TILLERING PATTERN, LEAF CHARACTERISTICS AND YIELD OF TEN MODERN RICE VARIETIES IN *AMAN* SEASON

THESIS

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CERTIFICATE

*This is to certify that the thesis entitled, **''TILLERING PATTERN, LEAF CHARACTERISTICS AND YIELD OF TEN MODERN RICE VARIETIES IN AMAN SEASON"** submitted to the Department Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRICULTURAL BOTANY**, embodies the results of a piece of bona fide research work carried out by, Registration No. **17-08265** 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: December, 2019
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DEDICATED TO

MY

BELOVED PARENTS, MY

FAMILY &SIBLINGS

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The Author

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ABSTRACT

The study was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar. Dhaka-1207 during the period from June 2018 to December 2018 to have a comparative study on ten modern rice varieties in *Aman* season in relation to their growth behaviour, leaf chlorophyll content and yield. The experiment consisted of 10 *Aman* rice genotypes (BRRI hybrid 4, BRRI dhan32, BRRI dhan33, BRRI dhan39, BRRI dhan49, BRRI dhan52, BRRI dhan54, BRRI dhan56, BRRI dhan57, BRRI dhan62). The experimental plots were laid out in randomized complete block design (RCBD). The field was divided into three blocks; representing three replications. Row to row and plant to plant distances were 25cm and 20cm respectively. Ten (10) genotypes were distributed to each plot of 4 m x 2.5 m size within each block randomly. The highest no. of filled grain per hill was obtained from the variety BRRI dhan56 and the lowest no. of filled grain per hill from BRRI dhan49. The highest no. of unfilled grain per hill was obtained from the variety BRRI dhan52 and the lowest no. of unfilled grain per hill from BRRI dhan49. The highest 1000 seed weight per hill was obtained from the variety BRRI hybrid 4 (28.16 g) which is statistically similar with BRRI hybrid 4 and the lowest 1000 seed weight per hill from BRRI dhan54. The highest grain yield per hill was obtained from the variety BRRI dhan33 (52.93 g) and the lowest grain yield per hill from BRRI dhan56 (29.9 g). The highest no. of unfilled grain per hill was obtained from the variety BRRI dhan54 (30.4 g) and the lowest no. of unfilled grain per hill from BRRI dhan57 (18.5 g). The highest biological yield per hill was obtained from the variety BRRI dhan32 (94.1 g). So, the variety BRRI dhan33 was better for higher yield and quality among the test modern *Aman* rice varieties.

CONTENTS

TABLES

FIGURES

APPENDICES

ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Co-efficient of Variance

CHAPTER 1

INTRODUCTION

Rice (*Oryza saliva* L.) is the staple food for at least 62.8% of total planet inhabitants and it contributes on an average 20% of apparent caloric intake of the world population and 30% of population in Asian countries. There is an upward shift in demand for rice worldwide due to population increase and urbanization (Rashid *et al.* 2016). No doubt, its demand will be increase following in near future. Rice alone constitutes 97% of the food grain production in Bangladesh and covers 75% of the total cropped area (Anis *et al.,* 2016). There are three seasons for rice cultivation in Bangladesh viz. *Aus, Aman* and *Boro*. Among these seasons *Aman* is the 2nd most important and occupied about 48% of the rice cultivated land in 2012-13.

Aman rice is sown (broadcast) in May or transplanted following the *Aus* harvest and mature throughout the kharif season. They are photoperiod-sensitive and flower in October/November. Since they have a long growth duration (120-160 days), *Aman* rice varieties are more productive than the *Aus* rice and produce, high quality fine and white grains. As rice is the foremost food of the developing countries of the world, it provides about four-fifth of the calories for more than two billion people of Asia and one- third calories intake of nearly one billion in Africa and Latin America.) World rice production has been doubled in a period of 25 years, from 257 million tons in 1990 (Khush *et al.* 1994). During that period, rice production was increased at a slightly higher rate than that of population growth. Total area under *Aman* rice has been estimated 13796773 acres (5583252 hectares) this year as compared to 13814090 acres (5590040 hectares) in Bangladesh. The harvested area has decreased by 0.13 % this year. Average yield rate of *Aman* rice for the Financial Year 2016-17 has been estimated 2.446 metric tons per hectare which is 1.41% higher than that of last year (BBS, 2018). However, the rate of increase of rice production is slowly declining and if the trend is not change, a severe food shortage can occur. The population of rice consuming countries is increasing faster than that of the rest part of the world, and the number of rice consumers will probably double by 2025.

Yearly increment of rice production in Bangladesh needs to be sustained to feed her ever increasing population. But there is population Yearly increment of rice production in Bangladesh needs to be sustained to feed her ever a little scope to increase rice area (Sarker *et*

al. 2008) rather agricultural land is declining @ 1.41% per annum (BBS, 2018). In Bangladesh two types of rice cultivars are cultivated viz. traditional (local) and modern (high yielding) varieties. Though the soil and climate of our country is quite suitable for the production of rice, still it is facing many problems of which the poor yielding inherent capability of our local varieties is the most important one. Poor plant type, such as tall plant, long and droopy leaves, weak culms, susceptible to lodging etc. are the main causes of the low yield of local varieties. On the other hand, modern varieties possess short and stout culms with dark green, thick and erect leaves and do not lodge. However, the recent yield level of modern rice varieties has been reached to plateau (Bhuiyan, 2002). Bangladesh needs 2.7% increases in rice production per year due to increasing population (Alam *et al.* 2004). The total rice area has also been continuously declining at about 1.00% per annum (Bhuiyan and Rahman, 2009). Among *Aus, Aman* and *Boro* seasons, *Aman* occupied the highest area coverage (34% of gross cropped area).

Variety plays an important role for successful crop production. Significant variation was found due to varietal difference on yield of rice. Among *Aus, Aman* and *Boro* seasons, the prospects of T. *Aman* rice are to be given more emphasis over the others due to some of its suitability in Bangladesh perspective. Such as, it is cultivated in rainy season based on rain water, no need of irrigation (only supplementary irrigation may be needed in some cases), soil salinity of coastal area become very low in this season due to heavy rainfall, fertilizer rate is comparatively low, land should not to be undertaken for other crops during this season which may provide more land area for rice and agriculture workers are available with relatively low wage rate; subsequently low cost is needed to grow rice in this season. So, for the development of more new higher yielding T. *Aman* rice varieties are very much important. As we know growth is directly related to various morpho-physiological process such as photosynthesis, respiration, enzyme activity etc. The yield of rice depends on its different growth parameters High dry matter production, leaf area index, leaf area duration, crop growth rate growth behavior and leaf chlorophyll content (Thakur,1998). Growth and formation of yield components in *Aman* rice during crop growth cycles. Spikelet size or weight is determined during the spikelet filling growth stage (Shamsuddin, 2002).

Farmers are generally replaced the local indigenous low yielding rice varieties by HYV and MV of rice developed by BRRI look forward to obtaining 20% to 30 % more yield unit^{-1} land area (Shahjahan, 2007).

The growth duration of local *Aman* cultivars is about 150-160 days that is more than modern varieties in Bangladesh in *Aman* season. Crop duration of modern *Aman* varieties is 20-40 days lower compared to local one. In our country some suitable rice *Aman* varieties have been released for cultivation in *Aman* season by BRRI. So it is prime need to evaluate their comparative performances in *Aman* season. Considering the above facts, the present investigation has been planned to achieve the following objectives.

Whatever, the present experiment was therefore, undertaken with following objectives:

1. To compare the tillering pattern and leaf area development of modern rice varieties in *Aman* season.
2. To evaluate the yield and yield contributing characters of modern rice varieties in *Aman* season.

CHAPTER II

REVIEW OF LITERATURE

The present study has aimed at studying the growth behavior and leaf chlorophyll content association among characters as yield contributing characters among the modern rice varieties in *Aman* season. The available information relevant to the present study has been reviewed in this chapter.

2.1 Growth behavior and yield contributing characters

Murshida *et al*. (2017) conducted an experiment with three varieties (*cv*. BRRI dhan28, BRRI dhan29 and Binadhan-14) and four water management systems to examine the effect of variety and water management system on the growth and yield performance of *Boro* rice. At 100 DAT, the highest plant height, maximum number of tillers hill-1, dry matter of shoot hill-1 and dry matter of root hill were obtained from BRRI dhan29 and the lowest values were found in Binadhan-14. Variety had significant effect on all the crop characters under study except 1000 grain weight. The highest grain yield was obtained from BRRI dhan29 and the lowest value was recorded from Binadhan-14.

Chamely *et al*. (2015) conducted an experiment with three varieties *viz*., BRRI dhan28, BRRI dhan29 and BRRI dhan45; and five rates of nitrogen *viz*., control, 50 kg, 100 kg, 150 kg and 200 kg effect of variety and rate of nitrogen on the performance of *Boro* rice. The growth analysis results indicate that the tallest plant (80.88 cm) and the highest number of total tillers hill-1 (13.80) were observed in BRRI dhan29 at 70 DAT and the highest total dry matter (66.41 g m^2) was observed in BRRI dhan45. The shortest plant (78.15 cm) and the lowest number of tillers hill-1 (12.41) were recorded from BRRI dhan45 and the lowest dry matter (61.24 g) was observed in BRRI dhan29. The harvest data reveal that variety had significant effect on total tillers $hill^{-1}$, effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, panicle length, grain yield, straw yield and harvest index. The highest grain yield (4.84 t ha^{-1}) was recorded from BRRI dhan29.

Sarkar *et al*. (2014) conducted an experiment to study the yield and quality of aromatic fine rice as affected by variety and nutrient management. The experiment comprised three aromatic fine rice varieties *viz*. BRRI dhan34, BRRI dhan37 and BRRI dhan38. The tallest plant (142.7 cm), the highest number of effective tillers $hill^{-1}$ (10.02), number of grains

panicle^{-1} (152.3), panicle length (22.71cm), 1000-grain weight (15.55g) and grain yield (3.71 t ha^{-1}) were recorded in BRRI dhan34.

Sarker *et al.* (2013) conducted an experiment to study morphological, yield and yield contributing characters of four *Boro* rice varieties of which three were local *viz*., Bashful, Poshursail and Gosi; while another one was a high yielding variety (HYV) BRRI dhan28. The BRRI dhan28 were significantly superior among the cultivars studied. 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 number of grains panicle^{-1} and bolder grains resulted in higher grain yield over the local cultivars. Further, BRRI dhan28 had more total dry mass than those of local varieties. The BRRI dhan28 produced higher grain yield (7.41 t ha^{-1}) than Bashful, Poshurshail and Gosi, respectively. Among the local rice cultivars, Gosi showed the higher yielding ability than Bashful and Poshursail.

Anwar and Begum (2010) reported that time of tiller separation of rice significantly influenced plant height, total number of tiller hill^{-1}, number of bearing tillers and panicle length but grain and straw yields were unaffected. Therefore, Sonarbangla-1 appeared to be tolerant to tiller separation and separation should be done between 20 to 40 DAT without hampering grain yield.

Islam *et al.* (2009) conducted pot experiments during T. *Aman* 2001 and 2002 (wet season) at Bangladesh Rice Research Institute (BRRI) in net house. Hybrid variety Sonarbangla-1 and inbred modern variety BRRI dhan-31 were used in both the seasons and BRRI hybrid dhan-l was used in 2002. The main objective of the experiments was to compare the growth and yield behavior of hybrid and inbred rice varieties under controlled condition.

In 2001, BRRI dhan-3l had about 10-15% higher plant height, very similar tillers/plant, 15-25% higher leaf area at all days after transplanting (DAT) compared to Sonarbangla-1. Sonarbangla-1 had about 40% higher dry matter production at 25 DAT but had very similar dry matter production at 50 and 75 DAT, 4-11% higher rooting depth at all DATs, about 22% higher root dry weight at 25 DAT, but 5-10% lower root dry weight at 50 and 75 DAT compared to BRRI dhan31. The photosynthetic rate was higher (20 µ mol m^2 sec^{-1}) in BRRI dhan3l at 35 DAT (maximum tillering stage) but at 65 DAT, Sonarbangla-l had higher photosynthetic rate of 19.5 µ mol m^2 sec^{-1}. BRRI dhan-3l had higher panicles plant^{-1} than

Sonarbangla-1, but Sonarbangla-1 had higher number of grains panicle^{-1}, 1000-grain weight and grain yield than BRRI dhan-31.

Chowdhury *et al.* (2005) conducted an experiment with 2, 4 and 6 seedlings hill to study their effect on the yield and yield components of rice varieties BR-23 and Pajam during the *Aman* season. They reported that the cv. BR-23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. number of productive tillers hill^{-1}, length of panicle, l000-grain weight, grain yield and straw yield. On the other hand, the cultivar Pajam produced significantly the tallest plant, total number of grains panicle^{-1}, number of filled grains panicle and number of unfilled grains panicle^{-1}.

BRRl (2005) reported a considerable variation in yield and yield contributing characters for 15 BRRI released T. *Aman* rice varieties. Days to 50% flowering was the major contributor to the arietal divergence followed by flag leaf area. From the d2 values it was found that the closest pair of T. *Aman* rice varieties is BRRI and BRRI dhan-30 followed by BRRI dhan-33 and BRRI dhan-39, while the distant pair is BR-3 and BRRI dhan-34 followed by BR-23 and BRRI dhan-34. Highest days to flowering was found in BR-10 (121 days) followed by BR-5, BRRI dhan-32 and BRRI dhan-23. The lowest days to 50% flowering was observed in BRRl dhan-33 (96 days) followed by BRRT dhan-39 (99days). Flag leaf area ranged from 25.21 (BRRl dhan-38) cm to 38.14 cm (BR-25).

Akbar (2004) reported that variety, seedling age and their interaction exerted significant influence on almost all the crop characters. Among the varieties, BRRI dhan-41 performed the best in respect of number of bearing tillers hill, panicle length, total spikelet's panicle^{-1} and number of grains panicle^{-1}. BRRI dhan-41 also produced the maximum grain and straw yields. Sonarbangla-1 ranked first in respect of total tillers hill^{-1} and 1000-grain weight but produced highest number of non-bearing tillers hill^{-1} and sterile spikelet's panicle^{-1}. Grain, straw and biological yields were found highest in the combination of BRRI dhan-41 with 15-day-old seedlings. Therefore, BRRI dhan4l may be cultivated using 15-day-old seedlings in *Aman* season following the SRI technique to have better grain and straw yields.

In 2002, BRRI dhan-31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhan-l had the highest plant height. Sonarbangla-1 had the largest leaf area at 25 and 50 DAT followed by BRRI dhan-31, but at 75 DAT, BRRI dhan31 had the largest leaf area. The highest shoot dry matter was observed in BRRI dhan31 followed by Sonarbangla-1 at all

DATs. Sonarbangla-1 had the highest rooting depth and root dry weight at all DAT. BRRI dhan31 gave the highest number of panicles plant^{-1} followed by Sonarbangla-1, BRRI hybrid dhan-l had the highest grains panicle^{-1} followed by BRRI dhan-31 and Sonarbangla-1 had the highest 1000-grain weight followed by BRRI dhan-31. The highest amount of grains plant^{-1} (34.6 g) was obtained from BRRI dhan31.

Julfiquar *et al.* (1998) reported that BRRI evaluated 23 hybrids along with three standard checks during boro season 1994-95 as preliminary yield trial at Gazipur and it was reported that five hybrids (IR58025A/IR54056, IR54883, PMS8A/IR46R) out yielded the check varieties (BR-14 and BR-16) with significant yield difference.

Julfiquar *et al.* (1998) also reported that thirteen rice hybrids were evaluated in three locations of BADC farm during the Boro season of 1995-96. Two hybrids out yielded the check variety of same duration by more than 1 t ha^{-1}.

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

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.

BRRI (1995) conducted an experiment to find out varietal performances of BR4, BR10, BR11, BR22, BR23 and BR25 varieties including to local checks 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 on seven varieties of rice, of which three were native (Maloti, Nizersail and Chandrashail) and four were improved (BR3, BR11, Pasam and Mala). Straw and grain yields were 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 II-You 92 and found an average yield of 7.5 t ha^{-1} which was 10% higher than that of standard hybrid Shanyou 64.

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

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

BRRI (1991) also reported that the filled grains penicle^{-1} of different modern varieties were 95-100 in BR3, 125 in BR4, 120-130 in BR22 and 110-120 in BR23 when they were cultivated in transplant *AMAN* season.

Shamsuddin *et al.* (1988) also observed that panicle number hill 1000-grain weight differed significantly among the varieties.

Kamal *et al.* (1988) evaluated BR3, IR20, and Pajam2 and found that number of grain panicle^{-1} were 107.6, 123.0 and 170.9 respectively, for the varieties.

Costa and Hoque (1986) studied during kharif-II season, 1985 at Tangail FSR site, Palima, Bangladesh with five different varieties of T. *AMAN* BR4, BR10, BR11, Nizersail and Indrasail. Significant differences were observed in panicle length and number of unfilled grains panicle^{-1} the tested varieties.

2.2 leaf chlorophyll content and yield contributing characters

Yuni Widyastuti *et al.* (2015) conducted a study with twenty-four experimental hybrid rice varieties. The results showed that grains yields were affected by locations, seasons, and genotypes. The genotypes × locations × seasons interaction effect was significant; therefore, the best hybrid was different for each location and season. A7/PK36 hybrid has the best performance in Batang during the dry season, while A7/PK40 and A7/PK32 are the best hybrids in the rainy season. In Sukamandi, nine hybrids were identified as better yielder than that of the check cultivar in the dry season, but not so in the rainy season.

Jisan *et al*. (2014) carried out an experiment 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. Among the varieties, BRRI dhan52 produced the tallest plant (117.20 cm), highest number of effective tillers hill^{-1} (11.28), grains panicle^{-1} (121.5) and 1000-grain weight (23.65 g) whereas the lowest values of these parameters were produced by BRRI dhan57. 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.

Md. Asadur Rahman *et al.* (2013) showed the flag leaves were excised after the emergence of panicle from some of the selected plants of all the examined varieties and let it to grow. Phenotypic observation indicated various defects existed in the leaf cut plants throughout maturation including late maturation, decaying, shrunken and reduced grain size, as well as increased sterility. Moreover, panicle length and branching were reduced. As a whole, those deformities acted as potential factors for the reduction of yield of the rice varieties. After harvesting 100 grains weight from leaf cut plant was measured and significant reduction of weight was observed compare to 100 grains weight of the control plant. Among varieties the 1000 grain weight of leaf cut plants was reduced about two-fold in the BR3 and BRRI dhan34 from those of uncut plants.

Md. Asadur Rahman *et al.* (2013), Chlorophyll content of FL and PL from the studied five varieties was measured. Results indicated that FL contained increased amount of total chlorophyll than that of PL for all of the studied varieties. The difference was more than two-fold in BRRI dhan34. Among the varieties, BRRI dhan34 showed the highest (54.22 mg/g) FL chlorophyll content than the others, whereas, BR3 showed maximum PL chlorophyll content. Chlorophyll content among the varieties varied significantly suggesting that the studied genotypes were genetically variable regarding chlorophyll content. Chlorophyll content had the strong and positive correlation with yield. Increased grain yield was observed when chlorophyll was higher as found in the BRRI dhan34, whereas, lower grain yield was observed at lower chlorophyll content as found in the cv. BR11.

An experiment was conducted by Karim and Rahman (2009), with 25 T. *Aman* rice varieties. Significant differences were observed among the varieties for all the characters studied. Flag leaf area ranged between 51.42 cm and 18.5 cm. Heritability was quite high for all the characters. The highest heritability was found in days to maturity while unfilled grain per panicle has the lowest. In this study LAI showed lowest heritability.

Abu-khalifa *et al.* (2008) conducted an intensive study on rice yield after cutting flag leaf and nearby leaf. Considering the importance of leaf on grain yield it is prerequisite to analyze the morphological and the physiological characteristics of functional leaves to improve grain yield in rice.

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

Ali (2005) established that SPAD based nitrogen management needs considerably lower amount of nitrogen than the standard nitrogen management practices without any yield losses.

Hussain *et al.* (2003) reported that the chlorophyll meter indicates the need of a nitrogen top dressing that would result greater agronomic efficiency of nitrogen fertilizer than commonly pre-application of nitrogen.

Mamin (2003) made study with 69 rice varieties for different morpho-physiological characters. Varieties differed markedly in growth duration with substantial year-to-year variation. It varied from I 21 days (Baildigha) to 158 days (Bunsha) in 1999 and in 2000 it ranged between 132 days (BRR1dhan29) to 176 days (Lalmota). Tiller mortality showed a range of 21-61% among the genotypes. Leaf area index (LAT) at flowering stage ranged between 3.15 (BRRidhan29) and 5.86 (Baildigha). Marked difference in LAI between HYVs and traditional varieties is not apparent; suggesting that lower yield of traditional varieties may not be attributed to higher LA1. Crop growth rate (CGR) and relative growth rate (RGR) also showed noticeable differences among genotypes. Mean CGR ranged between 7.52 g/m^2/day (Tilbazal) and 17.74 g/m^2/day (BRRldahn32), whereas RGR was in the range of 0.02-0.04 gig/day.

Among the hybrids tested, PA 6201 recorded the highest leaf area index. Roy (1999) reported that in Nizersail, leaf area index peaked around panicle initiation stage and in BRRI Dhan 31, although maximum leaf area index was attained at or just before heading stage, the increase of leaf area index from panicle initiation stage to heading stage was only small.

Garcia *et al.* (1996) previously reported that use of SPAD in determination the time of nitrogen fertilizer applies caused increase of yield and leaves with high SPAD value have the

high chlorophyll content. Studies showed that nitrogen leaf statue has a closely relationship with photosynthesis rate and biomass production and it can control the photosynthesis and Crop Growth Rate (CGR).

Balasubramanian *et al.* (1999) studied chlorophyll meter or SPAD (Soil plant analysis development) offers a new strategy for synchronizing N application with actual crop demand in rice.

Mian *et al.* (1997) reports chlorophyll pigments play an important role in the photosynthetic process as well as biomass production. Genotypes maintaining higher leaf chlorophyll-a and chlorophyll-b during growth period may be considered potential donor for the ability of producing higher biomass and photosynthetic capacity. Higher photosynthesis rate is supported by leaf chlorophyll content in leaf blades.

Shen (1980); Ohno (1976) and Chen *et al.* (1995) expressed that the photosynthetic pigment chlorophyll is another important molecule associated with photosynthesis in plant leaves that directly affects the biomass and grain yield of crops.

Chlorophyll is positively correlated with photosynthetic rate. Ohno (1976) also reported significant differences with photosynthetic rate in rice and suggested high yielding rice could be developed by selecting varieties with high photosynthesis.

CHAPTER 3

MATERIALS AND METHODS

The study was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar. Dhaka-1207 during the period from June 2018 to December 2018 to have a comparative study on ten modern rice varieties in *Aman* season in relation to their growth behavior, leaf chlorophyll content and yield. The materials and methods were adopted for conducting the experiments are discussed under the following heading and sub-headings:

3.1 Field experiment and observations

3.1.1 Experiment site

The experimental field was located at 90°33.5' E longitude and 23°77.4W N latitude at an altitude of 9 meter above the sea level. The field experiment was set up on the medium high land of the experimental farm.

3.1.2 Soil and climate of the experimental site

The soil of the experiment site was a medium high land, clay loam in texture and having pH 5.47 to 5.63. The land was located in Agro-ecological Zone of 'Madhupur Tract' (AEZ No. 28). The climate of the experimental site is sub-tropical characterized by heavy rainfall during April to July and sporadic during the rest of the year.

3.1.4 Materials

The experimental materials of the study comprised of 10 *Aman* rice genotypes. The seeds were collected from Research farm of Sher-e-Bangla Agricultural University (SAU). The details of these genotypes are given below:

BRRI hybrid4, BRRI dhan32, BRRI dhan33, BRRI dhan39, BRRI dhan49, BRRI dhan52, BRRI dhan54,BRRI dhan56, BRRI dhan57, BRRI dhan62

3.1.3 Design and layout

The experiment was laid out in randomized complete block design (RCBD). The field was divided into three blocks; representing three replications. Row to row and plant to plant

distances were 25cm and 20cm respectively. Ten (10) genotypes were distributed to each plot of 4 m × 2.5 m size within each block randomly.

3.1.5 Germination of seeds

Seeds of all collected rice genotypes soaked separately for 48 hours in clothes bag. Soaked seeds were picked out from water and wrapped with straw and gunny bag to increase the temperature fin facilitating germination.

3.1.6 Preparation of seedbed and raising seedling

The irrigated land was prepared thoroughly by 3 to 4 times ploughing and cross ploughing followed by laddering to attain a good puddle. Weeds and stubbles were removed. Thirty live separate strips were made and sprouted seeds were sown on each strip in 14th July of 2018. Seedbed was irrigated with regular interval to maintain moisture.

3.1.7 Preparation of main land

The experimental plot was at a lower elevation with high water holding capacity. The land was prepared thoroughly by 3-4 Limes ploughing and cross ploughing followed by laddering after application of cow dung to attain a good puddle. Weeds and stubbles were removed and land was finally prepared by the addition of basal dose of fertilizers.

3.1.8 Uprooting seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on August 10, 2018 without causing much mechanical injury to the roots.

3.1.9 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on August 10, 2018 and the rice seedlings were transplanted in lines each having a line to line distance of 25 cm and plant to plant distance was 20 cm for all test varieties in the well prepared plot.

3.1.10 Application of fertilizers

The experimental plot was fertilized by applying urea TSP. MP and Gypsum at the rate of 180, 100, 70 and 60 kg/ha, respectively. Total TSP. MP and Gypsum were applied at final

land preparation. Total Urea was applied in three installments, at 15 days after transplanting (DAT), 30 DAT and 50 DAT.

3.1.11 Intercultural operation

Necessary intercultural operations were made during cropping period for proper growth and development of the plants. Irrigation with regular interval was given to maintain 5-7 cm water up to hard drought stage of rice.

3.1.12 Plant protection measures

Proper control measures were taken against rats and birth.

3.1.13 Harvest and post-harvest operations

The crops were harvested separately only after attaining maturity and threshed, cleaned and dried in proper ways avoiding any kind of mixtures within the varieties.

3.2 Collection of data

Data were collected from 5 hills of each genotype on the following parameters:

1. Plant height at 7,14,21 and 28 days after transplant (DAT)
2. Total no. of tiller hill^{-1}
3. Total no. of effective tiller hill^{-1}
4. No. of leaves hill^{-1}
5. Leaf length
6. Leaf breath
7. Flag leaf SPAD reading
8. Plant height after harvest
9. No. of leaves after harvest
10. Total no. of tiller after harvest
11. Total no. of filled grain hill^{-1}
12. Total no. of unfilled grain hill^{-1}
13. Grain yield
14. Straw yield
15. 1000 seed weight
16. Biological yield
17. Harvest index

3.2.1 Procedure of data collection

3.2.1.1 Plant height

The height of plant was recorded in centimeter (cm) at 15, 30, 45 DAS and at harvest. Data were recorded from 5 plants from each plot and average plant height per plant was recorded as per treatment. The height was measured from the ground level to the tip of the plant by a meter scale.

3.2.1.2 Number of tillers hill^{-1}

Average number of tillers form 5 hill bearing panicles per hill was recorded.

3.2.1.3 Effective tillers hill^{-1}

Average number of effective tillers form 5 hill bearing panicles per hill was recorded.

3.2.1.4 Number of leaves hill^{-1}

Average number of leaves form 5 hill bearing was recorded per hill.

3.2.1.5 Leaf length

Average number of leaves length form 5 hill bearing was recorded in centimeter (cm) per hill by a meter scale.

3.2.1.6 Leaf breath

Average number of leaves breath form 5 hill bearing was recorded in centimeter (cm) per hill by a meter scale.

3.2.1.7 Flag leaf SPAD reading

Flag leaf SPAD reading were recorded at 6 days after flowering using SPAD meter. Data were recorded from 5 plants from each plot.

3.2.1.8 Plant height at harvest

The height of plant was recorded in centimeter (cm) after harvest. Data were recorded from 5 plants from each plot and average plant height per plant was recorded as per treatment. The height was measured from the ground level to the tip of the plant by a meter scale.

3.2.1.9 No. of leaves at harvest

Average number of leaves form 5 hill bearing was recorded per hill after harvest.

3.2.1.10 Number of tillers at harvest

Average number of tillers form 5 hill bearing panicles per hill was recorded after harvest.

3.2.1.11 Filled grains hill^{-1}

Average number of filled grains per panicle was recorded.

3.2.1.12 Unfilled grains hill^{-1}

Average number of unfilled grains per panicle was recorded.

3.2.1.13 Grain yield

Average weight of grains per hill was calculated.

3.2.1.14 Straw yield

Average dry weight of leaves and tiller per hill was calculated and the combined data expressed as straw yield.

3.2.1.15 Biological yield

The summation of seed yield and above ground straw yield per hectare was the biological yield.

Biological yield = Grain yield + Straw yield

3.2.1.16 1000 seed weight

The dry weight of 1000 grain was recorded and adjusted it at 14% moisture then it was multiplied by 5. Following formula was used for adjustment of weight at 14% moisture,

Weight of grain at 14% moisture = $\frac{Wd\ (100-Md)}{100-14}$

Where,

W d= weight of sun dried

Md=% moisture of sun-dried grain

3.2.1.17 Harvest index

The dry weight of straw of 5 hills was recorded and harvest index was calculated by following formula,

$$\text{Harvest index} = \frac{\text{Dry weight of grain of 5 hills}}{(\text{Dry weight of grain+ dry weight of straw}) \text{ of 5 hills}}$$

3.3 Statistical analysis

The data obtained for different parameters were analyzed to have a comparative study on ten modern rice varieties in *Aman* season in relation to their growth behavior, leaf chlorophyll content and yield. The mean values of all the characters were calculated and the analysis of variance (ANOVA) was performed by the 'F' (variance ratio) test using Statistical Tool for Agricultural Research (STAR) software. The significance of the difference among the treatment means was estimated by the LSD (Least Significant Difference) test at 5% level of probability.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results from the experiment. The study was conducted to have a comparative study on ten modern rice varieties in *Aman* season in relation to their growth behavior, leaf chlorophyll content and yield. The data of this study have been presented and expressed in table (s) and figures for discussion, comparison and understanding of the experimental findings. A summary of all the parameters have been shown in possible interpretation wherever necessary have given under the following headings.

4.1 Plant height

Plant height is one of the important parameters. Plant height was recorded at 7, 14, 21 and 28 days after transplanting (DAT) which showed significant differences to different plant growing structures. At 7 DAT V_1=BRRI hybrid 4 showed the highest plant height as (45.73) cm which is statistically similar to V_{10}=BRRI dhan62 (40.5 cm) and the lowest plant height was from V_5=BRRI dhan49. Similarly, for 14 DAT maximum plant height given by V_{10}=BRRI dhan62 (72.86 cm) and lowest plant height was from V_2=BRRI dhan32 (58.43 cm). At 21 DAT V_3=BRRI dhan33 showed the highest plant height as (80.13 cm) and at 28 DAT V_3=BRRI dhan33 showed the highest plant height as V_1=BRRI hybrid 4 as (90.40 cm). The following results indicate the early plant growth of BRRI hybrid 4. (Table 1)

Table 1: Effect of variety on plant height of modern rice *in Aman season*

Variety	Plant height (cm)			
	7 DAT	14 DAT	21 DAT	28 DAT
BRRI Hybrid 4	45.73 a	67.03 abc	79.17	90.40
BRRI dhan32	31.70 c	58.43 c	73.17	87.93
BRRI dhan33	37.23 bc	71.03 ab	80.13	89.80
BRRI dhan39	32.56 c	63.23 abc	73.00	85.13
BRRI dhan49	31.67 c	65.47 abc	73.33	85.20
BRRI dhan52	32.20 c	61.03 bc	78.13	87.13
BRRI dhan54	32.53 c	64.33 abc	78.97	84.60
BRRI dhan56	34.20 bc	65.07 abc	78.83	89.13
BRRI dhan57	37.10 bc	66.27 abc	76.70	86.93
BRRI dhan62	40.50 ab	72.87 a	78.57	91.70
LSD	13.01	4.54	NS	NS
CV(%)	6.28	5.31	5.65	5.54

CV=Coefficient of variance; In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance;,NS= Non-Significant.

4.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} was recorded at 7, 14, 21 and 28 days after transplanting (DAT) which showed significant differences to different plant growing behavior of the different *Aman* varieties under the study. At 7 DAT V_2=BRRI dhan32 showed the highest no. of tiller per hill as (12.66) and the lowest no. of tiller per hill was from V_9=BRRI dhan57 (8). Similarly, for 14 DAT V_2=BRRI dhan32 showed the highest no. of tiller per hill as (15.66) and lowest no. of tiller per hill was from V_{10}=BRRI dhan62 (10.66). At 21 DAT V_2=BRRI Dhan32 showed the highest no. of tiller per hill as (17.66) and lowest no. of tiller per hill was from V_{10}=BRRI dhan62 (12.33) and at 28 DAT V_2=BRRI dhan32 showed the highest no. of tiller per hill as 19.33 and lowest no. of tiller per hill was from V_{10}=BRRI dhan62 (14.66). The following results indicate the early plant growth of BRRI dhan32 and indicate the possible higher Stover yield. (Table 2)

Table 2: Effect of variety on number of tillers hill^{-1} of modern rice *in Aman season*

Variety	**Number of tillers hill^{-1}**			
	7 DAT	**14 DAT**	**21 DAT**	**28 DAT**
BRRI Hybrid 4	11.67 ab	15.67	17.33	19.00
BRRI dhan32	12.67 a	15.67	17.67	19.33
BRRI dhan33	9.00 ab	14.00	13.67	15.33
BRRI dhan39	8.67 ab	13.67	12.67	14.67
BRRI dhan49	11.67 ab	13.00	13.67	16.67
BRRI dhan52	12.00 ab	12.33	15.33	17.33
BRRI dhan54	10.33 ab	11.33	15.67	17.33
BRRI dhan56	9.00 ab	11.00	14.67	17.00
BRRI dhan57	8.00 b	10.67	14.67	17.67
BRRI dhan62	9.67 ab	10.67	12.33	14.67
LSD	3.60	NS	NS	NS
CV(%)	14.51	15.44	14.08	13.93

CV=Coefficient of variance; In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance,NS= Non-Significant.

4.3 No. of leaves hill^{-1}

No. of leaves hill^{-1} was recorded at 7, 14, 21 and 28 days after transplanting (DAT) which showed significant differences to different plant growing behavior of the different *Aman*

varieties under the study. At 7 DAT V_1=BRRI hybrid 4 showed the highest no. of leaves per hill as (35) and the lowest no. of leaves per hill was from V_8= BRRI dhan56 (19.33). Similarly, for 14 DAT V_1=BRRI hybrid 4 showed the highest no. of leaves per hill as (50) and the lowest no. of leaves per hill was from V_9= BRRI dhan57 as (36). At 21 DAT V_1=BRRI hybrid 4 showed the highest no. of leaves per hill as (54.33) and the lowest no. of leaves per hill was from V_{10}=BRRI dhan62 as (36) and at 28 DAT V_1=BRRI hybrid 4 showed the highest no. of leaves per hill as (59) and the lowest no. of leaves per hill was from V_5=BRRI dhan49. The following results indicate the early plant growth of BRRI hybrid 4 and indicate the possible higher Stover yield. (Table 3)

Table 3: Effect of variety on number of leaves hill^{-1} of modern rice *in Aman season*

Variety	**No. of leaves hill^{-1}**			
	7 DAT	**14 DAT**	**21 DAT**	**28 DAT**
BRRI Hybrid 4	35.00 a	50.00 a	54.33 a	59.00 a
BRRI dhan32	31.33 ab	45.67 ab	44.67 ab	54.33 ab
BRRI dhan33	26.33 b-d	37.67 b	44.33 ab	54.00 ab
BRRI dhan39	30.67 ab	36.33 b	44.00 ab	43.00 b
BRRI dhan49	21.33 cd	40.00 ab	42.33 ab	41.00 b
BRRI dhan52	24.00 b-d	35.67 b	42.33 ab	51.00 ab
BRRI dhan54	29.00 a-c	37.00 b	40.67 b	45.67 ab
BRRI dhan56	19.33 d	40.33 ab	39.67 b	46.33 ab
BRRI dhan57	24.33 b-d	36.00 b	39.67 b	48.67 ab
BRRI dhan62	25.00 b-d	37.33 b	36.00 b	50.67 ab
LSD	9.89	4.39	3.53	3.14
CV(%)	9.99	9.85	10.43	10.99

CV=Coefficient of variance; In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance.

4.4 Leaf length

Leaf length was recorded at 7, 14, 21 and 28 days after transplanting (DAT) which showed significant differences to different plant growing behavior of the different *Aman* varieties under the study. At 7 DAT V_{10}=BRRI dhan62 showed the highest leaf length as (16.13 cm) and the lowest leaf length was from V_7= BRRI dhan54 (11.16 cm). Similarly, for 14 V_{10}=BRRI dhan62 showed the highest leaf length as (16.63 cm))and the lowest leaf length

was from V_7= BRRI dhan54 (11.36 cm). At 21 V_{10}=BRRI dhan62 showed the highest leaf length as (17.26 cm) and the lowest leaf length was from V_7= BRRI dhan54 (13.05 cm) and at 28 V_{10}=BRRI dhan62 showed the highest leaf length as (17.53 cm) and the lowest leaf length was from V_7= BRRI dhan54 (13.86 cm). The following results indicate the early plant growth of BRRI hybrid 4 and indicate the possible higher Stover yield as the amount of leaf area index depends on the leaf size and the no. of leaves. (Table 4)

Table 4: Effect of variety on number of leaf length of modern rice *in Aman season*

Variety	**Leaf length (cm)**			
	7 DAT	**14 DAT**	**21 DAT**	**28 DAT**
BRRI Hybrid 4	13.37 bc	13.97 abc	14.97 ab	15.33 ab
BRRI dhan32	13.17 bc	13.47 bc	14.30 ab	14.77 ab
BRRI dhan33	12.63 bc	13.40 bc	13.93 b	14.43 ab
BRRI dhan39	12.23 bc	12.57 bc	13.53 b	14.00 b
BRRI dhan49	14.23 ab	14.53 ab	15.07 ab	15.40 ab
BRRI dhan52	12.37 bc	12.87 bc	13.60 b	14.07 b
BRRI dhan54	11.17 c	11.37 c	13.50 b	13.87 b
BRRI dhan56	12.50 bc	13.27 bc	13.93 b	14.33 ab
BRRI dhan57	13.20 bc	13.53 bc	14.57 ab	14.83 ab
BRRI dhan62	16.13 a	16.63 a	17.27 a	17.53 a
LSD	7.22	6.68	3.73	2.92
CV(%)	6.60	6.78	7.04	7.37

CV=Coefficient of variance; In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance.

4.5 Leaf breath

Leaf breath was recorded at 7, 14, 21 and 28 days after transplanting (DAT) which showed significant differences to different plant growing behavior of the different *Aman* varieties under the study. At 7 DAT V_2=BRRI dhan33 showed the highest leaf breath as (0.466 cm) which is statistically similar to V_2=BRRI dhan32 (0.43) and the lowest leaf breath was from V_{10}=BRRI dhan62 (0.4 cm). Similarly, for 14 DAT V_2=BRRI dhan32 showed the highest leaf breath as (0.766 cm) and the lowest leaf breath was from V_{10}=BRRI dhan62 (0.633 cm). At 21 V_2=BRRI dhan32 showed the highest leaf breath as 1.0 cm and the lowest leaf breath was from V_2=BRRI dhan32 (0.733 cm) and at 28 DAT V_2=BRRI dhan32 showed the highest leaf breath as 1.06 cm and the lowest leaf breath was from V_7=BRRI dhan54 (0.86 cm). The following results indicate the early plant growth of BRRI dhan32 and indicate the possible

higher Stover yield as the amount of leaf area index depends on the leaf size and the no. of leaves. (Table 5)

Table 5: Effect of variety on number of leaf breath of modern rice *in Aman season*

Variety	**Leaf breath (cm)**			
	7 DAT	**14 DAT**	**21 DAT**	**28 DAT**
BRRI Hybrid 4	0.40	0.60	0.80 ab	0.93
BRRI dhan32	0.43	0.77	1.00 a	1.07
BRRI dhan33	0.47	0.67	0.90 ab	0.93
BRRI dhan39	0.40	0.53	0.67 b	0.90
BRRI dhan49	0.47	0.60	0.77 ab	0.90
BRRI dhan52	0.43	0.63	0.77 ab	0.90
BRRI dhan54	0.50	0.63	0.73 ab	0.90
BRRI dhan56	0.40	0.60	0.77 ab	1.03
BRRI dhan57	0.50	0.63	0.77 ab	1.00
BRRI dhan62	0.40	0.63	0.73 ab	0.87
LSD	NS	NS	2.20	NS
CV(%)	20.65	19.82	13.95	15.89

CV=Coefficient of variance; In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance,NS= Non-Significant.

4.6 Flag leaf SPAD Reading

Flag leaf SPAD reading data was collected at 7, 14, 21 and 28 DAT which is one of the most important yield contributing character to the selection of better yielding *Aman* variety. At 7 DAT the highest data was found from V_2=BRRI dhan32 as (40.40) and the lowest from V_3=BRRI dhan33 as (35). For 14 DAT the highest data was found from V_2=BRRI dhan32 as (42.06) and the lowest from V_3=BRRI dhan33 as (36.13 Flag leaf SPAD reading at 21 DAT indicates the highest amount of flag leaf chlorophyll content was from V_8=BRRI dhan57 as 44 which statistically similar to V_2= BRRI dhan32 and the lowest from the variety V_3=BRRI dhan33 as (37). The chlorophyll measurement at 28 DAT indicates the highest amount of flag leaf chlorophyll content was from V_8= BRRI dhan56 (46.60) which statistically similar to V_2= BRRI dhan32 and the lowest from the variety V_3=BRRI dhan 33 as (38). (Table 6)

Table 6: Effect of variety on flag leaf SPAD reading of modern rice *in Aman season*

Variety	Flag leaf SPAD reading			
	7 DAT	**14 DAT**	**21 DAT**	**28 DAT**
BRRI Hybrid 4	39.70	40.20	40.43	41.43
BRRI dhan32	40.40	42.07	42.93	43.93
BRRI dhan33	35.00	36.13	37.00	38.00
BRRI dhan39	38.83	39.70	40.37	42.37
BRRI dhan49	40.27	40.33	40.10	41.10
BRRI dhan52	37.50	36.10	36.37	38.37
BRRI dhan54	35.13	34.53	38.23	39.23
BRRI dhan56	38.43	40.20	44.60	46.60
BRRI dhan57	38.13	39.20	38.67	39.67
BRRI dhan62	35.20	36.73	38.3	39.3
LSD	NS	NS	NS	NS
CV(%)	8.22	8.70	8.33	8.78

CV=Coefficient of variance; In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance, NS= Non-Significant.

4.7 Plant height at harvest

Plant height is one of the important parameters. Plant height was recorded at harvesting the crops for lab comparison of the growth contributing character. The highest plant height was obtained from the variety from V_9=BRRI dhan57 (113.27 cm) and the lowest plant height from V_{10}=BRRI dhan62 for (101.23 cm). (Table 7)

4.8 No. of leaves at harvest

No. of leaves at harvest was recorded at harvesting the crops for lab comparison of the growth contributing character. The highest no. of leaves was obtained from the variety V_7= BRRI dhan54 (17) and the lowest no. of leaves from V_3=BRRI dhan33 as (11). (Table 7)

4.9 Number of tillers at harvest

Number of tillers at harvest was recorded at harvesting the crops for lab comparison of the growth contributing character. The highest no. of tiller at harvest was obtained from the

variety V_8= BRRI dhan56 as 37 and the lowest no. of tillers at harvest from V_5=BRRI dhan49 for 27. (Table 7)

4.10 Filled grains hill^{-1}

Filled grains hill^{-1} was recorded at harvesting the crops for lab comparison of the growth contributing character. The highest no. of filled grain per hill was obtained from the variety V_8= BRRI dhan56 and the lowest no. of filled grain per hill from V_5=BRRI dhan49. (Table 7)

Table 7: Effect of variety on growth and yield parameters of modern rice in *Aman* season

Variety	Plant height at harvest	No. of leaves at harvest	Number of tillers at harvest	Filled grains hill^{-1}	Unfilled grains hill^{-1}
BRRI Hybrid 4	107.57	13.67 a-d	31.00 ab	2108.70 bc	336.67 cd
BRRI dhan32	104.17	10.33 d	32.00 ab	2420.30 ab	255.33 def
BRRI dhan33	107.27	11.00 cd	32.67 ab	2047.70 bcd	549.00 b
BRRI dhan39	102.33	11.33 bcd	33.00 ab	1719.70 cd	635.33 ab
BRRI dhan49	109.13	13.33 a-d	27.00 b	1598.00 d	323.00 c-e
BRRI dhan52	106.00	11.67 bcd	25.67 b	1968.30 bcd	699.33 a
BRRI dhan54	102.20	17.00 a	28.67 ab	2065.00 bc	354.00 c
BRRI dhan56	109.03	13.33 a-d	37.00 a	2723.30 a	235.33 ef
BRRI dhan57	113.27	15.33 ab	33.00 ab	1692.70 cd	193.33 f
BRRI dhan62	101.23	15.00 abc	33.00 ab	1991.70 bcd	212.67 f
LSD	NS	0.77	6.08	13.87	86.66
CV(%)	4.97	13.30	11.42	7.78	7.97

CV=Coefficient of variance; In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance; ,NS= Non-Significant.

4.11 Unfilled grains hill^{-1}

Unfilled grains hill^{-1} was recorded at harvesting the crops for comparison of the growth contributing character. The highest no. of Unfilled grains hill^{-1} was obtained from the variety V_6= BRRI dhan52 and the lowest no. of unfilled grain per hill from V_5=BRRI dhan49. (Table 7)

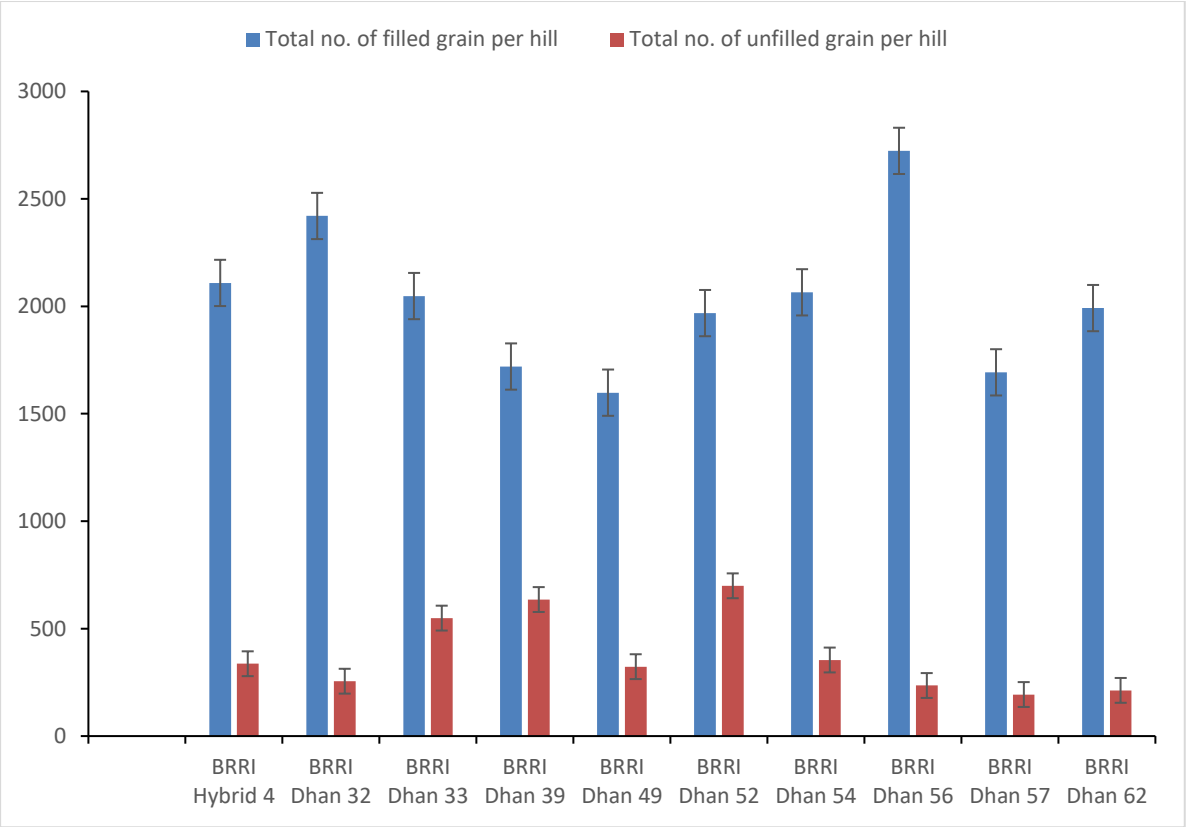

Figure 1: Effect of variety on filled grains hill^{-1} and unfilled grains hill^{-1} in *Aman* season; vertical bars represent the standard errors of the treatment means at $P \leq 0.01$

4.12 Dry matter hill^{-1}

Total Dry matter hill^{-1} was recorded for 30, 40, 50, 60 and 70 days after transplanting for different *Aman* and at 30 DAT the highest dry matter was collected from BRRI Dhan54 (7.02 g) and the lowest for BRRI Dhan39 (4.51 g). At 40 DAT the highest dry matter was collected from BRRI Dhan54 (8.48 g) which was statistically similar to BRRI Hybrid 4 (8.01 g) and the lowest for BRRI Dhan33 (7.17 g). At 50 DAT the highest dry matter was collected from BRRI Dhan54 (8.60 g) which is statistically similar to BRRI Dhan 32 (8.26 g) and the lowest for BRRI Dhan33 (7.20 g). At 60 DAT the highest dry matter was collected from BRRI Dhan54 (14.92 g) which is statistically similar to BRRI Dhan32 (14.26 g) and the lowest for BRRI Dhan49 (11.78 g). At 70 DAT the highest dry matter was collected from BRRI Dhan54 (15.37 g) which is statistically similar to BRRI Hybrid 4 (14.67 g) and the lowest for BRRI Dhan39 (13.73 g)

Table 8: Effect of variety on dry matter hill^{-1} at different days after transplanting in *Aman* season

Variety	Dry matter hill^{-1}				
	30 DAT	**40 DAT**	**50 DAT**	**60 DAT**	**70 DAT**
BRRI Hybrid 4	5.60 c	8.01 ab	8.20 ab	13.35 bc	14.67 ab
BRRI Dhan32	6.41 b	8.02 b	8.26 ab	14.27 ab	14.61 abc
BRRI Dhan33	6.25 b	7.17 c	7.20 c	13.38 bc	14.41 bcd
BRRI Dhan39	4.51 e	7.44 bc	7.56 bc	11.82 de	13.73 d
BRRI Dhan49	4.80 de	7.38 bc	7.45 bc	11.78 e	13.80 cd
BRRI Dhan52	4.83 de	7.35 bc	7.56 bc	12.07 de	13.85 cd
BRRI Dhan54	7.02 a	8.48 a	8.60 a	14.92 a	15.37 a
BRRI Dhan56	5.50 c	7.96 ab	8.05 b	13.31 bc	14.68 ab
BRRI Dhan57	5.21 cd	7.60 bc	7.80 bc	12.99 cd	14.37 bcd
BRRI Dhan62	5.10 cd	7.56 bc	7.58 bc	12.38 cde	14.21 bcd
LSD	0.532	0.510	0.513	1.048	0.753
CV(%)	6.47	4.34	4.38	5.43	3.58

CV=Coefficient of variance; In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance.

4.13 Days to panicle initiation

Statistically significant variation was recorded due to different rice variety in terms of days to panicle initiation (Table 9). The maximum days to panicle initiation (73.75) were recorded from BRRI dhan33 which were statistically similar (73.50) to BRRI dhan49 whereas the minimum days (55.25) were recorded from BRRI dhan32 which was statistically similar (58.25) to BRRI dhan56 (Table 9).

4.14 Days to maturity

Statistically significant variation was recorded due to different rice variety in terms of days to maturity (Table 9). The maximum days to maturity (134.25) were recorded from BRRI dhan49 which were statistically similar (133.25 and 130.25) to BRRI dhan33 while the minimum days to maturity (100.50) were recorded from BRRI dhan32.

4.15 Non-effective tillershill^{-1}

Statistically significant variation was recorded due to different rice variety in terms of non-effective tiller hill^{-1}. The maximum number ineffective tiller hill^{-1} (2.85) were recorded from BRRI dhan49 whereas the minimum number of ineffective tiller hill^{-1} (1.80) was recorded from BRRI dhan33 which was statistically similar (1.85 and 2.05) BRRI dhan52 (Table 9).

4.16 Filled grains panicle^{-1}

Statistically significant variation was recorded due to different rice variety in terms of filled grains panicle^{-1}. The maximum number of filled grains panicle^{-1} (89.90) were recorded from BRRI dhan33 which were statistically similar (87.10 and 85.2) to BRRI hybrid 4 and BRRI dhan52 whereas the minimum number of filled grains panicle $^{-1}$ (75.80) was recorded from BRRI dhan49 (Table 9).

4.17 Unfilled grains panicle^{-1}

Statistically significant variation was recorded due to different rice variety in termsofunfilledgrainspanicle^{-1}(Table9).Themaximumnumberofunfilledgrains panicle^{-1} (9.20) were recorded from BRRI dhan49 whereas the minimum number of unfilled grains panicle $^{-1}$ (5.15) was recorded from BRRI dhan33 which was statistically similar (5.40) to BRRI hybrid 4 (Table 9).

Table 9. Yield contributing characters for modern 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 Hybrid 4	64.75 b	130.25 ab	1.85 de	87.10 ab	5.40 d
BRRI Dhan32	55.25 c	100.50 c	2.10 cd	83.40 bc	7.10 b
BRRI Dhan33	73.75 a	133.25 a	1.80e	89.90 a	5.15 d
BRRI Dhan39	67.00 b	119.75 b	2.25 c	81.30 cd	8.80 a
BRRI Dhan49	73.50 a	134.00 a	2.85 a	75.80 d	9.20 a
BRRI Dhan52	65.50 b	108.00 c	2.05 cde	85.20 abc	6.35 c
BRRI Dhan54	67.75 b	105.25 c	2.55 b	80.90 cd	8.90 a
BRRI Dhan56	58.25 c	101.00 c	2.75 ab	77.40 d	9.00 a
BRRI Dhan57	55.20c	102.30c	1.83de	76.45 d	6.50 c
BRRI Dhan62	65.00b	105.75c	2.54ab	85.20 abc	7.20 b
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

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance. CV=Coefficient of variance

4.18 1000 seed weight

1000 seed weight was recorded after harvesting the crops for lab comparison of the growth contributing character. The highest 1000 seed weight per hill was obtained from the variety V_1=BRRI hybrid 4 (28.16 g) which is statistically similar with V_1=BRRI hybrid 4 and the lowest 1000 seed weight per hill from V_7= BRRI Dhan54 (19.36 g). (Figure 2)

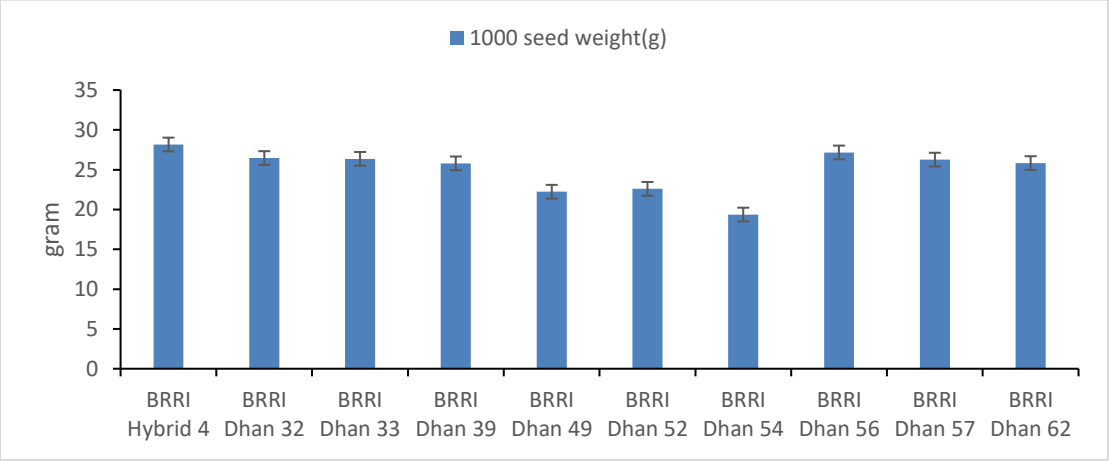

Figure 2: Effect of variety on 1000 seed weight in *Aman* season; Vertical bars represent the standard errors of the treatment means at $P \leq 0.01$

4.19 Grain yield

Grain yield was recorded after harvesting the crops for lab comparison of the growth contributing character. The highest grain yield per hill was obtained from the variety V_3=BRRI Dhan33 (62.66 g) which is statistically similar with V_1=BRRI hybrid 4 and the lowest grain yield per hill from V_8= BRRI Dhan56 (44.2 g). (Figure 3)

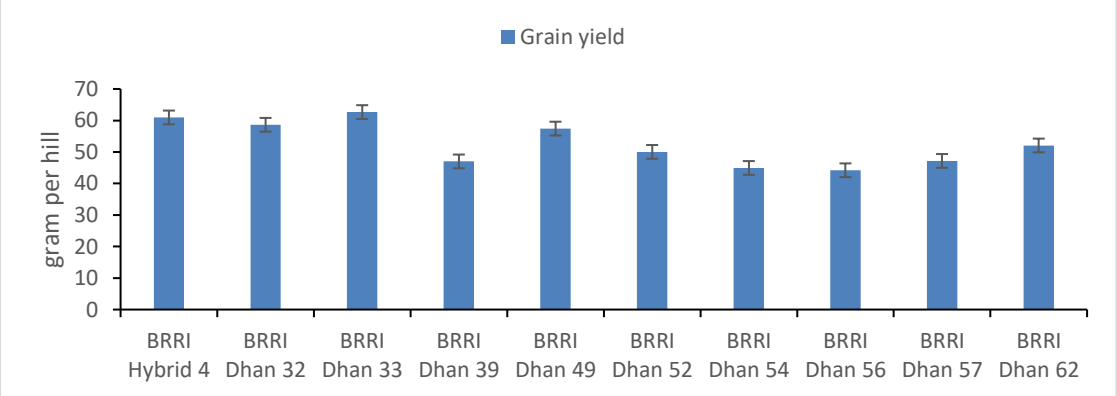

Figure 3: Effect of variety on grain yield in *Aman* season; Vertical bars represent the standard errors of the treatment means at $P \leq 0.01$

4.20 Straw yield

Straw was recorded after harvesting the crops for lab comparison of the growth contributing character. The highest no. of straw yield per hill was obtained from the variety V_7= BRRI Dhan54 (30.4 g) and the lowest no. of unfilled grain per hill from V_9=BRRI57 (14.6 g). (Figure 4)

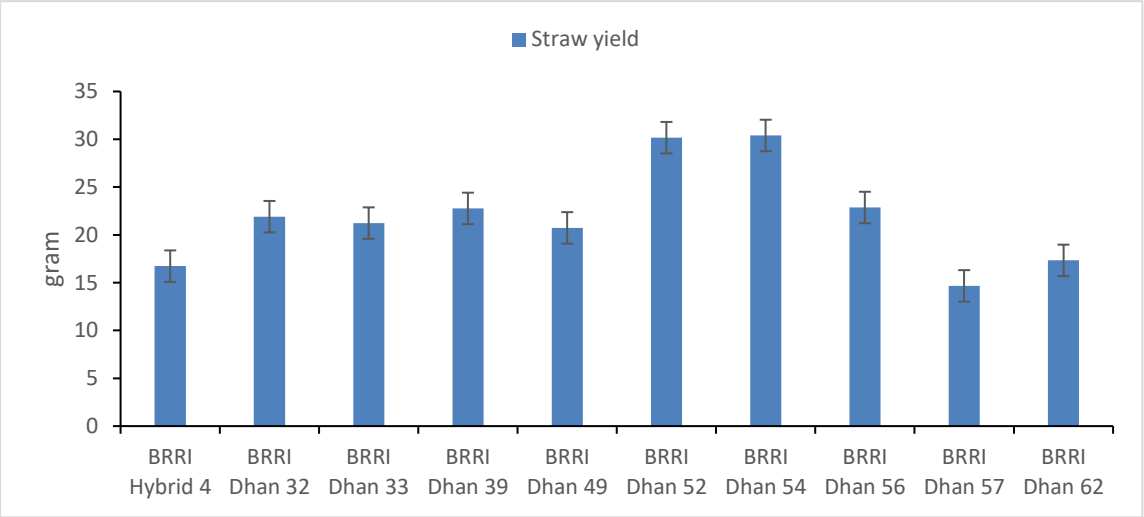

Figure 4: Effect of variety on straw yield in *Aman* season; Vertical bars represent the standard errors of the treatment means at $P \leq 0.01$

4.21Biological yield

Biological yield was recorded at harvesting the crops for lab comparison of the growth contributing character. The highest biological yield per hill was obtained from the variety V_2=BRRI dhan32 (94.1 g) and the lowest biological yield per hill from V_9= BRRI dhan57 (59.56 g). (Figure 5)

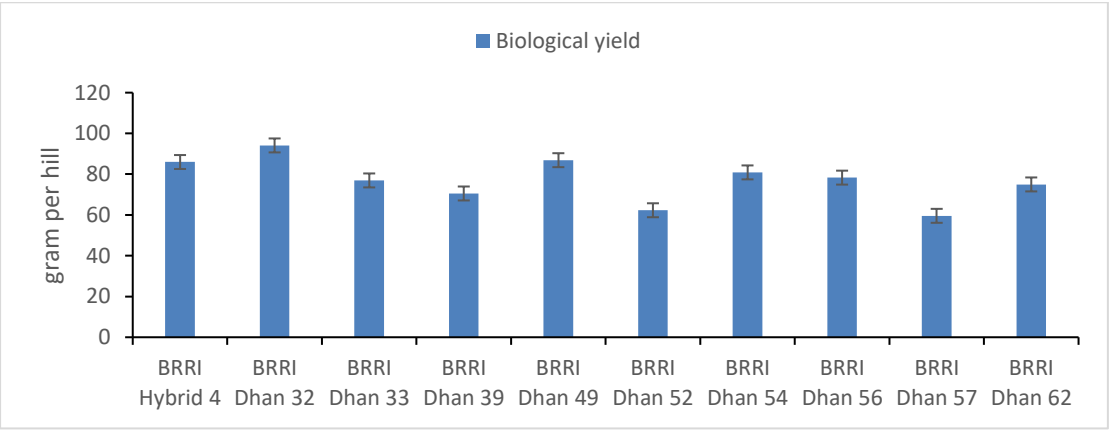

Figure 5: Effect of variety on biological yield in *Aman* season Vertical bars represent the standard errors of the treatment means at $P \leq 0.01$

4.22 Harvest index (%)

Harvest index was recorded at harvesting the crops for comparison of the growth contributing character. The highest harvest index per hill was obtained from the variety V_1=BRRI hybrid 4 (61.86 %) and the lowest harvest index per hill from V_{10}=BRRI Dhan62 (44.2 %). (Figure 6)

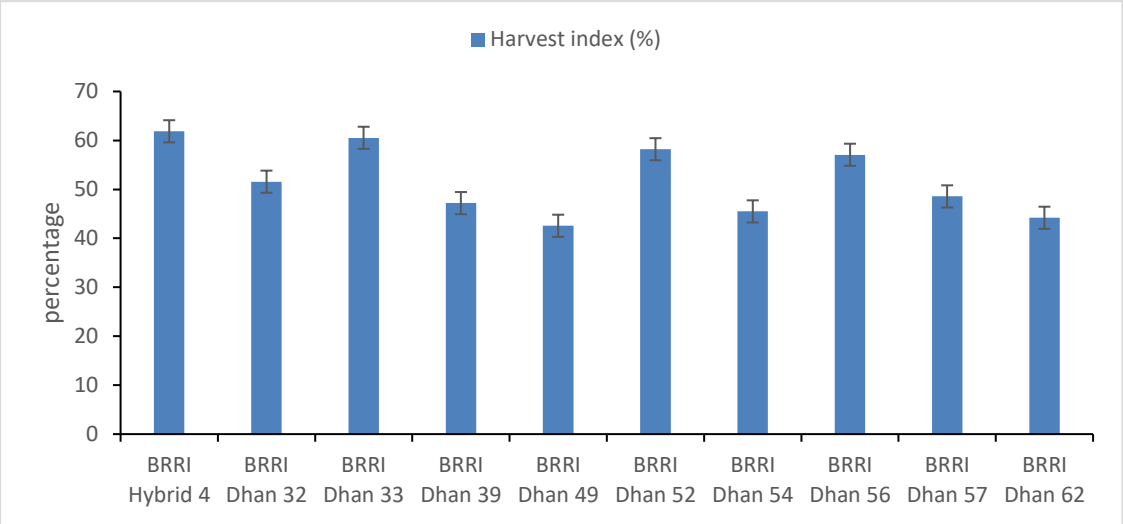

Figure 6: Effect of variety on grain and harvest index in *Aman* season Vertical bars represent the standard errors of the treatment means at $P \leq 0.01$

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar. Dhaka-1207 during the period from June 2018 to December 2018 to have a comparative study on ten modern rice varieties in *Aman* season in relation to their growth behavior, leaf chlorophyll content and yield. The experiment consisted of 10 *Aman* rice genotypes (BRRI hybrid 4, BRRI dhan32, BRRI dhan33, BRRI dhan39, BRRI dhan49, BRRI dhan52, BRRI dhan54, BRRI dhan56, BRRI dhan57, BRRI dhan62). The experiment was laid out in randomized complete block design (RCBD). The field was divided into three blocks; representing three replications. The recorded data on various parameters were statistically analyzed using Statistical Tool for Agricultural Research (STAR) software. The significance of the difference among the treatment means was estimated by the LSD (Least Significant Difference) test at 5% level of probability. Data were taken on growth and yield contributing characters and the collected data were statistically analyzed for evaluation of the treatment effects. The summary of the results has been described in this chapter.

At 7 DAT V_1=BRRI hybrid 4 showed the highest plant height as 45.73 cm which is statistically similar to V_{10}=BRRI dhan62 (40.5 cm) and the lowest plant height was from V_5= BRRI dhan49. Similarly, for 14 DAT maximum plant height given by V_{10}=BRRI dhan62 (72.86 cm) and lowest plant height was from V_2= BRRI dhan32 (58.43 cm). At 21 DAT V_3= BRRI dhan33 showed the highest plant height as 80.13 cm and at 28 DAT V3= BRRI dhan33 showed the highest plant height as V_1=BRRI hybrid 4 as 90.40 cm. At 7 DAT V_2= BRRI dhan32 showed the highest no. of tiller per hill as 12.66 and the lowest no. of tiller per hill was from V_9= BRRI dhan57 (8). Similarly, for 14 DAT V_2= BRRI dhan32 showed the highest no. of tiller per hill as 15.66 and lowest no. of tiller per hill was from V_{10}=BRRI dhan62 (10.66). At 21 DAT V_2= BRRI dhan32 showed the highest no. of tiller per hill as 17.66 and lowest no. of tiller per hill was from V_{10}= BRRI dhan62 (12.33) and at 28 DAT V_2= BRRI dhan32 showed the highest no. of tiller per hill as 19.33 and lowest no. of tiller per hill was from V_{10}= BRRI dhan62 (14.66). At 7 DAT V_1=BRRI hybrid 4 showed the highest no. of leaves per hill as 35 and the lowest no. of leaves per hill was from V_8= BRRI

dhan56(19.33). Similarly, for 14 DAT V_1=BRRI hybrid 4 showed the highest no. of leaves per hill as 35 and the lowest no. of leaves per hill was from V_9= BRRI dhan57. At 21 DAT V_1=BRRI hybrid 4 showed the highest no. of leaves per hill as 35 and the lowest no. of leaves per hill was from V_{10}= BRRI dhan62 and at 28 DAT V_1=BRRI hybrid 4 showed the highest no. of leaves per hill as 35 and the lowest no. of leaves per hill was from V_{10}= BRRI dhan62. At 7 DAT V_{10}= BRRI dhan62 showed the highest leaf length as 16.13 cm and the lowest leaf length was from V_7= BRRI dhan54 (11.16 cm). Similarly, for 14 V_{10}= BRRI dhan62 showed the highest leaf length as 16.63 cm and the lowest leaf length was from V_7= BRRI dhan54 (11.36 cm). At 21 V_{10}= BRRI dhan62 showed the highest leaf length as 17.26 cm and the lowest leaf length was from V_7= BRRI dhan54 (13.05 cm) and at 28 V_{10}= BRRI dhan62 showed the highest leaf length as 17.53 cm and the lowest leaf length was from V_7= BRRI dhan54 (13.86 cm).At 7 DAT V_3= BRRI dhan33 showed the highest leaf breath as 4.66 cm and the lowest leaf breath was from V_{10}= BRRI dhan62 (0.4 cm). Similarly, for 14 DAT V_2= BRRI dhan32 showed the highest leaf breath as 0.766 cm and the lowest leaf breath was from V_{10}= BRRI dhan62 (0.633 cm). At 21 V_2= BRRI dhan32 showed the highest leaf length as 1.0 cm and the lowest leaf breath was from V_2= BRRI dhan32 (0.733 cm) and at 28 DAT V_2= BRRI dhan32 showed the highest leaf breath as 1.06 cm and the lowest leaf breath was from V_7= BRRI dhan54 (0.86 cm). At 7 DAT the highest data was found from V_2= BRRI dhan32 as 40.40 and the lowest from V_3= BRRI dhan33 as 35. For 14 DAT the highest data was found from V_2= BRRI dhan32 as 42.06 and the lowest from V_3= BRRI dhan33 as 36.13.

The chlorophyll measurement at 21 DAT indicates the highest amount of flag leaf chlorophyll content was from V_8= BRRI dhan56 (29.44 cm) which statistically similar to V_2= BRRI dhan32 and the lowest from the variety V_3= BRRI dhan32 as 37. The highest plant height was obtained from the variety from V_9 = BRRI dhan57 for 113.27 cm and the lowest plant height from V_{10} = BRRI dhan62 for 101.23 cm. The highest no. of leaves was obtained from the variety V_7 = BRRI dhan54 for 17 and the lowest no. of leaves from V_3 = BRRI dhan33 as BRRI dhan11.

The height no. of tiller after harvest was obtained from the variety V_8 = BRRI dhan56 as 37 and the lowest no. of tiller after harvest from V_5 = BRRI dhan49 for 27. The highest no. of filled grain per hill was obtained from the variety V_8 = BRRI dhan56 and the lowest no. of filled grain per hill from V_5= BRRI dhan49.The highest no. of

unfilled grain per hill was obtained from the variety V_6= BRRI dhan52 and the lowest no. of unfilled grain per hill from V_5= BRRI dhan49.

The highest 1000 seed weight per hill was obtained from the variety V_1=BRRI hybrid 4 (28.16 g) which is statistically similar with V_1=BRRI hybrid 4 and the lowest 1000 seed weight per hill from V_7= BRRI dhan54. The highest grain yield per hill was obtained from the variety V_1=BRRI dhan33 (52.93 g) and the lowest grain yield per hill from V_9= BRRI dhan57 (29.9 g). The highest no. of unfilled grain per hill was obtained from the variety V_{10}= BRRI dhan62 (30.4 g) and the lowest no. of unfilled grain per hill from V_4= BRRI dhan39 (18.5 g). The highest biological yield per hill was obtained from the variety V_2= BRRI dhan32 (94.1 g) and the lowest biological yield per hill from V_9= BRRI dhan57 (59.56 g). The highest harvest index per hill was obtained from the variety V_1=BRRI hybrid 4 (61.86 %) and the lowest harvest index per hill from V_{10}=BRRI dhan62 (44.2 %).

Conclusion:

BRRI dhan33 was superior in *Aman* season consideration of yield attributes and yield.

Recommendation:

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

1. BRRI dhan33 should be chosen for getting higher grain yield *in Aman* season.
2. This experiment should be carried out in different agro-ecological zone (AEZ) zone of Bangladesh for confirmation of the results.

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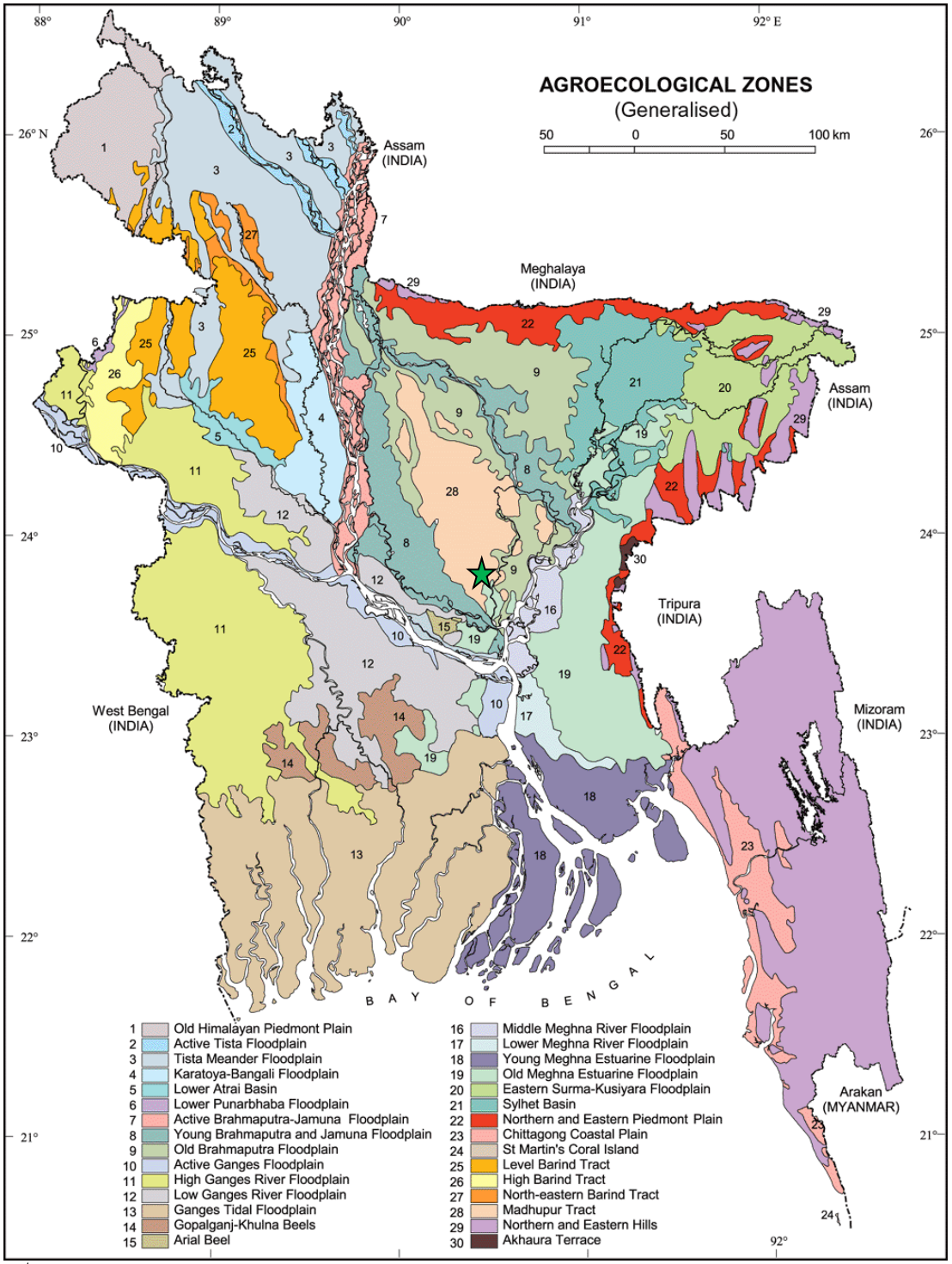
APPENDICES

Appendix I. Map showing the experimental site under the study



★ The experimental site under the study

Appendix II: Morphological, Physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Chemical and physical composition of initial soil (0-15 cm)

Characteristics	Value
Textural class	Silty–clay
pH	5.7
Organic Matter (%)	1.79
Total Nitrogen (%)	0.134
Available P µg/g	3.1
Exchangeable K meq/100g	0.30
Available S µg/g	32
Sand (2.00 – 0.5 mm dia)	28.2
Silt (0.5 – 0.002 mm dia)	41.2
Clay (below 0.002 mm dia)	30.6

Appendix iii: Analysis of variance (mean square values) of plant height of *Aman* rice

Source of variance	Degree of freedom	Plant Height (cm)			
		7 DAT	14 DAT	21 DAT	28 DAT
Replication	2	2.44	2.21	14.2170	49.9703
Varieties	9	64.79	54.7986	23.2363	17.6907
Error	18	4.97	12.0751	18.8977	23.6818

Appendix iv: Analysis of variance (mean square values) of number of tillershill^{-1}

Source of variance	Degree of freedom	Number of Tillers			
		7 DAT	14 DAT	21 DAT	28 DAT
Replication	2	17.0333	11.2000	22.4333	22.8000
Varieties	9	7.9852	11.1259	9.6333	7.9296
Error	18	2.2185	3.9037	4.3222	5.5407

Appendix v: Analysis of variance (mean square values) of number of leaves hill^{-1}

Source of variance	Degree of freedom	No. of leaves			
		7 DAT	14 DAT	21 DAT	28 DAT
Replication	2	20.2333	77.2000	22.3000	61.6333
Varieties	9	70.1074	66.8000	70.3852	92.4037
Error	18	7.0852	15.2000	19.9296	29.4481

Appendix vi: Analysis of variance (mean square values) of Leaf length

Source of variance	Degree of freedom	Leaf length			
		7 DAT	14 DAT	21 DAT	28 DAT
Replication	2	6.74800	7.39300	5.69033	6.23233
Varieties	9	5.39185	5.65244	3.87111	3.49559
Error	18	0.74652	0.84633	1.03811	1.19826

Appendix vii: Analysis of variance (mean square values) of Leaf breath

Source of variance	Degree of freedom	Leaf breath			
		7 DAT	14 DAT	21 DAT	28 DAT
Replication	2	9.000E-03	0.00300	0.00400	0.02433
Varieties	9	5.037E-03	0.01070	0.02670	0.01337
Error	18	8.259E-03	0.01559	0.01215	0.02248

Appendix viii: Analysis of variance (mean square values) of flag leaf SPAD reading

Source of variance	Degree of freedom	No. of breath		
		7 DAT	14 DAT	21 DAT
Replication	2	9.5590	6.9010	9.6640
Varieties	9	13.2665	18.0016	19.7289
Error	18	9.6875	11.2295	10.9262

Appendix ix: Analysis of variance (mean square values) of of plant height after harvest, no. of leaves after harvest, total no. of tiller after harvest, total no. of filled grain per hill, total no. of unfilled grain per hill.

Sources of Variation	Degrees of freedom	Mean Square				
		Plant height after harvest	No. of leaves after harvest	Total no. of tiller after harvest	Total no. of filled grain hill^{-1}	Total no. of unfilled grain hill^{-1}
Replication	2	13.57	59.14	14.49	1244970.9	449307.4
Varieties	9	126.67	17.93	23.09	1370257.5	189711.31
Error	18	63.35	18.56	9.97	1174511.3	194127.3