VARIETAL PERFORMANCE OF BORO RICE UNDER INTEGRATED NUTRIENT MANAGEMENT

NAHID SULTANA

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

DECEMBER, 2016

VARIETAL PERFORMANCE OF BORO RICE UNDER INTEGRATED NUTRIENT MANAGEMENT

BY

NAHID SULTANA

REG. NO. : 15-06932

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

MASTER OF SCIENCE (MS)

IN

SOIL SCIENCE

SEMESTER: JULY-DECEMBER, 2016

Approved by:

Dr. Alok Kumar Paul
Professor
Supervisor

Dr. Mohammad MosharrafHossain
Professor
Co-Supervisor

Dr. MohammadMosharrafHossain
Professor
Chairman
Examination Committee

DEPARTMENT OF SOIL SCIENCE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **'Varietal Performance of Boro Rice under Integrated Nutrient Management'** submitted to the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in SOIL SCIENCE**, embodies the results of a piece of bonafide research work carried out by**NAHID SULTANA**, Registration No. **15-06932** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

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

Supervisor

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are due to the Omnipotent Allah, the Supreme Ruler of the universe who enables the author to complete this present piece of work. The author deems it a great pleasure to express her profound gratefulness to her respected parents, who entiled much hardship inspiring for prosecuting her studies, receiving proper education.

The author feels proud to express her heartiest sence of gratitude, sincere appreciation and immense indebtedness to her supervisor ***Dr. Alok Kumar Paul****, Professor, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka, for his continuous scholastic and intellectual guidance, cooperation, constructive criticism and suggestions in carrying out the research work and preparation of thesis, without his intense co-operation this work would not have been possible.*

The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her co-supervisor, ***Dr. MohammadMosharrafHossain****, Professor, Department of Soil Science, SAU, Dhaka, for his scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.*

The author expresses her sincere gratitude towards the sincerity of the Chairman ***Dr. Mohammad MosharrafHossain****,Professor, Departement of Soil Science, SAU, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses her heartfelt thanks to all the teachers of the Department of Soil Science, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.*

The author expresses her sincere appreciation to her colleages, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

The Author

VARIETAL PERFORMANCE OF BORO RICE UNDER INTEGRATED NUTRIENT MANAGEMENT

NAHID SULTANA

ABSTRACT

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the boro season from December 2015 to May 2016 to evaluate the yield performance of BRRI dhan63 and hybrid variety Heera 4 under Integrated Nutrient Management system and to identify the combined optimum level of vermicompost and nitrogenous fertilizer regarding better yield parameters of rice..The variety BRRI dhan63 and Heera 4 was used as the test crop.The experiment comprised of two factors as, Factor A: variety (2) BRRI dhan63 and Heera 4 and Factor B: combination of organic and inorganic fertilizer including five treatments *viz.* T_1= control, T_2 = 140 kg N ha^{-1} from urea, T_3=100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost, T_4 = 80 kg N ha^{-1} from Urea + 60 kg N ha^{-1} supplemented by vermicompost, T_5=Full organic (140 kg N ha^{-1} supplemented by vermicompost). Variety Heera 4 performed better than BRRI dhan63 regarding the plant height, panicle length,grain yield, straw yield and harvest index. In case of plant height, Heera4 was taller (87.47 cm) than BRRI dhan63 (83.53 cm). The longest paniclewas obtained fromHeera 4 (25.13cm) and lowest in BRRI dhan63 (23.53cm). Rest of the characters i.e no. of effective tillers plant^{-1}, no. of grains panicle^{-1}, and 1000 grain wt (g), showed insignificant result. From the studymore thousand-grain wt (26.87), highest yield of grain and straw (6.08 and 6.88 t ha^{-1} respectively) were obtained from the variety Heera 4 incomparison to BRRI dhan63 where BRRI dhan63 gave more effective tillers hill^{-1} (17.73) and highest number of grains panicle^{-1} (96.20). From the study treatment T_3 (100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost) showed the best performance at all the characters. The tallest plant (87.83 cm), longest panicle (24.83cm), more grains panicle^{-1} (104.20), highest weight of 1000 grain wt (26.50 g), highest yield of grain and straw (6.28 and 7.13 t ha^{-1} respectively) and highest HI (46.98%) were recorded in T_3 where above all characters were lowest in T_1 (control). The combinations (Heera 4 x 100 kg N ha^{-1}from urea x 40 kg N ha^{-1} supplemented by vermicompost) showed superior result among the whole characters of the study. So, it could be concluded that the cultivar Heera 4 applied with urea and vermicompost would be the suitable variety and optimum organic (vermicompost) + inorganic (urea) N combination, for getting the higher production. The above results also suggested that the application of organic fertilizer as vermicompost can reduce by 30% use of inorganic fertilizer and also reduce the soil pollution by chemical fertilizer and improve soil physical properties.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal crop of the poaceae family and a staple food that is widely consumed all over the world irrespective of race, religion and political association (Ohajianya and Onyenweaku, 2002). It is the most important food crop and a major food grain for more than one third of the world population and 50% of the third world population (Zhao *et al.*, 2011). 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). In Bangladesh, rice contributes 87.29%of the total grain production and covers 61% of the total calorie intake of the people of the country (MoA, 2009). 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). Bangladesh is the 5th largest country of the world in respect to rice cultivation (BBS, 2013),where about 82% of the total cultivable area is used for rice cultivation (Alam, 2012).Bangladesh has produced around 34.449 million tons of rice, basis milled, in FY 2013-14 (July-June), up about 2.7% from around 33.833 million tons produced in FY 2012-13, according to provisional official estimates from the Department of Agriculture Extension.In case of boro rice, it covers the area of 11780 (41.37% of total rice cultivable area) T acre (local 193 + HYV 9965 + HYB 1622 T acre) with a 1.86 million tons of production (55.52%) havingthe average yield per acreis about 1175 kg during FY 2011-12 (BBS, 2013).According to the latest estimation made by BBS, in 2016, among the three, seasonal rice boro rice covers 480 million hectare area of land and production was 1920 million metric tons.

The overall population of our country is increased by two million year^{-1} and may grow by additional 30 million in next 18 years. Therefore, it will require around 27.25 million ton rice by the year 2020 (BRRI, 2011). Throughout that time total rice cultivation area will also decrease to 10.27 million hectares. Therefore, rice yield should be increased by 53.33% for the increased growth of population (Mahamud *et al.*, 2013). But, total cultivable land is shrinking day by day. About 210 hectares of cultivable lands are decreasing every year because of industrialization, urbanization and road construction purposes. Increased food deficit has also been an alarming problem in Bangladesh due to excessive growth of population and lower yield of crops per unit area. Low yield is also experienced due to the use of local varieties. So, it is the time to think now to solve the food deficit problem of Bangladesh. As,it has a little scope of expanding horizontal area of rice cultivation, so attempts should be taken to maximize the yield per unit area. But, the rice production potential depends on several factors like variety, application of fertilizer, methods, time of sowing, seed rate etc. Among these, selection of a better variety regarding the local condition of the cultivable area and proper uses of fertilizer are the most significant factors for increasing the rice yield.

Reduction of soil fertility is a key constriction for crop production in our country. Most of the cultivable soils have below 1.5% organic matter content while conversely the rate of adding of new organic matter is extremely low. Experiments from different agro-ecological zones (AEZ)show that organic matter content has decreased by 15 to 30% in the last 20 years (Miah, 1994).Constant use of some inorganic fertilizer (mainly urea) deteriorates important soil properties and nutrient imbalance is caused which ultimately causing microbial deficiency (Rahman *et al,* 2009). Moreover, inorganic fertilizers cause soil and water pollution which makes our environment difficult to live in while organic matter plays a crucial role to develop the physical, chemical and biological properties of soil.

Nitrogen is the most important elements in increasing rice yield. It is required in large amount and limits grain yield when in short supply (Kirk, 2000). Nitrogen fertilizer plays an important role regarding growth and yield of rice (Prasertsak and Fukai, 1997). Physiological basis of variation in the yield of rice is due to grain filling duration and grain growth (Jones *et al.*, 1979 and Sadeque, 1985). Unlike phosphate and potassium fertilizers, which normally require a single application, urea needs to be applied several times during the growing season. In urea the loss of N is more because of volatilization and leaching, but in case of vermicompost such loss is absent.

Vermicompost is rich source of macro- and micro-nutrients, vitamins, enzymes, antibodies; growth hormones and immobilized microflora (Bhawalker, 1991).They have greatly increased surface areas, providing more micro sites for microbial decomposing organisms, and strong adsorption and retention of nutrients.Vermicompost also stimulate plant growth and help in preventing plant diseases (Szczech and Brzeski, 1994; Surekha and Rao, 2000), besides increasing the quality of produce (Singh and Rai, 1998).

In combination with integrated nutrient management, it looks up physical, chemical and biological properties of soil and helps to improve the productivity of soil. In addition, usage of organic fertilizers such as vermicompost is more economic than other chemical fertilizers to evade the attack of insects, pests and disease. So, using of organic fertilizer and chemical fertilizers combination would be relatively promising for the stability in production and it would also maintain better soil health by keeping the environment eco-friendly.

This detailed study was under taken with the following objectives:

i. To evaluate the yield performance of BRRI dhan63 and hybrid variety Heera 4 under Integrated Nutrient Management system;

ii. To identify the combined optimum level of vermicompost and nitrogenous fertilizer regarding better yield parameters of rice.

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh and other rice growing countries of the world, a good number of research has been carried out on the response of vermicompost on rice, but more experiments has been done in other cereals like wheat, maize, sorghum, vegetables likes tomato, cabbageridge gourd, oil crops like sunflower and other crops like potato. The farmers are advised to use vermicompost on respect of crops but information on the effect of vermicompost on grain yield as well as on soil properties are very limited in our country.

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 bororice 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 Bereratna. 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 Bereratna 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 tillers 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}.

Akter (2014) investigated the growth, yield and nutrient content of 15 bororice cultivars. BR 15, BRRI dhan29 and BRRI dhan28 were the three rice cultivars having high potentials for grain and straw production during boroseason. The highest yield was recorded 5.26 t ha^{-1}which is still very low compared to other rice growing countries of the world. Cholaboro and Sadaboro 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 BRRI dhan28 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 BRRI dhan28 produced higher grains panicle^{-1}and bolder grains resulted in higher grain yield over the local cultivars. The BRRI dhan28 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.

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.

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}.

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.

2.2 Importance of nitrogen in plant nutrition

Nitrogen has traditionally been considered one of the most important plant nutrients. However, there are many observations in respect of significance of nitrogen fertilizers.

Nitrogen is the important nutrient, representing two-third or more of total nutrients consumption in Asia (Barker and Robert, 1985). Accordingly, the plant must absorb larger amount of nitrogen to produce higher grain yield (Murayama, 1979).

Nitrogen gas comprises about 78 percent of the earth's atmosphere. Growing plants, animals and microbial populations need a continual source of N. It is an essential component of the proteins that build cell material and plant tissue. In addition, it is necessary for the function of other essential biochemical agents, including chlorophyll (which makes photosynthesis possible), many enzymes (which help organisms carry out biochemical processes and assimilate nutrients), and nucleic acids such as DNA, RNA (which are involved in reproduction) (Rao *et al.*, 1986).

Just as too little N can cause problems, too much N can also cause problems. These problems can extend to plants, humans, animals, and the environment. For example, in plants, too much N can produce weak stems in grain crops which lead to lodging (BRRI, 1978).

2.2.1 Importance of nitrogen in relation to rice production

Plant characters may be influenced by different levels and time of N fertilization. In a low-response cultivar the related uptake of nutrients at later growth stages may be related to serious mutual shading of the lower leaves.

Rice plant solely depends upon soil and applied source of N for the growth and yield. N plays a key role in supporting plant activity and increasing rice yield (BRRI, 1997 and Behera, 1998). The application of nitrogen fertilizer is essential to rice (Rao *et al*. 1980). So, it is clear that nitrogen fertilizer is crucially important for the maximization of rice yield.

Among the various nutrients, nitrogen has the strongest influence on the growth and yield of rice. Nitrogen is one of the major nutrients, which is required in adequate amount at early, mid tillering, panicle initiation and ripening stage for better grain development (Matsushima, 1976).

Adequate N fertilizer is required during the period immediately after transplanting of seedlings (Haque and Bhuiyan, 1980; De Datta, 1978). Nitrogen is the most important limiting nutrient in rice production and has heavy system losses when applied as inorganic sources in puddle field (Fillery *et al*., 1984).

Agronomic management is highly important for the better yield in rice production. Among the management practices, soil fertilization, particularly N management is the most important. Many workers at home and abroad investigated the response of N on rice growth for its successful production (Sarker and Ghatak, 1988; Park, 1987).

2.2.2 Nitrogenous effect on different growth parameters

2.2.2.1 Effect of nitrogen on plant height

Plant height depends on fertilizer application, especially N-fertilizer. Hossain (1992) reported that plant height increases significantly with increase of N-supply.

Awan *et al*., (1984) found that the higher dose of N application increased the plant height. Singh and Sharma (1987) also found the same result.

Thakur (1991b) obtained the highest plant height when 40%, 30% and 30% N were applied as basal dose, at maximum tillering and panicle initiation stages, respectively. Plant height increased with increasing rates of N application (Talukder. 1973).

The higher levels of N (120 kg ha^{-1}) significantly increased the plant height (Lenka and Behera.1967).

Islam (1978) observed that S application along with urea-N, increased plant height. Similar report was given by Haque and Khan (1981).

2.2.2.2 Effect of nitrogen on number of tillers

Tillering is one of the most important developmental stages of rice, since it has a decisive bearing on grain yield. Tiller number is strongly correlated with grain yield, depending on the cultivars and crop environment.

Nitrogen fertilizer increases plant height, tillering and vegetative growth, grain, straw yield and number of heads usually proportionally to the amount of nitrogen added (Leonard *et al*., 1976).

Number of tillers $hill^{-1}$ increases with increasing nitrogen rates. Nitrogen application increased the number of tillers $hill^{-1}$ (Jasim *et. al.*, 1984).

Tillering of rice is strongly influenced by fertilizer (De Datta, 1981).

Tanaka (1983) observed in a typical tropical rice cultivar that N-content higher than 2.0% in the culm promoted tillering and lower than 0.8% favored the death of tillers.

Finally tiller number $hill^{-1}$ was a linear function of the maximum tiller at booting stage (Khanam. 1994).

Lin and Lin (1983) raised two rice cultivars treated with 80, 120 and 160 kg N ha^{-1}. They found that high N levels resulted in the higher tiller number unit $area^{-1}$.

2.2.2.3 Effect of nitrogen on number of effective tillers

Nitrogen has a positive influence on the production of effective tillers $plant^{-1}$, yield and yield attributes (Jashim *et al*., 1984; BRRI, 1990).

Productive tillers $hill^{-1}$, grains $panicle^{-1}$, grain yield and straw yield significantly increased with increasing nitrogen fertilizer up to 150 kg N ha^{-1} but seed size had no significant difference between the nitrogen fertilizer rates (Rao *et al*., 1980).

Dixit and Singh (1979) observed that increased nitrogen application increased the productive tillers $plant^{-1}$.

2.2.2.4 Effect of nitrogen on panicle length

Singh and Sharma (1987) found that plant height, panicle number $hill^{-1}$, panicle length, straw yield and grain yield increased with increasing nitrogen doses.

Similar result was obtained by Kehinde and Fagade (1987). Dixit and Singh (1979) found that the increased nitrogen application increased the panicle length.

2.2.2.5Effect of nitrogen on number of filled grains

Plants also need nitrogen at the reproductive and ripening stages for optimum number of grains $panicle^{-1}$ and percentage of filled grains.

Maurya and Yadav (1987) observed that plant height, panicle number, filled grains $panicle^{-1}$ and grain yield increased with increasing nitrogen fertilizer doses. There was almost a liner response of grain yield to applied nitrogen.

Panicle number, grains panicle^{-1}, filled grains panicle^{-1}and grain yield were in linear response to nitrogen application.

Thakur (1991a) reported that total grains panicle^{-1} was the highest when 40%, 30% and 30% N was applied as basal, at maximum tillering and panicle initiation stages, respectively. Filled grains are an important yield contributing factor and it is highly affected by such factors as climate, soil, variety and nitrogen application (Yoshida and Parao, 1976).

2.2.2.6Effect of nitrogen on 1000-grain weight

Islam *et al*. (1990) reported that there was an increasing trend of 1000-grain weight with an increase in levels of nitrogen up to 80 kg ha^{-1}. A high nitrogen supply is reported to decrease the 1000 grain weight.

Awan *et al*. (1984) found that 1000-grain weight increased by the application of higher dose of nitrogen fertilizer.

Mondal *et al*. (1987) observed that increasing rates of N from 40 to 160 kg ha^{-1} increased the 1000-grain weight.

2.2.2.7Effect of nitrogen on grain and straw yield

Bhattacharya (1981) reported that the grain yield showed positive correlations with number of total grains panicle^{-1} and number of filled grains panicle^{-1}.

A considerable amount of research indicated the positive response of rice to nitrogen fertilization (Pandey and Sinha, 1971). In general, grain yield increases with nitrogen addition up to a certain level. Dixit and Singh (1979) showed that 80 kg N ha^{-1} increased rice yield from 2.18 t ha^{-1} to 4.19 t ha^{-1}.

Higher doses of N produced higher amount of straw and grain (Awan *et al*., 1984: Srivastava *et al*., 1987). Grain yield increases with increasing nitrogen fertilizer up to a level and then decreased (Singh and Pillai, 1991).N application time and number of splitting may have effect on grain yield.

Wagh and Throat (1988) reported that 50+30+10+10 kg N ha^{-1} applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering gave the highest yield. Number of splitting of urea-N may have effect on grain yield. Milam *et al*. (1986) observed that 3 split applications of urea yielded higher than pre-plant incorporation.

2.2.2.8Effect of nitrogen on biological yield and harvest index

Park (1987) observed that high N rates tended to increase biological yield and decrease harvest index.

Prasad (1981) found that the increasing rates of N application from 0 to 100 and 200 kg ha^{-1} increased biological yield but decreased harvest index.

Harvest index of rice tends to be lower as total dry matter production increases (Machlis *et al*., 1972).

The harvest index is the ratio of the yield of grain to the biological yield. The harvest index is about 0.3 for traditional tall varieties and 0.5 for improved short varieties (Yoshida, 1981). The harvest index for rice is negatively correlated with plant height (Tanaka *el al.* 1966).

2.2.2.9 Nitrogen fertilizer use efficiency

The term fertilizer efficiency or fertilizer use efficiency could be interpreted in various ways. Fertilizer use efficiency is the output of any crop per unit of fertilizer applied under a specific set of soil and climatic conditions (De Datta, 1978). Barbar (1977) defined fertilizer efficiency as the increase in yield of harvest portion of the crop per unit amount of fertilizer nutrient applied. But the profitable rate of fertilizer application was the maximization of grain yields at lower fertilizer rates.

Fertilizer N use efficiency in rice is therefore, the amount of grain yield per unit amount of added fertilizer nitrogen. De Datta (1981) reported that the highest yield of 6.0 ton ha^{-1} with efficiency of 16 kg rice kg^{-1} N was obtained at IRRI. The other approach to fertilizer efficiency was based on plant uptake the least amount of fertilizer needed to match plant use with maximum grain yield was the most efficient rate of fertilizer application (De Datta, 1978).

According to Yoshida (1975) efficiency of utilization of grain production in tropical wetland rice is about 50 kg ha^{-1} N absorbed.

2.2.3 Effect of vermicompost on different growth parameter of rice

Vermicompost is the product or process of composting using various worms, usually red wigglers, white worms, and other earthworms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast. The effects of vermicompost on different parameter of rice growth are as followes-

2.2.3.1 Plant growth

Murali and Setty (2000) while working on scented rice reported that vermicompost @ 5 t ha^{-1} resulted in significantly higher plant height, number of tillers $hill^{-1}$.

2.2.3.2 Yield and yield attributes

The increase in the yield of rice by increasing two times of the ears and grain per plant were reported with the application of vermicompost by Sitajanaki and Sreehari (1997).

Jadhav *et al.* (1997) reported highest dry matter production from 75 kg N ha^{-1} as urea plus 25 kg N ha^{-1} as vermicompost.

In scented rice, use of vermicompost @ 5 t ha^{-1} resulted in significantly higher number of panicles, number of grains $panicle^{-1}$, and 1000 seed weight over no vermicompost (Murali and Setty, 2000).

In scented rice application of vermicompost @ 5 t ha^{-1} resulted in significantly higher grain yield and straw yield over no vermicompost (Murali and Setty, 2000).

Prakash and Bhadoria (2002) reported that the treatments with vermicompost recorded highest grain yield of rice and imparted maximum tolerance to pathogen than any other nutrient sources.

Jadhav *et al.* (1997) reported that when 75 kg N ha^{-1} was applied from chemical fertilizers along with 25 kg N ha^{-1} from vermicompost, it resulted in significantly highest grain yield of rice.

Rani and Shrivastava (1997) found that in comparison with the N fertilizers alone, supplying 1/3rd or 1/4th of nitrogen from vermicompost increased grain yield of rice.

Ushakumari*et al.* (1999) reported that vermicompost as an organic source along with full recommended dose of inorganic fertilizers produced the highest yield than vermicompost + basal dose of NPK (25:8:25) and vermicompost + ¾ recommended dose of NPK.

Das *et al.* (2002) recorded highest paddy yield by application of 50% vermicompost + 50% chemical fertilizer and yield components increased more by integrated application of vermicompost and chemical fertilizers.

Sudha and Chandini (2002) reported highest grain and straw yield of rice by application of 100% NPK alone as compared to FYM or vermicompost or different integrated treatments.

Singh *et al*. (2003) observed that application of FYM, vermicompost or green manure reduced the rate of NPK fertilizers by 1/3rd without reducing rice or wheat yields.

2.2.3.3Nutrient uptake

Kale *et al.* (1992) and Sudhakar *et al.* (2002) have also reported that availability and uptake of nitrogen and phosphorus were more in vermicompost treated plots as compared to FYM treated plots.

A considerable increase in the uptake of major and secondary nutrients was observed in all vermicompost treatments and highest N uptake was recorded when 75% N through urea and 25% N through vermicompost was applied to rice crop (Jadhav *et al*., 1997).

Vanaja and Raju (2002) reported that highest total N uptake by rice crop at maturity was recorded with the application of poultry manure @ 2 t ha^{-1} + 75% of recommended dose of fertilizer N. 150% of NPK resulted in highest N, P, K uptake as compared to 50%, 100% RDF and 5 t ha^{-1} of vermicompost treatments.

2.2.3.4 Soil properties

Earthworms have been reported to increase the availability of the plant nutrients in soil (Krishnamoorthy and Vajranabbiah, 1986) and also production of plant growth regulators.

An increase in the density of microbes and nitrogen fixers due to vermicompost application has also been reported by Kale *et al.* (1992).

Venkatesh *et al.* (1997) reported that application of chemical fertilizers along with vermicompost resulted in greater availability of micronutrients. Similar results were also reported by Sudhakar *et al*. (2002).

Chowdappa *et al.* (1999) reported that the content of all major and micronutrients were slightly higher in all soil samples containing vermicompost than the normal samples.

Application of vermicompost alone or with chemical fertilizers decreased the bulk density, improved the soil porosity and maximum water holding capacity of the soil, but it increased the pH and organic carbon of the soil as reported by Maheswarappa *et al.* (1999).

Significant reduction in bulk density was recorded in treatments receiving vermicompost (Vasanthi and Kumaraswamy, 1999).

2.2.3.5 Residual effect on succeeding crop

Padalia (1980) reported that the residual effect of inorganic N levels in absence of organic manures were beneficial only during 1st year of residual study but compost not only increased the yields during the year of application but also had beneficial residual effects on succeeding rice crop even up to 5 years.

Harnowo (1998) found that residual effects of fertilizers on rice and its interaction effects with fertilizers application to soybean were significant for soybean seed yield.

Application of vermicompost @ 5 t ha^{-1} also increased the residual availability of NPK status of soil over control (Patil and Bhilare, 2000) in rice crop.

CHAPTER III

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 2015-16 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(vermicompost) 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 $23^0 77^{'}$N latitude and $90^0 33^{'}$E longitude at an altitude of 8.2 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 (Appendix I).

3.1.3 Experimental period

The experiment was conducted during the period from November 2015 to May 2016 in boro season. Transplanting, irrigation, split doses of N fertilizers and organic matter, application of pesticides, weeding were done during the period between January to April 2016. And harvesting of the crop was done on May 5, 2016.

3.1.4 Characteristics of soil

The soil of the experimental site belongs to the general soil type, Deep Red Brown Terrace Soils under Tejgaon Series. Top soils were silty-clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.8 and had organic matter 1.12%. The experimental area was flat having available irrigation and drainage system and above flood level. Initial soil samples from 0-15 cm depths were collected before transplanting the rice seedling. The collected soil was air-dried, grind and passed through 2 mm sieve and 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 ratio @ 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
Drainage	Well drained

Table 3.2 Physical and chemical properties of the initial soil sample

Characteristics	Value
% Sand (2.0-0.02mm)	18.60
% Silt (0.02-0.002mm)	45.40
% Clay(0.002mm)	36.00
Textural class	Silty-clay loam
pH	5.8
Bulk Density (g/cc)	1.45
Particle Density (g/cc)	2.52
Organic matter (%)	1.12
Total N (%)	0.06
Available P (mg kg^{-1})	19.23
Exchangeable K (meq/100g soil)	0.11
Available S (mg kg^{-1})	14.40

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

3.1.5 Climatic condition:

The experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from the month of November to February, the pre monsoon period or hot season from the month of March to April and the monsoon period from the month of May to October. The detailed meteorological data in respect of air temperature, relative humidity total rainfall and sunshine hour during the crop growing period were recorded from Weather Yard, Bangladesh Meteorological Department, Dhaka, presented in Appendix 2

3.2 Experimental materials

3.2.1 Variety

The following two high yielding varieties were selected for the experiment. V_1: BRRI dhan63 and V_2: Heera 4

The characters of following two varieties are as follows:

BRRI dhan63: BRRI dhan63, a fine quality high-yielding rice variety newly developed by Bangladesh Rice Research Institute (BRRI),officially released to farmers in 2013 for growing from the next boro season, reports UNB. ‘Sorubalam’ or BRRI dhan63 is thin and long like miniket rice and it has no aroma, BRRI sources said. The BRRI dhan63 was developed with making hybrid between BRRI dhan28 and Iranian Amul-3,produced around eight tonnes of rice in only145 to 148 days, which takes little time than BRRI dhan28 and BRRI dhan29 and shows somewhat more production than that of the traditional rice.BRRI dhan63 is fine and tall, can be harvested seven days earlier than any other hybrid rice and its production and quality is very good.

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 67th NSB in 2008 (17/9/2008) and 70th 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.

3.2.2 Treatment combination of the experiment

It has two factor experiment following five treatments including control treatment were included in the present experiment where the treatments were the combinations of organic (vermicompost) and inorganic (urea) fertilizer(s).

Factor 1:

V_1: BRRI dhan63 and V_2: Heera4

Factor 2:

T_1= control

T_2 = 140 kg N ha^{-1} from urea

T_3 = 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost

T_4 = 80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost

T_5 = Full organic (140 kg N ha^{-1} supplemented by vermicompost)

There were on the whole 10 (2×5) treatments combination as V_1T_1, V_1T_2, V_1T_3, V_1T_4, V_1T_5, V_2T_1, V_2T_2, V_2T_3, V_2T_4 and V_2T_5

3.3 Crop management

3.3.1 Seed collection

Healthy and vigorous seeds of BRRI dhan63 were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur. And Heera 4 were collected from the market.

3.3.2 Seed sprouting

On 15th December 2015, the selected seeds were immersed in water in a bucket 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 Seed sowing and raising seedlings

A piece of high land was selected in the Field 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 19th December 2015. 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 Design (RCBD)

Factor A: Variety -2

Factor B: (Organic + inorganic fertilizer treatments) -5

Treatment combinations: 10

Replication: 3

Total number of plots: 30

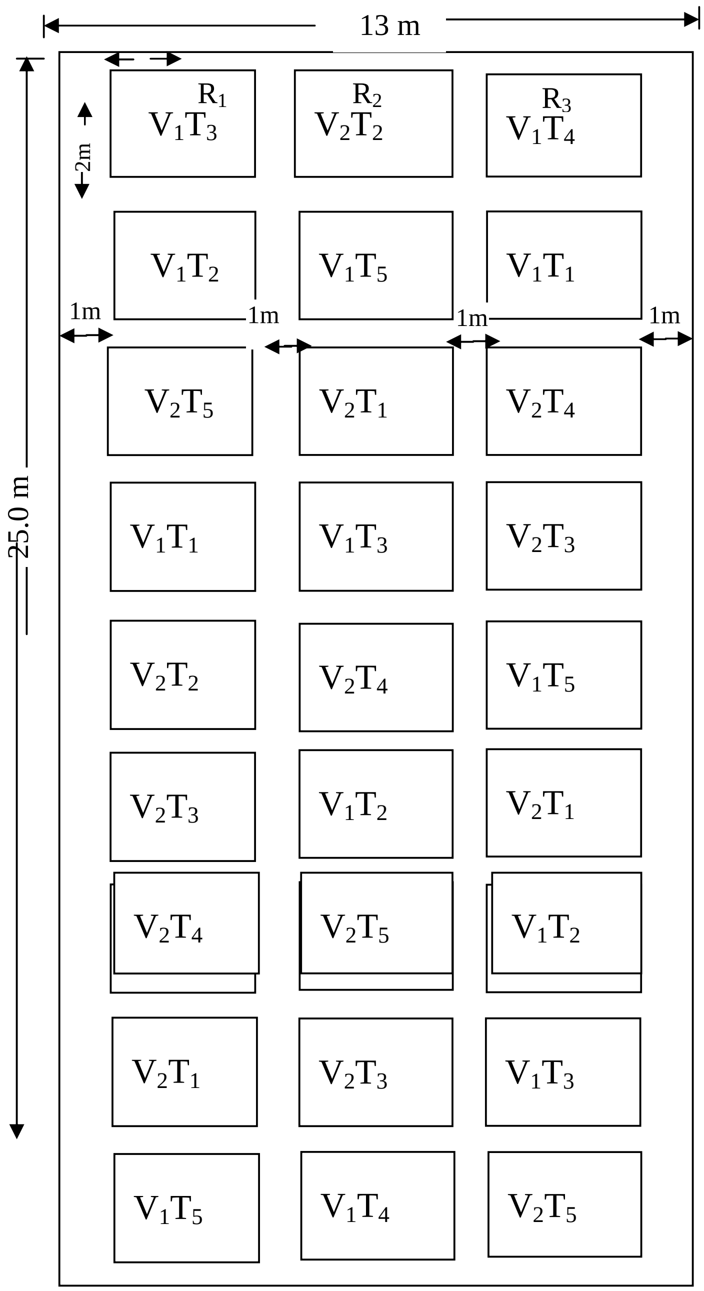
Plot size: 3 m × 2 m

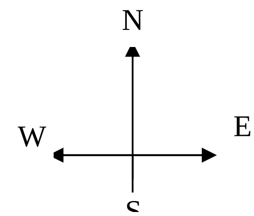
Block to block distance: 1 m

Plot to plot distance: 0.5 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 ten unit plots. The treatments wererandomly distributed to the unit plots in each block. The total number of plots was 30 (10×3). The unit plot size was 3 m × 2 m. Block to block distance was 2 m and plot to plot distance was 0.5 m. The layout of the experiment has been shown in Fig. 3.2.





Plot size: 3 m × 2 m

Plot spacing: 0.5 m

Between replication: 1.0 m

Factor A: Variety

i) BRRI dhan63= V_1

ii) Heera4= V_2

FactorB: organic-inorganic fertilizer combinations

i. T_1=control

ii. T_2=140 kg N/ha from urea

iii. T_3=100 kg N/ha from urea + 40 kg N/ha from vermicompost

iv. T_4=80 kg N/ha from urea + 60 kg N/ha from vermicompost

v. T_5=Full organic(140 kg N/ha from vermicompost

Fig.3.1. Layout of the experimental plot

3.5 Land preparation

The plot selected for conducting the experiment was opened on 12 January 2016 with the help of a tractor drawn disc plough and left exposed to the sun for a week. On January 21, 2016 the land was irrigated and harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. All weeds and other plant residues of previous crop were removed from the field. The field layout was made on January 22, 2016 as per treatment combination. Final land preparation was made by application of full required amounts of TSP, MoP, gypsum, ZnSO4 and vermicompost on 27 January 2016. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

3.6 Application of fertilizers

The fertilizers P, K, S and Zn in the form of TSP, MoP, Gypsum and zinc sulphate, respectively were applied @ 20 kg, 80 kg, 16 kg and 2.0 kg ha^{-1} (BRRI, 2015). Vermicompost 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 following chart showing the amount of studied vermicompost and urea levels as pertreatments regarding ha^{-1} and $plot^{-1}$:

Table 3.3:The amount of studied vermicompost and urea levels as per treatments regarding ha^{-1} and $plot^{-1}$

Treatments	Amount (ha^{-1})		Amount ($plot^{-1}$)	
	Urea (kg)	Vermicompost (kg)	Urea (g)	Vermicompost (kg)
T_1	0	0	0	0
T_2	304	0	182	0
T_3	217	2000	130	1.2
T_4	174	3000	104	1.8
T_5	0	6670	0	4

3.7 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

3.8 Transplanting of seedlings

On 28 January, 2016, 40 days 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 similar plant population density for each plot.

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 common weeds, during the early stage of crop establishment. Two hand weeding were done. 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 Irrigation

Proper irrigations were provided to the plots as and when necessary during the growing period of rice crop. It was allowed to dry out water for 2 to 4 days during tillering. 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 (*Scirphophagu sincertolus*) 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 March 02, 2016. Ripcord insecticide was applied on March 09 and March 20, 2016 @ 10 ml/10 liter of water for 5 decimal lands.

3.10Plant sampling at harvest

Plants from 1 m^2 were randomly selected from each plot to record the yield contributing characters. The selected hills were collected before harvesting.

3.11 Harvesting

The crop was harvested at full maturity on 5 May, 2016 when 80-90% of grains were turned into straw color. The harvested crop was bundled separately, properly tagged and cleaned plot-wise. Fresh weight of rice grain and straw were recorded plot-wise from $1m^2$ area. The grains were dried, cleaned and weighed for individual plot. Grain and straw yields were recorded separately plot-wise and expressed at t ha^{-1}on sun dry basis and adjusted to moisture percentage of 14%. Dry weight for both grain and straw were also recorded.

3.12 Data collection on yield components and yield

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 height of plant 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}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing tiller during harvesting Data on effective tillers hill^{-1} were counted from selected hills and average value was recorded.

3.12.3 Length of Panicle

The length of panicle was measured in cm with a meter scale from 10 selected plants and the average value was recorded as per plant.

3.12.4 Number of grains panicle^{-1}

The total numbers of grain was collected randomly from selected 10 plants of a plot by adding filled and unfilled grain and then average numbers of grains panicle^{-1} was recorded.

3.12.5 Weight of 1000-grain

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})

Straw obtained from each unit plot was sun dried and weighed carefully to record the final straw yield plot $^{-1}$ and finally converted to t ha^{-1}

3.12.8 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

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

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 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by Page *et al.*, 1982.

3.13.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_{4.}$ To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van

Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.13.3 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).

3.13.4 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 nm wave length by Spectrophotometer and available P was calculated with the help of standard curve.

3.13.5 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 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 IV

RESULTS AND DISCUSSION

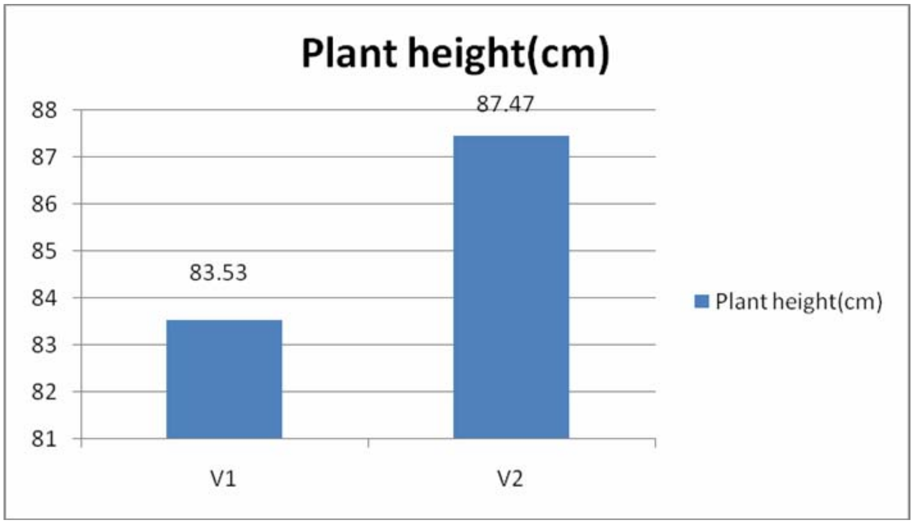
Results found from the present study concerning the effect of cultivar and various treatment combinations of organic (vermicompost) and inorganic (urea) fertilizers on growth, yield and yield attributes of bororice are presented and discussed in this chapter. The results have been presented and discussed under discrete heads and sub-heads as follows:

4.1 Yield contributing characters of boro rice

4.1.1 Plant height

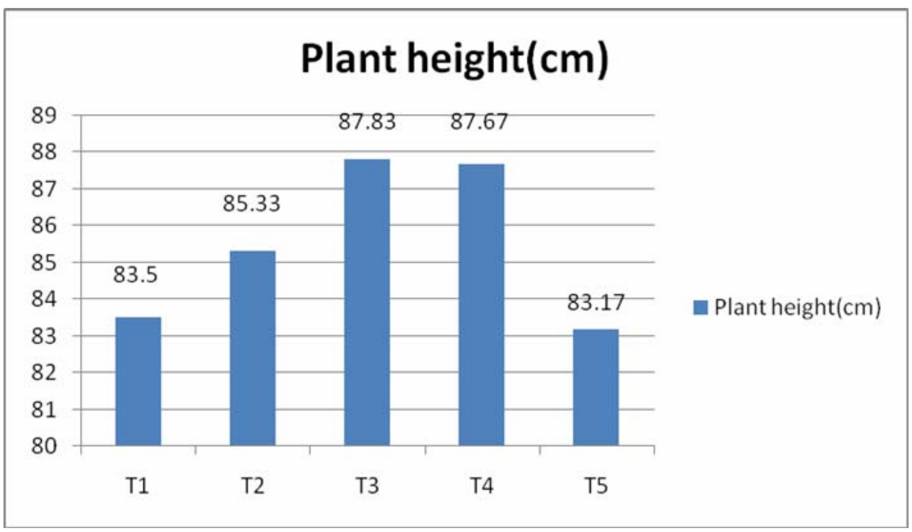
4.1.1.1 Effect of variety

Plant height is one of the most effective characters for better yield of rice which was also directly allied to straw yield. Plant height is a vertical spatial distribution of plant. Plant height was recorded at harvest stage where plant height was significantly influenced due to the effect of variety (Appendix III and Fig. 4.1). Between the varieties, Heera4 was taller (87.47 cm) than BRRI dhan63 (83.57 cm) under wetland condition during the boro season. This variation in plant height was found because of the variation in adaptability and genetic variability in experiment area. Similar results were also found by Islam *et al*. (2013) who also observed significant and genetic variation between the varieties concerning height of plant. Mahamud *et al*. (2013),observed that the variation in height was specified by the differentiation of genetic characteristics and their genotype also. Identical results were also found 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 climate and soil of the experimented area were favorable for the better growing of Heera 4 that eventually resulted higher plant height than that of BRRI dhan63.



V_1: BRRI dhan63 and V_2: Heera4

Fig. 4.1 Effect of variety on plant height at harvest



T_1 = Control (no organic or nitrogen fertilizer) ;T_2 = 140 kg N ha^{-1} from urea; T_3 = 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost;T_4 = 80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost; T_5 = Full organic (140 kg N ha^{-1} supplemented by Vermicompost)

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

4.1.1.2 Effect of integrated nutrient management (INM)

Plant height varied significantly due to the effect of vermicompost and urea treatments at harvest while plant height ranges from 83.17 cm to 87.83 cm (Appendix IV and Fig. 4.2). Fig. 4.2 shows that all the treatment showing significantly higher plant height over full organic (T_5). Result from the Fig. 4.2 shows that the tallest plant of 87.83 cm was found from the treatment T_3. The shortest plant height of 83.17 cm was found in T_5 (full organic) treatment which was similar to control treatment (no vermicompost or urea). Such effect of vermicompost associated with urea on plant height might be resulted the significant effect of vermicompost and urea on several process of physiology which includes cell division and cell elongation of the plant. These results were similar to that of Shaha (2014) who observed that the different amounts of vermicompost with inorganic fertilizers gave significant effect on plant height. Likewise, Yoseftabar (2013) reported that with the use of different rates of Nitrogen fertilizer plant height increases significantly. Pramanik and Bera (2013) also reported higher plant height in N 150 kg ha^{-1}. Besides, Islam (2008) reported that the higher plant height (109.49 cm) was found from the combination of 50% nitrogen fertilizer with 5 t ha^{-1}cowdung which is more or less similar with the results obtained from present study. Gowda *et al*. (2004); Jha *et al*. (2004) and many other scientists also found that the combination of vermicompost and nitrogen fertilizer affect significantly on plant height.

4.1.1.3 Interaction effect of variety and vermicompost along with urea

Analysis of variance data on plant height at harvest varied significantly due to the effect of interaction of variety and vermicompost along with urea fertilizers where plant height varied significantly from 81.67cm to 92.67 cm (Appendix V and Table 4.1). The highest plant height of 92.67cm was produced from the variety Heera 4 receiving of 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} from vermicompost (V_2T_3) which was statistically differed from other interactions. The shortest plant of 81.67 cm was found from the variety BRRI dhan63 while it received only vermicompost (full organic)without urea which was statistically close (82.33 cm) to V_1T_1 under having no fertilizers. A regular trend of increase in the plant height was observed with vermicompost + urea treatment due to each variety (Table 4.1).

Table 4.1 Interaction effect of varieties and vermicompost mixed with urea fertilizer on plant height, number of effective tillers, length of panicle and number of grains panicle^{-1}.

Treatment	Plant height (cm)	No of effective tillers/plant	Panicle length(cm)	No of grains /panicle
V_1T_1	81.67c	18.67	22.67c	85.33bc
V_1T_2	83.00bc	16.67	23.33bc	93.33abc
V_1T_3	83.67bc	17.00	23.67bc	105.33ab
V_1T_4	87.00abc	17.00	24.33b	109.33ab
V_1T_5	82.33c	19.33	23.67bc	87.67abc
V_2T_1	85.33bc	18.00	24.33b	88.33abc
V_2T_2	87.00abc	16.67	26.00a	93.00abc
V_2T_3	92.67a	17.00	26.00a	115.00a
V_2T_4	88.33ab	16.67	24.67ab	75.67c
V_2T_5	84.00bc	18.00	24.67ab	88.67abc
LSD Value$_{(0.05\%)}$	**5.72**	**3.10**	**1.45**	**7.71**
CV%	3.90	10.34%	3.47%	13.16%
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% level of probability; NS= Non-significant

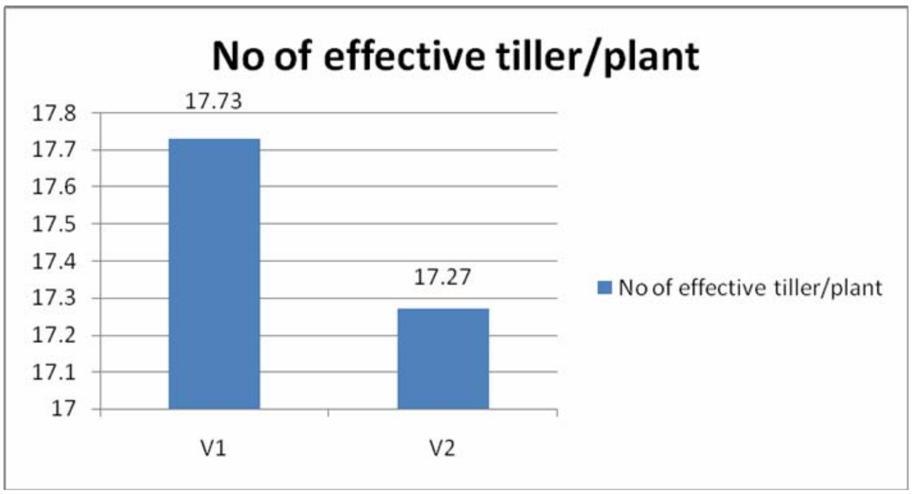
4.1.2 Number of effective tillers plant^{-1}

4.1.2.1 Effect of variety

Number of effective tillers i.e. ear bearing tillers is one of the most important parameters to determine the rice yield. All the tillers those are produced at early stage to do not become effective. All of them do not bear panicles. This is why; this attribute is straightly related rice yield. The studied varieties did not show significant variation in case of number of effective tillers hill^{-1} (Appendix III). BRRI dhan63 had maximum number of effective tillers hill^{-1} (17.73) in comparison to Heera 4 (17.27) at harvest (Fig. 4.3). Result showed that BRRI dhan63 produced higher number of effective tillers hill^{-1} than Heera 4 due to their genetic variation. Similarly, variation were also found by Panwar *et al*. (2012); Alam *et al*. (2012); Islam *et al*. (2007)

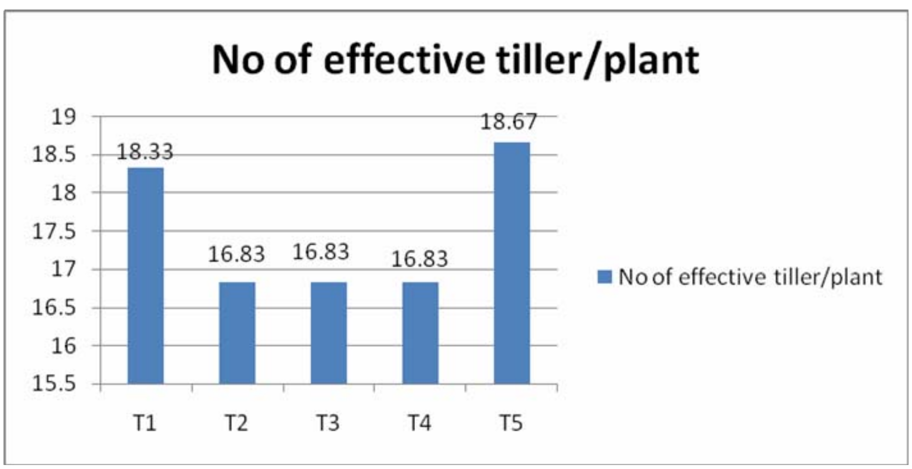
4.1.2.2 Effect of integrated nutrient management (INM)

The levels of vermicompost associated with urea had non-significant effect on number of effective tillers hill^{-1}(Appendix IV). The lowest number of effective tillers hill^{-1} (16.83) was found in treatment T_2, T_3 and T_4 having 140 kg N ha^{-1} from urea, 100 kg Nha^{-1} from urea and 40 kg N ha^{-1} supplemented by vermicompost,80 kg N ha^{-1} from urea and 60 kg N ha^{-1} supplemented by vermicompost respectively. The number of effective tillers hill^{-1} (18.33) was found in T_1which is having no organic or inorganic fertilizers. So, the number of effective tillers hill^{-1} varied from 16.83 to 18.67 (Fig. 4.4). These result showed that 140 kg nitrogen fertilizer from vermicompost ha^{-1} was adequate to produce the tillers at the productive level because rice plant can utilize the applied nitrogen effectively. Such results were also found by Shaha (2014) who showed that the vermicompost levels associated with BRRI RD of chemical fertilizer revealed the more effective tillers hill^{-1} which may be as a result of the combination of vermicompost and inorganic fertilizer rise the nutrient of soil and increase the capacity of tillering. Rashid *et al*. (2011) also revealed that the effect of urea- nitrogen + cowdung + poultry manure + urban wastes singly or interactively effect the growth, development and yield of boro rice where N_{50} + PM_{50} provided greater number (43.39%) of effective tiller hill^{-1} than that of control treatment. Hoshain (2010) also revealed that the greater number of effective tillers hill^{-1} was found from the association of 6 t ha^{-1} cowdung + 120 kg N ha^{-1}. Islam (2008); Jha *et al*. (2004) and many other scientists also showed their findings with the effect of vermicompost and urea fertilizer which eventually supported the present study.



V1: BRRI dhan63 and V2: Heera 4

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



T_1 = Control (no organic or nitrogen fertilizer) ;T_2 = 140 kg N ha^{-1} from urea; T_3 = 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost; T_4 = 80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost; T_5 = Full organic (140 kg N ha^{-1} supplemented by vermicompost)

Fig.4.4 Effect of vermicompost and urea on number of effective tillers $hill^{-1}$ at harvest

4.1.2.3 Interaction effect of varieties and vermicompost along with urea fertilizer

The interaction between varieties and vermicompost with urea fertilizer affect non-significantly in case of number of productive tillers $hill^{-1}$ (Appendix V). Results in Table 4.1 showed that the effective tillers ranged from 16.67 to 19.33 where the highest number of productive tillers $hill^{-l}$ (19.33) was found from the cultivar BRRI dhan63applied with full organic fertilizer (V_1T_5) whereas, the lowest number of productive tillers $hill^{-l}$ (16.67) was found from the cultivarHeera4 applied with80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost (V_2T_4) followed by Heera4 applied with100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost (V_2T_3)(Table 4.1).

4.1.3 Panicle length

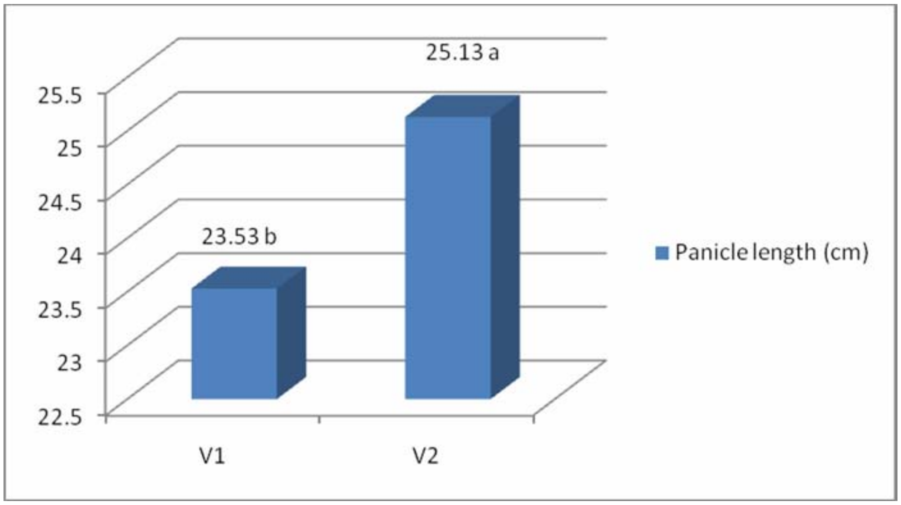
4.1.3.1 Effect of variety

Panicle length varied significantly by the variety according to the analysis of variance (Appendix III and Fig. 4.5). It was revealed that the variety Heera 4 produced longer panicle (25.13 cm) than BRRI dhan63 (23.53 cm). This result produced significant variation between the varieties might be because of its genetic diversity. 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 found the similar results. They also observed significant variation in case of panicle length probably due to the genetic variation of the cultivars of rice.

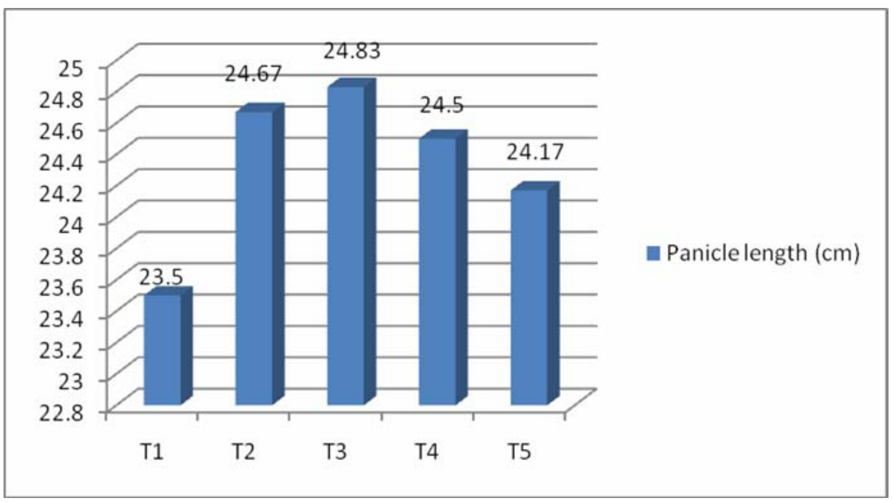
4.1.3.2 Effect of integrated nutrient management (INM)

Length of panicle provided significant variation between the vermicompost and urea treatments according to the analysis of variance data (Appendix IV and Fig. 4.6). The greatest panicle (24.83 cm) was found from the treatment T_3having 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost followed by T_2 having 140 kg N ha^{-1} from urea . Shortest panicle (23.50cm) was found from T_1 which having no fertilizer. These result showed that only urea (140 kg N ha^{-1} from urea) or combination of urea and vermicompost (100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost) was highly effective for the length of panicle and these have significant effect. Rashid *et al*. (2011) showed that the urea, vermicompost, cowdung and sewage wastes had significant influence on the panicle length with the application of 47.5 kg urea along with 9.5 t cowdung ha^{-1} provided the longest panicle length (27.03 cm) having arise of 18.03 percent over control. So, the present results totally agreed the above findings which was also approved by the findings work of Hoshain (2010); Islam (2008) and other scientists also.



V_1: BRRI dhan63 and V_2: Heera4

Fig. 4.5 Effect of variety on panicle length at harvest



T_1 = Control (no organic or nitrogen fertilizer) ; T_2 = 140 kg N ha^{-1} from urea; T_3 = 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost; T_4 = 80 kg Nha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost; T_5 = Full organic (140 kg Nha^{-1} supplemented by vermicompost)

Fig. 4.6 Effect of vermicompost and urea on panicle length at harvest

4.1.3.3 Interaction effect of varieties and vermicompost along with urea fertilizer

A significant variation in length of panicle was observed at harvest due to the combined effect of varieties and vermicompost (Appendix V). From the result of Table 4.1 also revealed that the panicle length significantly varied from 22.67 to 26.00 cm. The greatest panicle (26.00 cm) was found from the cultivar Heera4 applied with100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost (V_2T_3) followed by Heera4 applied with140 kg N ha^{-1} from urea (Table 4.1), while minimum panicle length (22.67 cm) was found from BRRI dhan63provided with no fertilizer (V_1T_1) (Table 4.1).

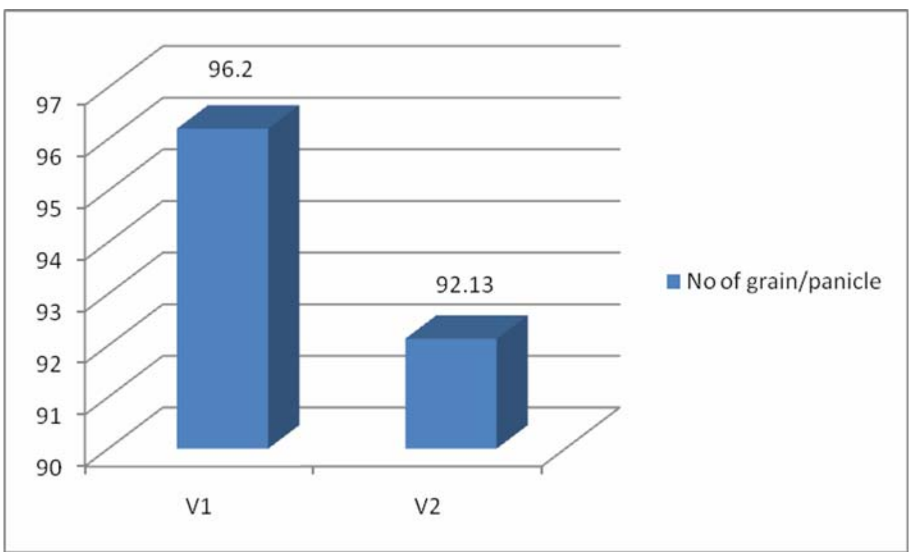
4.1.4 Number of grains panicle^{-1}

4.1.4.1 Effect of variety

Number of grains panicle^{-1}was not significantly variable among the varieties according to the analysis of variance (Appendix III). Data of Fig. 4.7 revealed that the variety BRRI dhan63 produced higher number of grains panicle^{-1}(96.2) than Heera4 (92.13) (Fig. 4.7). Filled grains hill^{-1}is the most important yield attribute which might be the result of the maximum grains hill^{-1}increased the yield for a crop. These result also showed that the different variety provided the difference in grains hill^{-1}for their different genetic properties and also the difference in their panicle length. Similar findings as the present results was also revealed by Uddin *et al*. (2011) who found the significant variations were found in filled grains panicle^{-1}while BRRI dhan44 produced significantly and Lalchicon excelled the lowest. Shiyam *et al*. (2014); Alam *et al*. (2012); Islam *et al*. (2013); Mahamud *et al*. (2013); Sarker *et al*. (2013); Bakul *et al*. (2009);Uddin *et al*. (2010)and many other scientists of home and abroad also found the present findings similarly.

4.1.4.2 Effect of integrated nutrient management (INM)

Number of grains panicle^{-1}varied non-significantly attributable to the effect of vermicompost and urea fertilizer applications (Appendix IV). Number of grains panicle^{-1}was highest (104.20) at the highest level of urea at T_3 having 100 kg N ha^{-1} from urea + 40 kg Nha^{-1}supplemented by vermicompost and whereas, it was minimum (86.83) at T_1having no fertilizer. On the contrary, Rashid *et al*. (2011) also got variation on the number of grains panicle^{-1} as a result of urea-nitrogen, vermicompost, poultry manure and swage wastes where (N_{50} + PM_{50}) provided the highest number of grains panicle^{-1} similarly. This result was also similar to the outcomes of Hoshain (2010) who also revealed significant variation as a result of the effect of cowdung and nitrogen fertilizer where the maximum number of filled grain panicle^{-1}was found from the association of cowdung (6 t ha^{-1}) + 120 kg N ha^{-1}. Thus, findings of the scientists agreed the present study.



V_1: BRRI dhan63 and V_2: Heera4

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

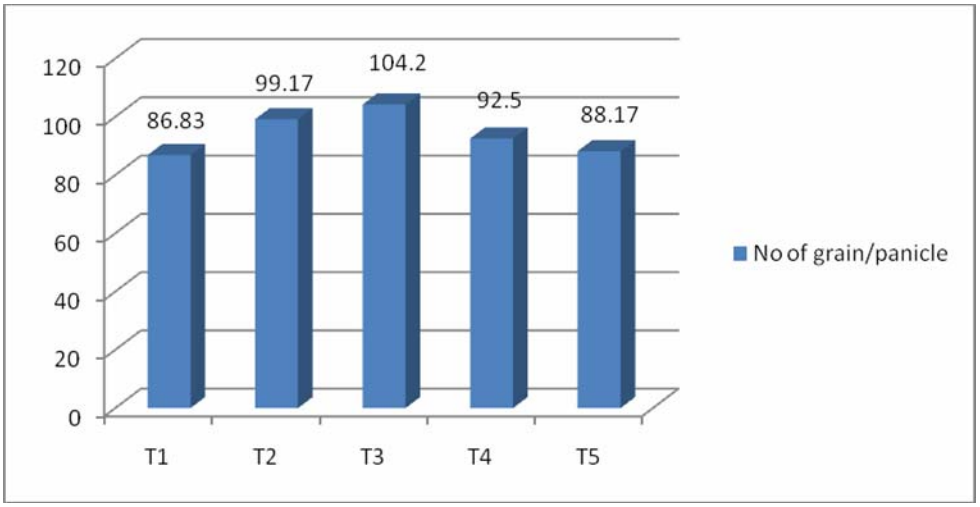


Fig. 4.8 Effect of vermicompost and urea on number of grains panicle^{-1}at harvest

4.1.4.3 Interaction effect of varieties and vermicompost with urea fertilizer

The number of grains panicle^{-1}was significantly influenced by the effect of interaction of varieties and vermicompost with urea fertilizer applications (Appendix V). The number of grains panicle^{-1}varied from 75.67 to 115.00 (Table 4.1). It was obtained that the highest number of grains panicle^{-1}was obtained from the variety Heera 4 having 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost (V_2T_3) followed by the variety BRRI dhan63 receiving of 100 kg Nha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost (V_1T_3) and the same variety receiving of 80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost (V_1T_4).Whereas, the lowest number of grains panicle^{-1}(75.67) was found from the varietyHeera4receiving of 80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost (V_2T_4) (Table 4.1).

4.1.5 Thousand-grain weight

4.1.5.1 Effect of variety

Thousand grains weight signifies grain size thus it is eventually attributed to the yield. The effect of rice cultivars on thousand-grain weight was insignificant. Heera 4 showed higher thousand-grains weight (26.87 g) than that of BRRI dhan63 (25.20 g) due to smaller grain (Table 4.2).The variation in thousand-grain weight may be due to genetic variation of specific genotype. Ali *et al*. (2014) observed similar outcome and they stated that 1000-grain weight varied significantly between the varieties, that was eventually reinforced by Hossain *et al*. (2005 and 2008). Shiyam *et al*. (2014); Islam *et al*. (2013); and many researchers of home and abroad also observed significant variation in thousand-grain weight of different varieties. These results also showed that the cultivar Heera 4 had more efficiency to produce larger sized grains than BRRI dhan63as it has maximum tillers and higher filled and total grain. The results of the conducted study are also similar to the observations of Oka *et al*. (2012); Alam *et al*. (2012).

4.1.5.2 Effect of integrated nutrient management (INM)

The levels of vermicompost and urea fertilizer revealed insignificant impact on thousand-grain weight. Between the treatments, treatment T_3(100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost) gave the highest thousand-grain weight (26.50 g) narrowly followed (26.17 g) by T_4having 80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost. Then again, control treatment T_1 (without fertilizer) provided the minimum (25.67 g) weight of thousand-grain (Table 4.3). Those outcomes showed that grain size increases with the increase of urea and vermicompost which may be as a result of the sufficient nutrient supply to the soil by these definite levels of urea and vermicompost. Similarly, the variation in thousand-grain weight was also revealed by Fakhrul Islam *et al*., (2013) who piloted their research with inorganic (urea) + organic (cowdung) manures where (60% RDCF + 4 ton PM ha^{-1}) revealed the maximum weight of thousand-grain. The present research was primarily on the outcome of organic + inorganic nutrients on bororice varieties and the similar kind of research were also conducted by Rashid *et al*. (2011) who researched to obtain the outcome of urea-nitrogen, vermicompost, poultry manure and sewage wastes where N @ 55 kg ha^{-1}+ PM @ 45 kg ha^{-1}gave the maximum weight of thousand-grains (29.33 g) of BRRI dhan29. This findings were also identical to the study of Hossaen *et al*. (2011) who also observed that the combined effect of inorganic and organic fertilizer was significantly effected the yield of Heera4 where the maximum weight of thousand seeds was obtained from T_6(75% NPKS + 2.2 t PM ha^{-1}).

4.1.5.3 Interaction effect of varieties and vermicompost with urea fertilizer

The effect of interaction between varieties and vermicompost along with urea found to be the significant variation in respect of 1000-grain weight. The cultivar Heera 4 showed the highest thousand-grain weight (27.00 and 27.33g) in case of treatment of T_1, T_3 and T_5 (V_2T_1,$V_2T_3$and V_2T_5 respectively). The similar variety having treatment T_2 (V_2T_2) and T_4 (V_2T_4)revealed the numerically close higher weight of thousand-grain (26.33 g and 26.67 g). Then again, BRRI dhan63revealed the minimum weight of thousand-grain (24.33 g) at control and it was numerically varied from other treatments interacted with same variety (Table 4.4).

Table 4.2 Effect of varieties on yield and yield attributes of bororice at harvest

Variety	1000 grain wt (g)	Grain Yield (t/ha)	Straw Yield (t/ha)	Harvest index (%)
V_1	25.20	5.12b	6.02b	45.96 b
V_2	26.87	6.08a	6.88a	46.91 a
LSD Value$_{(0.05\%)}$	1.78	0.70	0.72	0.70
CV%	6.52%	12.01%	11.76%	11.50%
Level of significance	NS	*	*	*

V_1: BRRI dhan63 and V_2: Heera4

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 and NS= non significant

Table 4.3 Effect of vermicompost and urea mixed fertilizer on yield and yield attributes of bororice at harvest

Treatment	1000 grain wt (g)	Grain Yield (t/ha)	Straw Yield (t/ha)	Harvest index (%)
T_1	25.67	4.91c	5.66b	46.45
T_2	25.83	5.85ab	6.60a	46.83
T_3	26.50	6.28a	7.13a	46.98
T_4	26.17	5.61abc	6.35ab	46.9
T_5	26.00	5.35bc	6.50ab	45.14
LSD Value$_{(0.05\%)}$	**2.05**	**0.81**	**0.91**	0.21
CV%	6.52%	12.01%	11.76%	13.2%
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% level of probability; NS= Non-significant

T_1 = Control (no organic or Nitrogen fertilizer); T_2 = 140 kg N ha^{-1} from urea; T_3 = 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost; T_4 = 80 kg N ha^{-1} from urea + 60 kg N ha^{-1}supplemented by vermicompost; T_5 = Full organic (140 kg N ha^{-1} supplemented by vermicompost)

Table 4.4 Interaction effects of varieties and vermicompost mixed with urea fertilizer on yield and yield attributes of bororice at harvest

Treatment	1000 grain wt (g)	Grain Yield (t/ha)	Straw Yield (t/ha)	Harvest index (%)
V_1T_1	24.33b	4.63d	5.50c	45.7
V_1T_2	25.67ab	5.50bcd	6.27bc	46.72
V_1T_3	25.33ab	5.27cd	6.20bc	45.94
V_1T_4	25.67ab	5.33bcd	6.03bc	46.91
V_1T_5	25.00ab	4.90cd	6.10bc	44.54
V_2T_1	27.00ab	5.20cd	5.83bc	47.14
V_2T_2	26.33ab	6.43ab	7.00ab	46.91
V_2T_3	27.33a	7.07a	8.00a	47.87
V_2T_4	26.67ab	5.90bc	6.67bc	46.93
V_2T_5	27.00ab	5.80bc	6.90ab	45.66
LSD Value$_{(0.05\%)}$	**2.91**	**1.15**	**1.30**	**1.11**
CV%	6.52%	12.01%	11.76%	12.33%
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% level of probability; NS= Non-significant

V_1: BRRI dhan63 and V_2: Heera4

T_1 = Control (no organic or nitrogen fertilizer); T_2 = 140 kg N ha^{-1} from urea; T_3 = 100 kg N ha^{-1} from urea + 40 kg Nha^{-1} supplemented by vermicompost; T_4 = 80 kg Nha^{-1} from urea + 60 kg N ha^{-1}supplemented by vermicompost

T_5 = Full organic (140 kg N ha^{-1} supplemented by vermicompost)

4.1.6 Grain yield

4.1.6.1 Effect of variety

The varieties revealed significant effect in case of grain yield. Among the varieties, higher grain yield (6.08 t ha^{-1}) was obtained from Heera4 than that of BRRI dhan63 (5.12 t ha^{-1}) (Table 4.2). It has caused because of the taller plant, higher number of effective tillers, longer panicles, more filled grains $panicle^{-1}$, larger sizes of grains of Heera 4 than that of BRRI dhan63. Ali *et al*. (2014); Shiyam *et al*. (2014); Uddin *et al*. (2010); Ashrafuzzaman *et al*. (2009) and many other scientists found that the cultivars that produces maximum number of effective tillers and respect maximum number of grains $panicle^{-1}$revealedmaximum grain yield ha^{-1}. Hossain *et al*. (2014a and 2014b); Islam *et al*. (2013); Mahmud *et al*. (2012) also found the same findings in rice. Sohel *et al*. (2009) reported in his research that the variation might be caused due to the difference in genetic makeup of the varieties.

4.1.6.2 Effect of integrated nutrient management (INM)

The grain yield because of the combined effect of organic (vermicompost) and inorganic (urea) nitrogen gave significant variation(Table 4.3). Among the treatments, T_3 (100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost) gave the highest grain yield (6.28 t ha^{-1}) followed by T_2(5.85 t ha^{-1}) having 140 kg N ha^{-1} from urea. On the other hand, control or T_1produced the lowest grain yield (4.91 t ha^{-1}) followed by T_5(140 kg N ha^{-1} supplemented by vermicompost). This result showed that combination of urea and vermicompost gave the better effect on yield of grain that may be the result of the higher number effective tillers $hill^{-1}$, longer panicle, more filled grains $panicle^{-1}$ and greater sized grains were found under this treatment. Similarly, combination of organic and inorganic fertilizer on boro rice were also researched by Shaha (2014); Sarkar (2014); Islam *et al*. (2013); Hoshain (2010); Rahman *et al* (2009); Nyalemegbe *et al*. (2009) and other researchers of home and abroad. Significant variation on yield of grains was found by all of the researchers by applying the combination of organic and inorganic fertilizer. Similarly, Shaha (2014) obtained highest yield of grain (5.65 t ha^{-1}) in vermicompost 7 t $ha^{-1}$and inorganic fertilizers (N); Sarkar (2014) obtained highest yield of grain in 70% RD of inorganic (N) fertilizers + 40% cowdung (5.5 t ha^{-1}); Hoshain (2010) obtained higher grain yield (6.15 t ha^{-1}) in the combination of 6.5 t ha^{-1}cowdung + 110 kg N ha^{-1}; Rahman *et al* (2009) found highest yield of grain in Urea 100 kg ha^{-1}+ PM 2.5 t ha^{-1}; Nyalemegbe *et al*. (2009) obtained highest grain yield in 10 t ha^{-1}organic + Urea (N) fertilizer @ 60 kg N ha^{-1} and 8 t ha^{-1}poultry manure with Urea @ 40 kg N ha^{-1}etc.

4.1.6.3 Interaction effect of varieties andvermicompost with urea fertilizer

Grain yield was significantly affected by the interaction effect of varieties and the application of vermicompost + urea (Table 4.4). From Table 4.4, it was observed that the grain yield varied from 4.63 to 7.07 t $ha^{-1}$where the treatment V_2T_3(Heera 4 receiving of 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost) gave the maximum grain yield and BRRI dhan63 while in control produced the minimum grain yield. This result showed that the growth and development of Heera 4 had highly productive in 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost for obtaining the tallest rice plant, highest effective tillers $hill^{-1}$and filled grains $panicle^{-1}$, longer panicle and higher weight of thousand-grain which finally results the maximum grain yield. Sarkar (2014) observed that the maximum yield of grain was obtained in BRRI dhan34 applied with 70% RD of inorganic fertilizers (urea) + 60% organic fertilizer.

4.1.7 Straw yield

4.1.7.1 Effect of variety

Analysis of variance data revealed significant variation between the varieties regarding to straw yield (Table 4.3). The cultivar Heera 4 produced the maximum straw yield (6.88 t ha^{-1}) whereas BRRI dhan63 gave the lowest straw yield (6.02 t ha^{-1}). The result showed that the yield of straw differed due to the genetic variation between the varieties genotypes and also for the different height of varieties. Uddin *et al*. (2011) found that the BRRI dhan34 produced maximum straw yield in comparison to the minimum by Lalchicon. This is caused due to differences in variety and also for the difference in plant height. Similar findings of the present study was also found by the scientists 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 integrated nutrient management (INM)

Straw yield was significantly influenced by the combination of organic and inorganic fertilizer. Straw yield increased with increased inorganic (urea) and decreasing organic (vermicompost) fertilizer. Thus, the maximum yield of straw (7.13 t ha^{-1}) was obtained from the treatment T_3 having 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost followed by treatment T_2(6.60 t ha^{-1}) having 140 kg N ha^{-1} from urea. The lowest yield (5.66 t ha^{-1}) was found from the treatment T_1 having no nitrogen (Table 4.3). The genetic variability of the studied varieties is the main reason for the variation in yield of straw. In addition, taller plants and higher total effective tillers were found in higher inorganic urea treatment that finally established the higher straw. Similar effect of organic and inorganic fertilizer on yield of straw was also found by Shaha (2014) who lead his experiment with the combination of organic and inorganic fertilizer. Liza *et al*. (2014) also showed that the treatment T_6 (60% RFD + residual effect of CD 2t ha^{-1}, PM 2 t ha^{-1}, and Com. 3 t ha^{-1}) gave the highest straw yield (7.25 t ha^{-1}) where Hasan (2014); Islam *et al*. (2013); Rahman *et al* (2009) and other researchers also found identical results with the present study while all the scientists studied on the combined effect of organic and inorganic fertilizer.

4.1.7.3 Interaction effect of varieties and vermicompost with urea fertilizer

Straw yield was significantly affected by the interaction effect of varieties and the application of vermicompost + urea (Table 4.4). From Table 4.4, it was observed that the grain yield varied from 5.50 to 8.00 t $ha^{-1}$where the treatment V_2T_3(Heera 4 receiving of 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost) gave the maximum straw yield and BRRI dhan63 while in control produced the minimum straw yield. This result showed that the growth and development of Heera 4 had highly productive in 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost for obtaining the tallest rice plant and highest effective tillers $hill^{-1}$which finally results the maximum straw yield.

4.1.8 Harvest index

4.1.8.1 Effect of variety

Harvest index (HI) show significant variation according to the ANOVA data because of the varieties effect. In this study they showed numerically similar HI (Table 4.2). The HI of Heera 4 (46.91%) was greater than that of BRRI dhan63 (45.96 %). Similar findings was reported by Uddin *et al*. (2011) who found that the harvest index varied significantly between the varieties because of their genetic variability. Such results were also found by Roy *et al*. (2014); Yao *et al*. (2012); Sritharan and Vijayalakshmi (2012); Islam (2011); Baset Mia and Shamsuddin (2011) many another many scientist.

4.1.8.2 Effect of integrated nutrient management (INM)

Harvest index was significantly influenced by the combination of organic and inorganic fertilizer (Table 4.3). From Table 4.3 it is found that harvest index maximized at 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost. The maximum harvest index (46.98%) was found in T_3having 100 kg Nha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost while it was numerically close to T_2(46.83%), T_4(46.90%) and T_1(45.45%). On the other hand, T_5 (only vermicompost) provided the minimum harvest index (45.14%) which was numerically close to other treatments of the study. Such effect on harvest index was also found by Islam (2008) who also revealed that the harvest index (46.40%) was found from the association of 60% inorganic fertilizer with 4 t ha^{-1}organic fertilizer.

4.1.8.3 Interaction effect of varieties and vermicompost with urea fertilizer

All the studied treatments of the interaction among varieties and vermicompost with urea fertilizer as a source of nitrogen provided statistically or numerically similar harvest index due to non-significant variation in this study (Table 4.4).

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

The present study was conducted at the Research Field of the Department of Soil Science, SAU, Dhaka during the boro season of 2015-16 to evaluate the growth, yield, yield attributes by the singly or their interaction effect of two rice varieties and organic (vermicompost) + inorganic (urea) fertilizer as a source of Nitrogen. Two rice varieties namely BRRI dhan63 (V_1) and Heera 4 (V_2) and five treatments including control *viz.*

T_1 = Control (no organic or nitrogen fertilizer)

T_2 = 140 kg N ha^{-1} from urea

T_3 = 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost

T_4 = 80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost

T_5 = Full organic (140 kg N ha^{-1} supplemented by vermicompost)

The two factors experiment (Factor A: Variety and Factor B: vermicompost + 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 6.0 m^2 (3 m × 2.0 m) while block to block and plot to plot distances were 1.0 m and 0.5 m, respectively. The total number of plots were 30 (treatment combinations: 10 × 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, plant height, number of effective tillers $plant^{-1}$, panicle length, grain yield, straw yield and harvest index were significantly affected due to the main effect of variety. Between the varieties, hybrid variety Heera 4 showed superior performance than BRRI dhan63 among the whole characters of the study. In case of the tallest plant (87.47 cm), more effective tillers $hill^{-1}$ (17.27), longest panicle (25.13 cm), more grains $panicle^{-1}$ (92.13), highest weight of 1000-grain (26.87 g), highest yield of grain and straw (6.08 and6.88 respectively) were obtained from the variety Heera 4 compared to BRRI dhan63.

Among the growth, yield and yield contributing characters due to the main effect of variety where T_3(100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost) showed the best performance at all the characters. The tallest plant (87.83 cm), more effective tillers $hill^{-1}$ (16.83), longest panicle (24.67cm), more grains $panicle^{-1}$ (104.20), highest weight of 1000-grain (24.50 g), highest yield of grain and straw (6.28 and 7.13 t ha^{-1}, respectively) and highest HI (46.90%) were recorded in $T_3$where above all characters were lowest in T_1(control).

In case of the effect of interaction between variety and vermicompost + urea fertilizer, plant height, number of effective tillers $plant^{-1}$, panicle length, number of grains $panicle^{-1}$grain yield and straw yield were significantly affected. Among the interactions, the variety Heera 4 receiving of 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost (V_2T_3) produced significantly the tallest plant (92.67 cm), more effective tillers $hill^{-1}$ (17.00), longest panicle (26.00 cm), more grains $panicle^{-1}$(115.00), highest 1000-grain weight (27.33 g), highest yield of grain and straw (7.07and 8.00 t ha^{-1}) while they were lowest in without treated BRRI dhan63.

5.2 Conclusion

From the present study finally it can be concluded that the organic (vermicompost) and inorganic (urea) fertilizer had varying degree of integrated effects on BRRI dhan63 and Heera 4. Between the varieties, Heera 4 had highly significant than BRRI dhan63 while application of vermicompost ha^{-1} 100 kg N ha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompostas 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 bororice.

There combinations (Heera 4 x100 kg Nha^{-1} from urea x 40 kg N ha^{-1} supplemented by vermicompost) also showed superior result among the whole characters of the study. So, it could concluded that the cultivar Heera 4 applied with urea and vermicompost singly or their interaction would be the suitable variety and optimum organic (vermicompost) + 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 vermicompost can reduce by 30% use of inorganic fertilizer which also reduce the soil pollution by chemical fertilizer and improve soil physical properties. vermicompost release nutrient at slow rate that can help to uptake nutrient for plant longer time. So, it is strongly recommended that the farmer of our country can use vermicompost 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 applied with urea and vermicompost singly or their interaction 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 during boro season in Bangladesh.

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

REFERENCES

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.

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:

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 amanrice. International Journal of Agriculture and Agricultural Research. 2(12): 10–15. http://archive.thedailystar.net/newDesign/news–details.php?nid=221607).

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.

Anonymous. (1998a). Annual Report for 1997–98. Technical report on hybrid rice Aalok6201.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.

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

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. InternationalJorunal 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 amanseason. Journal of Agriculture and Rural Development. 5(1&2): 13–16

Awan, I.U.; Ahmad, H.K. and Gandapur, S.U.D. 1984.Effect of different nitrogen applications on rice grain yield. Intl. Rice Res. Newsl, 9(6):26.

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.

Barber, S. A. 1977. Efficient fertilizer use in agronomic research for food spec. Publ. No. 26, Aml.Soc.Agron., Madison, Wisconsin. pp. 13-29

Barker, R. and Robert, W.H., 1985.The rice economy of Asia. Intl. Rice Res. Newsl., P.1.

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.

BBS (Bangladesh Bureau of Statistics) (2013).Statistical Year Book of Bangladesh. Bangladesh Bur., Stat. Div., Min. Plan., Govt. people's Repub. Bangladesh, Dhaka. Pp. 32-37.

BBS (Bangladesh Bureau of Statistics) (2016).Agriculture crop cutting. Estimation of Boro rice 2015–2016.Government of the People's Republic of Bangladesh. Web site: http://www. bbs.gov.bd

Behera, A. K. 1998. Response of scented rice (*Oryza sativa)* to nitrogen under transplanted condition. Indian J. Agron., 43(1):64-67.

Bhattacharya, R. K. 1981. Interrelationship between grain yield and some quantitative characters in rice adapted to saline soils, *Oryza,* 18(3):147-149.

Bhawalker, U.S. 1991. Vermiculture technology for LEISA. Seminar on Low External Input Sustainable Agriculture held at Amsterdam, Netherlands pp 41-42.

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) (2015). Adhunik Dhaner Chash (in bengali). Bangladesh Rice Research Institute, Joydebpur, Gazipur. p. 80.

BRRI (Bangladesh Rice Research Institute).1978. Annual Report for 1976-1977. Bangladesh Rice Res. Inst. Joydebpur, Gazipur.

BRRI (Bangladesh Rice Research Institute).1990. Annual Report for 1990. Bangladesh Rice Res. Inst. Joydebpur, Gazipur.

Chowdappa, P.,Biddappa, C.C. and Sujatha, S. 1999. Efficient recycling of organic wastes in arecanut (Areca catechu) and Cocoa (Theobroma cocoa) plantation through vermicomposting. Indian Journal of Agricultural Sciences 69(8) : 563-566.

Das, P.K., Jena, M.K. and Sahoo, K.C. 2002. Effect of integrated application of vermicompost and chemical fertilizer on growth and yield of paddy in red soil of south eastern ghat zone of Orissa. Environment and Ecology 20(1) : 13-15.

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.

De Datta, S.K. 1981. Principles and Practices of Rice Production. John Willy and Sons. New York. pp. 100-102.

Dixit, R.S. and Singh, M.M. 1979. Response of rice varieties for N levels under rainfed or direct seeded conditions. Intl. Rice Comm. Newsl., 28(2):26-28.

Fakhrul Islam, MdAsaduzzaman 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

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

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.

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

Haque, M.A. and Khan, M.A.H. 1981. Role of higher nitrogen rate, sulphur and zinc application in bridging the yield gap of farmer's boro rice in Bangladesh. IRRN., 6(5):20.

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.

Haque, M.S. and Bhuiya, Z.H. 1980. Effect of NPK fertilizer on the performance of Dharial rice growth and yield characteristics. Bangladesh J. Agril., 2:180-190.

Harnowo, D. 1998. Residual effect of NPK on rice for soybean grown after low land rice.Seminar Hasil Penelitian Tanaman Kacang-Kacangandan Umbi-Umbian Malang (Indonesia) 23-24.

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

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. A. 1992. Growth analysis of BR3 and BR14 grown under different nitrogen levels during *aus* season. M. Sc. (Ag.) Thesis in Crop Botany, BAU, Mymensingh.

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.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.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.

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

Islam, A.J.M.A. 1978. Sulphur deficiency symptom corrective measure and result obtained. Proc. Sulphur Nutrition in Rice. pp. 20-28.

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.; Hoque, M.S. and Bhuiya, Z.H. 1990.Effect of nitrogen and sulphur fertilization on yield response and nitrogen and sulphur composition of rice.Bangladesh J. Agril. Sci. 17(2) :299-302.

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.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.

Jadhav, A.D., Talashilkar, S.C. and Powar, A.G. 1997. Influence of conjunctive use of FYM, vermicompost and urea on growth and nutrient uptake in rice. Journal of Maharashtra Agricultural Universities 22(2) : 249-250.

Jashim, C. U. and Ahmed, K. U. 1984. Response of rice varieties to applied nitrogen in saline soils. IRRN. 9(5):22.

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.

Jones, D.B., Patersen, R.L. and Geng, S. 1979. Association between grain filling rate and duration and yield components in rice. Crop Sci., 19: 641-644.

Kale, R.D., Mallesh, B.C., Bano, K. and Bagyaraj, D.J. 1992. Influence of vermicompost application on the available micronutrient and selected microbial population in a paddy field. Soil Biology and Biochemistry 24 : 1317-1320.

Kehinde, J.K. and Fagade, S.O. 1987. Response of upland rices to nitrogen. Intl. Rice Res. Newsl., 12 (4) 60. [Cited from Rice Abstracts 1989. 12(4):pp. 60, 192.]

Khanam, M. 1994. Nitrogen and population Density; Effect on Growth nitrogen uptake and yield of long grain rice. M.S Thesis. Institute of Post Graduate Studies in Agriculture. Gazipur, Bangladesh.

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.

Kirk, G.J.D. 2000. Rate-limiting steps in nitrogen acquisition by rice in flooded soil. In: Sheey, J.E., Mitchel, P.L. and Hardy, B. (Eds.). Redesigning Rice Photosynthesis to Increase Yield. Elsevier Science B.V., The Netherlands and International Rice Research Institute, Manila, Philippines. pp. 45-49.

Krishnamoorthy, R.V. and Vajranabhiah, S.N. 1986. Biological activity of earthworm cast : An assessment of plant growth promoter levels in casts. In : Proceedings of Indian Academy of Science (Animal Science) 95 : 341.

Lenka, D. and Behera,P.C. 1967. Response of four Tiwan and two local varieties of paddy to high levels of nitrogen. Indian J. of Agron. 12: 353-358-7.

Leonard, W.H.; John, H. and Martin, P.1976.Principles of Field Crop Production.The Macmillan Company Ltd. pp.622.

Lin, J.L. and Lin, T.L. 1983. Tiller number and leaf area index in rice community as influenced by planting density and N fertilizer. J. Agril. Assoc. China. 12: 14-34.

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.

Machlis, L., Briggs, W.R. and Park, R.B. 1972. Ann. Rev. of Rice Plant Phsiol.23: 441.

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.

Maheshwarappa, H.P., Nanjappa, H.V. and Hedge, M.R. 1999. Influence of organic manures on the yield of arrowroot, soil-physicochemical and biological properties when grown as an inter crop in coconut garden. Annals of Agricultural Research 20(3) : 318-323.

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.

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

Matsushima, S. 1976. High Yielding Rice Cultivation. Japan scientific society Press.pp.37-39.

Maurya, D.M. and Yadav, M.P. 1987. Performance of average seedling at different N levels. IRRN, 12(4): 9.

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.

Milam, M.R.; Hickingbottom, K. and Mckenzie, K.S. 1986. Rice commercial variety test. In Ann. Prop. Rep. Northeast Res. Sta. and Macon Ridge Res. Sta. pp. 50-52. [Cited from Field Crop Abst., 42(2):88.]

MoA.(2009). Handbook of Agricultural Statistics. 2009. Dhaka: Ministry of Agriculture (MoA), Government of Bangladesh.

Mondal, S.S., Dasmahapatra, A.N. and Chaterjee, B.N. 1987. Effect of high rates of potassium and nitrogen on rice yield components. Environ. Ecol., 5(2): 300-303.

Murali, M.K. and Setty, R.A. 2000. Effects of levels of NPK, vermicompost and growth regulators (Triacontanol) on growth and yield of scented rice. Mysore Journal of Agricultural Sciences 34(4) : 335-339.

Murayama, N. 1979.The importance of nitrogen for rice production. Nitrogen and Rice.IRRI, Los Banos, Philippines.pp.5-9.

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

Ohajianya DO, Onyenweaku CE. Farm size and relative efficiency in rice production in Ebonyi State, Nigeria. Modeling Simulation Coni, D, 23, 2002;1-16. 18

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

Padalia, C.R. 1980. Residual effects of NPK fertilizers and organic manures on yield of rice crop. *Oryza* 17(1) : 55-57.

Page, A.L., Miller, R.H. and Keeney, D.R. (1982). Methods of analysis part 2, Chemical and Microbiological Properties, Second Edition American Society of Agronomy, Inc., Soil Science Society of American Inc. Madson, Wisconsin, USA. p. 403-430.

Pandey, N. K. and Sinha, R. N. 1971.Response of high yielding rice to nitrogen fertilization. Indian J. Agron., 16(3): 363-365.

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

Park, S.T. 1987. Effect of nitrogen application on biological yield and harvest index. Research reports of the Rural development Administration, Crops, Korea Republic. 29(2): 92-106.

Parkash, Y.S. and Bhadoria, P.B.S. 2002. Influence of organic manures on crop tolerance to pathogens and pests in two varieties of rice. Annals of Agricultural Research 23(1) : 79-85.

Patil, V.S. and Bhilare, R.L. 2000. Effect of vermicompost prepared from different organic sources on growth and yield of wheat. Journal of Maharashtra Agricultural Universities 25(3) : 305-206.

Prasad, M. 1981. Biological yield and harvestindex of rice *Oryza*., 18(1): 31-34.

Prasertsak, A. and Fukai, S. 1997. Nitrogen availability and water stress interaction of rice growth and yield. Field Crops Res., 52(3): 249-260.

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.

Rani, R. and Shrivastava, O.P. 1997.Vermicompost : a potential supplement to nitrogenous fertilizers in rice nutrition. International Rice Research Notes 22(3) : 30-31.

Rao, C.M., Ramaiah, N.V., Reddy S.N., and Reddy, G. 1986.Effect of urea and urea supergranules on dry matter accumulation, yield and nutrient uptake a rice (*Oryza sativa*). J. Res., 14(1): 1-13.

Rao, Y.; Yogeswara, C.; Subbireddy, F.; Khan, W.A., Mirza, P.N. and Naidu, N.G. 1980. Performance of promising rice cultivars under different nitrogen levels in *kharif* season. Indian J. Agron., 25:256-258.

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 Urea nitrogen, Cowdung, Poultry Manure and Urban Wastes on Yield and Yield Components of BoroRice. International Journal of Agriculture, Environment and Biotechnology. 4(1): 9–13

Roy, S.K., Ali, M.Y., Jahan, M.S., Saha, U.K., Ahmad–Hamdani, M.S., Hasan.M.M.andAlam, M.A. (2014).Evaluation of growth and yield attributing characteristics of indigenous Boro rice varieties. Life Sciences Journal 11(4): 122–126.

Sadeque, M.A. 1985. A study of grain filling in barley. An unpublished Ph.D. Thesis.Univ. Canterury, New Zealand., p.151.

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.

Sarker, R.K. and Ghatak, S. 1988. Growth analysis and agronomic appraisal of Indian rape under nitrogen application. Indian J. Agron., 32(i): 63-69.

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.

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.

Singh, F., Kumar, R., Pal, S., Singh, F., Kumar, R. and Pala, S. 2003. Integrated nutrient management in rice-wheat cropping system for sustainable productivity. Progressive Agriculture 3(1-2) :115-116.

Singh, J. and Rai, S.N. 1998. Industrial vermicomposting for sustainable agriculture in India. Indian Farming 48(4) : 15-20.

Singh, K.N. and Sharma, D.K. 1987. Response of nitrogen on rice in sodic soil. IRRN, 12:45.

Singh, S.P. and Pillai, K.G. 1991. Response to nitrogen in semidwarf rice varieties. IRRN, 19:16.

Sitajanaki, P. and Sreehari, N. 1997.Vermicompost increases ears and grains of rice. Indian Farming 47(8) : 29.

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.

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

Srivastava, S.K., Singh, J. R. and Chandrautanshi, B.R. 1987. Nitrogen management for increasing N efficiency in transplanted rice. IRRN, 12:4. p.51.

Sudha, B. and Chandini, S. 2002. Nutrient management in rice. Journal of Tropical Agriculture 40(1-2) : 63-64.

Sudhakar, G., Lourduraj, A.C., Rangaswamy, A., Subian, P. and Velayuthem, A. 2002.Effect of vermicompost application on soil properties, nutrient availability, uptake and yield of rice- a review. Agricultural Reviews 23(2) : 127-133.

Surekha, J. and Rao, P.A. 2000. Influence of vermicompost and FYM on the pest complex of bhindi. Andhra Agricultural Journal 47(3-4) : 228-231.

Szczech, M. and Brzeski, M.V. 1994.Vermicompost fertilizer or biopesticides.ZeszytyNaukoweAkademiiRolniczejinHugonaKllatajiWkrakonieSesjaNaukowa41 : 77-83.

Talukder, M. N.1973.Effect of nitrogen on yield and other characteristics of three varieties of rice IR8-288-3.IRATOM-24 and IRATOM-38. M. Sc. (Ag) Thesis, Dept. Agron. Bangladesh Agril.Univ.Mymensingh.p.96.

Tanaka, A.; Kawano, K. and Yamaguchi, J. 1966. Photosynthesis, respiration and plant type of the tropical rice plant. Intl. Rice Res. Tech. Bull.No.7.P 46.

Thakur, R.B. 1991a. Effect of split application of nitrogen on grain yield and N uptake in wetland rice. Indian J. Agron., 38:191-194.

Thakur, R.B. 1991b. Relative efficiency of prilled urea and modified urea fertilizer on rainfed low land rice. Indian J. Agron., 36(1): 87-90.

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, 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

Ushakumari, K., Prabhakumari, P. and Padmaja, P. 1999. Efficiency of vermicompost on the growth and yield of summer crop okra (*Abelmoschusesculentus* M.). Journal of Tropical Agriculture 37(1-2) 63-64.

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

Vankatesh, Patil, P.B., Kumar, K.S., Patil, C.V. and Giradii, R.S. 1997. Influence of in situ vermiculture and vermicompost on availability and plant content of micronutrients. Advances in Agricultural Research in India 8 : 53-56.

Vasanthi, D. and Kumaraswamy, K. 1999. Efficacy of vermicompost to improve soil fertility and rice yield. Journal of Indian Society of Soil Science 47(2) : 268-272.

Wagh, R.G. and Throat, S.T. 1988. Response of rice (*Oryza sativa*) variety R24 to different times of coastal soils. J. Indian Soc. Coastal Agril. Res., 43:33.

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

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.

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.

Yoshida, S. 1981. Fundamentals of Rice Crop Science. Intl. Rice Res. Inst. PP. 22-33. 26. 28-29. 61. 178.

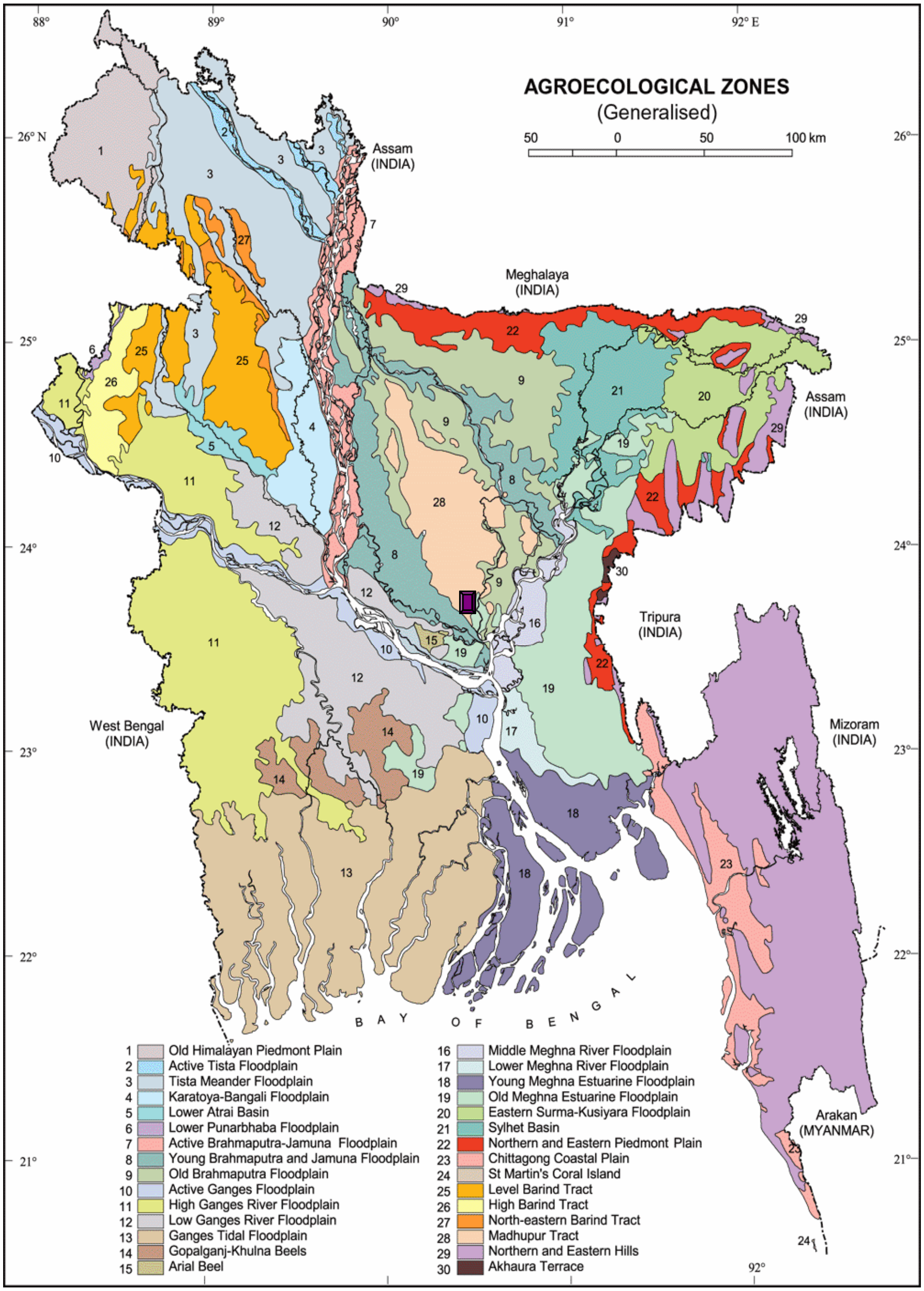
Yoshida, S. and Hayakawa, Y. 1975.Effect of mineral nutrition on tillering of rice. Soil Sci. Plant Nutr- 16:186-191

Yoshida, S. and Parao, F.T. 1976.Climatic influence on yield and yield components of lowland rice in the tropics.Climate and Rice. IRRI, Los Banos, Philippines., pp. 471-494.

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.

APPENDICES

Appendix I. The Map of the experimental site



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

Month	*Air temperature (ºc)		*Relative humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
November, 2015	25.8	16.0	78	00	6.8
December, 2015	22.4	13.5	74	00	6.3
January, 2016	24.5	12.4	68	00	5.7
February, 2016	27.1	16.7	67	30	6.7
March, 2016	31.4	19.6	54	11	8.2

* Monthly average, * Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Effect of variety on plant height, No of effective tillers plant^{-1}, Panicle length, No of grain/panicle of bororice at harvest

Variety	Plant height (cm)	No of effective tiller/plant	Panicle length (cm)	No of grain/panicle
V_1	83.53 b	17.73	23.53b	96.20
V_2	87.47a	17.27	25.13a	92.13
LSD Value$_{(0.05\%)}$	2.55	1.38	0.648	16.98
CV%	3.90%	10.34%	3.47%	13.16%
Level of significance	*	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% level of probability; NS= Non-significant

V1: BRRI dhan63 and V2: Heera 4

Appendix IV. Effect of vermicompost and urea mixed fertilizer on plant height, No of effective tillers plant^{-1}, Panicle length, No of grain/panicle of boro rice at harvest

Treatment	Plant height (cm)	No of effective tiller/plant	Panicle length (cm)	No of grain/panicle
T_1	83.50b	18.33	23.50b	86.83
T_2	85.33ab	16.83	24.67a	99.17
T_3	87.83a	16.83	24.83a	104.2
T_4	87.67a	16.83	24.50ab	92.50
T_5	83.17b	18.67	24.17ab	88.17
LSD Value$_{(0.05\%)}$	**4.04**	**2.19**	**1.02**	**19.60**
CV%	3.90%	10.34%	3.47%	13.16%
Level of significance	*	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% level of probability; NS= Non-significant

T_1 = Control (no organic or nitrogen fertilizer) ;T_2 = 140 kg N ha^{-1} from urea; T_3 = 100 kg Nha^{-1} from urea + 40 kg N ha^{-1} supplemented by vermicompost; T_4 = 80 kg N ha^{-1} from urea + 60 kg N ha^{-1} supplemented by vermicompost; T_5 = Full organic (140 kg N ha^{-1} supplemented by vermicompost)

Appendix V. Interaction effects of varieties and vermicompost mixed with Urea fertilizer on plant height, No of effective tillers plant^{-1}, Panicle length, No of grain/panicle of boro rice at harvest

Treatment	Plant height (cm)	No of effective tiller/plant	Panicle length (cm)	No of grain/panicle
V_1T_1	81.67c	18.67	22.67c	85.33bc
V_1T_2	83.00bc	16.67	23.33bc	93.33abc
V_1T_3	83.67bc	17.00	23.67bc	105.33ab
V_1T_4	87.00abc	17.00	24.33b	109.33ab
V_1T_5	82.33c	19.33	23.67bc	87.67abc
V_2T_1	85.33bc	18.00	24.33b	88.33abc
V_2T_2	87.00abc	16.67	26.00a	93.00abc
V_2T_3	92.67a	17.00	26.00a	115.00a
V_2T_4	88.33ab	16.67	24.67ab	75.67c
V_2T_5	84.00bc	18.00	24.67ab	88.67abc
LSD Value$_{(0.05\%)}$	**5.72**	**3.10**	**1.45**	**7.71**
CV%	3.90	10.34%	3.47%	13.16%
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% level of probability; NS= Non-significant