A COMPARATIVE STUDY ON GROWTH AND YIELD OF DIFFERENT AMAN RICE VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **'A Comparative Study on Growth and Yield of Different Aman Rice Varieties'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of Master of Science in Agricultural Botany, embodies the result of a piece of bonafide research work carried out by **S. A. M. SALAHIN**, Registration number: **10-04153** 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 duly been acknowledged.

Dated: June, 2016
Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED PARENTS

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The Author

A COMPARATIVE STUDY ON GROWTH AND YIELD OF EIGHT AMAN RICE VARIETIES

ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during *Aman* season (July -November) 2016 to study the growth, yield and yield attributes of different *Aman* rice varieties. The experiment comprised of eight *Aman* rice varieties viz., BRRI dhan32, BRRI dhan33, BRRI dhan34, BRRI dhan39, BRRI dhan54, BRRI dhan56, BRRI dhan57 and BRRI dhan62. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Different growth characteristics, yield and yield attributes varied considerably among the studied varieties. At 15, 30, 45, 60 and 75 DAT (days after transplanting) and at harvest, the tallest plant (26.00, 54.10, 77.96, 92.88, 116.00 and 122.68 cm, respectively) were recorded from BRRI dhan32, whereas the shortest plant (21.97, 42.84, 65.32, 75.42, 101.00 and 101.88 cm, respectively) from BRRI dhan62. At 15, 30, 45, 60 and 75 DAT, the highest leaf area index (0.41, 1.75, 3.89, 5.94 and 6.94, respectively) and the highest total dry matter hill^{-1} (3.24, 7.02, 8.68, 14.92 and 15.37 g, respectively) were recorded from BRRI dhan54, whereas the lowest leaf area index (0.35, 1.48, 2.99, 4.18 and 4.80, respectively) and the lowest total dry matter hill^{-1} (2.86, 4.51, 7.47, 11.82 and 13.73 g, respectively) from BRRI dhan34. The maximum days to maturity (134.25) were recorded from BRRI dhan34, while the minimum days (100.50) from BRRI dhan33. The maximum number effective tiller hill^{-1} (16.75) were recorded from BRRI dhan54, whereas the minimum number (12.05) from BRRI dhan34. The longest panicle (25.76 cm) was recorded from BRRI dhan54, while the shortest panicle (21.30 cm) from BRRI dhan34. The maximum number of filled grains panicle^{-1} (89.90) were recorded from BRRI dhan54, whereas the minimum number (75.80) from BRRI dhan34. The highest weight of 1000-grains (25.71 g) was obtained from BRRI dhan54, while the lowest (19.45 g) from BRRI dhan57. The highest grain yield (5.45 t ha^{-1}) were achieved from BRRI dhan54, whereas the lowest (3.49 t ha^{-1}) from BRRI dhan34. The highest straw yield (7.97 t ha^{-1}) were recorded from BRRI dhan54, whereas the lowest straw yield (6.58 t ha^{-1}) from BRRI dhan34. Among the tested *Aman* rice varieties, BRRI dhan54 was the best in consideration of yield attributes and yield.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
cv	Co-efficient of variation
DAT	Days After Transplanting
et al.	and others
etc	Etcetera
FAO	Food and Agriculture Organization
g	Gram
IRRI	International Rice Research Institute
LSD	Least Significance Difference
m^2	Square meter
mm	Millimeter
MoP	Muriate of Potash
ppm	Parts per million
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources Development Institute
t ha^{-1}	ton per hectare
TSP	Triple Super Phosphate
^0C	Degree Celsius

CHAPTER I

INTRODUCTION

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INTRODUCTION

Rice (*Oryza sativa* L.), belongs to the family Gramineae, is the most important food in tropical and subtropical regions (Singh *et al*., 2012). It is grown in more than a hundred countries with a total area of about 160 million hectares, producing more than 700 million tons every year (IRRI, 2013). More than three billion people in the world are taking rice as their main food (IRRI, 2009). In Asia, more than 90% of all produced rice has been consumed (FAO, 2006). Rice contributes on an average 20% of apparent calorie intake of the world and 30% of Asian populations (Hien *et al*., 2006). In Bangladesh 10.4 million hectares of land is used for rice production which is about 84.67% of total cropped area, with annual production of 30.42 million tons (BBS, 2014). Bangladesh ranks 4th in both area and production and 6th in the production of per hectare yield of rice (Sarkar *et al*., 2016).

Rice is grown in Bangladesh in three distinct growing seasons namely *Aus*, *Aman* and *Boro* rice covers the area of 5.66 million hectares with a production of 13.3 million tons (AIS, 2012). According to FAO (2014) in Bangladesh, the average yield of rice is about 2.92 t ha^{-1} which is very low compared to other rice growing countries of the world, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}). The population of Bangladesh is increasing at an alarming rate and the cultivable land is decreasing due to urbanization and industrialization. The nation is still adding about 2.3 million people in every year to its total of 150 million (Momin and Husain, 2009). Thus, the population will swell progressively to 223 million by the year 2030 which will demand additional 48 million tons of food grains (Julfiquar *et al*., 2008). Population growth required a continuous increase in rice production in Bangladesh and the highest priority has been given to produce more rice (Bhuiyan, 2004). Rice production has to be increased at least 60% by 2020 to meet up food requirement of the increasing population (Masum, 2009).

Rice yields are either stagnating/declining in post green revolution era mainly due to different factors related to crop production (Prakash, 2010). The reasons for low productivity of rice includes various factors like erratic rainfall, drought, weed, insect pest diseases, unavailability of quality seeds, non adoption of recommended production and plant protection technology but the major reason attributed to prevalence of local varieties instead of high yielding rice varieties (Mandira, 2016). On the other hand due to the storage of land, the possibility of horizontal expansion of rice production area has come to a standstill for Bangladesh, so that the farmers and scientists are diverting their attention towards vertical expansion of rice production. Therefore, attempts should be taken to increase the rice yield from per unit area. For vertical expansion it is necessary to use of modern production technologies such as use of quality high yielding and hybrid varieties, optimum time of planting, appropriate number of seedling $hill^{-1}$, adopting proper plant protection measures, seedlings raising techniques, fertilizer management, and use of potential rice variety with high yielding and so on.

Generally, variety is the key component for producing higher yield of rice depending upon their differences in genotypic characters, input requirements and off course the prevailing environmental conditions during the entire growing season (Anonymous, 2003). In Bangladesh high yielding rice variety has been introduced through BRRI, BINA, IRRI and different seed companies and it gains positive monumentaion in rice production in three distinct growing seasons specific (Haque and Biswas, 2011). Improving and increasing the world's supply will also depend upon the development and improvement of rice varieties with better yield potential, and to adopt various conventional and biotechnological approaches for the development of high yielding varieties that having resistance against biotic and a biotic stresses (Khush, 2005). High yielding varieties typically yield 10 to 20% more than conventional varieties on similar soil due to the heterotic effect (Li *et al.*, 2009; Zhou *et al*., 2012).

High yielding varieties have higher yields but lower milling quality than conventional rice varieties (Lyman and Nalley, 2013). The growth process of rice plants under a given agro-climatic condition differs due to specific rice variety (Alam *et al*., 2012). Hybrid rice variety also showed high yield potentiality. Hossain and Deb (2003) reported that although farmers got about 16% yield advantage in the cultivation of hybrids compared to the popularly grown inbred varieties, the yield gains was not stable. Now a days different high yielding rice variety are available in Bangladesh which have more yield potential than conventional rice varieties (Akbar, 2004). During vegetative growth, high yielding rice variety accumulates more dry matter in the early and middle growth stages which results in more spikelets panicle^{-1}. They have bigger panicles and more spikelets panicle^{-1}. Very recently various new rice varieties was developed by BRRI and available as BRRI dhan and maximum of them is exceptionally high yield potentially. Compared with conventional cultivars, the high yielding varieties have larger panicles, heavier seeds, resulting in an average rice grain yield increase of 7.27% (Bhuiyan *et al*., 2014). This variety however, needs further evaluation under different adaptive condition to interact with different agro-climatic conditions.

Based on above proposition, this research work was designed for comparative study on growth and yield of different *Aman* rice varieties with the following specific objectives:

- To evaluate the tillering pattern, leaf area development and dry matter production of BRRI released different *Aman* rice varieties;
- To study the yield variation and its causes in afore-said rice varieties.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Rice is the staple food more than three billion people in the world and around ninety per cent of rice is grown and consumed in south and Southeast Asia, the highly populated area. Bangladesh produces different high yielding rice varieties and most of them have excellent production and eating quality for regular consumption. Most of the high yielding rice varieties of Bangladesh have been developed by IRRI, BRRI and BINA. Variety itself is the genetical factor which contributes a lot for producing yield and yield components. Different researcher reported the effect of rice varieties on yield contributing component and grain yield. However, some of the important and informative works and research findings related to the morpho-physiological attributes, yield contributing characters and yield of different rice varieties, so far been done at home and abroad, reviewed in this chapter under the following headings-

2.1 Plant height of different rice varieties

Jisan *et al*. (2014) carried out and experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of nitrogen. Data revealed that among the varieties, BRRI dhan52 produced the tallest plant (117.20 cm), whereas the lowest plant height by BRRI dhan57.

An experiment was conducted by Haque and Biswash (2014) with five varieties of hybrid rice and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties was Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks was BRRI dhan28 and BRRI dhan29 and the highest plant height was 101.5 cm was recorded from BRRI dhan28 and the lowest plant height from Richer (82.5 cm).

Bhuiyan *et al.* (2014) carried out an experiment with aimed to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of plant growth. Based on the findings of the study it was revealed that the different hybrid rice varieties had significant effects on plant height at maturity.

To study the effect of nitrogen fertilizer and seedling age on Giza 178, H1 and Sakha 101 field experiments was conducted by Salem *et al.* (2011) at the Rice Research and Training Center (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt during summer seasons. The results indicated that Sakha 101 variety surpassed than other varieties in terms of plant height.

Khalifa (2009) conducted a field experiment at the experimental farm of Rice research and training centre (RRTC), Sakha, Kafr-El sheikh governorate, Egypt rice season for physiological evaluation of some hybrid rice varieties under different sowing dates. Four hybrid rice H_1, H_2, GZ 6522 and GZ 6903 was evaluated at six different sowing dates. Results indicated that H_1 hybrid rice variety surpassed other varieties in terms of plant height.

Masum *et al.* (2008) observed that plant height of rice affected by varieties in *Aman* season where Nizershail produced the taller plant height than BRRI dhan44 at different days after transplanting (DAT).

Mandavi *et al.* (2004) found from their experiment that plant height was negatively correlated with grain yield. Thus, in improved genotypes, plant height was not a limiting factor for grain yield because of reduced lodging and conducted better translocation of assimilates.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes namely Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and the findings revealed that the variety Mukti gave the longest plant compared to the others of their experiment.

Ghosh (2001) carried out an experiment with four rice hybrids and four high yielding rice cultivars and concluded that hybrids have higher plant height as compared with high yielding varieties. Pruneddu and Spanu (2001) conducted an experiment and found that plant height ranged from less than 65 cm to 80–85 cm in Mirto, Tejo, Gladio, Lamone and Timo.

Chen-Liang *et al.* (2000) reported that the cross between Peiai 64s and the new plant type lines had longest plant height compared to the others. On the other hand, Xu and Li (1998) observed that the maintainer lines was generally shorter than restorer line.

An experiment was carried out at Anonymous (1998) to find out varietal performance of advance line (BINA 8-110-2-6) along with three check varieties - Iratom 24, BR26 and BRRI Dhan27. The result indicated that BINA 8-110-2-6 appeared similar to BRRI Dhan27 in terms of plant height.

Munoz *et al.* (1996) observed that IR8025A hybrid rice cultivar produced 16% longer plant than the commercial variety Oryzica Yacu-9. Anonymous (1993) evaluated the performance of four rice varieties (IRAATOM 24, BR14, BINA13 and BINA19) and the findings revealed that the varieties differed significantly in respect of plant height of rice.

It was recorded that the plant height differed significantly among BR3, BR11, BR14, Pajam and Zagali varieties in the *Boro* season (Anon., 1991). Hosain and Alam (1991) found that the plant height in modern rice varieties BR3, BR11, BR14 and Pajam was 90.4, 94.5, 81.3 and 100.7 cm, respectively.

Miah *et al.* (1990) conducted an experiment where rice cv. Nizersail and mutant lines Mutant NSI and Mutant NSS was planted and found that plant height was greater in Mutant NSI than Nizersail. Shamsuddin *et al.* (1988) conducted a field trial with nine different rice varieties and observed that plant height differed significantly among the varieties tested.

2.2 Tillering pattern of different rice varieties

Sarkar *et al.* (2016) carried out an experiment to evaluate the performance of five hybrid rice varieties namely Shakti 2, Suborna 8, Tia, Aloron and BRRI hybrid dhan 2 in *Aman* season with an inbred BRRI dhan33 as checked. The result showed that the hybrid varieties exhibited superiority in respect of tillers hill^{-1} and these hybrid varieties showed higher effective tillers hill^{-1}.

Haque and Biswash (2014) experimented with five varieties of hybrid rice which was collected from different private seed companies and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties were Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks was BRRI dhan28 and BRRI dhan29. In case of no. of effective tillers, Hira showed the best performance (17.7) and Sonarbangla-1 showed the least performance (13.3).

Bhuiyan *et al*. (2014) conducted an experiment with aimed to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had significant effects on number of tillers, number of productive tillers. RGBU010A × SL8R is therefore recommended as planting material among hybrid rice varieties because it produced more productive tillers.

Jisan *et al*. (2014) carried out and experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of N. Among the varieties, BRRI dhan52 produced the highest number of effective tillers hill^{-1} (11.28), while the lowest values of these parameters were produced by BRRI dhan57.

A field experiment was conducted by Khalifa (2009) at the experimental farm of Rice research and training centre (RRTC), Sakha, kafr-El sheikh governorate, Egypt for physiological evaluation of some hybrid rice varieties under different sowing dates. Four hybrid rice H_1, H_2, GZ 6522 and GZ 6903 was evaluated at six different sowing dates. Results indicated that H_1 hybrid rice variety surpassed other varieties in consideration of effective and total tillers hill^{-1}.

Masum *et al*. (2008) stated that number of total tillers hill^{-1} was significantly influenced by cultivars at all stages of crop growth. Nizersail was achieved maximum (25.63) tiller at 45 DAT, then with advancement to age it declined up to maturity, whereas in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and observed that Mukti gave the highest tillers hill^{-1} compared to the others. Song *et al.* (2004) found that hybrids produced a significantly higher number of tillers than their parental species and Minghui-63 had the least number of tillers.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4/m^2) than other tested varieties.

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

Islam (1995) in an experiment with four rice cultivars *viz*. BR10, BR11, BR22 and BR23 found that the highest number of non bearing tillers hill^{-1} was produced by cultivar BR11 and the lowest number by BR10. Chowdhury *et al.* (1993) reported that the cultivar BR23 showed superior performance over Pajam in respect of number of productive tillers hill^{-1}.

2.3 Dry matter content of different rice varieties

Sarkar *et al.* (2016) carried out an experiment to evaluate the performance of five hybrid rice varieties namely Shakti 2, Suborna 8, Tia, Aloron and BRRI hybrid dhan 2 in *Aman* season with an inbred BRRI dhan33 as checked. The result showed that the hybrid varieties exhibited superiority in respect of total dry matter (TMD) $hill^{-1}$ and the highest TDM $hill^{-1}$ (84.0 g) was observed Tia and lowest TDM $hill^{-1}$ (70.10 g) was observed in BRRI dhan33.

Field experiments were conducted by Haque *et al.* (2015) including two popular indica hybrids (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrids accumulated higher amount of biomass before heading and exhibited greater remobilization of assimilates to the grain in early plantings compared to the inbred variety.

In order to evaluate the response to planting date in rice hybrids line dry method of working, was carried out by Shaloie *et al.* (2014) at the Agricultural Research Station, Agriculture and Natural Resources Research Center of Khuzestan Shavuor. Hybrid rice Hb2 and Hb1 was used in the sub plots. Results showed traits was significantly affected in terms of dry matter and mentioned trait was more in hybrid Hb_2 than Hb_1.

Xie *et al.* (2007) found that Shanyou-63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}). Masum *et al.* (2008) found that total dry matter production differed due to varieties. Total dry matter of BRRI dhan44 Nizershail significantly varied at different sampling dates.

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

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

Mandavi *et al.* (2004) carried out an experiment to study on the morphological and physiological indicators of rice genotypes, a field experiment was conducted at the Rice Research Institute of Iran. In that study, Onda had the greater total dry matter (TDM) among other genotypes (this genotype also had the highest grain yield). Higher TDM was obtained from improved genotype than traditional genotypes (1445 and 1626 GDD, respectively). At flowering the dry matter weight was higher for Jasesh and was lower for Ramazan Ali Tarom (923.93 g m^{-2} and 429 g m^{-2}, respectively). So the photosynthetic potential of improved genotypes was higher as reflected by their TDM which had positive correlation with grain yield.

Sharma and Haloi (2001) conducted an experiment in Assam during the kharif season with 12 varieties of scented rice cultivars and observed that cv. Kunkuni Joha consistently maintained a higher rate of dry matter production at all growth stages and the highest dry matter accumulation at the panicle initiation stage.

Evans and Fisher (1999) reported that achieving higher yield depends on increasing total crop biomass, because there is little scope to further increase the proportion of that biomass allocated to grain.

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

2.4 Yield attributes of different rice varieties

Sarkar *et al.* (2016) carried out an experiment to evaluate the performance of five hybrid rice varieties namely Shakti 2, Suborna 8, Tia, Aloron and BRRI hybrid dhan2 in *Aman* season with an inbred BRRI dhan33 as checked and these hybrid varieties also showed higher 1000-grain over the inbred.

Dou *et al.* (2016) carried out an experiment with the objective to determine the effects of water regime/soil condition (continuous flooding, saturated, and aerobic), cultivar ('Cocodrie' and 'Rondo'), and soil texture (clay and sandy loam) on rice grain yield, yield components and water productivity using a greenhouse trial. The spikelet number of Cocodrie was 29% greater than that of Rondo, indicating that rice cultivar had greater effect on spikelet number. Results indicated that cultivar selection is an important factors in deciding what water management option to practice.

Field experiments were conducted by Haque *et al.* (2015) including two popular indica hybrids (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Filled grain (%) declined significantly at delayed planting in the hybrids compared to elite inbred due to increased temperature impaired inefficient transport of assimilates.

An experiment was conducted by Hosain *et al.* (2014) at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during *Aus* season to observe the effect of transplanting dates on the yield and yield attributes of exotic hybrid rice varieties. The experiment comprised of three rice varieties (two hybrids-Heera2, Aloron and one inbred- BRRI dhan48). Hybrid varieties Heera2 (3.03 t ha^{-1}) and Aloron (2.77 t ha^{-1}) gave the higher spikelet sterility.

Haque and Biswash (2014) experimented with five varieties of hybrid rice which was collected from different private seed companies and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties were Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two

checks were BRRI dhan28 and BRRI dhan29. In panicle length status, Richer showed the best performance (27.7 cm) while BRRI dhan28 showed the least performance (26 cm). Number of filled grains panicle^{-1} was the highest for BRRI dhan29 (163.3), whereas, Jagoron only 118. Number of total grains was highest in BRRI dhan29 (201.7) and for Jagoron it was only 133.7. On the other hand, for 1000-grain weight, Aloron was the best than other hybrids.

Bhuiyan *et al*. (2014) conducted an experiment with aimed to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had significant effects on number of filled and unfilled grains, length of panicle and yield. RGBU010A × SL8R is therefore recommended as planting material among hybrid rice varieties because it produced longer panicles and heavy seeds. In the absence of this variety, RGBU02A × SL8R, RGBU003A × SL8R and RGBU0132A × SL8R may also be used as planting material.

In order to evaluate the response to planting date in rice hybrids Line dry method of working, was carried out by Shaloie *et al.* (2014) at the Agricultural Research Station, Agriculture and Natural Resources Research Center of Khuzestan Shavuor. Hybrid rice Hb2 and Hb1 was used in the sub plots. Results showed traits was significantly affected in terms of panicle length, fertility percentage, and mentioned traits was more in hybrid Hb_2 than Hb_1.

Jisan *et al*. (2014) carried out and experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of N. Data revealed that variety exerted significant influence on yield contributing characters. Among the varieties, BRRI dhan52 produced the grains panicle^{-1}

(121.5) and 1000-grain weight (23.65 g), whereas the lowest values of these parameters was produced by BRRI dhan57.

Forty five aromatic rice genotypes were evaluated by Fatema *et al*. (2011) to assess the genetic variability and diversity on the basis of nine characters. Significant variations were observed among the genotypes for all the characters. Thousand grain weight have been found to contribute maximum towards genetic diversity in 45 genotypes of aromatic rice.

Two field experiments was conducted by Salem *et al*. (2011) at the Rice Research and Training Center (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt during summer seasons to study the effect of nitrogen fertilizer and seedling age on Giza 178, H1 and Sakha 101. The results indicated that Sakha 101 variety surpassed than other varieties in terms of 1000 seeds weight.

Islam *et al.* (2010) studied yield potential of 16 rice genotypes including 12 hybrids, 3 inbreds and 1 New Plant Type (NPT) at the International Rice Research Institute (IRRI) farm under optimum crop management to achieve maximum attainable yield during the wet season (WS) of 2004 and dry season (DS) of 2005. Yield and yield components was determined at maturity. Hybrid produced higher spikelets panicle^{-1} and 1000-grain weight than inbred rice. Spikelet filling percent was higher in inbred than hybrid rice. The NPT rice genotype had the lowest spikelet filling percent, but the highest 1000-grain weight across the season.

A field experiment was conducted by Khalifa (2009) at the experimental farm of Rice research and training centre (RRTC), Sakha, kafr-El sheikh governorate, Egypt rice season for physiological evaluation of some hybrid rice varieties under different sowing dates. Four hybrid rice H_1, H_2, GZ 6522 and GZ 6903 was evaluated at six different sowing dates. Results indicated that H_1 hybrid rice variety surpassed other varieties for studied characters except for number of days to panicle initiation and heading date.

Islam *et al.* (2009) conducted pot experiments during T. *Aman* season in net house at Bangladesh Rice Research Institute (BRRI). Hybrid variety Sonarbangla-1 and inbred modern variety BRRI dhan31 was used in both the seasons. BRRI dhan3l had higher panicles plant^{-1} than Sonarbangla-1, but Sonarbangla-1 had higher number of grains panicle^{-1}, 1000-grain weight.

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

Myung (2005) worked with four different panicle types of rice varieties and observed that the primary rachis branches (PRBs) panicle^{-1} and grains was more on Sindongjinbyeo and Iksan467 varieties, but secondary rachis branches (SRBs) was fewer than in Dongjin1 and Saegyehwa varieties.

Chaturvedi *et al.* (2004) evaluated newly released commercial rice hybrids (DRRH 1, PHB 71, Pro-Agro 6201, KHR 2, ADTHR 1, UPHR 1010 and Pant Sankar Dhan 1) and two high yielding varieties as checks (Pant Dhan 4 and Pant Dhan 12) for their agronomic and morpho-physiological traits in a field experiment. Hybrids although could not excel the best HYV owing to high percentage of spikelet sterility but they showed potential for higher yield as these produced large sink (higher number of spikelets m^{-2}).

Obulamma *et al.* (2004) recorded hybrid APHR 2 significantly higher grain yield than hybrid DRRH 1. The increased grain yield was due to increase in number of panicles m^{-2} and number of filled grain panicle^{-1} in hybrid APHR 2 than hybrid DRRH 1.

Guilani *et al*. (2003) carried out an experiment on crop yield and yield components of rice cultivars (Anboori, Champa and LD183) in Khusestan, Iran. They observed that grain number panicle^{-1} was not significantly different among cultivars. The highest grain number panicle^{-1} was obtained with Anboori. Grain fertility percentages were different among cultivars. Among cultivars, LD183 had the highest grain weight.

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

Anonymous (1994) studied the performance of BR14, BR5, Pajam, and Tulsimala and reported that Tulsimala produced the highest number of filled grains panicle^{-1} and BR14 the lowest.

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

Anonymous (1991) reported that the filled grains panicle^{-1} of different modern varieties was 95-100 in BR3, 125 in BR4 , 120-130 in BR22 and 110-120 in BR23 when they was cultivated in the *Aman* season. Idris and Matin (1990) also observed that panicle length differed among the six rice varieties and it was longer in IR20 than in indigenous high yielding varieties.

2.5 Yield of different rice varieties

Yield test of 41 entries, 32 new hybrids, 8 male parents restore lines and 1 inbred variety, was conducted by Huang and Yan (2016) on the farm of University of Arkansas at Pine Bluff (UAPB). Results showed that the yields of 7 hybrids were 25.7%-30.7% higher than check Francis. Hybrid 28s/BP23R had the highest yield, 10846.6 kg/hectare and over check by 30.7%. The yield of hybrid 28s/PB-24, was 10628.9 kg/hectare and over check by 28.1%. The yields of hybrid 28s/PB-22 and 33A/PB24 were 10549.8 and 10539.8 kg/hectare and over check by 27.1% and 27.0%, respectively.

Sarkar *et al.* (2016) carried out an experiment to evaluate the performance of five hybrid rice varieties namely Shakti 2, Suborna 8, Tia, Aloron and BRRI hybrid dhan 2 in *Aman* season with an inbred BRRI dhan33 as checked. The highest grain yield was achieved from Tia (7.82 t ha^{-1}), which was closely followed by Shakti 2 (7.65 t ha^{-1}). These two hybrid varieties produced 24.0% higher yield over the inbred BRRI dhan33.

A study was conducted by Mandira *et al.* (2016) in South Tripura district of Tripura for three consecutive kharif seasons to evaluate the performance of rice variety gomati at farmers field under rainfed conditions. The gomati variety of rice was found superior over farmers' existing practices with local varieties. Rice variety gomati with improved production technologies followed in FLDs, increased mean grain yield by 41.62% over farmers' existing practices with only Rs. 1817 ha-1 extra expenditure on inputs.

A study was design by Wagan *et al.* (2015) to compare the economic performance of hybrid and conventional rice production and reported that total costs per hectare of hybrid rice was 148992.23 Rs per hectare which was more then conventional rice was 140661.68 Rs per hectare. On an average higher yield (196.14 monds per hectare) was obtained from hybrid rice while conventional rice yield (140.14 monds per hectare) was less then hybrid rice. There was 16.64

percent increase in hybrid rice yield comparing with conventional rice which gives additional income to poor farmers.

Field experiments were conducted by Haque *et al.* (2015) including 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. Results suggest that greater remobilization of shoot reserves to the grain rendered higher yield of hybrid rice varieties.

Kanfany *et al*. (2014) conducted an experiment by at the Africa Rice Sahel Regional Station during two wet seasons with the aim of assessing the performances of introduced hybrid cultivars along with an inbred check cultivar under low input fertilizer levels. There were significant cultivar effects for all traits. The grain yield of rice hybrids (bred by the International Rice Research Institute) was not significantly higher than that of the check cultivar widely grown in Senegal.

An experiment was conducted by Hosain *et al*. (2014) at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during *Aus* season (March to July 2010) to observe the effect of transplanting dates on the yield and yield attributes of exotic hybrid rice varieties. The experiment comprised of three rice varieties (two hybrids-Heera2, Aloron and one inbred- BRRI dhan48). BRRI dhan48 produced the highest grain yield (3.51 t ha^{-1}).

Jisan *et al*. (2014) carried out and experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh wit h a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of N. Data revealed that highest grain yield (5.69 t ha^{-1}) was obtained from BRRI dhan52

followed by BRRI dhan49 (5.15 t ha^{-1}) and the lowest one (4.25 t ha^{-1}) was obtained from BRRI dhan57.

Bhuiyan *et al.* (2014) conducted an experiment with aimed to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Findings revealed that different hybrid rice varieties had significant effects on yield. RGBU010A × SL8R is therefore recommended as planting material among hybrid rice varieties because it produced favorable yield.

Haque and Biswash (2014) experimented with five varieties of hybrid rice which was collected from different private seed companies and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties were Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks were BRRI dhan28 and BRRI dhan29. In case of biological yield (g), BRRI dhan29 showed highest yield (49.6 g) and Hira only 18 g.

An experiment was carried out by Alam *et al.* (2012) at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the kharif season to study the effect of variety, spacing and number of seedlings $hill^{-1}$ on the yield potentials of transplant *Aman* rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings $hill^{-1}$ viz. 2 seedlings $hill^{-1}$, 3 seedlings $hill^{-1}$, 4 seedlings $hill^{-1}$ and 5 seedlings $hill^{-1}$. Variety had significant effects on almost all the yield component characters and yield. Variety BR11 produced the highest grain yield (5.92 t ha^{-1}).

Samonte *et al.* (2011) reported that the two elite lines recommended for release are high yielding in Texas. RU0703190 is also very early maturing conventional long grain rice. The high yield potential of these new releases will impact grain production of rice farmers and their income.

Tabien and Samonte (2007) observed that several elite lines at the multi-state trials had high yield potential relative to the check varieties and these can be released as new varieties after series of yield trials. With improved yield, the new varieties are expected to increase rice production. The elite lines generated are also potential germplasm for rice improvement projects. The initial effort to identify high biomass rice will enhance the development of dedicated feedstock for bioenergy production.

Swain *et al.* (2006) reported from their experiment that the control cultivar IR64, with high translocation efficiency and 1000-grain weight and the lowest spikelet sterility recorded a grain yield of 5.6 t ha^{-1} that was statistically similar to the hybrid line PA6201.

Several *indica/japonica* (I/J) lines was screened and evaluated by Roy (2006) for higher grain yield in the *Boro* season. The highest grain yield of 9.2 t ha^{-1} was obtained from selected I/J line IR58565-2B-12-2-2, which was equal to that of indica hybrid CNHR3 and significantly higher than that of modern variety IR36.

Molla (2001) reported that Pro-Agro6201 (hybrid) had a significant higher yield than IET4786 (HYV), due to more mature panicles m^{-2}, higher number of filled grains $panicle^{-1}$ and greater seed weight.

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

Julfiquar *et al.* (1998) reported that BRRI evaluated 23 hybrids along with three standard checks during *Boro* season. It was reported that five hybrids (IR58025A/IR54056, IR54883, PMS8A/IR46R) out yielded the check varieties (BR14 and BR16) with significant yield difference. Two hybrids out yielded the check variety of same duration yielded by more than 1 t ha^{-1}.

Kamal *et al.* (1998) conducted an experiment to assess the yield of 9 modern varieties (MV) and 6 local improved varieties (LIV) and observed that modern variety BR11 gave the highest grain yield followed by BR10, BR23, Binasail and BR4.

Chowdhury (1997) undertook a research on BINA-19, BR14, BR3 and Iratom-24 varieties with different methods of transplanting. He found that the yields for BINA-19, BR14, BR3 and Iratom-24 was 6.49 t ha^{-1}, 6.22 t ha^{-1}, 6.22 t ha^{-1}, 5.75 t ha^{-1} and 5.60 t ha^{-1}, respectively.

Nematzadeh *et al.* (1997) reported that local high quality rice cultivars Hassan Sarai and Sang-Tarom was crossed with improved high yielding cultivars Amol 3, PND160-2-1 and RNR1446 in all possible combinations and released in 1996 under the name Nemat, which gave an average grain yield of 8 t ha^{-1}, twice as much as local cultivars.

Radhakrisna *et al.* (1996) conducted a trial at Mamdya, Karnataka and found that hybrid cultivar KRH-2 gave an average yield of 9.3 t ha^{-1} with an yield advantage of 1.5 t ha^{-1} over the best check variety Jaya.

Anonymous (1995) conducted an experiment to find out varietal performances of BR4, BR10, BR11, BR22, BR23 and BR25 varieties including two local check Challish and Nizersail, produced yields of 4.38, 3.18, 3.12, 3.12 and 2.70 5 t ha^{-1}, respectively.

Chowdhury *et al.* (1995) studied seven varieties of rice, of which three was native (Maloti, Nizersail and Chandrashail) and four was improved (BR3, BR11, Pasam and Mala). Straw and grain yields was recorded and found that both the grain and straw yields were higher in the improved than the native varieties. Liu (1995) conducted a field trial with new indica hybrid rice You 92 and found an average yield of 7.5 t ha^{-1} which was 10% higher than that of standard hybrid Shanyou 64.

Leenakumari *et al.* (1993) evaluated eleven hybrid cultivars against four standard check varieties-Jaya, Rasi, IR20 and Margala. They concluded that hybrid cultivar OR 1002 gave the highest yield of 7.9 t ha^{-1} followed by the hybrid cultivar OR 1001 (6.2 t ha^{-1}). Among the control varieties, Jaya gave the highest yield (8.4 t ha^{-1}). Among the cv. BR22 gave the highest grain yield from most of the sowing dates for both of the years (Ali *et al*., 1993).

Chowdhury *et al*. (1993) reported that the cultivar BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. grain yield straw yield.

Suprihatno and Sutaryo (1992) conducted an experiment with seven IRRI hybrids and 13 Indonesian hybrids using IR64 and way-seputih. They observed that TR64 was highest yielding, significantly out yielding IR64616H, IR64618, IR64610H and IR62829A/IR54 which in turn out yielded way-seputih.

Chandra *et al.* (1992) reported that hybrid IR58025A out yielded the IR62829A hybrids and the three control varieties Jaya, IR36 and hybrids IR58025A x 9761-191R and IR58025A IR58025A x 1R35366-62-1-2-2-3R.

Hossain and Alam (1991) conducted an experiment on farmers production technology in haor area and found that the grain yield of modern rice varieties of *Boro* rice was 2.12, 2.18, 3.17, 2.27 and 3.05 t ha^{-1}, with BR14, BR11, BR9, IR8 and BR3, respectively.

From the above cited literature, it is observed that varieties have a significant influence on yield attributes and yield of rice. The literature suggests that different rice variety produced different yield attributes and rice and suitable variety increases the grain yield of rice. It was revealed that the grain yield is mainly attributed by the increases of number of tiller $hill^{-1}$, grains $panicle^{-1,}$ panicle length, 1000-grains weight and other yield attributes due to variety itself in different environmental condition.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted for the comparative study on morphological characteristics and yield of different *Aman* rice varieties. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials that was used for the experiment, treatment and design of the experiment, growing of crops, data collection procedure and procedure of data analysis that followed in this experiment has been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted at the period of July to November 2016.

3.1.2 Experimental location

The present research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

3.1.3 Soil characteristics

The soil belonged to "The Modhupur Tract", AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.2 and had organic carbon 0.43%. The experimental area was flat having available irrigation and drainage system and above flood level. The details have been presented in Appendix II.

3.1.4 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic condition is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-

monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment has been presented in Appendix III.

3.2 Experimental details

3.2.1 Treatment of the experiment

The experiment comprised of different *Aman* rice varieties which were used as treatment for the experiment and they was as follows.

i. V_1: BRRI dhan32

ii. V_2: BRRI dhan33

iii. V_3: BRRI dhan34

iv. V_4: BRRI dhan39

v. V_5: BRRI dhan54

vi. V_6: BRRI dhan56

vii. V_7: BRRI dhan57

viii. V_8: BRRI dhan62

3.2.2 Description of rice varieties

BRRI dhan32

BARI dhan32 is a modern rice variety developed by BRRI in 1994 through crossing BR4/BR2662 and its growth duration is about 130 days. It is recommended for *Aman* seasons. On an average, BRRI dhan32 produce yield of 5.0 t ha^{-1} and plant height is about 120 cm. Its grain is medium, coarse and white the panicle remains above the flag leaf at flowering stage.

BRRI dhan33

BARI dhan33 is a modern rice variety developed by BRRI in 1997 through crossing BG388/BG367-4 and its growth duration is about 118 days. It is

recommended for *Aman* seasons. On an average, BRRI dhan33 produce yield of 4.5 t ha^{-1} and plant height is about 100 cm. Its grain is short, coarse, white and it is a early variety.

BRRI dhan34

BARI dhan34 is a modern rice variety developed by BRRI in 1997 through a selection process from parentage Khaskani and its growth duration is about 135 days. It is recommended for *Aman* seasons. On an average, BRRI dhan34 produce yield of 3.5 t ha^{-1} and plant height is about 117 cm. Its grain is short, coarse, scented.

BRRI dhan39

BARI dhan39 is a modern rice variety developed by BRRI in 1999 through crossing BR1185-2B-56-2-1-1/BR1674-28-3-1-1/BR2558-7-32-2 and its growth duration is about 120 days. It is recommended for *Aman* seasons. On an average, BRRI dhan39 produce yield of 4.5 t ha^{-1} and plant height is about 106 cm. Its grain is long and fine.

BRRI dhan54

BARI dhan54 is a modern rice variety developed by BRRI in 2010 for coastal area saline soil and other area. Its growth duration is about 135 days. It is recommended for *Aman* seasons. On an average, BRRI dhan54 produce yield of 5.5 t ha^{-1} and plant height is about 115 cm. Its grain is medium and coarse.

BRRI dhan56

BARI dhan56 is a modern rice variety developed by BRRI in 2011 through crossing IR55419 and WAY RAREM (a drought tolerant local variety) and its growth duration is about 105-110 days. It is recommended for *Aman* seasons. On an average, BRRI dhan56 produce yield of 4.5-5.0 t ha^{-1} and plant height is about 115 cm. Its grain is long and coarse and white.

BRRI dhan57

BARI dhan57 is a modern rice variety developed by BRRI in 2011 through crossing 'INGER' line and CR146-7027-224 and its growth duration is about 100-105 days. It is recommended for *Aman* seasons. On an average, BRRI dhan57 produce yield of 4.0-4.5 t ha^{-1} and plant height is about 110-115 cm. Its grain is long and fine and it is a early variety.

BRRI dhan62

BARI dhan62 is a modern rice variety developed by BRRI in 2013 through crossing Jirakateri and BRRI dhan39 and its growth duration is about 100 days. It is recommended for *Aman* seasons. On an average, BRRI dhan62 produce yield of 3.5-4.0 t ha^{-1} and plant height is about 98 cm. Its grain is long, fine and white and it is a early variety.

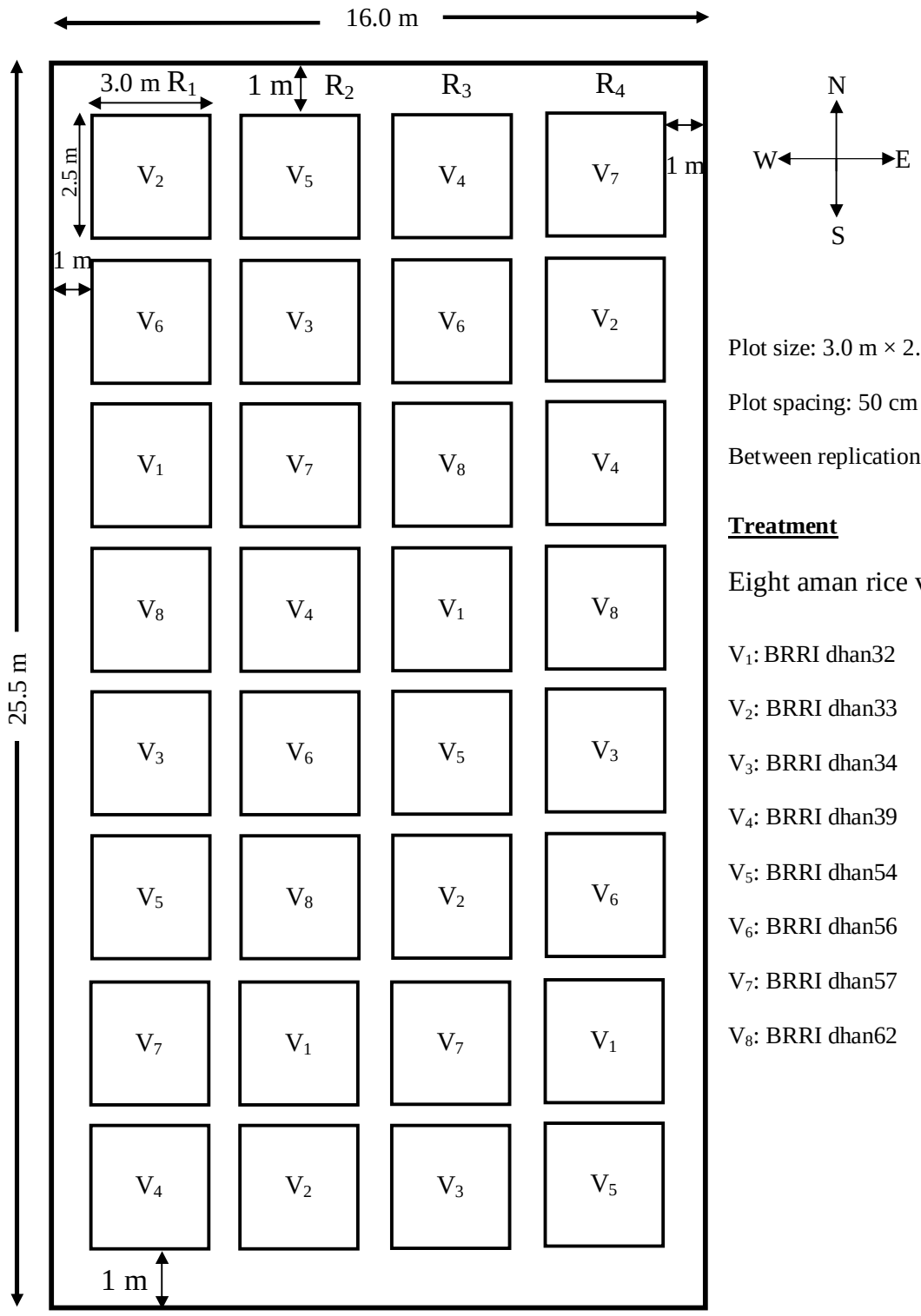
3.2.3 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with four replications, where the experimental area was divided into four blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into 8 unit plots as treatments demarked with raised bunds. Thus the total numbers of plots was 32. The unit plot size was 3.0 m × 2.5 m. The distance maintained between two blocks and two plots was 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur and local market just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds was immersed in water in a bucket for 24 hours. The imbibed seeds was then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which was suitable for sowing in 72 hours.



Plot size: 3.0 m × 2.5 m

Plot spacing: 50 cm

Between replication: 1.0 m

Treatment

Eight aman rice varieties:

V_1: BRRI dhan32

V_2: BRRI dhan33

V_3: BRRI dhan34

V_4: BRRI dhan39

V_5: BRRI dhan54

V_6: BRRI dhan56

V_7: BRRI dhan57

V_8: BRRI dhan62

Figure 1. Layout of the experimental plot

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds as uniformly as possible. Irrigation was gently provided to the bed and when needed to bring favorable condition for seedling growth. No fertilizer was used in the nursery bed. Seeds were sawn at 22th July, 2016 in the seed beds.

3.3.3 Land preparation

The plot selected for conducting the experiment was ploughed in the 10th August 2016 with a power tiller, and left exposed to the sun for a week. After three days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below in 2.3.4 were mixed with the soil of each unit plot.

3.3.4 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MoP, Gypsum, zinc sulphate and borax, respectively was applied @ 80 kg, 60 kg, 90 kg, 12 kg, 2.0 kg and 10 kg (Anon., 2013). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax was applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages.

3.3.5 Transplanting of seedling

Twenty seven days old seedlings was carefully uprooted from the seedling nursery and transplanted on 17th August, 2016 in well puddled plot. Two seedlings were transplanted in each hill. After one week of transplanting all plots was checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.3.6.1 Irrigation and drainage

In the early stages to establishment of the seedlings irrigation was provided to maintain a constant level of standing water upto 6 cm and then maintained the amount drying and wetting system throughout the entire vegetative phase. No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

3.3.6.2 Weeding

Weedings was done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds was uprooted carefully at 30 DAT (days after transplanting) and 60 DAT by mechanical means.

3.3.6.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity based on variety when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw was recorded plot wise. The grains was dried, cleaned and weighed for individual plot. The weight was adjusted to a moisture content of 14%. Yields of rice grain and straw was recorded from each plot and converted to hectare yield and expressed in t ha^{-1}.

3.5 Data collection

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at 15, 30, 45, 60, 75 DAT and at harvest. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

3.5.2 Number of tillers hill^{-1}

Number of tillers hill^{1} was recorded at 15, 30, 45, 60 and 75 DAT. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.5.3 Leaf area index

Leaf area index (LAI) measured manually at the time of 15, 30, 45, 60 and 75 DAT. Data was recorded as the average of 5 plants selected at random the inner rows of each plots. The final data calculated multiplying by a correction factor 0.75 as per Yoshida (1981).

3.5.4 Total dry matter hill^{-1}

Total dry matter hill^{-1} was recorded at 15, 30, 45, 60 and 75 DAT by drying plant sample. Data was recorded as the average of 5 sample hill^{-1} collected at random from the inner rows of each plot and expressed in gram (g).

3.5.5 Days to panicle initiation

Days to panicle initiation was recorded by counting the number of days required to starting of 1st initiation of panicle in each plot.

3.5.6 Days to maturity

Days to maturity was recorded by counting the number of days required to harvest in each plot.

3.5.7 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} was counted from 5 selected hills and average value was recorded.

3.5.8 Ineffective tillers hill^{-1}

The total number of ineffective tiller hill^{-1} was counted as the number of non-panicle bearing tiller during harvesting. Data on ineffective tiller hill^{-1} was counted from 5 selected hills and average value was recorded.

3.5.9 Panicle length

The length of panicle was measured with a meter scale from 5 selected panicles and the average length was recorded as per panicle in cm.

3.5.10 Filled grains panicle^{-1}

The total numbers of filled grain was collected randomly from selected 5 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

3.5.11 Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 5 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

3.5.12 Total grains panicle^{-1}

The total numbers of grain was collected randomly from selected 5 plants of a plot by adding filled and unfilled grain and then average numbers of grains panicle^{-1} was recorded.

3.5.13 Weight of 1000-grain

One thousand grains was counted randomly from the total cleaned harvested grains and then weighed in grams and recorded.

3.5.14 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of each plot was taken the final grain yield plot^{-1} and finally converted to ton hectare^{-1} (t ha^{-1}).

3.5.15 Straw yield

Straw obtained from each unit plot was sun-dried and weighed carefully. The dry weight of straw from each plot and finally converted to ton hectare^{-1} (t ha^{-1}).

3.5.16 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.5.17 Harvest index

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

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

3.6 Statistical analysis

The data obtained for different characters was statistically analyzed to observe the significant difference among different varieties of *Aman* rice. The mean values of all the characters were calculated and analysis of variance was performed by using MSTAT-C software. The significance of the difference among the means values of different varieties of rice was estimated by the Least Significant Difference (LSD) Test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted for the comparative study on morphological characteristics and yield of different *Aman* rice varieties. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix IV-IX. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Statistically significant variation was recorded for plant height of different rice varieties at 15, 30, 45, 60 and 75 days after transplanting (DAT) and at harvest (Appendix IV). Data revealed that at 15, 30, 45, 60 and 75 DAT and at harvest, the tallest plant (26.00, 54.10, 77.96, 92.88, 116.00 and 122.68 cm, respectively) was recorded from BRRI dhan32 which was statistically similar (25.55, 52.19, 74.89, 90.97, 114.35 and 119.63 cm, respectively) to BRRI dhan34, whereas the shortest plant (21.97, 42.84, 65.32, 75.42, 101.00 and 101.88 cm, respectively) was recorded from BRRI dhan62 (Table 1). Data revealed that at different days after transplanting of rice seedling of rice variety produced different plant height under the present experiment. Varieties produced different plant height on the basis of their varietal characters and also genetical influences but environmental and different management practices also influences different growth parameters as well as plant height. Masum *et al*. (2008) observed that plant height of rice affected by varieties in *Aman* season where Nizershail produced the taller plant height than BRRI dhan44 at different days after transplanting (DAT). Jisan *et al*. (2014) reported that BRRI dhan52 produced the tallest plant (117.20 cm), whereas the lowest plant height by BRRI dhan57 from their experiment that was conducted with rice variety dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57. Haque and Biswash (2014) also found the highest plant height was 101.5 cm from BRRI dhan28 and the lowest plant height from Richer (82.5 cm).

Table 1. Plant height at different days after transplanting and harvest for different rice varieties in *Aman* season

Rice Variety	Plant height (cm) at					
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
BRRI dhan32	26.00 a	54.10 a	77.96 a	92.88 a	116.00 a	122.68 a
BRRI dhan33	22.11 c	44.15 de	67.82 bc	77.16 c	101.26 c	102.09 c
BRRI dhan34	25.55 ab	52.19 ab	74.89 ab	90.97 a	114.35 a	119.63 a
BRRI dhan39	22.86 bc	46.18 cde	68.74 bc	80.65 bc	105.58 bc	108.21 bc
BRRI dhan54	23.97 abc	47.90 cd	72.35 abc	87.59 ab	110.56 ab	115.94 ab
BRRI dhan56	24.33 abc	49.18 bc	73.14 ab	88.65 a	111.34 ab	116.23 ab
BRRI dhan57	23.28 abc	46.63 cde	70.91 abc	86.24 ab	109.99 ab	113.04 ab
BRRI dhan62	21.97 c	42.84 e	65.32 c	75.42 c	101.00 c	101.88 c
$LSD_{(0.05)}$	2.696	3.657	6.868	6.714	7.500	9.160
Level of significance	0.05	0.01	0.05	0.01	0.01	0.01
CV(%)	7.72	5.19	6.54	5.38	4.69	5.54

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} showed statistically significant variation due to different rice varieties at 15, 30, 45, 60 and 75 days after transplanting (DAT) and at harvest (Appendix V). The maximum number of tillers hill^{-1} at 15, 30, 45, 60 and 75 DAT and at harvest (4.00, 9.10, 15.50, 17.15, 17.80 and 18.55, respectively) was recorded from BRRI dhan54 which was statistically similar (3.95, 8.90, 15.00, 15.95, 16.80 and 17.60, respectively) to BRRI dhan32, whereas the minimum number (3.10, 6.95, 11.50, 12.55, 13.90 and 14.90, respectively) was recorded from BRRI dhan34 which was statistically similar (3.25, 7.10, 12.80, 13.70, 14.50 and 15.50, respectively) to BRRI dha62 at same date of data recording (Table 2). Haque and Biswash (2014) reported that in case of no. of effective tillers, Hira showed the best performance (17.7) and Sonarbangla-1 showed the least performance (13.3). Masum *et al*. (2008) observed that the maximum (25.63) tiller at 45 DAT, then with advancement to age it declined up to maturity, whereas, in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT.

4.3 Leaf area index

Leaf area index showed statistically significant variation due to different rice varieties at 15, 30, 45, 60 and 75 days after transplanting (DAT) (Appendix VI). The highest leaf area index at 15, 30, 45, 60 and 75 DAT (0.41, 1.75, 3.89, 5.94 and 6.94, respectively) was recorded from BRRI dhan54 which was statistically similar (0.40, 1.66, 3.55, 5.66 and 6.59, respectively) to BRRI dhan32, whereas the lowest leaf area index (0.35, 1.48, 2.99, 4.18 and 4.80, respectively) was recorded from BRRI dhan34 (Table 3). Jisan *et al*. (2014) reported that BRRI dhan52 produced the leaf area index, while the lowest values of this parameters was produced by BRRI dhan57. Similar results also reported by Amin *et al*. (2006), Son *et al*. (1998) and Shaloie *et al*. (2014) from their earlier study.

Table 2. Number of tillers hill^{-1} at different days after transplanting for different rice varieties in *Aman* season

Rice Variety	Tillers hill^{-1} (No.) at					
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
BRRI dhan32	3.95 a	8.90 a	15.00 a	15.95 b	16.80 ab	17.60 ab
BRRI dhan33	3.90 a	9.00 a	14.55 ab	15.75 b	16.35 b	16.60 bc
BRRI dhan34	3.10 b	6.95 c	11.50 d	12.55 e	13.90 c	14.90 d
BRRI dhan39	3.15 b	7.90 b	12.25 cd	13.15 de	13.70 c	14.70 d
BRRI dhan54	4.00 a	9.10 a	15.50 a	17.15 a	17.80 a	18.55 a
BRRI dhan56	3.70 a	7.95 b	13.50 bc	14.50 c	14.90 c	15.50 cd
BRRI dhan57	3.75 a	8.05 b	13.10 c	14.10 cd	14.65 c	15.35 cd
BRRI dhan62	3.25 b	7.10 c	12.80 c	13.70 cde	14.50 c	15.50 cd
$LSD_{(0.05)}$	0.395	0.542	1.208	1.166	1.121	1.472
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	7.45	4.54	6.07	5.43	4.98	6.22

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Table 3. Leaf area index at different days after transplanting for different rice varieties in *Aman* season

Rice Variety	Leaf area index at				
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
BRRI dhan32	0.40 ab	1.66 ab	3.55 b	5.66 ab	6.59 ab
BRRI dhan33	0.39 ab	1.61 abc	3.49 b	5.29 bc	6.13 bc
BRRI dhan34	0.35 b	1.48 c	2.99 d	4.18 d	4.80 d
BRRI dhan39	0.37 ab	1.50 bc	3.09 d	4.00 d	4.62 d
BRRI dhan54	0.41 a	1.75 a	3.89 a	5.94 a	6.94 a
BRRI dhan56	0.37 ab	1.61 abc	3.46 bc	5.25 bc	6.09 bc
BRRI dhan57	0.37 ab	1.58 bc	3.21 cd	5.22 bc	6.04 bc
BRRI dhan62	0.37 ab	1.56 bc	3.27 bcd	4.98 c	5.74 c
$LSD_{(0.05)}$	0.047	0.147	0.259	0.426	0.542
Level of significance	0.05	0.05	0.01	0.01	0.01
CV(%)	6.57	6.32	5.24	5.74	6.29

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.4 Total dry matter hill^{-1}

Total dry matter hill^{-1} showed statistically significant differences due to different rice varieties at 15, 30, 45, 60 and 75 days after transplanting (DAT) (Appendix VII). The highest total dry matter hill^{-1} at 15, 30, 45, 60 and 75 DAT (3.24, 7.02, 8.68, 14.92 and 15.37 g, respectively) was recorded from BRRI dhan54 which was statistically similar (3.18, 6.41, 8.17, 14.27 and 14.61 g, respectively) to BRRI dhan32, whereas the lowest total dry matter hill^{-1} (2.86, 4.51, 7.47, 11.82 and 13.73 g, respectively) was recorded from BRRI dhan34 (Table 4).

4.5 Days to panicle initiation

Statistically significant variation was recorded due to different rice varieties in terms of days to panicle initiation (Appendix VIII). The maximum days to panicle initiation (73.75) was recorded from BRRI dhan54 which was statistically similar (73.50) to BRRI dhan34 and closely followed (67.75, 67.00, 65.50 64.75) by BRRI dhan57, BRRI dhan39 BRRI dhan56 and BRRI dhan32 and they was statistically similar, whereas the minimum days (55.25) was recorded from BRRI dhan33 which was statistically similar (58.25) to BRRI dhan62 (Table 5).

4.6 Days to maturity

Statistically significant variation was recorded due to different rice varieties in terms of days to maturity (Appendix VIII). The maximum days to maturity (134.25) was recorded from BRRI dhan34 which was statistically similar (133.25 and 130.25) to BRRI dhan54 and BRRI dhan32 and closely followed (119.75) by BRRI dhan39, while the minimum days to maturity (100.50) was recorded from BRRI dhan33 which was statistically similar (101.00, 105.25 and 108.00) to BRRI dhan62, BRRI dhan57 and BRRI dhan56 (Table 5).

Table 4. Total dry matter hill^{-1} at different days after transplanting for different rice varieties in *Aman* season

Rice Variety	Total dry matter hill^{-1} (g) at				
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
BRRI dhan32	3.18 ab	6.41 b	8.17 ab	14.27 ab	14.61 abc
BRRI dhan33	3.05 abc	6.25 b	8.18 ab	13.38 bc	14.41 bcd
BRRI dhan34	2.86 c	4.51 e	7.47 c	11.82 e	13.73 d
BRRI dhan39	2.86 c	4.83 de	7.74 bc	12.07 de	13.80 cd
BRRI dhan54	3.24 a	7.02 a	8.68 a	14.92 a	15.37 a
BRRI dhan56	2.94 c	5.50 c	8.06 b	13.31 bc	14.68 ab
BRRI dhan57	2.91 c	5.21 cd	7.90 bc	12.99 cd	14.37 bcd
BRRI dhan62	2.97 bc	5.10 cd	7.66 bc	12.38 cde	14.21 bcd
$LSD_{(0.05)}$	0.208	0.532	0.512	1.048	0.753
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.69	6.46	4.35	5.42	3.56

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Table 5. Yield contributing characters for different rice varieties in *Aman* season

Rice Variety	Days to panicle initiation	Days to maturity	Ineffective tillers hill^{-1} (No.)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)
BRRI dhan32	64.75 b	130.25 ab	1.85 de	87.10 ab	5.40 d
BRRI dhan33	55.25 c	100.50 c	2.10 cd	83.40 bc	7.10 b
BRRI dhan34	73.50 a	134.00 a	2.85 a	75.80 d	9.20 a
BRRI dhan39	67.00 b	119.75 b	2.25 c	81.30 cd	8.80 a
BRRI dhan54	73.75 a	133.25 a	1.80 e	89.90 a	5.15 d
BRRI dhan56	65.50 b	108.00 c	2.05 cde	85.20 abc	6.35 c
BRRI dhan57	67.75 b	105.25 c	2.55 b	80.90 cd	8.90 a
BRRI dhan62	58.25 c	101.00 c	2.75 ab	77.40 d	9.00 a
$LSD_{(0.05)}$	4.852	10.97	0.246	5.314	0.453
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	5.02	6.40	7.37	4.37	4.13

4.7 Effective tillers hill^{-1}

Statistically significant variation was recorded due to different rice varieties in terms of effective tillers hill^{-1} (Appendix VIII). The maximum number effective tillers hill^{-1} (16.75) was recorded from BRRI dhan54 which was statistically similar (15.75) to BRRI dhan32 and closely followed (14.50) by BRRI dhan33, whereas the minimum number of effective tillers hill^{-1} (12.05) was recorded from BRRI dhan34 which was statistically similar (12.45, 12.75, 12.80 and 13.45) to BRRI dhan39, BRRI dhan62, BRRI dhan57 and BRRI dhan56 (Figure 2).

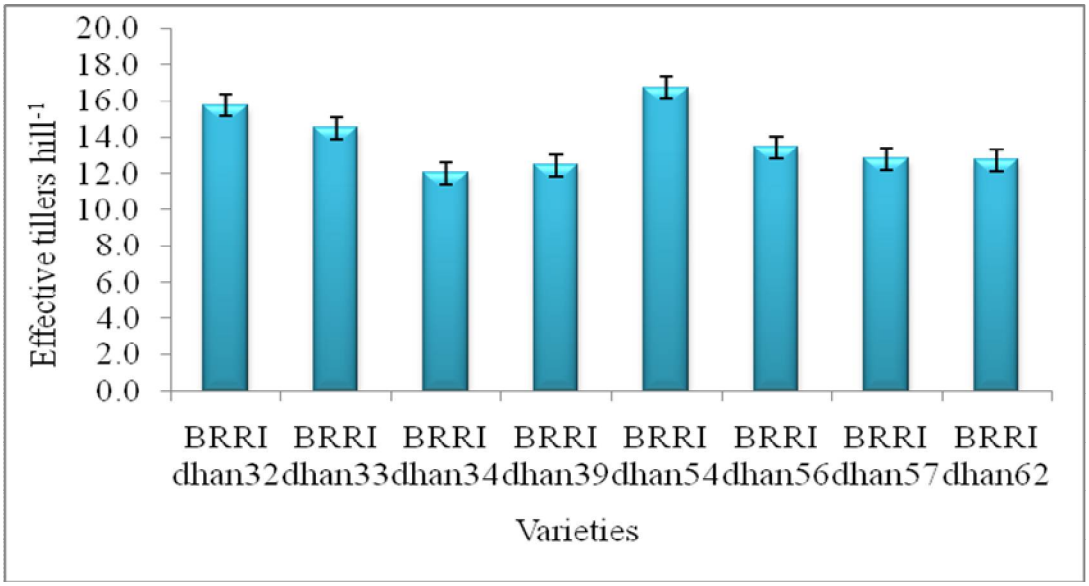


Figure 2. Effective tillers hill^{-1} of different rice varieties

4.8 Ineffective tillers hill^{-1}

Statistically significant variation was recorded due to different rice varieties in terms of ineffective tillers hill^{-1} (Appendix VIII). The maximum number ineffective tillers hill^{-1} (2.85) was recorded from BRRI dhan34 which was statistically similar (2.75) to BRRI dhan62 and closely followed (2.55) by BRRI dhan57, whereas the minimum number of ineffective tillers hill^{-1} (1.80) was recorded from BRRI dhan54 which was statistically similar (1.85 and 2.05) to BRRI dhan32 and BRRI dhan56 (Table 5).

4.9 Panicle length

Statistically significant variation was recorded due to different rice varieties in terms of panicle length (Appendix VIII). The longest panicle (25.76 cm) was recorded from BRRI dhan54 which was statistically similar (25.01, 24.67 cm and 23.75 cm) to BRRI dhan32, BRRI dhan56 and BRRI dhan33 and closely followed (23.40) by BRRI dhan39, while the shortest panicle (21.30 cm) was recorded from BRRI dhan34 which was statistically similar (21.94 cm and 22.03 cm) to BRRI dhan62 and BRRI dhan57 (Figure 3).

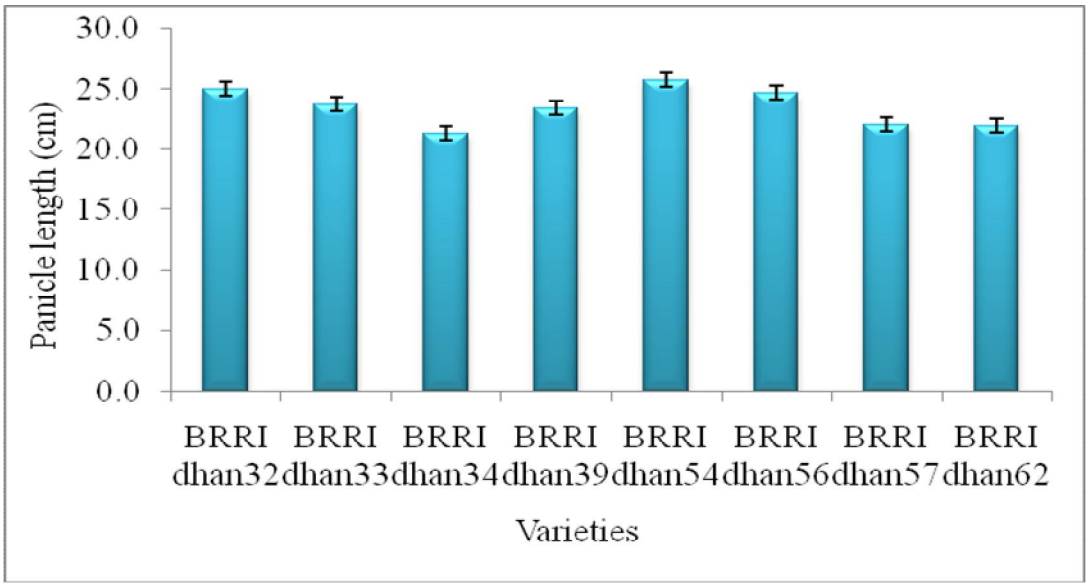


Figure 3. Panicle length for different rice varieties

4.10 Filled grains panicle^{-1}

Statistically significant variation was recorded due to different rice varieties in terms of filled grains panicle^{-1} (Appendix VIII). The maximum number of filled grains panicle^{-1} (89.90) was recorded from BRRI dhan54 which was statistically similar (87.10 and 85.2) to BRRI dhan32 and BRRI dhan56 and closely followed (83.40) by BRRI dhan33, whereas the minimum number of filled grains panicle $^{-1}$ (75.80) was recorded from BRRI dhan34 which was statistically similar (77.40, 80.90 and 81.30) to BRRI dhan62, BRRI dhan57 and BRRI dhan39 (Table 5).

4.11 Unfilled grains panicle^{-1}

Statistically significant variation was recorded due to different rice varieties in terms of unfilled grains panicle^{-1} (Appendix VIII). The maximum number of unfilled grains panicle^{-1} (9.20) was recorded from BRRI dhan34 which was statistically similar (9.00, 8.90 and 8.80) to BRRI dhan62 BRRI dhan57 and BRRI dhan39 and closely followed (7.10) by BRRI dhan33, whereas the minimum number of unfilled grains panicle $^{-1}$ (5.15) was recorded from BRRI dhan54 which was statistically similar (5.40) to BRRI dhan32 and closely followed (6.35) by BRRI dhan56 (Table 5).

4.12 Total grains panicle^{-1}

Statistically significant variation was recorded due to different rice varieties in terms of total grains panicle^{-1} (Appendix VIII). The maximum number total grains panicle^{-1} (95.05) was recorded from BRRI dhan54 which was statistically similar (92.50, 91.55, 90.50, 90.10 and 89.80) to BRRI dhan32, BRRI dhan56, BRRI dhan33, BRRI dhan39 and BRRI dhan57, while the minimum number of total grains panicle $^{-1}$ (85.00) was recorded from BRRI dhan34 which was statistically similar (86.40) to BRRI dhan62 (Figure 4). Jisan *et al*. (2014) reported that BRRI dhan52 produced the grains panicle^{-1} (121.5) whereas the lowest values of these parameters were produced by BRRI dhan57.

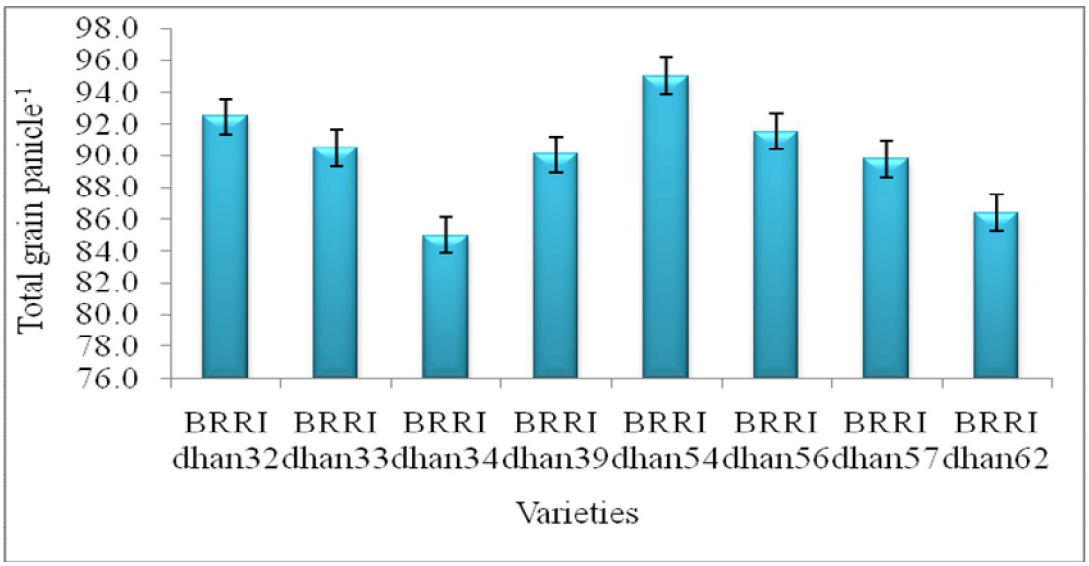


Figure 4. Total grain panicle^{-1} for different rice varieties

4.13 Weight of 1000-grain

Statistically significant variation was recorded due to different rice varieties in terms of weight of 1000-grain (Appendix IX). The highest weight of 1000-grains (25.71 g) was recorded from BRRI dhan54 which was statistically similar (24.64 g) to BRRI dhan62 and closely followed (23.69 g) by BRRI dhan56, while the lowest weight of 1000-grains (19.45 g) was recorded from BRRI dhan57 which was statistically similar (20.65 g) to BRRI dhan34 (Table 6). Sarkar *et al.* (2016) reported that hybrid varieties showed higher 1000-grain over the inbred. Jisan *et al.* (2014) reported that BRRI dhan52 produced the 1000-grain weight (23.65 g), whereas the lowest values of these parameters were produced by BRRI dhan57.

4.14 Grain yield

Statistically significant variation was recorded due to different rice varieties in terms of grain yield (Appendix IX). The highest grain yield (5.45 t ha^{-1}) was recorded from BRRI dhan54 which was statistically similar (5.10 t ha^{-1}) to BRRI dhan32 and closely followed (4.61 t ha^{-1}, 4.59 t ha^{-1} and 4.43 t ha^{-1}) by BRRI dhan33, BRRI dhan56 and BRRI dhan57, whereas the lowest grain yield (3.49 t ha^{-1}) was recorded from BRRI dhan34 which was closely followed (4.16 t ha^{-1}) by BRRI dhan62 (Table 6). Jisan *et al.* (2014) reported that the highest grain yield (5.69 t ha^{-1}) was obtained from BRRI dhan52 followed by BRRI dhan49 (5.15 t ha^{-1}) and the lowest one (4.25 t ha^{-1}) was obtained from BRRI dhan57.

4.15 Straw yield

Statistically significant variation was recorded due to different rice varieties in terms of straw yield (Appendix IX). The highest straw yield (7.97 t ha^{-1}) was recorded from BRRI dhan54 which was statistically similar (7.76, 7.64 and 7.45 t ha^{-1}) to BRRI dhan32, BRRI dhan33 and BRRI dhan56 closely followed (7.20 t ha^{-1}) by BRRI dhan57, whereas the lowest straw yield (6.58 t ha^{-1}) was recorded from BRRI dhan34 which was statistically similar (6.85 t ha^{-1}) to BRRI dhan39 (Table 6).

Table 6. Weight of 1000-grain, yield and harvest index for different rice varieties in *Aman* season

Rice Variety	Weight of 1000-grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest index (%)
BRRI dhan32	22.44 cd	5.10 a	7.76 ab	12.86 ab	39.59 a
BRRI dhan33	22.50 cd	4.61 b	7.64 abc	12.25 bc	37.66 ab
BRRI dhan34	20.65 de	3.49 d	6.58 e	10.07 e	34.70 b
BRRI dhan39	21.38 d	4.07 c	6.85 de	10.92 d	37.37 ab
BRRI dhan54	25.71 a	5.45 a	7.97 a	13.42 a	40.58 a
BRRI dhan56	23.69 bc	4.59 b	7.45 abcd	12.04 bc	38.13 a
BRRI dhan57	19.45 e	4.43 bc	7.20 bcde	11.63 cd	38.11 a
BRRI dhan62	24.64 ab	4.16 c	6.93 cde	11.09 d	37.47 ab
$LSD_{(0.05)}$	1.705	0.372	0.669	0.812	2.852
Level of significance	0.01	0.01	0.01	0.01	0.05
CV(%)	5.14	5.65	6.23	4.69	5.11

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.16 Biological yield

Statistically significant variation was recorded due to different rice varieties in terms of biological yield (Appendix IX). The highest biological yield (13.42 t ha^{-1}) was recorded from BRRI dhan54 which was statistically similar (12.86 t ha^{-1}) to BRRI dhan32 and closely followed (12.25 t ha^{-1} and 12.04 t ha^{-1}) by BRRI dhan33 and BRRI dhan56, whereas the lowest biological yield (10.07 t ha^{-1}) was recorded from BRRI dhan34 which was closely followed (11.09 and 11.63 t ha^{-1}) by BRRI dhan62 and BRRI dhan57 (Table 6).

4.17 Harvest index

Statistically significant variation was recorded due to different rice varieties in terms of harvest index (Appendix IX). The highest harvest index (40.58%) was recorded from BRRI dhan54 which was statistically similar (39.59%, 38.13%, 38.11%, 37.66% and 37.47%) to BRRI dhan32, BRRI dhan56, BRRI dhan57, BRRI dhan33 and BRRI dhan39, while the lowest harvest index (34.70%) was recorded from BRRI dhan34 (Table 6).

CHAPTER V

SUMMARY AND CONCLUSION

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SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka at the period of July to November 2016 for the comparative study on morphological characteristics and yield of different *Aman* rice varieties. The experiment comprised of eight *Aman* rice varieties viz., BRRI dhan32, BRRI dhan33, BRRI dhan34, BRRI dhan39, BRRI dhan54, BRRI dhan56, BRRI dhan57 and BRRI dhan62. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Data was recorded for different yield attributes and yield of rice.

At 15, 30, 45, 60 and 75 DAT and at harvest, the tallest plant (26.00, 54.10, 77.96, 92.88, 116.00 and 122.68 cm, respectively) was recorded from BRRI dhan32, whereas the shortest plant (21.97, 42.84, 65.32, 75.42, 101.00 and 101.88 cm, respectively) was recorded from BRRI dhan62. The maximum number of tillers hill^{-1} at 15, 30, 45, 60 and 75 DAT and at harvest (4.00, 9.10, 15.50, 17.15, 17.80 and 18.55, respectively) was recorded from BRRI dhan54, whereas the minimum number (3.10, 6.95, 11.50, 12.55, 13.90 and 14.90, respectively) was recorded from BRRI dhan34. The highest leaf area index at 15, 30, 45, 60 and 75 DAT (0.41, 1.75, 3.89, 5.94 and 6.94, respectively) was recorded from BRRI dhan54, whereas the lowest leaf area index (0.35, 1.48, 2.99, 4.18 and 4.80, respectively) was recorded from BRRI dhan34. The highest total dry matter hill^{-1} at 15, 30, 45, 60 and 75 DAT (3.24, 7.02, 8.68, 14.92 and 15.37 g, respectively) was recorded from BRRI dhan54, whereas the lowest total dry matter hill^{-1} (2.86, 4.51, 7.47, 11.82 and 13.73 g, respectively) was recorded from BRRI dhan34.

The maximum days to panicle initiation (73.75) was recorded from BRRI dhan54, whereas the minimum days (55.25) was recorded from BRRI dhan33. The maximum days to maturity (134.25) was recorded from BRRI dhan34,

while the minimum days to maturity (100.50) was recorded from BRRI dhan33. The maximum number effective tiller hill^{-1} (16.75) was recorded from BRRI dhan54 which was similar (15.75) to BRRI dhan32, whereas the minimum number of effective tiller hill^{-1} (12.05) was recorded from BRRI dhan34. The maximum number ineffective tiller hill^{-1} (2.85) was recorded from BRRI dhan34, whereas the minimum number of ineffective tiller hill^{-1} (1.80) was recorded from BRRI dhan54. The longest panicle (25.76 cm) was recorded from BRRI dhan54 which was similar (25.01 cm) to BRRI dhan32, while the shortest panicle (21.30 cm) was recorded from BRRI dhan34. The maximum number of filled grains panicle^{-1} (89.90) was recorded from BRRI dhan54, whereas the minimum number of filled grains panicle $^{-1}$ (75.80) was recorded from BRRI dhan34. The maximum number of unfilled grains panicle^{-1} (9.20) was recorded from BRRI dhan34, whereas the minimum number of unfilled grains panicle $^{-1}$ (5.15) was recorded from BRRI dhan54. The maximum number total grains panicle^{-1} (95.05) was recorded from BRRI dhan54 which was similar (92.50) to BRRI dhan32, while the minimum number (85.00) from BRRI dhan34.

The highest weight of 1000-grains (25.71 g) was recorded from BRRI dhan54, while the lowest weight of 1000-grains (19.45 g) was recorded from BRRI dhan57. The highest grain yield (5.45 t ha-1) was recorded from BRRI dhan54 similar (5.10 t ha^{-1}) to BRRI dhan32, whereas the lowest grain yield (3.49 t ha^{-1}) was recorded from BRRI dhan34. The highest straw yield (7.97 t ha^{-1}) was recorded from BRRI dhan54, whereas the lowest straw yield (6.58 t ha^{-1}) was recorded from BRRI dhan34. The highest biological yield (13.42 t ha^{-1}) was recorded from BRRI dhan54, whereas the lowest biological yield (10.07 t ha^{-1}) was recorded from BRRI dhan34. The highest harvest index (40.58%) was recorded from BRRI dhan54, while the lowest harvest index (34.70%) was recorded from BRRI dhan34.

From the findings it is concluded that BRRI dhan54 was superior in *Aman* season in consideration of yield attributes and yield. BRRI dhan32 was statistically similar with BRRI dhan54 in terms of maximum grain yield.

Considering the results of the present experiment, further studies in the following areas may be suggested:

1. BRRI dhan54 and BRRI dhan32 should be chosen among the test *Aman* rice varieties for getting higher grain yield.

2. This experiment should be carried out in different agro-ecological zones (AEZ) of Bangladesh for confirmation of the results.

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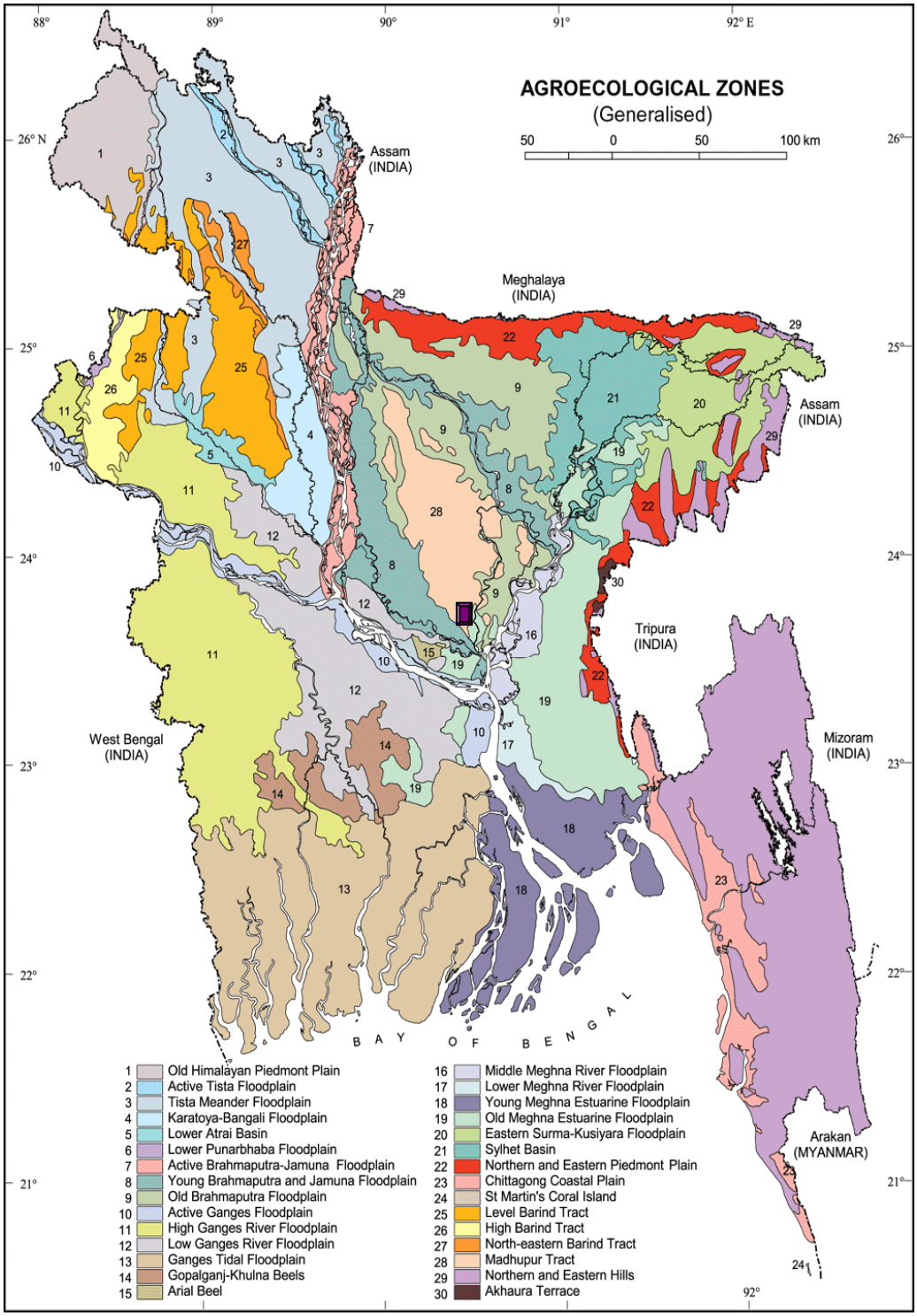
APPENDICES

APPENDICES

Appendix I. The Map of Bangladesh showing the experimental site



Appendix II. Characteristics of the soil of the experimental field

A. Morphological characteristics of the soil of experimental field

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

B. Physical and chemical properties of the initial soil

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

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

Appendix III. Monthly recorded air temperature, relative humidity and rainfall of the experimental site during the period from July to November 2016

Month (2016)	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
July	36.0	24.6	83	563
August	36.0	23.6	81	319
September	34.8	24.4	81	279
October	26.5	19.4	81	22
November	25.8	16.0	78	00

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

Appendix IV. Analysis of variance of the data on plant height of different rice varieties

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm) at					
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
Replication	2	0.336	2.197	3.732	0.608	14.629	8.365
Treatment (Variety)	7	8.889*	58.660**	66.399*	166.573**	126.685**	240.063**
Error	21	3.361	6.185	21.814	20.847	26.015	38.800

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix V. Analysis of variance of the data on tillers hill^{-1} of different rice varieties

Source of variation	Degrees of freedom	Mean square					
		Tillers hill^{-1} (No.) at					
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
Replication	2	0.003	0.011	0.177	0.325	0.377	0.588
Treatment (Variety)	7	0.560**	2.763**	7.749**	9.727**	8.766**	7.534**
Error	21	0.072	0.136	0.675	0.629	0.581	1.001

**: Significant at 0.01 level of significance

Appendix VI. Analysis of variance of the data on leaf area index of different rice varieties

Source of variation	Degrees of freedom	Mean square				
		Leaf area index at				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.0001	0.001	0.017	0.015	0.039
Treatment (Variety)	7	0.002*	0.030*	0.332**	1.795**	2.591**
Error	21	0.001	0.010	0.031	0.084	0.136

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VII. Analysis of variance of the data on total dry matter hill^{-1} of different rice varieties

Source of variation	Degrees of freedom	Mean square				
		Total dry matter hill^{-1} (g) at				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.001	0.051	0.036	0.290	0.022
Treatment (Variety)	7	0.083**	3.020**	0.571**	4.591**	1.090**
Error	21	0.020	0.131	0.121	0.508	0.262

**: Significant at 0.01 level of significance

Appendix VIII. Analysis of variance of the data on yield contributing characters of different rice varieties

Source of variation	Degrees of freedom	Mean square							
		Days to panicle initiation	Days to maturity	Effective tillers hill^{-1} (No.)	Ineffective tillers hill^{-1} (No.)	Panicle length (cm)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)
Replication	2	3.698	0.750	0.595	0.010	0.270	11.507	0.018	11.818
Treatment (Variety)	7	169.817**	0.750**	11.488**	0.640**	10.440**	90.740**	11.545**	41.322**
Error	21	10.888	55.607	1.000	0.028	1.976	13.061	0.095	12.355

**: Significant at 0.01 level of significance

Appendix IX. Analysis of variance of the data on weight of 1000-grains, yield and harvest index of different rice varieties

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		Weight of 1000-grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest index (%)
Replication	2	0.228	0.039	0.037	0.142	0.421
Treatment (Variety)	7	17.272**	1.482**	0.956**	4.747**	11.956*
Error	21	1.345	0.064	0.207	0.305	3.761

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance