PERFORMANCE OF SOME SELECTED HYBRID RICE VARIETIES IN *AUS* SEASON

TOWFIA JANNAT

MASTER OF SCIENCE

IN

AGRICULTURAL BOTANY

DEPARTMENT OF AGRICULTURAL BOTANY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

DECEMBER, 2013

PERFORMANCE OF SOME SELECTED HYBRID RICE VARIETIES IN *AUS* SEASON

By

TOWFIA JANNAT

REGISTRATION NO.: 07-02336

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

MASTER OF SCIENCE

IN

AGRICULTURAL BOTANY

SEMESTER: JULY-DECEMBER, 2013

Approved by:

Professor Dr. Md. Moinul Haque **Department of Agricultural Botany** **Supervisor**	**Prof. Dr. Kamal Uddin Ahamed** **Department of Agricultural Botany** **Co-supervisor**

Prof. Dr. Mohammad Mahbub Islam
Chairman
Examination Committee

DEPARTMENT OF AGRICULTURAL BOTANY
Sher-e-Bangla Agricultural University (SAU)
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled ***"PERFORMANCE OF SOME SELECTED HYBRID RICE VARIETIES IN AUS SEASON"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRICULTURAL BOTANY****, embodies the results of a piece of bonafide research work carried out by* ***TOWFIA JANNAT,*** *Registration no.:* ***07-02336*** *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 of during the course of this investigation has duly been acknowledged.

Dated: December, 2013
Place: Dhaka, Bangladesh

Dr. Md. Moinul Haque
Professor
Department of Agricultural Botany
SAU, Dhaka-1207
Supervisor

DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises to Almightly Allah, the Great, Gracious, Mercifull, Whose blessings enabled the author to complete this research work successfully. In particular, the author deems it a great pleasure to express her profound thankfulness to her respected parents, who entiled much hardship inspiring for prosecuting her studies, receiving proper education.

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

The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her co-supervisor Profesor, **Dr. Kamal Uddin Ahmed**, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, for his scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.

The author expresses her sincere respect and sence of gratitude to Chairman, **Dr. Mohammad Mahbub Islam,**Professor, Departement of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses her heartfelt thanks to all the teachers of the Department of Agricultural Botany, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

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

The Author

PERFORMANCE OF SOME SELECTED HYBRID RICE VARIETIES IN *AUS* SEASON

ABSTRACT

The experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during March to August (*Aus* season), 2013 to study the performance of some selected hybrid rice varieties namely BRRI hybrid dhan1, BRRI hybrid dhan2, ACI hybrid2, Jagoron and Panna1. Inbred BRRI dhan48 was used as check variety. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Growth characters, yield and yield attributes were significantly different among the studied varieties. All the studied hybrid varieties exhibited superiority in respect of growth characters viz. plant height, tillers hill^{-1}, stem dry matter hill^{-1}, leaf dry matter hill^{-1}, total dry matter hill^{-1}, leaf area index (LAI) over the inbred BRRI dhan48, Flag leaf chlorophyll content and chlorophyll a:b ratio, and light interception (%) were higher in all the hybrid rice varieties compared to the inbred. ACI hybrid2, Jagoron and Panna1 showed better performance in yield related characters viz. effective tillers hill^{-1}, spikelets fertility (%) and 1000-grain weight over the rest test varieties. Consequently, these three hybrid varieties produced the considerable higher grain yield compared to BRRI dhan48 (2.51 t ha$^{-1)}$. Higher grain yield of these varieties was related with their higher dry matter production.Among the hybrid rice varieties, ACI hybrid 2 provided the highest grain yield (3.05 t ha^{-1}) which was closly followed by Jagoron (2.97 t ha^{-1}) and Panna1 (2.82 t ha^{-1}).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

CHAPTER I

INTRODUCTION

Rice is the most important food crop around the world and the staple food for approximately more than two billion people in Asia (Hien *et al.,* 2006). Ninety percent of all rice is grown and consumed in Asia (Anon., 1997, Luh, 1991). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. The nation is still adding about 2.3 million every year to its total of 150 million people (Momin and Husain, 2009). Thus, the present population will swell progressively to 223 million by the year 2030 which will require additional 48 million tons of food grains instead of current deficit of about 1.2 million tons every year (Julfiquar *et al*., 2008). So, the highest priority has been given to produce more rice (Bhuiyan, 2004).

Horizontal expansion of rice area and rice yield per unit area need to be increased to meet this ever-increasing demand of food. Management practices also can help for horizontal expansion of rice area and yield per unit area. In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, the national average rice yield in Bangladesh (4.2 t ha^{-1}) is very low compared to those of other rice growing countries, like China (8.75 t ha^{-1}), Japan (8.22 t ha^{-1}) and Korea (8.04 t ha^{-1}) (FAO, 2009). In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area of which around 79% is occupied by high yielding rice varieties (BBS, 2008).

Rice yield can be increased in many ways of them developing new high yielding variety and by adopting proper agronomic management practices to the existing varieties to achieve their potential yield is important. For developing high yielding varieties, Japan initiated first breeding program in 1981 (Wang, 2006). IRRI also started super rice breeding program to give up to 30% more rice yield (13-15 t ha^{-1}) than the current modern high yielding plant types (IRRI, 1993). Generally the yield of hybrid rice varieties is 10%-15% more than the improved inbred varieties. It has grate potentiality for food security of poor countries where arable land is scarce populations is expanding and labour is cheap. In our country BRRI has started breeding program for the development of super high yielding varieties with large panicles and high yield potentialities.

Growth and yield of rice are strongly influenced by genotype as well as environmental factors (BRRI, 2003). The genetic potentiality of a rice variety is almost fixed, but grain yield can be increased by the manipulation of management practices and by growing in recommended season (BRRI, 1999). Now a days different hybrid rice variety are available in Bangladesh which have more yield potential than conventional high yielding varieties (Akbar, 2004). Improvement of rice grain yield is the main target of breeding program to develop rice varieties for diverse ecosystems. However, grain yield is a complex trait, controlled by many genes and highly affected by environment (Jennings *et al.*, 1979). In addition, grain yield also related with other characters such as plant type, growth duration and yield components (Yoshida, 1981).

Very recently various new rice varieties were developed and available as BRRI dhan and maximum of them is exceptionally high yielding. On the other hand, compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%. This variety however, needs further evaluation under different adaptive condition to interact with different environmental conditions. There are three distinct rice growing seasons in Bangladesh namely Aus, Aman and Boro. Among these three, Aus rice covers only 12.27% of the rice growing area with average yield 1.45 t ha^{-1} (BBS, 2010). The rice yield in the Aus season is low as compared to the other growing seasons, which need to be improved. Hybrid rice is one of the viable options for increasing the yield over the best modern varieties. Based on above proposition, this research work is designed to evaluate the growth and yield performance of some selected hybrid rice varieties in Aus season with the following specific objectives:

- To evaluate the growth performance of hybrid rice varieties in *Aus* season
- To investigate the yield variation among the selected hybrid rice varieties
- To compare the yield and yield components of the hybrid and recommended inbred rice varieties in *Aus* season.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characters of rice are considerably depended on manipulation of basic ingredients of agriculture. The basic ingredients include variety, climatic condition, agronomic practices and hazardous factors. Among the above factors variety until now a considerable matter for rice growing in respect of production. Varieties in respect of local, high yielding and hybrid are generally more adaptive to appropriate and they greatly affect the return of rice cultivation. But the available relevant reviews related to variety in respect of their performance are very limited in the context of Bangladesh and also in specific cropping season. Some of the recent past information on varietal performance on rice have been reviewed under the following headings:

An experiment was conducted by Bhuiyan *et al.* (2014) to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had significant effects on plant height at maturity, number of days to maturity, number of tillers, number of productive tillers, number of filled and unfilled grains, length of panicle and yield. RGBU010A X SL8R is therefore recommended as planting material among hybrid rice varieties because it produced favorable yield, produced more productive tillers and filled grains, produced longer panicles, heavy seeds, high harvest index and are accepted by consumers. In the absence of this variety, RGBU02A × SL8R, RGBU003A × SL8R and RGBU0132A × SL8R may also be used as planting material.

An experiment was conducted during *Aus* season to observe the effect of transplanting dates on the yield and yield attributes of exotic hybrid rice varieties by Hosain *et al.* (2014) at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. The experiment comprised of three rice varieties (two hybrids-Heera2, Aloron and one inbred- BRRI dhan48). From the findings it was revealed that BRRI dhan48 produced the highest grain yield (3.51 t ha^{-1}) where as the hybrid varieties Heera2 (3.03 t ha^{-1}) and Aloron (2.77 t ha^{-1}) achieved lower grain yield due to higher spikelet sterility.

Tabien *et al.* (2012) reported that two newly released high yielding rice varieties, Antonio and Colorado would be the new choices for rice farmers in Texas for commercial production in the future. Both inbred varieties show great promise of high yields. These could also be good recipients of important traits needed in future climate or environment. The screening and yield performance trials identified donors for tolerance to higher rate of herbicide.

Mallikarjuna *et al.* (2012) were mapped in 2 mapping populations derived from *Oryza sativa* cv Swarna in a Quantitative trait loci (QTLs) for 12 grain quality traits *nivara*. QTLs for 4 quality traits were associated with 5 of the 7 major yield QTLs reported in the same 2 mapping populations. Useful introgression lines have been developed for several agronomic traits.

Samonte *et al.* (2011) reported that the two elite lines recommended for release are high yielding in Texas. RU0703190 is also a very early maturing conventional long grain rice. The high yield potential newly released varieties will increase the production of rice and the income of the farmers. The germination and seedling cold tolerant donors that were identified will be useful in developing variety for early plantings.

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

Khalifa (2009) conducted a field experiment at the experimental farm of Rice research and training centre (RRTC), Sakha, kafr-El sheikh governorate, Egypt in 2008 rice season for physiological evaluation of some hybrid rice varieties under different sowing dates. Four hybrid rice H_1, H_2, GZ 6522 and GZ 6903 were evaluated at six different sowing dates. Results indicated that H_1 hybrid rice variety surpassed other varieties for studied characters except for number of days to panicle initiation and heading date.

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

Xie *et al.* (2007) found that Shanyou-63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}). Amin *et al.* (2006) conducted a field experiment to find out the influence of variable doses of N fertilizer on growth, tillering and yield of three traditional rice varieties (*viz.* Jharapajam, Lalmota, Bansful Chikon) compared with that of a modern variety (*viz.* KK-4) and reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

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

Bisne *et al.* (2006) conducted an experiment with eight promising varieties using four CMS lines of rice and showed that plant height differed significantly among the varieties and Pusa Basmati gave the highest plant height in each line.

Myung (2005) worked with four different panicle types of rice varieties and observed 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.

The relationships among the plant traits, including harvest index (HI) and yield components of 11 newly released japonica rice (*Oryza sativa*) cultivars in Zhejiang, China, were investigated by Li *et al.* (2005). The results showed that there were positive correlations between the yield and HI, grain weight plant^{-1}, number of grains panicle^{-1}, seed setting percentage, grain density. Positive correlations were observed among HI and grain density, and spikelet production per area. However, there were negative correlations between yield and panicle length, second and third upper leaves of plants, the days from sowing to heading, and dry matter production. Rice yield mainly depended on dry matter production after heading, which was closely correlated with the lengths and areas of the upper third leaves.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and observed that Mukti (5268 kg ha^{-1}) out yielded the other genotypes and recorded the maximum number of filled grains and had lower spikelet sterility (25.85%) compared to the others.

Sumit *et al.* (2004) worked with newly released four commercial rice hybrids (DRRH 1, PHB 71, Pro-Agro 6201, KHR 2, ADTHR 1, UPHR 1010 and Pant Sankar Dhan 1) and two high yielding cultivars (HYV) as controls (Pant Dhan 4 and Pant Dhan 12) and reported that KHR 2 gave the best yield (7.0 t ha^{-1}).

Dongarwar *et al.* (2003) comprised an experiment to investigate the response of hybrid rice KJTRH-1 in comparison with 2 traditional cultivars, Jaya and Swarna, to 4 fertilizer rates, i.e. 100:50:50, 75:37.5:37.5, 125:62.5:62.5 and 150:75:75 kg NPK ha^{-1} and reported that KJTRH-1 produced significantly higher yield (49.24 q ha^{-1}) than Jaya (39.64 q ha^{-1}) and Swarna (46.06 q ha^{-1}). Bokyeong *et al.* (2003)

reported that applied with same nitrogen dose Sindongjinbyeo and Iksan467 of rice varieties gave high primary rachis branches than Sindongjinbyeo and Dongjin No.1 varieties.

Baloch *et al.* (2002) carried out an experiment with three mutant strains Basmati 370-32, Jajai 77-30 and Sonahri Sugdasi-6 along with their respective mother varieties Basmati 370, Jajai 77, Sonahri Sugdasi and check variety Basmati 385 were evaluated under different plant population for grain yield and yield contributing parameters. An increase in spacing induced vigorous plant growth as well as increased the number of panicles hill^{-1}, grain yield hill^{-1}, filled grains panicle^{-1} and 1000 grain weight. The mutant strains Jajai 77-30 produced significantly higher grain yield at all spacings as compared with all other entries.

Pandey and Awasthi (2001) studied genetic variability in 21 genotypes of aromatic rice for yield contributing traits. Significant genetic variability was observed among the 21 genotypes for the entire yield contributing traits. They concluded that traits plant height, days to 50% flowering effective tillers plant^{-1}, panicle length, number of grains panicle^{-1}, test weight and grain yield plant^{-1} play a major role in the enhancement of production of grain yield.

An experiment was conducted by Sucharitha and Boopathi (2001) during the samba season (August-December) to investigate the effect of different methods of phosphorus application on the growth parameters and yield components of rice cultivars (ADT 39, MDU 2, Co 43, MDU 4 and IR 20) at the Agricultural College and Research Institute, Madurai, Tamil Nadu, India. The treatments consisted of 5 methods of P application. Among the cultivars tested, ADT 39 expressed remarkable superiority over other cultivars by increased growth parameters and yield attributes.

Shanthi and Singh (2001) studied 16 M_6 generation of induced mutant along with non- mutant Mashuri for variation in yield and component and found significant variation among the genotypes for all characters studied.

Xu and Wang (2001) evaluated ten restorer and ten maintainer lines. They observed that the restorer lines showed more spikelet fertility than maintainer lines. They studied growth duration, number of effective tillers, number of spikelets panicle^{-1} and adaptability.

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

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

Chen-Liang *et al*. (2000) showed that the cross between Peiai 64s and the new plant type lines had strong heterosis for filled grains plant^{-1}, number of spikes plant^{-1} and grain weight plant^{-1}, but heterosis for spike fertility was low.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4 m^{-2}) and filled grains $panicle^{-1}$ (111.0) than other varieties, whereas IR36 gave the highest 1000-grain weight (21.07 g) and number of panicles m^{-2} than other tested varieties.

Ahmed *et al.* (1998) obtained 11 better maintainer lines with good maintainability for corresponding CMS lines in an evaluation program of 64 maintainers with respective CMS lines from different countries. They recorded differences for growth duration, number of effective tillers, number of spikelets $panicle^{-1}$ and adaptability.

Julfiquar *et al.* (1998) reported that BRRI evaluated 23 hybrids along with three standard checks during *boro* season 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 significant yield difference. They also reported that thirteen rice hybrids were evaluated in three locations of BADC farm during the boro season. Two hybrids out yielded the check variety of same duration by more than 1 t ha^{-1}.

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

Xu and Li (1998) observed that the maintainer lines in generally shorter than restorer line. Devaraju *et al.* (1998) in a study with hybrid rice cultivar KRH2 and 1R20 as a check variety having different levels of N from 0 to 200 kg N ha^{-1} found that KRH2 out yielded IR20 at all levels of N. The increased grain yield of KRH2 was mainly attributed to the higher number of productive tillers hill^{-1}, panicle length, weight and number filled grains panicle^{-1}.

Mishra and Pandey (1998) evaluated standard heterosis for seed yield in the range of 44.7 to 230.9% and 42.4 to 81.4%, respectively. Plant height, panicle plant^{-1}, grain panicle^{-1} and 1000 grain weight increase the yield in modern varieties. Xu and Li (1998) observed that the maintainer lines were generally shorter than restorer line.

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

Devaraju *et al.* (1998) in a study with two rice hybrids such as Karnataka Rice Hybrid 1 (KRH1) and Karnataka Rice Hybrid-2 (KRI42) using HYV IR20 as the check variety and found that KRH2 out yielded than IR20. In IR20, the tiller number was higher than that of KRH2.

Ahmed *et al.* (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail and respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

Dwivedi (1997) in a field experiment found that scented genotypes, Kamini and Sugandha gave higher grain and straw yields than four other cultivars RP615, Harban, Basmati and Kasturi under midupland sandy loam soil conditions of Agwanpur (Bihar).

Munoz *et al.* (1996) noted that IR8025A hybrid rice cultivar produced an average yield of 7.1 t ha^{-1} which was 16% higher than the commercial variety Oryzica Yacu-9.

Islam (1995) in an experiment with four rice cultivars *viz.* BR10, BR11, BR22 and BR23 found that the highest number of non bearing tillers $hill^{-1}$ was produced by cultivar BR11 and the lowest number was produced by the cultivar BR10.

BRRI (1995) conducted an experiment with rice cv. BR10, BR22, BR23 and Rajasail (ck.) at three locations in the aman season. It was found that BR23 gave the highest yield (5.71 t ha^{-1}) which was similar to BR22 (5.02 t ha^{-1}) and the check Rajasail yielded the lowest (3.63 t ha^{-1}). Roy *et al.* (1995) observed that the plants, which needed more days for 50% flowering generally gave more yield.

BRRI (1994) also reported that among the four varieties of rice viz. BR14, Pajam, BR5 and Tulsimala, BR14 produced the highest tillers $hill^{-1}$ and the lowest number of spikelet $panicle^{-1}$ respectively. They also observed that the finer the grain size, the higher was the number of spikelet $panicle^{-1}$.

BINA (1993) conducted an experiment with four varieties/advance lines and reported significant variation in plant height, number of non-bearing tillers hill^{-1}, panicle length and unfilled spikelets panicle^{-1}. They also noted that grain yield did not differ significantly among the varieties.

Chowdhury *et al.* (1993) observed that the cultivar BR23 showed superior performance over cultivar Pajam in respect of number of productive tillers hill^{-1}, length of panicle, 1000-grain weight, grain and straw yields but cultivar Pajam produced significantly taller plants, more number of total spikelet panicle^{-1}, grain panicle^{-1} and sterile spikelet panicle^{-1}. They also observed that the finer the grain size the higher the number of spikelet.

BINA (1992) reported in a field experiment that under transplanting conditions the grain yield of BINA dhan varied from 5.39 and 5.57 t ha^{-1}, respectively and maturity of the above strains were 160 and 166 days, respectively.

Rice tillering is a major determinant for panicle production (Miller *et al.*, 1991) and as a consequence affects total yield. The high tillering capacity is considered as a desirable trait in rice production, since number of tillers plant^{-1} is closely related to number of panicles plant^{-1}. To some extent, yield potential of a rice variety may be characterized by tillering capacity. On the other hand, it was reported that the plants with more tillers showed a greater inconsistency in mobilizing assimilates and nutrients among tillers. Moreover, grain quality could be also affected by tillering ability due to different grain development characteristics. It has been well documented that either excessive or insufficient tillering is unfavorable for high yield.

Hossain and Alam (1991) reported that the growth characters like plant height, total tillers hill^{-1} and the number of grains panicle^{-1} differed significantly among BR3, BRll, BR14 and Pajam varieties of rice in boro season. Idris and Matin (1990) conducted an experiment with six varieties and observed that panicle length differed among varieties and it was greater in IR 20 than in indigenous and high yielding varieties.

Miah *et al.* (1990) conducted an experiment where rice cv. Nizersail and mutant lines Mut. NSI and Mut. NSS were planted and found that plant height were greater in Mut. NSI than Nizersail.

Patnaik *et al.* (1990) found that hybrids with intermediate to tall plant height having non-lodging habit could be developed gave more than 20% grain yield than the standard checks. They also reported that in hybrids, yield was primarily influenced by effective tillers plant^{-1} and fertile grains panicle^{-1}, whereas in parents it was panicle length, maturity and effective tillers plant^{-1}. Number of effective tillers plant^{-1} and fertile grains panicle^{-1} remained constant and common in explaining heterosis for yield of most of the hybrids. The heterosis for grain yield was mainly due to the significant heterosis for the number of spikelets panicle^{-1}, test weight and total dry matter accumulation.

Saha *et al.* (1989) studied the characteristics of CMS lines V20A, 279A, V41A and P203A with their corresponding maintainer (B) lines and two restorer (R) lines IR50 and IR54. In maintainer lines tiller number were recorded highest in V20B. Saha *et al.* (1989) studied the characteristics of CMS lines V20A, 279A, V41A and

P203A with their corresponding maintainer (B) lines and two restorer (R) lines IR50 and IR54 and in maintainer lines tiller number were recorded highest.

Ghosh and Hossain (1988) reported that effective tillers plant^{-1}, number of grains panicle^{-1} and grain weight as the major contributory characters for grain yield it had positive correlations with number of productive tillers plant^{-1}.

Shamsuddin *et al.* (1988) conducted a field trial with nine different rice varieties and observed that plant height differed significantly among varieties. Sawant *et al.* (1986) conducted an experiment with the new rice lines R-73-1-1, R-711 and the traditional cv. Ratna and reported that the traditional cv. Ratna was the shortest.

Dwarfness may be one of the most important agronomic characters, because it is often accompanied by lodging resistance and thereby adapts well to heavy fertilizer application (Futsuhara and Kikuchi, 1984).

In addition, grain yield also related with other characters such as plant type, growth duration, and yield components (Yoshida, 1981). Rice yield is a product of number of panicles per unit area, number of spikelets panicle^{-1}, percentage of filled grains and weight of 1000 grains (De Datta, 1981).

It may be understood from the above reviews that variety is an important factor for rice cultivation. Consideration of local, high yielding and hybrid variety variation was observed in respect of yield contributing characters and yield of rice by different researchers in their earlier study.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out to study the performance of some selected hybrid rice varieties in Aus season. This chapter includes materials and methods that were used in conducting the study are presented below under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from March to August, 2013 in Aus season.

3.1.2 Site description

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

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar, Dhaka and has been presented in Appendix I.

3.1.4 Characteristics of soil

The soil of the experimental area belongs 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 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system. The details of the experimental soil as per SRDI have been presented in Appendix II.

3.2 Experimental details

3.2.1 Treatments

The experiment comprised of six rice variety which were used as treatment for the experiment and they were as follows.

i. V_1: BRRI dhan48

ii. V_2: BRRI hybrid dhan1

iii. V_3: BRRI hybrid dhan2

iv. V_4: ACI hybrid2

v. V_5: Jagoron

vi. V_6: Panna1

3.2.2 Description of cultivars

BRRI dhan48

BARI dhan48 is a modern variety developed by BRRI in 2008 through crossing BR1543-3-9-2-1/IR13249-49-3-2-2 and its growth duration is about 110 days. It is recommended for Aman seasons. It is a photoperiodic sensitive variety like Naizersail. On average, BRRI dhan48 produce yield of 4.7 t ha^{-1} and plant height is about 105 cm. Its grain is medium, coarse and the panicle remains above the flag leaf at flowering stage.

BRRI hybrid dhan1

It is a hybrid rice variety developed by BRRI in 2001 and it is recommended for cultivation in both wet and dry seasons of Bangladesh. BRRI hybrid dhan1 takes 120-125 days in wet season and 145-155 days in dry seasons for maturity. It is an early ripening and lodging and shattering resistant variety with low sterility, coarse grain and tasty rice. Plant is semi dwarf and the plant height is about 100 to 110 cm. BRRI hybrid dhan1 gives grain yield in average 8.5 t ha^{-1}.

BRRI hybrid dhan2

BRRI hybrid dhan2 is the latest hybrid rice variety developed by BRRI in 2008 and it is recommended for cultivation in both wet and dry seasons of Bangladesh. It is an early ripening and lodging and shattering resistant variety with low sterility, coarse grain, non-glutinous and tasty rice. It takes 110-115 days in wet season and 140-145 days in dry seasons for maturity. Average plant height of this variety is about 105 cm. BRRI hybrid dhan2 gives grain yield average 8.0 t ha^{-1}.

ACI hybrid2

ACI hybrid2 is a commercial hybrid rice variety developed in China and ACI Ltd., Bangladesh has been imported its seeds for cultivation. It is lodging and shattering resistant variety, medium fine grain rice and tasty rice. It takes 135-140 days for maturity. The variety has the ability to produce grain yield 9.5 to 10.0 t ha^{-1}

Jagoron

It is a hybrid rice variety and developed in China. BRAC (Bangladesh Rural Advancement Committee) is the sole agent for this variety in Bangladesh. The variety has the ability to produce grain yield 8.5 to 9.5 t ha^{-1}, growth duration 110-130 days. Plant is semi dwarf and the plant height is about 100 to 120 cm. It is suitable for cultivation in irrigated soil.

Panna1

Panna1 is a hybrid rice variety developed in China and marketed in Bangladesh by ACI Ltd. It was recommended for Boro season (November to February)cultivation. The grains are medium fine and white in color. It requires about 145 days on an average for completing its life cycle with average grain yield of 8.0 t ha^{-1}.

3.2.3 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 18 plots for 6 rice variety in each of 3 replications. The 6 rice variety of the experiment were assigned at random in 6 pots of each replication. The layout of the experiment presented in Figure 1.

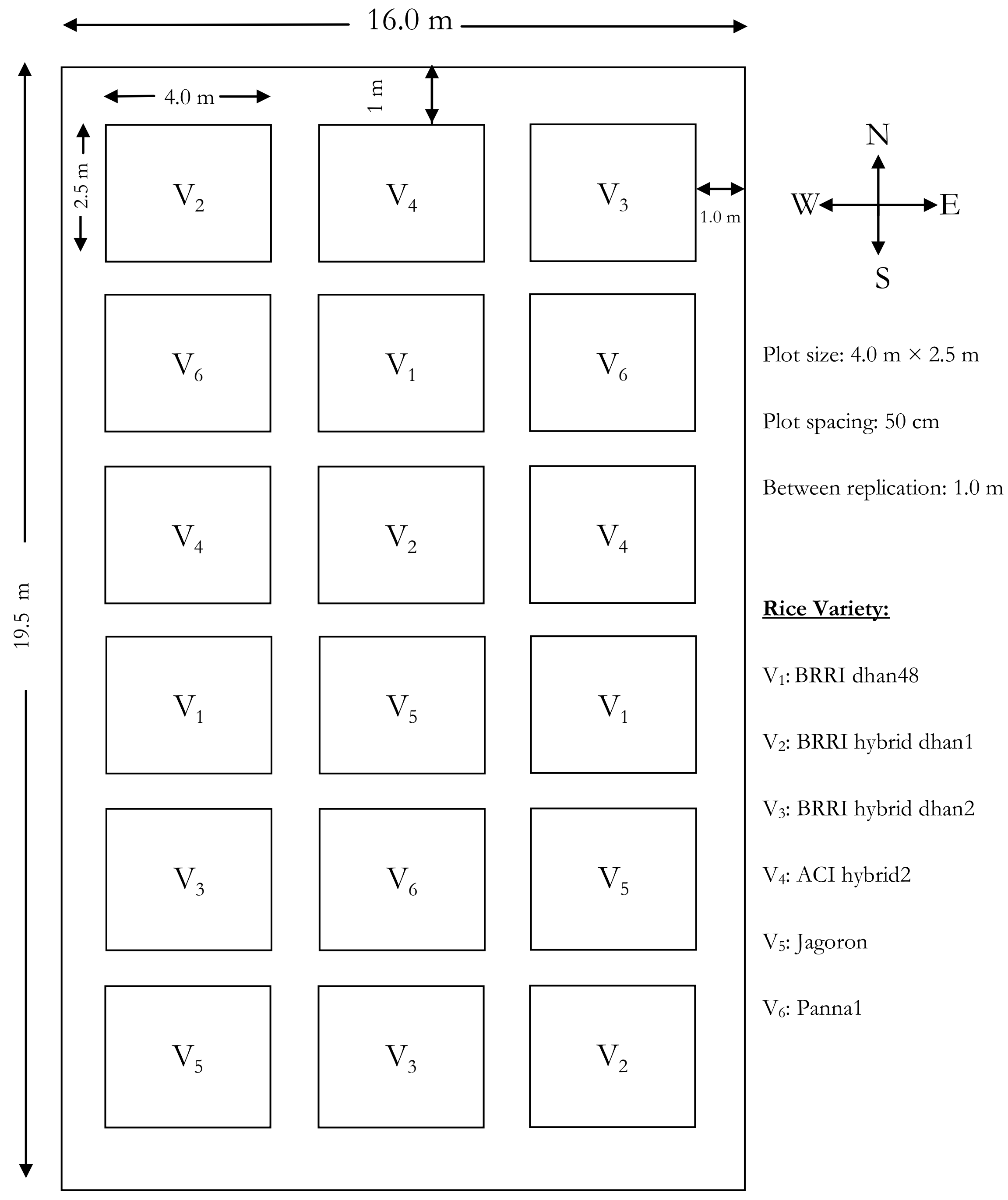

Figure 1. Layout of the experimental plot

3.3 Growing of crops

3.3.1 Raising seedlings

3.3.1.1 Seed collection

The seeds of BRRI dhan48, BRRI hybrid dhan1, BRRI hybrid dhan2 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur and ACI hybrid2, Jagoron and Panna1 were procured from respected company. The seeds were collected just 20 days ahead of the sowing of seeds in seed bed.

3.3.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method and then immersed in water bucket for 24 hours and then they were kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.3.1.3 Preparation of seedling nursery bed and seed sowing

As per BRRI recommendation seed bed was prepared with 1 m wide seed bed adding nutrients as per the requirements of soil. Seeds were sown in the seed bed on March 10, 2013 in order to transplant the seedlings in the plot as per experimental design.

3.3.2 Preparation of experimental land

The plot selected for conducting the experiment was opened in the 1st week of April 2013 with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for transplanting seedlings. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated in below were mixed with the soil of each unit plot.

3.3.3 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MP, gypsum, zinc sulphate and borax, respectively were applied. The entire amount of TSP, MP, gypsum, zinc sulphate and borax were applied during the final preparation of plot land. Mixture of cowdung and compost was applied @ 10 t ha^{-1} during 10 days before transplantation. Urea was applied in two equal installments at tillering and before panicle initiation. The dose and method of application of fertilizers are shown in Table 1.

Table 1. Dose and method of application of fertilizers

Fertilizers	Dose (kg ha^{-1})	Application (%)		
		Basal	1st installment	2nd installment
Urea	150	--	50.00	50.00
TSP	100	100	--	--
MP	100	100	--	--
Gypsum	60	100	--	--
Zinc sulphate	10	100	--	--
Borax	10	100	--	--

Source: BRRI, 2012, Adhunik Dhaner Chash, Joydevpur, Gazipur

3.3.4 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting of the seedlings. The seedlings were uprooted on April 09, 2013 without causing much mechanical injury to the roots.

3.3.5 Transplanting of seedlings

Rice seedlings were transplanted in lines each having a line to line 30 cm and plant to plant 25 cm distance in the well prepared plot at 10 April, 2013. Total 2 healthy seedlings were transplanted in a hill.

3.3.6 After care

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

3.3.6.1 Irrigation and drainage

Flood irrigation was given to maintain a constant level of standing water upto 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering. The field was finally dried out 15 days before harvesting.

3.3.6.2 Gap filling

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

3.3.6.3 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at tillering stage and at panicle initiation stage by mechanical means.

3.3.6.4 Top dressing

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

3.3.6.5 Plant protection

Furadan 57 EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

3.4 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 pot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during 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}.

3.5 Data recording

Data were recorded on yield attributing characters and yield in each replication as follows-

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 45, 60 and 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.

3.5.2 Tillers $hill^{-1}$

The number of tillers $hill^{-1}$ was recorded at the time of 30, 45, 60 and 75 DAT by counting total tillers of five respective hills and finally averaged to $hill^{-1}$ basis and recorded.

3.5.3 Leaf area index

Leaf area index measured manually at the time of 30, 45, 60 and 75 DAT. Data were recorded as the average of 05 plants selected at random the inner rows of each plots. The final data calculated multiplying by a correction factor 0.75 as per Yoshida (1981).

3.5.4 Stem dry matter hill^{-1}

Stem dry matter hill^{-1} was recorded at 30, 45, 60 and 75 DAT from 3 randomly collected stems hill^{-1} of each plot from inner rows leaving the boarder row. Collected stems were oven dried at 70^{0}C for 72 hours then transferred into desiecator and allowed to cool down at room temperature, final weight was taken and converted into stem dry matter content hill^{-1}.

3.5.5 Leaves dry matter hill^{-1}

Leaves dry matter hill^{-1} was recorded at 30, 45, 60 and 75 DAT from 3 randomly collected leaves hill^{-1} of each plot from inner rows leaving the boarder row. Collected stems were oven dried at 70^{0}C for 72 hours then transferred into desiecator and allowed to cool down at room temperature, final weight was taken and converted into leaves dry matter content hill^{-1}.

3.5.6 Total dry matter hill^{-1}

Total dry matter hill^{-1} was recorded at 30, 45, 60 and 75 DAT by adding stem dry matter and leaves dry matters hill^{-1}.

3.5.7 Light interception (LI)

The fraction of light intercepted by the rice canopy was measured with a sunflec-ceptometer, a 1 m long light quantum sensor (Model-Decagon, Pullman, Washington, USA) within 12.00 noon to 2.00 pm. At the top, middle and bottom of the rice plant at flowering stage. The LI (%) was calculated based on light transmission (LT) using the following formula:

$$LT_t = \frac{I_i}{I_0} \times 100 \qquad LT_m = \frac{I_m}{I_0} \times 100$$

$$LI_t = 100 - LT_i \qquad LI_m = 100 - LT_m$$

$$LI_{t\text{-}m} = LI_t - LI_m$$

Where,

I_0 = Light meter reading at the top of the canopy

I_i = Light meter reading at the bottom of the canopy

I_m = Light meter reading at the middle of the canopy

3.5.8 Chlorophyll content

Flag leaves were sampled from main tillers at 2, 9, 16 and 23 days after flowering and a segment of 20 mg from middle portion of leaf was used for chlorophyll content estimated on fresh weight basis extracting with 80% acetone and used double beam spectrophotometer (Model: U-2001, Hitachi, Japan) according to Witham *et al.* (1986).

3.5.9 Chlorophyll a:b

Chlorophyll a:b was estimated by dividing chlorophyll a amount by chlorophyll b.

3.5.10 Days from sowing to harvest

Days from sowing to harvest were recorded by counting the number of days required to harvest in each plot.

3.5.11 Effective tillers hill^{-1}

The total number of effective tiller hill^{-1} was counted as the number of panicle bearing hill plant^{-1}. Data on effective tiller hill^{-1} were counted from 5 selected hills at harvest and average value was recorded.

3.5.12 Non-effective tillers hill^{-1}

The total number of non effective tillers hill^{-1} was counted as the number of no panicle bearing tillers plant^{-1}. Data on non effective tiller hill^{-1} were counted from 5 selected hills at harvest and average value was recorded.

3.5.13 Total tillers hill^{-1}

Number of total tillers hill^{-1} was counted by adding effective and in-effective tillers hill^{-1}.

3.5.14 Panicle length

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

3.5.15 Filled spikelets panicle^{-1}

The total number of filled spikelets was counted randomly from selected 10 panicles of a plot on the basis of grain in the spikelet and then average number of filled spikelets panicle^{-1} was recorded.

3.5.16 Unfilled grains panicle^{-1}

The total number of unfilled spikelets was counted randomly from the same 10 panicles where filled grains were counted of a plot on the basis of no grain in the spikelet and then average number of unfilled spikelets panicle^{-1} was recorded.

3.5.17 Total spikelets panicle^{-1}

Number of total spikelets panicle^{-1} was counted by adding filled and unfilled spikelets panicle^{-1}.

3.5.18 Spikelets fertility

Spikelets fertility was computed using the formula:

$$\text{Spikelets fertility (\%)} = \frac{\text{Filled spikelets panicle}^{-1}}{\text{Total spikelets panicle}^{-1}} \times 100$$

3.5.19 Weight of 1000-grains

One thousand grains were counted randomly from the total cleaned harvested grains of each individual plot and then weighed in grams and recorded.

3.5.20 Grain yield

Grains of rice variety obtained from each unit plot were sun-dried and weighed carefully and finally adjusted to 14% moisture basis using a digital moisture meter. The dry weight of grains of each plot from harvested area was measured and converted to t ha^{-1}.

3.5.21 Straw yield

Straw of rice variety obtained from each unit plot were sun-dried and weighed carefully. The sub-samples of the straw of each plot was oven dried and finally converted to t ha^{-1}.

3.5.22 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.5.23 Harvest index

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

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.6 Statistical Analysis

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

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to study the performance of some selected hybrid rice varieties in *Aus* season. BRRI dhan48, BRRI hybrid dhan1, BRRI hybrid dhan2, ACI hybrid2, Jagoron and Panna1 were used as rice variety. The analyses of variance (ANOVA) of the data on different crop growth characters, yield contributing characters and yield are presented in Appendix III-XIII. With the help of table and graphs the results have been presented and discussed and also possible interpretations given under the following headings:

4.1 Crop growth characters

4.1.1 Plant height

Plant height of different rice variety showed statistically significant variation at 30, 45, 60, 75 days after transplanting (DAT) and at harvest (Appendix III). At 30, 45, 60, 75 DAT and at harvest, the tallest plant (35.87, 50.40, 76.50, 95.77 and 139.97 cm, respectively) was recorded from ACI hybrid2 which was statistically similar (35.00, 49.03, 76.20, 92.97 and 110.40, respectively) with Jagoron, whereas the shortest plant (29.33, 41.73, 69.03, 82.57 and 102.93 cm, respectively) was found from BRRI dhan48 (Table 2). Different varieties produced different plant height on the basis of their varietal characters and improved varieties is the first and foremost requirement for initiation and accelerated production program. Growth of rice is strongly influenced by genotype as well as environmental factors (BRRI, 2003).

Table 2. Plant height at different days after transplanting and at harvest of some selected hybrid rice varieties

Rice variety	Plant height at (cm)				
	30 DAT	**45 DAT**	**60 DAT**	**75 DAT**	**Harvest**
BRRI dhan48	29.33 b	41.73 b	69.03 c	82.57 c	102.93 b
BRRI hybrid dhan1	30.30 b	43.30 b	70.20 bc	88.53 abc	106.77 b
BRRI hybrid dhan2	29.43 b	42.57 b	69.07 c	86.03 bc	106.30 b
ACI hybrid2	35.87 a	50.40 a	76.50 a	95.77 a	139.97 a
Jagoron	35.00 a	49.03 a	76.20 a	92.97 ab	110.40 b
Panna1	31.00 b	45.47 ab	73.30 ab	89.90 abc	105.50 b
$LSD_{(0.05)}$	**3.675**	**5.426**	**3.733**	**8.066**	**9.764**
CV(%)	**6.35**	**6.57**	**4.84**	**4.97**	**4.79**

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

4.1.2 Tillers hill^{-1}

Statistically significant variation was recorded in terms of tillers hill^{-1} due to different rice variety at 30, 45, 60 and 75 DAT (Appendix IV). At 30, 45, 60 and 75 DAT, the maximum tillers hill^{-1} (5.67, 8.80, 15.70 and 16.80, respectively) was recorded from ACI hybrid2 which was similar (5.53, 8.53, 14.03 and 15.73, respectively) with Jagoron (Figure 2). On the other hand, the minimum tillers hill^{-1} (4.07, 6.27, 9.57 and 12.03, respectively) was observed from BRRI dhan48 which was similar with BRRI hybrid dhan2 (4.13, 6.47, 9.90 and 12.73, respectively) and BRRI hybrid dhan1 (4.33, 6.93, 10.03, 12.73, respectively) at 30, 45, 60 and 75 DAT (Figure 2). Management practices influence the number of tillers hill^{-1} but varieties itself also manipulated it.

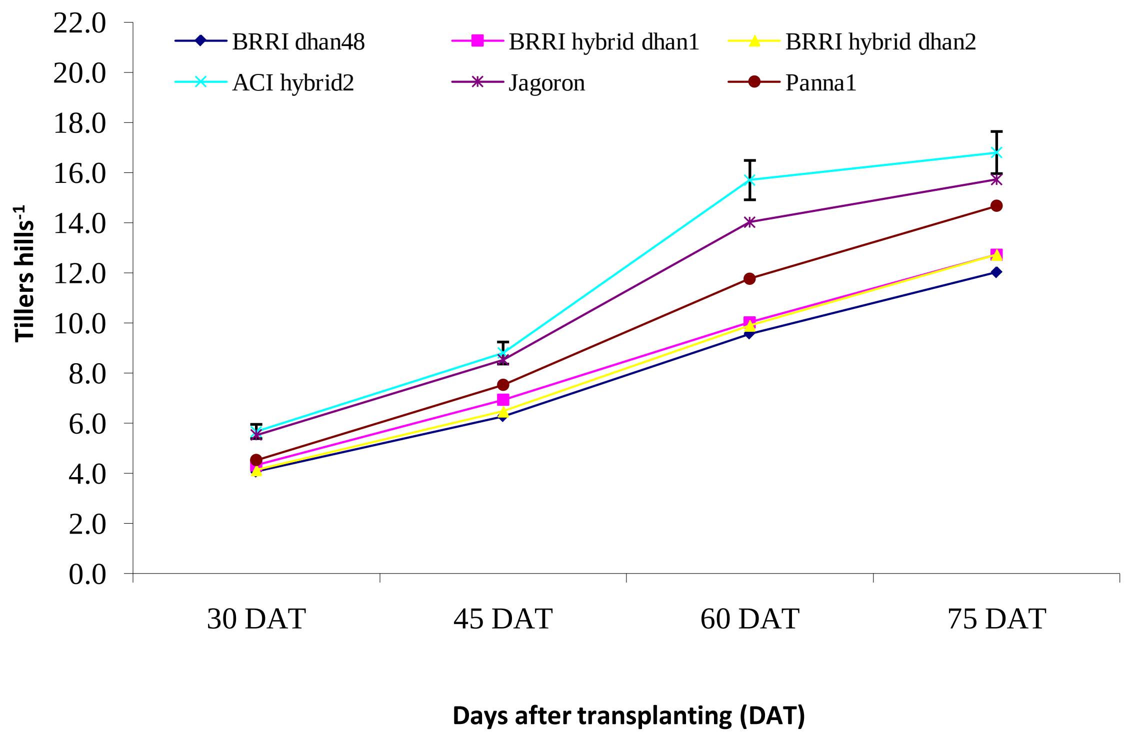

Figure 2. Tillers hill^{-1} at different days after transplanting of some selected hybrid rice. (*Vertical bar represents LSD value.)*

4.1.3 Leaf area index

Leaf area index of different rice variety varied significantly at 30, 45, 60 and 75 DAT (Appendix V). At 30, 45, 60 and 75 DAT, the highest leaf area index (0.254, 1.188, 3.64 and 5.91, respectively) was observed from ACI hybrid2 which was similar (0.243, 1.067, 3.44 and 5.68, respectively) with Jagoron at same DAT, while the lowest leaf area index (0.202, 0.836, 2.64 and 5.13, respectively) was found from BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 (0.204, 0.922, 2.96 and 5.03, respectively) at 30, 45, 60 and 75 DAT (Table 3).

Table 3. Leaf area index at different days after transplanting of some selected hybrid rice varieties

Rice variety	Leaf area index at			
	30 DAT	**45 DAT**	**60 DAT**	**75 DAT**
BRRI dhan48	0.202 c	0.836 c	2.64 c	5.13 b
BRRI hybrid dhan1	0.222 b	0.955 bc	3.11 abc	5.12 b
BRRI hybrid dhan2	0.204 c	0.922 bc	2.96 bc	5.03 b
ACI hybrid2	0.254 a	1.188 a	3.64 a	5.91 a
Jagoron	0.243 ab	1.067 ab	3.44 ab	5.68 ab
Panna1	0.232 b	1.024 ab	3.15 abc	5.60 ab
$LSD_{(0.05)}$	**0.058**	**0.163**	**0.592**	**0.721**
CV(%)	**12.27**	**8.88**	**10.29**	**7.32**

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

4.1.4 Stem dry matter hill^{-1}

Significant variation was recorded in terms of stem dry matter hill^{-1} of different rice variety at 30, 45, 60 and 75 DAT (Appendix VI). At 30, 45, 60 and 75 DAT, the highest stem dry matter hill^{-1} (2.63, 3.79, 6.16 and 5.85, respectively) was recorded from ACI hybrid2 which was similar (2.46, 3.47, 5.82 and 5.58 g, respectively) with Jagoron, whereas the lowest stem dry matter hill^{-1} (1.98, 2.98, 4.53 and 4.37 g, respectively) was observed from BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 (2.08, 3.28, 4.10 and 5.07, respectively) and BRRI hybrid dhan1 (2.12, 3.33, 4.40 and 5.51 g, respectively) at 30, 45, 60 and 75 DAT (Table 4). Varieties plays an important role in producing dry matter in stem of hybrid rice and it also varied for different varieties might be due to genetical and environmental influences as well as management practices.

Table 4. Stem dry matter hill^{-1} at different days after transplanting and at harvest of some selected hybrid rice varieties

Rice variety	Stem dry matter hill^{-1} at (g)			
	30 DAT	45 DAT	60 DAT	75 DAT
BRRI dhan48	1.98 c	2.98 c	4.53 c	4.37 c
BRRI hybrid dhan1	2.12 bc	3.33 abc	5.51 ab	5.40 ab
BRRI hybrid dhan2	2.08 c	3.28 bc	5.07 bc	5.02 bc
ACI hybrid2	2.63 a	3.79 a	6.16 a	5.85 a
Jagoron	2.46 ab	3.47 ab	5.82 a	5.58 ab
Panna1	2.15 bc	3.36 abc	5.60 ab	5.22 b
$LSD_{(0.05)}$	**0.257**	**0.438**	**0.630**	**0.521**
CV(%)	**6.32**	**7.16**	**6.36**	**6.67**

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

4.1.5 Leaf dry matter hill^{-1}

Leaf dry matter hill^{-1} of different rice variety varied significantly at 30, 45, 60 and 75 DAT (Appendix VII). Data revealed that at 30, 45, 60 and 75 DAT, the highest leaf dry matter hill^{-1} (1.58, 2.83, 5.39 and 5.04 g, respectively) was attained from ACI hybrid2 which was similar (1.56, 2.70, 4.75 and 4.63 g, respectively) with Jagoron at same DAT (Table 5). On the other hand, the lowest leaf dry matter hill^{-1} (1.23, 2.17, 4.12 and 4.06 g, respectively) was recorded from BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 (1.39, 2.49, 4.27 and 4.24 g, respectively) at 30, 45, 60 and 75 DAT .

Table 5. Leaf dry matter hill^{-1} at different days after transplanting and at harvest of some selected hybrid rice varieties

Rice variety	Leaf dry matter hill^{-1} at (g)			
	30 DAT	45 DAT	60 DAT	75 DAT
BRRI dhan48	1.23 c	2.17 c	4.12 b	4.06 c
BRRI hybrid dhan1	1.45 ab	2.59 ab	4.19 b	4.07 c
BRRI hybrid dhan2	1.39 abc	2.49 b	4.27 b	4.24 bc
ACI hybrid2	1.58 a	2.83 a	5.39 a	5.04 a
Jagoron	1.56 ab	2.70 ab	4.75 ab	4.63 ab
Panna1	1.37 bc	2.43 bc	4.61 ab	4.38 bc
LSD$_{(0.05)}$	**0.191**	**0.304**	**0.787**	**0.386**
CV(%)	**7.40**	**6.63**	**9.52**	**6.20**

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

4.1.6 Total dry matter hill^{-1}

At 30, 45, 60 and 75 DAT total (stem and leaves) dry matter hill^{-1} showed statistically significant variation due to different rice variety under the present trial (Appendix VIII). At 30, 45, 60 and 75 DAT, the highest total dry matter hill^{-1} (4.21, 6.62, 11.55 and 10.89 g, respectively) was observed from ACI hybrid2 which was similar (3.92, 6.17, 10.56 and 10.21 g, respectively) with Jagoron (Table 6). Again, at 30, 45, 60 and 75 DAT, the lowest total dry matter hill^{-1} (3.21, 5.14, 8.653 and 8.43 g, respectively) was found from BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 (3.47, 5.77, 9.34 and 9.26 g, respectively) at same data recording date. Amin *et al.* (2006) reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

Table 6. Total dry matter $hill^{-1}$ at different days after transplanting and at harvest of some selected hybrid rice varieties

Rice variety	Total dry matter $hill^{-1}$ at (g)			
	30 DAT	**45 DAT**	**60 DAT**	**75 DAT**
BRRI dhan48	3.21 c	5.14 c	8.65 c	8.43 c
BRRI hybrid dhan1	3.57 bc	5.92 ab	9.61 bc	9.47 b
BRRI hybrid dhan2	3.47 c	5.77 bc	9.34 bc	9.26 bc
ACI hybrid2	4.21 a	6.62 a	11.55 a	10.89 a
Jagoron	3.92 ab	6.17 ab	10.56 ab	10.21 ab
Panna1	3.52 c	5.80 bc	10.20 b	9.60 bc
$LSD_{(0.05)}$	**0.382**	**0.700**	**1.258**	**0.840**
CV(%)	**5.78**	**6.53**	**6.92**	**5.97**

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

4.1.7 Light interception

Light interception showed statistically significant variation due to different rice variety in different position of flowering stage (Appendix IX). At the position of top to middle, light interception was the highest (53%) in ACI hybrid2 which was similar (49%) with Jagoron, while, the lowest light interception (44%) was found in BRRI dhan48 which was statistically similar (45%) with BRRI hybrid dhan2 (Figure 3). At the position of middle to bottom, the highest light interception (38%) was recorded in ACI hybrid2 which was similar (37%) with Jagoron, while, the lowest (34%) was found in BRRI dhan48 which was statistically similar (36%) with BRRI hybrid dhan2. At the position of top to bottom, the highest light interception (91%) was recorded in ACI hybrid2 which was followed (86%) by Jagoron, whereas the lowest (78%) was found in BRRI dhan48 which was statistically similar 81%) with BRRI hybrid dhan2.

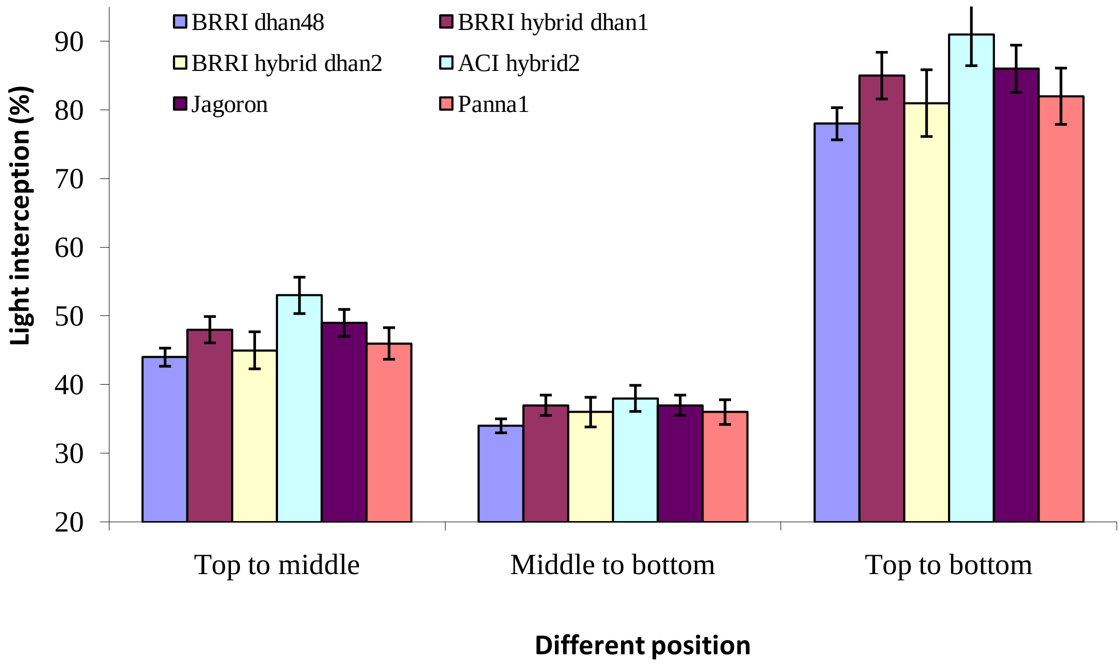

Figure 3. Light interception by the canopy at flowering stage of some selected hybrid rice. *(Vertical bar represents LSD value.)*

4.1.8 Chlorophyll content

Chlorophyll content showed statistically significant variation due to different rice variety at 2, 9, 16 and 23 DAF (days after flowering), under the present trial (Appendix X). At 2, 9, 16 and 23 DAF, the highest chlorophyll content (2.51, 2.16, 1.85 and 1.71 mg g^{-1}, respectively) was observed from ACI hybrid2 which was similar (2.46, 2.03, 1.75 and 1.67 mg g^{-1}, respectively) with Jagoron (Figure 4). Again, at 2, 9, 16 and 23 DAF, the lowest chlorophyll content (2.05, 1.67, 1.41 and 1.28 mg g^{-1}, respectively) was found from BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 (2.16, 1.71, 1.48 and 1.32 mg g^{-1}, respectively) at same data recording date.

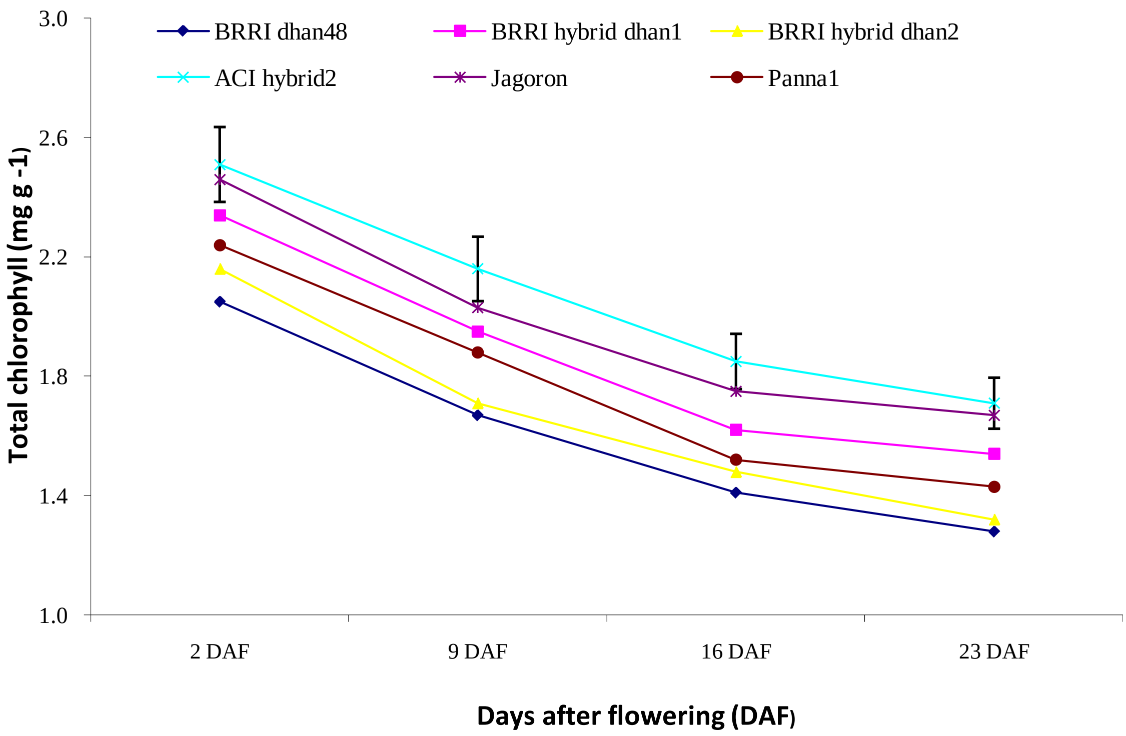

Figure 4. Total chlorophyll content in flag at different days after flowering of some selected hybrid rice. *(Vertical bar represents LSD value)*

4.1.9 Chlorophyll a:b

Chlorophyll a:b showed statistically significant variation due to different rice variety at 2, 9, 16 and 23 DAF (days after flowering), under the present trial (Appendix XI). At 2, 9, 16 and 23 DAF, the highest chlorophyll a:b (3.42, 2.48, 2.05 and 1.85, respectively) was observed from ACI hybrid2 which was similar (3.25, 2.31, 1.89 and 1.73, respectively) with Jagoron (Figure 5). On the other hand, at 2, 9, 16 and 23 DAF, the lowest chlorophyll a:b (2.46, 1.72, 1.48 and 1.32, respectively) was found from BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 (2.69, 1.89, 1.53 and 1.42, respectively) at same data recording date.

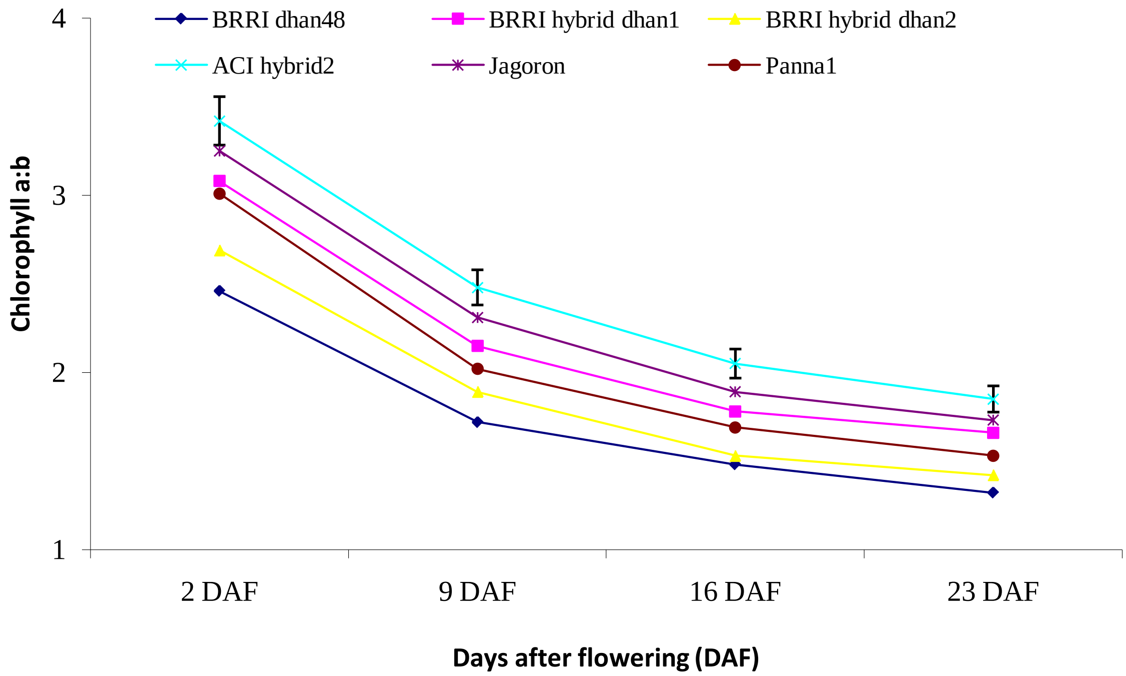

Figure 5. Chlorophyll a:b at different days after flowering of some selected hybrid rice. *(Vertical bar represents LSD value.)*

4.2 Yield contributing characters

4.2.1 Days to maturity

Days to maturity of rice in Aus season showed statistically significant variation due to different rice variety (Appendix XII). The maximum days to maturity (125.00) was observed from ACI hybrid2 and Jagoron which was similar (117 days) with Panna1, whereas the minimum days (105) was found from BRRI hybrid dhan1 which was statistically similar (106 days and 109 days) with BRRI hybrid dhan2 and BRRI dhan48 (Table 7). Roy *et al.* (1995) observed that the plants, which needed more days for maturity generally gave more yield. Varieties plays an important role in case of days from sowing to harvest of rice and it also varied for different varieties might be due to genetical and environmental influences as well as management practices.

4.2.2 Effective tillers hill^{-1}

Statistically significant variation was recorded in terms of effective tillers hill^{-1} of rice due to different rice variety (Appendix XII). The maximum number of effective tillers hill^{-1} (14.27) was recorded from ACI hybrid2 which was similar (13.13 and 11.80) with Jagoron and Panna1, while the minimum number of effective tillers hill^{-1} (10.07) was obtained from BRRI dhan 48 which was statistically similar (10.60 and 10.73) with BRRI hybrid dhan2 and BRRI hybrid dhan1 (Table 7). Bhowmick and Nayak (2000) observed that CNHR2 produced more number of productive tillers (413.4 m^{-2}) than other tested varieties

Table 7. Days to maturity, effective, non-effective and total tillers hill^{-1} of some selected hybrid rice varieties

Rice variety	Days to maturity	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)
BRRI dhan48	109 b	10.07 c	2.40 b	12.47 c
BRRI hybrid dhan1	105 b	10.73 bc	2.87 a	13.60 bc
BRRI hybrid dhan2	106 b	10.60 bc	2.93 a	13.53 bc
ACI hybrid2	125 a	14.27 a	1.93 c	16.20 a
Jagoron	125 a	13.13 ab	2.13 bc	15.27 ab
Panna1	117 ab	11.80 abc	2.20 bc	14.00 abc
$LSD_{(0.05)}$	**12.09**	**2.551**	**0.431**	**2.348**
CV(%)	**5.81**	**11.92**	**9.78**	**9.10**

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

4.2.3 Non-effective tillers hill^{-1}

Different rice variety showed statistically significant variation for non-effective tillers hill^{-1} of rice under the present trial (Appendix XII). The minimum number of non-effective tillers hill^{-1} (1.93) was observed from ACI hybrid2 which was similar (2.13 and 2.20) with Jagoron and Panna1, whereas the maximum number (2.93) from BRRI hybrid dhan2 which was statistically similar (2.87) with BRRI hybrid dhan1 and closely followed (2.40) by BRRI dhan48 (Table 7).

4.2.4 Total tillers hill^{-1}

Statistically significant variation was recorded in terms of total tillers (effective and non-effective) hill^{-1} of rice due to different rice variety in Aus season (Appendix XII). The maximum number of total tillers hill^{-1} (16.20) was observed from ACI hybrid2 which was similar (15.27 and 14.00) with Jagoron and Panna1, while the minimum number of total tillers hill^{-1} (12.47) was found from BRRI dhan48 which was statistically similar (13.53 and 13.60) with BRRI hybrid dhan2 and BRRI hybrid dhan1 (Table 7).

4.2.5 Panicle length

Panicle length of different rice variety showed statistically significant variation under the present trial (Appendix XIII). The longest panicle (23.39 cm) was observed from ACI hybrid2 which was similar (22.80 cm and 21.39 cm) with Jagoron and Panna1, whereas the shortest panicle (18.60 cm) from BRRI dhan48 which was statistically similar (19.03 cm) with BRRI hybrid dhan1 and followed (20.89 cm) by BRRI hybrid dhan2 (Table 8). Wang *et al.* (2006) reported that compared with conventional cultivars, the hybrids had larger panicles.

Table 8. Panicle length, filled, unfilled and total spikelets panicle^{-1} of some selected hybrid rice varieties

Rice variety	Panicle length (cm)	Filled spikelets panicle^{-1} (No.)	Unfilled spikelets panicle^{-1} (No.)	Total spikelets panicle^{-1} (No.)
BRRI dhan48	18.60 d	71.27 b	8.87 a	80.13 b
BRRI hybrid dhan1	19.03 cd	80.00 ab	9.57 a	89.57 ab
BRRI hybrid dhan2	20.89 bc	79.73 ab	9.67 a	89.40 ab
ACI hybrid2	23.39 a	89.00 a	6.87 b	95.87 a
Jagoron	22.80 ab	86.87 a	7.03 b	93.90 a
Panna1	21.39 ab	78.87 ab	8.37 a	87.23 ab
$LSD_{(0.05)}$	**2.185**	**9.674**	**1.316**	**9.487**
CV(%)	**5.72**	**6.57**	**8.62**	**5.84**

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

4.2.6 Filled spikelets panicle^{-1}

Statistically significant variation was recorded in terms of filled spikelets panicle^{-1} of rice due to different rice variety in Aus season (Appendix XIII). The maximum number of filled spikelets panicle^{-1} (89.00) was observed from ACI hybrid2 which was similar (86.87, 80.00, 79.73 and 78.87) with Jagoron, BRRI hybrid dhan1, BRRI hybrid dhan2 and Panna1, while the minimum number of filled spikelets panicle^{-1} (71.27) was found from BRRI dhan48 (Table 8). Molla (2001) reported that Pro-Agro6201 (hybrid) had higher number of filled spikelets panicle^{-1}.

4.2.7 Unfilled spikelets panicle^{-1}

Different rice variety showed statistically significant variation in terms of unfilled spikelets panicle^{-1} of rice (Appendix XIII). The minimum number of unfilled spikelets panicle^{-1} (6.87) was observed from ACI hybrid2 which was similar (7.03) with Jagoron (Table 8). On the other hand, the maximum number of unfilled spikelets panicle^{-1} (9.67) was found from BRRI hybrid dhan2 which was statistically similar (9.57, 8.87 and 8.37) with BRRI hybrid dhan1, BRRI dhan48 and Panna1.

4.2.8 Total spikelets panicle^{-1}

Statistically significant variation was recorded in terms of total spikelets panicle^{-1} of rice due to different rice variety in Aus season (Appendix XIII). The maximum number of total spikelets panicle^{-1} (95.87) was recorded from ACI hybrid2 which was statistically similar (93.90, 89.57, 89.40 and 87.23) with Jagoron, BRRI hybrid dhan1, BRRI hybrid dhan2 and Panna1, whereas the minimum number of total spikelets panicle^{-1} (80.13) was found from BRRI dhan48 (Table 8).

4.2.9 Spikelets fertility

Spikelets fertility of rice showed statistically significant variation due to different rice variety in Aus season (Appendix XIII). The highest spikelets fertility (92.83%) was obtained from ACI hybrid2 which was statistically similar (92.51%, 90.42%, 89.40% and 89.32%) with Jagoron, Panna1, BRRI hybrid dhan2 and BRRI hybrid dhan1, while the lowest spikelets fertility (88.94%) was observed from BRRI dhan48 (Figure 6).

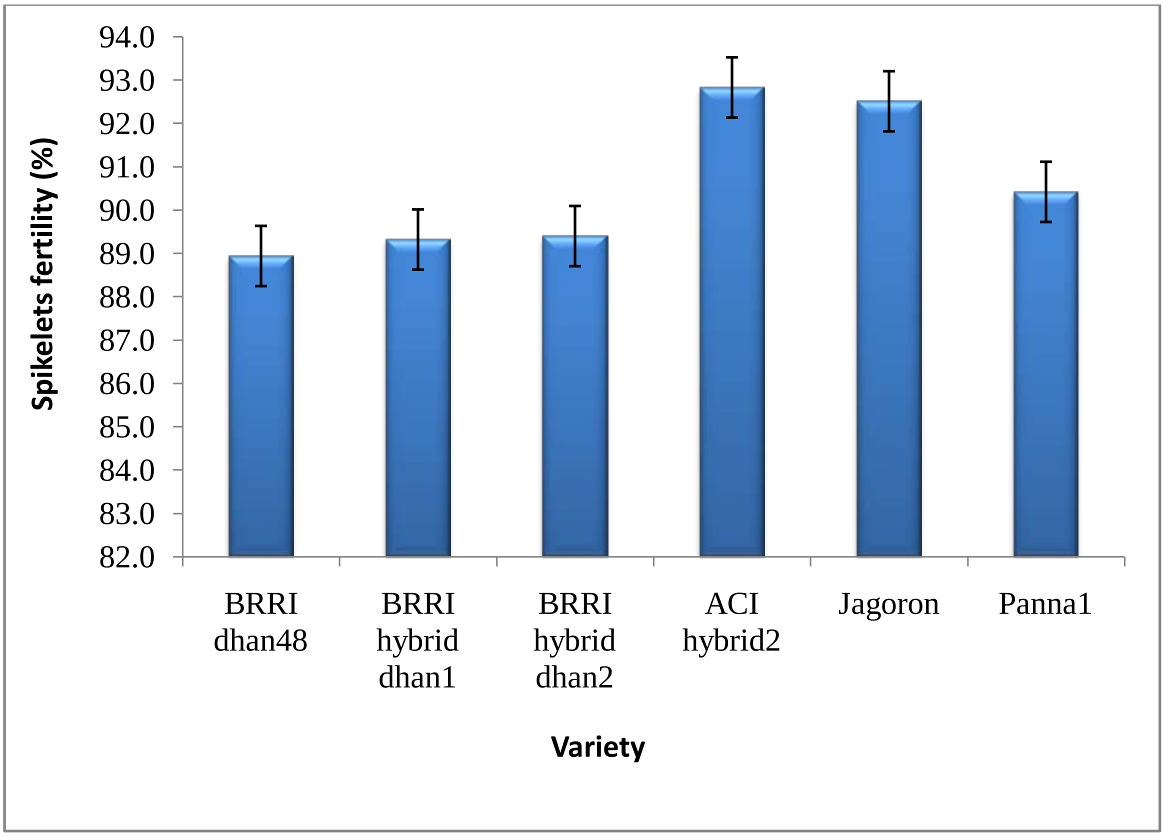

Figure 6. Spikelets fertility of some selected hybrid rice. *(Vertical bar represents LSD value.)*

4.2.10 Weight of 1000 grains

Weight of 1000 grains panicle^{-1} of rice varied significantly due to different rice variety (Appendix XIII). The highest weight of 1000 grains (22.63 g) was found from ACI hybrid2 which was statistically similar (22.33 g and 21.40 g) with Jagoron and Panna1, while the lowest weight of 1000 grains (20.10 g) was found from BRRI dhan48 which was statistically similar (20.23 g and 20.38 g) with BRRI hybrid dhan2 and BRRI hybrid dhan1 (Figure 7). Wang *et al.* (2006) reported that compared with conventional cultivars, the hybrids had heavier seeds. Molla (2001) reported that Pro-Agro6201 (hybrid) had greater seed weight.

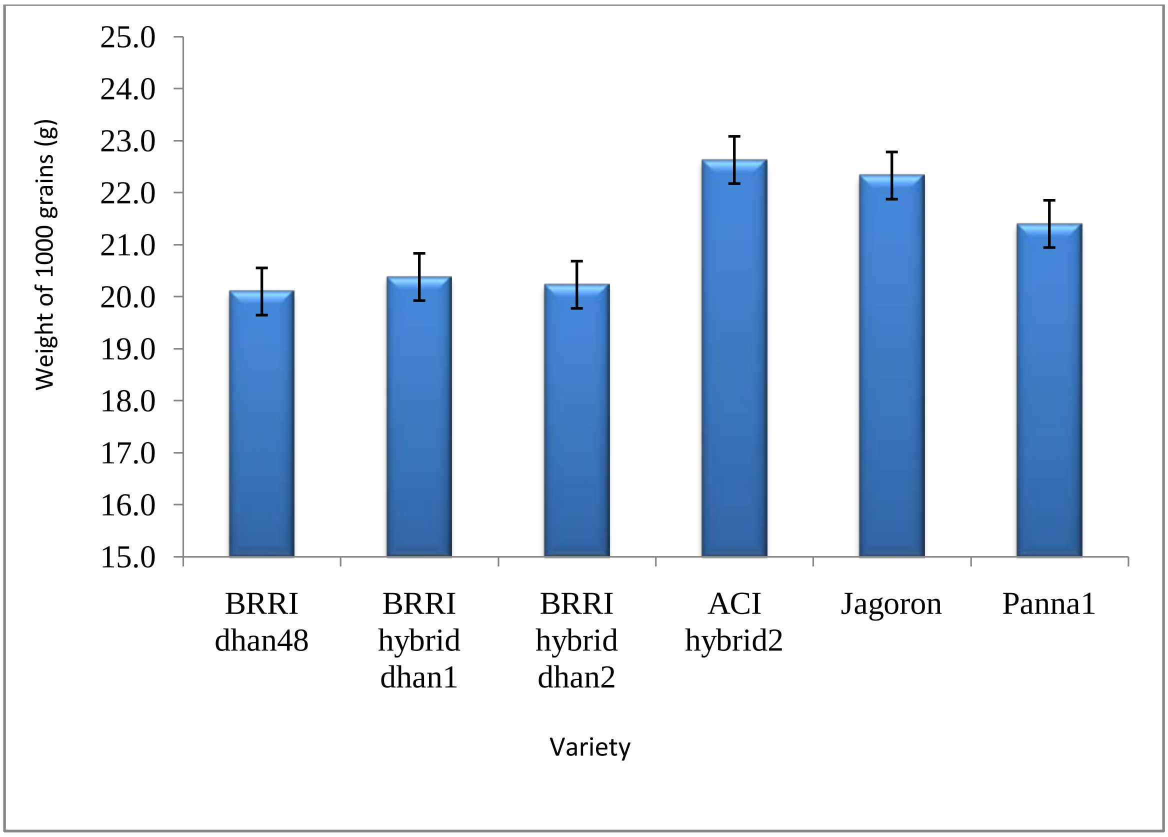

Figure 7. Weight of 1000-grains of some selected hybrid rice. *(Vertical bar represents LSD value)*

4.3 Yield

4.3.1 Grain yield

Different rice variety showed statistically significant variation in terms of grain yield of rice (Appendix XIV). The highest grain yield (3.05 t ha^{-1}) was obtained from ACI hybrid2 which was statistically similar (2.97 t ha^{-1} and 2.82 t ha^{-1}) with Jagoron and Panna1, whereas the lowest grain yield (2.51 t ha^{-1}) was observed from BRRI dhan48 (Table 9). Varieties plays an important role in producing high yield of hybrid rice and yield also varied for different varieties might be due to genetical and environmental influences as well as management practices. IRRI also started super rice breeding program to increase rice yield up to 30% more (13-15 t ha^{-1}) than the current modern high yielding plant types (IRRI, 1993). Different hybrid rice varieties are available in Bangladesh which has more yield potential than conventional high yielding varieties (Akbar, 2004). Xie *et al.* (2007) found that Shanyou-63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}). Wang *et al.* (2006) reported that compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%. Pandey and Awasthi (2001) reported that traits plant height, days to 50% flowering effective tillers plant^{-1}, panicle length, number of grains panicle^{-1}, 1000-seeds weight and grain yield plant^{-1} play a major role in the enhancement of production of grain yield.

Table 9. Grain, straw, biological yield and harvest index of some selected hybrid rice varieties

Rice variety	**Grain yield (t ha^{-1})**	**Straw yield (t ha^{-1})**	**Biological Yield (t ha^{-1})**	**Harvest index (%)**
BRRI dhan48	2.51 b	3.87 b	6.38 b	39.34 b
BRRI hybrid dhan1	2.66 b	4.11 a	6.77 b	39.29b
BRRI hybrid dhan2	2.75 b	4.05 a	6.80 b	40.44ab
ACI hybrid2	3.05 a	4.20 a	7.25 a	42.07 a
Jagoron	2.97 a	4.15 a	7.12 a	41.71 a
Panna1	2.82 a	4.02 a	6.84 a	41.23 a
$LSD_{(0.05)}$	**0.281**	**0.182**	**0.486**	**1.478**
CV(%)	**4.61**	**5.12**	**4.04**	**5.11**

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

4.3.2 Straw yield

Straw yield of rice showed statistically significant variation due to different rice variety (Appendix XIV). The highest straw yield (4.20 t ha^{-1}) was observed from ACI hybrid2 which was statistically similar (4.15 t ha^{-1}, 4.11 t ha^{-1}, 4.4.05 and 4.02 t ha^{-1}) with Jagoron, BRRI hybrid dhan1, BRRI hybrid dhan2 and Panna1 (Table 9). On the other hand, the lowest straw yield (3.87 t ha^{-1}) was recorded from BRRI dhan48. Patel (2000) reported that mean yield increased with Kranti over IR36 was 10.0% for straw yield.

4.3.3 Biological yield

Statistically significant variation was recorded in terms of biological yield of rice due to different rice variety (Appendix XIV). The highest biological yield (7.25 t ha^{-1}) was found from ACI hybrid2 which was statistically similar (7.12 t ha^{-1} and 6.84 t ha^{-1}) with Jagoron and Panna1, while the lowest biological yield (6.38 t ha^{-1}) was found from BRRI dhan48 (Table 9).

4.3.4 Harvest index

Harvest index of rice showed statistically significant variation due to different rice variety under the present trial (Appendix XIV). The highest harvest index (42.07%) was recorded from ACI hybrid2 which was statistically similar (41.71% and 41.23%) with Jagoron and Panna1 whereas the lowest harvest index (39.34%) was attained from BRRI dhan48 (Table 9).

CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from March to August, 2013 in Aus season in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to study the performance of some selected hybrid rice varieties in Aus season. The rice variety BRRI dhan48, BRRI hybrid dhan1, BRRI hybrid dhan2, ACI hybrid2, Jagoron and Panna1 were used as the experimental treatment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on different crop growth characters, yield contributing characters and yield of rice and statistically significant variation was recorded for different characters that studied.

ACI hybrid2 produced the tallest plant (35.87, 50.40, 76.50, 95.77 and 139.97 cm, respectively) at 30, 45, 60, 75 DAT and harvest, whereas BRRI dhan48 produced the shortest plant (29.33, 41.73, 69.03, 82.57 and 102.93 cm, respectively). At 30, 45, 60 and 75 DAT, the maximum number of tillers hill^{-1} (5.67, 8.80, 15.70 and 16.80, respectively) was recorded from ACI hybrid2 and the minimum number (4.07, 6.27, 9.57 and 12.03, respectively) from BRRI dhan48. At 30, 45, 60 and 75 DAT, the highest leaf area index (0.254, 1.188, 3.64 and 5.91, respectively) was observed from ACI hybrid2, while the lowest leaf area index (0.202, 0.836, 2.64 and 5.13, respectively) from BRRI dhan48. At 30, 45, 60 and 75 DAT, the highest stem dry matter hill^{-1} (2.63, 3.79, 6.16 and 5.85, respectively) was recorded from ACI hybrid2, whereas the lowest stem dry matter hill^{-1} (1.98, 2.98, 4.53 and 4.37 g, respectively) from BRRI dhan48. At 30, 45, 60 and 75 DAT, the highest leaf dry matter hill^{-1} (1.58, 2.83, 5.39 and 5.04 g, respectively) was attained from ACI hybrid2 and the lowest leaf dry matter hill^{-1} (1.23, 2.17, 4.12 and 4.06 g, respectively) from BRRI dhan48. At 30, 45, 60 and 75 DAT, the highest total dry matter hill^{-1} (4.21, 6.62, 11.55 and 10.89 g, respectively) was observed from ACI hybrid2 and the lowest total dry matter hill^{-1} (3.21, 5.14, 8.653 and 8.43 g, respectively) from BRRI dhan48. At the position of top to bottom, the highest light interception (91%) was recorded in ACI hybrid2, whereas the lowest (78%) was found in BRRI dhan48. At 2, 9, 16 and 23 DAF, the highest chlorophyll content (2.51, 2.16, 1.85 and 1.71 mg g^{-1}, respectively) was observed from ACI hybrid2 and the lowest chlorophyll content (2.05, 1.67, 1.41 and 1.28 mg g^{-1}, respectively) was found from BRRI dhan48. At 2, 9, 16 and 23 DAF, the highest chlorophyll a:b (3.42, 2.48, 2.05 and 1.85, respectively) was observed from ACI hybrid2 and the lowest chlorophyll a:b (2.46, 1.72, 1.48 and 1.32, respectively) was found from BRRI dhan48.

The maximum days to maturity (125.00) were observed from ACI hybrid2 and Jagoron, whereas the minimum days (105) from BRRI hybrid dhan1. The maximum number of effective tillers hill^{-1} (14.27) was recorded from ACI hybrid2, while the minimum number (10.07) from BRRI dhan48. The minimum number of non-effective tillers hill^{-1} (1.93) was observed from ACI hybrid2, whereas the maximum number (2.93) from BRRI hybrid dhan2. The maximum number of total tillers hill^{-1} (16.20) was observed from ACI hybrid2, while the minimum number (12.47) from BRRI dhan48. The longest panicle (23.39 cm) was observed from ACI hybrid2, whereas the shortest panicle (18.60 cm) from BRRI dhan48. The maximum number of filled spikelets panicle^{-1} (89.00) was observed from ACI hybrid2, while the minimum number (71.27) from BRRI dhan48. The minimum number of unfilled spikelets panicle^{-1} (6.87) was observed from ACI hybrid2 and the maximum number (9.67) from BRRI hybrid dhan2. The maximum number of total spikelets panicle^{-1} (95.87) was recorded from ACI hybrid2, whereas the minimum number (80.13) from BRRI dhan48. The highest spikelets fertility (92.83%) was obtained from ACI hybrid2, while the lowest (88.94%) from BRRI dhan48. The highest weight of 1000 grains (22.63 g) was found from ACI hybrid2, while the lowest weight (20.10 g) from BRRI dhan48.

The highest grain yield (3.05 t ha^{-1}) was obtained from ACI hybrid2, whereas the lowest grain yield (2.51 t ha^{-1}) from BRRI dhan48. The highest straw yield (4.20 t ha^{-1}) was observed from ACI hybrid2 and the lowest straw yield (3.87 t ha^{-1}) from BRRI dhan48. The highest biological yield (7.25 t ha^{-1}) was found from ACI hybrid2, while the lowest biological yield (6.38 t ha^{-1}) from BRRI dhan48. The highest harvest index (42.07%) was recorded from ACI hybrid2, whereas the lowest (39.34%) from BRRI dhan48.

Above finding revealed that the ACI hybrid2 was superior from the rest varieties in relation to crop growth characters, yield contributing characters and yield. Jagoron & Panna 1 were almost similar with ACI hybrid 2 in term of grain yield.

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

1. The hybrid rice varieties ACI hybrid2, Jagoron and Panna1 may be cultivated in *Aus* season.
2. More study is needed in different agro-ecological zones (AEZ) of Bangladesh for confirmation of the findings.

REFERENCES

REFERENCES

Ahmed, G. J. U., Mamun, A. A., Hossain, S. M. A., Siddique, S. B. and Mirdha, A. J. (1997). Effect of Bosagran and raking combined with hand weeding to control weeds in aus rice . *Bangladesh Agron***.** *J***.,** **7** (1&2): 31-32.

Ahmed, M. I., Vijayakumar, C. H. M., Viraktamath, B. C., Ramesha, M. S. and Singh, S. (1998). Yield stability in rice hybrids. *Int. Rice Res. Notes*. **23**(1): 12.

Akbar, M. K. (2004). Response of hybrid and inbred rice varieties to different seedlings ages under system of rice intensification in transplant aman season. M.S. (Ag.) Thesis Dept. Agron. B.A.U, Mymensingh.

Amin, M. R., Hamid, A., Choudhury, R. U., Raquibullah, S. M. and Asaduzzaman M. (2006). Nitrogen Fertilizer Effect on Tillering, Dry Matter Production and Yield of Traditional Varieties of Rice. *Int. J. Sustain. Crop Prod.*, **1**(1): 17-20.

Anonymous. (1997). Production Year Book .Food and Agriculture Organization of the United Nations. p. 51.

Baloch, A. W., Soomro, A. M., Javed, M. A. and Ahmed, M. (2002). Optimum Plant Density for High Yield in Rice (O*ryza sativa* L.). *Asian J. Plant Sci*., **1**(1): 25-27.

BBS (Bangladesh Bureau of Statistics). (2008). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Stat. Div., Min. Plan. Govt. of the Peoples Repub. of Bangladesh. p.125-127.

BBS. (2010). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. p. 71.

Bhowmick, N. and Nayak, R. L. (2000). Response of hybrid rice (*Oryza sativa*) varieties to nitrogen, phosphorus and potassium fertilizers during dry (boro) season in West Bengal. *Indian J. Agron.*, **45**(2): 323-326.

Bhuiyan, M. S. H., Zahan, A., Khatun, H., Iqbal, M., Alam, F and Md. Rezaul Manir, M. R. (2014). Yield performance of newly developed test crossed hybrid rice variety. *Intl. J. Agron. Agril. Res.*, **5**(4): 48-54.

Bhuiyan, N. I. (2004). The Hybrid Rice Program for Bangladesh. In: ‘Hybrid Rice in Bangladesh: Progress and Future Strategies’. pp. 3-5. Bangladesh Rice Res. Inst. Publication No. 138.

BINA (Bangladesh Institute of Nuclear Agriculture). (1993). Annual Report for 1992-93. Bangladesh Inst. Nucl. Agric., Mymensingh. p. 143 - 147.

BINA (Bangladesh Institute of Nuclear Agriculture). (1992). Annual Report for 1990-91. Bangladesh Inst. Nucl. Agric., Mymensingh. p. 6.

Bisne, R., Motiramani, N. K. and Sarawgi, A. K. (2006). Identification of high yielding hybrids in rice. *Bangladesh J. Agril. Res*. **31**(1): 171-174.

Bokyeong, K., Kiyoung, K., Myungkyu, O., Jaekil, Jaekwon, K. and Heekyoung, K. (2003). Effects of nitrogen level and seedling number on panicle structure in japonica rice. *Korean J. Crop Sci.*, **48**(2): 120-126.

BRRI (Bangladesh Rice Research Institute). (1994). Annual Report for 1993. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. pp. 8-9.

BRRI (Bangladesh Rice Research Institute). (1995). Adunik Dhaner Chash (in bangla). Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. p. 34.

BRRI (Bangladesh Rice Research Institute). (1999). Annual Report for January 1998-June 1999. Bangladesh Rice Res. Inst. Gazipur, Pub. 135. p. 9-35, 243.

BRRI (Bangladesh Rice Research Institute). (2003). Annual Internal Review, held on 19-23 October, 2003. Grain Quality and Nutrition Division. Bangladesh Rice Res. Inst. p. 1-20.

BRRI (Bangladesh Rice Research Institute). (2012). Adhunik Dhaner Chash. Joydebpur, Dhaka. p. 10.

Chawdhury, M. J. U., Sarkar, A. U., Sarker, M. A. R. and Kasem, M. A. (1993). Effect of variety and number of seedlings per hill on the yield and its components on late transplanted aman rice. *Bangladesh J. Agril. Sci*., **20**(2): 311-316.

Chen-Liang, Y., Laignelet, B. and Marie, R. (2000). Variation of technological quality in rice according to genotype and environment. *Agron*., **3**(2): 179-183.

De Datta, C. (1981). Grain quality consideration in hybrid rice. In: hybrid rice technology: new development and future prospects. S. S.Virmani, (ed.). IRRI, Manilla, Philippines. p. 123-130.

Devaraju, K. M., Gowada, H. and Raju, B. M. (1998). Nitrogen response of Karnataka Rice Hybrid. *Intl. Rice Res. Notes*. **23**(2): 43.

Dongarwar, U. R., Patankar, M. N and Pawar, W. S. (2003). Response of hybrid rice to different fertility levels. *J. Soils and Crops*. **13**(1): 120-122.

Dwivedi, D. K. (1997). Response of scented rice (Oryza sativa) genotypes to nitrogen under mid-upland situation. *Indian J. Agron*. **42**(1): 74-76.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. p. 118.

FAO (Food and Agriculture Organization). (1988). Production Year Book. Food and Agricultural Organizations of the United Nations Rome, Italy. **42**: 190-193.

FAO (Food and Agriculture Organization). (2009). FAO Production Yearbook, Food and Agriculture Organization, Rome, Italy. 56-77.

Futsuhara, J. and Kikuchi, Y. (1984). Grain quality evaluation and improvement at IRRI. *In proc*. The workshop on chemical aspect of rice grain quality. Intl. Rice Res. Inst., Philippines.

Ghosh, P. K. and Hossain, M. R. (1988). Rice grain quality as an emerging priority in National rice breeding program. In: rice grain marketing and quality issues. Los Banos, Laguna, IRRI. p. 55-64.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). Int. Rice Res. Inst., A Willey Int. Sci., p. 28-192.

Hien, N. L., Yoshihashi T. and Sarhadi, W. A. (2006). Evaluation of aroma in rice (*Oryza sativa* L.) using KOH method, molecular markers and measurement of 2-acetyl-1-pyrroline concentration. *Japanese. J. Trop. Agron*., **50**: 190-198.

Hosain, M. T., Ahamed, M. T., Haque, K. U., Islam, M. M., Fazle Bari, M. M. and Mahmud, J. A. (2014). Performance of Hybrid Rice (*Oryza sativa* l.) Varieties at Different Transplanting Dates in *Aus* Season. *App. Sci. Report.* **1**(1): 1-4.

Hossain, S. M. A. and Alam, A. B. M. M. (1991). Productivity of cropping patterns of participating farmers. In: Fact searching and intervention in two FSRDP sites, activities. 1989-90. Farming Systems Research and Development Programme. BAU, Mymensingh. p. 44-48.

Idris, M. and Matin, M. A. (1990). Response of four exotic strains of aman rice to urea. *Bangladesh J. Agril. Sci*., **17**(2): 271 -275.

IRRI (International Rice Research Institute). (1993). IRRI Almanac Intl. Rice Res. Inst.Los Bonos, Philippines. p. 110.

Islam, S. (1995). Effect of variety and fertilization on yield and nutrient uptake in transplant *aman* rice. M. S. thesis. Dep. Agron. Bangladesh Agril. Univ. Mymensingh. p. 26, 29.

Jennings, I., Juliano, B. O. and Duff, D. (1979). Rice grain quality as an emerging priority in National rice breeding program. In: rice grain marketing and quality issues. Los Banos, Laguna, IRRI. p. 55-64.

Julfiquar, A. W., Haque, M. M., Haque, A. K. G. M. E. and Rashid, M. A. (2008). Current Status of Hybrid Rice Research and Future Program in Bangladesh. *Proc. Workshop on use and development of hybrid rice in Bangladesh*, held at BARC, 18-19, May, 2008.

Julfiquar, A. W., Haque, M. M., Haque, A. K. G. M. E. and Rashid, M. A. (1998). Current status of Hybrid Rice Research and Future Program in Bangladesh. Proc. Workshop on Hybrid Rice in Bangladesh, held at BARC, 22-23, April, 1998.

Kaniz Fatema, Rasul, M. G., Mian M. A. K. and Rahman, M. M. (2011). Genetic Variability for grain quality traits in aromatic rice (*Oryza sativa* L). *Bangladesh J. Pl. Breed. Genet*., **24**(2): 19-24.

Khalifa, A. A. B. A. (2009). Physiological evaluation of some hybrid rice varieties under different sowing dates. *Australian J. Crop Sci.*, 3(3):178-183.

Li, Q. L., G. T., Guo, G. Z., Jiang, G. and Zhu, V. (2005). Study on high yield breeding and genetic analysis of yield components of main rice cultivars in Jilin. *Heriditas China*. **13**(5): 3-6.

Luh, B. S. (1991). Rice Production. Vol. 1. Second Edn. AVI Publication Company, Inc. USA.

Mallikarjuna, B. P., Swamy, K. K., Aladhar, N., Shobha R. G. S. V., Prasad, B. C., Viraktamath, G. Ashok Reddy, and Sarla, N. (2012). QTL Analysis for Grain Quality Traits in 2 BC_2F_2 Populations Derived from Crosses between Oryza sativa cv Swarna and 2 Accessions of *O. nivara*. *J. Heredity*, **10**: 1093.

Miah, M. H., Karim, M. A., Rahman, M. S. and Islam, M. S. (1990). Performance of Nizersail mutants under different row spacing. *Bangladesh J. Train. Dev.*, **3**(2): 31-34.

Miller, B. C., Hill, J. E., Roberts, S. R. **(**1991). Plant population effects on growth and tied in water seeded rice. *Agron. J.*, **83***:* 291-297.

Mishra, P. K. and Pandey, R. (1998). Physico-chemical properties of starch and protein and their relation to grain quality and nutritional value of rice. Rice Breed. Pub. IRRI, Los Banos, Phillippines. p. 389-405.

Molla, M. A. H. (2001). Influence of seedling age and number of seedlings on yield attributes and yield of hybrid rice in the wet season. *Intl. Rice. Res. Notes.* **26**(2): 73-74.

Momin, S. I. and Husain, M. (2009). Technology development and dissemination to augment rice production in Bangladesh. *In*: 'The Guardian'. p. 33-35.

Munoz, D., Gutierrez, P. and Carredor, E. (1996). Current status of research and development of hybrid rice technology in Colombia. In. Abst., Proc. 3r Intl. Symp. On Hybrid Rice. November 14-16. Directorate Rice Res., Hyderabad, India. p. 25.

Murthy, K. N. K., Shankaranarayana, V., Murali, K., Jayakumar, B. V. (2004). Effect of different dates of planting on spikelet sterility in rice genotypes (Oryza sativa L.). *Res. Crops.* **5**(2/3): 143-147.

Myung, K. (2005). Yearly variation of genetic parameters for panicle characters of Japonica rice (*Oryza sativa* L.). E mail: Ind_Chaturvedi@yahoo.com. Accepted for publication: May 27, 2005.

Pandey, V. K. and Awasthi, L. P. (2001). Studies on genetic variability for yield contributing traits in aromatic rice. *Crop Res. Hisar*., **23**(2): 214-218.

Patel J. R. (2000). Effect of water regime, variety and blue green algae on rice (*Oryza sativa*). *Indian J. Agron*., **45**(1): 103-106.

Patnaik, M. M., Bautista, G. M., Lugay, J. C. and Reyes A. C. (1990). Studies on the physiochemical properties of rice. *J. Agr. Food Technol*., **19**: 1006-1011.

Rajendra, P., Shaarma, S. N., Surendra, S. and Zaman, F. U. (1998). Productivity of hybrid rice pusa HR3 under late planting conditions. *Ann. Agril. Res.*, **19**(1): 92-93.

Roy, A., Panwar, D. V. S. and Sarma, R. N. (1995). Genetic variability and causal relationship in rice. *Madras Agril. J*., **82**(4): 251-255.

Saha, A. K., Haque, E., Quader, B., Hussain, T. Z. and Miah, N. M. (1989). Correlation and path analysis of some yield contributing characters in some high yielding and local varieties of irrigated rice. *Bangladesh J. Pl. Breed. Genet*., **2**(1&2): 19-22.

Samonte, S. O. P. B., Tabien, R. E. and Wilson, L. T. (2011). Variation in yield-related traits within variety in large rice yield trials. *Texas Rice*., **11**(5): 9-11.

Sawant, A. C., Thorat, S. T., Khadse, R. R. and Bhosale, R. J. (1986). Response of early rice varieties to nitrogen levels and spacing in coastal Maharastra. J. *Maharashtra Agril. Univ*., **11**(2): 182-184.

Shamsuddin, A. M., Islam, M. A. and Hossain, A. (1988). Comparative study on the yield and agronomic characters of nine cultivars of aus rice. *Bangladesh J. Agril. Sci.*, **15**(1): 121-124.

Shanthi, P. and Singh, J. (2001). Variability studies in induced mutants of Mahsuri rice (*Oryza sativa* L.). *Madras Agril. J.*, **88**(10-12): 707-709.

Son, Y., Park, S. T., Kim, S. Y., Lee, H. W. and Kim, S. C. (1998). Effects plant density on the yield and yield components of low-tillering large panicle type rice. *RDA J. Crop Sci.*, **40**: 2.

Sucharitha, C. and Boopathi, K. R. (2001). Effect of different methods of phosphorus application on the growth parameters and yield components of rice cultivars. *Indian J. Agril. Sci*., **69**(7): 477-481.

Sumit, C., Pyare, L., Singh, A. P. and Tripathi, M. K. (2004). Agronomic and morpho-physiological analysis of growth and productivity in hybrid rice (*Oryza sativa* L.). *Annals Biol*., **20**(2): 233-238.

Tabien, R. E. and Samonte, S. O. P. B. (2007). Flowering traits and head rice yield. *Texas Rice Newsl*., **7**(7): 8-9.

Tabien, R. E., Harper, C. L., Samonte, S. O. P. B., Wilson, L. T. and Frank, P. (2012). Two very early maturing breeding lines with high grain yield and milling quality potentials in Texas. Proceedings 34th Rice Technical Working Group Meeting Feb. 27-March 1, 2012. Hot Springs, Arkansas. p. 44.

Wang, J. L., Xu, Z. J. and Yi, X. Z. (2006). Effects of seedling quantity and row spacing on the yields and yield components of hybrid and conventional rice in northern China. *Chinese J. Rice Sci.*, **20**(6): 631-637.

Witham, H., Blaydes, D. F. and Devlin, R. M. (1986). Excerises in plant physiology. 2nd edition. PWS Publishers, Boston. USA. p. 128-131.

Xie, W., Wang, G. and Zhang, Q. (2007). Potential production simulation and optimal nutrient management of two hybrid rice varieties in Jinhua, Zhejiang Province. *J. Zhejiang Univ. Sci.*, **8**(7): 486–492.

Xu, S. and Li, B. (1998). Managing hybrid rice seed production. In hybrid rice. IRRI, Manila, Philippines, p. 157-163.

Xu, S. and Wang, C. (2001). Study of yield attributes of some restorer and maintainer lines. *Int. Rice Res. Newsl.*, **26**(7): 136-138.

Yoshida, S. (1981). Fundamentals of Rice Crop Science. International Rice Research Institute, Los Banos Manila, Philippines. p. 269.

APPENDICES

APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from March to August 2013

Month (2013)	Air temperature (^0C)		Relative humidity (%)	Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
March	31.4	19.6	54	11	8.2
April	34.2	23.4	61	112	8.1
May	34.7	25.9	70	185	7.8
June	35.4	22.5	80	577	4.2
July	36.0	24.6	83	563	3.1
August	36.0	23.6	81	319	4.0

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

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 soil of experimental field

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

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

Appendix III. Analysis of variance of the data on plant height of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAT	45 DAT	60 DAT	75 DAT	Harvest
Replication	2	0.027	1.545	2.180	12.417	43.061
Treatment (Variety)	5	24.810**	38.452*	35.606**	67.331*	581.414**
Error	10	4.081	8.896	4.211	19.658	28.802

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

Appendix IV. Analysis of variance of the data on number of tillers hill^{-1} of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at			
		30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.260	0.062	0.180	0.802
Treatment (Variety)	5	1.648*	3.380**	19.147**	10.970**
Error	10	0.396	0.553	1.775	1.371

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

Appendix V. Analysis of variance of the data on leaf area index of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square Leaf area index at			
		30 DAT	**45 DAT**	**60 DAT**	**75 DAT**
Replication	2	0.0001	0.0001	0.066	0.033
Treatment (Variety)	5	0.009*	0.045**	0.375*	0.400*
Error	10	0.001	0.008	0.106	0.157

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

Appendix VI. Analysis of variance of the data on stem dry matter plant^{-1} of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square Stem dry matter plant^{-1} (g) at			
		30 DAT	**45 DAT**	**60 DAT**	**75 DAT**
Replication	2	0.014	0.069	0.030	0.062
Treatment (Variety)	5	0.169**	0.208*	0.497**	0.999**
Error	10	0.020	0.058	0.082	0.120

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

Appendix VII. Analysis of variance of the data on leaf dry matter plant^{-1} of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square Leaf dry matter plant^{-1} (g) at 30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.016	0.016	0.020	0.312
Treatment (Variety)	5	0.051*	0.161**	0.236**	0.727*
Error	10	0.011	0.028	0.045	0.187

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

Appendix VIII. Analysis of variance of the data on total dry matter plant^{-1} of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square Total dry matter plant^{-1} (g) at 30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.026	0.151	0.099	0.363
Treatment (Variety)	5	0.383**	0.715**	1.396**	3.105**
Error	10	0.044	0.148	0.213	0.478

**: Significant at 0.01 level of significance

Appendix IX. Analysis of variance of the data on light interception as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square		
		Light interception (%)		
		Top to middle	Middle to bottom	Top to bottom
Replication	2	4.675	3.381	9.453
Treatment (Variety)	5	32.568**	19.557**	56.897**
Error	10	6.897	3.981	7.095

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

Appendix X. Analysis of variance of the data on chlorophyll content of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square			
		Chlorophyll content			
		2 DAF	9 DAF	16 DAF	23 DAF
Replication	2	0.012	0.009	0.013	0.032
Treatment (Variety)	5	0.123*	0.342**	0.345**	0.123*
Error	10	0.023	0.034	0.057	0.033

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

Appendix XI. Analysis of variance of the data on chlorophyll a:b of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square			
		Chlorophyll a:b			
		2 DAF	9 DAF	16 DAF	23 DAF
Replication	2	0.034	0.034	0.011	0.123
Treatment (Variety)	5	0.456**	0.456**	0.234**	1.003**
Error	10	0.022	0.045	0.053	0.023

**: Significant at 0.01 level of significance

Appendix XII. Analysis of variance of the data on days to maturity, effective, non-effective and total tillers hill^{-1} of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square			
		Days to maturity	Effective tillers hill^{-1} (No.)	Ineffective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)
Replication	2	23.321	0.132	0.016	0.201
Treatment (Variety)	5	254.082**	8.063*	0.498**	5.390*
Error	10	44.185	1.966	0.056	1.666

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

Appendix XIII. **Analysis of variance of the data on panicle length, filled, unfilled and total spikelets panicle^{-1}, spikelets fertility and weight of 1000 grains of rice as influenced by different variety in Aus season**

Source of variation	Degrees of freedom	Mean square					
		Panicle length (cm)	Filled spikelets panicle^{-1} (No.)	Unfilled spikelets panicle^{-1} (No.)	Total spikelets panicle^{-1} (No.)	Spikelets fertility (%)	Weight of 1000-grains (g)
Replication	2	2.301	1.909	1.034	2.542	12.154	0.573
Treatment (Variety)	5	11.261**	120.180*	4.442**	91.588*	109.56*	3.713**
Error	10	1.443	28.277	0.523	27.196	33.145	0.558

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

Appendix XIV. Analysis of variance of the data on grain, straw, biological yield and harvest index of rice as influenced by different variety in Aus season

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest index (%)
Replication	2	0.897	0.009	0.992	1.742
Treatment (Variety)	5	3.020*	1.819*	9.354*	7.124*
Error	10	0.695	0.445	1.974	3.408

*: Significant at 0.05 level of significance