# SCREENING OF HYBRID RICE LINES FOR T. AMAN SEASON

**GOLAPY KHATUN**

**DEPARTMENT OF AGRONOMY**
**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**
**DHAKA-1207**

**DECEMBER, 2015**

# SCREENING OF HYBRID RICE LINES FOR T. AMAN SEASON

**BY**

**GOLAPY KHATUN**

**REG. NO. : 14-06361**

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**
**AGRONOMY**

**SEMESTER: JULY-DECEMBER, 2015**

**Approved by:**

| | |
|---|---|
| **Prof. Dr. H. M. M. Tariq Hossain** | **Prof. Dr. Md. Shahidul Islam** |
| **Supervisor** | **Co-Supervisor** |

**Prof. Dr. Md. Fazlul Karim**
Chairman
Examination Committee

# DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University

**Sher-e-Bangla Nagar, Dhaka-1207**


## CERTIFICATE

This is to certify that the thesis entitled **'Screening of Hybrid Rice Lines for T. Aman 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 **Agronomy**, embodies the result of a piece of bonafide research work carried out by **Golapy Khatun**, Registration No.: **14-06361** 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. H. M. M. Tariq Hossain**
Department of Agronomy
Sher-e-Bangla Agricultural University
Dhaka-1207

*DEDICATED*

*TO*

*MY BELOVED PARENTS*

## *ACKNOWLEDGEMENTS*

*All praises are due to the Omnipotent Allah, the Supreme Ruler of the universe who enables the author to complete this present piece of work. The author deems it a great pleasure to express profound gratefulness to her respected parents, who entiled much hardship inspiring for prosecuting her studies and also receiving proper education.*

*The author feels proud to express her heartiest gratitude, sincere appreciation and immense indebtedness to her Supervisor* ***Dr. H. M. M. Tariq Hossain,*** *Professor, Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his continuous scholastic and intellectual guidance, cooperation, constructive criticism and suggestions in carrying out the research work and preparation of thesis, without his intense co-operation this work would not have been possible.*

*The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her Co-supervisor* ***Dr. Md. Shahidul Islam,*** *Professor, Department of Agronomy, SAU, Dhaka, for his scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.*

*The author also expresses her sincere respect and sence of gratitude to* ***Dr. Md. Fazlul Karim****, Professor and Chairman, Departement of Agronomy, SAU, Dhaka for valuable suggestions and cooperation during the study period.The author also expresses her heartfelt thanks to all the teachers of the Department of Agronomy, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.*

*The author expresses her sincere appreciation to her brothers, sister, relatives, well wishers and friends especially Md.Shahadat Hossain,Rupaly Khatun,Fatema for their inspiration, help and encouragement throughout the study.*

***The Author***

# SCREENING OF HYBRID RICE LINES FOR T. AMAN SEASON


## ABSTRACT

A field experiment was conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka 1207, during the period of July to November, 2014 to compare the growth and yield of hybrid rice lines for T. Aman season with a known inbred one. Eighteen hybrid rice lines and one inbred variety were used as planting materials for this experiment. The single factor experiment was laid out in a Randomized Complete Block Design with three replications. Data on different growth characters, yield contributing characters and yield were recorded. At 30, 45, 60, 75 DAT (days after transplanting) and at harvest, the tallest plant was recorded from BRRI dhan57 (37.38, 55.86, 78.15, 91.81 and 95.27 cm, respectively), whereas the shortest plant from hybrid line-4 (30.02, 41.73, 60.62, 71.76 and 75.10 cm, respectively) was detected among the materials under study. The maximum number of effective tillers $hill^{-1}$ was recorded from hybrid line-14 (13.33), while that of the minimum was found in hybrid line-12 (10.00).The longest and the shortest panicles were recorded from hybrid line-14(25.89 cm) and hybrid line -12 (21.60 cm) respectively. The maximum number of filled grains $panicle^{-1}$ was recorded from hybrid line-14 (92.00), while the minimum number was detected from hybrid line-12 (79.60). The highest weight of 1000-grains was found in hybrid line-11 (24.49 g), while the lowest weight was shown by the hybrid line-1 (20.06 g). The highest grain yield was found in hybrid line-14 (5.92 t $ha^{-1}$) and that of the lowest in hybrid line-12 (4.19 t $ha^{-1}$). The highest straw yield was found in hybrid line-6 (7.79 t $ha^{-1}$), whereas the lowest value was shown by the hybrid line-4 (6.55 t $ha^{-1}$). Grain yield advantage over check was estimated and the highest positive advantage was recorded for the hybrid line-14 (6.28%) and the lowest positive advantage was observed in hybrid line-7 (0.18%) whereas the highest negative advantage was found in hybrid line-12 (-24.78%) and the lowest negative advantage was observed in hybrid line-2 (-2.51%). Among the different hybrid rice lines, hybrid line-14 induced comparatively superior growth, yield contributing characters and yield compared to the other hybrid lines.

## LIST OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF APPENDICES

## LIST OF ABBREVIATED TERMS

| ABBREVIATION | FULL NAME |
|---|---|
| AEZ | Agro-Ecological Zone |
| BBS | Bangladesh Bureau of Statistics |
| BRRI | Bangladesh Rice Research Institute |
| Cm | Centimeter |
| Cv | Co-efficient of variation |
| $^0$C | Degree Celsius |
| *et al.* | and others |
| Etc | Etcetera |
| DAT | Days After Transplanting |
| G | Gram |
| IRRI | International Rice Research Institute |
| LSD | Least Significant Difference |
| $m^2$ | Square meter |
| Mm | Millimeter |
| MoP | Muriate of Potash |
| ppm | Parts per million |
| SAU | Sher-e-Bangla Agricultural University |
| SRDI | Soil Resources Development Institute |
| t $ha^{-1}$ | ton per hectare |
| TSP | Triple Super Phosphate |

# CHAPTER I

# INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food in tropical and subtropical regions (Singh *et al*., 2012). It is the staple food for nearly half of the world's population as well as for 148.10 million people of Bangladesh (AIS, 2008). More than three billion people in the world are taking rice as their main food (IRRI, 2009). Rice production and consumption is concentrated in Asia, where more than 90% of produced rice is consumed (FAO, 2006). The slogan 'Rice is life' is most appropriate for Bangladesh as this crop plays a vital role in our food security and is a means of livelihood for millions of peoples. About 84.67% of cropped area of Bangladesh is used for rice production, with annual production of 30.42 million tons from 10.4 million hectare of land (BBS, 2014).

In Bangladesh, the average yield of rice is about 2.92 t $ha^{-1}$ (BBS, 2014) which is very low compared to other rice growing countries of the World, like China (6.30 t $ha^{-1}$), Japan (6.60 t $ha^{-1}$) and Korea (6.30 t $ha^{-1}$) (FAO, 2009). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in shortage of food. The nation is still adding about 2.3 million mouths every year (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 (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). Rice yields are decelerating/stagnating/declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, irrigation and weeding schedule, type of cropping system practiced, lack of suitable rice genotypes/variety for low moisture adaptability and disease resistance (Prakash, 2010).

The possibility of horizontal expansion of rice production area has come to a standstill and as there is very little scope for horizontal expansion of rice production in Bangladesh. For that farmers and agricultural scientists are diverting their attention towards vertical expansion for increased crop production and therefore, attempts should be taken to increase the yield per unit area. For vertical expansion, improved agronomic practices including such as, use of quality seeds, high yielding and hybrid varieties, optimum age and number of seedling hill$^{-1}$, adopting proper plant protection measures, seedling raising techniques, fertilizer management etc. should be practiced. Growth and yield of rice are strongly influenced by genotype as well as environmental factors (BRRI, 2003). Variety is the key component to produce higher yield of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season. The growth process of rice plants under a given agro-climatic condition differs with variety (Alam *et al*., 2012).

The genetic potentiality in terms of yield of a rice variety is almost fixed, but grain yield can be increased by the manipulation of management practices (BRRI, 1999). Now a days, hybrid rice varieties are available in Bangladesh which has 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, controlled by many genes and highly affected by environment. In addition, grain yield also related with other characteristics such as plant type, growth duration and yield components (Yoshida, 1981). Very recently various new rice varieties were developed and available as BRRI dhan and maximum of them is exceptionally high yielding variety. On the other hand, compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average grain yield increase of 7.27% (Bhuiyan *et al*., 2014). This variety however, needs further evaluation under different adaptive condition to interact with different environmental conditions.

It has great potentiality for food security of poor countries where arable land is scarce but populations is expanding and labour is cheap. Hybrid rice technology has been introduced in Bangladesh during the last ten years (Masum, 2009). Hybrid rice has a 15–30% advantage in yield over modern inbred rice varieties or conventional pure line varieties (Peng *et al.,* 1999; Julfiquar *et al.,* 2002; Yuan *et al*., 2005; Julfiquar, 2009) but does not frequently exhibit higher yield potential (Ying *et al.*, 1998; Peng *et al.,* 1999; Yang *et al.,* 2002; Horie *et al.*, 2003; Nayak *et al.,* 2003; Abou Khalifa, 2009). However, information on morpho-physiological traits and yield performances of hybrid rice varieties are meager in Bangladesh. But very limited verities were available and yield performances of these varieties are not evaluated to compare with the BRRI developed high yielding varieties. Different varieties perform differently in a particular environment. It is for this reason that this study was conceptualized to find out which among the numerous hybrid rice varieties is best adopted in Bangladesh. With conceiving the above scheme in mind, the present research work has been undertaken with fulfilling the following objectives:

- To compare the growth and yield performances of selected hybrid rice lines with a known inbred one as a check variety.
- To select good line (s) towards releasing as variety (s) in Bangladesh.

# CHAPTER II

# REVIEW OF LITERATURE

Rice is the staple food and in south and Southeast Asia the highly populated area and around ninety per cent of rice is grown and consumed in this area. Bangladesh produces hybrid rice varieties and most of them have excellent production. Most of the rice varieties have been imported from China and some also developed in Bangladesh. Very limited research works related to yield and quality analysis of hybrid rice in comparison with our high yielding rice variety have been carried out in home and abroad. The research work so far done in Bangladesh is not adequate and conclusive. Variety itself is the genetical factor which contributes a lot for producing yield and yield components and different researcher reported the effect of rice varieties on yield attributes and grain yield. However, some of the important and informative research findings related to the yield and quality of hybrid and high yielding rice variety, so far been done at home and abroad, reviewed in this chapter under the following headings-

## 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 evaluated had significant effects on plant height at maturity.

Haque and Biswash (2014) carried out an experiment with five varieties of hybrid rice which were collected from different private seed companies and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties were Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks were BRRI dhan28 and BRRI dhan29. In the experiment the highest plant height was 101.5 cm for BRRI dhan28 and the lowest plant height was for Richer (82.5 cm).

Alam *et al*. (2012) conducted an experiment at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the kharif season to find out the effect of variety, spacing and number of seedlings $hill^{-1}$ on the yield potentials of transplant aman rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings $hill^{-1}$. Variety had significant effects on plant height.

Salem *et al*. (2011) conducted two field experiments at the Rice Research and Training Center (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt during summer seasons to study the 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 plant height.

Abou Khalifa (2009) conducted a field experiment at the experimental farm of Rice research and training centre (RRTC), Sakha, Kafr-El sheikh governorate, Egypt rice season for physiological evaluation of some hybrid rice varieties under different sowing dates. Four hybrid rice $H_1$, $H_2$, GZ 6522 and GZ 6903 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 BRRI dhan 44 at different days after transplanting (DAT).

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

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

Ghosh (2001) worked with four rice hybrids and four high yielding rice cultivars and concluded that hybrids have higher plant height as compared with high yielding varieties.

Pruneddu and Spanu (2001) conducted an experiment and found that plant height ranged from less than 65 cm to 80–85 cm in Mirto, Tejo, Gladio, Lamone and Timo.

Chen-Liang *et al*. (2000) 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.

BINA (1998) conducted an experiment to find out varietal performance of advance line (BINA 8-110-2-6) along with three check varieties - Iratom 24, BR26 and BRRI dhan27. The result indicated that BINA 8-110-2-6 appeared similar to BRRI dhan27 in terms of plant height and panicle length.

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, Bina dhan13 and Bina dhan19). It was recorded that varieties differed significantly in respect of plant height of rice.

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

Hossain and Alam (1991) found that the plant height in modern rice varieties BR3, BR11, B 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 Mut. NSI and Mut. 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 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 Tillering pattern

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

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

Abou Khalifa,A.A. (2009) conducted a field experiment 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.

Song *et al.* (2004) found that hybrids produced a significantly higher number of tillers than their parental species and Minghui-63 had the least number of tillers.

Laza *et al.* (2001) concluded that the early vigor of hybrid rice (*Oryza sativa* L.) developed in temperate region has been mainly attributed to its higher tillering rate. However, the tillering rate of hybrids was significantly lower than or equal to that of conventional varieties.

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 number of productive tillers hill$^{-1}$.

BINA (1993) conducted an experiment with four varieties/advance lines (Iratom24, BR14, Binadhan13 and Binadhan19) and reported significant variation in number of non-bearing tillers hill$^{-1}$.

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

**2.3 Dry matter**

Haque *et al*. (2015) conducted a field experiments by including two popular indica hybrids (BRRI hybrid dhan 2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrids accumulated higher amount of biomass before heading and exhibited greater remobilization of assimilates to the grain in early plantings compared to the inbred variety. Flag leaf photosynthesis parameters were higher in the hybrid varieties than those of the inbred variety. Results suggest that greater remobilization of shoot reserves to the grain rendered higher yield of hybrid rice varieties.

Shaloie *et al*. (2014) conducted a experiment at the Agricultural Research Station, Agriculture and Natural Resources Research Center of Khuzestan Shavuor in order to evaluate the response to planting date in rice hybrids Line dry method of working 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.

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

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

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

Son *et al*. (1998) reported that dry matter production of four inbred lines of rice (low-tillering large panicle type), YR15965ACP33, YR17104ACP5, YR16510-B-B-B-9, and YR16512-B-B-B-10, and cv. Namcheonbyeo and Daesanbyeo, 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.

Reddy *et al*. (1994) observed that dry matter production and grain yield were positively and significantly associated with each other and also with Net Assimilation Rate (NAR).

**2.4 Yield contributing characters**

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

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

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

Haque and Biswash (2014) experimented with five varieties of hybrid rice which were collected from different private seed companies and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties were

Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks were BRRI dhan28 and BRRI dhan29. In panicle length status, Richer showed the best performance (27.7 cm) while BRRI dhan28 showed the least performance (26 cm). Number of filled grains panicle$^{-1}$ was the highest for BRRI dhan29 (163.3), whereas, Jagoron only 118. Number of total grains was highest in BRRI dhan29 (201.7) and for Jagoron it was only 133.7. On the other hand, for 1000-grain weight, Aloron was the best than other hybrids.

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

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

Kaniz Fatema *et al*. (2011) evaluated by forty five aromatic rice genotypes 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.

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

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

Abou Khalifa ,A.A.(2009) conducted a field experiment by 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 for studied characters except for number of days to panicle initiation and heading date.

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

Wang *et al*. (2006) studied the effects of plant density and row spacing (equal row spacing and one seedling hill$^{-1}$, equal row spacing and 3 seedlings hill$^{-1}$,

wide-narrow row spacing and one seedling hill$^{-1}$, and wide-narrow row spacing and 3 seedlings hill$^{-1}$ on the yield and yield components of hybrids and conventional cultivars of rice. Compared with conventional cultivars, the hybrids had larger panicles, highest total grains, heavier seeds, resulting in an average yield increase of 7.27%.

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

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

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

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

Ahmed *et al.* (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11,

BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was 60-60-40 kg $ha^{-1}$ of N, $P_2O_5$ and $K_2O$, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

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, Binadhan13 and Binadhan19. They found that varieties differed significantly on panicle length and sterile spikelets $panicle^{-1}$. It was also reported that varieties Binadhan13 and Binadhan19 each had better morphological characters like more grains $panicle^{-1}$ compared to their better parents which contributed to yield improvement in hybrid lines of rice.

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) also observed that panicle length differed among the six rice varieties and it was longer in IR20 than in 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*. (1998) 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, 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.

**2.5 Grain, straw and biological yield**

Haque *et al*. (2015) conducted a field experiments by including two popular indica hybrids (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrid varieties out yielded the inbred. However, the hybrids and inbred varieties exhibited statistically identical yield in late planting. Results suggest that greater remobilization of shoot reserves to the grain rendered higher yield of hybrid rice varieties.

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

Hossain *et al*. (2014) conducted an experiment 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. Findings revealed that different hybrid rice varieties had significant effects on yield. RGBU010A × SL8R is therefore recommended as planting material among hybrid rice varieties because it produced favorable yield.

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

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

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

Tabien and Samonte (2007) observed that several elite lines at the multi-state trials had high yield potential relative to the check varieties and these can be released as new varieties after series of yield trials. With improved yield, the

new varieties are expected to increase rice production. The elite lines generated are also potential germplasm for rice improvement projects. The initial effort to identify high biomass rice will enhance the development of dedicated feedstock for bioenergy production.

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

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

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

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

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

Kamal *et al.* (1998) conducted an experiment to assess the yield of 9 modern varieties (MV) and 6 local improved varieties (LIV) and observed that modern

variety BR11 gave the highest grain yield followed by BR10, BR23, Binasail and BR4.

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.

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

Nematzadeh *et al*. (1997) reported that local high quality rice cultivars Hassan Sarai and Sang-Tarom 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.

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

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.

Leenakumari *et al.* (1993) evaluated eleven hybrid cultivars against four standard check varieties – Jaya, Rasi, IR20 and Margala. They concluded that hybrid cultivar OR 1002 gave the highest yield of 7.9 t $ha^{-1}$ followed by the hybrid cultivar OR 1001 (6.2 t $ha^{-1}$). Among the control varieties, Jaya gave the highest yield (8.4 t $ha^{-1}$).

Ali *et al*. ( 1993) conducted a field experiments at Gazipur where 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 .

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.

BRRI (1985) reported that 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

The above cited reviews revealed variety greatly affect the growth and as well as the yield of rice. But the literatures on the comparison between different hybrid and of rice have not been well defined and have no definite conclusion in this aspect under the agro climatic condition of Bangladesh.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted to compare the growth and yield of hybrid rice lines for aman season with a known inbred one. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials used, treatment and design of the experiment, growing of crops, data collection and data analysis procedure that followed in this experiment have been presented under the following headings:

## 3.1 Description of the experimental site

### 3.1.1 Experimental period

The experiment was conducted during the period of July to November, 2014.

### 3.1.2 Experimental location

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

### 3.1.3 Soil characteristics

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 6.2 and had organic carbon 0.43%. The experimental area was flat having available irrigation and drainage system and above flood level. The details have been presented in Appendix II.

### 3.1.4 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al.*, 1979). Details of the

meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment has been presented in Appendix III.

### 3.2 Experimental details

#### 3.2.1 Planting materials

Eighteen hybrid rice lines with one inbred variety were used as planting materials for this experiment. The name of the hybrid rice lines are presented in the Table 1. Among them BRRI dhan57 was used as a check variety.

**Table 1. Name of the hybrid rice lines used in the study**

| # | Hybrid rice line | # | Hybrid rice line |
|---|---|---|---|
| 01 | Hybrid line-1 | 11 | Hybrid line-11 |
| 02 | Hybrid line-2 | 12 | Hybrid line-12 |
| 03 | Hybrid line-3 | 13 | Hybrid line-13 |
| 04 | Hybrid line-4 | 14 | Hybrid line-14 |
| 05 | Hybrid line-5 | 15 | Hybrid line-15 |
| 06 | Hybrid line-6 | 16 | Hybrid line-16 |
| 07 | Hybrid line-7 | 17 | Hybrid line-19 |
| 08 | Hybrid line-8 | 18 | Hybrid line-20 |
| 09 | Hybrid line-9 | 19 | BRRI dhan57 |
| 10 | Hybrid line-10 | | |

#### 3.2.2 Experimental design and layout

The single factor experiment was laid out in a Randomized Complete Block Design with three replications. An area of 58.5 m × 13.0 m was divided into 3 blocks. The nineteen rice entities were assigned in the 57 unit plots. The size of the each unit plot was 3.0 m × 2.5 m. The space between two blocks and two plots were 1.00 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

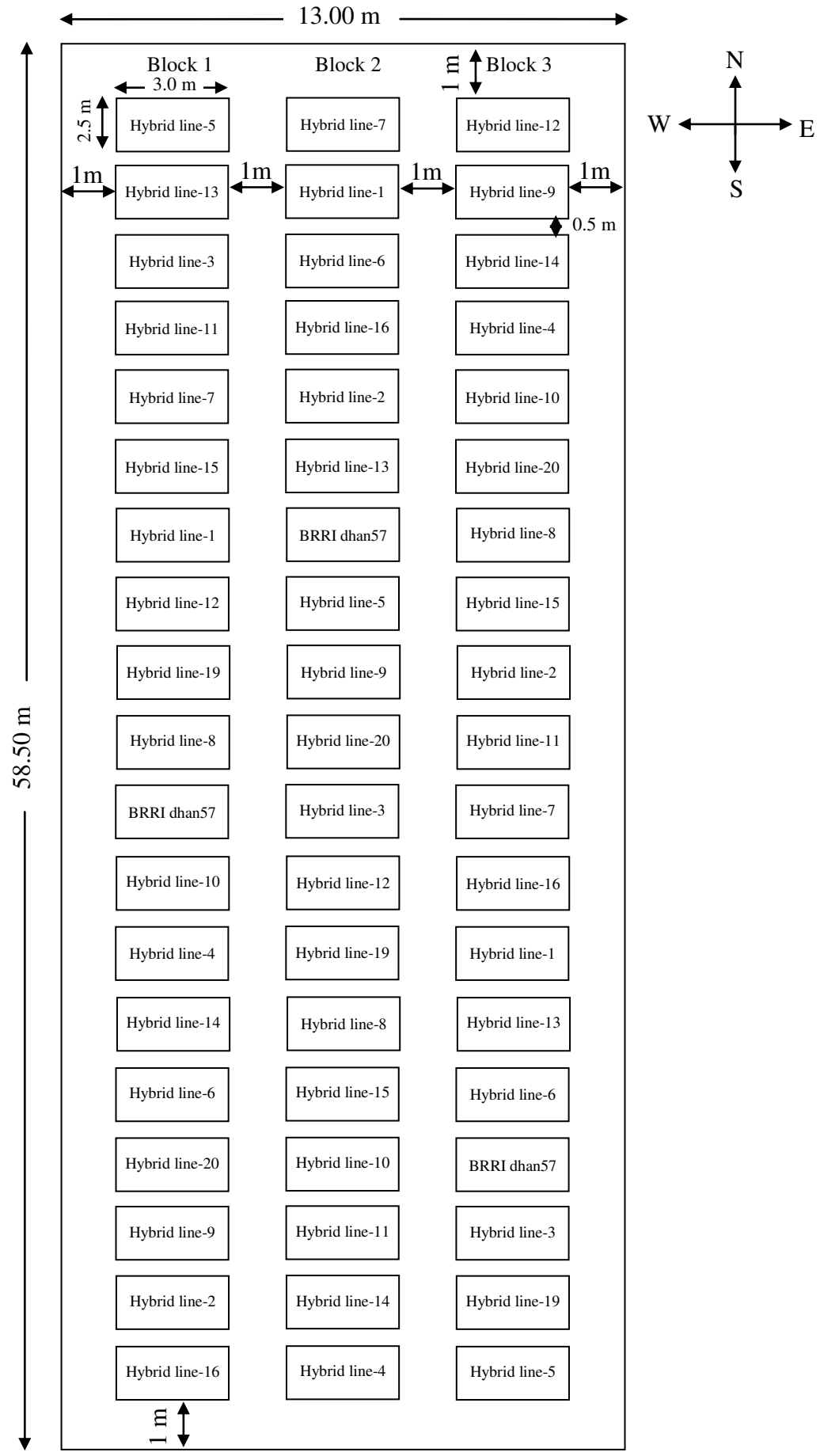



Figure 1. Field layout of the experiment

### 3.3 Growing of crops

#### 3.3.1 Seed collection and sprouting

Seeds were collected from a seed company named ACI limited and BRRI, Gazipur just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting in gunny bags after 48 hours which were suitable for sowing in 72 hours.

#### 3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds on July 16, 2014 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

#### 3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the August 2, 2014 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

#### 3.3.4 Fertilizers and manure application

The fertilizers N, P and K in the form of urea, TSP and MoP, respectively were applied. The entire amount of TSP and MoP were applied during the final preparation of plot land. Mixture of cowdung and compost was applied @ 10 t $ha^{-1}$ during 15 days before transplantation. Urea was applied in three equal installments at after recovery, tillering and before panicle initiation. The dose and method of application of fertilizers are shown in Table 2.

**Table 2. Dose and method of fertilizers application**

| Fertilizers | Dose (kg $ha^{-1}$) | Application (%) | | | |
|---|---|---|---|---|---|
| | | Basal | 1st installment | 2nd installment | 3rd installment |
| Urea | 150 | -- | 33.33 | 33.33 | 33.33 |
| TSP | 100 | 100 | -- | -- | -- |
| MoP | 100 | 100 | -- | -- | -- |

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

### 3.3.5 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 11 August, 2014 in well puddled plots with one seedling $hill^{-1}$ with maintaining line to line distance 20 cm and hill to hill distance 15 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required followed by the treatment of number of seedlings $hill^{-1}$.

### 3.3.6 Intercultural operations

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

#### 3.3.6.1 Irrigation and drainage

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

#### 3.3.6.2 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 25 DAT and 45 DAT by sickles.

### 3.3.6.3 Insect and pest control

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

## 3.4 Harvesting, threshing and cleaning

The crop was started harvesting at full maturity from November 20, 2014 when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. The grains were dried up to moisture content 14% (approximate), then cleaned and weighed for individual plot. Straw also dried and weighed for individual plot.

## 3.5 Data recording

### 3.5.1 Plant height (cm)

The plant height was recorded in centimeter (cm) at 30, 45, 60, 75 DAT and at harvest 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 longest leaf.

### 3.5.2 Tillers $hill^{-1}$ (No.)

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

### 3.5.3 Total dry matter content (g $hill^{-1}$)

Total dry matter content $hill^{-1}$ was recorded at 30, 45, 60 and 75 DAT. Data were recorded as the average of 3 hills collected at random from the inner rows of each plot. For estimation of dry matter, collected hills sliced into very thin pieces were put into envelop and placed in oven maintained at $70^{0}$C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken.

### 3.14.4 Days to 1st panicle initiation

Days to 1st panicle initiation were recorded by counting the number of days required to the 1st initiation of panicle from each plot.

### 3.14.5 Days to maturity

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

### 3.5.6 Effective tillers hill$^{-1}$ (No.)

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

### 3.5.7 Non-effective tillers hill$^{-1}$ (No.)

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

### 3.5.8 Total tillers hill$^{-1}$ (No.)

The total number of tiller hill$^{-1}$ was counted by adding the number of effective tillers hill$^{-1}$ and non-effective tillers hill$^{-1}$. Data on total tillers hill$^{-1}$ were counted from 5 selected hills and average value was recorded.

### 3.5.9 Panicle length (cm)

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

### 3.5.10 Filled grains panicle$^{-1}$ (No.)

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

### 3.5.11 Unfilled grains panicle$^{-1}$ (No.)

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

### 3.5.12 Total grains panicle$^{-1}$ (No.)

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

### 3.5.13 Weight of 1000-grains (g)

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

### 3.5.14 Grain yield (t ha$^{-1}$)

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

### 3.5.15 Straw yield (t ha$^{-1}$)

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

### 3.5.16 Biological yield (t ha$^{-1}$)

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

Biological yield (t ha$^{-1}$) = Grain yield (t ha$^{-1}$) + Straw yield (t ha$^{-1}$).

### 3.5.17 Harvest index (%)

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

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

### 3.6 Statistical analysis

The data obtained on different characters were statistically analyzed to observe the significant difference among different treatment . The mean values of all the characters were calculated and analysis of variance test was performed using MSTAT-C software. The mean separation test for different treatments were performed by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

The analyses of variance (ANOVA) of the data on different growth characters, yield contributing characters and yield are presented in Appendix IV-IX. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

## 4.1 Crop growth characters

### 4.1.1 Plant height (cm)

Plant height at 30, 45, 60, 75 DAT and at harvest showed statistically significant differences among hybrid rice lines and check variety BRRI dhan57 (Table 3 and Appendix IV). At the said intervals, the tallest plant was recorded from BRRI dhan57 (37.38, 55.86, 78.15, 91.81 and 95.27 cm, respectively), whereas the shortest plant was observed from hybrid line-4 (30.02, 41.73, 60.62, 71.76 and 75.10 cm, respectively) which was statistically similar to hybrid line-1 (30.41, 42.49, 61.16, 73.86 and 75.74 cm, respectively) and hybrid line-3 (30.80, 44.35, 68.82, 77.70 and 80.97 cm, respectively). Different treatments showed different plant height on the basis of their genetical character although management practices influenced plant height. Data revealed that the check variety (BRRI dhan57) produced the tallest plant compare with the other hybrid lines. Hybrid line is the key component to produce plant height of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season. Miah *et al*. (1990) reported that plant height were longest in Mutant NSI than Nizersail. Munoz *et al.* (1996) found that IR8025A hybrid rice cultivar produced 16% longer plant than the commercial variety Oryzica Yacu-9. Abou Khalifa, A,A, (2009) reported that $H_1$ hybrid rice variety surpassed other varieties in terms of plant height. Bhuiyan *et al*. (2014) reported that the different hybrid rice varieties had significant effects on plant height.

**Table 3. Plant height at different days after transplanting (DAT) and harvest of selected rice hybrid lines and BRRI dhan57**

| Treatment | Plant height (cm) at | | | | |
|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 75 DAT | Harvest |
| Hybrid line-1 | 30.41 cd | 42.49 ef | 61.16 de | 73.86 de | 75.74 f |
| Hybrid line-2 | 32.20 a-d | 49.38 a-e | 69.86 a-c | 81.42 a-e | 84.66 b-f |
| Hybrid line-3 | 30.80 cd | 44.35 d-f | 68.82 b-d | 77.70 c-e | 80.97 ef |
| Hybrid line-4 | 30.02 d | 41.73 f | 60.62 e | 71.76 e | 75.10 f |
| Hybrid line-5 | 34.85 a-d | 51.25 a-d | 67.17 c-e | 85.09 a-d | 88.38 a-e |
| Hybrid line-6 | 36.71 ab | 53.22 a-c | 76.23 ab | 91.16 ab | 92.67 a-c |
| Hybrid line-7 | 33.75 a-d | 51.93 a-d | 71.78 a-c | 85.81 a-d | 89.39 a-e |
| Hybrid line-8 | 33.40 a-d | 49.99 a-e | 68.95 b-d | 81.88 a-e | 86.61 a-e |
| Hybrid line-9 | 32.05 a-d | 46.36 c-f | 68.24 b-e | 77.73 c-e | 82.00 d-f |
| Hybrid line-10 | 33.27 a-d | 49.70 a-e | 72.22 a-c | 83.65 a-e | 87.14 a-e |
| Hybrid line-11 | 37.18 a | 55.40 ab | 73.46 a-c | 89.66 a-c | 94.18 ab |
| Hybrid line-12 | 36.41 ab | 54.49 ab | 75.90 ab | 89.00 a-c | 91.80 a-d |
| Hybrid line-13 | 32.66 a-d | 50.38 a-d | 67.35 c-e | 81.24 a-e | 85.85 a-e |
| Hybrid line-14 | 34.10 a-d | 49.66 a-e | 73.03 a-c | 83.09 a-e | 87.34 a-e |
| Hybrid line-15 | 35.71 a-c | 52.77 a-c | 74.32 a-c | 87.33 a-c | 92.56 a-c |
| Hybrid line-16 | 33.33 a-d | 49.86 a-e | 69.90 a-c | 82.60 a-e | 86.24 a-e |
| Hybrid line-19 | 34.15 a-d | 50.78 a-d | 71.27 a-c | 84.13 a-d | 87.89 a-e |
| Hybrid line-20 | 31.61 b-d | 47.70 b-f | 67.17 c-e | 79.31 b-e | 82.49 c-f |
| BRRI dhan57 | 37.38 a | 55.86 a | 78.15 a | 91.81 a | 95.27 a |
| $S\bar{x}$ | 1.590 | 2.255 | 2.485 | 3.632 | 3.075 |
| CV(%) | 8.18 | 7.83 | 6.12 | 7.57 | 6.15 |

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

### 4.1.2 Tillers hill$^{-1}$ (No.)

Statistically significant variation was recorded on number of tillers hill$^{-1}$ at 30, 45, 60 and 75 DAT among hybrid rice lines and BRRI dhan57 (Table 4 and Appendix V ). At 30, 45, 60 and 75 DAT, the maximum numbers of tillers hill$^{-1}$ were found from hybrid line-14 (7.53, 12.60, 15.27 and 16.60, respectively) which was statistically similar with other hybrid lines except hybrid lines-12, hybrid lines-1 and hybrid lines-4, while the minimum number of tillers hill$^{-1}$ were recorded from hybrid line-12 (5.13, 10.07, 11.17 and 14.20, respectively) which was statistically similar to hybrid line-1 (5.47, 10.47, 11.47 and 14.40, respectively) and hybrid line-4 (5.53, 10.47, 12.39 and 14.60, respectively). Masum *et al*. (2008) reported maximum (25.63) tiller at 45 DAT, then it declined up to maturity, whereas, in the case of BRRI dhan44, maximum tiller (18.92) was observed at panicle initiation stage at 60 DAT.

### 4.1.3 Dry matter content (g hill$^{-1}$)

Hybrid rice lines and check variety showed statistically significant variation on dry matter content at 30, 45, 60 and 75 DAT (Table 5 and Appendix VI ). At 30, 45, 60 and 75 DAT, the highest dry matters content were recorded from hybrid line-14 (3.82, 4.89, 6.70 and 7.87 g hill$^{-1}$, respectively), whereas the lowest dry matter content was recorded from hybrid line-4 (3.08, 4.09, 5.07 and 6.16 g hill$^{-1}$, respectively) which was statistically similar to hybrid line-12 (3.10, 4.10, 6.11 and 6.64 g hill$^{-1}$, respectively).

## 4.2 Yield contributing characters

### 4.2.1 Days to 1$^{st}$ panicle initiation

Statistically significant variation was recorded on days to 1$^{st}$ panicle initiation among hybrid lines and check variety (Table 6 and Appendix VII ). The highest days to 1$^{st}$ panicle initiation was recorded from hybrid line-9 (70.67 days) which was statistically similar to hybrid line-15 (66.67 days), while the lowest days to 1$^{st}$ panicle initiation was recorded from hybrid line-3 (60.33 days) which was statistically similar to hybrid line-12 (60.67 days) and hybrid line-1 (61.00).

**Table 4. Number of tillers hill$^{-1}$ at different days after transplanting (DAT) of selected rice hybrid lines and BRRI dhan57**

| Treatment | Tillers hill$^{-1}$ (No.) at | | | |
|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 75 DAT |
| Hybrid line-1 | 5.47 cd | 10.47 de | 11.47 ef | 14.40 bc |
| Hybrid line-2 | 6.87 a-c | 10.53 de | 11.77 d-f | 14.33 bc |
| Hybrid line-3 | 6.53 a-d | 10.60 de | 11.77 d-f | 14.40 bc |
| Hybrid line-4 | 5.53 b-d | 10.47 de | 12.30 c-f | 14.60 bc |
| Hybrid line-5 | 7.00 a-c | 11.33 a-e | 13.03 b-f | 16.20 ab |
| Hybrid line-6 | 7.13 a | 11.53 a-d | 14.33 ab | 14.93 a-c |
| Hybrid line-7 | 6.93 a-c | 11.07 b-e | 12.87 b-f | 14.47 bc |
| Hybrid line-8 | 6.53 a-d | 11.40 a-e | 13.73 a-c | 15.87 a-c |
| Hybrid line-9 | 6.87 a-c | 11.27 a-e | 13.47 a-d | 16.13 ab |
| Hybrid line-10 | 7.00 a-c | 11.27 a-e | 13.67 a-d | 15.13 a-c |
| Hybrid line-11 | 7.07 ab | 12.07 a-c | 14.47 ab | 16.00 a-c |
| Hybrid line-12 | 5.13 d | 10.07 e | 11.17 f | 14.20 c |
| Hybrid line-13 | 7.13 a | 11.20 b-e | 13.37 a-d | 14.80 a-c |
| Hybrid line-14 | 7.53 a | 12.60 a | 15.27 a | 16.60 a |
| Hybrid line-15 | 7.04 ab | 12.13 ab | 14.74 ab | 15.91 a-c |
| Hybrid line-16 | 6.77 a-c | 11.24 b-e | 13.25 b-e | 15.28 a-c |
| Hybrid line-19 | 6.98 a-c | 11.62 a-d | 13.69 a-d | 15.56 a-c |
| Hybrid line-20 | 6.38 a-d | 10.71 c-e | 12.33 c-f | 14.68 bc |
| BRRI dhan57 | 6.98 a-c | 11.33 a-e | 13.54 a-d | 14.92 a-c |
| $S\bar{x}$ | 0.457 | 0.403 | 0.569 | 0.561 |
| CV(%) | 11.87 | 6.24 | 7.48 | 6.39 |

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

**Table 5. Dry matter content in plant at different days after transplanting (DAT) of selected rice hybrid lines and BRRI dhan57**

| Treatment | Dry matter content (g $hill^{-1}$) in plant at | | | |
|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 75 DAT |
| Hybrid line-1 | 3.35 b-e | 4.25 c-e | 5.58 d-f | 6.79 d-f |
| Hybrid line-2 | 3.33 c-e | 4.54 a-d | 5.84 c-e | 6.72 ef |
| Hybrid line-3 | 3.27 c-e | 4.20 de | 5.51 ef | 6.72 ef |
| Hybrid line-4 | 3.08 e | 4.09 e | 5.07 f | 6.17 g |
| Hybrid line-5 | 3.51 a-c | 4.55 a-d | 6.17 a-c | 7.12 c-f |
| Hybrid line-6 | 3.72 ab | 4.75 ab | 6.56 ab | 7.23 b-e |
| Hybrid line-7 | 3.53 a-c | 4.69 ab | 6.28 a-c | 7.02 c-f |
| Hybrid line-8 | 3.57 a-c | 4.42 b-e | 5.97 c-e | 7.03 c-f |
| Hybrid line-9 | 3.34 b-e | 4.51 a-d | 5.59 d-f | 7.16 c-f |
| Hybrid line-10 | 3.47 a-d | 4.51 a-d | 5.96 c-e | 7.05 c-f |
| Hybrid line-11 | 3.59 a-c | 4.78 ab | 6.65 ab | 7.36 bc |
| Hybrid line-12 | 3.10 de | 4.10 e | 6.11 b-d | 6.64 f |
| Hybrid line-13 | 3.34 b-e | 4.42 b-e | 5.84 c-e | 7.07 c-f |
| Hybrid line-14 | 3.82 a | 4.89 a | 6.70 a | 7.87 a |
| Hybrid line-15 | 3.51 a-c | 4.86 a | 6.20 a-c | 7.27 b-d |
| Hybrid line-16 | 3.45 a-e | 4.50 a-d | 5.91 c-e | 6.98 c-f |
| Hybrid line-19 | 3.54 a-c | 4.63 a-c | 6.08 b-e | 7.14 c-f |
| Hybrid line-20 | 3.28 c-e | 4.42 b-e | 5.53 d-f | 6.72 ef |
| BRRI dhan57 | 3.80 a | 4.90 a | 6.64 ab | 7.66 ab |
| $S\bar{x}$ | 0.112 | 0.119 | 0.173 | 0.156 |
| CV(%) | 5.64 | 4.56 | 4.99 | 6.84 |

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

### 4.2.2 Days to maturity

Days to maturity also showed statistically significant variation among hybrid lines under study (Table 6 and Appendix VII ). The highest days to maturity was recorded from hybrid line-9 (140.00 days), while the lowest days to maturity was recorded from hybrid line-4 (120.67 days). It was revealed that different days to maturity was required for different rice hybrid lines.

### 4.2.3 Effective tillers hill$^{-1}$ (No.)

Statistically significant variation was recorded in terms of number of effective tillers hill$^{-1}$ among hybrid lines (Table 6 and Appendix VII ). The maximum number of effective tillers hill$^{-1}$ was recorded from hybrid line-14 (13.33) which was statistically similar with other hybrid lines except hybrid lines-12, while the minimum number of effective tillers hill$^{-1}$ was recorded from hybrid line-12 (10.00). Khalifa (2009) reported that $H_1$ hybrid rice variety surpassed other varieties in consideration of effective tillers hill$^{-1}$.

### 4.2.4 Non-effective tillers hill$^{-1}$ (No.)

Number of non-effective tillers hill$^{-1}$ showed statistically significant variation among hybrid rice lines (Table 6 and Appendix VII ). The maximum number of non-effective tillers hill$^{-1}$ was recorded from hybrid line-4 (3.13), whereas the minimum number of non-effective tillers hill$^{-1}$ was recorded from hybrid line-11 (2.00).

### 4.2.5 Total tillers hill$^{-1}$ (No.)

Hybrid rice lines showed statistically significant differences in terms of number of total tillers hill$^{-1}$ (Figure 2). The maximum number of total tillers hill$^{-1}$ was recorded from hybrid line-14 (15.60) which was statistically similar with hybrid lines-5 (15.53), while the minimum number of total tillers hill$^{-1}$ was recorded from hybrid line-12 (12.53) which was statistically similar to hybrid line-1 (13.67) and hybrid line-13 (13.67). Abou Khalifa ,A.A. (2009) from earlier experiment reported that $H_1$ hybrid rice variety surpassed other varieties in consideration of total tillers hill$^{-1}$.

**Table 6. Days to 1st panicle initiation, days to maturity, effective and non-effective tillers hill$^{-1}$ of selected rice hybrid lines and BRRI dhan57**

| Treatment | Days to 1st panicle initiation | Days to maturity | Effective tillers hill$^{-1}$ (No.) | Non-effective tillers hill$^{-1}$ (No.) |
|---|---|---|---|---|
| Hybrid line-1 | 61.00 c | 122.33 bc | 10.53 a | 3.07 ab |
| Hybrid line-2 | 64.33 bc | 123.00 bc | 11.87 a | 2.93 a-d |
| Hybrid line-3 | 60.33 c | 126.67 bc | 11.87 a | 2.87 a-d |
| Hybrid line-4 | 63.67 bc | 120.67 c | 11.80 a | 3.13 a |
| Hybrid line-5 | 65.67 bc | 131.33 a-c | 12.53 a | 3.00 a-c |
| Hybrid line-6 | 61.33 bc | 128.67 a-c | 12.40 a | 2.67 a-f |
| Hybrid line-7 | 64.67 bc | 127.67 bc | 12.33 a | 2.80 a-e |
| Hybrid line-8 | 64.00 bc | 131.67 a-c | 12.53 a | 2.33 e-g |
| Hybrid line-9 | 70.67 a | 140.00 a | 12.80 a | 2.33 e-g |
| Hybrid line-10 | 64.00 bc | 130.67 a-c | 11.80 a | 2.33 e-g |
| Hybrid line-11 | 64.00 bc | 133.67 ab | 13.00 a | 2.00 g |
| Hybrid line-12 | 60.67 c | 132.67 ab | 10.00 b | 2.33 e-g |
| Hybrid line-13 | 63.33 bc | 133.67 ab | 11.20 a | 2.60 b-f |
| Hybrid line-14 | 62.67 bc | 124.00 bc | 13.33 a | 2.27 fg |
| Hybrid line-15 | 66.67 ab | 133.33 ab | 12.60 a | 2.27 fg |
| Hybrid line-16 | 63.67 bc | 129.67 a-c | 11.67 a | 2.53 c-f |
| Hybrid line-19 | 65.00 bc | 132.67 ab | 12.00 a | 2.47 d-g |
| Hybrid line-20 | 64.33 bc | 125.00 bc | 10.73 a | 2.93 a-d |
| BRRI dhan57 | 62.67 bc | 132.33 ab | 12.40 a | 2.47 d-g |
| $S\bar{x}$ | 1.571 | 3.391 | 0.524 | 0.151 |
| CV(%) | 4.26 | 4.54 | 7.57 | 10.10 |

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

### 4.2.6 Panicle length (cm)

Statistically significant variation was recorded in terms of panicle length among hybrid rice lines and check variety BRRI dhan57 (Table 7 and Appendix VIII ). The longest panicle was recorded from hybrid line-14 (25.89 cm) which was statistically similar with most of the hybrid lines, while the shortest panicle was found from hybrid line-12 (21.60 cm). Hybrid line is the key component to produce panicle length of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season. Wang *et al.* (2006) reported that compared with conventional cultivars, the hybrids had larger panicles.

### 4.2.7 Filled grains panicle$^{-1}$ (No.)

Statistically significant variation was recorded in terms of filled grains panicle$^{-1}$ among hybrid lines (Table 7 and Appendix VIII ). The maximum number of filled grains panicle$^{-1}$ was recorded from hybrid line-14 (92.00) which was statistically similar with most of the hybrid lines, while the minimum number of filled grains panicle$^{-1}$ was observed from hybrid line-12 (79.60). Different hybrid lines produced different number of filled grains panicle$^{-1}$ based on their genetical characters. Obulamma *et al.* (2004) recorded highest number of filled grain panicle$^{-1}$ in hybrid APHR 2 than hybrid DRRH 1.

### 4.2.8 Unfilled grains panicle$^{-1}$ (No.)

Unfilled grains panicle$^{-1}$ varied significantly among hybrid lines (Table 7 Appendix VII ). The maximum number of unfilled grains panicle$^{-1}$ was recorded from hybrid line-2 (8.73) and hybrid line-7 (8.73) which was statistically similar to hybrid line-20 (8.60), while the minimum number of unfilled grains panicle$^{-1}$ was observed from hybrid line-14 (6.23) which was statistically similar to hybrid line-11 (6.80). Hossain *et al.* (2014) reported that hybrid varieties Heera2 and Aloron gave the higher spikelet sterility.

**Table 7. Panicle length, filled grains, unfilled grains and weight of 1000 grains of selected rice hybrid lines and BRRI dhan57**

| Treatment | Panicle length (cm) | Filled grains panicle$^{-1}$ (No.) | Unfilled grains panicle$^{-1}$ (No.) | Weight of 1000 grains (g) |
|---|---|---|---|---|
| Hybrid line-1 | 22.12 cd | 83.13 bc | 8.00 a-d | 20.06 d |
| Hybrid line-2 | 22.13 cd | 84.27 bc | 8.73 a | 22.26 a-d |
| Hybrid line-3 | 22.22 cd | 84.60 bc | 8.53 ab | 22.93 a-c |
| Hybrid line-4 | 22.39 cd | 85.93 a-c | 8.33 ab | 21.10 cd |
| Hybrid line-5 | 24.11 a-d | 85.93 a-c | 8.13 a-d | 23.22 a-c |
| Hybrid line-6 | 23.39 a-d | 89.00 ab | 8.27 a-c | 23.45 a-c |
| Hybrid line-7 | 22.17 cd | 87.60 ab | 8.73 a | 22.75 a-c |
| Hybrid line-8 | 25.00 a-c | 89.27 ab | 7.53 a-e | 22.83 a-c |
| Hybrid line-9 | 24.41 a-d | 84.87 bc | 6.87 c-e | 21.31 b-d |
| Hybrid line-10 | 22.46 b-d | 86.47 ab | 7.73 a-d | 22.71 a-c |
| Hybrid line-11 | 23.94 a-d | 85.60 a-c | 6.80 de | 24.49 a |
| Hybrid line-12 | 21.60 d | 79.60 c | 6.87 c-e | 22.10 a-d |
| Hybrid line-13 | 23.91 a-d | 83.93 bc | 8.20 a-d | 23.65 ab |
| Hybrid line-14 | 25.89 a | 92.00 a | 6.23 e | 23.56 ab |
| Hybrid line-15 | 25.61 ab | 85.07 bc | 7.20 b-e | 23.42 a-c |
| Hybrid line-16 | 23.82 a-d | 86.27 ab | 7.93 a-d | 22.54 a-c |
| Hybrid line-19 | 24.53 a-d | 87.47 ab | 7.67 a-d | 23.13 a-c |
| Hybrid line-20 | 22.24 cd | 84.27 bc | 8.60 ab | 22.15 a-d |
| BRRI dhan57 | 25.26 a-c | 88.87 ab | 8.07 a-d | 23.23 a-c |
| $S\bar{x}$ | 0.941 | 1.943 | 0.416 | 0.710 |
| CV(%) | 6.92 | 3.91 | 9.23 | 5.42 |

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

### 4.2.9 Total grains panicle$^{-1}$ (No.)

Statistically significant variation was recorded in terms of total grains panicle$^{-1}$ among hybrid rice lines and BRRI dhan57 (Figure 3). The maximum number of total grains panicle$^{-1}$ was recorded from hybrid line-14 (98.23) which was statistically similar to other hybrid line except hybrid line-12 and hybrid line-1, while the minimum number of total grains panicle$^{-1}$ from hybrid line-12 (86.47) which was statistically similar to hybrid line-1 (91.13). Guilani *et al*. (2003) observed that grain number panicle$^{-1}$ was not significantly different among cultivars.

### 4.2.10 Weight of 1000 grains (g)

Weight of 1000 grains showed statistically significant variation among hybrid rice lines and BRRI dhan57 (Table 7 and Appendix VIII ). The highest weight of 1000-grains was observed from hybrid line-11 (24.49 g) which was statistically similar to other hybrid line except hybrid line-1, hybrid line-20.06 g) which was statistically similar to hybrid line-4 (21.10 g) and hybrid line-9 (21.31 g). Wang *et al*. (2006) reported that compared with conventional cultivars, the hybrids had 4 and hybrid line-9, while the lowest weight from hybrid line-1 heavier seeds.

## 4.3 Yield of rice, harvest index and yield advantages over check

### 4.3.1 Grain yield (t ha$^{-1}$)

Statistically significant variation was recorded in terms of grain yield among hybrid rice lines and BRRI dhan57 (Table 8 and Appendix IX ). The highest grain yield was found from hybrid line-14 (5.92 t ha$^{-1}$) which was statistically similar to hybrid line-1, hybrid line-15 (5.75 t ha$^{-1}$) and hybrid line-6 (5.73 t ha$^{-1}$). On the other hand, the lowest grain yield was observed from hybrid line-12 (4.19 t ha$^{-1}$) which was statistically similar to hybrid line-1 (4.46 t ha$^{-1}$) and hybrid line-9 (4.73 t ha$^{-1}$). Kanfany *et al*. (2014) reported that grain yield of rice hybrids (bred by the International Rice Research Institute) was not significantly higher than that of the check cultivar.

**Table 8. Yield, harvest index and grain yield advantages over check variety of selected rice hybrid lines and BRRI dhan57**

| Treatment | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Harvest index (%) | Grain yield advantages over check (%) |
|---|---|---|---|---|
| Hybrid line-1 | 4.46 fg | 6.83 e-g | 39.45 de | -19.93 |
| Hybrid line-2 | 5.43 a-d | 6.94 d-g | 43.89 ab | -2.51 |
| Hybrid line-3 | 5.27 b-e | 6.91 d-g | 43.17 a-c | -5.39 |
| Hybrid line-4 | 4.80 ef | 6.55 g | 42.31 a-c | -13.82 |
| Hybrid line-5 | 4.95 d-f | 7.68 ab | 39.16 e | -11.13 |
| Hybrid line-6 | 5.73 ab | 7.79 a | 42.40 a-c | 2.87 |
| Hybrid line-7 | 5.58 a-c | 7.38 a-d | 43.08 a-c | 0.18 |
| Hybrid line-8 | 4.97 c-f | 7.18 c-e | 40.83 c-e | -10.77 |
| Hybrid line-9 | 4.73 e-g | 6.91 d-g | 40.64 c-e | -15.08 |
| Hybrid line-10 | 5.03 c-f | 7.15 c-e | 41.28 b-e | -9.69 |
| Hybrid line-11 | 5.42 a-d | 7.48 a-c | 42.04 a-d | -2.69 |
| Hybrid line-12 | 4.19 g | 7.50 a-c | 35.85 f | -24.78 |
| Hybrid line-13 | 5.19 b-e | 7.13 c-e | 42.07 a-d | -6.82 |
| Hybrid line-14 | 5.92 a | 7.47 a-c | 44.23 a | 6.28 |
| Hybrid line-15 | 5.75 ab | 7.36 a-d | 43.83 ab | 3.23 |
| Hybrid line-16 | 5.24 b-e | 7.08 c-f | 42.52 a-c | -5.92 |
| Hybrid line-19 | 5.41 a-d | 7.23 b-e | 42.79 a-c | -2.87 |
| Hybrid line-20 | 5.03 c-f | 6.66 fg | 43.04 a-c | -9.69 |
| BRRI dhan57 | 5.57 a-c | 7.28 b-e | 43.37 a-c | -- |
| $S\bar{x}$ | 0.184 | 0.140 | 0.840 | -- |
| CV(%) | 6.12 | 3.38 | 3.47 | -- |

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

### 4.3.2 Straw yield (t ha$^{-1}$)

Straw yield varied significantly among hybrid rice lines and BRRI dhan57 (Table 8 and Appendix IX). The highest straw yield was found from hybrid line-6 (7.79 t ha$^{-1}$) which was statistically similar to hybrid line-5 (7.68 t ha$^{-1}$), whereas the lowest straw yield was found from hybrid line-4 (6.55 t ha$^{-1}$) which was statistically similar to hybrid line-20 (6.66 t ha$^{-1}$). Different hybrid lines produced different straw yield based on their genetical characters. Patel (2000) observed significantly higher grain and straw yield from Kranti than IR36.

### 4.3.3 Biological yield (t ha$^{-1}$)

Statistically significant variation was recorded in terms of biological yield among hybrid rice lines and BRRI dhan57 (Figure 4). The highest biological yield was recorded from hybrid line-6 (13.52 t ha$^{-1}$) which was statistically similar to hybrid line-14 (13.39 t ha$^{-1}$), while the lowest biological yield was found from hybrid line-12 (11.29 t ha$^{-1}$) which was statistically similar to hybrid line-9 (11.35 t ha$^{-1}$). Hybrid line is the key component for biological yield of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season.

### 4.3.4 Harvest index (%)

Hybrid rice lines and check variety showed statistically significant variation in terms of harvest index (Table 8 and Appendix IX). The highest harvest index was found from hybrid line-14 (44.23%) which was statistically similar to hybrid line-2 (43.89%) and hybrid line-15 (43.83%), whereas the lowest harvest index was found from hybrid line-12 (35.85%) which was followed by hybrid line-5 (39.16%).

### 4.3.5 Grain yield advantages over check

Grain yield advantages over check was estimated and as per Table 8 it was revealed that the positive advantages was observed for hybrid line-6 (2.87%), hybrid line-7 (0.18%), hybrid line-14 (6.28%) and hybrid line-15 (3.23%), whereas the negative advantages was found from hybrid line-1 (-19.93%), hybrid line-2 (-2.51%), hybrid line-3 (-5.39%), hybrid line-4 (-13.46) observed from hybrid line-2 (-2.51%).

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of July to November, 2014 to compare the growth and yield of hybrid rice lines for T. Aman season with a known inbred one. Eighteen hybrid rice lines and a one inbred variety were used as planting materials for this experiment. The single factor experiment was laid out in a Randomized Complete Block Design with three replications. Data on different growth characters, yield contributing characters and yield were recorded and statistically significant variation was observed for different parameters.

At 30, 45, 60, 75 DAT and at harvest, the tallest plant was recorded from BRRI dhan57 (37.38, 55.86, 78.15, 91.81 and 95.27 cm, respectively), whereas the shortest plant from hybrid line-4 (30.02, 41.73, 60.62, 71.76 and 75.10 cm, respectively). At 30, 45, 60 and 75 DAT, the maximum number of tillers hill$^{-1}$ was found from hybrid line-14 (7.53, 12.60, 15.27 and 16.60, respectively), while the minimum number from hybrid line-12 (5.13, 10.07, 11.17 and 14.20, respectively). At 30, 45, 60 and 75 DAT, the highest dry matter content was recorded from hybrid line-14 (3.82, 4.89, 6.70 and 7.87 g hill$^{-1}$ , respectively), whereas the lowest from hybrid line-4 (3.08, 4.09, 5.07 and 6.16 g hill$^{-1}$, respectively).

The highest days to 1$^{st}$ panicle initiation was recorded from hybrid line-9 (70.67 days), while the lowest from hybrid line-3 (60.33 days). The highest days to maturity was recorded from hybrid line-9 (140.00 days), while the lowest from hybrid line-4 (120.67 days). The maximum number of effective tillers hill$^{-1}$ was recorded from hybrid line-14 (13.33), while the minimum from hybrid line-12 (10.00). The maximum number of non-effective tillers hill$^{-1}$ was recorded from hybrid line-4 (3.13), whereas the minimum from hybrid line-11 (2.00). The maximum number of total tillers hill$^{-1}$ was recorded from hybrid line-14 (15.60),

while the minimum number from hybrid line-12 (12.53). The longest panicle was recorded from hybrid line-14 (25.89 cm), while the shortest panicle from hybrid line-12 (21.60 cm). The maximum number of filled grains panicle$^{-1}$ was recorded from hybrid line-14 (92.00), while the minimum number from hybrid line-12 (79.60). The maximum number of unfilled grains panicle$^{-1}$ was recorded from hybrid line-2 (8.73) and hybrid line-7 (8.73), while the minimum number from hybrid line-14 (6.23). The maximum number of total grains panicle$^{-1}$ was recorded from hybrid line-14 (98.23), while the minimum number from hybrid line-12 (86.47). The highest weight of 1000-grains was found from hybrid line-11 (24.49 g), while the lowest weight from hybrid line-1 (20.06 g).

The highest grain yield was found from hybrid line-14 (5.92 t ha$^{-1}$) and the lowest from hybrid line-12 (4.19 t ha$^{-1}$). The highest straw yield was found from hybrid line-6 (7.79 t ha$^{-1}$), whereas the lowest from hybrid line-4 (6.55 t ha$^{-1}$). The highest biological yield was recorded from hybrid line-6 (13.52 t ha$^{-1}$), while the lowest from hybrid line-1 (11.29 t ha$^{-1}$). The highest harvest index was found from hybrid line-14 (44.23%), whereas the lowest from hybrid line-12 (35.85%). Grain yield advantage over check was estimated and the highest positive advantage was recorded for the hybrid line-14 (6.28%) and the lowest positive advantage was observed from hybrid line-7 (0.18%), whereas the highest negative advantage was found from hybrid line-12 (-24.78%) and the lowest negative advantage was observed from hybrid line-2 (-2.51%).

**Conclusion**

Among the hybrid rice lines, the line -14 performed better growth, yield contributing characters and yield compared to other lines under study. Although the hybrid line - 14 showed highest yield advantage over the check variety, apparently it could not be treated as a cultivable variety in the transplanted aman season in Bangladesh because the yield advantage is below 20% of the check variety. However, further studies can be repeated in different agro-ecological zones of Bangladesh for regional trial before drawing the final conclusions about the said line.

## REFERENCES


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

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.

Ahmed, Z., Khan, D.R., Alim, S.D., Tahir, M. and Marwat, K.B. (1998). Effect of economics of time and weed removal on the yield and yield components of rice. *Sarhad J. Agril*., **14**(4): 335-338.

AIS (Agriculture Information Service). (2008). Krishi Diary. AIS, Khamarbari, Dhaka. p. 66.

Akbar, M.K. (2004). Response of hybrid and inbred rice varieties to different seedlings ages under system of rice intensification in transplant aman season. M.S. (Ag.) Thesis, Dept. Agron. B.A.U., Mymensingh. p. 78.

Alam, M.S., Biswas, B.K., Gaffer, M.A. and Hossain, M.K. (2012). Efficiency of weeding at different stages of seedling emergence in direct-seeded aus rice. *Bangladesh J. Sci. Ind. Res*., **30**(4): 155-167.

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.

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.

BBS. (2014). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. p. 64.

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 Manir, M.R. (2014). Yield performance of newly developed test crossed hybrid rice variety. *Intl. J. Agron. Agril. Res*., **5**(4): 48-54.

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

BINA (Bangladesh Institute of Nuclear Agriculture) (1998). Annual Report for 1997–98. BINA, Mymensingh, Dhaka, Bangladesh. p. 156.

BINA. (1993). Annual Report (1992-93). Bangladesh Inst. Nucl. Agric. P.O. Box No. 4. Mymensingh. pp. 143-147.

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

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

BRRI. (2012). Adhunik Dhaner Chash (in bengali). Bangladesh Rice Research Institute, Joydebpur, Gazipur. pp. 15-18.

BRRI. (1995). Adhunik Dhaner Chash (in bengali). Pub. by Bangladesh Rice Research Institute, Joydebpur, Gazipur. pp. 12-23.

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

BRRI (Bangladesh Rice Research Institute). (1991). Annual Report for 1988. BRRI Pub. No. 98. Joydebpur, Gazipur, Bangladesh. pp. 7-84, 294-300.

BRRI. (1985). Annual report for 1982. Bangladesh Rice Research Institute, Joydebpur, Gazipur, Bangladesh. BRRI pub. No. 79. pp. 236-238.

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.

Chaturvedi, S., Lal, P., Singh, A.P. and Tripathi, M.K. (2004). Agronomic and morpho-physiological analysis of growth and productivity in hybrid rice (*Oryza sativa* L.). *Ann. Biol*. **20**(2): 233–238.

Chen-Liang, C.Q., Li, Z.C. and 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.R.I. (1997). Agronomic parameters of some selected rice varieties/mutants as affected by method of transplanting in boro season. M.S. thesis, Dept. Agron., BAU, Mymensingh. p. 82.

Chowdhury, M.J.U., Sarker, A.U., Sarkar. M.A.R. and Kashem, M.A. (1993). Effect of variety and number of seedlings hill$^{-1}$ on the yield and its components of late transplant *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. pp. 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): 43-49.

Dou, F., Soriano, J., Tabien, R.E., Chen, K. (2016). Soil texture and cultivar effects on rice (*Oryza sativa*, L.) grain yield, yield components and water productivity in three water regimes. *Plos One*., **11**(3): 15-21.

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.

Evans, L.T. and Fischer, R.A. (1999). Yield potential: Its definition, measurement, and significance. *Crop Sci*., **39**: 1544–1551.

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

FAO (Food and Agriculture Organization). (2006). Retrieved from: http// www.fao.org.

FAO (Food and Agriculture Organization). (1988). Production Yearbook for 1998. FAO, UN. Rome, Italy. p. 118.

Ghosh, M. (2001). Performance of hybrid and high-yielding rice varieties in Teraj region of West Bengal. *J. Intl. Academicians*. **5**(4): 578–581.

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

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.M., Pramanik, H.R., Biswas, J.K., Iftekharuddaula, K. M. and Mirza Hasanuzzaman, M. (2015). Comparative Performance of Hybrid and Elite Inbred Rice Varieties with respect to Their Source-Sink Relationship. *The Scientific World J*., **15**: 1-11.

Haque, M. and Biswash, M.R. (2014). Characterization of commercially cultivated hybrid rice in Bangladesh. *World J. Agric. Sci.*, **10**(5): 300–307.

Horie, T. (2003). Increasing yield potential in irrigated rice: breaking the yield barrier. International Rice Research Institute (IRRI). Manila, Philippines. p. 56.

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

Hossain, S.M.A. and Alam, A.B.M.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. pp. 41-44.

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

IRRI (International Rice Research Institute). (2009). Rough rice production by country and geographical region-USDA. Trend in the rice economy. In: world rice statistics. Retrieved from: www.irri.org/science/ricestat.

Islam, M.S., Bhuiya, M.S.U., Rahman, S. and Hussain M.M. (2010). Evaluation of SPAD and LCc based nitrogen management in rice (*Oryza sativa* L.)," *Bangladesh J. Agril. Res.,* **34**(4): 661-672.

Islam, M.S.H., Bhuiyan, M.S.U., Gomosta, A.R., Sarkar, A.R. and Hussain, M.M. (2009). Evaluation of growth and yield of selected hybrid and inbred rice varieties grown in net house during transplanted aman season. *Bangladesh J. Agril. Res.,* **34**(1): 67–73.

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

Julfiquar, A.W. (2009). BRRI: research and development of hybrid rice. *The Guardian*, **19**(3): 33-39.

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

Julfiquar, A.W., Hasan, M.J., Azad, A.K. and Nurunnab, A.M. (2002). Research and development of hybrid rice in Bangladesh: Progress and Future Strategies, Bangladesh Rice Research Institute, Gazipur, Bangladesh, p. 9-19.

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, 12-13, April, 1998.

Kamal, A.M.A., Azam, M.A. and Islam, M.A. (1998). 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.

Laza, M.R.C., Peng, S., Sanico, A.L., Visperas, R.M. and Akita, S. (2001). Higher leaf area growth rate contributes to greater vegetative growth of $F_1$ rice hybrids in the tropics," *Plant Prod. Sci.*, **4**(3): 184–188.

Leenakumari, S., Mahadevappa, M., Vadyachandra, B.J. and Krishnamurthy, R.A. (1993). Performance of experimental rice hybrid in Bangalore, Karnataka, India. *Intl. Rice Res. Newsl*. **18**(1): 16.

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

Mandavi, F., Eamaili, M.A., Pirdashti, H. and Fallah, A. (2004). Study on the physiological and morphological indices among the modern and old rice (*Oryza sativa* L.) genotypes: New directions for a diverse planet. Proc. 4th Int. Crop Sci. Congress; Brisbane, Australia**.**

Masum, M. (2009). Impact of hybrid rice on Bangladesh. In: 'The Guardian". pp. 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.

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'. pp. 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. and 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.). *Australian J. Crop Sci.,* **2**(1): 65-71.

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.

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

Peng, S., Cassman, K.G., Virmani, S.S., Sheehy, J. and Khush, G.S. (1999). Yield potential trends of tropical rice since the release of IR8 and the challenge of increasing rice yield potential. *Crop Science*, **39**(6): 1552-1559.

Prakash, N.B. (2010). Different sources of silicon for rice farming in Karnataka. Paper presented in Indo-US workshop on silicon in agriculture, held at University of Agricultural Sciences, Bangalore, India, 25-27$^{th}$ February 2010. p. 14.

Pruneddu, G. and Spanu, A. (2001). Varietal comparison of rice in Sardinia. *Informatore Agrario.*, **57**(5): 47–49.

Radhakrishna, R.M., Vidyachandra, B., Lingaraju, S. and Gangadhariah, S. (1996). Karnataka rice hybrids. **In:** Abst. Proc. 3rd Intl. Symp. on hybrid Rice. Nov. 14–16. DRR, Hyderabad, India. p. 3–8.

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.

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.

Reddy, Y.A.N., Prasad, T.G., Kumar, M.U. and Sharkar, R.U. (1994). Selection for high assimilation efficiency: An approach to improve productivity in rice. *Indian J. Plant Physiol.* **37**(2): 133–135.

Roy, S.K.B. (2006). Increasing yield in irrigated boro rice through *indica/japonica* improved lines in West Bengal, India. Proc. Int. Rice Res. Conf. - Rice research for food security and poverty alleviation.

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.

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. Maharashtra 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.

Sharma, S.K. and Haloi, B. (2001). Characterization of crop growth variables in some selected rice cultivars of Assam. *Indian J. Plant Physiol.*, **6**(2): 166–171.

Singh, A.K., Chandra, N. and Bharati, R.C. (2012). Effects genotypes and planting time on phenology and performance of rice (*Oryza sativa* L.). *Vegetos*, **25**: 151-156.

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.

Son, Y., Park, S.T., Kim, S.Y., Lee, H.W. and Kim, S.C. (1998). Effects of plant density on the yield and yield components of low-tillering large panicle type rice. *J. Crop Sci*., **40**: 2-10.

Song, Z.P., Lu, B.R., Wang, B. and Chen, J.K. (2004). Fitness estimation through performance comparison of F1 hybrids with their parental species *Oryza rufipogon* and *O. sativa. Ann. Bot.*, **93**(3): 311–316.

Suprihatno, B. and Sutaryo, B. (1992). Yield performance of some new rice hybrids varieties in Indonesia. *Intl. Rice Res. Newsl*., **17**(3): 12-18.

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.

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. IRRI, Manila, Philippines, pp. 157-163.

Yang, J., Peng, S., Zhang, Z., Wang, Z., Visperas, R.M. and Zhu, Q. (2002). Grain and dry matter yields and partitioning of assimilates in japonica/indica hybrid rice. *Crop Sci.*, **42**(3): 766-772.

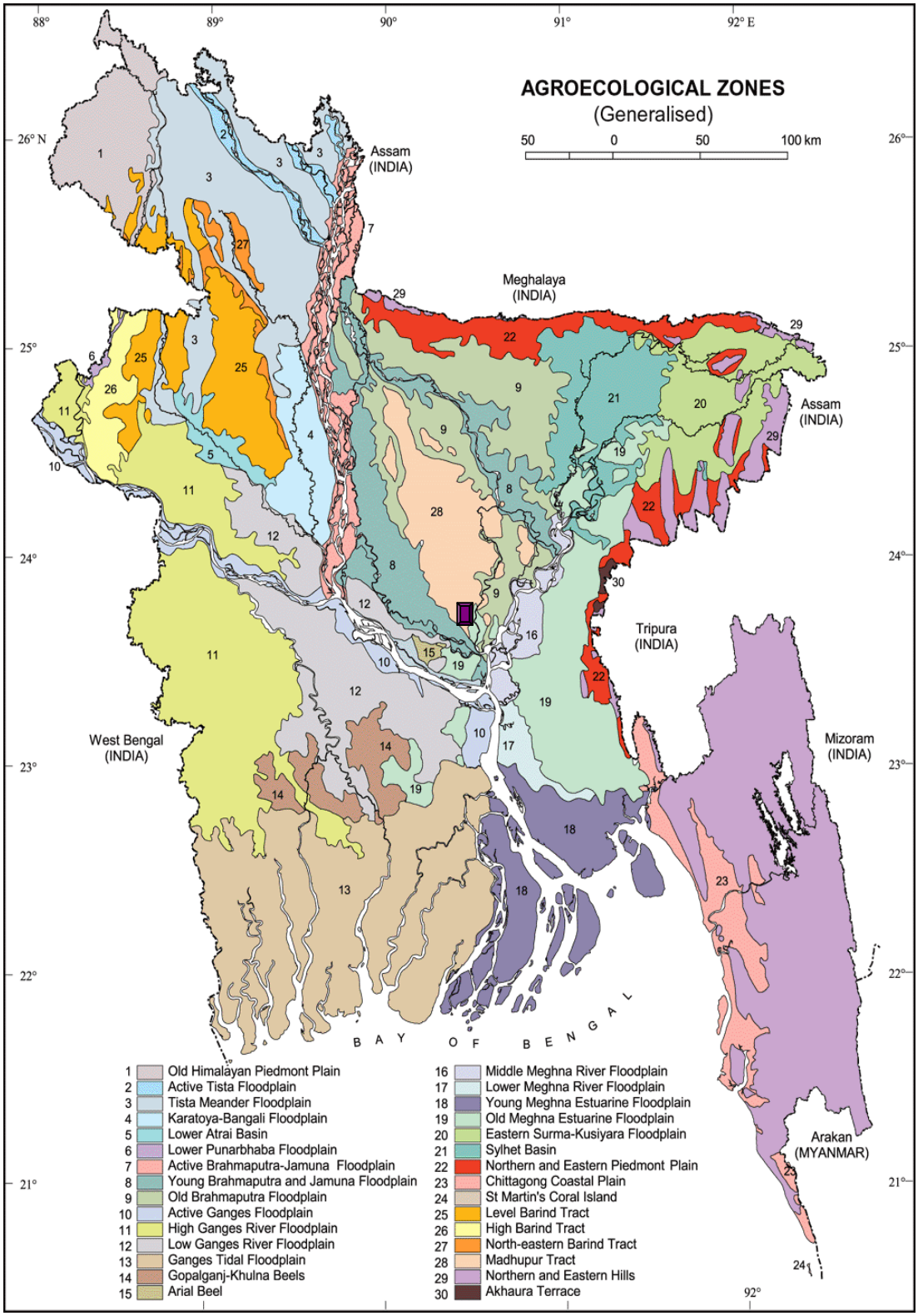
Ying, J., Peng, S. and He, Q. (1998). Comparison of high-yield rice in tropical and subtropical environments I. Determinants of grain and dry matter yields," *Field Crops Res.*, **57**(1): 71-84.

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

Yuan, J.C., Liu, C.J., Cai, G.C., Zhu, Q.S. and Yang, J.C. (2005). Study on variation and its characteristics of yield components of high-quality rice in Panxi region. *Southwest China J. Agric. Sci.*, **18**(2): 144–148.

# APPENDICES

## Appendix I. The Map of the experimental site



## Appendix II. 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 | Agronomy 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, Khamarbari, Farmgate, Dhaka

## Appendix III. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from July to November, 2014

| Month (2014) | Air temperature ($^0$c) | | Relative humidity (%) | Rainfall (mm) | Sunshine (hr) |
|---|---|---|---|---|---|
| | Maximum | Minimum | | | |
| July | 36.0 | 24.6 | 83 | 563 | 5.1 |
| August | 36.0 | 23.6 | 81 | 319 | 5.0 |
| September | 34.8 | 24.4 | 81 | 279 | 4.4 |
| October | 26.5 | 19.4 | 81 | 22 | 6.9 |
| November | 25.8 | 16.0 | 78 | 00 | 6.8 |

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

**Appendix IV. Analysis of variance of the data on plant height of rice as influenced by selected rice hybrid lines and BRRI dhan57**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Plant height at | | | | |
| | | 30 DAT | 45 DAT | 60 DAT | 75 DAT | Harvest |
| Replication | 2 | 0.451 | 0.375 | 6.257 | 10.643 | 16.914 |
| Treatment | 18 | 15.240* | 47.183** | 63.790** | 90.571* | 94.981** |
| Error | 36 | 7.588 | 15.259 | 18.521 | 39.580 | 28.371 |

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

**Appendix V. Analysis of variance of the data on number of tillers hill$^{-1}$ of rice as influenced by selected rice hybrid lines and BRRI dhan57**

| Source of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Tillers hill$^{-1}$ at | | | |
| | | 30 DAT | 45 DAT | 60 DAT | 75 DAT |
| Replication | 2 | 0.113 | 0.264 | 0.391 | 0.040 |
| Treatment | 18 | 1.209* | 1.230** | 3.903** | 1.676* |
| Error | 36 | 0.628 | 0.488 | 0.970 | 0.942 |

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

**Appendix VI. Analysis of variance of the data on dry matter content in plant of rice as influenced by selected rice hybrid lines and BRRI dhan57**

| Source of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Dry matter content in plant at | | | |
| | | 30 DAT | 45 DAT | 60 DAT | 75 DAT |
| Replication | 2 | 0.0001 | 0.0001 | 0.096 | 0.167 |
| Treatment | 18 | 0.125** | 0.186** | 0.588** | 0.428** |
| Error | 36 | 0.038 | 0.043 | 0.090 | 0.073 |

**: Significant at 0.01 level of probability

**Appendix VII. Analysis of variance of the data on days to 1st panicle initiation, days to maturity, effective, non-effective and total tillers hill$^{-1}$ of rice as influenced by selected rice hybrid lines and BRRI dhan57**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Days to 1st panicle initiation | Days to maturity | Effective tillers hill$^{-1}$ | Non-effective tillers hill$^{-1}$ | Total tillers hill$^{-1}$ |
| Replication | 2 | 5.333 | 18.018 | 0.034 | 0.003 | 0.020 |
| Treatment | 18 | 16.717* | 71.897* | 2.105** | 0.318** | 1.728* |
| Error | 36 | 7.407 | 34.499 | 0.823 | 0.069 | 0.689 |

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

**Appendix VIII. Analysis of variance of the data on panicle length, filled, unfilled and total grains and weight of 1000-grains of rice as influenced by selected rice hybrid lines and BRRI dhan57**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Panicle length | Filled grains panicle$^{-1}$ | Unfilled grains panicle$^{-1}$ | Total grains panicle$^{-1}$ | Weight of 1000-grains |
| Replication | 2 | 0.367 | 1.695 | 0.796 | 3.122 | 0.852 |
| Treatment | 18 | 5.484* | 22.105* | 28.408** | 22.249* | 3.183* |
| Error | 36 | 2.655 | 11.322 | 18.717 | 10.730 | 1.512 |

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

**Appendix IX. Analysis of variance of the data on yield and harvest index of rice as influenced by selected rice hybrid lines and BRRI dhan57**

| Source of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Grain yield | Straw yield | Biological yield | Harvest index |
| Replication | 2 | 0.054 | 0.032 | 0.028 | 2.863 |
| Treatment | 18 | 0.612** | 0.329** | 1.283** | 12.399** |
| Error | 36 | 0.101 | 0.059 | 0.210 | 2.117 |

**: Significant at 0.01 level of probability