STUDY OF GROWTH CHARACTERISTICS AND YIELD ATTRIBUTES OF INDIGENOUS AND HIGH YIELDING VARIETIES OF RICE IN AMAN SEASON

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CERTIFICATE

This is to certify that the thesis entitled ***"STUDY OF GROWTH CHARACTERISTICS AND YIELD ATTRIBUTES OF INDIGENOUS AND HIGH YIELDING VARIETIES OF RICE IN AMAN SEASON"*** *submitted to the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in AGRICULTURAL BOTANY****, embodies the result of a piece of bonafide research work carried out by* ***ARIFUL ISLAM,*** *Registration No.* ***12-04900*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

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Dedicated to those who

“Working to feed the hungry planet”

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ABSTRACT

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka,Bangladesh during the period from July to December 2017**,** to study the growth, development and yield of some local and high yielding rice varieties during *aman* season. Ten rice varieties were used as treatments; among them seven were local varieties (Kanchancni, Chinisagar, Sunashail, Ranjay, Lohadang, Haldijan, Kohabinni) and three were high yielding varieties (HYV) (BRRI dhan46, BR11 and BRRI dhan51).The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. There were significant difference among the data obtained from different growth, developmental and yield characters. At 25 and at 50 days after transplanting the highest plant height (62.21cm and 105.57cm respectively) was observed in Kanchancni. Highest plant height at 75 DAT (134.15cm) and at harvest (139.03cm) was found in Lohadang. Highest number of leaves hill^{-1} at 25 days after transplanting (26.00) was found in BRRI dhan46, at 50 DAT (56.67) and at 75 DAT (60.67) was found in Kohabinni, at harvest (34.87) in Ranjay . Highest number of tillers hill^{-1} at 25 DAT (6.67) was found in Ranjay, Haldijan, BRRI dhan46 respectively, at 50 DAT (16.33) was found highest in BRRI dhan46, at 75 DAT (11.64) was found highest in Sunashail, at harvest (25.00) was found highest in Kanchancni. Highest number of effective tiller (15.33) was found in BRRI dhan51, number of ineffective tiller (5.67) was found in Kanchancni and highest (17.67) total tiller was found in BRRI dhan51. Highest crop growth rate (54.86 g cm^{-2} day^{-1}) and absolute grain growth rate (1.85 mg grain^{-1} day^{-1}) was found in Sunashail. Highest flag leaf area (56.20 m^2) was found in Lohadang. Pancle length (30.33 cm) was found highest in Haldijan, filled grain panicle^{-1} (113.67) was found highest in BRRI dhan46, unfilled grain panicle^{-1} (23.00) was found highest in Chinisagar, seed size (28.02 mg) was found highest in Haldijan, grain yield (3.62 tha^{-1}) was found highest in BRRI dhan46, straw yield (4.17 tha^{-1}) was found highest in Chinisagar, total biological yield (6.23 tha^{-1}) was found highest in Chinisagar, harvest index (59.73) was found highest in BRRI dhan46. Panicles hill^{-1} and filled grains panicle^{-1} mainly contributed to the higher grain yield of the high yielding varieties over the inbred.

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ABBREVIATIONS AND ACRONYMS

%	= Percent
AEZ	= Agro ecological zone
BAU	= Bangladesh Agricultural University
BBS	= Bangladesh Bureau of Statistics
BCSRI	= Bangladesh Council of Scientific Research Institute
BRRI	= Bangladesh Rice Research Institute
Ca	= Calcium
cm	= Centimeter
CV %	= Percent Coefficient of Variation
DAS	= Days After Sowing
DMRT	= Duncan's Multiple Range Test
e.g.	= exempli gratia (L), for example
et al.,	= And others
etc.	= Etcetera
FAO	= Food and Agriculture Organization
g	= Gram (s)
GM	= Geometric mean
i.e.	= id est (L), that is
K	= Potassium
Kg	= Kilogram (s)
L	= Litre
LSD	= Least Significant Difference
M.S.	= Master of Science
m^2	= Square meter
mg	= Miligram
ml	= Mililitre
NaOH	= Sodium hydroxide
No.	= Number
^0C	= Degree Celsius
P	= Phosphorus
SAU	= Sher-e-Bangla Agricultural University
USA	= United States of America
var.	= Variety
WHO	= World Health Organization
HYV	= High Yielding Variety
μg	= Microgram
USG	= Urea Super Granule

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for at least 62.8% of total planet populations and it contributes on an average of 20% of calorie intake of the world population and 30% of inhabitants in Asian countries (Asbur, 2013)**.** Bangladesh is one of the top rice producing countries in Asia covering an area of about 7.85 million hectares arable lands where 70% of cultivated area is used for rice production (Awal *et al.,*2007). Bangladesh ranks 4th in both area and production of rice. The population of Bangladesh is increasing at an alarming rate and the cultivable land area is lessening due to urbanization and industrialization; resulting in more scarcity of food. Thus, the present population will enlarge progressively to 223 million by the year 2030 which will require additional 48 million tons of food grains as a substitute of current deficit of about 1.2 million tons every year (BBS, 2015).

Population growth requires a constant increase in rice production in Bangladesh. So, the main concern has been given to produce more rice (Awal *et al*, 2007). Production of rice has to be augmented by at least 60% to meet up food demand of the increasing population by the year 2020 (Alam *et al*, 2014). Two types of rice cultivar are grown in Bangladesh viz. traditional (local) and modern (high yielding) varieties. Though the soil and environment of our country is quite appropriate for production of rice, still it is facing many difficulties of which the poor yielding natural capability of our local varieties is the most vital one. Poor plant type, such as tall plants, long and droopy leaves, weak culms, susceptible to lodging etc. are the main reason of low yielding of local rice varieties. Bangladesh Rice Research Institute (BRRI) has developed 86 rice varieties with yield potential of 4 to 8 tha^{-1}. Bangladesh Institute of Nuclear Agriculture (BINA) has also developed many modern high yielding rice cultivars. The varieties released by BRRI and BINA have still could not restore the local cultivar completely. That means local varieties have some special qualities for which they are also cultivated in Bangladesh.

Bangladesh is famous for wide-ranging rice biodiversity. The farmers have long been growing enormous number of traditional land races with different quality of grains, resistance to number of diseases and insects and with varying growing environment, due

to its diverse agro-ecological conditions (Hossain *et al.* 2012). It is reported that the IRRI Gene Bank contains more than 8,000 traditional rice varieties collected from Bangladesh (IRRI, 1993). Many of these land races such as Lati Shail and Niger Shail have been used by rice breeders as donors to develop privileged lines that have been used as parents for popular and improved rice varieties grown throughout Asia (Hossain et al., 2001, Cabanallia, 2000, Hargrove, 1979).

The current level of yearly rice production of about 545 million tons could be increased to about 700 million tons to feed an additional 650 million rice eaters by 2025 using less land indeed the great challenge in Asia (Dawe, 2003). Rice is widely grown in Bangladesh in the three seasons namely *Aus*, *Aman* and *Boro* which covers total 80% of the total cultivable area of the country (AIS, 2011). Among these cropping seasons transplanted *aman* is most significant and occupied about 46% of the rice cultivated land in 2009-10.The rest 41, 9 and 4 percent of the land is occupied by *Boro*, *Aus* and sown *Aman* correspondingly. Area covered by *Aus* is 10.50 lac hectare and the production 23 lac metric ton, area covered by *Aman* is 56 lac hectare and the production is 131 lac metric ton, lastly area covered by *Boro* is 48 lac hectare and the production is 192 lac metric ton (BBS, 2016). In *Aman* season, however, available information regarding the yield and yield contribution characters, both morpho-physiological characteristics of HYV rice varieties are not enough in Bangladesh. That is why, it is a prime need to carry out more research work to find out and develop sustainable technologies regarding HYV rice cultivation under the prevailing local conditions in the *aman* season. Julfiquar et al.1998, observed that the modern inbred rice varities in Bangladesh had longer growth period of 135-150 days in *aman* season with a low daily yield, while high daily yield in hybrid and high yielding rice was due to its short duration of 120-130 days. Therefore, if HYV rice is introduced, crop duration can be reduced by 20-40 days. In the year 2010, among the *aman* rice varieties high yielding modern varieties covered 66.63% and yield was 2.49 t ha^{-1} and local varieties covered 24.97 % and yield was 1.58 t ha^{-1} (BBS, 2010). It is the farmers who have increasingly replaced the local indigenous low yielding rice varieties by high yielding ones and modern varieties of rice developed by Bangladesh Rice Research Institute (BRRI) only because of getting 20 to 30% more yield per unit land area (Shahjahan, 2007).

But, the cultivation of modern varieties (MVs) was introduced in Bangladesh in the *boro* season through importation of seeds of IR-8. The variety produced almost 2.5 times higher yield that of traditional *boro* varieties grown at that time. Beginning in 1970, another IRRI bred variety, IR-20 (IRRI Shail) was introduced to farmers for growing in the *aman* season. In addition to the IRRI Varieties, Paizam (or Pajam, or Masuri, or mansuli as known in different parts of South Asia) a high yield varieties of Malaysian source developed under an FAO project was another improved variety grown in the *aman* season. IRRI parent materials were not found suitable for the *aman* season which are subjected to water and extended water logging. For this season, BRRI scientists have crossed international elite lines with Bangladeshi land races to develop suitable varieties. Most popular of them is BR11, released in 1981.As a result of the introduction of these modern varieties, many traditional rice varieties have completely disappeared or on the way of extinction. Despite of low yield, which is one of the major reasons for continuing production of local varieties is varietal adaptation to soils and other environmental factors (Zimmerer and Douches 1991). That is, the more diverse the conditions in which farmers cultivate the crop, the higher the extent to which they provide agronomic (adaptation to soils, maturity, disease resistance, fodder and grain yield) and consumption (taste, appearance) attributes (Benin 2003). The total number of landraces as well as the area planted to landraces in Bangladesh is declining over time (Hossain, *et al*. 2012). However, several traditional varieties are still popular among farmers/consumers due to their extraordinary traits. Hossain and Jaim (2009) reported that farmers in Bangladesh still cultivate more than 1,000 traditional varieties/landraces. It is important to find out the special characteristics of our huge local rice cultivars in order to improve our HYV of rice through gene transfer. Considering the above statements in mind, the present study was under taken with the following objectives-

OBJECTIVES:

1. To study the different growth and yield characteristics of the selected local and HYV *aman* rice.
2. To identify the important characteristics that contribute in yield.

CHAPTER II

REVIEW OF LITERATURE

Rice is the major food product of the people of Bangladesh and the world. Yield and yield contributing characteristics of rice are considerably depended on management of basic ingredients of agriculture. The basic ingredients include varieties of rice, surroundings and agronomic practices.

Research on this crop is going on various aspects in increase its potential yield including number of seedlings hill^{-1} and varieties which are responsible for the growth and yield of rice. Local varieties have higher plant height, longer growing period, disease and pest susceptibility, higher grain sterility and shattering loss where as High yielding varieties (HYV) are generally more adaptive to appropriate number of seedlings hill^{-1}, short growing period, lower plant height, rich in nutrient, lower grain sterility and higher yield. Some of the main and informative works and research results related to different rice varieties done at home and abroad have been reviewed under the following headings:

2.1 Plant Height

Bhuiyan *et al*. (2014) conducted an experiment which intend to find out the adaptability and performance of different hybrid rice varieties and to categorize the best hybrid rice variety in terms of plant growth and suggest it to rice farmers. Based on the findings of the study, the dissimilar hybrid rice varieties evaluated had significant effects on plant height at maturity. Asbur (2013) conducted an experiment to find out the effects of seedling number per hill and seedling age on plant growth, and grain yield Ciherang rice and reported that reducing seedling number per hill from 5 to 3 and 1, respectively, increased plant growth extensively. Sarkar *et al*. (2011) carried out an experiment to observe the effect of row arrangement, age of tiller seedlings and number of tiller seedlings hill^{-1} on the vegetative characters, yield and yield causing characters of transplant *aman* rice. The experiment consisted of three levels of row arrangement, two types of tiller seedlings, and three levels of number of tiller seedling hill^{-1} viz. 2, 4 and 6 seedlings hill^{-1}. Plant height was the maximum when 2 tiller seedlings were transplanted hill^{-1}. Salem *et al*. (2011) conducted two field experiments at the Rice Research and Training Center (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt during summer

seasons to study the consequence 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 expressions of plant height. Masum *et al*. (2008) found that plant height of rice affected by varieties in *aman* season where Nizershail had the taller plant height than BRRI dhan44 at different days after transplanting (DAT). Murthy *et al.* (2004) researched with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and found that Mukti gave the tallest plant compared to the others. Hybrid rice variety superior than other varieties in terms of plant height. BINA (1993) evaluated the performance of four rice varieties (IRAATOM 24, BR14, BINA13 and BINA19). It was found that varieties differed extensively in respect of plant height.

BRRI (1991) observed the plant height differed considerably among BR3, BR11, BR14, Pajam and Zagali varieties in the *Boro* season. Hosain and Alam (1991) found that the plant height in present rice varieties BR3, BR11, BR14 and Pajam were 90.4, 94.5, 81.3 and 100.7 cm, respectively. Hossain *et al.* (2005) conducted a study to investigate the relationship between grain yield with the morphological parameters of five local and three modern aromatic rice varieties. The varieties were Kataribhog, Radhunipagal, Chinigura, Badshabhog, Kalizera, BRRI dhan34, BRRI dhan37 and BRRI dhan38. The highest plant height was observed in Chinigura which was statistically similar to Kataribhog.

2.2 Number of tillers hill^{-1}

Sarkar *et al*. (2016) carried conducted an experiment to find out 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 check. The result showed that the hybrid varieties were superior in respect of tillers hill^{-1} and these hybrid varieties showed higher fertile tillers hill^{-1}. Jisan *et al*. (2014) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to inspect the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRIdhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of N. Among the varieties, BRRI dhan52 produced the maximum number of fertile tillers hill^{-1} (11.28), while the lowest values of these parameters were produced by BRRI dhan57. Bhuiyan *et al*. (2014) carried out an

experiment which aimed to find out the adaptability and performance of different hybrid rice varieties and to recognize the best hybrid rice variety in terms of yield and suggest it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had noteworthy effects on number of tillers, number of productive tillers RGBU010A X SL8R is therefore recommended as planting material among hybrid rice varieties because it formed more productive tillers Masum *et al*. (2008) said that number of total tillers hill^{-1} was considerably influenced by cultivars at all stages of crop growth. Nizersail 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 found around panicle initiation stage at 60 DAT. Murthy *et al.* (2004) carried out an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and found that Mukti gave the highest tillers hill compared to the others. Bhowmick and Nayak (2000) carried out 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 fertile tillers (413.4/m^2) than other tested varieties. Ahmed *et al*. (1998) found 11 better maintainer lines with good maintainability for corresponding CMS lines in an assessment program of 64 maintainers with respective CMS lines from different countries and recorded differences for number of effective tillers.

2.3 Number of leaves hill^{-1}

Sarkar (2014) found a noteworthy difference on total number of leaves per hill from vegetative to reproductive stage. He found maximum no of leaves in Tia (78.67) and lowest in BRRI hybrid dhan 2 (64.34). Hassan (2001) expressed that photo synthetically active leaves hill^{-1} of all varieties increased with the growth period up to booting stage except in Binasail. He also found that maximum number of leaves were produced at the tillering stage and then declined. The speed of declination was sharp in local varieties than that of hybrid varieties.

2.4 Leaf area

Sarkar (2014) exhibited that hybrid rice variety generated the higher leaf area than the check variety and the variation in leaf area might occur due to the variation in number of

leaves. Islam (2006) found that the increment of leaf area hill^{-1} varied considerably due to genotype at all growth stages. Song *et al*. (2004) found that flag leaf area was highest in Minghui-63, Hybrid was intermediate, and *O. rufipogon* had the smallest area. Piranhas *et al.* (1997) observed that all the cultivars produced maximum leaf area during panicle initiation.

2.5 Varietal difference

Sultan *et al.* (2018) conducted an experiment to observe the growth and yield of transplant *aman* rice cv. BRRI dhan46. The spacing 25cm × 15cm produced the highest grain yield, highest straw yield and highest biological yield. In the interaction between seedling age and spacing the highest grain yield was obtained when 30-day old seedlings were transplanted with 25cm × 20cm spacing, which was statistically identical to 45-days old seedlings at the same spacing. From the results, it may be concluded that 45-days old seedlings transplanted with 25cm× 15cm to 25cm × 20cm spacing appeared as the promising practice to obtain maximum grain yield of transplant *aman* rice cv. BRRI dhan46 under staggered transplanting condition. Murshida *et al*. (2017) carried out an experiment with three varieties (cv. BRRIdhan28, BRRI dhan29 and Binadhan-14) and four water management systems to observe the effect of variety and water management system on the growth and yield performance of *boro* rice. At 100 DAT, the maximum plant height, highest number of tillers hill^{-1}, dry matter of shoot hill^{-1} and dry matter of root hill^{-1}were found from BRRI dhan29 and the lowest values were found from Binadhan-14.Variety had noteworthy effect on all the crop characters under study except seed size. The maximum grain yield was found from BRRI dhan29 and the lowest value was recorded from Binadhan-14. Kumar *et al*.(2016) carried out an experiment in the *kharif* season of 2011 at Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Kaul, India to study the comparative performance of scented/basmati rice (CSR 30) under five different methods of planting *viz.*, machine transplanting under pudlled (M1) and unpuddled conditions (M2), direct seeding under *vattar* conditions (M3), direct seeding under zero tillage (with residue) (M4), conventional practice (nursery raising) (M5) in a randomized block design with three replications. The growth indices like LAI, CGR, RGR, NAR, LAD, LWR, SLA, SLW, ULR, LRGR, LAPF and agro-meteorological indices *i.e*. AGDD, AHTU, APTU, RUE

and HUE showed significantly positive correlation with yield and yield attributes. Chamely *et al*. (2015) carried out an experiment with three varieties *viz*., BRRIdhan28 (V1), BRRI dhan29 (V2) and BRRI dhan45 (V3); and five rates of nitrogen *viz*., control (N0), 50 kg (N1), 100 kg (N2), 150 kg (N3) and 200 kg (N4) N ha-1 to study the effect of variety and rate of nitrogen on the performance of *Boro* rice. The growth analysis results shows that the highest plant (80.88 cm) and the highest number of total tillers hill^{-1} (13.80) were observed in BRRI dhan29 at 70DATs and the highest total dry matter (66.41 g m^{-2})was observed in BRRI dhan45. The lowest plant height (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 expresses 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 maximum grain yield (4.84 t ha^{-1}) was recorded from BRRI dhan29. Sarkar *et al*. (2014) carried out an experiment to study the yield and quality of aromatic fine rice as influenced by variety and nutrient management. The experiment consisted three aromatic fine rice varieties *viz*. BRRI dhan34, BRRIdhan37 and BRRI dhan38. The highest plant (142.7 cm), the maximum number of effective tillers hill^{-1} (10.02), number of grains panicle^{-1} (152.3), panicle length (22.71cm), seed size (15.55mg) and grain yield (3.71 t ha^{-1}) were recorded in BRRI dhan34. Haque *et al.* (2013) carried out an experiment to assess some physiological traits and yield of three hybrid rice varieties (BRRI hybrid dhan2, Heera 2, and Tia) in comparison to BRRI dhan48 in Aus season. Compared to BRRI dhan48, hybrid varieties gathered greater shoot dry matter at anthesis, higher flag leaf chlorophyll at 2, 9, 16 and 23 days after flowering (DAF), flag leaf photosynthetic rate at 2 DAF and longer panicles. Heera2 and BRRI hybrid dhan2 maintained considerably higher chlorophyll a, b ratio over Tia and BRRI dhan48 at 2, 9, 16and 23 DAF in their flag leaf. Shoot reserve remobilization to grain expressed higher degree of sensitivity to rising of minimum temperature in the studied hybrids compared to the inbred. Inefficient photosynthetic activities of flag leaf and poor shoot reserve translocation to grain resulted poor grain filling percentage in the test hybrids. Therefore the studied hybrids showed significantly lower grain yield (36.7%) as compared to inbred BRRI dhan48, irrespective of planting date in *Aus* season. Myung (2005) experimented with four different panicle

types of rice varieties and found that the primary rachis branches (PRBs) panicle^{-1} and grains were more on Sindongjinbyeo and Iksan467 varieties, but secondary rachis branches (SRBs)were fewer than in Dongjin1 and Saegyehwa varieties. Anwar and Begum (2004) stated 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. Julfiquar *et al.* (1998) expressed 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 (BR14 and BR16) with considerable yield difference. They also stated that thirteen rice hybrids were evaluated in three locations of BADC farm during *Boro* season of 1995-96. Two hybrids out yielded the check variety of equal duration by more than 1 t ha^{-1}.

Sarker *et al.*(2013) carried out an experiment to study morphological, yield and yielding characters of four *Boro* rice varieties of which three were traditional *viz*., Bashful, Poshursail and Gosi; while another one was a high yielding variety (HYV) BRRI dhan28. The BRRI dhan28 were considerably superior among the cultivars studied. The BRRI dhan28 was shorter in plant height, having more tillering capacity, higher leaf number which in turn exhibited superior growth character and yielded more than those of the local cultivars. The HYV BRRI dhan28 obtained higher number of grains panicle^{-1} and coarse grains resulted in higher grain yield over the local cultivars. BRRI dhan28 had more total dry mass than those of local varieties. The BRRI dhan28 obtained higher grain yield (7.41 t ha^{-1}) than Bashful, Poshurshail and Gosi, respectively. Among the local rice cultivars, Gosi exhibited the higher yielding ability than Bashful and Poshursail. Mannan *et al*. (2012) carried out an experiment at the Bangladesh Rice Research Institute Farm, Gazipur, in *boro* season to find out the optimum planting date and to select the varieties having high yield potential. Traditional aromatic photoperiod sensitive fine rice varieties; Kalijira, Kataribhog, Chinigura and Badshabhog were transplanted from 10 December and continued up to 25 January, both in 2000 and 2001 years, at an interval of 15 days. Forty-day old seedlings were transplanted spaced at 20 cm x 20 cm. Results showed that

plant tallness, number of tillers and dry matter increased with the advancement of planting dates. On the contrary, the number of panicles, grains panicle^{-1}, panicle length, grain yield, straw yield and growth duration declined with delaying of planting dates. The intermediate short stature plant type of Chinigura showed higher number of panicles (300-331 m^{-2}) and comparatively heavier individual grain (12.25-12.31 g), consequently gave higher grain yield (2.79-3.53 t/ha) planted within December. In late planted situation in 10 January Kalijira showed higher number of panicles, grains panicle^{-1}, resulted higher grain yield than the rest of the varieties. Thus, cultivation of traditional aromatic fine rice Chinigura and Kalijira have the ability to produce higher grain yield when planted in early December in *Boro* season.

2.6 Crop growth rate (CGR)

Yang *et al*. (2010) found that CGR was significantly positively correlated with yield of rice. But at the early stage CGR was not considerably different with the yield. Horie (2006) showed that the most critical growth attribute for rice yield under intensive management is CGR during the latter half of the reproductive period (15 to 20 day before heading). Maximum CGR occurred at flowering stage for all genotypes than old genotypes. Generally modern genotypes showed greater CGR than old genotypes (Mandavi *et al.*, 2004). Miah *et al.* (1996) expressed that crop growth rate during the heading to maturity stage were the lowest among the cultivars due to the gradual decreasing of LAI and SPAD at grain filling stage. The genotypes with highest and lowest dry matter had highest and lowest CGR respectively in leaves cause parallel decrease in NAR and eventually low growth rate.

2.7 Days to maturity

Swain *et al.* (2007) observed that among the medium-duration varieties (115–130 days), there was good agreement between simulated and observed leaf area index, biomass, and grain yield. The simulated biomass of long-duration varieties (135–150 days) showed high deviation from observed biomass at flowering. In the wet season of 2000, the model accurately predicted the grain yield, biomass and leaf area index of medium and long-duration varieties. Wei *et al.* (2004) stated that Yueza 122 was bred by crossing GD-IS

with Guanghui 122. It shows wide adaptability, high and stable grain yield, moderate growth period, and fine grain quality, high resistance to rice blast and medium resistance to bacterial blight. Wang (2000) carried out an experiment in plot trials in 1998 and 1999, where growth period of early hybrid rice cv. Zhe 9516 was 116 and 117 days, respectively. Huang *et al.* (1999) studied the morphological and physiological features of Yueza 122. The results exhibited that it was an early matured hybrid combination with duration of 83 days from sowing to heading in the early cropping season. Yu, H. Y *et al*. (1995) stated that hybrid variety was bred from the crossII32A/Hui 92 in the Zhejiang province of China it reaches a height of 90 cm and has a growth period of 122-125 days.

2.8 Flag leaf chlorophyll content

Haque *et al* (2014) stated that the hybrid varieties synthesized considerably higher amounts of chlorophyll and maintained higher chlorophyll a: b ratio in their flag leaf over inbred BRRI dhan45. Flag leaf chlorophyll content and chlorophyll a:b ratio steadily decreased in the hybrid and inbred varieties with advanced maturity. Decrease of chlorophyll content at 23 days after flowering compared to days after flowering was 33 and 36% in hybrids and inbred, respectively. Planting dates had little influence on flag leaf chlorophyll composition. Chlorophyll a:b ratio of the flag leaf was superior in both the hybrids. However, environmental effect on total chlorophyll content of flag leaf was relatively small. Salem *et al.* (2011) expressed that crop growth rate during three dissimilar growth periods and chlorophyll content were significantly increased for the 20 days seedling and 40 days seedling gave the minimum value for chlorophyll content.

2.9 Duration from Germination to Maturity

Rao and Patnaik (2006) found that most of the long period hybrids possessed long panicles with high grain number panicle^{-1}. The flowering period was observed to be highest in CR 874-23 (153 days) followed by CR 758-16 (151 days). The earliest varieties were found to be Swarna (110 days). Hybrid JR 6408A 827 having growth duration of 110 days gave the highest yield of 6.08 MT/ha in the summer cropping season of 1996, compared to 4.38 MT/ha of CR203 (check), 5.1 MT/ha of Shan You 63, and 4.95 MT/ha of Shan You Gui 99 (DAFE, 2003). In the medium-duration varieties (115-130 d), there was good harmony between simulated and observed leaf area index,

biomass, and grain yield. The simulated biomass of long-duration varieties (135-1 50 d) showed large deviation from observed biomass at flowering. Patnaik and Mohanty (2006) showed that there was a wide variation in the maturity duration of varieties.

2.10 Number of effective tillers hill^{-1}

Awal *et al*. (2007) found no significant variation among the treatments regarding no. of panicle hill^{-1}. Sonarbanla-3 resulted in the highest filled up grains (176 grains panicle^{-1}) but did not differ considerably with BRRI dhan32 (149 grains panicle^{-1}). Sonarbangla-3 had clear statistical edge over Sonarbangla-2, BRRI dhan33 and BR11 in this respect. Somnath and Ghosh (2004) stated that the association of yield and yield related traits with the number of fertile tillers and had negative association with yield and yield components. Ma *et al.* (2001) found that ADTRH1 is a rice hybrid. It tillers abundantly (12-15 productive tillers per hill) under 20 x 10 cm spacing, with each panicle 27.5 cm long, producing 142 grains. In different trials, ADTRH1 showed 26.9 and 24.5 % superior yield over CORH1 and ASD18, respectively, with an average yield of 6.6 t/ha. Lee *et al.* (1992) found that the number of spikelet panicle^{-1}, panicle length and grain yield panicle^{-1} were higher in the main tiller and decreased with increasing tiller order with delaying panicle emergence in rice.

Hossain *et al.* (2005) conducted a study to investigate the relationship between grain yield with the morphological parameters of five local and three modern aromatic rice varieties. The varieties were Kataribhog, Radhunipagal, Chinigura, Badshabhog, Kalizera, BRRI dhan34, BRRI dhan37 and BRRI dhan38. The highest number of effective tillers hill^{-1} was observed in BRRI dhan37 which identically followed by Radhunipagal, Badshabhog, Chinigura, BRRI dhan38.

2.11 Total grains panicle^{-1}

Yuan *et al.* (2005) studied the difference in the yield components of 75 high quality rice cultivars. Among the yield components, the greatest difference was recorded for number of grains panicle^{-1} in *indica* rice, and no. of panicles plant^{-1} in *japonica* rice. Ma *et al*, (2001) studied a hybrid under 20 cm × 10 cm spacing, producing 142 grains panicle^{-1} and with more than 90% spikelet fertility. The hybrid recorded the highest grain yield (11.4 t ha^{-1}). Oka and Saito (1999) studied and found that among F1 hybrids crosses with rice cv.

Sasanishiki; plant height, panicle length and number of grains panicle^{-1} were higher in the hybrids than in Sasanishiki, but the seed size was lower.

2.12 Panicle length

Chakma (2006) experimented that BINA dhan-5 produced the longest panicle (22.86 cm) followed by BRRI dhan29 (22.78 cm) and BINA dhan-6 (22.28 cm). Ghosh (2001) experimented the performance of 4 rice hybrids and 4 high yielding rice cultivars. Hybrids, in general, gave higher results for panicle length compared with high yielding cultivars. Nehru *et al.* (2000) found that values for yield and test weight differed considerably for hybrids (21–24 g) and check varieties (19–23 g). No dissimilarities in panicle length were noted between the two groups. Oka and Saito (1999) stated that there were relationships with parental values for panicle length, grains panicle^{-1} and panicle emergence date. The hybrid MH2005 gave a yield of 6.09 t ha^{-1} compared with 4.36 t ha^{-1} from cv. Hitomebore. Ramalingam *et al.* (1994) found that varieties with long panicles, higher no. of filled grains panicle^{-1} and more primary rachis would be appropriate for selection because these characters had higher positive association with grain yield and were correlated among themselves.

2.13 Number of filled grains panicle^{-1}

Parvez *et al.* (2003) stated that yield advantage for the hybrid rice was mostly due to the proportion of filled grains panicle^{-1}, heavier grain weight (35%) and increased harvest index values than the control (28%). Shrirame and Mulley (2003) carried out an experiment on variability and correlation of different biometric and morphological plant characters with grain yield. Grain yield was considerably correlated with number of filled grains panicle^{-1}. Ganesan (2001) conducted research with 48 rice hybrids. Filled grains panicle^{-1} (0.895) had the highest considerable positive direct effect on yield plant^{-1} followed by number of tillers plant^{-1} (0.688), panicle length (0.167) and plant height (0.149). Mrityunjay (2001) carried out an experiment to study the performance of 4 rice hybrids and 4 high yielding rice cultivars. Hybrids, in general; gave superior values for number of filled grains panicle^{-1}, plant height at harvest and panicle length compared with the others. Srivastava and Tripathi (1998) observed that the increase in grain yield in

local check variety in comparison with hybrid might be attributed to the increased fertile grains panicle^{-1}.

2.14 Number of unfilled grains panicle^{-1}

Chowdhury *et al.* (1995) stated that the cultivar BR23 showed higher performance over Pajam in respect of yield and yield contributing characters i.e. number of fertile tillers hill^{-1}, length of panicle, 1000-grain weight, grain and straw yield. On the other hand, the cultivar Pajam produced considerably taller plant, higher number of total spikelets panicle^{-1}, grains panicle^{-1}and unfilled spikelets panicle^{-1}.

2.15 Grain sterility

Ullah *et al.* (2016) carried out research to determine the suitable nitrogen source for increasing the grain yield by reducing spikelets sterility in *boro* rice. The experiment comprised four nitrogen sources such as no nitrogen (T0), BRRI recommended dose of prilled urea (T1), Govt. approved dose of mixed NPK (T2) and BARC recommended dose of USG (T3), and four varieties viz. BRRI dhan29 (V1), BRRI dhan58 (V2), BADC SL8H (V3) and Heera (V4). The application of USG showed the highest grain yield (8.6 t/ha) and the lowest percentage of spikelet sterility than any other nitrogen sources. All the studied characters except leaf area, dry matter weight and harvest index varied significantly among the varieties. This is mainly attributable to the highest number of filled grains (98.8/panicle) with markedly lower level of spikelet sterility (7.3%) was found from BRRI dhan29. The combination of the USG application and BRRI dhan29 had the higher performance in terms of producing the highest grain yield by significant reduction of spikelet sterility among the interaction effects.

2.16 Seed size

Neerja and Sharma (2002) carried out an experiment on non-aromatic (cvs. IRB, Jaya, PR113, PR103, PR106, PR108, PR115 and PR116) and aromatic (cvs. Basmati 370, Basmati 385, Basmati 386 and Pusa Basmati No. 1) rice and observed that the highest 1000 kernel weight rice, brown rice and milled rice was recorded for PR113. Ma *et al.* (2001) researched with ADTRH1 which was a hybrid rice. Its 1000-grain weight was 23.8 g. In different trials, ADTRH1 showed 26.9 and 24.5% higher yield over CORH1 and ASD18. Uddin *et al.* (2001) carried out an experiment to obtain the crop performance

of hybrid, inbred and local improved rice varieties and reported that variety had considerable effect on all crop characters under study. Sonarbangla-1 ranked first in respect of 1000-grain weight followed by Alok 6201 and Habigonj.

2.17 Grain yield

Adhikari *et al.* (2018) conducted the research at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during *aman* season from July to December, 2015 to study the effect of nitrogen fertilizer and weed management on the growth and yield of transplant *aman* rice cv. BRRI dhan46. The experiment consisted of four fertilizer treatments viz. 0 kg N ha^{-1} (N0), 40 kg N ha^{-1} (N1), 80 kg N ha^{-1} (N2) and 120 kg N ha^{-1} (N3). The experiment was laid out in randomized complete block design with three replications. The highest plant height (113.00 cm), number of total tillers $hill^{-1}$ (8.74), number of effective tillers $hill^{-1}$ (6.18), panicle length (21.98 cm), number of grains $panicle^{-1}$(114.20), grain yield (4.00 t ha^{-1}), straw yield (5.25 t ha^{-1}) and biological yield (9.25 t ha^{-1}) were recorded in N2 (80 kg N ha^{-1}) treatment. The lowest plant height (106.00 cm), number of total tillers $hill^{-1}$ (7.20),number of effective tillers $hill^{-1}$ (5.00), panicle length (20.70 cm), number of grains $panicle^{-1}$ (97.60), grain yield (3.52 t ha^{-1}), straw yield (4.46 t ha^{-1}) and biological yield (7.97 t ha^{-1}) were recorded from N0 (No nitrogen fertilizer control) treatment. Therefore, 80 kg N ha^{-1} may be used for obtaining the highest grain and straw yields of BRRI dhan46. Wu *et al*. (2016) observed that typical *japonica* type rice is sensitive to high temperature. Pon-Lai rice is a special *japonica* type with adaptation to the subtropical climate in Taiwan. Facing climate change, rising temperatures would damage the yield and quality of rice production. This research was conducted using Pon- Lai rice in the field of a subtropical climate. They conducted 2 experiments, including a year-round experiment and collection of samples from different districts for building different temperature conditions. They analyzed the correlation between rising temperature and rice yield or quality. In their results, the critical period of temperature effect is 0–15 days after heading (H15). The threshold of high temperature damage in yield and appearance quality was 25–27 °C. Grain weight decreased about 2–6 %, while the temperature of H15 was raised 1 °C above the thresholds. Perfect grain ratio and chalky grain ratio decreased and increased, respectively, while the temperature of H15 was raised above the thresholds. However, the high temperature in H15 affected the

physicochemical characteristics. In addition, they found positive correlation between grain length to width ratio and perfect grain ratio. Grain length to width ratio could be an index of temperature effects for grain quality. In our study, when the temperature was below 30 °C, a rising temperature of H15 could damage rice yield and appearance quality, and change grain shape. Their results could provide reference for dealing with the warming future in other temperate rice-cultivated countries. Siddiqua *et al.* (2016) conducted an experiment at Bangladesh Agricultural University, Mymensingh, during T. *Aman* 2010 with a view to investigate the effect of rate and method of urea application on the yield and yield components of transplanted *aman* rice cv. BRRI dhan46. The experiment comprises of two methods of urea application and five rates of urea fertilizer. The experiment was laid out in a randomized complete block design with four replications and the data collected on 10 parameters. The results showed that the method of urea application had significant effect on number of total tillers per hill, number of effective tillers per hill, number of grains per panicle, grain yield, straw yield and harvest index. The highest grain yield (4.66 tha^{-1}) was recorded with split application of urea fertilizer. The effect of urea rate had significant influence on most of the plant characters except panicle length and 1000 grains weight. The highest grain yield (5.07 tha^{-1}) was produced in U1 (140 kg urea ha^{-1}). The interaction between rate and method of urea application also significantly influenced most of the parameter studied. The highest grain yield (5.15 tha^{-1}) was recorded with the interaction combination of M1U1 (split application of urea @ 140 kg urea ha^{-1}). Iftekharuddaula *et al.* (2015) developed submergence tolerant high yielding rice variety using BR11 as a recipient parent applying foreground, phenotypic and background selection approaches. Recombinant selection was found essential to minimize linkage drag by BC2F2 generation. Without recombinant selection, the introgression size in the backcross recombinant lines (BRLs) was approximately 15 Mb on the carrier chromosome. The BRLs were found submergence tolerance compared to the check varieties under complete submergence for two weeks at Bangladesh Rice Research Institute, and produced higher yield compared to the isogenic Sub1-line under controlled submerged condition. The BRL IR85260-66-654-Gaz2 was released as BRRI dhan52 in 2010, which was the first high yielding submergence tolerant variety in Bangladesh. BRRI dhan52 produced grain yield ranging from 4.2 to 5.2 tha^{-1}

under different flash flood prone areas of Bangladesh in three consecutive seasons. The study demonstrated the efficiency of recombinant selection and better adaptability of the newly released submergence tolerant high yielding variety in flashflood prone different areas of the country with respect to submergence tolerance and yield potential. Shrirame and Mulley (2003) found that grain yield showed a very strong positive correlation with harvest index. Grain yield was also considerably correlated with dry matter weight hill^{-1}, effective tillers hill^{-1} and no. of filled grains panicle^{-1}. Pruneddu and Spanu (2001) carried out an experiment in Sardinia on varietal comparison of rice. They used 18 varieties and organized into groups according to grain properties (round, medium, long A. long B and aromatic). The maximum yields were obtained from the long-grained varieties Alice (9.1 t ha^{-1}, long A) and Ebro (8.4 t ha^{-1}, long B). Singh *et al.* (1998) studied the productivity of two rice hybrids viz. TNH-1 and TNH- 2 using Rasi and Jaya as standard checks during Kharif season of 1992 and found that Jaya produced considerably highest grain yield (5.12 t ha^{-1}). The grain yield of Rasi and TNH-1 were higher and at par but TNH-2 was recorded for the lowest grain yield (3.06 t ha^{-1}). Geetha *et al.* (1994) experimented with six hybrids for grain characters. ADRH4 was the maximum yielding (19.7 gm plant^{-1}). The higher yield in this hybrid was due to higher no. of grains plant^{-1}. Correlation analysis expressed that only grains plant^{-1} had a strong positive association with grain yield.

Ashrafuzzaman et al. (2009) undertook a study to evaluate the growth performance and grain quality of six aromatic rice varieties BR34, BR38, Kalizira, Chiniatop, Kataribhog and Basmati grown under rainfed conditions. The rice varieties differed significantly ($P<0.05$) with respect to leaf chlorophyll content, plant height, internode length, thousand grain weight and grain and straw yields. Varieties differed in morphological and yield and yield contributing traits. Thousand grain weight and grain yield both was highest in BR38. Basmati required shorter days to maturity and Kalizira longest days to maturity. Hassan *et al.* (2003) stated that grain yield is a function of interplay of various yield components such as number of productive tillers plant^{-1}, spikelets panicle^{-1} and 1000-grain weight. Maksudul et al. (2015) carried out the experiment from July to December 2012 to study the effect of varieties and number of guti urea hill^{-1} on the yield of Transplant *Aman* rice where three varieties *viz.* Moulata, Shakorkura and BRRI dhan51

and three levels of guti urea hill^{-1} *viz.* 0, 1 and 2 guti hill^{-1} were used for the present study. The factorial experiment was laid out in a split–plot design with three replications. Responses of variety had significant among the whole yield, yield. However, the variety Shakorkura had the tallest plant and higher production of straw at harvest but BRRI dhan51 gave the highest total tillers effective (8.523) and total tillers hill^{-1} (9.712), total grains panicle^{-1} (141.8), 1000 grain weight (31.01 g), grain yield (6.071 t ha^{-1}) and harvest index (43.17%). All the characters were lower in without guti hill^{-1}. Among the interaction between varieties and guti urea hill^{-1}, significantly the tallest plant (136.4 cm), higher straw yield (10.99 t ha^{-1}) and higher biological yield (16.49 t ha^{-1}) were recorded in 2 guti hill^{-1} of Shakorkura while 2 guti hill^{-1} interaction with BRRI dhan51 observed the maximum effective (8.767) and total tillers hill^{-1} (9.833), maximum total grains panicle^{-1} (147.4), thousand grain weight (32.07 g) and grain yield (6.420 t ha^{-1}). These results suggested that the variety BRRI dhan51 and 2 guti hill^{-1} individually or combined would be more effective for greater yield of T *aman* rice. Hossain *et al.* (2005) conducted a study to investigate the relationship between grain yield with the morphological parameters of five local and three modern aromatic rice varieties. The varieties were Kataribhog, Radhunipagal, Chinigura, Badshabhog, Kalizera, BRRI dhan34, BRRI dhan37 and BRRI dhan38. Among the varieties highest grain yield was observed in BRRI dhan34 which was followed by Kataribhog.

2.18 Straw yield

Summers *et al.* (2003) experimented with eight common California rice cultivars at multiple sites for the 1999 and 2000 seasons and found variability in straw quantity and quality which can have critical impacts on biomass industries. The length of the pre-heading period was the strongest indicator for straw yield. Harvested straw yield is also strongly affected by cutting height with a non-linear distribution resulting in nearly half of the straw biomass occurring in the lower third of the plant.

2.19 Total Biological yield

Peng *et al.*, (2000) showed that the increasing trend in yield of cultivars due to the improvement in harvest index (HI), while increase in total biomass was associated with yield trends for cultivars–lines. Ramesha *et al.* (1998) obtained that the high yielding ability of the hybrids over the controls resulted from increased total biomass and

increased panicle weight, with almost the same level of harvest index. Kim and Rutger (1988) stated that hybrids that gave superior grain yields also produced higher biomass. In addition, biomass yield at different growth stages showed different patterns for hybrid rice and traditional rice. Hybrid rice has more dry matter accumulation in the early and middle growth stages.

2.20 Harvest index

Senapati *et al.* (2004) found adaptability of *aman* paddy under sundarban areas of West Bengal. Grain yield and number of days to maturity were studied in 40 *aman* rice genotypes grown during the *kharif* seasons of 1997, 1998, 1999 and 2000 under rainfed lowland condition of Kakdwip, West Bengal, India. They found significant genetic variation and genotype-environment interaction for both traits. They found 21 genotypes were stable for number of days to maturity. Of these, CR-626-26-2-3, CR-383-10, Dudhraj, Lilabati, Dhusari and Bogamanohar were late matured variety, which was desirable for *aman* rice cultivation in Sundarban areas. Twenty-two genotypes were highly even for grain yield and widely adapted to Sundarban areas. Shrirame and Mulley (2003) carried out an experiment on variability and correlation studies of different biometric and morphological plant characters of rice with grain yield. It was conducted with rice hybrids TNRH10, TNRH13 and TNRH18 and cultivar Jaya. They observed that grain yield exhibited a very strong positive correlation with harvest index. Grain yield was also considerably correlated with dry matter weight hill^{-1}, effective tillers hill^{-1} and number of filled grains panicle^{-1}. Peng *et al.* (2000) stated that the increasing trend in yield of cultivars released before 1980 was mainly due to the improvement in harvest index (HI), while an increase in total biomass was associated with increasing yield trends for cultivars–lines developed after 1980. Cui *et al.* (1998) carried out a varietal trial of Japanese rice varieties (J group) along with 20 high yielding Asian rice varieties (H group). They reported considerably higher yield and harvest index in H group than that of the J group. Days to heading (DTH) showed considerable positive correlation with total dry matter weight and a considerable negative correlation with harvest index.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka-1207 during July to December 2017. This chapter consists of materials used and methods followed during the experimental period. A brief description of materials used, treatments, location of the experimental site, characteristic of soil, climate and weather, experimental design, fertilizer application, transplanting of the seedlings, application of soil enhancer, intercultural operations, harvesting, data collection and statistical analysis were described in this chapter.

3.1. Experimental site

The study was conducted in the experimental farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the experimental site is $23^{0}74^{/}$N latitude and $90^{0}33^{/}$E longitude and at an elevation of 8.4 m from sea level (Anon., 1989). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.2. 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.

3.3. Climate

The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in *kharif* season (April-September) and less rainfall associated with moderately low temperature during the *Rabi* season (October-March). The weather data during the study period of the experimental site is shown in Appendix III.

3.4. Treatments

Single factor experiment was conducted where ten *aman* rice varieties were considered as the treatment for the present study. The respected varieties were as follows:

V_1= Kanchancni, V_2= Chinisagar, V_3=Sunashail, V_4=Ranjay, V_5=Lohadang, V_6 =Haldijan, V_7=Kohabinni, V_8= BRRI dhan46, V_9= BR11, V_{10}= BRRI dhan51.

3.5. Description of cultivars

Kanchancni: Seed elongated, white. Plant height high, leaf no low, high tillering capacity, crop growth rate and absolute grain growth rate low, flowers early, flag leaf weight high, no of effective tiller high, total no of tiller high.

Chinisagar: Grain awned, white, slender. Plant height high, less tillering capacity, crop growth rate and absolute grain growth rate lower. Flag leaf area higher, unfilled grain high, straw yield higher, grain sterility higher.

Sunashail: Grain coarser, white, leaf no high, tillering lower, crop growth rate and grain growth high, chlorophyll content lower, panicle length high, high unfilled grain, grain yield low, harvest index high.

Ranjay: Grain coarse, white coloured endosperm, plant height high, high tillering, flowers early, high no of ineffective tiller.

Lohadang: Plant height higher, low tillering, flag leaf area higher, no of ineffective tiller higher, specific leaf weight lower.

Haldijan: Grain awned, elongated. Plant height lower than other local varieties low tillering, flowers early, life cycle higher, no of ineffective tiller higher, high panicle length, seed size high.

Kohabinni: Plant height high, leaf no lower, high tillering, flag leaf area lower, flag leaf area lower, panicle length smaller, unfilled grain in a panicle low.

BRRI dhan46: BRRI dhan46 is a modern variety developed by BRRI in 2005 through crossing with BR11 and ‘shornolata’ and from ARC14766. This variety comes from the breeding line BR5226-6-3-2 and its growth duration is about 124 days. It is recommended for *Aman* seasons. It is a photoperiodic sensitive variety like Naizersail. On average, BRRI dhan46 produce yield of 4.7 t ha^{-1} and plant height is about 105 cm. Its grain is coarse and the panicle remains above the flag leaf at flowering stage.

BR11:BR11 is a modern variety developed by BRRI in 1980.Main characteristics T. Aman, Plant height 115cm, clean rice medium bold. Planting time *Kharif* II, T. *Aman* mid June to mid July. Average yield 6.5 t/ha. Moderately resistant to tungro and tolerant to rice yellow stem borer.

BRRI dhan51: BRRI dhan51 is a modern variety developed by BRRI in 2010.It is developed through hybridization. Plant height 90 cm, clean rice, medium bold, white. Planting time mid June- mid July. Average yield 4.0t/ha.

3.6. Collection of plant materials

Seven local rice varieties *viz*. Kanchancni, Chinisagar, Sunashail, Ranjay, Lohadang, Haldijan, Kohabinni and three HYV varieties *viz*. BRRI dhan46, BR11 and BRRI dhan51were collected from BRRI, Joydebpur, Gazipur, Bangladesh.

3.7. Seed sprouting

Seeds were dipped in water in a bucket for 24 hours. These were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were fit for sowing in 72 hours.

3.8. Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown as evenly as possible. Irrigation was lightly provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.9. Preparation of main field

The land was prepared with the help of power tiller by three consecutive ploughing and cross-ploughing followed by laddering. The experimental field was puddled by stagnant water. Weeds and crop residues of previous crop were removed from the field. The experimental area was laid out according to the design of the experiment. The unit plot was leveled before transplanting.

3.10. Fertilizer application

The following doses of fertilizer were used for cultivation of crop (BRRI, 2016).

Fertilizer name	Doses (kg ha^{-1})
Urea	150
TSP	100
MoP	100
Zinc Sulphate	10
Gypsum	60
Borax	10

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MoP, gypsum, zinc sulphate and borax, correspondingly were applied. The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of land. Mixture of cowdung and compost was applied at the rate of 10 t ha^{-1} during 15 days before transplanting. Urea was applied in three equal installments at seedling establishment, tillering and before panicle initiation.

3.11. Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications (block). Each block was first divided into 10 sub plots where varieties of rice were assigned. Thus the total number of unit plots was 10×4=40. The size of the unit plot was 3m ×2m. The distance maintained between two unit plots was 0.5m and that between blocks was 1m. The treatments (varieties) were randomly assigned to the plots within each block.

3.12. Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on August 5, 2017 without causing much mechanical damage to the roots.

3.13. Transplanting of seedlings in the field

The 22 days aged seedlings were transplanted in the main field on August 5, 2017 with a spacing 15 cm from hill to hill and 20 cm from row to row.

3.14. After care

After establishment of seedlings, different intercultural operations were done for better growth and development of the rice seedlings.

3.15. Irrigation and drainage

Flood irrigation was given to maintain a regular level of standing water up to 5 cm in the early stages to increase tillering and 10-12 cm in the later stage to discourage late tillering. The field was finally dried out 15 days before harvesting.

3.16. Gap filling

Gap filling was done for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings.

3.17. Weeding

Weeding was done to keep the plots free from weeds, which ultimately resulted better growth and development. The newly emerged weeds were uprooted carefully at tillering stage and at panicle initiation stage by mechanical ways. Weeding was done after 15, 32 and 52 days of transplanting.

3.18. Top dressing

After basal dose, the remaining doses of urea were top-dressed in 2 equal installments. The fertilizers were applied on both sides of seedlings rows with the soil.

3.19. Plant protection

There were some occurrence of insects specially grasshopper, stem borer, rice ear cutting caterpillar, thrips and rice bug which was controlled by spraying Furadan 5G and Sumithion. Brown spot of rice was controlled by spraying Tilt.

3.20. Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The harvested crop of each plot was tied singly, properly tagged and brought to threshing floor. Adequate care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%.The

straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}.

3.21. Data recording

Data were recorded on different growth and yield characters. Such as-

Growth characters

1. Plant height
2. Number of leaves hill^{-1}
3. Number of total tillers hill^{-1}
4. Crop growth rate (CGR)
5. Absolute grain growth rate (AGGR)
6. SPAD value of flag leaf during anthesis and grain filling stage
7. Flag leaf area
8. Flag leaf dry weight
9. Specific leaf weight
10. Days to first anthesis
11. Duration from anthesis to maturity
12. Duration from germination to maturity

Yield contributing parameters

1. Number of effective tillers plant^{-1}
2. Number of ineffective tillers plant^{-1}
3. Panicle length
4. Number of filled grains panicle^{-1}
5. Number of unfilled grains panicle^{-1}
6. Grain Sterility
8. Seed size

Yield parameters

1. Grain yield
2. Straw yield
3. Biological yield
4. Harvest index

Plant height

The height of plant was recorded in centimeter (cm) at the time of 25, 50, 75 DAT (Days after transplanting) and at harvest. The height was measured from the ground level to the tip of the plant of five hills and finally averaged.

Tillers hill^{-1}

The number of tillers hill^{-1} was recorded at the time of 25, 50, 75 DAT by counting total tillers of five respective hills and finally averaged to hill^{-1}basis.

Number of leaves hill^{-1}

Number of leaves hill^{-1} was counted from the average of same 5 plants pre-selected at random from the inner rows of each plot.

Absolute grain growth rate (AGGR)

During anthesis, different main panicles were tagged; some were sampled and packed in separate brown paper packet as per treatment. Then the packets were kept in oven at 70ºC for 72 hrs. The tagged panicles were collected after 10 days gap from anthesis to maturity. Then the panicles were packed and oven dried at the same process. After drying 20 grains were randomly collected from each panicles and the weight of one grain was calculated. The absolute grain growth rate (AGGR) was calculated using the following formula according to Hasan (2009). The average values were taken from each treatment for analysis.

$$\text{AGGR (mg/grain/day)} = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where,

W_1 = Grain dry weight at initial time

W_2 = Grain dry weight at final time

t_2 and t_1 = time interval in days

Crop growth rate (CGR)

CGR is the rate of dry material production per unit of land area per unit of and was worked out by the following formula,

$$CGR = \frac{(w_2 - w_1)}{(t_2 - t_1)} \times \frac{1}{A} \quad g\ cm^{-2}\ day^{-1}$$

Where,

W1 = dry weight of the plant at time t_1

W2 = dry weight of the plant at time t_2

A = land area covered by the plant in cm^2

t_2 and t_1 = time interval in days

Number of effective tillers plant^{-1}

The total number of effective tillers plant^{-1} was counted from 5 selected plants at harvest and average value was recorded.

Number of ineffective tillers plant^{-1}

The total number of ineffective tillers plant^{-1} was counted from 5 selected plants at harvest and average value was recorded.

Flag leaf area

Flag leaf area was calculated by multiplying length and breadth of the leaf from 10 selected plants and the mean values were recorded.

Flag leaf dry weight

Flag leaf weight was calculated from 10 selected plants and the mean values were recorded.

Specific Leaf Weight

It is measured by dividing dry weight of leaf (g) to leaf area (cm^2)

$$SLW = \frac{\text{Leaf dry weight (g)}}{\text{Leaf area } (cm^{2})}$$

SPAD value of flag leaf

Flag leaf SPAD value was recorded at anthesis stage and at grain filling stage.

Days to first anthesis

From randomly select 10 plants, days to first anthesis was recorded by keen observation and the mean value was recorded.

Duration from Anthesis to Maturity

From randomly select 10 plants, days from anthesis to maturity was recorded by keen observation and the mean value was recorded.

Duration from Germination to Maturity

From randomly select 10 plants, days from germination to maturity was recorded by keen observation and the mean value was recorded.

Grain sterility

It is counted by dividing sterile spikelet per panicle to total spikelet per panicle multiplied by 100.

$$\text{Grain sterility (\%)} = \frac{\text{Sterile spikelet panicle}^{-1}}{\text{Total spikelet panicle}^{-1}} \times 100$$

Panicle length

The length of the panicle was calculated with a meter scale from 10 selected panicles and the average value was recorded.

Number of filled grains panicle^{-1}

The total number of filled grains was collected at random from selected 5 plants of a plot and then average number of filled grains panicle^{-1} was recorded.

Number of unfilled grains panicle^{-1}

The total number of unfilled grains was collected at random from selected 5 plants of a plot and then average number of unfilled grains panicle^{-1} was recorded.

Seed size

One thousand cleaned dried grains were counted at random from each plot and weighed by using a digital electric balance when the grains retained 12% moisture and the mean weight was expressed in gram. Then the grain weight was divided by 1000 to obtain

single seed weight which was multiplied with 1000 to obtain single seed size in milligram.

Grain yield

Grain yield was recorded from the middle $1m^2$ undisturbed area of each plot was used to calculate grain yield m^{-2} and then it was expressed as t ha^{-1} on 12% moisture basis. Digital moisture tester was used to determine the moisture (%).

Straw yield

Straw yield was determined from the middle $1m^2$ area of each plot, after separating the grains. The sub-samples were oven dried to a stable weight and finally converted to t ha^{-1}.

Total Biological yield

Grain yield and straw yield are all together recorded as biological yield. The biological yield was calculated with following formula:

Total biological yield (BY) = Grain yield + straw yield.

Harvest index

Harvest index expresses the connection between grain yield and biological yield. It was calculated by using the following formula:

$$\text{Harvest Index} = \frac{\text{Grain Yield}}{\text{Total Biological Yield}} \times 100$$

3.22. Statistical analysis

The data composed on different parameters were statistically analyzed to get the level of significance using the Statistix 10 (Kareem, 2015) computer package program. Analysis of variance was done following two factors randomized complete block design. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises of the presentation and discussion of the results obtained from the current study. The results have been presented in tabular and graphical forms and discussion with possible interpretations were done. The results obtained from the experiment have been presented under separate headings and subheadings as follows:

4.1.1. Plant height

Plant height of different *aman* rice varieties differed significantly among them. The local and HYV rice varieties (Table 1) also differed remarkably. Plant height increased gradually with increasing age of the plants.

At 25 DAT, the tallest (62.21 cm) plant was observed in V_1 (Kanchancni) which was statistically similar with V_2 (Chinisagar) and V_6 (Haldijan) and the shortest (34.92 cm) plant was observed from V_9 (BR11) which is statistically similar with V_8 (BRRI dhan46) and V_{10} (BRRI dhan51).

At 50 DAT, the tallest (105.57 cm) plant was obtained from V_1 (Kanchancni) followed by V_3 (Sunashail) and V_4 (Ranjay) which is statistically similar with V_2 (Chinisagar), V_5 (Lohadang) and V_6 (Haldijan). The shortest (64.40 cm) plant was obtained from V_{10} (BRRI dhan51) which was statistically similar with V_9 (BR11).

At 75 DAT, the tallest (134.15cm) plant was obtained from V_5 (Lohadang) followed by V_2 (Chinisagar) which was statistically similar with V_3 (Sunashail), V_4 (Ranjay), V_6 (Haldijan). The shortest (76.04 cm) plant was obtained from V_{10} (BRRI dhan51) which was statistically similar with V_9 (BR11).

At harvest, the tallest (139.03 cm) plant was observed in V_5 (Lohadang) which was statistically similar with V_1 (Kanchancni), V_3 (Sunashail), V_4 (Ranjay) and V_6 (Haldijan) followed by V_2 (Chinisagar). The shortest (97.33 cm) was obtained from V_8 (BRRI dhan 46) which was statistically similar with V_{10} (BRRI dhan51). The local varieties had the higher plant height than HYV varieties. Plant height in local varieties is higher than that of high yielding varieties. Similar results on plant height were also observed by Sarker *et al.* (2013), Anwar and Begum (2010) and Islam *et al*. (2009).

Table 1. Plant height of different *aman* rice varieties at various days after transplanting (DAT) and at harvest.

Variety	Plant height			
	25 DAT	**50 DAT**	**75 DAT**	**At Harvest**
V_1	62.21 a	105.57 a	133.2 a	135.53 a
V_2	59.62 a-c	95.93 ab	121.48 b	125.20 b
V_3	50.35 d	94.25 b	133.73 a	138.43 a
V_4	54.34 b-d	90.04 b	125.59 ab	130.73 ab
V_5	52.84 cd	97.42 ab	134.15 a	139.03 a
V_6	59.71 ab	98.66 ab	129.37 ab	133.79 ab
V_7	49.85 d	79.53 c	105.45 c	110.53 c
V_8	41.06 e	78.17 c	93.17 d	97.33 d
V_9	34.92 e	67.22 d	83.80 de	111.00 c
V_{10}	39.28 e	64.40 d	76.04 e	104.33 cd
$LSD_{0.05}$	**6.84**	**9.65**	**10.65**	**9.37**
CV (%)	**7.91**	**6.46**	**5.46**	**4.45**

Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51

4.1.2. Number of leaves hill^{-1}

Significant difference on total number of leaves hill^{-1} in the rice varieties was observed from 25 DAT, 50 DAT, 75 DAT and at harvest (Table 2).The total number of leaves was continued to increase up to 75 DAT and there after declined.

At 25 DAT, the highest (26.00) number of leaves was obtained from V_8 (BRRI dhan46) which was statistically similar with V_4 (Ranjay) and V_7 (Kohabinni) followed by V_6 (Haldijan). The lowest (14.00) leaf number was obtained from V_1 (Kanchancni) which was statistically similar with V_2 (Chinisagar), V_3 (Sunashail),V_5 (Lohadang), V_9 (BR11) and V_{10} (BRRI dhan51).

At 50 DAT, the highest (56.67) number of leaves was obtained from V_7 (Kohabinni) which was statistically similar with V_3 (Sunashail) and V_8 (BRRI dhan46) followed by V_1 (Kanchancni). The lowest (33.25) number of leaves was obtained from V_2 (Chinisagar) which was statistically similar with V_5 (Lohadang) and V_{10} (BRRI dhan51).

At 75 DAT, the highest (60.67) number of leaves was obtained from V_7 (Kohabinni) which was statistically similar with V_8 (BRRI dhan46) followed by V_3 (Sunashail) and V_9 (BR11). The lowest (33.67) number of leaves was obtained from V_2 (Chinisagar) which was statistically similar with V_5 (Lohadang), V_6 (Haldijan) and V_{10} (BRRI dhan51).

At harvest, the highest (34.87) number of leaves was obtained from V_4 (Ranjay) which was statistically similar with V_1 (Kanchancni), V_2 (Chinisagar), V_5 (Lohadang), V_6 (Haldijan), V_7 (Kohabinni), V_8 (BRRI dhan46), V_9 (BR11) followed by V_{10} (BRRI dhan51). The lowest (22.33) number of leaves was found from V_3 (Sunashail) which was statistically similar with V_6 (Haldijan) and V_{10} (BRRI dhan51). The number of leaves plant^{-1} was higher in local varieties than HYV varieties. Haque *et al.* (2013), Sarker *et al.* (2013) and Abou-Khalif (2009) also found similar on number of leaves plant^{-1}.

Table 2. Number of leaves hill^{-1} of *aman* rice varieties at various days after transplanting (DAT) and at harvest.

Variety	Number of leaves hill^{-1}			
	25 DAT	**50 DAT**	**75 DAT**	**At Harvest**
V_1	14.00 d	44.17 b	44.33 c-e	33.02 ab
V_2	15.33 cd	33.25 d	33.67 f	33.24 ab
V_3	17.33 b-d	52.00 a	52.33 bc	22.33 c
V_4	22.33 ab	42.08 bc	47.00 b-d	34.87 a
V_5	15.33 cd	36.33 d	37.00 ef	33.93 ab
V_6	20.00 bc	34.00 d	35.00 f	29.62 a-c
V_7	20.67 a-c	56.67 a	60.67 a	30.11 ab
V_8	26 .00 a	53.67 a	54.67 ab	30.94 ab
V_9	17.67 b-d	42.00 bc	49.67 bc	32.13 ab
V_{10}	17.67 b-d	38.00 cd	41.33 d-f	26.58 bc
$LSD_{0.05}$	**5.37**	**5.18**	**8.02**	**7.65**
CV (%)	**16.86**	**6.99**	**10.26**	**14.55**

Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.1.3. No of tillers hill^{-1}

Significant variation was found on number of number of total tillers plant^{-1} at different growth stages affected by various rice varieties (Table 3).

At 25 DAT, the highest (6.67) number of tillers was obtained from V_4 (Ranjay), V_6 (Haldijan), V_8 (BRRI dhan46) which was statistically similar with V_1 (Kanchancni), V_2 (Chinisagar), V_3 (Sunashail), V_7 (Kohabinni), V_9 (BR11), V_{10} (BRRI dhan51). The lowest (4.67) no of tillers was obtained from V_5 (Lohadang).

At 50 DAT, the highest (16.33) number of tillers was obtained from V_8 (BRRI dhan46) which was statistically similar with V_1 (Kanchancni), V_4 (Ranjay), V_5 (Lohadang), V_7 (Kohabinni), V_9 (BR11), V_{10} (BRRI dhan51) followed by V_2 (Chinisagar). The lowest (9.75) number of tillers was obtained from V_6 (Haldijan) which was statistically similar with V_2 (Chinisagar).

At 75 DAT, the highest (11.67) number of tiller was obtained from V_4 (Ranjay) which was statistically similar with V_1 (Kanchancni) and V_7 (Kohabinni) followed by V_3 (Sunashail), V_6 (Haldijan), V_9 (BR11), V_{10} (BRRI dhan51). The lowest (6.00) number of tillers was obtained from V_5 (Lohadang) which was statistically similar with V_2 (Chinisagar), V_6 (Haldijan), V_9 (BR11), V_{10} (BRRI dhan51).

At harvest, the highest (21.00) number of tillers was obtained from V_8 (BRRI dhan46) followed by V_1 (Kanchancni), V_3 (Sunashail), V_6 (Haldijan), V_9 (BR11), V_{10} (BRRI dhan51). The lowest (11.67) number of tillers was obtained from V_5 (Lohadang) which was statistically similar with V_1 (Kanchancni), V_2 (Chinisagar), V_3 (Sunashail), V_6 (Haldijan), V_7 (Kohabinni), V_9 (BR11).

From the above study it was found that the highest number of tillers plant^{-1} was in high yielding varieities and the lowest number of tillers plant^{-1} was in local varieties. The results from the study was similar with the findings of Md. Tipu *et al*. (2018) and Jyoti *et al*. (2018).

Table 3. Number of total tillers hill^{-1} of *aman* rice varieties at various days after transplanting (DAT) and at harvest.

Variety	Number of tillers hill^{-1}			
	25 DAT	**50 DAT**	**75 DAT**	**At Harvest**
V_1	6.33 a	14.08 ab	9.67 ab	15.00 bc
V_2	5.33 a	11.58 b	6.67 c	12.67 c
V_3	6.00 a	12.5 ab	8.00 bc	13.67 bc
V_4	6.67 a	12.92 ab	11.67 a	20.00 a
V_5	4.67 a	12.42 ab	6.00 c	11.67 c
V_6	6.67 a	9.75 b	7.67 bc	15.67 bc
V_7	7.00 a	14.00 ab	11.00 a	14.00 bc
V_8	6.67 a	16.33 a	8.00 bc	21.00 a
V_9	6.00 a	12.08 ab	7.67 bc	13.67 bc
V_{10}	5.67 a	12.67 ab	7.67 bc	17.00 ab
$LSD_{0.05}$	**3.30**	**4.55**	**2.40**	**4.03**
CV (%)	**31.50**	**20.69**	**16.65**	**15.23**

Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.1.4. Flag leaf area

Flag leaf area was significantly influenced by different varieties of rice (Table 4). Results revealed that the highest (56.20 cm^2) flag leaf area was observed from the variety, V_5 (Lohadang) which was statistically identical with V_2 (Chinisagar) where the lowest (23.59 cm^2) flag leaf area was observed from the variety, V_7 (Kohabinni) which was statistically similar with V_4 (Ranjay) and V_{10} (BRRI dhan51). Flag leaf area was higher in local varieties than high yielding varieties. The results obtained from the present study were similar with the findings of Haque *et al.* (2013).

4.1.5. Flag leaf dry weight

Flag leaf weight was significantly varied due to different varieties of rice (Table 4). It was noted that the highest (0.27 g) flag leaf dry weight was observed from the variety, V_1 (Kanchancni) which was statistically similar with V_2 (Chinisagar), V_3 (Sunashail), V_5 (Lohadang). The lowest (0.14 g) flag leaf dry weight was observed from the variety, V_7 (Kohabinni) and V_9 (BR11) which was statistically similar with V_4 (Ranjay), V_8 (BRRI dhan46). Flag leaf area was higher in local varieties than HYV varieties and flag leaf weight was higher in local varieties. This might be due to the thickness of leaf local varieties. Haque *et al.* (2013) also found similar result with the present study.

4.1.6. SPAD value of flag leaf at anthesis stage and grain filling stage

SPAD value of flag leaf at anthesis stage and grain filling stage showed significant variation among the varieties of rice (Table 4). It was observed that the highest (60.20 and 49.77 respectively) SPAD value of flag leaf at anthesis stage and at grain filling stage was found from the variety, V_{10} (BRRI dhan51) which was followed by V_9 (BRRI dhan46). The lowest SPAD value (34.33) at anthesis and at grain filling stage (31.50) was found from the variety, V_7 (Kohabinni) and V_6 (Haldijan) respectively. Among the local varieties at anthesis stage the highest SPAD value was observed from V_4 (Ranjay) at anthesis and at grain filling stage the highest SPAD value was observed from V_5 (Lohadang). SPAD value was higher in high yielding varieties than local varieties. The result on SPAD value under the present study was in agreement with the findings of Haque *et al.* (2013).

Table 4. Flag leaf area, Flag leaf Weight and SPAD value of flag leaf of different *aman* rice varieties.

Variety	Flag leaf area (cm^2)	Flag leaf weight (g)	SPAD Value of flag leaf	
			Anthesis stage	Grain filling stage
V_1	42.63c	0.27a	38.80cd	39.13b
V_2	53.17ab	0.26ab	41.97c	38.50b
V_3	49.70b	0.26ab	38.50cd	31.90c
V_4	27.62e	0.16c	42.53c	38.63b
V_5	56.20a	0.25ab	37.57cd	40.07b
V_6	36.77d	0.23b	40.73c	31.50c
V_7	23.59e	0.14c	34.33d	36.77b
V_8	36.69d	0.17c	40.67c	36.73b
V_9	32.74d	0.14c	49.50b	39.67b
V_{10}	27.08e	0.23b	60.20a	49.77a
$LSD_{0.05}$	**4.70**	**0.03**	**5.73**	**3.59**
CV (%)	**7.10**	**9.15**	**7.87**	**5.47**

Values followed by same letter(s) did not differ significantly at 5% level of probability.

V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.1.7. Crop growth rate (CGR)

Crop growth rate (CGR) of different *aman* rice varieties differed significantly among the local and HYV rice varieties (Fig 1). The local rice V_3 (Sunashail) showed the highest (54.86 g cm^{-2} day^{-1}) CGR which is statistically similar with V_8 (BRRI dhan46) which was followed by V_4 (Ranjay) and V_5 (Lohadang). The lowest (10.95 g cm^{-2} day^{-1}) CGR was observed in local rice V_2 (Chinisagar) which was statistically similar with V_1 (Kanchancni) and V_7 (Kohabinni). Though the plant height was higher in local varieties than HYV varieties and the CGR was recorded higher in local varieties than high yielding varieties. These results are consistent with the result of Miah et al. (1996) and Piranhas et al. (1997) who reported that varietal differences of CGR were significant at different growth stage.

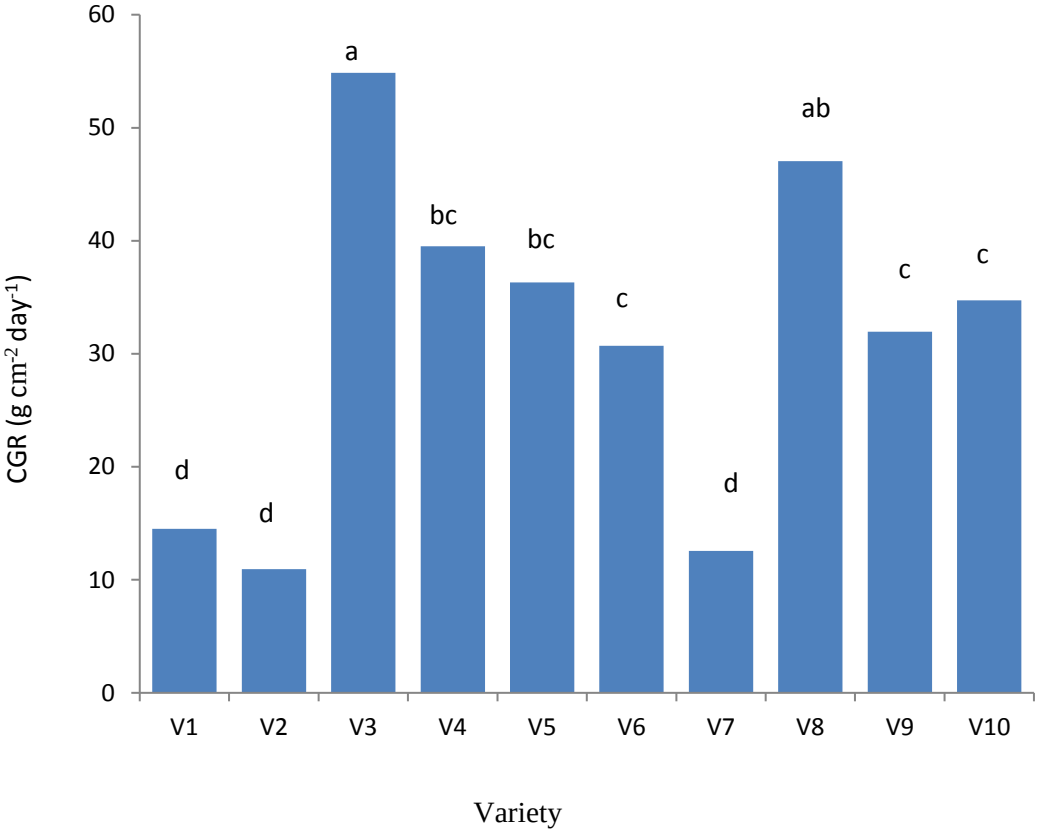

Fig 1. Crop growth rate of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.1.8. Absolute grain growth rate (AGGR)

Absolute grain growth rate of different *aman* rice varieties differed significantly among the local and hybrid rice varieties (Fig. 2). The local rice V_3 (Sunashail) showed the highest (1.85 mg grain^{-1} day^{-1}) AGGR value which is followed by V_8 (BRRI dhan46). The lowest (0.33 mg grain^{-1} day^{-1}) AGGR was observed in local rice V_2 (Chinisagar) which is statistically similar with V_1 (Kanchancni) and V_7 (Kohabinni). Higher grain growth helps to give better yield. AGGR was higher in local varieties than high yielding varieties. The result of the study are in agreement with the result of Ahmed (2017).

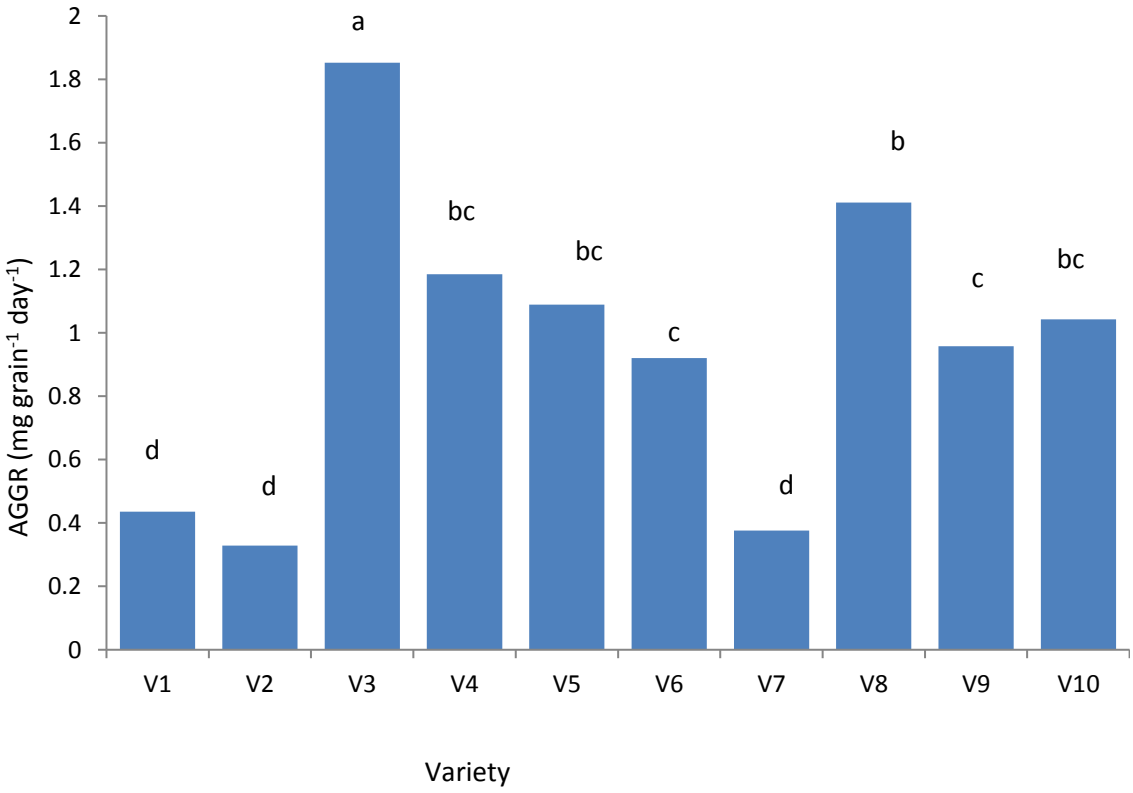

Fig 2. Absolute Grain Growth Rate of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.

V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.1.9. Specific Leaf Weight

Specific leaf weight was significantly varied due to different varieties of rice (Fig 3).It was found that highest (8.67 g cm^{-2}) specific leaf weight was found in V_{10} (BRRI dhan51) followed by V_1 (Kanchancni). The lowest (4.33 g cm^{-2}) specific leaf area was found in V_8 (BRRI dhan46) and V_9 (BR11). Specific leaf weight was higher in high yielding varieties than local varieties. Amanullah (2015), LIU *et al.* (2016) also found similar results.

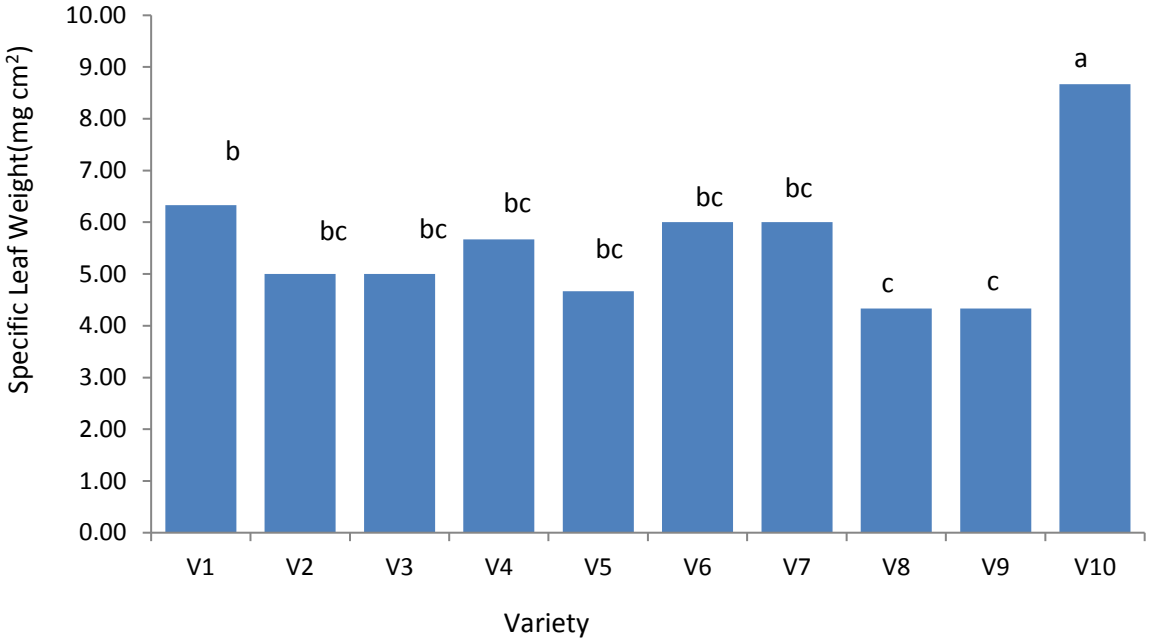

Fig 3. Specific Leaf Weight of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.1.10. Days to anthesis

Days to anthesis was significantly varied due to different varieties of rice (Table 5). It was found that the highest (84.67) days to anthesis was observed from the variety, V_1 (Kanchancni), V_4 (Ranjay), V_6 (Haldijan), V_7 (Kohabinni) which was significantly different from other varieties, which was followed by V_2 (Chinisagar), V_3 (Sunashail),V_5 (Lohadang), V_9 (BR11) and V_{10} (BRRI dhan51). The lowest (67.67) days to anthesis was observed from the variety V_8 (BRRI dhan46). Haque *et al.* (2013) also found similar results with the present study.

4.1.11. Duration from anthesis to maturity

Days to anthesis to maturity was significantly varied due to different varieties of rice (Table 5). It was found that the highest (76.33) days from anthesis to maturity was observed from the variety, V_5 (lohadang), which was statistically similar with V_6 (Haldijan), V_8 (BR11). The lowest (56.00) days from anthesis to maturity was observed from the variety V_1 (Kanchancni).

4.1.12. Life duration from germination to maturity

Considerable variation was observed on total life duration of *aman* rice influenced by different varieties (Table 5). Results showed that variety, V_6 (Haldijan) showed highest (159.33) life duration where the lowest (141.00) life duration was found from varieties of V_1 (Kanchancni). High yielding varieties are of shorter duration than those of local vaeities. Similar results were also observed by Julfiquar *et al.* (1998), BRRI (1995) and Siddiquee *et al.* (2002).

Table 5. Days to first anthesis, Duration from anthesis to maturity and Life duration from Germination to maturity of different *aman* rice varieties.

Variety	Days to first Anthesis (Days)	Duration from Anthesis to maturity (Days)	Life Duration from Germination to maturity (Days)
V_1	84.67 a	56.00 e	141.00 e
V_2	77.67 b	69.33 b	147.33 cd
V_3	77.67 b	67.67 bc	145.67 cd
V_4	84.67 a	63.67 cd	148.67 c
V_5	77.67 b	76.33 a	154.33 b
V_6	84.67 a	74.33 a	159.33 a
V_7	84.67 a	62.33 d	147.33 cd
V_8	67.67 c	78.33 a	143.33 de
V_9	77.67 b	66.00 b-d	144.00 de
V_{10}	77.67 b	68.00 b	146.00 cd
$LSD_{0.05}$	**0.15**	**4.22**	**4.23**
CV (%)	**0.23**	**3.61**	**1.67**

Values followed by same letter(s) did not differ significantly at 5% level of probability
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51

4.2.1. Effective, ineffective, total tiller number of *aman* rice varieties

Significant variation was found on number of number of total tillers plant^{-1} at different growth stages affected by different rice varieties (Table 6).

Number of effective tiller, highest (15.33) obtained from V_{10} (BRRI dhan51) which was statistically similar with V_3 (Sunashail), V_4 (Ranjay), V_7 (Kohabinni) and followed by V_1 (Kanchancni), V_9 (BR11). The lowest (10.00) was obtained from V_5 (Lohadang) which was statistically similar with V_2 (Chinisagar), V_6 (Haldijan), V_8 (BRRI dhan46).

Number of ineffective tiller, highest (5.67) obtained from V_6 (Haldijan) which was statistically similar with V_1 (Kanchancni). The lowest (1.67) obtained from V_2 (Chinisagar) and V_3 (Sunashail) which was statistically similar with V_1 (Kanchancni), V_5 (Lohadang), V_7 (Kohabinni), V_8 (BRRI dhan46), V_9 (BR11), V_{10} (BRRI dhan51).

Number of total tiller, highest (17.67) obtained from V_{10} (BRRI dhan51) which was statistically similar with V_1 (Kanchancni), V_3 (Sunashail), V_4 (Ranjay), V_9 (BR11) followed by V_2 (Chinisagar), V_8 (BRRI dhan46). The lowest (12.00) obtained from V_5 (Lohadang) which was statistically similar with V_2 (Chinisagar), V_8 (BRRI dhan46).

From the above study it was found that the highest number of tillers plant^{-1} was in high yielding varieties and the lowest number of tillers plant^{-1} was in local varieties. The results obtained from the study was similar with the findings of Islam *et al*. (2009), Obaidullah *et al*. (2009), Ashrafuzzaman *et al.* (2008), Chowdhury *et al*. (2005) and Akbar (2004).

Table 6. Number of total tillers plant^{-1} of *aman* rice varieties at various days after transplanting (DAT) and at harvest.

Variety	No of effective tillers	No of un effective tillers	Total tillers
V_1	11.00 bc	5.67 ab	13.67 a-c
V_2	11.00 bc	1.67 b	12.67 bc
V_3	12.00 a-c	1.67 b	13.67 a-c
V_4	14.67 ab	3.33 a	16.67 ab
V_5	10.00 c	2.00 ab	12.00 c
V_6	10.67 c	5.67 a	14.00 a-c
V_7	12.00 a-c	4.00 ab	15.00 a-c
V_8	10.67 c	4.67 ab	13.00 bc
V_9	11.00 bc	3.33 ab	13.67 a-c
V_{10}	15.33 a	3.00 ab	17.67 a
$LSD_{0.05}$	**3.97**	**0.64**	**4.55**
CV (%)	**19.58**	**31.46**	**18.69**

Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.2.2. Panicle Length

Different variety showed significant effect on panicle length of T. aman rice (Table 7). The longest panicle (30.33 cm) was recorded from V_6 (Haldijan) treatment. In comparison, the shortest panicle (22.00 cm) was observed in V_5 (Lohadang) treatment. Panicle length was higher in local varieties than high yielding varieties. The results obtained under the study were in conformity with the findings of Sarkar *et al*. (2014), Anwar and Begum (2010), Abou-Khalif (2009), Wang *et al.* (2006) also found similar results with the present study.

4.2.3. Filled Grains Panicle^{-1}

Different variety showed significant effect on filled grain panicle^{-1} of T. *aman* rice (Table 7). The highest number of filled grain panicle^{-1} (113.67) was recorded from V_8 (BRRI dhan46) treatment. In comparison, the lowest number of filled grain panicle^{-1} (37.33) was observed in V_7 (Kohabinni) treatment. Filled grain per panicle was found higher in high

yielding varieties which contributed to increased yield. Similar results were also observed by Ashrafuzzaman *et al.* (2008), Chowdhury *et al*. (2005) and Murthy *et al.* (2004).

4.2.4. Unfilled grain panicle^{-1}

Number of unfilled grains panicle^{-1} was significantly varied due to different varieties of rice (Table 7). It was observed that the highest (23.00) number of unfilled grains panicle^{-1} was observed from the variety, V_2 (Chinisagar) which was significantly higher than any other variety. The lowest (11.33) number of unfilled grains panicle^{-1} was observed from the variety, V_7 (Kohabinni) which was statistically same with V_1 (Kanchancni), V_3 (Sunashail), V_4 (Ranjay), V_5 (Lohadang), V_6 (Haldijan), V_8 (BRRI dhan46), V_9 (BR11), V_{10} (BRRIdhan51). Unfilled grains per panicle was found higher in local varieties which resulted in lower yield in local varieties. Mallick (1994) and Chowdhury *et al*. (2005) also found similar results with the present study.

Table 7. Panicle length, No of filled grains panicle^{-1}, No of unfilled grains panicle^{-1} of different *aman* rice varieties.

Variety	Yield contributing parameters		
	Panicle length (cm)	**Number of filled grains panicle^{-1}**	**Number of unfilled grains panicle^{-1}**
V_1	22.43 cd	94.33 c	14.33 b
V_2	23.03 b-d	63.67 d	23.00 a
V_3	27.47 ab	110.33 ab	15.33 b
V_4	22.73 cd	107.67 ab	17.00 b
V_5	22.00 cd	76.67 d	16.33 b
V_6	30.33 a	97.33 bc	16.33 b
V_7	18.50 d	37.33 e	11.33 b
V_8	26.17 a-c	113.67 a	12.33 b
V_9	23.23 bc	112.00 a	11.67 b
V_{10}	22.87 b-d	109.67 ab	11.67 b
$LSD_{0.05}$	**4.68**	**13.31**	**5.68**
CV (%)	**11.42**	**8.41**	**22.17**

Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.2.5. Seed Size

Different varieties of rice showed significant variation on Seed Size (Fig 4). It was noted that the highest (28.02 mg) Seed size was observed from the variety, V_6 (Haldijan) which was statistically similar with V_4 (Ranjay) and V_9 (BR11) followed by V_2 (Chinisagar). The lowest (17.87 mg) seed size was observed from the variety, V_8 (BRRI dhan46) which was close to V_5 (Lohadang). Seed size was higher in local varieties than high yielding varieties. Similar results were also observed by Murshida *et al*. (2017), Jisan *et al*. (2014) and Sarkar *et al*. (2014).

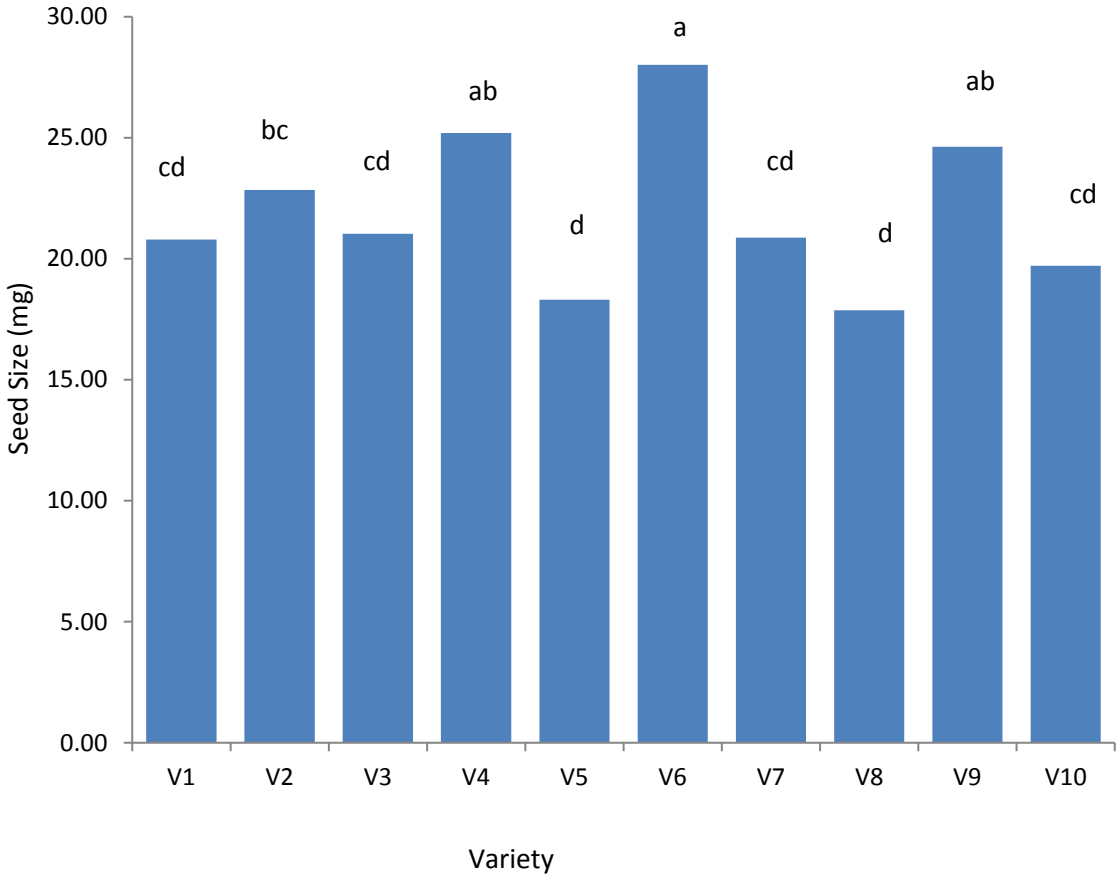

Fig 4. Seed Size of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.2.6. Grain Sterility

Different varieties of rice showed significant variation on Seed Size (Fig 5). Highest (26.52) grain sterility was found in V_2 (Chinisagar) which was statistically similar to V_7 (Kohabinni) followed by V_5 (Lohadang). Lowest (9.37) grain sterility was found in V_9 (BR11) which was statistically similar to V_{10} (BRRI dhan51) and V_3 (Sunashail). Higher grain sterility leads to lower yield in local varieties and lower grain sterility helps in increased yield in high yielding varieties. Similar results were also observed by Weerakoon *et al.* (2008) and Puteh *et al*. (2014).

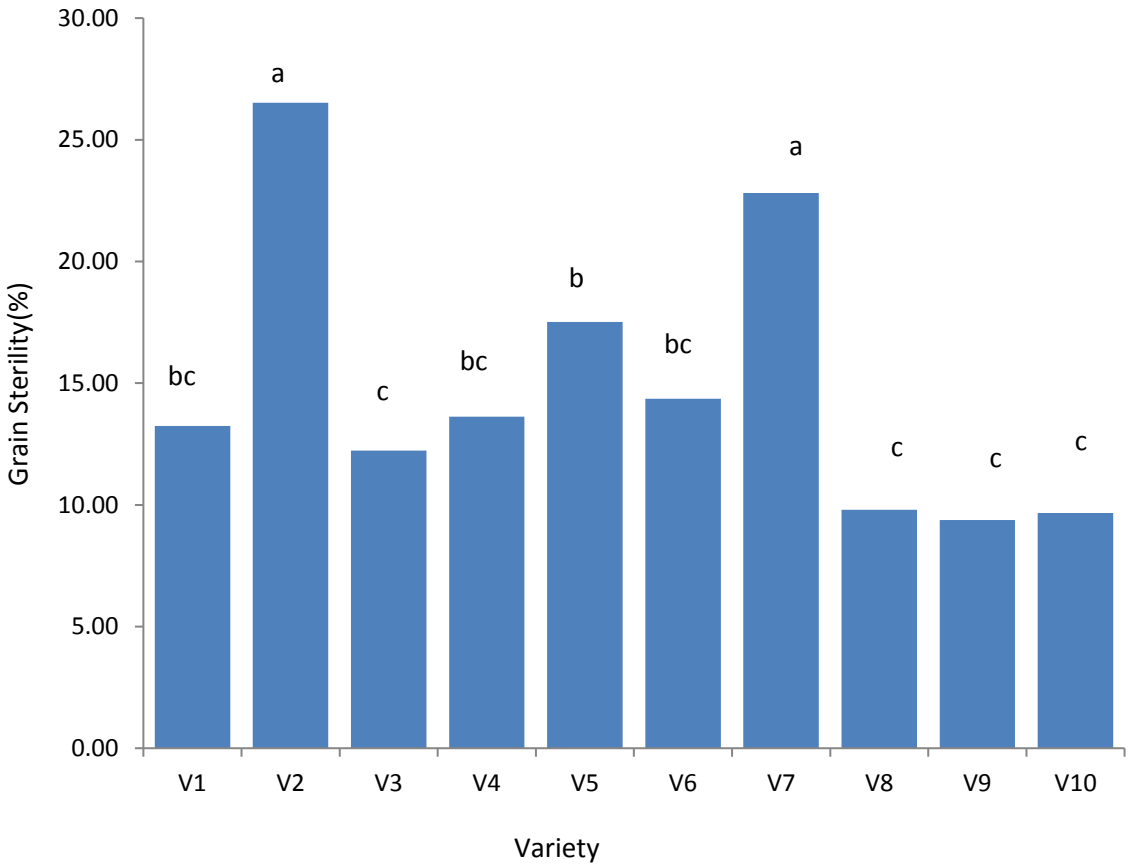

Fig 5. Grain Sterility (%) of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.2.7. Grain Yield

Statistically significant variation was recorded due to different rice varieties in terms of grain yield (Fig 6). It was noted that the highest (3.62 t/ha) grain yield was observed from the variety, V_8 (BRRI dhan46) which was statistically identical with V_9 (BR11), V_{10} (BRRI dhan51), followed by V_1 (Kanchancni). The lowest (1.16 t/ha) grain yield was observed from the variety, V_3 (Sunashail) which was statistically similar with V_4 (Ranjay) and V_5 (Lohadang). This result indicated that the HYV rice had remarkable superiority of grain yield over local rice varieties but among the local rice varieties, V_1 (Kanchancni) and V_2 (Chinisagar) gave the higher grain yield. Higher no of filled grains per panicle, higher no of effective tiller and lower grain sterility leads to higher yield in high yielding varieties than local varieties. The results found from the study was conformity with the findings of Murshida *et al*. (2017), Chamely *et al*. (2015), Sarker *et al.* (2013), Haque *et al.* (2013) and Islam *et al*. (2009)

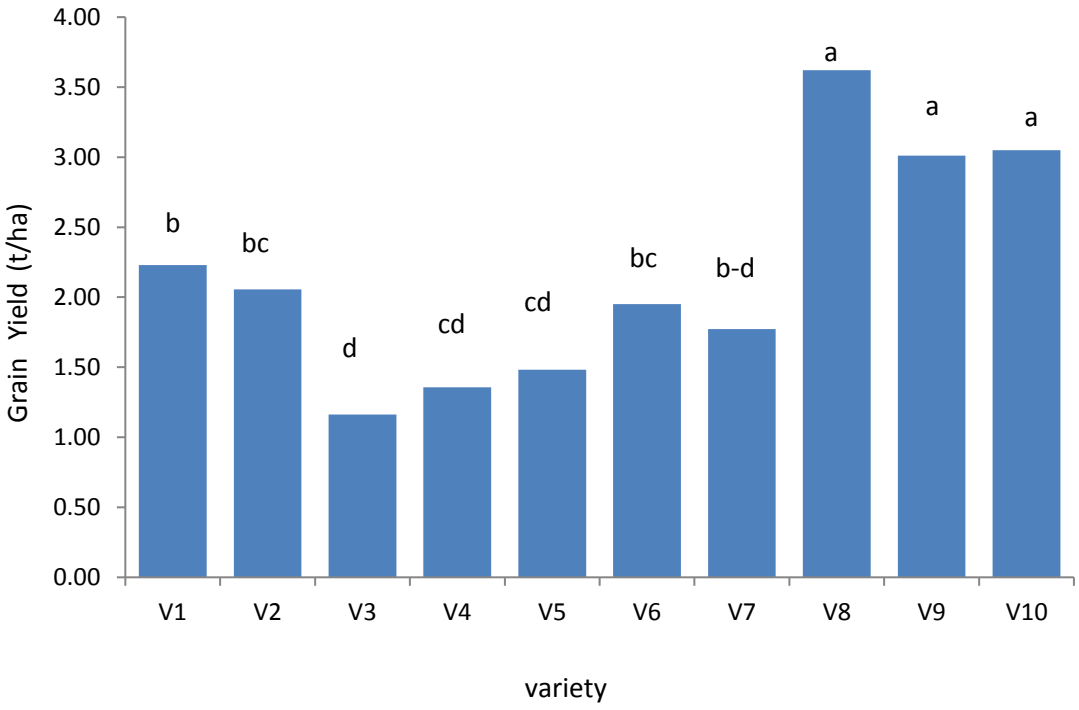

Fig 6. Grain Yield (t/ha) of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.2.8. Relationship between grain sterility percentage and grain yield

There was a negative correlation between grain sterility percentage and grain yield (Figure 7). The highest grain yield was observed when grain sterility percentage was the lowest. The grain yield gradually decreased with the increasing of grain sterility percentage in all the varieties. This negative association (r = - 0.45) between grain sterility percentage and grain yield clearly demonstrated that higher grain yield of different aman rice varieties might be due to restriction on grain sterility. Puteh *et al*. (2014), Wu *et al*. (2016) also experimented on grain sterility and yield.

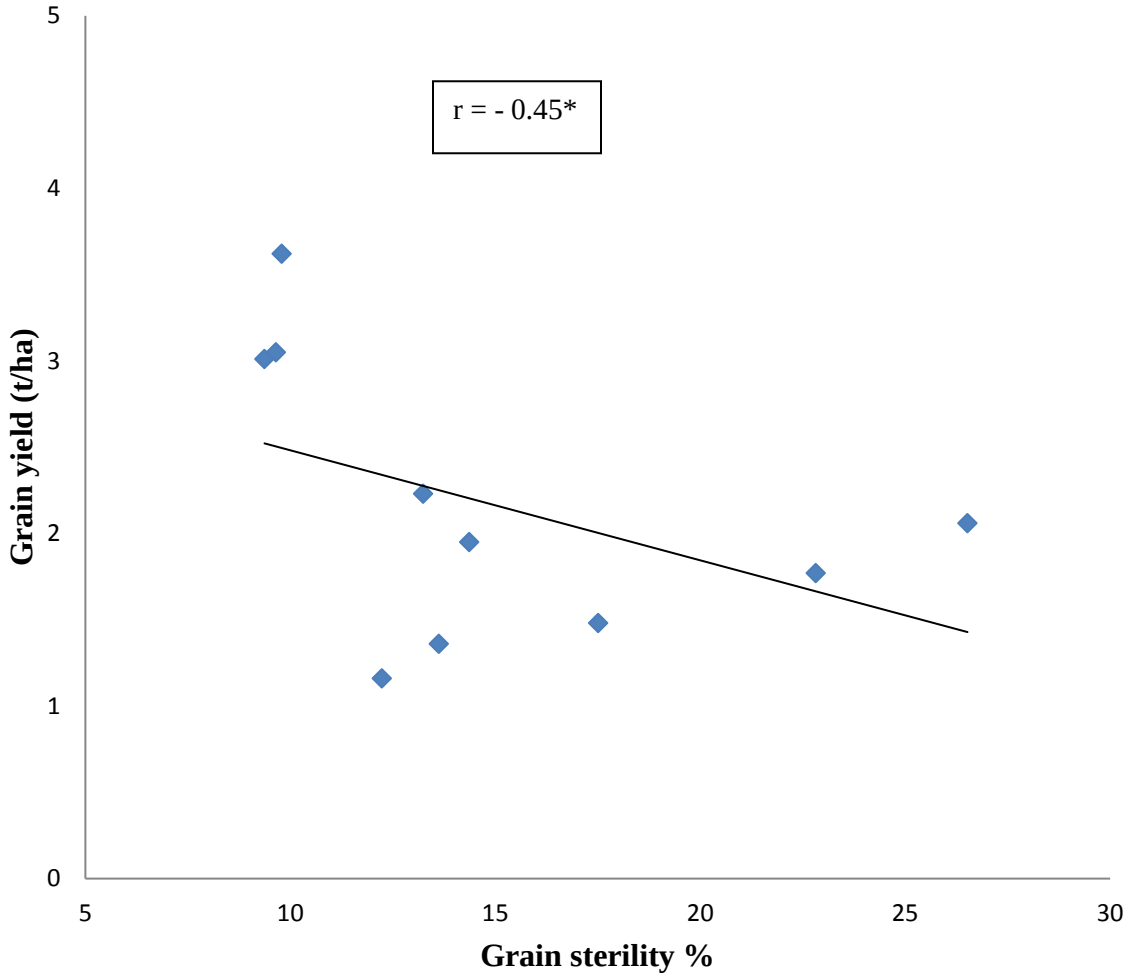

Fig 7. Relationship (r=-0.45*, n=10) between grain sterility percentage and grain yield of different aman rice varieties.

4.2.9. Straw yield

Straw yield (t/ha) was significantly influenced by different varieties of rice (Fig 7). The highest (4.17 t /ha) Straw yield was observed from the variety, V_2 (Chinisagar) which was statistically similar with V_7 (Kohabinni). The lowest (2.05 t /ha) Straw yield was observed from the variety, V_{10} (BRRI dhan51). Higher plant height resulted in increased straw yield in local varieties than high yielding ones. Chowdhury *et al*. (2005), Akbar (2004) and Anwar and Begum (2004) also found similar results with the present study.

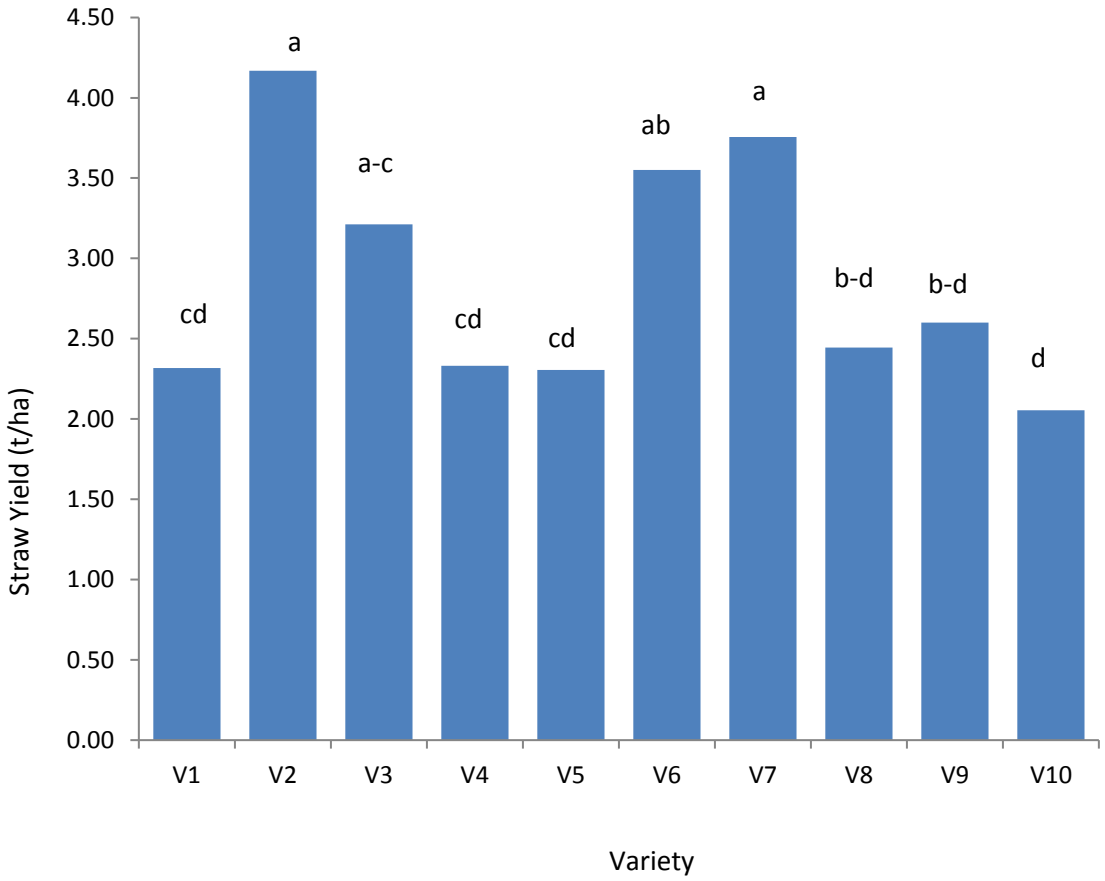

Fig 8. Straw Yield (t/ha) of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.2.10. Biological yield

Different variety of rice had significant influence on biological yield (Fig 8). The highest (6.23 t/ha) biological yield was observed from the variety, V_2 (Chinisagar) which was statistically identical with V_8 (BRRI dhan46), where the lowest (3.69 t/ha) biological yield was observed from the variety, V_4 (Ranjay) which was statistically similar to V_5 (Kartikjhul). As the grain yield of local rice variety was low but straw yield higher ultimately total biological yield also increased. That means local rice produced more biological yield than HYV rice varieties. Sallauddin (2012) and Sarkar (2014) reported that hybrid rice varieties produced more biological yield than inbred one.

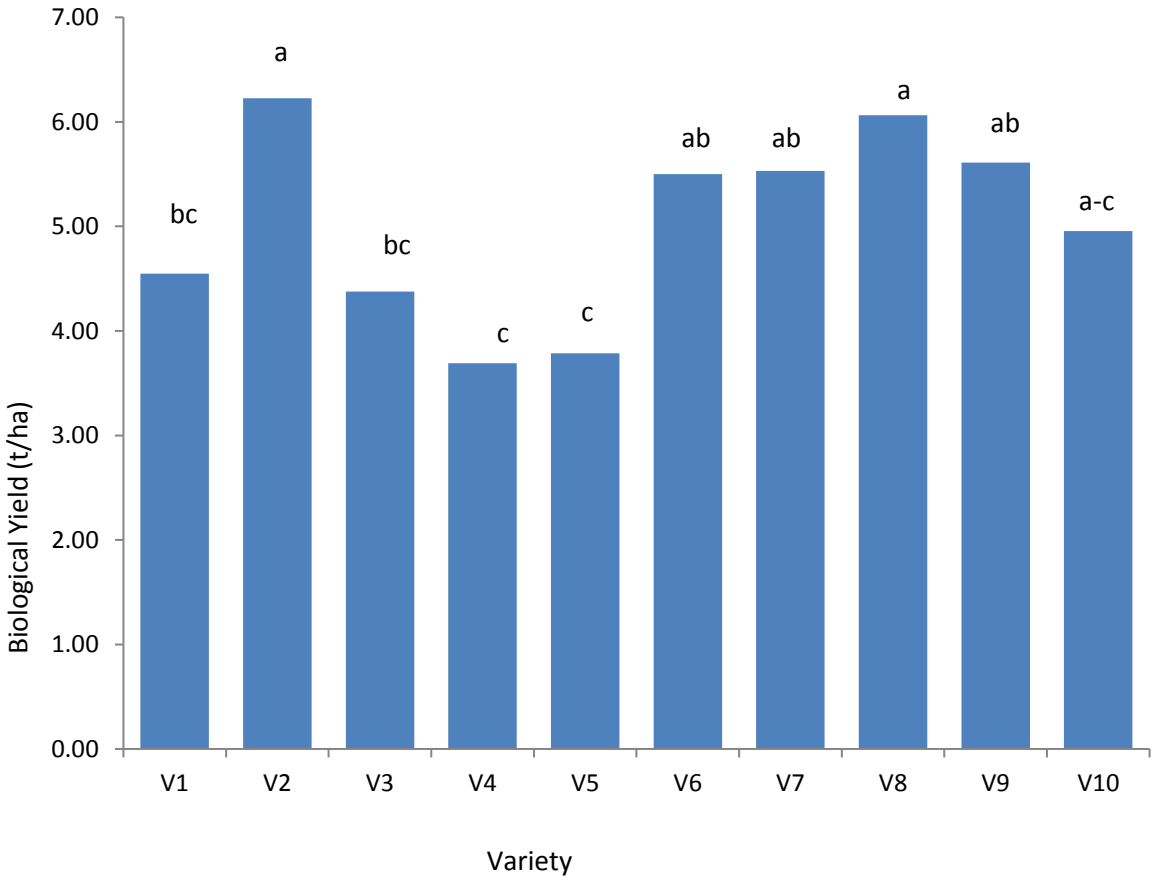

Fig 9. Biological Yield (t/ha) of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

4.2.11. Harvest index

Harvest index was significantly influenced by different varieties of rice (Fig 9). It was observed that the highest (59.73 %) harvest index was observed from the variety, V_8 (BRRI dhan46) which was statistically identical with V_9 (BR11) and V_{10} (BRRI dhan51). The lowest (27.37 %) harvest index was observed from the variety, V_3 (Sunashail) which was statistically identical with V_2 (Chinisagar), V_4 (ranjay), V_6 (Haldijan), V_7 (Kohabinni). From the results it was observed that among the local rice varieties V_1 (Kanchancni) gave the highest (48.74 %) harvest index. Higher grain yield and lower straw yield resulted in higher harvest index in high yielding rice varieties over local ones. Bhowmick and Nayak (2000), Cui *et al.*, (2000) and Chamely *et al*. (2015) also found similar results.

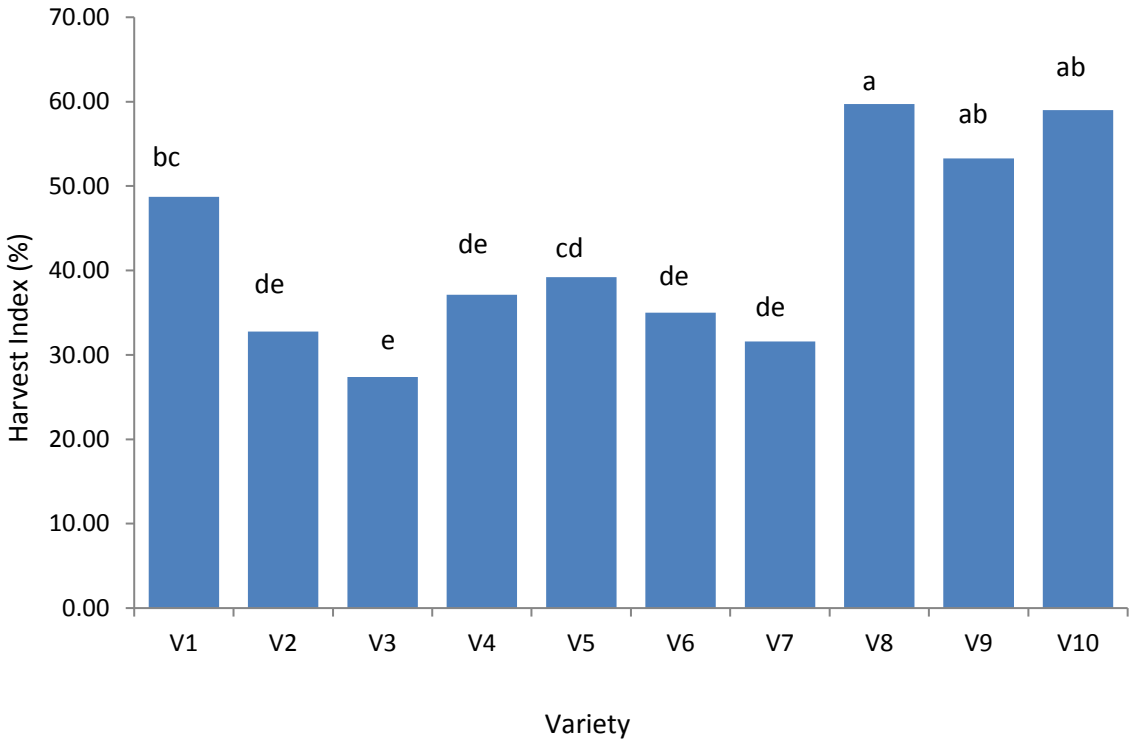

Fig. 10: Harvest Index (%) of different *aman* rice varieties. Values followed by same letter(s) did not differ significantly at 5% level of probability.
V_1 =Kanchancni, V_2 = Chinisagar , V_3 = Sunashail, V_4 = Ranjay, V_5 = Lohadang, V_6 = Haldijan, V_7 = Kohabinni, V_8 = BRRI dhan46, V_9= BR11, V_{10} = BRRI dhan51.

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from July 2017-December 2017**.** To study the Growth, Development and Yield of some local and high yielding varieties of rice during *aman* season and to identify the significant vegetative, reproductive and yield characteristics which might contribute to higher yield. The experiment comprised of single factor (variety). Ten rice varieties were used as treatments. Among the varieties, seven were local (Kanchancni, Chinisagar, Sunashail, Ranjay, Lohadang, Haldijan, Kohabinni) and three were HYV varieties (BRRI dhan46, BR11 and BRRI dhan51). The experiment was laid out in a Randomized complete Block Design (RCBD) with four replications. Data on different growth parameters, developmental parameters and yield with yield contributing characters were recorded. The collected data were statistically analyzed for assessment of the treatment effect.

Results signified that highest plant height at 25 DAT (62.21cm) and at 50 DAT (105.57cm) was found in V_1 (Kanchancni) and at 75 DAT (134.15cm) and at harvest (139.03cm) was found in V_5 (Lohadang). Highest numbere of leaves hill^{-1} at 25 DAT (26.00) was found in V_8 (BRRI dhan46), at 50 DAT (56.67) and at 75 DAT (60.67) was found in V_7 (Kohabinni), at harvest (34.87) in V_4 (Ranjay). Highest number of tillers hill^{-1} at 25 DAT (6.67) was found in V_4 (Ranjay), V_6 (Haldijan), V_8 (BRRI dhan46) respectively, at 50 DAT (16.33) was found highest in V_8 (BRRI dhan46), at 75 DAT (11.64) was found highest in V_4 (Sunashail), at harvest (25.00) was found highest in V_1 (Kanchancni). Highest number of effective tiller (15.33) was found in V_{10} (BRRI dhan51), number of ineffective tiller (5.67) was found in V_1 (Kanchancni) and highest (17.67) total tiller was found in V_{10} (BRRI dhan51). Highest crop growth rate (54.86) and Absolute grain growth rate (1.85) was found in V_3 (Sunashail). Highest flag leaf area (56.20 cm^2) was found in V_5 (Lohadang). Highest flag leaf weight (0.27g) was found in V_1 (Kanchancni). Highest specific leaf weight (8.67gcm^{-2}) was found in V_{10} (BRRIdhan51). Highest SPAD value during anthesis (60.20) and grain filling stage (49.77) was found in V_{10} (BRRI dhan51). Days to anthesis (84.67) was found highest in V_1 (Kanchancni), V_4 (Ranjay), V_6 (Haldijan),V_7 (Kohabinni) respectively. Duration from

anthesis to maturity was found highest in V_5 (Lohadang). Duration from germination to maturity (159.33) was found highest in V_6 (Haldijan). Grain sterility (%) (26.52) was found highest in V_2 (Chinisagar). Pancle length (30.33cm) was found highest in V_6 (Haldijan), filled grain panicle^{-1} (113.67) was found highest in V_8 (BRRI dhan46), unfilled grain panicle^{-1} (23.00) was found highest in V_2 (Chinisagar), seed size (28.02 mg) was found highest in V_6 (Haldijan), Grain yield (3.62 t/ha) was found highest in V_8 (BRRI dhan46), straw yield (4.17 t/ha) was found highest in V_2 (Chinisagar), total biological yield (6.23 t/ha) was found highest in V_2 (Chinisagar), harvest index (59.73) was found highest in V_8 (BRRI dhan46). Lowest plant height at 25 DAT (34.92cm) was observed in V_9 (BR11), lowest plant height at 50 DAT (64.40cm) and at 75 DAT (76.04cm) was found in V_{10} (BRRI dhan51), lowest plant height at harvest (97.33cm) was found in V_8 (BRRI dhan46). Lowest number of leaves hill^{-1} at 25 DAT (14.00) was found in V_1 (Kanchancni), at 50 DAT (33.25) and at 75 DAT (33.67) was found in V_2 (Chinisagar), at harvest (22.33) lowest leaves hill^{-1} was found in V_3 (Sunashail). Lowest number of tillers hill^{-1} at 25 DAT (4.67), at 75 DAT (6.00) and at harvest (11.67) was found in V_5 (Lohadang), lowest number of tillers hill^{-1} at 50 DAT was found in V_6 (Haldijan). Lowest number of effective tiller (10.00) and total tiller (12.00) was found in V_5 (Lohadang), lowest number of ineffective tiller (1.67) was found in V_2 (Chinisagar) and V_3 (Sunashail). Lowest Crop growth rate (10.95 g cm^{-2} day^{-1}) and Absolute grain growth rate (0.33 mg grain^{-1} day^{-1}) was found in V_2 (Chinisagar). Lowest flag leaf area (23.59 cm^2) was found in V_7 (Kohabinni) and lowest flag leaf weight (0.14g) was found in V_7 (Kohabinni) and V_9 (BR11). Lowest specific Leaf weight (4.33 gcm^{-2}) was found in V_8 (BRRI dhan46) and V_9 (BR11). Lowest SPAD value during anthesis (34.33) was found in V_7 (Kohabinni) and at grain filling stage (31.50) was found in V_6 (Haldijan). Days to anthesis lowest (67.67) in V_8 (BRRI dhan46). Duration from anthesis to maturity (56.00) and germination to maturity (141.00) was found lowest in V_1 (Kanchancni). Lowest grain sterility (9.37) was found in V_9 (BR11). Lowest panicle length (22.00) was found in V_5 (Lohadang). Lowest filled grain panicle^{-1} (37.33) and unfilled grain panicle^{-1} (11.33) was found in V_7 (Kohabinni). Lowest seed size (17.87mg) was found in V_8 (BRRI dhan46). Lowest Grain yield (1.16 t/ha) and Harvest index (27.37) was found in V_3

(Sunashail). Lowest straw yield (2.05 t/ha) was found in V_{10} (BRRI dhan51). Lowest total biological yield (3.69 t/ha) was found in V_4 (Ranjay).

Conclusions:

Based on the result of the present study, the conclusion may be drawn as:

1. Different growth, development and yielding characteristics of ten *aman* rice varieties varied significantly.

2. Among the local varieties, V_1 (Kanchancni) showed better performance due to its less days taken from duration from anthesis to maturity, lowest days taken from germination to maturity, flag leaf weight, high specific leaf weight, high grain yield, high harvest index, low grain sterility.

3. Among all the rice varieties, the HYV variety V_8 (BRRI dhan46) performed better due to its highest leaf no, highest crop growth rate, highest absolute grain growth rate, lowest days taken to anthesis, duration from anthesis to maturity, highest biological yield, highest harvest index, less grain sterility and highest grain yield.

4. Among the local varieties, highest flag leaf weight and lowest life duration from germination to maturity was observed in V_1 (Kanchancni), highest Crop Growth Rate and Absolute Grain Growth Rate was found in V_3 (Sunashail), flag leaf area was found highest in V_5 (Lohadang), lowest no of ineffective tiller was found in V_2 (Chinisagar) and V_3 (Sunashail), highest panicle length and highest seed size was found in V_6 (Haldijan), lowest no of unfilled grains per panicle was found in V_7 (Kohabinni). These characters might be incorporated in our HYV of rice which will contribute towards higher yield.

From the above findings, it can be concluded that among the HYV the variety V_8 (BRRI dhan46) performed better considering its growth, development and yielding characters, compared to other varieties.

On the other hand among the local rice varieties V_1 (Kanchancni) showed better performance considering its growth, development and yielding characters, compared to other local varieties.

Recommendations:

Further research with more parameters of rice plant is suggested to have more information and more experiments are necessary with the varieties of my experiment at different locations of Bangladesh for final recommendation. It needs more trials under farmer's field conditions at diverse agro-ecological zones of Bangladesh.

CHAPTER VI

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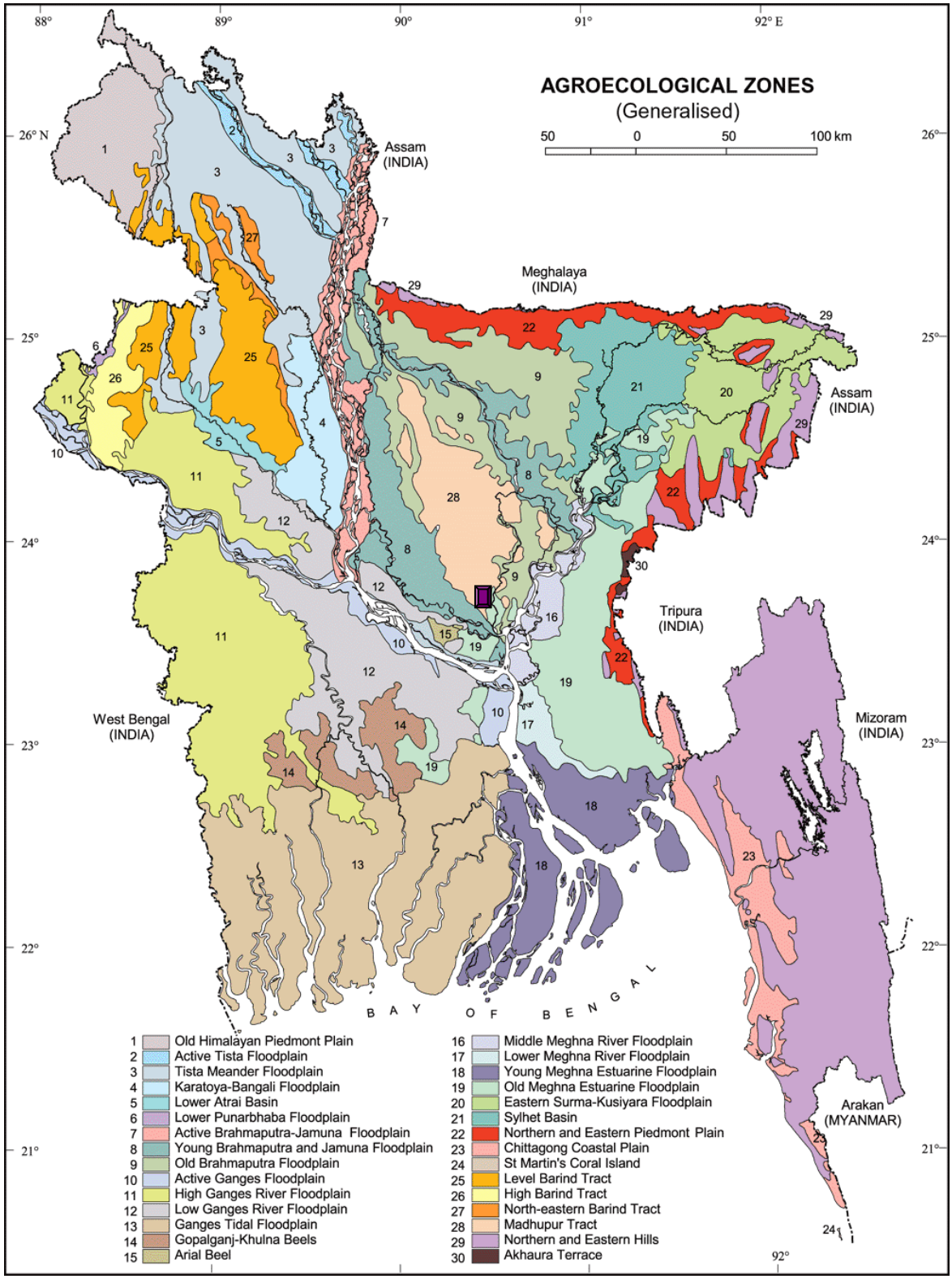
APPENDICES

Appendix I. The Map of Bangladesh showing the experimental site.



Appendix II. Characteristics of the soil of 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	6.2
Organic carbon (%)	0.43
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 record of air temperature, relative humidity and rainfall of the experimental site during the period from June to December 2017

Month (2017)	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	**Minimum**		
June	35.40	22.50	80.00	577.00
July	36.00	24.60	83.00	563.00
August	36.00	23.60	81.00	319.00
September	34.80	24.40	81.00	279.00
October	26.50	19.40	81.00	22.00
November	24.33	12.56	75.35	34.34
December	25.53	12.79	79.78	00.00

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

Plates

Plate 1 : Different type of local and high yielding seeds of rice which used in experiment

Plate 2 : Sprouted seeds ready to be sown in seedbed

a

b

Plate 3 : a) Weeding operation in the seedbed
b) Data collection in the experimental plot

Plate 4 : Data collection in the laboratory after harvesting.