EFFECT OF PLANTING DATES ON MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF HYBRID RICE VARIETIES IN *AUS* SEASON

A. K. M. MAKSUDUL ALAM

DEPARTMENT OF AGRICULTURAL BOTANY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2014

EFFECT OF PLANTING DATES ON MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF HYBRID RICE VARIETIES IN *AUS* SEASON

BY

A. K. M. MAKSUDUL ALAM

REG. NO. : 07-02230

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

MASTER OF SCIENCE (MS)

IN

AGRICULTURAL BOTANY

SEMESTER: JANUARY-JUNE, 2014

APPROVED BY:

Prof. Dr. Kamal Uddin Ahamed
Department of Agricultural Botany
SAU, Dhaka

Supervisor

Prof. Dr. Md. Moinul Haque
Department of Agricultural Botany
SAU, Dhaka

Co-Supervisor

Dr. Md. Ashabul Hoque
Chairman
Examination Committee

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

CERTIFICATE

This is to certify that the thesis entitled **'Effect of Planting Dates on Morpho-physiological and Yield Attributes of Hybrid Rice Varieties in *Aus* Season'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agricultural Botany**, embodies the result of a piece of bonafide research work carried out by **A. K. M. Maksudul Alam**, Registration number: **07-02230** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

Prof. Dr. Kamal Uddin Ahamed
Department of Agricultural Botany
SAU, Dhaka
Sher-e-Bangla Agricultural University
Dhaka-1207

Supervisor

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises to Almighty's and Kindfull trust on to "Omnipotent Creator" for His never-ending blessing, the author deems it a great pleasure to express his profound thankfulness to his respected parents, who entiled much hardship inspiring for prosecuting his studies, receiving proper education.

The author likes to express his deepest sense of gratitude to his respected supervisor Dr. Kamal Uddin Ahamed, Professor, Department of Agricultural Botany, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his scholastic guidance, support, encouragement and valuable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript writing.

The author also expresses his gratefulness to his respected Co-Supervisor, Dr. Md. Moinul Hoque, Associate Professor, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses his sincere gratitude towards the sincerity of the Chairman, Dr. Md. Ashabul Hoque, Associate Professor, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for his valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Agricultural Botany, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

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

The Author

EFFECT OF PLANTING DATES ON MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF HYBRID RICE VARIETIES IN *AUS* SEASON

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to July 2013 to study the effect of planting dates on morpho-physiological and yield attributes of hybrid rice varieties in *Aus* season. The experiment comprised of two factors. Factor A: Transplanting time: 2 dates- T_1: Transplanting at 1st March, 2013, T_2: Transplanting at 1st April, 2013 and Factor B: Different rice variety: 6 rice varieties- V_1: BRRI hybrid dhan2, V_2: BRRI hybrid dhan3, V_3: BRRI hybrid dhan4, V_4: BINA dhan7, V_5: BINA dhan14 and V_6: BRRI dhan48 (check). The experiment was laid out in two factor Randomized Complete Block Design with four replications. Data on different yield contributing characters and yield were recorded. For planting times, at 30, 50, 70 DAT and harvest, the tallest plant (29.37, 62.19, 92.81 and 113.26 cm, respectively) were recorded from T_1, whereas the shortest plant (27.84, 58.40, 89.22 and 109.08 cm, respectively) from T_2. The highest filled grains panicle^{-1} (84.39) was recorded from T_1, whereas the lowest (80.06) was obtained from T_2. The highest grain yield (6.88 t ha^{-1}) was observed from T_1, whereas the lowest (6.09 t ha^{-1}) was recorded from T_2. In case of different rice varieties, at 30, 50, 70 DAT and harvest, the tallest plant (30.40, 62.84, 93.73 and 113.46 cm, respectively) were observed from V_3, while the shortest plant (27.09, 55.32, 87.60 and 106.42 cm, respectively) were observed from V_2. The highest filled grains panicle^{-1} (89.10) was recorded from V_3, whereas the lowest (76.47) was found from V_2. The highest grain yield (7.19 t ha^{-1}) was observed from V_3, whereas the lowest (5.74 t ha^{-1}) was observed from V_2. Due to the interaction effect of planting time and different varieties, at 30, 50, 70 DAT and harvest, the tallest plant (32.46, 67.94, 97.29 and 118.24 cm, respectively) was observed from treatment combination of T_1V_3 and the shortest plant (24.12, 53.72, 84.93 and 105.26 cm) was recorded from treatment combination of T_2V_4. The highest filled grains panicle^{-1} (94.80) was recorded from treatment combination of T_1V_3, while the lowest (63.13) was found from treatment combination of T_2V_4. The highest grain yield (8.00t ha^{-1}) was found from T_1V_3 and the lowest (5.29 t ha^{-1}) was recorded from treatment combination of T_2V_4. The highest straw yield (9.35 t ha^{-1}) was observed from treatment combination of T_1V_3, while the lowest (6.81 t ha^{-1}) was recorded from of T_2V_4. From the above results it can be concluded that 1st March planting provided best yield for most of the varieties and BRRI hybrid dhan4 and BRRI hybrid dhan2 provided better yield than the other varieties.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*) belongs to the family Gramineae, is the staple food for at least 62.8% of total planet inhabitants and it contributes on an average 20% of apparent calorie intake of the world population and 30% of population in Asian countries. This calorie contribution varies from 29.5% for China to 72.0% for Bangladesh (Calpe and Prakash, 2007). It 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). Population growth demands a continuous increase in rice production in Bangladesh. So, the highest priority has been given to produce more rice (Bhuiyan, 2004). Production of rice has to be increased by at least 60% to meet up food requirement of the increasing population by the year 2020 (Masum, 2009). Horizontal expansion of rice area and rice yield per unit area is 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 varieties 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 increase 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 great 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.

Very recently various new rice varieties were developed and available as BRRI dhan and most of them are exceptionally high yielding. These varieties however, needs further test under different planting times to interact with different environmental conditions of the season. Planting time for successful rice production widely depends on varietal life duration, sensitivity to photoperiod, temperature, rainfall and other environmental factors (Rahman, 2003). In Bangladesh, planting of *Aus* rice starts from early March and continues through April. Such longer period of planting time of *Aus* rice is associated with inconsistent rainfall, late harvesting of preceding crops, late receding of early flood water and other socioeconomic factors (Zaman, 1986). It is assumed that late planting reduces vegetative phase which results reduced growth and yield of rice (Jhoun, 1989). In the contrary, early planted *Aus* rice sometimes lodges due to over growth or other natural hazards prevailing in long growing season. It is therefore, essential to generate adequate information relating planting time of *Aus* season to exploit its better growth and productivity. Planting time affects not only growth and productivity of *Aus* rice but also affects generally on seed quality. Planting time affects seed quality through affecting seed growth and development as it prevails different environmental conditions in the processes of seed development and seed maturation (Castillo *et al*., 1994).

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 is also related with other characters such as plant type, growth duration and yield components (Yoshida, 1981). 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. Based on above proposition, this research work is designed to evaluate the growth and yield performance of some selected hybrid rice varieties in different planting time with the following specific.

Objectives

- To compare the morphological and physiological characters of studied hybrid and inbred rice varieties in *Aus* season;
- To find out the effect of planting times on growth, reproductive and yield behavior of hybrid and inbred rice varieties in *Aus* season.

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 varieties of rice, environment and agronomic practices (planting time & density, fertilizer, irrigation etc.). Among the mentioned factors planting time and varieties are more responsible for the growth and yield of rice. High yielding varieties (HYV) are generally more adaptive to appropriate planting time. The available relevant reviews related to planting times and varieties in the recent past have been presented and discussed under the following headings:

2.1 Effect of planting time

Planting time for successful rice production widely depends on varietal life duration, sensitivity to photoperiod, temperature, rainfall and other environmental factors. Some literature related to planting time on growth and yield of rice are reviewed below-

2.1.1 Growth parameters

Vegetative growth of Indica rice is more affected by time of transplanting than that of other type of rice (Langfield and Basinski, 1960). Time of transplanting has profound influence on the performance of different cultivars of photo and thermo-sensitive in nature (Takahashi *et al.*, 1967). The time between July 15 and August 15 is the best for transplantation of high yielding cultivars of transplant *Aman* rice in Bangladesh. However, better results are obtained from early transplanting than late transplanting (Alim *et al.*, 1993; Hedayetullah *et al.*, 1994). It was revealed that mildly photoperiod-sensitive cultivars had a reduced likelihood of encountering low temperature compared with photoperiod-insensitive cultivars. The benefits of photoperiod sensitivity include greater sowing flexibility and reduced water use as growth duration is shortened when sowing is delayed (Farrell *et al*., 2006).

If photosensitive varieties are transplanted a little early, their vegetative growth extended which resulted more plant height and leafy growth. Due to increased plant height, such varieties lodge badly when transplanted early. As a result, the grain yield from such a crop is reduced drastically. On the other hand, when transplanting is delayed beyond normal period, the grain development is very poor which results in more quantity of under developed grains and ultimately severe reduction in yield (Kainth and Mehra, 1985). Flowering of rainfed lowland rice occurs within optimum time if sowing was conducted from May onwards up to the first week of August. However, Sowing can be delayed up to the first week of August for rainfed lowland cultivars if there is any crop failure due to flooding at the beginning of the cropping season **(**Sarkar and Reddy, 2006).

The vegetative stage of rice may be extended due to low temperature (Vergara and Chang, 1985). In November planting of BR3 when the temperature was cool, the vegetative phase was extended by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast with planting in July when the temperature was high, the relative tillering rate reached the highest value within 15 to 25 days after transplanting. In most cases, tillering rate decreases because of low temperature. So, appropriate planting time and the use of photoperiod-sensitive cultivars can be advantageous in a region in avoiding low temperature damage during reproductive development. Gohain and Saikia (1996) reported that earlier planting of high yielding varieties of rice around mid-July was the best. Late planting might have exposed the crop to relatively more adverse condition in terms of water stagnation at the tillering phase and low temperature at the reproductive phase which might have pulled down the yield compared to earlier planting.

In rice, the optimum leaf area index (LAI) at flowering and optimum crop growth rate (CGR) during panicle initiation has been identified as the major determinants of yield (Sun *et al*., 1999). A combination of these growth variables explains variation in yield better than any individual growth variable (Gosh and Singh, 1998). Thakur and Patel (1998) reported that dry matter production, leaf area index, leaf area duration (LAD), crop growth rate (CGR), net assimilation rate (NAR) and relative growth rate (RGR) are ultimately reflected in higher grain yield of rice. Crop growth rate is the most critical growth attributes for rice yield under intensive management during the latter half of the reproductive period (Horie, 2001). The CGR at this stage critically affects final spikelet number by regulating spikelet degeneration, potential single-grain weight by determining husk size, and grain filling by forming active sinks and determining endosperm cell number at initial grain filling. Early plating of hybrid rice, exhibited the maximum total and effective tillers per hill, leaf-area index, leaf-area duration, dry-matter accumulation, relative growth rate, fertile spikelets per panicle, 1000 grains weight and straw yields (Nayak, *et al.*, 2003). Hundal *et al.* (2005) observed the significant linear and exponential relationships between leaf area index and aboveground biomass and yield of rice. Planting time had direct influenced on above attributes.

2.1.2 Yield parameters

Among the yield components grain size in rice is considered to be the most stable character (Matsushima, 1957). Little variation in single grain weight or grain size would further increase the grain yield potential of rice. Evidence suggests that increase in grain yield can be achieved through improvement of one or more than one of the yield components of rice.

Yield components like panicle per plant, grains per panicle and 1000 grain weight increase yield in modern varieties (Saha Ray *et al.*, 1993). Haque *et al*. (1991) reported negative association of 1000 grain weight and yield per plant in traditional varieties but positive association of yield per plant with number panicle per plant in modern varieties. Other reports revealed that number of panicles per hill, panicle length and 1000-grain weight were positively associated with grain yield of rice (Padmavathi *et al.*, 1996; Marwat *et al*., 1994). Panwar *et al.* (1989) noticed that spikelet number was the main component character affecting the rice yield. Number of panicles per hill and number of spikelets per panicle had negative direct effects on grain yield (Padmavathi *et al.*, 1996). Surek *et al.* (1998)

found that biological yield of rice had the highest direct effect on grain yield followed by harvest index and 1000 grain weight.

The highest grain yield was obtained from 15 July transplanting of rice. The highest grain yield was obtained due to cumulative effect of longer panicle, highest number of grains per panicle and 1000 grain weights (Salam *et al*., 2004). Similar result was also reported by Rahman (2003). Islam *et al.* (2008) reported that direct wet-seeded rice produced 10% higher grain yield than transplanted rice and 31 December seeded rice produced the highest grain yield. Rice planted on 1 December significantly reduced the grains per panicle and January planted rice significantly reduced the panicle per unit area.

Different yield and yield parameters like number of tillers per hill, grains per panicle, 1000 grain weight and sterility were significantly affected by transplanting time. Basmati-385 and Super Basmati produced maximum paddy yield (5655 and 5612 kg/ha) when transplanted on July 1 and July 11, respectively. Minimum sterility was recorded in rice varieties 98901 (5.25%) and Super Basmati (5.08%) and maximum (13.08%) in PK 5261-1-2-1. Minimum sterility was observed in rice transplanted on July 21 followed by July 1, July 11 and July 31 (Akram *et al*., 2004). Yield and spikelet sterility of rice in temperate Kashmir was influenced by transplanting dates and nutrient management. Spikelet sterility was higher in rice transplanted on 30 June as compared with that on 15 June due to reduced growth phases and low temperature during reproductive phase. Further, increasing levels of N under delayed transplanted conditions increased spikelet sterility and reduced grain yield of rice (Singh *et al*., 2005).

The higher the temperature and the longer the high temperature stress, the lower the pollen vigour and germination percentage, therefore, the less the seed setting rate and lower the yield (Zheng *et al.*, 2007). Two genotypes were grown at 30/24^{0}C day/night temperature in a greenhouse, in both genotypes one hour exposure to 33.7^{0}C at anthesis caused sterility. In IR64, spikelet fertility was reduced about 7% by per degree increase of temperature (Jagadish *et al*., 2007).

On the other hand, yield and quality of aromatic rice were superior when exposed to a lower temperature (day mean temperature 23^0C). Yield, filled grain rate, and number of filled grains per panicle reduced significantly under the highest temperature (day mean temperature 30^0C). The highest temperature also increased the chalkiness score, and reduced milled rice, milling quality of head rice, amylose content, alkali value, eating and aroma scores, and gel consistency in rice (Xu *et al.*, 2006).

Spikelet sterility of rice results from low temperatures during panicle development. However, this temperature alone cannot fully explain the fluctuations in sterility observed in the field, since the susceptibility of rice plants to low temperature often changes according to its physiological status during sensitive stages. Low water temperature (below 20^0C) during vegetative growth stage of rice plant significantly increased the sterility. On the other hand, low air temperature during vegetative growth also significantly increased the sterility, but this effect was diminished by warm water temperature even at low air temperature. There was a close and negative correlation between sterility and water temperature during vegetative growth (Shimono *et al.*, 2007). These results suggest that temperatures before panicle initiation change the susceptibility of a rice plant to low temperatures during panicle development which results in spikelets sterility.

Linscombe *et al.* (2004) reported that planting date had a major effect on grain yield. Grain yield at one location in southwest Louisiana was highest (8600 kg ha^{-1}) when rice was planted in late March, and grain yield (6500 kg ha^{-1}) decreased linearly as planting was delayed until early June. Other authors (Patel *et al.,* 1987) also reported that grain yield of rice markedly declined with delayed planting time in rice.

2.2 Effect of rice varieties

Rice is the staple food and around ninety per cent of rice is grown and consumed in south and Southeast Asia, the highly populated area. Bangladesh produces hybrid rice varieties and most of them have excellent production and eating quality for regular consumption. Different researcher reported the effect of rice varieties on yield contributing component and grain yield. However, some of the important and informative works and research findings related to the yield and quality of hybrid, so far been done at home and abroad, reviewed below-

2.2.1 Plant height

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

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

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

Masum *et al.* (2008) found that plant height of rice affected by varieties in *Aman* season where Nizershail produced the taller plant height than the BRRI dhan 44 at different days after transplanting (DAT).

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

Chen-Liang *et al.* (2000) showed that the cross between Peiai 64s and the new plant type lines had longest plant height.

Xu and Li (1998) observed that the maintainer lines were generally shorter than restorer line.

Munoz *et al.* (1996) noted that IR8025A hybrid rice cultivar produced 16% longer plant than the commercial variety Oryzica Yacu-9.

BINA (1993) evaluated the performance of four rice varieties (IRAATOM 24, BR14, BINA13 and BINA19). It was found that varieties differed significantly in respect of plant height.

BRRI (1991) observed the plant height differed significantly among BR3, BR11, BR14, Pajam and Zagali varieties in the *Boro* season.

Hosain and Alam (1991) carried out an experiment and found that the plant height in modern rice varieties BR3, BR11, BR14 and Pajam were 90.4, 94.5, 81.3 and 100.7 cm, respectively.

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

Shamsuddin *et al.* (1988) conducted a field trial with nine different rice varieties and observed that plant height and other yield contributing characters and yield differed significantly among the varieties tested.

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.

2.2.2 Tillering pattern

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

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

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

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and observed that Mukti gave the highest tillers hill^{-1} compared to the others.

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

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 and recorded differences for number of effective tillers.

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

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

Chowdhury *et al*. (1993) reported that the cultivar BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i. e. number of productive tillers hill^{-1}.

BINA (1993) conducted an experiment with four varieties/advance lines (IRATOM24, BR14, BINA13 and BINA19) and reported significant variation in number of non-bearing tillers hill^{-1}.

Hossain and Alam (1991) also found that the growth characters like total tillers hill^{-1} differed significantly among BR3, BR11, Pajam and Jaguli varieties in the *Boro* srason.

Idris and Matin (1990) stated that number of total tillers hill^{-1} was identical among the six varieties studied.

2.2.3 Dry matter

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

Masum *et al*. (2008) found that total dry matter production differed due to varieties. Total dry matter of BRRI dhan 44 Nizershail significantly varied at different sampling dates.

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

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

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

2.2.4 Panicle length, filled & unfilled grains panicle^{-1} and 1000-grains weight

An experiment was conducted by Hosain *et al*. (2014) at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during *Aus* season (March to July 2010) to observe the effect of transplanting dates on the yield and yield attributes of exotic hybrid rice varieties. The experiment comprised of three rice varieties (two hybrids-Heera2, Aloron and one inbred- BRRI dhan48). Hybrid varieties Heera2 (3.03 t ha^{-1}) and Aloron (2.77 t ha^{-1}) gave the higher spikelet sterility.

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

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

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.

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

A field experiment was conducted by Khalifa (2009) at the experimental farm of Rice research and training centre (RRTC), Sakha, kafr- El sheikh governorate, Egypt 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.

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%.

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.

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

Guilani *et al*. (2003) studied on crop yield and yield components of rice cultivars (Anboori, Champa and LD183) in Khusestan, Iran, during 1997. They observed that grain number panicle^{-1} was not significantly different among cultivars. The highest grain number panicle^{-1} was obtained with Anboori. Grain fertility percentages were different among cultivars. Among cultivars, LD183 had the highest grain weight.

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

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

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

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

Idris and Matin (1990) observed that panicle length differed among the six rice varieties and it was longer in IR20 than in the indigenous high yielding varieties.

Singh and Gangwer (1989) conducted an experiment with rice cultivars C-14-8, CR-10009, IET-5656 and IET-6314 and reported that grain number $panicle^{-1}$, 1000-grain weight were higher for C-14-8 than those of any other three varieties.

Rafey *et al*. (1989) carried out an experiment with three different rice cultivars and reported that weight of 1000 grain differed among the cultivars studied.

Shamsuddin *et al*. (1988) also observed that panicle number $hill^{-1}$ and 1000-grain weight differed significantly among the varieties.

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

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

2.2.5 Straw and grain yield

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

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

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

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

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

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

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

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

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

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.

BRRI (1997) reported that three modern upland rice varieties namely, BR20, BR21, BR24 was suitable for high rainfall belts of Bangladesh. Under proper management, the grain yield was 3.5 ton for BR20, 3.0 ton ha^{-1} for BR21 and 3.5 ton ha^{-1} for BR24.

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

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

Chowdhury *et al*. (1995) studied seven varieties of rice, of which three were native (Maloti, Nizersail and Chandrashail) and four were improved (BR3, BR11, Pasam and Mala). Straw and grain yields were recorded and found that both the grain and straw yields were higher in the improved than the native varieties.

Liu (1995) conducted a field trial with new indica hybrid rice You 92 and found an average yield of 7.5 t ha^{-1} which was 10% higher than that of standard hybrid Shanyou 64.

In field experiments at Gazipur rice cv. BR11 (weakly photosensitive), BR22, BR23 and Nizersail (strongly photosensitive) were sown at various intervals from July to September and transplanted from August to October. Among the cv. BR22 gave the highest grain yield from most of the sowing dates for both of the years (Ali *et al*., 1993).

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

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

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

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

In evaluation of performance of four HYV and local varieties-BR4, BR16, Rajasail and Kajalsail in *Aman* season, BR4 and BR16 were found to produce more grain yield among four varieties (BRRI, 1985).

From the above literature, it is evident that planting times and varieties have a significant influence on yield and yield components of rice. The literature suggests that optimum planting time and suitable variety for this time increases the grain yield of rice. Reduction in grain yield is mainly attributed by the reduced number of tiller $hill^{-1}$, grains $panicle^{-1,}$ panicle length and thousand grain weight due to restriction of development of these parameters for the effect of planting time and variety itself.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to July 2013 to study the influence of planting times in *Aus* season on morpho-physiological and yield attributes of hybrid rice varieties. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^{0}74^{/}$N latitude and $88^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level.

3.1.2 Soil

The soil 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 and above flood level. The selected plot was medium high land. The details have been presented in Appendix I.

3.1.3 Climate

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 II.

3.2 Test crop

BRRI hybrid dhan2, BRRI hybrid dhan3, BRRI hybrid dhan4, BINA dhan7, BINA dhan14 and BRRI dhan48 (check)were used as the test crop in this experiment. These varieties were developed at the Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA).

3.3 Experimental details

3.3.1 Treatments

The experiment comprised of two factors.

Factor A: Transplanting time: 2 dates

i. T_1: Transplanting at 1st March, 2013
ii. T_2: Transplanting at 1st April, 2013

Factor B: Different rice varieties: 6 rice varieties

i. V_1: BRRI hybrid dhan2
ii. V_2: BRRI hybrid dhan3
iii. V_3: BRRI hybrid dhan4
iv. V_4: BINA dhan7
v. V_5: BINA dhan14
vi. V_6: BRRI dhan48 (check)

As such there were 12 treatments combinations viz. T_1V_1, T_1V_2, T_1V_3, T_1V_4, T_1V_5, T_1V_6, T_2V_1, T_2V_2, T_2V_3, T_2V_4, T_2V_5 and T_2V_6.

3.3.2 Experimental design and layout

The experiment was laid out in two factor Randomized Complete Block Design with four replications. The layout of the experiment was prepared for distributing the combination of transplanting time and rice variety. There were 12 plots of 4 m × 2.5 m size in each of 4 replications. The 12 treatment combinations of the experiment were assigned at random in 12 plots of each replication.

3.4 Growing of crops

3.4.1 Raising seedlings

3.4.1.1 Seed collection

The seeds of the test crop BRRI hybrid dhan2, BRRI hybrid dhan3, BRRI hybrid dhan4 and BRRI dhan48 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur and BINA dhan7 and BINA dhan14 were collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh.

3.4.1.2 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.

3.4.1.3 Preparation of seedling nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide, adding nutrients as per the requirements of soil (BRRI, 2013). Seeds were sown in the seed bed on February 03, 2013 and March 06, 2013 in order to transplant the seedlings in the main field.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the last week of February 2013 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.4.3 Fertilizers and manure application

The fertilizers N, P, K, S and B in the form of urea, TSP, MP, Gypsum and borax, respectively were applied. The entire amount of TSP, MP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Urea was applied in two equal installments at tillering and panicle initiation stage. The dose and method of application of fertilizers are shown in Table 1.

Table 1. Dose and method of application of fertilizers in rice field

Fertilizers	Dose (kg/ha)	Application (%)		
		Basal	1st installment	2nd installment
Urea	As per treatment	33.33	33.33	33.33
TSP	100	100	--	--
MP	80	100	--	--
Gypsum	60	100	--	--
Borax	10	100	--	--

Source: BRRI, 2013 (Adunik Dhaner Chash), Joydevpur, Gazipur

3.4.4 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 February 28, 2013 and March 31, 2013 for transplant on the date of 1st March, 2013 and 1st April, 2013 without causing much mechanical injury to the roots.

3.4.5 Transplanting of seedlings in the field

On the scheduled dates as per experiment the rice seedlings were transplanted in lines each having a line to line distance of 30 cm and plant to plant distance 25 cm in the well prepared plots.

3.4.6 After care

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

3.4.6.1 Irrigation and drainage

Flood irrigation was provided 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 at 15 days before harvesting.

3.4.6.2 Gap filling

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

3.4.6.3 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.

3.4.6.4 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.

3.4.6.5 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.

3.5 Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The harvested crop of each plot was 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 12%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}.

3.6 Data recording

3.6.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 50, 70 DAT (Days after transplanting) and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the tiller.

3.6.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} was recorded at the time of 30, 50, 70 DAT and at harvest by counting total tillers. Data were recorded as the average of 5 hills selected at random from the inner rows of each plot.

3.6.3 Effective tillers hill^{-1}

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

3.6.4 Non-effective tillers hill^{-1}

The total number of non effective tillers hill^{-1} was counted as the number of non 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.

3.6.5 Days to starting of panicle emergence

Days to starting of panicle emergence were recorded by counting the number of days required to starting emergence of panicle.

3.6.6 Days to maturity

Days to maturity were recorded by counting the number of days required to mature in each plot. Maturity date was estimated by ken observation of plant and when the plant became brownish in color than the rice plant attained it maturity.

3.6.7 Leaf area of flag leaf

Leaf area of flag leaf was measured manually. Data were recorded as the average of 05 plants selected at random the inner rows of each plots. The final data were calculated multiplying by a correction factor 0.75 as per Yoshida (1981).

3.6.8 Length of panicle

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

3.6.9 Total dry matter plant^{-1}

Total dry matter plant^{-1} was recorded at harvest by drying plant sample. Data were recorded as the average of 3 sample hill^{-1} selected at random from the inner rows of each plot and expressed in gram.

3.6.10 Filled grain panicle^{-1}

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

3.6.11 Unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected 5 plants of a plot on the basis of no grain in the spikelet and then average number of unfilled grains panicle^{-1} was recorded.

3.6.12 Total grains panicle^{-1}

The total number of grains was calculated by adding filled and unfilled grains and then average number of grains panicle^{-1} was recorded.

3.6.13 Weight of 1000 seeds

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

3.6.14 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area and five sample plants were added to the respective grain yield m^{-2} and converted to t ha^{-1}.

3.6.15 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area and five sample plants were added to the respective straw yield m^{-2} and finally converted to t ha^{-1}.

3.6.16 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.

3.6.17 Harvest index

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

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

3.7 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatments. The mean values of all the data were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Duncan's Multiple Range Difference (DMRT) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the influence of planting times on morpho-physiological and yield attributes of hybrid rice varieties in *Aus* season. Data on different yield contributing characters and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-VII. The results have been presented with the help of table and graphs and possible interpretations have been given under the following headings:

4.1 Plant height

Statistically significant variation ($P \leq 0.01$) was recorded for plant height of rice due to different planting times at 30, 50, 70 days after transplanting (DAT) and at harvest (Figure 1). Data revealed that at 30, 50, 70 DAT and harvest, the tallest plant (29.37, 62.19, 92.81 and 113.26 cm, respectively) were recorded from T_1 (Transplanting at 1st March, 2013), whereas the shortest plant (27.84, 58.40, 89.22 and 109.08 cm, respectively) from T_2 (Transplanting at 1st April, 2013). Probably delayed planted crop prevailed lesser time in favor of growing environment which might have shorten the plant height of the variety. This result is in agreement with that of Hedayetullah *et al.* (1994) and they reported that plant height reduced with delayed transplanting of rice.

Plant height varied significantly ($P \leq 0.01$) for different rice varieties at 30, 50, 70 DAT and harvest (Figure 2). At 30, 50, 70 DAT and harvest, the tallest plant (30.40, 62.84, 93.73 and 113.46 cm, respectively) were observed from V_3 (BRRI hybrid dhan4), while the shortest plant (27.09, 55.32, 87.60 and 106.42 cm, respectively) from V_2 (BRRI hybrid dhan3). Varieties produced different plant height on the basis of their varietal characters and also genetical influences but environmental and different management practices also influences plant height. Khalifa (2009) reported earlier that H_1 hybrid rice variety surpassed other varieties in terms of plant height. Bhuiyan *et al*. (2014) reported earlier significant effects on plant height for different rice variety.

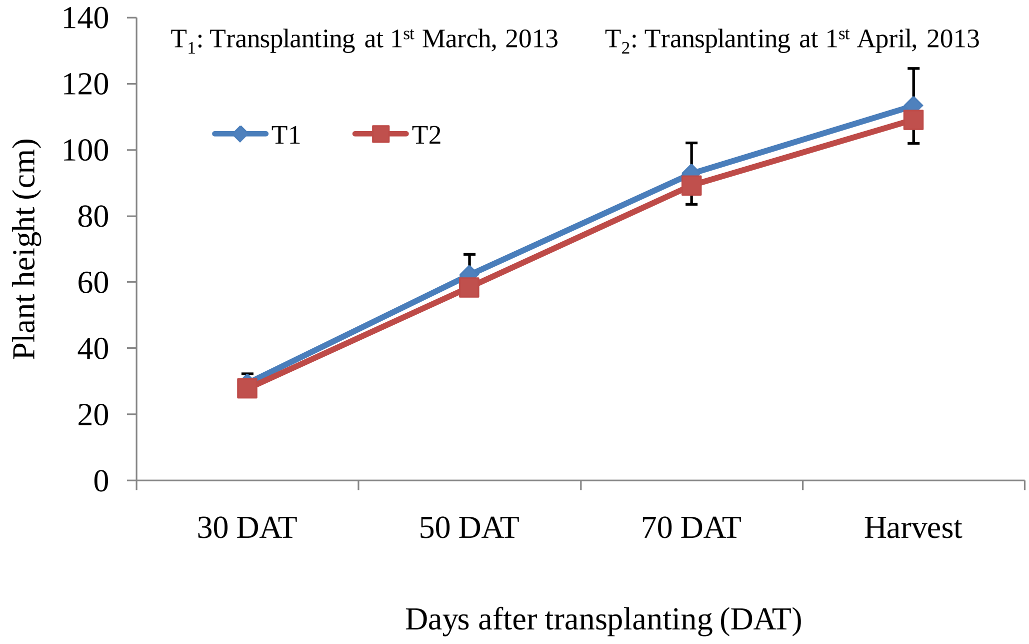

Figure 1. Effect of different planting times on plant height of rice. Vertical bars are LSD values at 5% level.

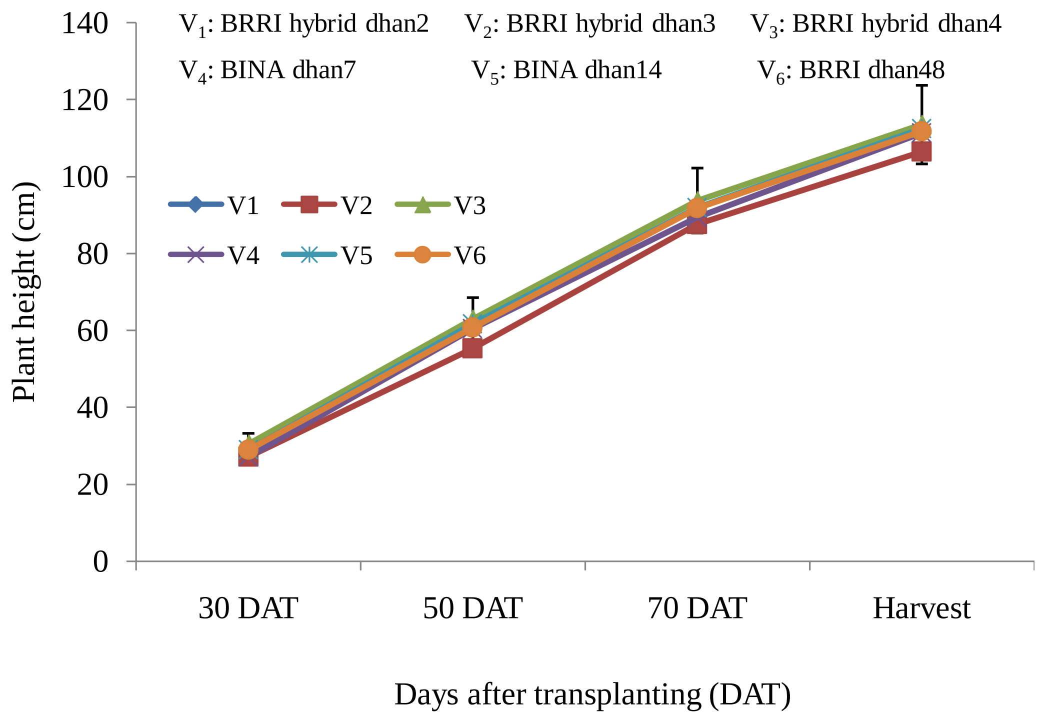

Figure 2. Effect of different rice varieties on plant height. Vertical bars are LSD values at 5% level.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on plant height of at 30, 50, 70 DAT and harvest (Table 2). At 30, 50, 70 DAT and harvest, the tallest plant (32.46, 67.94, 97.29 and 118.24 cm, respectively) was observed from treatment combination of T_1V_3 (Transplanting at 1st March, 2013 with BRRI hybrid dhan4) and the shortest plant (24.12, 53.72, 84.93 and 105.26 cm) was recorded at 30, 50, 70 DAT and harvest, respectively from treatment combination of T_2V_4 (Transplanting at 1st April, 2013 with BINA dhan7).

4.2 Number of tillers hill^{-1}

Different planting times showed statistically significant variations ($P \leq 0.01$) for number of total tillers hill^{-1} at 30, 50, 70 days after transplanting (DAT) and at harvest (Figure 3). At 30, 50, 70 DAT and harvest, the maximum number of total tillers hill^{-1} (4.61, 8.32, 12.77 and 13.31, respectively) were found from T_1, while the minimum number (4.04, 7.46, 11.91 and 12.89, respectively) from T_2. The number of tiller per hill decreased rationally irrespective of all transplanting times after peak as tiller survival was negatively correlated to the maximum tiller number (Sarkar and Reddy, 2006) and mutual shading of the crop (Farrell *et al*., 2006). Kainth and Mehra (1985) reported that in November planting of BR3 when the temperature was cool, the vegetative phase was extended by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast with planting in July when the temperature was high, the relative tillering rate reached the highest value within 15 to 25 days after transplanting.

Significant variation ($P \leq 0.01$) was recorded in terms of number of total tillers hill^{-1} for different rice varieties at 30, 50, 70 DAT and harvest (Figure 4). At 30, 50, 70 DAT and harvest, the maximum number of total tillers hill^{-1} (4.77, 8.80, 13.20 and 13.37, respectively) were recorded from V_3, again the minimum number (4.13, 7.53, 11.67 and 12.07, respectively) were obtained from V_2. Bhuiyan *et al*. (2014) recommended hybrid rice varieties because it produced more productive tillers. Devaraju *et al*. (1998) also reported Rice Hybrid-2 (KRH2) produced highest tiller number than the others variety.

Table 2. Interaction effect of planting times and different rice varieties on plant height at different days after transplanting (DAT) and at harvest

Treatment	Plant height (cm) at			
	30 DAT	50 DAT	70 DAT	Harvest
T_1V_1	27.65 cd	58.80 cde	90.98 b-e	110.40 def
T_1V_2	25.81 de	54.55 ef	87.04 ef	105.22 g
T_1V_3	32.46 a	67.94 a	97.29 a	118.24 a
T_1V_4	30.19 ab	66.37 ab	93.95 abc	117.33 ab
T_1V_5	30.78 ab	64.61 ab	94.64 ab	115.44 abc
T_1V_6	29.35 bc	61.69 bcd	92.96 bcd	112.92 cde
T_2V_1	30.39 ab	62.89 bc	92.61 bcd	113.20 b-d
T_2V_2	28.38 bc	56.92 def	88.17 ef	107.63 fg
T_2V_3	28.46 bc	57.73 def	90.18 cde	108.68 efg
T_2V_4	24.12 e	53.72 f	84.93 f	105.26 g
T_2V_5	27.10 cd	58.65 cde	88.95 de	109.36 d-g
T_2V_6	28.62 bc	59.63 cd	90.50 cde	110.34 def
$LSD_{(0.05)}$	2.131	4.370	3.653	4.020
Significant level	0.01	0.01	0.01	0.01
CV(%)	5.18	5.04	6.79	4.51

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 1st March, 2013

T_2: Transplanting at 1st April, 2013

V_1: BRRI hybrid dhan2

V_2: BRRI hybrid dhan3

V_3: BRRI hybrid dhan4

V_4: BINA dhan7

V_5: BINA dhan14

V_6: BRRI dhan48

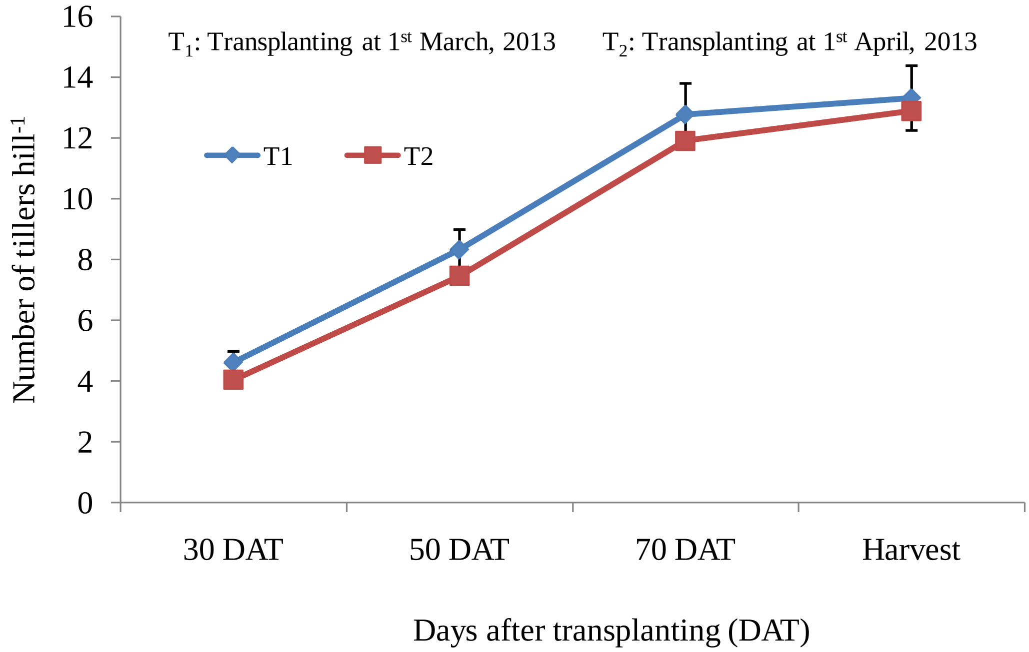

Figure 3. Effect of different planting times on number of tillers hill^{-1} of rice. Vertical bars are LSD values at 5% level.

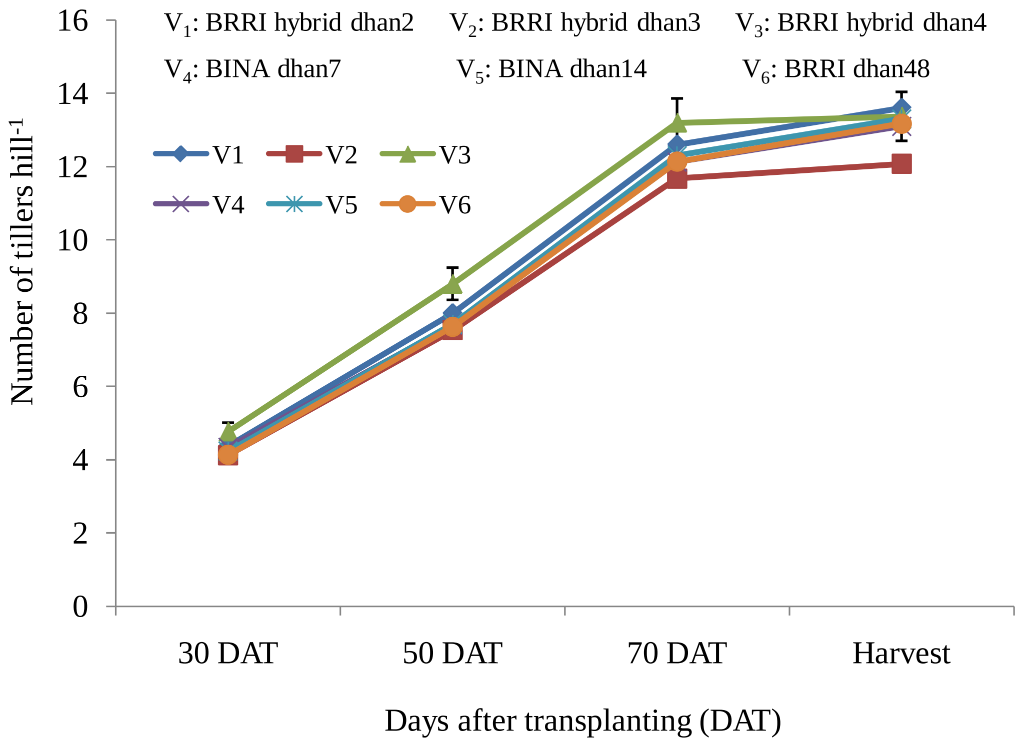

Figure 4. Effect of different rice varieties on number of tillers hill^{-1}. Vertical bars are LSD values at 5% level.

Number of total tillers hill^{-1} of at 30, 50, 70 DAT and harvest showed significant variation due to the interaction effect of different planting times and rice varieties (Table 3). At 30, 50, 70 DAT and harvest, the maximum number of total tillers hill^{-1} (5.40, 9.80, 14.20 and 14.24, respectively) were found from treatment combination of T_1V_3, whereas the minimum number (3.80, 6.93, 11.00 and 12.33, respectively) was recorded at 30, 50, 70 DAT and harvest, respectively from treatment combination of T_2V_4.

4.3 Number of effective tillers hill^{-1}

Significant variation ($P \leq 0.01$) was observed for number of effective tillers hill^{-1} due to different planting time (Table 4). The maximum number of effective tillers hill^{-1} (11.89) was found from T_1, whereas the minimum number (11.13) was found from T_2. Probably delayed planted crop prevailed lesser time in favor of growing environment which might have minimum number of effective tillers hill^{-1}.

Number of effective tillers hill^{-1} varied significantly ($P \leq 0.01$) for different rice varieties (Table 4). The maximum number of effective tillers hill^{-1} (12.03) was observed from V_3 (BRRI hybrid dhan4), which were statistically identical (11.90, 11.80 and 11.70) to V_5 (BINA dhan14), V_1 (BRRI hybrid dhan2) and V_6 (BRRI dhan48) and followed (11.33) by V_4 (BINA dhan7) and the minimum number (10.30) was observed from V_2 (BRRI hybrid dhan3).

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on number of effective tillers hill^{-1} (Table 5). The maximum number of effective tillers hill^{-1} (13.07) was found from treatment combination of T_1V_3, while the minimum number (10.20) was observed from treatment combination of T_2V_2.

4.4 Non-effective tillers hill^{-1}

Different planting time varied significantly ($P \leq 0.01$) for number of non-effective tillers hill^{-1} (Table 4). The minimum number of non-effective tillers hill^{-1} (1.42) was recorded from T_1, whereas the maximum number (1.76) from T_2.

Table 3. Interaction effect of planting times and different rice varieties on number of tillers hill^{-1} at different days after transplanting (DAT) and at harvest

Treatment	Number of tillers hill^{-1}			
	30 DAT	50 DAT	70 DAT	Harvest
T_1V_1	4.47 c	8.00 bc	12.47 bc	13.20 cd
T_1V_2	4.40 cd	8.00 bc	11.87 cd	12.07 e
T_1V_3	5.40 a	9.80 a	14.20 a	14.24 a
T_1V_4	4.87 b	8.40 b	13.27 b	13.87 abc
T_1V_5	4.33 cd	8.00 bc	12.60 bc	13.40 bc
T_1V_6	4.20 cde	7.73 bcd	12.20 cd	13.13 cd
T_2V_1	4.27 cd	8.00 bc	12.73 bc	14.00 ab
T_2V_2	3.87 ef	7.07 d	11.47 de	12.07 e
T_2V_3	4.13 c-f	7.80 bcd	12.20 cd	12.53 de
T_2V_4	3.80 f	6.93 d	11.00 e	12.33 e
T_2V_5	4.13 c-f	7.40 cd	12.00 cd	13.20 cd
T_2V_6	4.07 def	7.53bcd	12.07 cd	13.20 cd
$LSD_{(0.05)}$	0.309	0.785	0.811	0.727
Significant level	0.01	0.05	0.01	0.01
CV(%)	4.94	6.92	4.57	5.85

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 1st March, 2013

T_2: Transplanting at 1st April, 2013

V_1: BRRI hybrid dhan2

V_2: BRRI hybrid dhan3

V_3: BRRI hybrid dhan4

V_4: BINA dhan7

V_5: BINA dhan14

V_6: BRRI dhan48

Table 4. Effect of planting times and different rice varieties on yield contributing characters

Treatment	Number of effective tillers $hill^{-1}$	Number of non effective tillers $hill^{-1}$	Days to starting panicle emergence	Days to maturity
T_1	11.89 a	1.42 b	73.22 a	127.87 a
T_2	11.13 b	1.76 a	70.22 b	122.45 b
$LSD_{(0.05)}$	0.253	0.095	1.480	3.343
Significant level	0.01	0.01	0.01	0.01
V_1	11.80 a	1.80 a	86.33 a	142.50 a
V_2	10.30 c	1.77 a	80.33 b	140.48 a
V_3	12.03 a	1.33 b	66.83 c	121.67 b
V_4	11.33 b	1.77 a	65.50 c	120.87 b
V_5	11.90 a	1.40 b	66.50 c	113.75 c
V_6	11.70 ab	1.47 b	64.83 c	111.68 c
$LSD_{(0.05)}$	0.439	0.164	2.564	5.790
Significant level	0.01	0.01	0.01	0.01
CV(%)	6.74	10.23	5.51	4.55

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 1st March, 2013

T_2: Transplanting at 1st April, 2013

V_1: BRRI hybrid dhan2

V_2: BRRI hybrid dhan3

V_3: BRRI hybrid dhan4

V_4: BINA dhan7

V_5: BINA dhan14

V_6: BRRI dhan48

Table 5. Interaction effect of planting times and different rice varieties on yield contributing characters

Treatment	Number of effective tillers $hill^{-1}$	Number of non effective tillers $hill^{-1}$	Days to starting panicle emergence	Days to maturity
T_1V_1	11.40 cd	1.80 abc	86.00 a	135.83 bc
T_1V_2	10.40 ef	1.67 bcd	80.33 b	141.33 ab
T_1V_3	13.07 a	1.13 e	71.00 c	130.83 c
T_1V_4	11.93 bc	1.93 a	69.33 cd	129.17 c
T_1V_5	12.40 b	1.00 e	67.00 de	117.50 d
T_1V_6	12.13 b	1.00 e	65.67 def	112.53 d
T_2V_1	12.20 b	1.80 abc	86.67 a	149.17 a
T_2V_2	10.20 f	1.87 ab	80.33 b	139.63 b
T_2V_3	11.00 de	1.53 d	62.67 fg	112.50 d
T_2V_4	10.73 def	1.60 cd	61.67 g	112.57 d
T_2V_5	11.40 cd	1.80 abc	66.00 def	110.00 d
T_2V_6	11.27 cd	1.95 a	64.00 efg	110.83 d
$LSD_{(0.05)}$	0.620	0.232	3.626	8.188
Significant level	0.01	0.05	0.01	0.01
CV(%)	6.74	10.23	5.51	4.55

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 1st March, 2013

T_2: Transplanting at 1st April, 2013

V_1: BRRI hybrid dhan2

V_2: BRRI hybrid dhan3

V_3: BRRI hybrid dhan4

V_4: BINA dhan7

V_5: BINA dhan14

V_6: BRRI dhan48

Number of non-effective tillers $hill^{-1}$ varied significantly ($P \leq 0.01$) for different rice varieties (Table 4). The minimum number of non-effective tillers $hill^{-1}$ (1.33) was found from V_3, which were statistically identical (1.40 and 1.47) to V_5 and V_6, whereas the maximum number (1.80) was obtained from V_1.

Significant variation ($P \leq 0.05$) was recorded due to interaction effect of different planting times and rice varieties in terms of number of non-effective tillers $hill^{-1}$ (Table 5). The minimum number of non-effective tillers $hill^{-1}$ (1.13) was found from treatment combination of T_1V_3 and the minimum number (1.95) was observed from treatment combination of T_2V_6.

4.5 Days to starting of panicle emergence

Statistically significant variation ($P \leq 0.01$) was recorded for days to starting of panicle emergence due to different planting time (Table 4). The maximum days to starting of panicle emergence (73.22) was found from T_1, while the minimum days (70.22) was attained from T_2.

Days to starting of panicle emergence varied significantly ($P \leq 0.01$) for different rice varieties (Table 4). The maximum days to starting of panicle emergence (86.33) was observed from V_1, which was followed (80.33) by V_2, again the minimum days (64.83) was observed from V_6.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on days to starting of panicle emergence (Table 5). The maximum days to starting of panicle emergence (86.67) was found from treatment combination of T_2V_1, while the minimum days (61.67) was recorded from treatment combination of T_2V_4.

4.6 Days to maturity

Statistically significant variation ($P \leq 0.01$) was recorded for days to maturity due to different planting time (Table 4). The maximum days to maturity (127.87) was recorded from T_1, whereas the minimum days (122.45) was recorded from T_2.

Days to maturity varied significantly ($P \leq 0.01$) for different rice varieties (Table 4). The maximum days to maturity (142.50) was found from V_1, which were statistically identical (140.48) to V_2 and followed (121.67 and 120.87) by V_3 and V_4, while the minimum days (111.68) from V_6. Similar results also reported by Masum *et al*. (2008); and Chowdhury *et al*. (1993) from their earlier experiment.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on days to maturity (Table 5). The maximum days to maturity (149.17) was obtained from treatment combination of T_2V_1 and the minimum days (110.00) was found from treatment combination of T_2V_5.

4.7 Leaf area of flag leaf

Statistically significant variation ($P \leq 0.01$) was recorded for leaf area of flag leaf due to different planting time (Figure 5). The highest leaf area of flag leaf (89.55 cm^2) was recorded from T_1, while the lowest (84.07 cm^2) was recorded from T_2. Probably delayed planted crop prevailed lesser time in favor of growing environment which might have lowest leaf area of flag leaf.

Leaf area of flag leaf varied significantly ($P \leq 0.01$) for different rice varieties (Figure 6). The highest leaf area of flag leaf (91.93 cm^2) was observed from V_3, which were statistically identical (89.30 cm^2 and 87.10 cm^2) to V_1 and V_6 and followed (86.66 cm^2 and 85.43 cm^2) by V_2 and V_5, again the lowest (80.46 cm^2) was observed from V_4.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on leaf area of flag leaf (Figure 7). The highest leaf area of flag leaf (98.69 cm^2) was observed from treatment combination of T_1V_3 and the lowest (73.74 cm^2) was recorded from treatment combination of T_2V_4.

4.8 Length of panicle

Statistically significant variation ($P \leq 0.01$) was recorded for length of panicle due to different planting time (Figure 8). The longest panicle (24.44 cm) was found from T_1, whereas the shortest (22.68 cm) was observed from T_2.

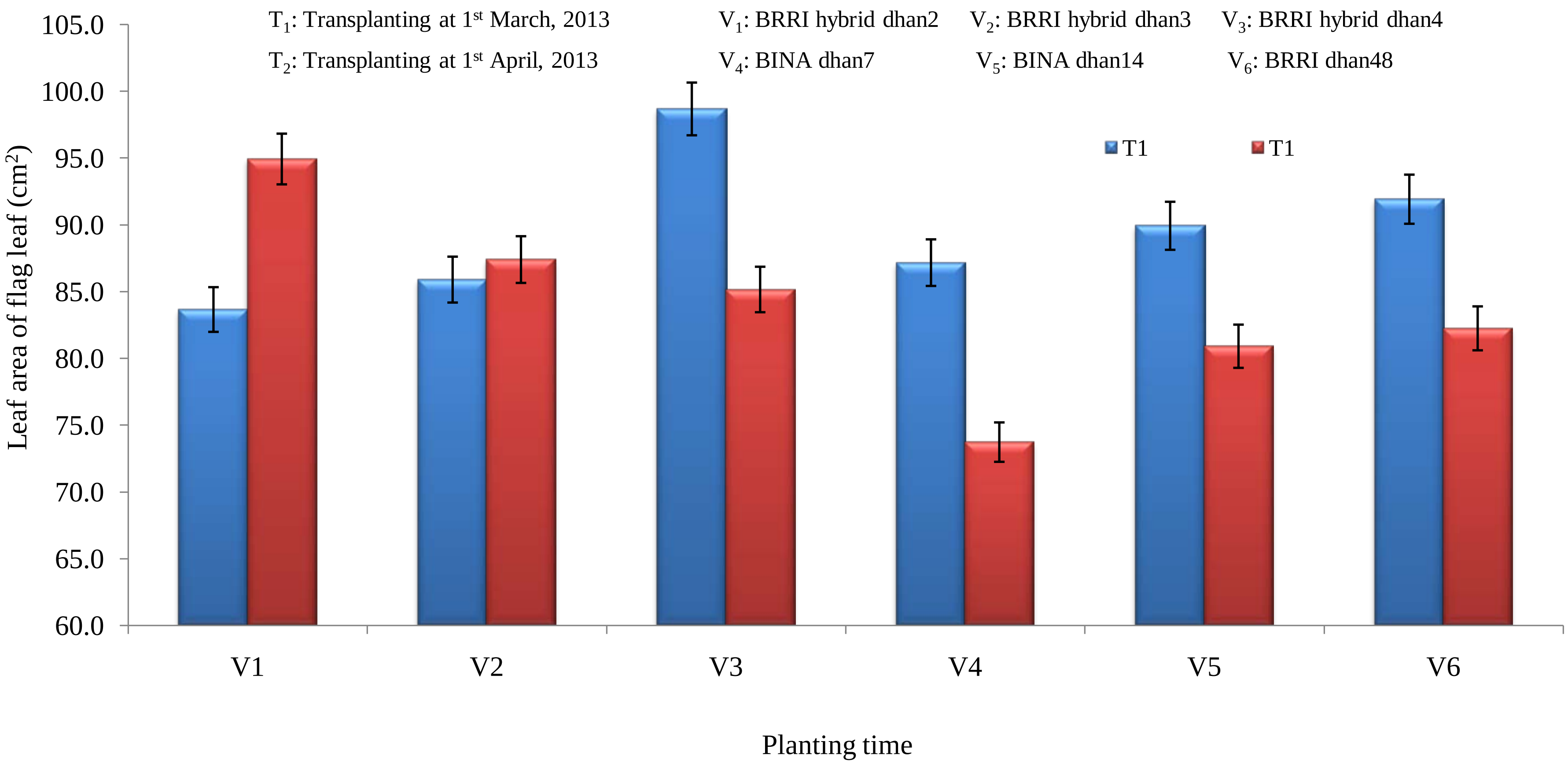

Figure 7. Interaction effect of different planting time sand rice varieties on leaf area of flag leaf. Vertical bars are LSD values at 5% level.

Length of panicle varied significantly ($P \leq 0.01$) for different rice varieties (Figure 9). The longest panicle (24.58 cm) was observed from V_3, which were statistically identical (23.89 cm, 23.78 cm and 23.74 cm) to V_5, V_1 and V_6, whereas the shortest (22.53 cm) was found from V_2. Devaraju *et al.* (1998) in a study with hybrid rice cultivar KRH2 and 1R20 as a check variety and reported that the increased grain yield of KRH2 was mainly attributed to the tallest panicle length. 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.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on length of panicle (Figure 10). The longest panicle (25.81 cm) was observed from treatment combination of T_1V_3 and the shortest (21.09 cm) was recorded from treatment combination of T_2V_4.

4.9 Total dry matter plant^{-1}

Statistically significant variation ($P \leq 0.01$) was recorded for total dry matter plant^{-1} due to different planting time (Table 6). The highest total dry matter plant^{-1} (11.68 g) was found from T_1, whereas the lowest (10.92 g) was recorded from T_2. Late planting might have exposed the crop to relatively more adverse growing environment including low temperature at reproductive phase which might pulled down the dry matter accumulation compared to those of earlier plantings (Gohain and Saikia, 1996). Hundal *et al.* (2005) observed the significant linear and exponential relationships between aboveground biomass and yield of rice and planting time had direct influence on above attributes.

Total dry matter plant^{-1} varied significantly ($P \leq 0.01$) for different rice varieties (Table 6). The highest total dry matter plant^{-1} (12.11 g) was obtained from V_3, which were followed (11.38 g, 11.31 g, 11.29 g and 11.14 g) by V_6, V_1, V_4 and V_5. On the other hand, the lowest (10.55 g) was found from V_2. Similar results also reported by Amin *et al.* (2006), Son *et al.* (1998) and Shaloie *et al.* (2014) from their earlier experiment in rice.

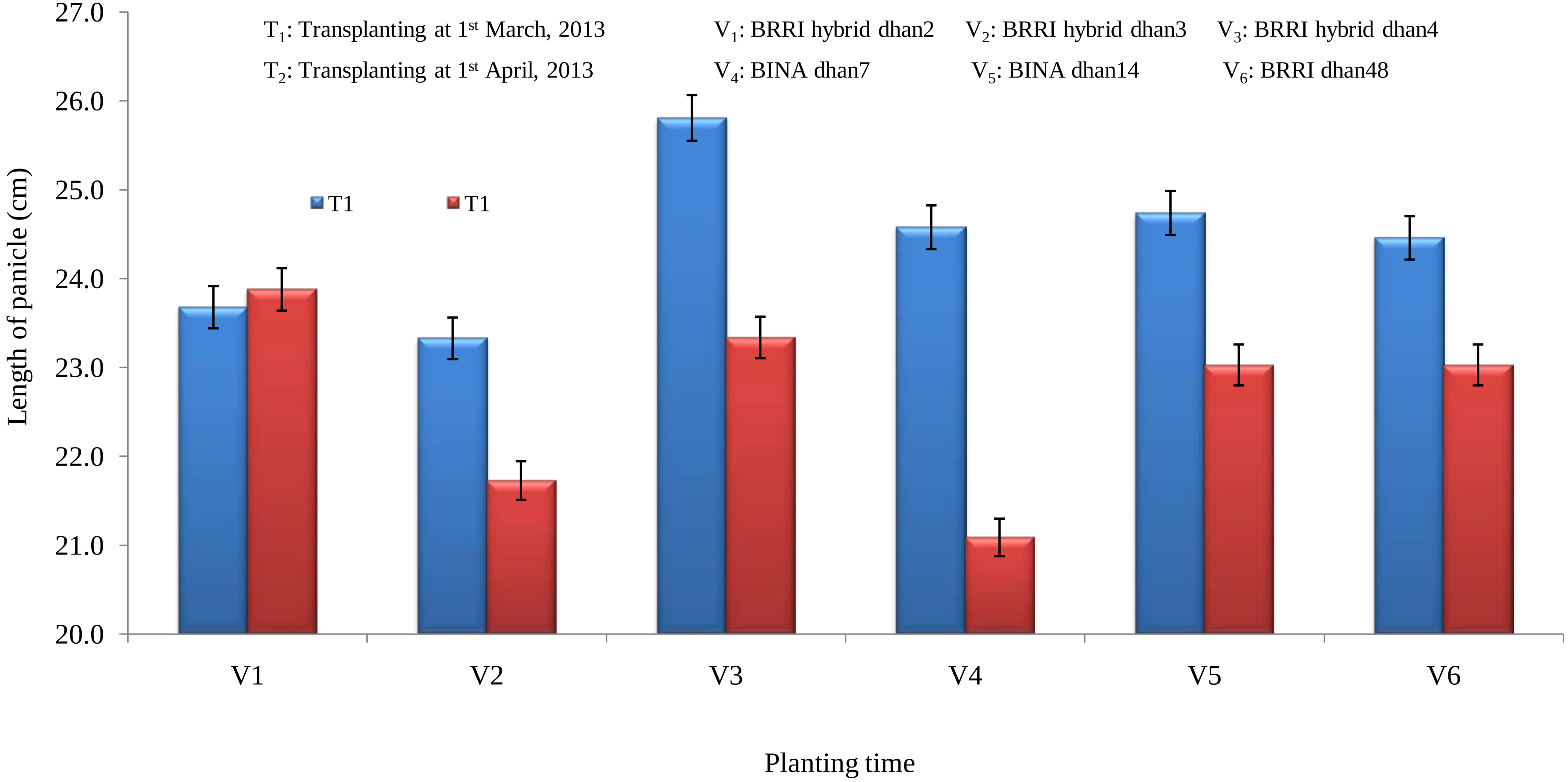

Figure 10. Interaction effect of different planting times and rice varieties on length of panicle of rice. Vertical bars are LSD values at 5% level. Vertical bars are LSD values at 5% level.

Table 6. Effect of planting times and different rice varieties on yield contributing characters and yield

Treatment	Total dry matter plant^{-1} (g)	Number of filled grain panicle^{-1}	Number of unfilled grain panicle^{-1}	Number of total grain panicle^{-1}
T_1	11.68 a	84.39 a	4.02 b	88.41 a
T_2	10.92 b	80.06 b	4.33 a	84.39 b
$LSD_{(0.05)}$	0.257	2.272	0.166	2.329
Significant level	0.01	0.01	0.01	0.01
V_1	11.31 b	87.23 ab	4.20 b	91.43 ab
V_2	10.55 c	76.47 c	4.57 a	81.03 d
V_3	12.11 a	89.10 a	3.73 c	92.83 a
V_4	11.29 b	77.00 c	4.25 b	81.25 d
V_5	11.14 b	83.90 b	4.03 b	87.93 bc
V_6	11.38 b	79.63 c	4.28 ab	83.92 cd
$LSD_{(0.05)}$	0.446	3.936	0.288	4.034
Significant level	0.01	0.01	0.01	0.01
CV(%)	7.88	4.71	6.78	4.59

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 1st March, 2013

T_2: Transplanting at 1st April, 2013

V_1: BRRI hybrid dhan2

V_2: BRRI hybrid dhan3

V_3: BRRI hybrid dhan4

V_4: BINA dhan7

V_5: BINA dhan14

V_6: BRRI dhan48

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.05$) on total dry matter plant^{-1} (Table 7). The highest total dry matter plant^{-1} (12.84 g) was found from treatment combination of T_1V_3 and the lowest (10.17 g) was observed from treatment combination of T_2V_5.

4.10 Filled grain panicle^{-1}

Statistically significant variation ($P \leq 0.01$) was recorded for filled grains panicle^{-1} due to different planting time (Table 6). The highest filled grains panicle^{-1} (84.39) was recorded from T_1, whereas the lowest (80.06) was obtained from T_2.

Filled grains panicle^{-1} varied significantly ($P \leq 0.01$) for different rice varieties (Table 6). The highest filled grains panicle^{-1} (89.10) was recorded from V_3, which were statistically identical (87.23) to V_1 and followed (83.90) by V_5, whereas the lowest (76.47) was found from V_2. Murthy *et al.* (2004) recorded different number of filled spikelets for different variety.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on filled grains panicle^{-1} (Table 7). The highest filled grains panicle^{-1} (94.80) was recorded from treatment combination of T_1V_3, while the lowest (63.13) was found from treatment combination of T_2V_4.

4.11 Unfilled grains panicle^{-1}

Statistically significant variation ($P \leq 0.01$) was recorded for unfilled grains panicle^{-1} due to different planting time (Table 6). The highest unfilled grains panicle^{-1} (4.33) was recorded from T_2, whereas the lowest (4.02) was recorded from T_1.

Unfilled grains panicle^{-1} varied significantly ($P \leq 0.01$) for different rice varieties (Table 6). The highest unfilled grains panicle^{-1} (4.57) was observed from V_2, which were statistically identical (4.28) to V_6 and followed (4.25, 4.20 and 4.03) by V_4, V_1 and V_5, while the lowest (3.73) was observed from V_3. BINA (1993) conducted an experiment with four varieties/advance lines and reported significant variation in unfilled spikelets panicle^{-1}.

Table 7. Interaction effect of planting times and different rice varieties on yield contributing characters and yield

Treatment	Total dry matter $plant^{-1}$ (g)	Number of filled grain $panicle^{-1}$	Number of unfilled grain $panicle^{-1}$	Number of total grain $panicle^{-1}$
T_1V_1	11.01 ef	84.33 cde	4.50 ab	88.83 bcd
T_1V_2	10.46 fg	76.60 fg	4.60 ab	81.20 ef
T_1V_3	12.84 a	94.80 a	3.00 d	97.80 a
T_1V_4	11.97 bc	90.87 ab	3.77 c	94.63 ab
T_1V_5	12.10 b	88.33 bcd	3.87 c	92.20 abc
T_1V_6	11.72 bcd	71.40 g	4.40 ab	75.80 f
T_2V_1	11.62 b-e	90.13 abc	3.90 c	94.03 abc
T_2V_2	10.64 fg	76.33 fg	4.53 ab	80.87 ef
T_2V_3	11.39 cde	83.40 de	4.47 ab	87.87 cd
T_2V_4	10.62 fg	63.13 h	4.73 a	67.87 g
T_2V_5	10.17 g	79.47 ef	4.20 bc	83.67 de
T_2V_6	11.04 def	87.87 bcd	4.17 bc	92.03 abc
$LSD_{(0.05)}$	0.630	5.566	0.407	5.706
Significant level	0.05	0.01	0.01	0.01
CV(%)	7.88	4.71	6.78	4.59

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 1st March, 2013

T_2: Transplanting at 1st April, 2013

V_1: BRRI hybrid dhan2

V_2: BRRI hybrid dhan3

V_3: BRRI hybrid dhan4

V_4: BINA dhan7

V_5: BINA dhan14

V_6: BRRI dhan48

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on unfilled grains panicle^{-1} (Table 7). The highest unfilled grains panicle^{-1} (4.73) was observed from treatment combination of T_2V_4 again the lowest (3.00) was recorded from treatment combination of T_1V_3.

4.12 Total grains panicle^{-1}

Statistically significant variation ($P \leq 0.01$) was recorded for total grains panicle^{-1} due to different planting time (Table 6). The highest total grains panicle^{-1} (88.41) was found from T_1, whereas the lowest (84.39) was recorded from T_2. Islam *et al.* (2008) reported that direct wet-seeded rice produced 10% higher grain yield than transplanted rice and 31 December seeded rice produced the highest grain yield. Rice planted on 1 December significantly reduced the grains per panicle and January planted rice significantly reduced the panicle per unit area.

Total grains panicle^{-1} varied significantly ($P \leq 0.01$) for different rice varieties (Table 6). The highest total grains panicle^{-1} (92.83) was attained from V_3, which were statistically identical (91.43) to V_1 and followed (87.93) by V_5, whereas the lowest (81.03) was observed from V_2.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on total grains panicle^{-1} (Table 7). The highest total grains panicle^{-1} (97.80) was found from treatment combination of T_1V_3 and the lowest (67.87) was observed from treatment combination of T_2V_4.

4.13 Weight of 1000 seeds

Statistically significant variation ($P \leq 0.01$) was recorded for weight of 1000 seeds due to different planting time (Figure 11). The highest weight of 1000 seeds (25.50 g) was found from T_1, whereas the lowest weight (24.13 g) was recorded from T_2. Alim *et al.*, 1993 reported that better results are obtained from early transplanting than late transplanting.

Weight of 1000 seeds varied significantly ($P \leq 0.01$) for different rice varieties (Figure 12). The highest weight of 1000 seeds (25.67 g) was recorded from V_1, which were statistically identical (25.59 g, 25.33 g and 25.17 g) to V_3, V_5 and V_6. On the other hand, the lowest weight (23.22 g) was observed from V_2. 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 and observed that IR36 gave the highest 1000-grain weight (21.07g).

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on weight of 1000 seeds (Figure 13). The highest weight of 1000 seeds (27.75 g) was found from treatment combination of T_1V_3 and the lowest (22.28 g) was recorded from treatment combination of T_2V_2.

4.14 Grain yield

Statistically significant variation ($P \leq 0.01$) was recorded for grain yield due to different planting time (Table 8). The highest grain yield (6.88 t ha^{-1}) was observed from T_1, whereas the lowest (6.09 t ha^{-1}) was recorded from T_2. These results agrees with the results of Nafziger (1994), in that an optimum planting date exists and the planting before or after that optimum results in yield reduction of crops. Singh *et al.,* 1995; Patel *et al.,* 1987 reported that grain yield of rice markedly declined with delayed planting.

Grain yield varied significantly ($P \leq 0.01$) for different rice varieties (Table 8). The highest grain yield (7.19 t ha^{-1}) was observed from V_3, which were statistically identical (6.98 t ha^{-1}) to V_1 and followed (6.76 t ha^{-1}) by V_2, whereas the lowest (5.74 t ha^{-1}) was observed from V_2. Swain *et al*. (2006) reported that the control cultivar IR64, with high translocation efficiency and 1000-grain weight and lowest spikelet sterility recorded a grain yield of 5.6 t ha^{-1} that was statistically similar to the hybrid line PA6201. Xie *et al.* (2007) reported different yield for different variety.

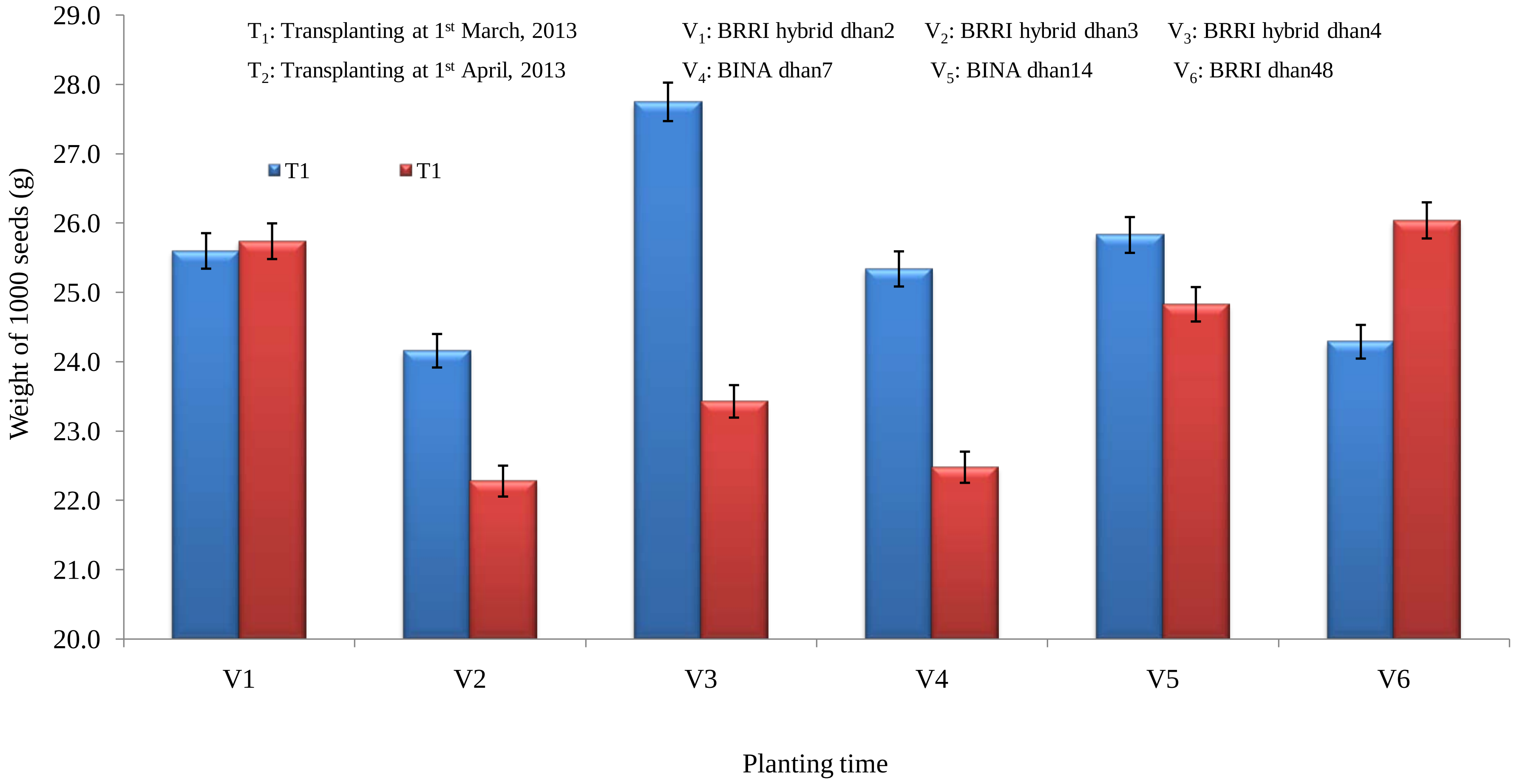

Figure 13. Interaction effect of different planting times and rice varieties on weight of 1000 seeds of rice. Vertical bars are LSD values at 5% level.

Table 8. Effect of planting times and different rice varieties on yield contributing characters and yield

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1	6.88 a	8.15 a	15.03 a	45.77
T_2	6.09 b	7.41 b	13.50 b	45.07
$LSD_{(0.05)}$	0.193	0.250	0.355	--
Significant level	0.01	0.01	0.01	NS
V_1	6.98 ab	8.28 ab	15.26 a	45.74 a
V_2	6.76 b	7.87 bc	14.63 b	46.28 a
V_3	7.19 a	8.34 a	15.53 a	46.36 a
V_4	5.74 d	7.50 cd	13.24 cd	43.30 b
V_5	6.35 c	7.49 cd	13.84 c	45.86 a
V_6	5.89 d	7.20 d	13.09 d	45.00 a
$LSD_{(0.05)}$	0.334	0.433	0.615	1.691
Significant level	0.01	0.01	0.01	0.01
CV(%)	5.06	5.46	4.23	5.66

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 1st March, 2013

T_2: Transplanting at 1st April, 2013

V_1: BRRI hybrid dhan2

V_2: BRRI hybrid dhan3

V_3: BRRI hybrid dhan4

V_4: BINA dhan7

V_5: BINA dhan14

V_6: BRRI dhan48

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on grain yield (Table 9). The highest grain yield (8.00 t ha^{-1}) was found from treatment combination of T_1V_3 and the lowest (5.29 t ha^{-1}) was recorded from treatment combination of T_2V_4.

4.15 Straw yield

Statistically significant variation ($P \leq 0.01$) was recorded for straw yield due to different planting time (Table 8). The highest straw yield (8.15 t ha^{-1}) was recorded from T_1, whereas the lowest (7.41 t ha^{-1}) was recorded from T_2.

Straw yield varied significantly ($P \leq 0.01$) for different rice varieties (Table 8). The highest straw yield (8.34 t ha^{-1}) was observed from V_3, which were statistically identical (8.28 t ha^{-1}) to V_1 and followed (7.87 t ha^{-1}) by V_2. On the other hand, the lowest (7.20 t ha^{-1}) was observed from V_6. Dongarwar *et al.* (2003) reported differences for different genotypes of rice.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on straw yield (Table 9). The highest straw yield (9.35 t ha^{-1}) was observed from treatment combination of T_1V_3, while the lowest (6.81 t ha^{-1}) was recorded from treatment combination of T_2V_4.

4.16 Biological yield

Statistically significant variation ($P \leq 0.01$) was recorded for biological yield due to different planting time (Table 8). The highest biological yield (15.03 t ha^{-1}) was observed from T_1, while the lowest (13.50 t ha^{-1}) was found from T_2. Kainth and Mehra, 1985 reported that when transplanting is delayed beyond normal period, the grain development is very poor which results in more quantity of under developed grains and ultimately severe reduction in yield.

Biological yield varied significantly ($P \leq 0.01$) for different rice varieties (Table 8). The highest biological yield (15.53 t ha^{-1}) was recorded from V_3, which were statistically identical (15.26 t ha^{-1}) to V_1 and followed (14.63 t ha^{-1}) by V_2, whereas the lowest (13.09 t ha^{-1}) was found from V_6.

Table 9. Interaction effect of planting times and different rice varieties on yield contributing characters and yield

Treatment	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
T_1V_1	7.12 b	8.47 b	15.59 b	45.66 ab
T_1V_2	6.90 bc	8.14 bc	15.04 bc	45.87 ab
T_1V_3	8.00 a	9.35 a	17.35 a	46.11 ab
T_1V_4	6.19 ef	8.20 bc	14.39 cd	42.93 c
T_1V_5	6.74 bcd	7.90 bcd	14.64 cd	46.01 ab
T_1V_6	6.33def	6.87 fg	13.20 e	48.06 a
T_2V_1	6.84 bcd	8.09 bc	14.93 bc	45.81 ab
T_2V_2	6.62 b-e	7.59 cde	14.22 cd	46.69 a
T_2V_3	6.39 c-f	7.33 d-g	13.72 de	46.62 a
T_2V_4	5.29 g	6.81 g	12.10 f	43.66 bc
T_2V_5	5.95 f	7.09 efg	13.04 e	45.70 ab
T_2V_6	5.45 g	7.53 c-f	12.97 e	41.94 c
$LSD_{(0.05)}$	0.473	0.612	0.869	2.391
Significant level	0.01	0.01	0.01	0.05
CV(%)	5.06	5.46	4.23	5.66

In a column, mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 1st March, 2013

T_2: Transplanting at 1st April, 2013

V_1: BRRI hybrid dhan2

V_2: BRRI hybrid dhan3

V_3: BRRI hybrid dhan4

V_4: BINA dhan7

V_5: BINA dhan14

V_6: BRRI dhan48

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.01$) on biological yield (Table 9). The highest biological yield (17.35 t ha^{-1}) was attained from treatment combination of T_1V_3 again the lowest (12.10 t ha^{-1}) was found from treatment combination of T_2V_4.

4.17 Harvest index

Statistically non significant variation ($P \leq 0.05$) was recorded for harvest index due to different planting time (Table 8). The highest harvest index (45.77%) was observed from T_1, whereas the lowest (45.07%) was recorded from T_2.

Harvest index varied significantly ($P \leq 0.01$) for different rice varieties (Table 8). The highest harvest index (46.36%) was recorded from V_3, which were statistically identical (46.28%, 45.86%, 45.74% and 45.00%) to V_2, V_5, V_1 and V_6, while the lowest (43.30%) was found from V_4.

Interaction effect of different planting times and rice varieties showed significant variation ($P \leq 0.05$) on harvest index (Table 9). The highest harvest index (48.06%) was obtained from treatment combination of T_1V_6. On the other hand, the lowest (41.94%) was found from treatment combination of T_2V_6.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to July 2013 to study the influence of planting times on morpho-physiological and yield attributes of hybrid rice varieties in *Aus* season. The experiment comprised of two factors. Factor A: Transplanting time: 2 dates- T_1: Transplanting at 1st March, 2013, T_2: Transplanting at 1st April, 2013 and Factor B: Different rice varieties: 6 rice varieties- V_1: BRRI hybrid dhan2, V_2: BRRI hybrid dhan3, V_3: BRRI hybrid dhan4, V_4: BINA dhan7, V_5: BINA dhan14 and V_6: BRRI dhan48 (check). The experiment was laid out in two factor Randomized Complete Block Design with four replications. Data on different yield contributing characters and yield were recorded and significant variation was observed.

For planting times, at 30, 50, 70 DAT and harvest, the tallest plant (29.37, 62.19, 92.81 and 113.26 cm, respectively) were recorded from T_1, whereas the shortest plant (27.84, 58.40, 89.22 and 109.08 cm, respectively) from T_2. At 30, 50, 70 DAT and harvest, the maximum number of total tillers hill^{-1} (4.61, 8.32, 12.77 and 13.31, respectively) were found from T_1, while the minimum number (4.04, 7.46, 11.91 and 12.89, respectively) from T_2. The maximum number of effective tillers hill^{-1} (11.89) was observed from T_1, whereas the minimum number (11.13) was found from T_2. The minimum number of non-effective tillers hill^{-1} (1.42) was recorded from T_1, whereas the maximum number (1.76) from T_2. The maximum days to maturity (127.87) was recorded from T_1, whereas the minimum days (122.45) was recorded from T_2. The highest leaf area of flag leaf (89.55 cm^2) was recorded from T_1, while the lowest (84.07 cm^2) was recorded from T_2. The longest panicle (24.44 cm) was found from T_1, whereas the shortest (22.68 cm) was observed from T_2. The highest total dry matter plant^{-1} (11.68 g) was found from T_1, whereas the lowest (10.92 g) was recorded from T_2. The highest filled grains panicle^{-1} (84.39) was recorded from T_1, whereas the lowest (80.06) was obtained from T_2. The highest unfilled grains panicle^{-1} (4.33) was recorded from T_2, whereas the lowest (4.02) was recorded from T_1. The highest total grains panicle^{-1} (88.41) was found from T_1, whereas the lowest (84.39) was recorded from T_2. The highest weight of 1000 seeds (25.50 g) was found from T_1, whereas the lowest weight (24.13 g) was recorded from T_2. The highest grain yield (6.88 t ha^{-1}) was observed from T_1, whereas the lowest (6.09 t ha^{-1}) was recorded from T_2. The highest straw yield (8.15 t ha^{-1}) was recorded from T_1, whereas the lowest (7.41 t ha^{-1}) was recorded from T_2. The highest biological yield (15.03 t ha^{-1}) was observed from T_1, while the lowest (13.50 t ha^{-1}) from T_2. The highest harvest index (45.77%) was observed from T_1, whereas the lowest (45.07%) from T_2.

In case of different rice varieties, at 30, 50, 70 DAT and harvest, the tallest plant (30.40, 62.84, 93.73 and 113.46 cm, respectively) were observed from V_3, while the shortest plant (27.09, 55.32, 87.60 and 106.42 cm, respectively) were observed from V_2. At 30, 50, 70 DAT and harvest, the maximum number of total tillers hill^{-1} (4.77, 8.80, 13.20 and 13.37, respectively) were recorded from V_3, again the minimum number (4.13, 7.53, 11.67 and 12.07, respectively) were obtained from V_2. The maximum number of effective tillers hill^{-1} (12.03) was observed from V_3 and the minimum number (10.30) was observed from V_2. The minimum number of non-effective tillers hill^{-1} (1.33) was found from V_3, whereas the maximum number (1.80) was obtained from V_1. The maximum days to maturity (142.50) was found from V_1, while the minimum days (111.68) was recorded from V_6. The highest leaf area of flag leaf (91.93 cm^2) was observed from V_3, again the lowest (80.46 cm^2) was observed from V_4. The longest panicle (24.58 cm) was observed from V_3, whereas the shortest (22.53 cm) was found from V_2. The highest total dry matter plant^{-1} (12.11 g) was obtained from V_3 and the lowest (10.55 g) was found from V_2. The highest filled grains panicle^{-1} (89.10) was recorded from V_3, whereas the lowest (76.47) was found from V_2. The highest unfilled grains panicle^{-1} (4.57) was observed from V_2, while the lowest (3.73) was observed from V_3. The highest total grains panicle^{-1} (92.83) was obtained from V_3, whereas the lowest (81.03) was observed from V_2. The highest weight of 1000 seeds (25.67 g) was recorded from V_1 and the lowest weight (23.22 g) from V_2. The highest grain yield (7.19 t ha^{-1}) was observed from V_3, whereas the lowest (5.74 t ha^{-1}) was observed from V_2. The highest straw yield (8.34 t ha^{-1}) was observed from V_3, and the lowest (7.20 t ha^{-1}) from V_6. The highest biological yield (15.53 t ha^{-1}) was recorded from V_3, whereas the lowest (13.09 t ha^{-1}) from V_6. The highest harvest index (46.36%) was recorded from V_3, while the lowest (43.30%) from V_4.

Due to the interaction effect of planting time and different varieties, at 30, 50, 70 DAT and harvest, the tallest plant (32.46, 67.94, 97.29 and 118.24 cm, respectively) was observed from treatment combination of T_1V_3 and the shortest plant (24.12, 53.72, 84.93 and 105.26 cm) was recorded from treatment combination of T_2V_4. At 30, 50, 70 DAT and harvest, the maximum number of total tillers $hill^{-1}$ (5.40, 9.80, 14.20 and 14.24, respectively) were found from treatment combination of T_1V_3, whereas the minimum number (3.80, 6.93, 11.00 and 12.33, respectively) was recorded at 30, 50, 70 DAT and harvest, respectively from treatment combination of T_2V_4. The maximum number of effective tillers $hill^{-1}$ (13.07) was found from treatment combination of T_1V_3, while the minimum number (10.20) was observed from treatment combination of T_2V_2. The minimum number of non-effective tillers $hill^{-1}$ (1.13) was found from treatment combination of T_1V_3 and the minimum number (1.95) was observed from treatment combination of T_2V_6. The maximum days to starting of panicle emergence (86.67) was found from treatment combination of T_2V_1, while the minimum days (61.67) was recorded from treatment combination of T_2V_4. The maximum days to maturity (149.17) was obtained from treatment combination of T_2V_1 and the minimum days (110.00) was found from treatment combination of T_2V_5. The highest leaf area of flag leaf (98.69 cm^2) was observed from treatment combination of T_1V_3 and the lowest (73.74 cm^2) was recorded from treatment combination of T_2V_4. The longest panicle (25.81 cm) was observed from treatment combination of T_1V_3 and the shortest (21.09 cm) was recorded from treatment combination of T_2V_4. The highest total dry matter plant^{-1} (12.84 g) was found from treatment combination of T_1V_3 and the lowest (10.17 g) was observed from T_2V_5. The highest filled grains panicle^{-1} (94.80) was recorded from treatment combination of T_1V_3, while the lowest (63.13) was found T_2V_4. The highest unfilled grains panicle^{-1} (4.73) was observed from treatment combination of T_2V_4 again the lowest (3.00) was recorded from T_1V_3. The highest total grains panicle^{-1} (97.80) was found from T_1V_3 and the lowest (67.87) was observed from T_2V_4. The highest weight of 1000 seeds (27.75 g) was found from T_1V_3 and the lowest (22.28 g) was recorded from T_2V_2. The highest grain yield (8.00t ha^{-1}) was found from treatment combination of T_1V_3 and the lowest (5.29 t ha^{-1}) was recorded T_2V_4. The highest straw yield (9.35 t ha^{-1}) was observed from treatment combination of T_1V_3, while the lowest (6.81 t ha^{-1}) was recorded from T_2V_4. The highest biological yield (17.35 t ha^{-1}) was obtained from T_1V_3 again the lowest (12.10 t ha^{-1}) was found from T_2V_4. The highest harvest index (48.06%) was obtained from treatment combination of T_1V_6. On the other hand, the lowest (41.94%) was found from T_2V_6.

From the above results it can be concluded that-

- BRRI hybrid dhan4 and BRRI hybrid dhan2 provided better yield than the other varieties.
- Planting at 1st March provided best yield for most of the varieties

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

- Future study may be carried out with different hybrid and inbreed rice varieties in different planting times.
- Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performances.

REFERENCES

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

Ahmed, M. R., Rashid, M. A., Alam, M. S., Billah, K. A. and Jameel, F. (1997). Performance of Eight Transplant Aman Rice Varieties under Irrigated Conditions. *Bangladesh Rice J.,* **8**(1&2): 43-44.

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. Thesis Dept. Agron. B.A.U, Mymensingh.

Akram, H.M., Ali, A., Nadeem, M. A. and Iqbal, M. S. (2004). Yield and yield components of rice varieties as affected by transplanting dates. *Pakistan J. Agron*., **3**: 501-509.

Ali , M. G., Mannan, M. A., Halder, K. P. and Siddique, S. B. (1993). Effect of planting dates on the growth and yield of modern transplanted *aman* rice. *Annals Bangladesh Agric*., **3**(2): 103-108.

Alim, M. G., Mannan, M.A., Halder, K. P. and Siddique, S. B. (1993). Effect of planting dates on the growth and yield of modern transplanted aman rice. *Ann. Bangladesh Agric*., 32: 103-108.

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. *Intl. J. Suatain*. *Crop Prod*., **1**(1): 17-20.

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

BBS (Bangladesh Bureau of Statistics). (2008). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Stat. Div., Min. Plan. Govt. of the Peoples Republic 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. (1993). Annual Report (1992-93). Bangladesh Inst. Nucl. Agric. P.O. Box No. 4. Mymensingh. p. 143-147.

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). (2013). Adhunik Dhaner Chash. Joydebpur, Dhaka. p. 80.

BRRI. (1985). Annual report for 1982. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. BRRI pub. No. 79. p. 236-238.

BRRI. (1991). Annual Report for 1988. Bangladesh Rice Res. Inst., Joydebpur, Gazipur. p. 8-15.

BRRI. (1994). Annual Report for 1993. Bangladesh Rice Res. Inst., Jodebpur, Gazipur. p. 8-9.

BRRI. (1995). Adhunik Dhaner Chash (in bengali). Pub no. Bangladesh Rice Res. Inst., Joydebpur, Gazipur. p. 12, 20-21, 23.

BRRI. (1997). Adhunik Dhaner Chash (in bengali). Bangladesh Rice Res. Inst., Joydebpur, Gazipur. p. 15-18.

Calpe, C. and Prakash, A. (2007). Sensitive and Special Products-a rice perspective. Commodity Market Review, FAO. p. 49-71.

Castillo, A.G., Hampton J. G. and Coolbear, P. (1994). Effect of sowing dates and harvest timing on seed vigor in garden pea (*Pisum sativum* L.). *New Zealand J. Crop and Hort Sci*., **22**: 91-95.

Chandra, B. V., Mahedvappa, M., Krishnamurthy, A. H. and Bhaskar, V. (1992). Performance of IRRI rice hybrids in Mandya, Karnataka, India. *Intl. Rice Res. Newsl*., **17**(2): 6.

Chen-Liang, Sun, C. Q., Li, Z. C. Wang, X. K. (2000). Study on heterotic ecotype of two-line japonica hybrid rice in north China. *J. China Agric. Univ*., **5**(3): 30-40.

Chowdhury, M. T. U., Sarker, A. U., Sarker, M. A. R. and Kashem, 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.

Chowdhury, S. A., Majid, M. A., Huque, K. S., Islam, M. and Rahman, M. M. (1995). Effect of variety on yield and nutritive value of rice straw. *Asian-Australasian J. Ani. Sci*., **8**(4): 329-335.

Costa, D. J. and Hoque, M. N. (1986). Superimposed variety trial on T. *aman* [Transplanted rice in Bangladesh]. Proc. Central Review Workshop, On-Farm Research Div. Jul. 5-10. BARI., Joydebpur, Bangladesh. p. 25-26.

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

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 Yearbook for 1988. FAO, UN. Rome, Italy. p. 118.

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

Farrell, T. C., Fukai S., and Williams, R. L. (2006). Minimising cold damage during reproductive development among temperate rice genotypes. I. Avoiding low temperature with the use of appropriate sowing time and photoperiod-sensitive varieties. CSIRO Publishing. Collingwood. Australia.

Gohain, T. and L. Saikia. (1996). Effect of date of transplanting on growth and yield of rainfed low rice (*Oryza sativa*). *Indian J. Agron*., **41**: 488-490.

Gomez K. A, Gomez A. A. (1984). Statistical procedure for agricultural research. International Rice Research Institute. *John Wiley and Sons*, New York, 139-240.

Gosh, D. C. and Singh, B. P. (1998). Crop growth modeling for wetland rice management. *Environ and Ecol*., **16**: 446-449.

Guilani, A. A., Siadat, S. A. and Fathi, G. (2003). Effect of plant density and seedling age on yield and yield components in 3 rice cultivars in Khusestan growth conditions. *Iranian J. Agric. Sci*., **34**(2): 427-438.

Haque, M. E., Baset, A., Zeenat Z. and Miah, N. M. (1991). Path coefficient analysis of seven characters in local tolerant rice. *Bangladesh Rice J*., **2**: 1-7.

Hedayetullah, S., Sen, S. and Nair, K. R.. (1994). A Statistical Note of Agriculture Workers. No. 20. Influence of dates of planting and spacing on some winter varieties of rice. *Indian J. Agril. Sci*., **14**:148-159.

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. *Japan. J. Trop. Agric*., **50**: 190-198.

Horie, T. (2001). Increasing yield potential in irrigated rice: breaking the yield barrier. International Rice Research Institute (IRRI). Manila, Philippines.

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*) Varieties at Different Transplanting Dates in *Aus* Season. *App. Sci. Report,* **1**(1): 1-4.

Hossain, S. M. A. and Alam, A. B. M. N. (1991). Productivity of cropping pattern of participating farmers. In: Fact searching and Intervention in two FSRDP Sites, Activities. Farming system Research and Development Programme, BAU, Mymensingh, Bangladesh. p. 41-44.

Hundal, S. S., Kaur, P. and Dhaliwa L. K. (2005). Growth and yield response of rice (*Oryza sativa*) in relation to temperature, photoperiod and sunshine duration in Punjab. *Association of Agrometeorologists*. Anand. India.

Idris, M. and Matin, M. A. (1990). Response of four exotic strains of *aman* rice to urea. *Bangladesh J. Agric. Assoc. China*. **118**: 48-61.

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

Islam, M. F., Sarkar, M.A.R., Abedin, M. Z., Razzaque M. A. and Parveen, S. (2008). Effects of date of planting using drum seeder on growth and yield of *boro* rice. *Bangladesh J. Agril. Res*., **33**: 19-29.

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.

Jagadish, S. V. K., Craufurd, P. Q and Wheeler, T. R. (2007). High temperature stress and spikelet fertility in rice (*Oryza sativa* L.). Oxford University Press. Oxford. UK.

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.

Jhoun, H. R. K. (1989). Effect of time of planting and age of seedling on growth and yield of dwarf rice. *Indian J. Agron*., **34**: 325-327.

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 Use and Development of Hybrid Rice in Bangladesh, held at BARC, 18-19, May, 1998.

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.

Kainth, G. S. and Mehra, P. L. (1985). Rice Production: Potentials and Constraints. Inter India Publication. New Delhi 110015.

Kamal, A. M. A., Azam, M. A. and Islam, M. A. (1988). Effect of cultivar and NPK combinations on the yield contributing characters of rice. *Bangladesh J. Agril. Sci.*, **15**(1): 105-110.

Kanfany, G., El-Namaky, R., Ndiaye, K., Traore, K. and Ortiz, R. (2014). Assessment of Rice Inbred Lines and Hybrids under Low Fertilizer Levels in Senegal. *Sustainability*. **6**: 1153-1162.

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.

Langfield, E. C. B. and Basinski, J. J. (1960). The effect of time of planting on the behavior of rice varieties in northern Australia. *Tropical Agric. Thrim*., **37**: 383-392.

Linscombe, S. D., Jordan, D. L., Burns A. B. and Viator, R. P. (2004). Rice response to planting date differs at two locations in Louisiana. *Crop Management Doi*., **10**: 1094.

Liu, X. (1995). You 92: new hybrid rice for late season. *Chinses Rice Res. Newsl*., **3**(2): 12.

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

Marwat, K. B., Tahir, M., Khan D. K. and Swati, M. S. (1994). Path coefficient analysis in rice (*Oryza sativa* L.). *Sarhad J. Agric*., **10**: 547- 551.

Masum, M. (2009). Impact of hybrid rice on Bangladesh. In: 'The Guardian". P. 56-58.

Masum, S. M., Ali, M. H. and Ullah, J. (2008). Growth and yield of two T. aman rice varieties as affected by seedling number per hill and urea supper granules. *J. Agric. Educ. Technol*., **11**(1&2): 51-58.

Matsushima, S. (1957). Analysis of developmental factors determining yield and yield prediction in low land rice. Bull. *Natl. Inst. Agril. Sci. Series*. **5**: 1-271.

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.

Molla, M. A. H. (2001). Influence of seedling age and number of seedling 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.

Nayak, B.C., Dalei, B. B. and Choudhury, B. K.. (2003). Response of hybrid rice (*Oryza sativa*) to date of planting, spacing and seedling rate during wet season. *Indian J. Agron*., **48**: 172-174.

Nematzadeh, G. A., Arefi, H. A., Amani, R and Mahi, B. C.. (1997). Release of a new variety of rice, namely “Nemat” with superiority in yield and quality. *Iranian J. Agric. Sci*., **28**(4): 79-86.

Obulamma , U., Reddy, M. R. and Kumari, C. R. (2004). Effect of spacing and number of seedlings per hill on yield attributes and yields of hybrid rice. *Madras Agric. J*., **91**(4-6): 344-347.

Padmavathi, N., Mahadevappa M. and Reddy, O. U. K. (1996). Association of various yield components in rice (Oryza sativa L.). *Crop Res. Hisar*. **12**: 353- 357.

Panwar, D. V. S., Bansal, M. P. and Madupuri, R. (1989). Correlatively and path coefficient analysis in advanced breeding lines of rice. *Oryza*. 26: 396-398.

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

Rafey, A., Khan, P. A. and Srivastava, V. C. (1989). Effect of Nitrogen on growth, yield and nutrient uptake of upland rice. *Indian J. Agron*., **34**(2):133-135.

Rahman, M. A. (2003). Effect of levels of USG and depth of placement on the growth and yield of transplant *aman* rice. M.S. Thesis, Dept. Agron, Bangladesh Agril. Univ. Mymensingh. p. 100.

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.

Saha Ray, P. K., Nahar, K., Ahmed, H. U., Miah, N. M. and Islam, M. A. (1993). Genetic variability and character association in irrigated rice Bang. *J. Plant Breed. Genet*. **6**: 69-74.

Salam, M. A., Ali, F., Anwar, M. P. and Bhuia, M. S. U. (2004). Effect of level of nitrogen and date of transplanting on the yield and yield attributes of transplanted *aman* rice under SRI method. *J. Bangladesh Agril. Univ.*, **2**: 31-36.

Salem, A. K. M., ElKhoby, W. M., Abou-Khalifa, A. B. and Ceesay, M. (2011). Effect of Nitrogen Fertilizer and Seedling Age on Inbred and Hybrid Rice Varieties. *American-Eurasian J. Agric. & Environ. Sci*., **11**(5): 640-646**.**

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.

Sarkar, R. K and Reddy, J. N. (2006). Response of lowland rice (*Oryza sativa*) cultivars to different sowing dates during rainy season. Indian Council of Agricultural Research. New Delhi. India.

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

Shaloie, M., Gilani, A. and Siadat, S. A. (2014). Evaluation of sowing date effect on hybrid rice lines production in dry-bed of Khuzestan. *Intl. Res. J. Appl. Basic Sci*., **8**(7): 775-779.

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.

Shimono, H., Okada, M., Kanda, E. and Arakawa, I. (2007). Low temperature-induced sterility in rice: evidence for the effects of temperature before panicle initiation. Elsevier. Amsterdam. Netherlands.

Singh, S. and Gangwer, B. (1989). Comparative studies on production potentials in traditional tall and improved rice cultivars. *J. Andaman Sci. Assoc*., **5**(1): 81-82.

Singh, S. K. and Modgal, Y. P. (2005) Effect of nitrogen, copper and magnesium fertilization on yield and nutrition of rice. *Pakistan J. Sci. Ind. Res*., **45**(2): 102-107.

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.

Sun, Y. F., Liang, J. M., Ye, J. and Zhu, W. Y. (1999). Cultivation of super-highe yielding rice plants. *China Rice*. **5**: 38-39.

Suprihatno, B. and Sutaryo, B. (1992). Yield performance of some new rice hybrids varieties in Indonesia. *Int. Rice Res. Newsl*., **17**(3):12.

Surek, H., Korkut, Z. K. and Bilgin, O. (1998). Correlation and path analysis for yield and yield components in rice in a 8-parent half diallel set of crosses. *Oryza*. **35**: 15- 18.

Swain, P., Annie, P. and Rao, K. S. (2006). Evaluation of rice (Oryza sativa) hybrids in terms of growth and physiological parameters and their relationship with yield under transplanted condition. *Indian J. Agric. Sci*., **76**(8): 496-499.

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

Takahashi, J.K., P.K. Chnomai, C. Veugsa and P. Kransaerindh. (1967). Increasing the yields of photosensitive varieties by modifying their cultural practices. *IRC. Newsl*., **16**: 39-44.

Thakur, D. S. and Patel, S. R. (1998). Response of split application of nitrogen on rice (*Oryza sativa L*.) with and without farm yard manure in inceptisols. *Environ. Ecol*., **16**(2): 310-313.

Vergera, B. S. and Chang, T. T. (1985). The flowering response of the rice plant to photoperiod: a review of the literature. Los Banos: International Rice Research Institute. P. 61.

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.

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, Z. J., Zhong, X. L., Wei, W., Ru, T. X., Hao, R. Y. and Lin, L. Z. (2006). Effect of temperature on yield and quality of aromatic rice. South China Agricultural University. Guangzhou. China.

Yoshida, S. (1981). Fundamentals of Rice Crop Science, IRRI, Philipines. pp. 1-41.

Zaman, S. M. H. (1986). Current status and prospects for rainfed food grain production in Bangladesh. BRRI, Gazipur, pp.5-6.

Zheng, J. C., Jing, S., Sheng. T. R. Lin, S. C. and Gen, C. L. (2007). Regularity of high temperature and its effects on pollen vigor and seed setting rate of rice in Nanjing and Anqing. Jiangsu Academy of Agricultural Sciences. Nanjing. China. p. 56.

APPENDICES

Appendix I. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

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

B. Physical and chemical properties of the initial soil

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

Source: SRDI, 2012

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from February to July 2013

Month (2013)	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
February	21.5	15.4	65	00
March	23.2	16.5	64	12
April	26.2	18.1	61	88
May	27.0	19.2	63	54
June	27.1	16.7	67	145
July	29.3	18.9	73	213

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on plant height at different days after transplanting (DAT) and at harvest as influenced by different planting times and rice varieties

Source of variation	Degrees of freedom	Mean square Plant height (cm) at			
		30 DAT	50 DAT	70 DAT	Harvest
Replication	3	0.028	3.706	4.165	0.993
Planting time (A)	1	28.031**	172.555**	154.604**	209.901**
Rice varieties (B)	5	13.222**	53.562**	37.160**	47.875**
Interaction (A×B)	5	26.827**	89.805**	38.842**	75.941**
Error	33	2.194	9.226	6.446	7.810

**: Significant at 0.01 level of probability:

Appendix IV. Analysis of variance of the data on number of tillers hill^{-1} at different days after transplanting (DAT) and at harvest as influenced by different planting times and rice varieties

Source of variation	Degrees of freedom	Mean square Number of tillers hill^{-1}			
		30 DAT	50 DAT	70 DAT	Harvest
Replication	3	0.021	0.010	0.021	0.080
Planting time (A)	1	3.851**	9.011**	8.784**	2.139**
Rice varieties (B)	5	0.446**	1.791**	2.156**	2.293**
Interaction (A×B)	5	0.479**	1.166*	2.142**	1.897**
Error	33	0.046	0.298	0.318	0.255

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on yield contributing characters of rice as influenced by different planting times and rice varieties

Source of variation	Degrees of freedom	Mean square					
		Number of effective tiller $hill^{-1}$	Number of non effective tiller $hill^{-1}$	Days to starting panicle emergence	Days to maturity	Leaf area of flag leaf (cm^2)	Length of panicle (cm)
Replication	3	0.083	0.003	3.685	6.004	9.304	0.275
Planting time (A)	1	6.850**	1.333**	108.000**	352.010**	360.511**	36.890**
Rice varieties (B)	5	3.266**	0.358**	679.970**	1404.75**	119.639**	4.496**
Interaction (A×B)	5	1.887**	0.462*	31.378**	270.185**	194.990**	2.981**
Error	33	0.186	0.026	6.352	32.393	22.233	0.673

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters of rice as influenced by different planting times and rice varieties

Source of variation	Degrees of freedom	Mean square			
		Total dry matter $plant^{-1}$ (g)	Number of filled grain $panicle^{-1}$	Number of unfilled grain $panicle^{-1}$	Number of total grain $panicle^{-1}$
Replication	3	0.023	7.983	0.005	8.365
Planting time (A)	1	7.038**	225.333**	1.162**	194.126**
Rice varieties (B)	5	2.010**	227.729**	0.619**	208.899**
Interaction (A×B)	5	1.985*	467.964**	1.214**	432.631**
Error	33	0.192	14.968	0.080	15.729

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on yield contributing characters and yield of rice as influenced by different planting times and rice varieties

Source of variation	Degrees of freedom	Mean square				
		Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	3	0.638	0.002	0.059	0.039	0.615
Planting time (A)	1	22.358**	7.427**	6.719**	28.275**	5.933
Rice varieties (B)	5	8.156**	2.806**	1.713**	8.556**	10.566**
Interaction (A×B)	5	9.332**	0.489**	1.676**	3.180**	14.422*
Error	33	1.279	0.108	0.181	0.365	2.762

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability