrogen, cowdung, poultry manure and urban wastes where N @ 50 kg ha^{-1} + PM @ 50 kg ha^{-1} produced the highest weight of 1000–grains (29.30 g) of BRRI dhan29. This study was also similar to the research findings of Hossaen *et al*. (2011) who also found that the combinations of organic and inorganic fertilizer was significantly influenced the yield and yield attributes of *Boro* rice where the highest weight of 1000 seeds was recorded from T_5 (70% NPKS + 2.4 t PM ha^{-1}).

Table 4.4 Interaction effect of varieties and cowdung mixed with Urea fertilizer on yield and yield attribues of *Boro* rice at harvest

Variety × treatments		Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
BRRI dhan29	T_0	24.80 f	4.537 i	6.530 gh	11.07 j	40.99
	T_1	27.16 e	5.003 g	6.633 fgh	11.64 i	42.99
	T_2	27.07 e	5.310 f	6.863 f	12.17 h	43.61
	T_3	27.44 e	5.537 e	7.107 e	12.64 g	43.79
	T_4	28.76 cd	6.063 c	7.650 bc	13.71 c	44.21
	T_5	28.09 cde	5.890 d	7.463 cd	13.35 e	44.11
	T_6	27.50 de	5.667 e	7.247 de	12.91 f	43.88
Heera 4	T_0	27.33 e	4.783 h	6.413 h	11.20 j	42.72
	T_1	29.30 c	5.110 g	6.740 fg	11.85 i	43.12
	T_2	30.85 b	5.620 e	7.250 de	12.87 fg	43.66
	T_3	31.22 b	5.917 cd	7.547 c	13.46 de	43.94
	T_4	33.10 a	6.530 a	7.963 a	14.49 a	45.05
	T_5	32.86 a	6.243 b	7.873 ab	14.12 b	44.22
	T_6	31.85 ab	6.030 cd	7.660 bc	13.69 cd	44.04
CV (%)		**2.47**	**1.50**	**1.99**	**1.08**	**1.66**
Level of significance		*	*	**	**	**ns**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

4.1.5.3 Interaction effect of varieties and Cowdung with Urea fertilizer

The effect of interaction between varieties and cowdung along with Urea found to be the insignificant variation in respect of 1000–grain weight (Appendix II). However, the variety Heera 4 showed numerically higher 1000–grain weight (33.10 and 32.86 g) due to both treatment of T_4 and T_5 (V_2T_4 and V_2T_5, respectively) respectively but the same variety receiving higher levels of cowdung (6.40 t ha^{-1}) and lower levels of Urea (140.0 kg ha^{-1}) (V_2T_6) showed the statistically close highest weight of 1000–grain (31.85 g). On the other hand, BRRI dhan29 showed the lowest weight of 1000–grain (24.80 g) while it did not received any fertilizer levels and it was statistically differed from other interaction treatments (Table 4.4).

4.1.6 Grain yield

4.1.6.1 Effect of variety

There was a significant difference between the varieties in respect of grain yield (Appendix II). Between the varieties, Heera 4 produced the highest grain yield (5.75 t ha^{-1}) than BRRI dhan29 (5.43 t ha^{-1}) (Table 4.2). The yield was higher in Heera 4 than that of BRRI dhan29 might be attributed to the production of taller plant, more effective tillers, longest panicle, more grains $panicle^{-1}$ as well as larger sizes grains. Ali *et al*. (2014); Shiyam *et al*. (2014); Uddin *et al*. (2010); Ashrafuzzaman *et al*. (2009) and many workers reported that the varieties which produced higher number of effective tillers $hill^{-1}$ and higher number of filled grains $panicle^{-1}$ also showed higher grain yield ha^{-1}. Similar results were also reported by Hossain *et al*. (2014a and 2014b); Islam *et al*. (2013); Mahmud *et al*. (2012) in rice. This variation in grain yield was also found due to their genetic difference between the varieties while Sohel *et al*. (2009) reported the same observation in his study.

4.1.6.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

A significant variation was found for the character of grain yield due to the effect of organic and inorganic nitrogen (Appendix II and Table 4.3). Among the treatments, 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} (T_4) produced significantly the highest yield of grain (6.30 t ha^{-1}) followed (6.07 t ha^{-1}) by T_5 (5.12 t cowdung ha^{-1} + 168.0 kg Urea ha^{-1}). Similarly, without organic and inorganic nitrogen (T_0 or control) showed the lowest yield of grain (4.66 t ha^{-1}) followed by T_1 (0 kg Cowdung ha^{-1} + 280.0 kg Urea ha^{-1}). This result revealed that the 30% cowdung (3.84 t ha^{-1}) + 70% Urea (196 kg ha^{-1}) as a source of N showed the greater effect on grain yield which might be due due to the more effective tillers hill^{-1}, longest panicle, more grains panicle^{-1} and larger grain were achieved under this treatment. The above findings indicated that the treatment combinations of 30% organic + 70% inorganic fertilizer would be the optimum level for getting the higher grain yield. Similarly, organic + inorganic fertilizer application on Boro rice were also conducted by Shaha (2014); Sarkar (2014); Liza *et al*. (2014); Hasan (2014); Islam *et al*. (2013); Hoshain (2010); Rahman *et al* (2009); Nyalemegbe *et al*. (2009) and many other researchers. All of them were found significant variation on grain yield due to the application of organic (cowdung) + inorganic (N) fertilizer. Shaha (2014) found highest grain yield (5.62 t ha^{-1}) in cowdung 7.5 t ha^{-1} + inorganic fertilizers; Sarkar (2014) found highest grain yield in 75% RD of inorganic fertilizers + 50% cowdung (5 t ha^{-1}); Hoshain (2010) found highest grain yield (6.13 t ha^{-1}) in combination of 6 t ha^{-1} cowdung + 120 kg N ha^{-1}; Rahman *et al* (2009) found highest grain yield in N (Urea) 80 kg ha^{-1} + PM 3 t ha^{-1}; Nyalemegbe *et al*. (2009) found highest grain yield in both 10 t ha^{-1} CD + Urea fertilizer @ 45 kg N ha^{-1} and 10 t ha^{-1} PM + Urea @ 60 kg N ha^{-1} etc.

4.1.6.3 Interaction effect of varieties and Cowdung with Urea fertilizer

Grain yield was significantly influenced by the interaction effect of varieties and the application of organic + inorganic fertilizer (Appendix II and Table 4.4). From the Table 4.4, it was found that the grain yield was significantly varied from 4.54 to 6.53 t ha^{-1} while the treatment V_2T_4 (Heera 4 receiving of 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1}) showed the highest grain yield and BRRI dhan29 showed the lowest grain yield under without fertilizer levels. This result revealed that the growth of Heera 4 had highly efficient in 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} for getting the tallest plant, maximum effective tillers hill^{-1} and grains panicle^{-1}, longest panicle and highest weight of 1000–grain which ultimately resulting the higher grain yield. Similarly, Sarkar (2014) found that the highest grain yield was found in BRRI dhan34 coupled with 75% RD of inorganic fertilizers + 50% cowdung.

4.1.7 Straw yield

4.1.7.1 Effect of variety

Statistical analysis of variance data showed significant difference between the varieties regarding to straw yield (Appendix II and Table 4.3). The variety Heera 4 recorded the highest straw yield (7.35 t ha^{-1}) than BRRI dhan29 (7.07 t ha^{-1}). These result revealed that straw yield differed significantly due to varieties which indicated there was a genetic variation among the genotypes and also the variation in height of plant. Uddin *et al*. (2011) reported that the BRRI dhan44 produced significantly higher straw yield against the lowest by Lalchicon. This might be due to varietal differences and also the variation in plant height. Similarly, the findings of the present was also agreed by the researchers of Mahamud *et al*. (2013); Panwar *et al*. (2012); Baset Mia and Shamsuddin (2011); Masum *et al*. (2008); Awal *et al*. (2007).

4.1.7.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

Straw yield was significantly influenced by the effect of organic + inorganic fertilizer (Appendix II). Straw yield was found to increase significantly with increased organic (cowdung) and decreasing inorganic (Urea) fertilizer combinations up to 30 and 70%, respectively. Therefore, the highest straw yield (7.81 t ha^{-1}) was produced from the treatment T_4 having 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) while numerically same straw yield (7.67 t ha^{-1}) was also produced from the treatment T_5 having 5.12 t cowdung ha^{-1} (40%) + 168 kg Urea ha^{-1} (60%). The lowest one (6.47 t ha^{-1}) was produced by the control treatment having no organic and inorganic nitrogen (Table 4.3). The variation in straw yield was found due to genetic variation of the studied cultivar. Besides, tallest plant and maximum total tillers were obtained under this treatment which ultimately confirmed the greater yield of straw in this study. Similar trend of the effect of organic (Cowdung) and inorganic (Urea) fertilizer on straw yield was also reported by Shaha (2014) who also conducted his study with the effect of organic + inorganic fertilizer. Similarly, Liza *et al*. (2014) also found that the treatment T_6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}) produced the highest straw yield (7.24 t ha^{-1}) while Hasan (2014); Islam *et al*. (2013); Rahman *et al* (2009) and other scientists also found similar results with the present study where all the researcher conducted their studied by the effect of organic + inorganic fertilzier.

4.1.7.3 Interaction effect of varieties and Cowdung with Urea fertilizer

The interaction effect between studied varieties and organic + inorganic fertilizer levels had significant effect on straw yield (Appendix II and Table 4.4). The highest straw yield (7.96 t ha^{-1}) was produced by the interaction of the variety Heera 4 × 3.84

t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} fertilizer (70%) (V_2T_4) while the same variety receiving of 5.12 t cowdung ha^{-1} (40%) + 168.0 kg Urea ha^{-1} (60%) (V_2T_5) showed the statistically close highest straw yield (7.87 t ha^{-1}). Similarly, without treated variety Heera 4 (V_2T_0) showed the lowest yield of straw (6.41 t ha^{-1}) which was also closely followed by the interaction treatments of V_1T_0 (6.53 t ha^{-1}) and V_1T_1 (6.63 t ha^{-1}). From the above result it was found that the variety Heera 4 and 80 g cowdung + 196 kg ha^{-1} Urea fertilizer produced greater yield of straw in case of the highest plant height and maximum number of tillers $hill^{-1}$ were directly implicated for obtaining the greater yield of straw.

4.1.8 Biological yield

4.1.8.1 Effect of variety

The total biomass production was measured in terms of biological yield between the rice varieties and found statistically significant (Appendix II). Between the varieties, Heera 4 produced significantly the higher biological yield (13.10 t ha^{-1}) than BRRI dhan29 (12.50 t ha^{-1}). Results revealed that biological yield differed significantly among the varieties which might be due to the genetic make up of the studied cultivars which result supported by Uddin *et al*. (2011) who reported that the BRRI dhan–44 produced higher biological yield than Lalchicon. Besides, this treatment (V_2T_4) produced the tallest plant and more tillers $hill^{-1}$ which ultimately highly influenced the straw yield. Similarly, Hossain *et al*. (2014a and 2014b); and many researchers found significant variation in biological due to the above reason of the present study.

4.1.8.2 Effect of nitrogen from organic & inorganic source

Analysis of variance data regarding biological yield was significantly influenced by organic and inorganic nitrogen levels whereas increasing level of organic fertilizer up to 30% and decreasing level of inorganic fertilizer (70) significantly increased the biological yield in this study (Appendix II and Table 4.4). The highest biological yield (14.10 t ha^{-1}) was produced from the treatment T_4 having 3.84 t cowdung ha^{-1} (30%) along with 196 kg Urea ha^{-1} (70%) while without organic and inorganic fertilizer application showed the lowest biological yield (11.13 t ha^{-1}). Similar trend of the effect of organic (Cowdung) and inorganic (Urea) fertilizer on straw yield was also reported by Hoshain (2010) who reported that the highest biological yield was obtained from the combination of 6 t cowdung ha^{-1} with 120 kg N ha^{-1}.

4.1.8.3 Interaction effect of varieties and Cowdung with Urea fertilizer

All the treatments of the interaction between varieties and cowdung + Urea fertilizer as a source of urea levels showed significant variation for the characters biological yield (Appendix II and Table 4.4). The biological yield significantly ranges from 11.07 to 14.49 t ha^{-1}. As a result, biological yield had higher (14.49 t ha^{-1}) in treatment combination of V_2T_4 [Heera 4 × 3.84 t ha^{-1} cowdung ha^{-1} (30%) along with 196 kg Urea ha^{-1} (70%)] while both variety (BRRI dhan29 and Heera 4) showed the lowest and numerically same biological yield (11.07 and 11.20 t ha^{-1}, respectively) due to control or without fertilizer application (Table 4.4)

4.1.9 Harvest index

4.1.9.1 Effect of variety

Analysis of variance data on harvest index (HI) did not vary significant due to the effect of varieties in this study as well as they produced numerically or statistically same HI (Appendix II and Table 4.2). However, the ranges of HI were Heera 4 (43. 82%) > BRRI dhan29 (43. 37 %). These findings were also similar to that of the study of Uddin *et al*. (2011) who reported that the harvest index differed significantly among the varieties due to its genetic variability. Such variation in genetic make up of the varieties regarding HI were also found by Roy *et al*. (2014); Yao *et al*. (2012); Sritharan and Vijayalakshmi (2012); Islam (2011); Baset Mia and Shamsuddin (2011) any another many scientist.

4.1.9.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

A significant variation was observed due to nitrogen levels (as a source of cowding and Urea fertilizer) regarding harvest index (Appendix II and Table 4.3). Table 4.3 shows that harvest index increased up to 30% organic (cowdung) + 70% inorganic (Urea) N fertilizer. The highest harvest index (44.63%) was recorded in T_4 having 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) while it was statistically close to T_5 (44.17%), T_6 (43.96%) and T_3 (43.86%). On the other hand, control (no fertilizer) showed the lowest harvest index (41.86%) which was not statistically close or identical among other treatments of the study. Such the organic and inorganic fertilizer combinations effect on harvest index were also obtained by Islam (2008) who also found that the harvest index (46.04%) was obtained from the combination of 50% recommended fertilizer with 5 t ha^{-1} cowdung.

4.1.9.3 Interaction effect of varieties and Cowdung with Urea fertilizer

All the treatments of the interaction between varieties and cowdung + Urea fertilizer as a source of urea were produced statistically or numerically same harvest index due to non significant variation in this study (Appendix II and Table 4.4).

4.2 Nutrient content in grain and straw of *Boro* rice

4.2.1 NPK content (%) in grain

4.2.1.1 Effect of variety

N, P and K content in grain was significantly influenced by the effect of varieties in this study (Appendix III). The percentage of N content had highest (1.099%) in grain of Heera 4 compare the grain of BRRI dhan29 (1.045%). Similarly, P content was the highest (0.316%) in grain of Heera 4 than BRRI dhan29 (0.302%) while the grain of Heera 4 further showed significantly the more K content (0.304%) than the grain of BRRI dhan29 (0.293%) (Table 4.5). This result revealed that NPK content in grain significantly affected by the effect of variety which might be due to the variation in their genetic characteristics. Such the similar observation with the present study was also obtained by Rahman *et al*. (2009) who found that Chola *Boro*, IRATOM 24 and BR 14 are three high rice–NPK containing varieties having breeding potentials to make our future rice plant strong.

4.2.1.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

Effect of organic and inorganic fertilizer as a source of N was significantly influenced the N, P and K content in grain of *Boro* rice (Appendix III and Table 4.6). In case of the N content in grain, the highest N content (1.163%) was found in those grain which was treated by the treatment T_5 having 5.12 t cowdung ha^{-1} (40%) + 168.0 kg Urea ha^{-1} (60%) while treatment T_6 having 6.40 t cowdung ha^{-1} (50%) + 140.0 kg Urea ha^{-1} (50%) showed the statistically close highest N content. On the other hand, without fertilizer treated grain showed the lowest N content (0.960) which was statistically differed from other all treatments of the study (Table 4.6). In case of P content, treatment T_4 having 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) treated grain recorded the highest content of P (0.326%) followed by (0.318%) the treatment T_5 having 5.12 t cowdung ha^{-1} (40%) + 168.0 kg Urea ha^{-1} (60%) while without treated grain obtained the lowest P content (0.290%) which was also statistically close P content (0.297%) to T_1 having 0 g cowdung ha^{-1} (0%) + 280 kg Urea ha^{-1} (100%).

In case of K content, both the treatment T_4 having 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (60%) and T_5 having 5.12 t cowdung ha^{-1} (40%) + 168.0 kg Urea ha^{-1} (60%) treated grain showed the highest and statistically or numerically same K content (0.316 and 0.311%, respectively) while treatment T_3 and T_6 treated grain recorded the statistically close K content (0.304 and 0.308%, respectively). On the other hand, both T_0 (no fertilizer) and T_1 having 0 g cowdung ha^{-1} (0%) + 280 kg Urea ha^{-1} (100%) treated grain noted the lowest and numerically similar K content (0.271 and 0.282%, respectively) (Table 4.6). Similar effect was also found by Al Fakhrul Islam *et al*. (2013) who reported that the highest concentrations of grain N, P, K, S were recorded in T_5 (50% RDCF + 4 ton PM ha^{-1}). Similar findings was also found by Basu *et al*. (2012) who also found that the application of cowdung and chemical fertilizers had significant effect on the content of N, P, K, S, Ca, Mg, B, Zn, protein, starch and amylose in rice grain. Akter (2011) also found that the N, P, K and S contents by BRRI dhan29 were profoundly influenced due to application of Urea in combination with cowdung, compost and poultry manure while this result was also supported by Yaqub *et al*. (2010).

4.2.1.3 Interaction effect of varieties and Cowdung with Urea fertilizer

All the treatments of interaction of varieties and organic + inorganic fertilizer treated grain showed the numerically similar percentage of P and K content while N content varied significantly due to interaction effect (Appendix III and Table 4.7). From the Table 4.7, it was found that the P content varied from 0.284 (V_1T_0) to 0.333% (V_2T_4) and K content varied from 0.268 (V_1T_0) to 0.321% (V_2T_4) but they were numerically identical. Table 4.7 also revealed that the percentage of N content significantly varied from 0.949% to 1.190% where the highest N content was found in those grain of Heera 4 which was treated by 5.12 t cowdung ha^{-1} (40%) + 168.0 kg Urea ha^{-1} (60%) (V_2T_5) and the lowest N content was obtained from the without fertilizer treated grain of BRRI dhan29 (Table 4.6).

Table 4.5 Effect of varieties on nutrient content (NPK) of grain and straw of *Boro* rice at harvest

Variety	Nutrient content of grain (%)			Nutrient content of straw (%)		
	N	P	K	N	P	K
BRRI dhan29	1.045 b	0.302 b	0.293	0.685 b	0.154 b	1.265 b
Heera 4	1.099 a	0.316 a	0.304	0.710 a	0.160 a	1.305 a
CV (%)	**1.34**	**0.45**	**0.26**	**1.90**	**0.64**	**0.96**
Level of significance	**	**	ns	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 1% level of probability and ns= non significant

Table 4.6 Effect of cowdung and Urea mixed fertilizer on nutrient content (NPK) of grain and straw of *Boro* rice at harvest

Treatments	Nutrient content of grain (%)			Nutrient content of straw (%)		
	N	P	K	N	P	K
T_0	0.960 f	0.290 d	0.271 c	0.659 e	0.136 f	1.120 g
T_1	0.986 e	0.297 cd	0.282 c	0.673 d	0.142 ef	1.175 f
T_2	1.016 d	0.307 bc	0.298 b	0.699 c	0.149 de	1.230 e
T_3	1.080 c	0.311 b	0.304 ab	0.701 c	0.156 cd	1.313 d
T_4	1.147 b	0.326 a	0.316 a	0.732 a	0.180 a	1.450 a
T_5	1.163 a	0.318 ab	0.311 a	0.714 b	0.172 ab	1.368 b
T_6	1.153 ab	0.314 b	0.308 ab	0.706 bc	0.166 bc	1.341 c
CV (%)	**1.34**	**0.45**	**0.26**	**1.90**	**0.64**	**0.96**
Level of significance	**	**	**	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

Table 4.7 Interaction effects of varieties and cowdung mixed with Urea fertilizer on nutrient content (NPK) of grain and straw of *Boro* rice at harvest

Variety × treatments		Nutrient content of grain (%)			Nutrient content of straw (%)		
		N	P	K	N	P	K
BRRI dhan29	T_0	0.949 h	0.284	0.268	0.646	0.134	1.098 j
	T_1	0.955 gh	0.290	0.277	0.660	0.139	1.151 i
	T_2	0.976 f	0.299	0.291	0.690	0.146	1.221 g
	T_3	1.023 e	0.305	0.295	0.689	0.155	1.301 f
	T_4	1.139 c	0.320	0.310	0.719	0.177	1.425 b
	T_5	1.137 c	0.311	0.306	0.701	0.167	1.335 e
	T_6	1.136 c	0.307	0.303	0.692	0.162	1.324 e
Heera 4	T_0	0.970 fg	0.296	0.275	0.672	0.138	1.141 i
	T_1	1.017 e	0.304	0.287	0.687	0.144	1.198 h
	T_2	1.057 d	0.314	0.305	0.707	0.153	1.238 g
	T_3	1.137 c	0.317	0.312	0.714	0.156	1.325 e
	T_4	1.154 bc	0.333	0.321	0.744	0.184	1.475 a
	T_5	1.190 a	0.324	0.317	0.728	0.177	1.401 c
	T_6	1.170 b	0.320	0.313	0.720	0.171	1.358 d
CV (%)		**1.34**	**0.45**	**0.26**	**1.90**	**0.64**	**0.96**
Level of significance		**	ns	ns	ns	ns	*

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

4.2.2 NPK content (%) in straw

4.2.2.1 Effect of variety

Effect of variety had statistically significant on the content of N, P and K in grain where the straw of Heera 4 showed the highest content of N, P and K (0.710, 0.160 and 1.350%, respectively) than that of BRRI dhan29 (0.685, 0.154 and 1.265%, respectively) (Appendix III and Table 4.5). Similarly, varietal difference in NPK content in straw was also obtained by Rahman *et al*. (2009) who found that Chola *Boro*, IRATOM 24 and BR 14 are three high straw–K containing varieties having breeding potentials to make our future rice plant strong.

4.2.2.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

Effect of organic and inorganic fertilizer was significantly influenced the N, P and K content in straw where N content varied from 0.659% (T_0) to 0.732% (T_4), P content varied from 0.136% (T_0) to 0.180 (T_4) and K content varied from 0.120% (T_0) to 1.450% (T_4) (Appendix III and Table 4.6). From the above variation in N, P and K content, it was found that the 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) treated straw produced the highest content of N while without treated straw obtained the lowest N content (Table 4.6). Similarly, treatment T_4 treated straw showed the highest P content closely followed (0.172%) by T_5 while without treated straw recorded the lowest P content. In case of K content in straw, it was the highest in treatment T_4 treated straw and lowest in without treated straw (Table 4.6). Similarly, Akter (2011) also found that NPK content by BRRIdhan 29 was significantly influenced by the effect of Urea, cowdung and poultry manure where the N, P, K and S contents by BRRI dhan29 straw were profoundly influenced due to application of Urea in combination with cowdung, compost and poultry manure. Similar effect was also found by AL Fakhrul Islam *et al*. (2013) who reported that the highest concentrations of straw N, P, K, S were recorded in T_5 (50% RDCF + 4 ton PM ha^{-1}).

4.2.2.3 Interaction effect of varieties and Cowdung with Urea fertilizer

The data of nutrient content (N, P and K) in straw did not vary significant due to the effect of interaction of varieties and N fertilizer (cowdung + Urea) (Appendix III). As a result, all the treatments of interaction treated straw showed numerically identical N, P and K content (Table 4.7). However, N content varied from 0.464% (V_1T_0) to 0.744% (V_2T_4), P content varied from 0.134% (V_1T_0) to 0.184% (V_2T_4) and K content varied from 1.098% (V_1T_0) to 1.475% (V_2T_4) in this study (Table 4.7).

4.3 Nutrient uptake by grain and straw of *Boro* rice

4.3.1 NPK uptake (kg ha^{-1}) by grain

4.3.1.1 Effect of variety

A significant variation was found due to the effect of variety for the characters of N, P and K uptake by grain (Appendix IV). The significant variation data on nutrient (N, P and K) uptake presented in Table 4.8 where the grain of Heera 4 showed the highest uptake of N, P and K (63.64, 18.21 and 17.58 kg ha^{-1}, respectively) than that of BRRI dhan29 (57.13, 16.47 and 15.98 kg ha^{-1}, respectively) (Table 4.8).

4.3.1.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

Nutrients (N, P and K) uptake by grain was significantly affected by the effect of organic and inorganic where N uptake varied from 44.75 to 72.24 kg ha^{-1}, P uptake varied from 13.53 to 20.57 kg ha^{-1} and K uptake varied from 12.65 to 19.88 kg ha^{-1} (Appendix IV and Table 4.9). From the Table 4.9, it was found that the treatment T_4 treated (3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1}) grain recorded the highest N uptake followed (70.66 kg ha^{-1}) by T_5 (5.12 t cowdung ha^{-1} + 168.0 kg Urea ha^{-1}) while N uptake was the lowest in those grain which was not treated by any fertilizer. Similarly, P content was the highest in T_4 treated grain (20.57 kg ha^{-1}) followed by T_5 treated grain (19.29%) while it was the lowest in without treated grain (13.53 kg ha^{-1}). Treatment T_4 treated grain further produced significantly the highest K uptake (19.88 kg ha^{-1}) followed by T_5 (18.90%) and without fertilizer treated grain showed the lowest K uptake (12.65 kg ha^{-1}) in this study (Table 4.9). This result revealed that organic and inorganic fertilizer fully influenced the NPK uptake by grain while Hasan (2014) also found similar result with the present findings. They found that the N, P and K uptake by BRRI dhan32 rice were influenced profoundly due to the application of USG alone or in combination with cowdung. Rifat–E–Mahbuba (2013) also agreed the present findings in case of the found that the N, P and K uptake by BRRI dhan28 rice were influenced profoundly due to the application of USG alone or in combination with cowdung while Akter (2011); Yaqub *et al*. (2010) also supported the present findings.

4.3.1.3 Interaction effect of varieties and Cowdung with Urea fertilizer

Analysis of variance data on N, P and K uptake by grain was statistically significant due to the effect of interaction of varieties and the application of organic + inorganic fertilizer (Appendix IV). In case of N uptake, the variety Heera 4 recorded the highest

N uptake by grain (75.38 and 74.33 kg ha^{-1}) while it was treated by both T_4 (V_2T_4) and T_6 (V_2T_6), respectively. On the other hand, without fertilizer treated BRRI dhan29 showed the lowest uptake of grain N (43.07 kg ha^{-1}). In case of P uptake, treatment T_4 having 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) treated Heera 4 obtained the highest P uptake by grain (21.73 kg ha^{-1}) while without fertilizer treated BRRI dhan29 showed the lowest P uptake by grain (12.87 kg ha^{-1}). Similarly, the highest K uptake by grain (21.73 kg ha^{-1}) was also produced from the variety Heera 4 treated by 3.84 t ha^{-1} cowdung ha^{-1} + 196 kg ha^{-1} Urea ha^{-1} (V_2T_4) while it was also the lowest (12.16) in without fertilizer treated variety BRRI dhan29. So, the above result revealed that the N uptake varied from 43.07 to 75.38 kg ha^{-1}, P uptake varied from 12.87 to 21.73 kg ha^{-1} and K uptake varied from 12.16 to 20.97 kg ha^{-1} (Table 4.10).

4.3.2 NPK uptake (kg ha^{-1}) by straw

4.3.2.1 Effect of variety

N, P and K uptake by straw also showed significant variation due to the effect of varieties where the variety Heera 4 took the more uptake of N, P and K by straw (52.32, 11.86 and 96.56 kg ha^{-1}, respectively) than BRRI dhan29 (48.42, 10.95 and 89.59 kg ha^{-1}, respectively) (Appendix IV and Table 4.8).

4.3.2.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

Effect of organic (cowuding) and inorganic (Urea) fertilizers as a source of N showed significant variation for nutrient uptake of N, P and K by straw (Appendix IV). From the Table 4.9, it was found that the N uptake by straw varied from 42.65 to 57.15 kg ha^{-1}, P uptake varied from 8.78 to 14.09 kg ha^{-1} and K uptake varied from 71.42 to 113.30 kg ha^{-1} (Table 4.9). This result revealed that the treatment T_4 having 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} treated straw showed the highest uptake of N, P and K by straw while it was the lowest in without fertilizer treated straw (Table 4.9). Similarly, Akter (2011) found that the N, P, K and S uptake by BRRI dhan29 were profoundly influenced due to application of Urea in combination with cowdung, compost and poultry manure which result fully associated the present result.

Table 4.8 Effect of varieties on nutrient uptake (NPK) of grain and straw of *Boro* rice at harvest

Variety	Nutrient uptake by grain (kg ha^{-1})			Nutrient uptake by straw (kg ha^{-1})		
	N	P	K	N	P	K
BRRI dhan29	57.13 b	16.47 b	15.98 b	48.42 b	10.95 b	89.59 b
Heera 4	63.64 a	18.21 a	17.58 a	52.32 a	11.86 a	96.56 a
CV (%)	**1.94**	**1.88**	**1.04**	**1.45**	**1.88**	**1.45**
Level of significance	**	**	**	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

Table 4.9 Effect of cowdung and Urea mixed fertilizer on nutrient uptake (NPK) of grain and straw of *Boro* rice at harvest

Treatments	Nutrient uptake by grain (kg ha^{-1})			Nutrient uptake by straw (kg ha^{-1})		
	N	P	K	N	P	K
T_0	44.75 g	13.53 g	12.65 g	42.65 g	8.781 g	71.42 g
T_1	49.90 f	15.03 f	14.28 f	45.04 f	9.438 f	78.63 f
T_2	55.63 e	16.77 e	16.31 e	48.87 e	10.53 e	86.85 e
T_3	61.99 d	17.83 d	17.40 d	51.42 d	11.40 d	96.29 d
T_4	72.24 a	20.57 a	19.88 a	57.15 a	14.09 a	113.3 a
T_5	70.66 b	19.29 b	18.90 b	54.81 b	13.22 b	105.0 b
T_6	67.52 c	18.35 c	18.04 c	52.65 c	12.41 c	100.1 c
CV (%)	**1.94**	**1.88**	**1.04**	**1.45**	**1.88**	**1.45**
Level of significance	**	**	**	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

Table 4.10 Interaction effect of varieties and cowdung mixed with Urea fertilizer on nutrient uptake (NPK) of grain and straw of *Boro* rice at harvest

Variety × treatments		Nutrient uptake by grain (kg ha^{-1})			Nutrient uptake by straw (kg ha^{-1})		
		N	P	K	N	P	K
BRRI dhan29	T_0	43.07 j	12.87 j	12.16 l	42.22 i	8.752 j	69.58 l
	T_1	47.80 i	14.53 i	13.88 j	43.76 h	9.201 i	76.45 j
	T_2	51.83 h	15.88 h	15.47 h	46.47 g	10.00 h	83.87 h
	T_3	56.66 g	16.89 g	16.34 g	48.97 f	11.02 g	92.53 f
	T_4	69.09 bc	19.40 c	18.80 c	55.01 c	13.52 c	109.0 b
	T_5	66.99 d	18.32 e	18.03 e	52.32 d	12.47 e	99.66 d
	T_6	64.43 e	17.38 fg	17.19 f	50.18 ef	11.72 f	96.02 e
Heera 4	T_0	46.44 i	14.18 i	13.14 k	43.09 hi	8.809 j	73.25 k
	T_1	52.00 h	15.54 h	14.67 i	46.31 g	9.675 h	80.81 i
	T_2	59.44 f	17.65 f	17.15 f	51.27 de	11.06 g	89.84 g
	T_3	67.31 cd	18.78 de	18.47 d	53.87 c	11.78 f	100.0 d
	T_4	75.38 a	21.73 a	20.97 a	59.28 a	14.66 a	117.5 a
	T_5	74.33 a	20.26 b	19.77 b	57.30 b	13.97 b	110.4 b
	T_6	70.61 b	19.32 cd	18.88 c	55.13 c	13.10 d	104.1 c
CV (%)		**1.94**	**1.88**	**1.04**	**1.45**	**1.88**	**1.45**
Level of significance		**	*	**	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

4.3.2.3 Interaction effect of varieties and Cowdung with Urea fertilizer

The data of nutrient uptake by straw was significantly influenced by the effect of interaction of varieties and various treatment combinations of organic (cowdung) and inorganic (Urea) fertilizer (Appendix IV). The highest N uptake by straw (59.28 kg ha^{-1}) was recorded from the variety Heera 4 while it was treated by 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) and the lowest N uptake by straw (42.22 kg ha^{-1}) was obtained in without fertilizer treated BRRI dhan29. Similarly, P and K uptake by straw was the highest (14.66 and 117.50 kg ha^{-1}, respectively) in 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) treated vareity Heera 4 while it was the lowest (8.752 and 69.58 kg ha^{-1}, respectively) in without treated BRRI dhan29. So, the above observation showed that the N uptake ranges from 42.22 to 59.28 kg ha^{-1}, P uptake ranges from 8.75 to 14.66 kg ha^{-1} and K uptake ranges from 69.58 to 117.50 kg ha^{-1} (Table 4.10).

4.4 Nutrient (NPK) content in postharvest soil

4.4.1 Effect of variety

Nutrient (NPK) content in postharvest soil varied significantly due to the effect of variety (Appendix V). The obtained result are presented in Table 4.11 and showed that the N content had maximum (0.0771 ppm) in Heera 4 than BRRI dhan29 (0.0728). Similarly, Heera 4 took the more P content in postharvest soil (28.82 ppm) than that of BRRI dhan29 (27.16 ppm) while Heera 4 further produced more K content in postharvest soil (0.0384 meq 100 g^{-1}) compare BRRI dhan29 (0.0367 meq 100 g^{-1}) in this study (Table 4.11).

4.4.2 Effect of organic (Cowdung) and inorganic (Urea) fertilizer

N, P and K content in postharvest soil also showed significant variation due to the effect of cowuding and Urea fertilizers where N content varied from 0.0475 to 0.0923 ppm, P content varied from 21.81 to 33.60 ppm and K content varied from 0.0248 to 0.0455 meq 100 g^{-1} (Appendix IV and Table 4.12). From the Table 4.12, it was also found that the highest value of the N, P and K content in postharvest soil were obtained from those soil which was treated by 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1}. Similarly, without fertilizer treated soil showed the lowest above mentioned content (Table 4.9).

Table 4.11 Effect of varieties on nutrient content (NPK) in postharvest soil of the experimental field

Variety	NPK content in postharvet soil		
	N (ppm)	P (ppm)	K (meq $100g^{-1}$)
BRRI dhan29	0.0728 b	27.16 b	0.0367
Heera 4	0.0771 a	28.82 a	0.0384
CV (%)	**1.58**	**0.79**	**1.00**
Level of significance	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

Table 4.12 Effect of cowdung and Urea mixed fertilizer on nutrient content (NPK) in postharvest soil of the experimental field

Treatments	NPK content in postharvet soil		
	N (ppm)	P (ppm)	K (meq $100g^{-1}$)
T_0	0.0475 d	21.81 g	0.0248 c
T_1	0.0633 c	23.56 f	0.0317 bc
T_2	0.0750 bc	26.19 e	0.0375 ab
T_3	0.0780 b	28.74 d	0.0390 ab
T_4	0.0923 a	33.60 a	0.0455 a
T_5	0.0862 ab	31.47 b	0.0430 ab
T_6	0.0823 ab	30.55 c	0.0412 ab
CV (%)	**1.58**	**0.79**	**1.00**
Level of significance	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

Table 4.13 Interaction effect of varieties and cowdung mixed with Urea fertilizer on nutrient content (NPK) in postharvest soil of the experimental field

Variety × treatments		NPK content in postharvet soil		
		N (ppm)	P (ppm)	K (meq $100g^{-1}$)
BRRI dhan29	T_0	0.0447 e	21.28 l	0.0243 c
	T_1	0.0613 cde	23.12 j	0.0307 abc
	T_2	0.0740 bc	25.60 h	0.0370 abc
	T_3	0.0767 bc	27.71 f	0.0383 abc
	T_4	0.0887 ab	32.51 b	0.0443 ab
	T_5	0.0850 ab	30.42 d	0.0423 abc
	T_6	0.0793 abc	29.49 e	0.0397 abc
Heera 4	T_0	0.0503 de	22.33 k	0.0253 bc
	T_1	0.0653 cd	24.00 i	0.0327 abc
	T_2	0.0760 bc	26.78 g	0.0380 abc
	T_3	0.0793 abc	29.76 e	0.0397 abc
	T_4	0.0960 a	34.70 a	0.0467 a
	T_5	0.0873 ab	32.53 b	0.0437 abc
	T_6	0.0853 ab	31.61 c	0.0427 abc
CV (%)		**1.58**	**0.79**	**1.00**
Level of significance		**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT

CV= Co–efficient of variation
*, **= significant at 5% and 1%, respectively level of probability and ns= non significant

T_0 = Controlled (No Fertilizer)
T_1 = 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea)
T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea)
T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea)
T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea)
T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea)
T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea)

However, the soil treated by both 5.12 t cowdung ha^{-1} + 168.0 kg Urea ha^{-1} (T_5) and 6.40 t cowdung ha^{-1} + 140.0 kg Urea ha^{-1} (T_6) recorded the lowest N, P and K content in postharvest soil. Similarly, organic + inorganic fertilizer effect on postharvest soil were also obtained by Qian *et al*. (2011) who found that organic manure application combined with chemical fertilizers treatments. AL Fakhrul Islam *et al*. (2013) also reported that the levels of organic matter and nutrient concentration were increased in the post harvest soils due to added manure plus inorganic fertilizer.

4.4.3 Interaction effect of varieties and Cowdung with Urea fertilizer

Analysis of variance data of the Appendix V revealed that there was a significant variation for nutrient content in postharvest soil due to the effect of interaction of varieties and the application of cowdung + Urea fertilizer (Appendix IV). The obtained results of Table 4.13 also revealed that the N content significantly varied from 0.0447 to 0.0960 ppm, P content varied from 21.28 to 34.70 ppm and K content varied from 0.0243 to 0.0467 meq 100 g^{-1}. From the above ranges, it was found that the highest value of N, P and K content in postharvest soil were found from the 3.84 t cowdung ha^{-1} (30%) + 196 kg Urea ha^{-1} (70%) treated soil while the lowest N, P and K content were recorded in those soil which were not treated by any levels of fertilizer (Table 4.13).

CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER 5
SUMMARY AND CONCLUSION

5.1 SUMMARY

The present experiment was conducted at the Research Field of the Department of Soil Science, SAU, Dhaka during the *Boro* season of 2012–13 to evaluate the growth, yield, yield attributes and integrated nutrient management as influenced by the singly or their interaction effect of two rice varieties and organic (cowdung) + inorganic (Urea) fertilizer as a source of urea. Two rice varieties namely BRRI dhan29 (V_1) and Heera 4 (V_2) and seven treatments including control *viz.* T_0: controlled or no fertilizer, T_1: 0 t ha^{-1} Cowdung (0% N) + 280 kg ha^{-1} Urea (100 % N as Urea), T_2 = 1.28 t ha^{-1} Cowdung (10% N as CD) + 252 kg ha^{-1} Urea (90%N as Urea), T_3 = 2.56 t ha^{-1} Cowdung (20% N as CD) + 224 kg ha^{-1} Urea (80%N as Urea), T_4 = 3.84 t ha^{-1} Cowdung (30% N as CD) + 196 kg ha^{-1} Urea (70%N as Urea), T_5 = 5.12 t ha^{-1} Cowdung (40 % N as CD) + 168 kg ha^{-1} Urea (60%N as Urea) and T_6 = 6.40 t ha^{-1} Cowdung (50 % N as CD) + 140 kg ha^{-1} Urea (50%N as Urea). The two factors experiment (Factor A: Variety and Factor B: Cowdung + Urea) was laid out in Randomized Completely Block Design (RCBD) method with three replications and analysis was done by the MSTAT–C package program whereas means were adjudged by DMRT at 5% level of probability. The size of unit plot was 7.0 m^2 (3.2 m × 2.0 m) while block to block and plot to plot distances were 2.0 m and 1.0 m, respectively. The total number of plots were 42 (treatment combinations: 14 × replication: 3). The row to row and plant to plant distances were also 25 and 20 cm, respectively.

In case of the effect of variety, all the characters of the study except harvest index and K content in postharvest soil were significantly affected due to the main effect of variety. Between the varieties, hybrid variety Heera 4 showed superior performance than BRRI dhan29 among the whole characters of the study. In case of the tallest plant (96.92 cm), more effective tillers hill^{-1} (21.23), longest panicle (30.06 cm), more grains panicle^{-1} (204.90), highest weight of 1000–grain (30.93 g), highest yield of grain, straw and biological (5.75, 7.35 and 13.10 t ha^{-1}, respectively) were obtained from the variety Heera 4 compare BRRI dhan29. Similarly, highest NPK content in grain (1.099, 0.316 and 0.304%, respectively) and straw (0.710, 0.160 and 1.305%, respectively) were recorded from Heera 4 while the variety Heera 4 also produced significantly the highest NPK uptake by grain (63.64, 18.21 and 17.58 kg ha^{-1}) and straw (52.32, 11.86 and 96.56 kg ha^{-1}) than than of BRRI dhan29. Similar performance regarding NPK content in postharvest soil (0.0771 ppm, 28.82 ppm and 0.0384 meq 100 g^{-1}) was also determined.

Among the growth, yield and yield contributing characters including integrated nutrient (NPK) characters were influenced significantly due to the main effect of variety where T_4 (3.84 t cowdung ha^{-1} + 196 kg Urea N ha^{-1}) showed the best performance at all the characters except N content in grain. The tallest plant (99.78 cm), more effective tillers $hill^{-1}$ (23.40), longest panicle (30.85 cm), more grains $panicle^{-1}$ (217.30), highest weight of 1000–grain (30.93 g), highest yield of grain, straw and biological (6.30, 7.81 and 14.10 t ha^{-1}, respectively) and highest HI (44.63%) were recorded in T_4 where above all characters were lowest in T_0 (control). However, P and K content in grain had highest (0.326 and 0.316%, respectively) in T4 but N content in grain had highest (1.163%) in T_5 having 5.12 t ha^{-1} cowdung ha^{-1} + 168.0 kg Urea ha^{-1} while without fertilizer treatment showed the lowest NPK content. NPK content in straw had also highest (0.732, 0.180 and 1.450%, respectively) in T_4 and lowest in T_0. Similarly, treatment T_4 further showed the highest NPK uptake by grain (72.24, 20.57 and 19.88 kg ha^{-1}, respectively) and straw (57.15, 14.09 and 113.30 kg ha^{-1}, respectively) and T_0 recorded the lowest NPK uptake by grain and straw. NPK content in postharvest soil, T_4 also recorded the highest content (0.0923 ppm, 33.60 ppm and 0.0455 meq 100 g^{-1}) and T_0 recorded the lowest content.

In case of the effect of interaction between variety and cowdung + Urea fertilizer, all the characters of growth and yield except HI showed significant variation while P, K content in grain and NP content in straw showed non ignificant variation and rest of the nutrient management characters were statistically significant. Among the interactions, the variety Heera 4 receiving of 3.84 t ha^{-1} cowdung ha^{-1} + 196 kg ha^{-1} Urea ha^{-1} (V_2T_4) produced significantly the tallest plant (101.40 cm), more effective tillers $hill^{-1}$ (23.90), longest panicle (33.14 cm), more grains $panicle^{-1}$ (219.30), highest 1000–grain weight (33.10 g), highest yield of grain, straw and biological (6.53, 7.96 and 14.49 t ha^{-1}) while they were lowest in without treated BRRI dhan29. However, N content in grain had highest (1.190%) in Heera 4 receiving of 5.12 t ha^{-1} cowdung ha^{-1} + 196 kg ha^{-1} Urea ha^{-1} (V_2T_5) and lowest in without treated BRRI dhan29 (V_1T_0) but K content in straw had highest (1.475%) in Heera 4 treated by T_4 (V_2T_4) and lowest in V_1T_0. NPK uptake in grain (75.38, 21.73 and 20.97 kg ha^{-1}, respectively) and straw (59.28, 14.66 and 117.50 kg ha^{-1}, respectively) were found in

V_2T_4 and lowest in V_1T_0. Similarly, V_2T_4 recorded the highest NPK content in postharvest soil (0.0960 ppm, 34.70 ppm and 0.0467 meq 100 g^{-1}, respectively) while V_1T_0 showed the lowest NPK content in postharvest soil.

5.2 CONCLUSION

From the present study finally it can be concluded that the organic (cowdung) and inorganic (Urea) fertilizer had varying degree of integrated effects on BRRI dhan29 and Heera 4. Between the varieties, Heera 4 had highly signifciant than BRRI dhan29 while application of 3.84 t cowdung ha^{-1} (30% N) + 196 kg Urea ha^{-1} (70%N) as a source of nitrogen performed the best compare to other treatments of the study in aspect of yield and yield contributing and nutrient management characters of *Boro* rice. There combinations (Heera 4 × 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1}) also showed superior result among the whole characters of the study. So, it could concluded that the cultivar Heera 4 and 3.84 t ha^{-1} cowdung + 196 kg ha^{-1} Urea singly or their interaction would be the suitable variety and optimum organic (cowdung) + inorganic (Urea) N, respectively for getting the higher production under the wetland condition. The above result also suggested that the application of organic fertilizer as cowdung can be reduced by 30% use of inorganic fertilizer which also reduced the soil pollution by chemical fertilizer and improve soil physical properties. Cowdung release nutrient at slow rate that can help to uptake nutrient for plant longer time. So, I strongly recommended that the farmer of our country can use cowdung as a source of N for increasing the rice production with higher nutrient capability that can improve soil physical properties as well. Considering the above observation of the present study, the following recommendation may be suggested:

i. Further study may be needed to ensuring the performance of Heera 4 and 3.84 t cowdung ha^{-1} + 196 kg Urea ha^{-1} as singly or their interaction in wetland condition for adaptability;
ii. More varieties or higher levels (100%+) of organic + inorganic fertilizer as a source of N may be needed to include for further study to make sure the performance of genotype and fertilizer for rice production in wetland conditon of Bangladesh.
iii. Such study is also needed in different agro–ecological zones (AEZ) of Bangladesh for regional adaptability and other performances;

REFERENCES

REFERENCES

Abbasi, H.R.A., Esfahan, M., Rabiei, B. and Kavousi, M. (2007). Effect of nitrogen fertilizing management on rice (cv. Khazar) yield and its components in a paddy soil of Guilan Province. *Journal of Science the Agricultural Natural Research*. **104**: 293–307.

Abodolereza, A. and Racionzer, P. (2009). Food Outlook: Global Market Analysis (December 2009). pp. 23–27.

Abou–Khalifa, A.A.B. 2012. Evaluation of some rice varieties under different nitrogen levels. *Advances in Applied Science Research*. **3**(2): 1144–1149.

Abro, M.B., Abbasi, Z.A., Maitlo, S.A., Maitlo, N.D. Bhatti, A.G. and Panhwar, N.A. (2002). Growth response of rice variety DR–82 as influenced by green manure (Dhaincha). *Pakistan Journal of Applied Science*. **27**(7):781–782.

Akinwale, M.G., Gregorio, G., Nwilene, F., Akinyele, B.O., Ogunbayo, S.A., Odiyi, A.C. and Shittu, A. (2011). Comparative performance of lowland hybrids and inbred rice varieties in Nigeria. *International Journal of Plant Breeding and Genetics*. **5**(3): 224–234.

Akram, M., Rehman, A., Ahmad, M. and Cheema, A.A. (2007). Evaluation of rice hybrids for yield and yield components in three different environments. *Journal of Animal and Plant Sciences*. **17**(3–4): 70–75.

Akter, S. (2011). Effects of nitrogen supplied from manures and fertilizers on the growth and yield of BRRI dhan29. MS thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh. pp.

Al Fakhrul Islam, M.M., Khan, M.A., Fazle Bari, A.S.M., Hosain, M.T. and Sabikunnaher. (2013). Effect of fertilizer and manure on the growth, yield and grain nutrient concentration of *Boro* rice (*Oryza sativa* L.) under different water management practices. *The Agriculturists*. **11**(2): 44–51.

Alam, M.M., Hasanuzzaman, M. and Nahar, K. (2009). Growth pattern of three high yielding rice varieties under different phosphorus levels. *Advances in Biological Research*. **3**(3–4): 110–116.

Alam, M.S. (2012). A research publication on “tech and productivity in rice sector”. Published in the Daily Star on February 9 (Thursday), 2012 (online available at: http://archive.thedailystar.net/newDesign/news–details.php?nid=221607).

Alam, M.S., Baki, M.A., Sultana, M.S., Ali, K.J. and Islam, M.S. (2012). Effect of variety, spacing and number of seedlings per hill on the yield potentials of transplant aman rice. *International Journal of Agricultrue and Agricultural Research.* **2**(12): 10–15.

Ali, A., Khalifa, A., Elkhoby, W. and Okasha, E.M. (2014). Effect of sowing dates and seed rates on some rice cultivars. *Afrrical Journal of Agriculture Research.* **9**(2): 196–201.

Alim, M.A. (2012). Effect of organic and inorganic sources and doses of nitrogen fertilizer on the yield of *Boro* rice. *Journal of Environmental Science and Natural Resources*. **5**(1): 273–282.

Amin, M.R., Hamid, A., Choudhury, R.U., Raquibullah, S.M. and Asaduzzaman M. (2006). Nitrogen fertilizer effect on tillering, dry matter production and yield of traditional varieties of rice. *International Journal of Sustainable Crop Prodduction.* **1**(1): 17–20.

Anonymous. (1991). Adhunik Dhaner Chash (Modem Rice Cultivation). 6th Edn. Booklet No 5 Bangladesh Rice Res. Inst. Joydebpur, Gazipur.

Anonymous. (2003). Agricultural technologies for rural poverty alleviation. Aug. Report no. 2 and 3. M.Z. Abedin and M.R.L. Bool, (eds.). Flood-prone Rice Farming Systems Series. Technical Advisory Notes. IRRI. [www.irri.org/publications /techbulletin/pdfs/technicaladvisorynotes.pdf].

Anonymous. (2004). Workshop on testing of rice knowledge bank. The Bangladesh Observer. [Online available at: www.bangladeshobserveronline.com/new/ 2004/07/18/national.htm].

Anonymous. (1998a). Annual Report for 1997–98. Technical report on hybrid rice Aalok 6201. Agronomy Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh. pp. 1–16.

Anonymous. (1998b). Technical report on hybrid rice Aalok 6201. Department of Soil Science, BAU, Mymensingh. pp. 1–7.

Ashrafuzzaman, M., M.R. Islam, M.R. Ismail, S.M. Shahidullah and M.M. Hanafi. (2009). Evaluation of six aromatic rice varieties for yield and yield contributing characters. *International Jorunal of Agricultural Biology*. **11**: 616–620.

Awal, M.A., Habib, A.K.M.A. and Hossain, M.A. (2007). A study on comparative performances of hybrid and conventional rice varieties in aman season. *Journal of Agriculture and Rural Development*. **5**(1&2): 13–16.

Awan, T.H., Ali R.I., Manzoor, Z., Ahmad M. and Akhtar M. (2011). Effect of different nitrogen levels and row spacing on the performance of newly evolved medium grain rice cultivar, ksk–133. *Animal and Plant Sciences.* **21**(2): 231–234.

Azarpour, E., Moraditochaee, M. and Bozorgi, H.R. (2014). Effect of nitrogen fertilizer management on growth analysis of rice cultivars. *International Journal of Biosciences*. **4**(5): 35–47.

Aziz, M.A. (2008). Effect of cowdung on the growth and yield of hybrid and HYV rice. MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 1–12.

Bakul, M.R.A., Akter, M.S., Islam, M.N., Chowdhury, M.M.A.A. and Amin, M.H.A. (2009). Water stress effect on morphological characters and yield attributes in some mutants T–aman rice lines. *Bangladesh Research Publication Jorunal*. **3**(2): 934–944.

BARC (Bangladesh Agricultural Research Council). (2012). Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council, Dhaka. pp. 80, 248, 256.

Baset Mia, M.A. and Shamsuddin, Z.H. (2011). Physio–morphological appraisal of aromatic fine rice (*Oryza sativa* L.) in relation to yield potential. *International Journal of Botany*. **7**(3): 223–229.

Basu, S.K., Talukder, N.M., Nahar, N.N., Rahman, M.M. and Prodhan, M.Y. (2012). Evaluation of nutritional status of grain of *Boro* rice (Cv. BRRI Dhan28) applying chemical fertilizers and organic manure cultivated under system of rice intensification. *Bangladesh Journal of Progress Science & Technology*. **10**: 053–056.

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

BBS (Bangladesh Bureau of Statistics) (2012). Agriculture crop cutting. Estimation of *Boro* rice 2011–2012. Government of the People's Republic of Bangladesh. Web site: http://www. bbs.gov.bd.

Bekere, W., Urayama, H. and Togashi, M. (2014). Growth Pattern and Yield of NERICA 1 and NERICA 4 rice varieties as a function of split nitrogen application at Tsukuba, East Japan. *Journal of Agriculture, Forestry and Fisheries.* **3**(1): 24–29.

Brahmacharii, K., Mondal, N.S., Pal, S. and Sarkar, B. (2005). Effect of organic and inorganic sources of nutrients of yield quality of crops under jute (*Corchorus olitorius*) rice (*Oryza sativa* L.) rape seed (*Brassica canpestris*) sequence. *Journal of Interacademicia*. **9**(l): 1622.

Bremner, J.M. and Mulvaney, C.S. (1982). Nitrogen–Total. In methods of soil Analysis Part 2. Edited by A.L. Page, R.H. Miller and D.R. Keeney. pp. 595–624. American Society for Agronomy, Inc. and Soil Science Society, American Inc., Madison, Wisconsin.

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

De Datta, S.K. (1978). Fertilizer management for efficient use in wetland rice soils. Soils and Rice , , Int. Rice Res. Inst., Los Banos, Phillippines, 671–679.

Dey, B.R. (2012). Effects of single and split application of p, k and s on the growth and yield of brri dhan29. MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Dwivedi, A.P., Dixit, R.S. and Singh, G..R. (2006). Effect of potassium levels on growth, yield and quality of hybrid rice, Department of Agronomy, Narendra Dev University *of* Agriculture and Technology, Uttar Parsesh, India. **43**(1.): 64–66.

Fageria, N.K., Moreira, A. and Coelho, A.M. (2011). Yield and yield components of upland rice as influenced by nitrogen sources. *Journal of Plant Nutrition*. **34**: 361–370

Fakhrul Islam, Md Asaduzzaman Khan, ASM Fazle Bari, MT Hosain, Sabikunnaher (2013). Effect of Fertilizer and Manure on the Growth, Yield and Grain Nutrient Concentration of *Boro* Rice (*Oryza sativa* L.) under Different Water Management Practices. *The Agriculturists*. **11**: 44–51

Garba, A.A., Mahmoud, B.A., Adamu, Y. and Ibrahim, U. (2013). Effect of variety, seed rate and row spacing on the growth and yield of rice in Bauchi, Nigeria. *African Journal of Food, Agriculture, Nutrition & Development*. **13**(4): 8155.

George, S.P., Bastian, D., Radhakrishan, N.V. and Aipe, K.C. (2005). Evaluation of aromatic rice varieties in Wayanad, Kerala. *Journal of Tropical Agriculture*. **43**(1–2): 67–69.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research. 2nd ed. John Wiley and Sons. New York. p 64.

Hach, C.V. and Nam, N.T.H. (2006). Esponses of some promising high–yielding rice varieties to nitrogen fertilizer. Omonrice **14**: 78–91.

Haque, A. (2013). Integrated use of manures and fertilizers for maximizing the growth and yield of *Boro* rice (cv. BRRI dhan28). MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh. pp. 1–68

Haque, M.M., Pramanik, H.R., Biswas, J.K., Iftekharuddaula, K.M. and Hasanuzzaman, M. (2015). Comparative performance of hybrid and elite inbred rice varieties with respect to their source–sink relationship. *The Scientific World Journal*. **2015**: 1–11.

Hasan, M.N. (2014). Effect of usg with cowdung on nitrogen use efficiency of rice and nitrogen dynamics in porewater. MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh. pp. 1–66

Hasanuzzaman, M., Ali, M.H., Karim, M.F., Masum, S.M. and Mahmud, J.A. (2012). Response of hybrid rice to different levels of nitrogen and phosphorus. *International Research Journal of Applied and Basic Sciences*. **3**(12): 2522–2528.

Hoshain, S. (2010). Effect of cowdung and nitrogen (urea) on growth, yield and yield contributing characters of aromatic rice cv. BRRI dhan50. MS Thesis. Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 4–20.

Hossaen, M.A., Shamsuddoha, A.T.M., Paul, A.K., Bhuiyan, M.S.I. and Zobaer, A.S.M. (2011). Efficacy of different organic manures and inorganic fertilizer on the yield and yield attributes of *Boro* rice. *The Agriculturists*. **9**(1&2): 117–125.

Hossain, M.B., Islam, M.O. and Hasanuzzaman, M. (2008). Influence of different nitrogen levels on the performance of four aromatic rice cultivars. *International Journal of Agricultural Biology*. **10**: 693696.

Hossain, M.F., Bhuiya, M.S.U. and Ahmed, M. (2005). Morphological and agronomic attributes of some local and modern aromatic rice varieties of Bangladesh. *Asian Journal of Plant Science*. **4**(6): 664–666.

Hossain, M.I., Uddin, M.N., Islam, M.S., Hossain, M.K. and Khan, M.A.H. (2010). Effects of manures and fertilizer on nutrient content and uptake by BRRIdhan 29. *Journal of Agroforestry and Environment*. **3**(2): 65–67.

Hossain, M.M., Sultana, F. and Rahman, A.H.M.A. (2014a). A comparative screening of hybrid, modern varieties and local rice cultivar for brown leaf spot disease susceptibility and yield performance. *Archives of Phytopathology and Plant Protection.* **47**(7): 795–802.

Hossain, M.S, Mosaddeque, H.Q.M, Alam, M.A., Moniruzzaman, S.M. and Ahmed, I. (2007a). Effect of different organic manures and nitrogen levels on yield and yield attributes of T. *aman* rice. *International Journal of Sustainable Agriculture and Technology*. **3**(1): 21–26.

Hossain, M.S., Sobahan, M.A., Alam, M.A., Ali, M.S. and Bhuiyan, M.S.H. (2007b). Effect of organic manures and nitrogen levels on plant height and number of tillers hill^{-1} of T. *aman* rice. *Journal of Subtropical Agricultural Research and Development.* **5**(3): 291–296.

Hossain, M.T., Ahmed, K.U., Haque, M.M., Islam, M.M., Bari, A.S.M.F. and Mahmud, J.A. (2014b). Performance of hybrid rice (*Oryza sativa* l.) varieties at different transplanting dates in Aus season. *Applied Scientific Report.* **1**(1): 1–4.

Hossaina, M.M., Sultana, F. and Rahmana, A.H.M.A. (2013). A comparative screening of hybrid, modern varieties and local rice cultivar for brown leaf spot disease susceptibility and yield performance. *Archives of Phytopathology and Plant Protection*. **47**(7): 795–802.

IRRI (International Rice Research Institute) (2010). http:// www.irri.org/about rice/ rice facts/what is rice?

Islam, M.R., Akther, M. Afroz, H. and Bilkis, S. (2013). Effect of nitrogen from organic and inorganic sources on the yield and nitrogen use efficiency of BRRI dhan28. *Bangladesh Journal of Progressive Science and Technology*. **11**(2): 179–184.

Islam, M.R., Rashid, M.B., Siddique, A.B. and Afroz, H. (2014). Integrated effects of manures and fertilizers on the yield and nutrient uptake by BRRI dhan49. *Journal of Bangladesh Agricultural University*. **12**(1): 67–72.

Islam, M.S., Akhter, M.M., Rahman, M.Sq., Banu, M.B. and Khalequzzaman, K.M. (2008). Effect of nitrogen and number of seedlings per hill on the yield and yield components of T. *aman* rice (BRRI dhan33). *International Journal of Sustainable Crop Production.* **3**(3): 61–65.

Islam, M.S., Hasanuzzaman, M., Rokonuzzaman, M. and Nahar, K. (2009b). Effect of split application of nitrogen fertilizer on morpho–physiological parameters of rice genotypes. *International Journal of Plant production.* **3**(1): 51–62.

Islam, M.S., Peng, S., Visperas, R.M., Bhuiya, M.S.U., Hossain, S.M.A. and Julfiqur, A.W. (2010). Comparative study on yield and yield attributes of hybrid, inbred, and npt rice genotypes in a tropical irrigated ecosystem. *Bangladesh Journal of Agricultural Research***.** **35**(2): 343–353.

Islam, M.S.H., Gomosta, A.R., Sarkar, A.R. and Hussain, M.M. (2009a). Evaluation of growth and yield of selected hybrid and inbred rice varieties grown in net–house during T. aman season. *Bangladesh Journal of Agricultural Research*. **34**(1): 67–73.

Islam, M.T. 2011. Effect of temperature on photosynthesis, yield attributes and yield of aromatic rice genotypes. *International Journal of Sustainable Crop Production.* **6**(1): 14–16.

Islam, M.Z., Baset Mia, M.A., Islam, M.R. and Akter, A. (2007). Effect of Different Saline Levels on Growth and Yield Attributes of Mutant Rice. *Journal of Soil Nature.* **1**(2): 18–22.

Islam, N., Kabir, M.Y., Adhikary, S.K. and Jahan, M.S. (2013). Yield performance of six local aromatic rice cultivars. *Journal of Agriculture and Veterinary Science.* **6**(3): 58–62.

Jackson, M.L. (1962). Soil Chemical Analysis. Prentice Hall. Inc. (Ed. Engle Wood, C.) N.J. USA: 46.

Jeng, T.L., Tseng, T.H., Wang, C.S., Chen, C.L. and Sung, J.M. (2009). Yield and grain uniformity in contrasting rice genotypes suitable for different growth environments. *Field Crops Research.* **99**: 59–66.

Jun, Q., Mei, Y.T., Feng, X., Zhang, Y.L. and Ping, L. (2011). Reduction of nitrogen fertilizer application under different crop rotation systems in paddy fields of Taihu Area. Zhongguo Shengtai Nongye *Xuebao / Chinese Journal of Eco Agriculture.* **19**(1): 24–31.

Kandil, A.A., El–Kalla, S.E., Badawi, A.T. and El–Shayb, O.M. (2010). Effect of hill spacing, nitrogen levels and harvest date on rice productivity and grain quality. *Crop Environmental.* **1**(1): 22–26.

Karim, M.R. (2011). Effect of nitrogen on growth, productivity and seed quality of long grain rice. MS Thesis, Dept. of Agronomy, BSMRAU, Salna, Gazipur.

Khan, T.N., Razzaq, A., Shahbaz, M., Ajmal, S., Ali, G.M. and Joyia, M.F. (2006). Performance of four varieties of fine rice for best yield and yield components under climatic conditions of Bahawalpur (Pakistan). *Journal of Agriculture and Social Science*. **2**(3): 187–188.

Khorshidi, Y.R., Ardakani, M.R., Ramezanpour, M.R., Khavazi, K. and Zargari, K. (2011). Response of yield and yield components of rice (*Oryza sativa* L.) to pseudomonas flouresence and azospirillum lipoferum under different nitrogen levels. *American–Eurasian Journal of Agriculture and Environmental Sciences*. **10**(3): 387–395.

Khushik, A.M., Lashari, M.I. and Memon, A. (2011). Performance of rice hybrid and other varieties in Sindh and Balochistan. *Jorunal of Agriculture Research*. **49**(4): 561–570.

Kumari, N., Singh, A.K., Pal, S.K. and Thakur, R. (2010). Effect of organic nutrient management on yield, nutrient uptake and nutrient balance sheet in scented rice (*Oryza sativa*). *Indian Journal of Agronomy*. **55**(3): 220–223.

Lawal, M.I. and Lawal, A.B. (2002). Influence of nitrogen rate and placement method on growth and yield of rice at kadawa, Nigeria. *Crop Research Hisar*. **23**(3): 403–411.

Liza, M.M.J., Islam, M.R., Jahiruddin, M., Hasan, M.M., Alam, M.A., Shamsuzzaman, S.M. and Samsuri, A.W. (2014). Residual effects of organic manures with different levels of chemical fertilizers on rice. *Life Science Journal* **.11**(12): 6–12.

Mahamud, J.A., Haque, M.M. and Hasanuzzaman, M. (2013). Growth, dry matter production and yield performance of transplanted aman rice varieties influenced by seedling densities per hill. *International Journal of Sustainable Agriculture.* **5**(1): 16–24.

Malik, T.H., Lal, S.B., Wani, N.R., Amin, D. and Wani, R.A. (2014). Effect of different levels of nitrogen on growth and yield attributes of different varieties of basmati rice (*Oryza sativa* L.). *International Journal of Scientific and Technology Research*. **3**(3): 444–448.

Mannan, M.A., Bhuiya, M.S.U., Akhan, M.I.M. and Rana, M.M. (2012). Influence of date of planting on the growth and yield of locally popular traditional aromatic rice varieties in *Boro* season. *Journal of Science Foundation*. **10**(1): 20–28.

Mannan, M.A., Bhuiya, M.S.U., Hossain, S.M.A. and Akhand, M.I.M. (2010). Nitrogen on yield and other plant characters of local T. *aman* rice, var. optimization of nitrogen rate for aromatic basmati rice (*Oriza sativa* L.) *Bangladesh Journal of Agricultural Research*. **35**(1): 157–165.

Manzoor, Z., Awan, T.H., Zahid, M.A. and Faiz, F.A. (2006). Response of rice crop (super basmati) to different nitrogen levels. *Journal of Animal and Plant Sciences*. **16**(1–2): 52–55.

Maqsood, M., Shehzad, M.A., Ali, S.N.A., and Iqbal, M. (2013). Rice cultures and nitrogen rate effects on yield and quality of rice (*Oryza sativa* L.). *Turkish Journal of Agriculture Forestry*. **37**: 665–673.

Mashkar, N.V and Thorat, S.T. (2005). Effect of nitrogen levels on NPK uptake and grain yield of scented rice varieties under Konkan condition. Nagpur, India. *Indian Jorunal of Soils Crops*. **15**(1): 206–209.

Masum, S.M., Ali, M.H. and Ullah, M.J. (2008). Growth and yield of two aman rice varieties as affected by seedling number hill^{-1} and urea super granules. *Journal of Agriculture Education and Technology***. 11**(1&2): 51–58.

Metwally, T.F., Gewaily, E.E. and Naeem, S.S. (2011). Nitrogen response curve and nitrogen use efficiency of Egyptian hybrid rice. *Journal of Agriculture Research Kafer El–Sheikh University*. **37**(1): 73

Miah, M.M.U. (1994). Prospects and problems of organic fanning in Bangladesh. Paperpresented at the workshop on Integrated Nutrient Management for Sustainable Agriculture. Soil Resource Division, Dhaka, June 26–28.

Mishra, P.K., Rajput, R.S., Tripathy, R.K. and Joshi, B.S. (2003). Effect of integrated nitrogen nourishment and growth regulators on yield attributes and grain yield of hybrid rice. *Annual Agricultural Research.* **24**(2): 411–415.

Mizan, R. (2010). Effect of nitrogen and plant spacing on the yield of boro rice cv. BRRI dhan45. MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh.

Mobasser HR, Delarestaghi MM, Khorgami A, Tari DB and Pourkalhor H (2007). Effect of planting density on agronomical characteristics of rice (*Oryza sativa* L.) varieties in North of Iran. *Pakistan Journal of Biological Science*. **10**(18): 3205–3209.

Mohaddesi, A., Abbasian, A., Bakhshipour, S. and Aminpanah, H. (2011). Effect of different levels of nitrogen and plant spacing on yield, yield components and physiological indices in high–yield rice (number 843). *American–Eurasian Journal of Agriculture and Environmental Science*. **10**(5): 893–900.

Mondal, M. and Swamy, S.N. (2003). Effect of time of N application on yield and yield attributes of rice (*Oryza sativa*) cultivars. *Environmental Ecology*. **21**: 411–413.

Muhammad, M., Babar, M.H. and Muhammad, T. (2005). Effect of nursery transplanting techniques and nitrogen levels of growth and yield of fine rice (Basmati–2000). *Pakistan Journal of Agricultural Science*. **42**(3/4): 21–24.

Naidu, G.J., Rao, K.T. and Rao, A.U. (2013). Performance of rice under sri as influenced by effect of graded nutrient levels and time of nitrogen application. *International Journal of Advanced Biological Research*. **3**(4): 572–575.

Naik, K.R. and Paryani, A.K. (2005). Response of rice hybrids to nitrogen and number of seedlings. *Crop Research (Hissar).* **29**(3) 379–381.

Ndaeyo, N.U., Iboko, K.U., Hary, 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. *Journal of Tropical Agriculture, Food, Environment and Extension.* **7**(3): 249–255.

Nori, H., Halim, R.A. and Ramlan, M.F. (2008). Effects of nitrogen fertilization management practice on the yield and straw nutritional quality of commercial rice varieties. *Malaysian Journal of Mathmatical Sciences*. **2**(2): 61–71.

Nyalemegbe, K., Oteng, J.W. and Asuming–Brempong, S. (2009). Integrated Organic–Inorganic Fertilizer Management for RiceProduction on the Vertisols of the Accra Plains of GhanaK. *West African Journal of Applied Ecology*. **16**: 23–32.

Oko, A.O., Ubi, B.E. and Efisue, A.A. (2012). A Comparative Study on Local and Newly Introduced Rice Varieties in Ebonyi State of Nigeria based on Selected Agronomic Characteristics. *International Journal of Agriculture and Forestry*. **2**(1): 11–17 (doi: 10.5923/j.ijaf.20120201.03.).

Olsen, S.R., Cole, C.U., Watanable, F.S. and Deun, L.A. (1954). Estiamtion of available P in soil extraction with sodium bicarbonate. U.S. Agril. Cir. pp: 929.

Panwar, C.S., Vishwakarma, S.K. and Verma, N. (2012). Comparative performance of different rice varieties in relation to growth and yield. *Bioinfolet*. **9**(4A): 631–632.

Parvez, M.S., Islam, M.R., Begum, M.R., Rahman. M.S. and Abedin Miah, M.J. (2008). Integrated use of manure and fertilizers for maximizing the yield of BRRI dhan30. *Journal of Bangladesh Society Agriculture Science and Technology*. **5**(1&2): 257–260.

Prasad, R., and De Datta, S.K (1979). Increasing fertilizer nitrogen efficiency in wetland rice. Nitrogen and Rice , Int. Rice Res. Inst., Los Banos, Phillippines. pp. 465–484.

Qian, H., Xiu, M.L., Rong, G.L., Zhang, L., Ren, Y.L., Lan, Y.H., Hua, J., Hong, S.C. and Quan, W.F. (2011). Effect of long–term located organic–inorganic fertilizer application on rice yield and soil fertility in red soil area of China. *Scientia Agricultura Sinica*. **44**: 516–523.

Rahman M.S. M.R. Islam, M.M. Rahman, and M.I. Hossain (2009). Effect of Cowdung, Poultry Manure and Urea on the Yield and Nutrient Uptake of BRRI Dhan29. *Bangladesh Research Publication Journal*. **2**(2): 552–558.

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 levels on growth and yield of BRRI dhan32. *Journal of Soil Nature*. **1**(2): 01–07.

Rahman, M.M., Sarker, M.N.H., Aktar, F.M.F. and Masood, M.M. (2005). Comparative yield performance of two high yielding rice varieties to different nitrogen levels. *Bangladesh Journal of Crop Science*. **16**(1): 73–78.

Raju, R.A. and Reddy, M.N. (2000). Sustaining of productivity in rice (Oryza sativa) rice sequential cropping pattern through integrated nutrient management in coastal ecosystem. *Indian Journal of Agronomy*. **45**(3): 447–452.

Rashid, M.M.U., Solaiman, A.R.M., Jahiruddin, M., Karim, A.J.M.S., Islam, M.S. and Nasim, A.S.B.M. (2011). Effect of Ureaitrogen, Cowdung, Poultry Manure and Urban Wastes on Yield and Yield Components of *Boro* Rice. *International Journal of Agriculture, Environment and Biotechnology*. **4**(1): 9–13.

Rashid, M.M.U., Solaiman, A.R.M., Jahiruddin, M., Karim, A.J.M.S., Islam, M.S. and Nasim, A.S.M. (2011). Effect of Ureaitrogen, Cowdung, Poultry Manure and Urban Wastes on Yield and Yield Components of *Boro* Rice. International *Journal of Agriculture, Environment and Biotechnology*. **4**(1): 9–13.

Razzaque, M.A., Haque, M.M., Khaliq, Q.A., Soliman, A.R.M. and Hamid, A. (2011). Effects of co2 and nitrogen levels on yield and yield attributes of rice cultivars. *Bangladesh Journal of Agricultural Research.* **36**(2): 213–221.

Razzaque, M.A., Talukder, N.M., Islam, M.S., Bhadra, A.K. and Dutta, R.K. (2009). The effect of salinity on morphological characteristics of seven rice (Oryza sativa) genotypes differing in salt tolerance. *Pakistan Journal of Biological Science*. **12**(5): 406–412.

Rifat–E–Mahbuba. (2013). Effect of urea super granule with cowdung on nitrogen use efficiency in rice cv. BRRI dhan28. MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh. pp. 1–53

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 Sciences Journal **11**(4): 122–126.

Russel, D.F. (1986). MSTAT–C package programme. Crop and Soil Science Department, Michigan State University, USA.

Saha, P.K. and Miah, M.A.M. (2009). Efficiency of IPNS–Based Chemical Fertilizer Application in Wet Land Rice. *Bangladesh Journal of Agricultural Research*. **34**(1): 5–13.

Saitoh, K., Kuroda, T. and Kumano, S. (2001). Effect of organic fertilization and pesticide application on growth and yield of field grown rice for 10 years. *Japanese Journal of Crop Science.* **70**(4): 530–540.

Salahuddin, K.M., Chowhdury, S.H., Munira, S., Islam, M.M. and Parvin, S. (2009). Response of nitrogen and plant spacing of transplanted *aman* rice. *Bangladesh Journal of Agricultural Research*. **34**(2): 279–285.

Salem, A.K.M., ElKhoby, W.M., Abou–Khalifa, A.B. and Ceesay, M. (2011). Effect of nitrogen fertilizer and seedling age on inbred and hybrid rice varieties. *American–Eurasian Journal of Agriculture and Environmental Sciences*. **11**(5): 640–646.

Saleque, M.A., Abedin, M.S., Bhuiyan, N.I., Zaman, S.K. and Panaullah, G.M. (2004). Longterm effect of inorganic and organic fertilizer sources on yield and nutrient accumulation of lowland rice. *Field Crops Research.* **86**: 53–65.

Sarkar, S.K. (2014). Effect of nutrient management on growth, yield and quality of aromatic fine rice. MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 1–119

Sarker, B.C., Zahan, M., Majumder, U.K., Islam, M.A. and Roy, B. (2013). Growth and yield potential of some local and high yielding *Boro* rice cultivars. *Journal of Agroforestry and Environment*. **7**(1): 107–110.

Shaha, U. (2014). Integrated use of cowdung and inorganic fertilizer on the performance of modern varieties of transplanted aman rice. MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 1–70.

Sharma, P., Abrol, V. and Kumar, R. (2012). Effect of water regimes and nitrogen levels on rice crop performance and nitrogen uptake. *Indian Journal of Soil Conservation*. **40**(2): 122–128.

Shiyam, J.O., Binang, W.B. and Ittah, M.A. (2014). Evaluation of growth and yield attributes of some lowland chinese hybrid rice (*Oryza sativa* L.) varieties in the Coastal Humid Forest Zone of Nigeria. *Journal of Agriculture and Veterinary Science*. **7**(2): 70–73.

Sidhu, M.S., Sikka, R. and Singh, T. (2004). Performance of transplanted Basmati rice in different cropping systems as affected by N application. *International Rice Research Notes*. **29**(1): 63–65.

Singh, R.P., Yadav, P.K. Singh, R.K., Singh, S.N., Bisen, M.K. and Singh, J. (2006). Effect of chemical fertilizer, FYM and biofertilizer on performance of rice and soil properties. *Crop Research*. **32**: 283–285.

Singh, S. and Shivay, Y.S. (2003). Coating of prilled urea with eco–friendly neem (*Azadirachta indica* A. Juss). *Acta Agroninica, Hungarica*. **51**(1) 53–59.

Sohel, M.A.T., Siddique, M.A.B., Asaduzzaman, M., Alam, M.N. and Karim, M.M. (2009). Varietal performance of transplant aman rice under differnt hill densities. *Bangladesh Journal of Agricultural Research.* **34**(1): 33–39.

Sokoto, M.B. and Muhammad, A. (2014). Response of rice varieties to water stress in Sokoto, Sudan Savannah, Nigeria. *Journal of Biosciences and Medicines*. **2**: 68–74.

Sritharan, N. and Vijayalakshmi, C. (2012). Physiological basis of rice genotypes under aerobic condition. *Plant Archives.* **12**(1): 209–214.

Subhendu, M., Salamy. S.N. and Mandal. S. (2003). Effect of time on nitrogen application on yield and yield attributes of rice (*Oryza saliva* L.) cultivars. *Environmental Ecology*. **21**(2): 411–413.

Tasnin, M.N. (2012). Yield performance of hyv rice cv. brri dhan51 during aman season under integrated nitrogen management. MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 1–57.

UAE/FAO. (2012). International exhibition to promote rice import & export. November 19th, 20th & 21st 2012, Dubai, UAE (online available at: http://www.riceexhibition.com/market_info.php)

Uddin, M.J., Ahmed, S., Harun–or–Rashid, M., Hasan, M.A. and Asaduzzaman, M. (2011). Effect of spacing on the yield and yield attributes of transplanted aman rice cultivars in medium lowland ecosystem of Bangladesh. *Journal of Agriculture Research*. **49**(4): 465–476.

Uddin, M.J., M.M., Hasan, S. Ahmed, and M.M. Hasan (2010). Effect of spacing on morpho–physilogical response of different. Aman rice cultivars under coastal high land ecosystem. *Indian Journal of Agricultural Research*. **44**(4): 251–258.

Uddin, S., Sarkar, M.A.R. and Rahman, M.M. (2013). Effect of nitrogen and potassium on yield of dry direct seeded rice cv. NERICA 1 in aus season. *International Journal of Agronomy and Plant Production*. **4**(1): 69–75.

Usman, M., Ullah, E., Warriach, E.A. Muhammad, F. and Liaqat, A. (2003). Effect of organic and inorganic manures on growth and yield of rice variety “Basmati–2000”. *International Journal of Agricultural Biology*. **5**(4): 481–483.

Vanaja, M. and Raju, A.S. 2002. Integrated nutrient management performance in rice crop. *Annals Agricultural Research*. **23**(1): 51–56.

Wiangsamut, B.F., Umnat, P., Koolpluksee, M. and Kassakul, W. (2015). Effects of number of seedlings on growth, yield, cost and benefit of 2 rice genotypes in transplanted fields. *Journal of Agricultural Technology*. **11**(2): 373–389.

Wirnas, D., Mubarrozzah, R.H., Noviarini, M., Marwiyah, S., Trikoesoemaningtyas, Aswidinnoor, H. andjahjo, S.H. (2015). Contribution of genetic x temperature interaction to performance and variance of rice yield in Indonesia. *International Journal of Agronomy and Agricultural Research (IJAAR)*. **6**(4): 112–119.

Wopereis, M.C.S., Defoer, T., Idinoba, F., Diack, S. and Marie–Josèphe Dugué, (2009). Technical Manual “Curriculum for Participatory Learning and Action Research (PLAR) for Integrated Rice Management (IRM) in Inland Valleys of Sub–Saharan Africa”. Online available at: http://www.africarice.org/publications/PLAR/techmanual/foreword.pdf

Yaduvanshi, N.P.P. 2003. Substitution of inorganic fertilizers by organic manure and the effect of soil fertility in a rice wheat rotation on reclaimed sodic soil. *Indian Jorunal of Agricultural Science*. **140**(2): 161–168.

Yao, F., Huang, I., Cui, K., Nie, L., Xiang, I, Liu, X., Wu, W., Chen, M. and Peng, S. (2012). Agronomic performance of high–yielding rice variety grown under alternate wetting and drying irrigation. *Field Crops Research*. **126**: 16–22.

Yaqub, M., Mahmood, T., Akhtar, M. Iqbal, M.M. and Ali, S. (2010). Induction of mungbean as a grain legume in the annual rice–wheat double cropping system. *Pakistan Journal of Botany*. **42**(5): 3125–3135.

Yoseftabar, S. (2013). Effect nitrogen management on panicle structure and yield in rice (*Oryza sativa* L.). *International Journal of Agriculture and Crop Sciences*. **5**(11): 1224–1227.

Yoseftabar, S., Fallah, A. and Daneshian, J. (2012). Comparing of yield and yield components of hybrid rice (Grh1) in different application of nitrogen fertilizer. *International Journal of Biology*. **4**(4): 60–65.

Zhao L, Wu L, Wu M, Li Y (2011). Nutrient uptake and water use efficiency as affected by modified rice cultivation methods with irrigation. *Paddy Water Environment*. **9**: 25–32.

Zhaowen Mo, Shenggang Pan, Bingshun Luo, Hua Tian, Meiyang Duan, Qingshan Lin, Yijun Jiang and Xiangru Tang. (2013). Growth and yield response of five “super” rice (*Oryza sativa* L.) cultivars to nitrogen fertilizer rates. *Journal of Food, Agriculture and Environment*. **11**(3&4): 1257–1262.

APPENDICES

APPENDICES

Appendix I. Mean square for yield contributing characters of *Boro* rice at harvest

Source of variation	Degrees of freedom	Mean square for			
		Plant height (cm)	No. of effective tillers hill^{-1}	Length of panicle (cm)	No. of grains panicle^{-1}
Replication	2	329.218	65.363	88.362	1610.63
Factor A	1	60.528**	8.869**	128.205**	257.524**
Factor B	6	75.052**	20.121**	22.906**	1609.1**
AB	6	1.816*	0.145*	0.493*	8.566*
Error	26	1.944	0.397	0.434	11.009

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

Appendix II. Mean square for yield and yield attributes of *Boro* rice at harvest

Source of variation	Degrees of freedom	Mean square for				
		Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	9.413	1.019	1.155	3.11	6.742
Factor A	1	141.313**	1.062**	0.818**	3.744**	2.153ns
Factor B	6	15.616**	1.977**	1.481**	6.866**	4.913**
AB	6	1.443*	0.020*	0.065**	0.13**	0.582ns
Error	26	0.515	0.007	0.021	0.019	0.525

*, **= Significant at 5% and 1%, respectively level of probability and ns= non significant

Appendix III. Mean square for nutrient content (NPK) of grain and straw

Source of variation	Degrees of freedom	Mean square for					
		Nutrient content of grain (%)			Nutrient content straw (%)		
		N	P	K	N	P	K
Replication	2	0.006	0.001	0.001	0.002	0.001	0.021
Factor A	1	0.031**	0.002**	0.001ns	0.006**	0.001ns	0.017**
Factor B	6	0.044**	0.001**	0.002**	0.004**	0.002**	0.081**
AB	6	0.002**	0.001ns	0.001ns	0.001ns	0.001ns	0.001*
Error	26	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

*, **= Significant at 5% and 1%, respectively level of probability and ns= non significant

Appendix IV. Mean square for nutrient uptake (NPK) of grain and straw

Source of variation	Degrees of freedom	Mean square for					
		Nutrient uptake grain (kg ha^{-1})			Nutrient uptake straw (kg ha^{-1})		
		N	P	K	N	P	K
Replication	2	170.732	6.673	10.501	76.491	6.521	399.898
Factor A	1	445.831**	31.786**	26.747**	160.08**	8.687**	510.308**
Factor B	6	676.286**	35.654**	39.627**	162.191**	23.027**	1325.694**
AB	6	8.602**	0.291**	0.419**	3.807**	0.397**	9.163**
Error	26	1.373	0.106	0.03	0.536	0.046	1.814

**= Significant at 1% level of probability

Appendix V. Mean square for nutrient content (NPK) in postharvest soil

Source of variation	Degrees of freedom	Mean square for NPK content in postharvet soil		
		N (ppm)	P (ppm)	K (meq 100g^{-1})
Replication	2	0.001	4.535	0.001
Factor A	1	0.001**	28.735**	0.001**
Factor B	6	0.001**	111.824**	0.001**
AB	6	0.001**	0.512**	0.001**
Error	26	0.0001	0.049	0.0001

**= Significant at 1% level of probability

LIST OF PLATES

Plate no. 1. Seedbed Preparation

Plate no. 2. Initial soil sample collection from the experimental plot

Plate no. 3. Seedling Transplanting in the main field

Plate no. 4. Field view of experimental field at ripening stage

Plate no. 5. Harvesting of Paddy