COMPERATIVE STUDY OF SOME HYBRID AND INBRED RICE VARIETIES IN AMAN SEASON

A Thesis

By

TANVIRUL ISLAM
Reg. No.: 08-3247

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
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By

TANVIRUL ISLAM
Reg. No.: 08-03247

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Approved by:

(Dr. A.K.M. Ruhul Amin)	**Dr. Md. Hazrat Ali)**
Professor	**Professor**
Supervisor	**Co-Supervisor**

(Prof. Dr. A.K.M. Ruhul Amin)
Chairman
Examination Committee

Dedicated to

My

Beloved Parents

for Their Love, Endless Support and Encouragement

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
PABX: 9110351 & 9144270-79

CERTIFICATE

This is to certify that the thesis entitled, "**COMPERATIVE STUDY OF SOME HYBRID AND INBRED RICE VARIETIES IN AMAN SEASON**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) IN AGRONOMY, embodies the result of a piece of bona fide research work carried out by TANVIRUL ISLAM , Registration No. 08-3247 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

(Dr. A.K.M. Ruhul Amin)
Professor
Supervisor

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ABSTRACT

A field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from June to October 2009 to find out the performance of some hybrid and inbreed rice varieties in T. Aman season. The experiment comprised of one factor 14 varieties viz. (i) BRRI dhan31, (ii) BRRI dhan32, (iii) MHR- 1, (iv) MHR- 2, (v) MHR- 3, (vi) MHR- 4, (vii) MHR- 5, (viii) MHR- 6, (ix) MHR- 7, (x) MHR- 8, (xi) MHR- 9, (xii) MHR- 10, (xiii) MHR- 11 and (xiv) MHR- 12. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. At the time of harvest, the longest plant (123.00 cm), numbers of leaves hill^{-1} (32.65), highest number of unfilled grains panicle^{-1} (83.77) and 1000 grain weight (27.34 g) were achieved by MHR- 8, BRRI dhan32, MHR- 10 and MHR- 1 respectively. But in terms of highest tiller number hill^{-1} (12.67), dry matter weight hill^{-1} (44.92 g), number of effective tillers hill^{-1} (10.40), panicle length (28.05 cm), number of filled grains panicle^{-1} (161.10), grain yield (5.46 t ha^{-1}), straw yield (5.86 t ha^{-1}) and harvest index (48.27%) were obtained by MRH- 4 and that of second highest performance was found in MHR- 3. So, MRH- 4 and MHR- 3 can be considered as the best variety under the present study.

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LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAT	=	Days after transplanting
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg ha^{-1}	=	Kilogram per hectare
g	=	gram (s)
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
PU	=	Prilled Urea
P^{H}	=	Hydrogen ion conc.
TSP	=	Triple Super Phosphate
T ha^{-1}	=	ton per hectare
USG	=	Urea Super Granule
%	=	Percent

Chapter 1
Introduction

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop of the tropical world. There are 111 rice-growing countries in the world that occupies about 146.5 million hectares more than 90% of which is in Asia (Anon., 1999). Rice is the staple food for more than two billion people in Asia and many millions in Africa and Latin America. To feed the fast increasing global population, the world's annual rice production must increase to 760 million tons by the year 2020 (Kundu and Ladha, 1995).

Bangladesh with a population of 140 million in a land area of 147570 Sq km is one of the most densely settled countries in the world (BBS, 2009). Agriculture is the mainstay of Bangladesh economy and it employs nearly 52% of its labor force and contributes one fourth of its gross national product (BER, 2007). The principal crop and the dominant staple food is rice, which occupies nearly 76% of its total cropped area in the country. It contributes 76 percent of the caloric and 66 percent of the protein intake (BNNC, 2008). It is, by far, the largest sectoral source of income, employment, savings and investment in the economy. The fluctuations in the productivity of rice influence the food security and to some extent ensure political stability of the country. However, Bangladesh needs to increase the rice yield further in order to meet the growing demand. The National Commission of Agriculture projected that in order to remain self-sufficient Bangladesh will need to produce 47 million tonnes of paddy (31.6 million tonnes of clean rice) by year 2020, implying a required rate of growth of production is 1.7 percent per year. An earlier Agricultural Research Strategy document prepared by the Bangladesh Agricultural Research Council (BARC) projected the required paddy production by 2020 at 52 million tonnes (34.7 million tonnes of rice), which would require a production growth of 2.2 percent per year (BARC,2006).

Rice plays a dominant role in the agriculture of Bangladesh. It covers the area of about 11.03 million hectares with a production of 26.80 million tonnes. Among the three distinct rice groups, transplant aman rice covers the largest area of about 5.678 million hectares with a production of 11.520 million tonnes of rice (BBS, 2004).

Rice, the principal cereal crop in the country supplies food to the people and feed to the domestic animal. It covers 85 % of the country's total cropped area. Annual per capita consumption of rice in Bangladesh is the highest in the world and it provides about 70 % of total calorie requirement of the people (Nasiruddin, 1993). In spite of these, Bangladesh is one of the food deficit countries of the world. The population is increasing at the rate of 1.78%, which is almost the same as the increase of food grain production. The annual food deficit is 1.79 million metric tonnes (Uddin, 2001). This food shortage is a great challenge for the nation in achieving self-sufficiency in food. But cropping area under rice cultivation could hardly be increased rather some land should be released for other non-rice crops and farming practices. At the same, the yield of high yielding varieties has come to stagnation in spite of using relatively high inputs and standard management practices. So, it is deemed important to look for an alternative way to boost up the production. Scientists are quite optimistic to break the existing yield ceiling by introducing a new approach in rice production through the hybrid rice technology.

The government of Bangladesh permitted four private seed companies to import seeds of rice hybrids for the 1998-99 boro season to make up the shortage of rice seeds after the floods in the 1998 aman (monsoon season rice) season, since there were no locally bred rice hybrids.

Now-a-days, different hybrid and high yielding rice varieties are available in Bangladesh which have more yield potential than conventional high yielding varieties (Akbar, 2004). But the expansion of hybrid rice and HYV rice area is not satisfactory mainly due to its higher seed cost. Furthermore, farmers have to collect seeds from the traders every year due to its complex and technical production procedure.

So, it is essentially required to know the effect of different rice varieties from the inbred and hybrid rice and also to determine the suitable variety that is adaptable to the environment. Under the above circumstances, the present experiment was under taken with the following objectives:

OBJECTIVES

1. Study the varietal performance of inbred and hybrid rice and
2. Select the best varieties for Aman season

Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

The growth and development of rice may be affected due to varietal performance of different rice cultivars. It may also be affected depending on inbred and hybrid varieties. Relevant reviews on the above aspects have been presented and discussed in this chapter.

2.1 Effect of inbred and hybrid rice variety

The successful production of any crop depends on manipulation of basic ingredients of crop culture. The variety of crop is one of the important basic ingredients. High yielding varieties of rice play an important role in achieving higher yield. Some of the works related to different rice varieties are cited below.

Islam *et al*. (2009) conducted pot experiments during T. aman 2001 and 2002 (wet season) at Bangladesh Rice Research Institute (BRRI) in net house. Hybrid variety Sonarbangla-1 and inbred modern variety BRRI dhan31 were used in both the seasons and BRRI hybrid dhanl was used in 2002. The main objective of the experiments was to compare the growth and yield behaviour of hybrid and inbred rice varieties under controlled condition. In 2001, BRRI dhan3l had about 10-15% higher plant height, very similar tillers/plant, 15-25% higher leaf area at all days after transplanting (DAT) compared to Sonarbangla-1. Sonarbangla- 1 had about 40% higher dry matter production at 25 DAT but had very similar dry matter production at 50 and 75 DAT, 4-11% higher rooting depth at all DATs, about 22% higher root dry weight at 25 DAT, but 5-10% lower root dry weight at 50 and 75 DAT compared to BRRI dhan31. The photosynthetic rate was higher (20 µ mol m^{-2} sec^{-1}) in BRRI dhan3l at 35

DAT (maximum tillering stage) but at 65 DAT, Sonarbangla-l had higher photosynthetic rate of 19.5 μ mol m^{-2} sec^{-1}. BRRI dhan3l had higher panicles $plant^{-1}$ than Sonarbangla-1, but Sonarbangla-1 had higher number of grains $panicle^{-1}$, 1000-grain weight and grain yield than BRRI dhan31. In 2002, BRRI dhan31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhanl had the highest plant height. Sonarbangla-1 had the largest leaf area at 25 and 50 DAT followed by BRRI dhan31, but at 75 DAT, BRRI dhan31 had the largest leaf area. The highest shoot dry matter was observed in BRRI dhan31 followed by Sonarbangla-1 at all DATs. Sonarbangla-1 had the highest rooting depth and root dry weight at all DATs. BRRI dhan31 gave the highest number of panicles $plant^{-1}$ followed by Sonarbangla-I, BRRI hybrid dhanl had the highest grains $panicle^{-1}$ followed by BRRI dhan31 and Sonarbangla-I had the highest 1000-grain weight followed by BRRI dhan31. The highest amount of grains $plant^{-1}$ (34.6 g) was obtained from BRRI dhan31.

Xia *et al.* (2007) in experiment found that Shanyou63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}).

Bisne *et al.* (2006) conducted an experiment with eight promising varieties using four CMS lines and showed that plant height, tiller number $hill^{-1}$ and grain yield differed significantly among the varieties and Pusa Basmati gave the highest plant height, tiller number $hill^{-1}$ and grain yield in each line.

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.

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

Chowdhury *et al*. (2005) conducted an experiment with 2, 4 and 6 seedlings hill^{-1} to study their effect on the yield and yield components of rice cv. BR23 and Pajam during the amen season. They reported that the cv. BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. number of productive tillers hill^{-1}, length of panicle, l000-grain weight, grain yield and straw yield. On the other hand, the cultivar Pajam produced significantly the tallest plant, total number of grains panicle^{-1}, number of filled grains panicle^{-1} and number of unfilled grains panicle^{-1}.

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 Iksan#467 varieties, but secondary rachis branches (SRBs) were fewer than in Dongjin#1 and Saegyehwa varieties.

Akbar (2004) reported that variety, seedling age and their interaction exerted significant influence on almost all the crop characters. Among the varieties, BRRI dhan41 performed the best in respect of number of bearing tillers hill^{-1}, panicle length, total spikelets panicle^{-1} and number of grains panicle^{-1}. BRRI dhan41 also produced the maximum grain and straw yields. Sonarbangla-1 ranked first in respect of total tillers hill^{-1} and 1000-grain weight but produced highest number of non-bearing tillers hill^{-1} and sterile spikelets panicle^{-1}. Grain, straw and biological yields were found highest in the combination of BRRI dhan 41 with 15 day-old seedlings. Therefore, BRRI dhan 4l may be cultivated using 15 day-old seedlings in aman season following the SRI technique to have better grain and straw yields.

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

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

Bokyeong *et al.* (2003) reported that applied with same nitrogen dose Sindongjinbyeo and Iksan#467 gave high primary rachis branches than Sindongjinbyeo and Dongjin No. 1 varieties.

Dongarwar *et al.* (2003) comprised an experiment to investigate the response of hybrid rice KJTRH-1 in comparison with 2 traditional cultivars, Jaya and

Swarna, to 4 fertilizer rates, i.e. 100:50:50, 75:37.5:37.5, 125:62.5:62.5 and 150:75:75 kg NPK ha^{-1} and reported that KJTRH-1 produced significantly higher yield (49.24 q ha^{-1}) than Jaya (39.64 q ha^{-1}) and Swarna (46.06 q ha^{-1}).

Siddiquee *et al*. (2002) conducted a study to evaluate the difference between hybrid and inbred rice in respect of their growth duration, yield and quality in Boro season, 1999. Among the varieties, Aalok 6201 had the highest grain yield followed by BRRI dhan29 and IR68877H but statistically they were similar. BRRI dhan28 had the lowest grain yield, which was statistically similar to Loknath503. BRRI dhan28 and the tested hybrid rice had lower growth duration than BRRI dhan29. Milling out turn varied from 67 to 70% among the tested varieties. Loknath 503 had the lowest milling out turn (70%) and, BRRI dhan28 and BRRI dhan29 had the highest milling out turn (70%) for unparboiled but parboiled rice the highest milling out turn(73%) were found in BRRI dhan28 and IR68877H . All tested hybrid rice were medium bold, whereas BRRI dhan29 and BRRI dhan28 were medium slender and long slender, respectively in both parboiled and unparboiled condition. Among the varieties, amylose content (%) was higher in BRRI dhan29 and protein content (%) was higher in IR68877H for both under parboiled and unparboiled condition. Alkali spreading value was higher in BRRI dhan28. Cooking quality of all the varieties was more or less similar.

Rahman *et al*. (2002) carried out an experiment with 4 varieties of transplant aman rice viz., BR1l, BR22, BR23 and Tuishimala and 6 structural arrangement of rows viz., 25 cm + 25 cm, 30 cm + 20 cm, 35 cm + 1 5 cm, 40 cm + 10 cm) 45 cm + 05 cm and haphazard planting at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Thousand grains weight and grain yield were highest in BR23 and these were lowest in Tulshirnaia.

Obulamma *et al.* (2002) performed an experiment with hybrid rice DRRHI and APHR-2 at Andhra Pradesh, India. The treatments were 4 spacing (15x10, 2U x10, 15x15 and 20x15 cm 2) and 3 seedling densities (1, 2 and 3 seedlings hill^{-1}). APHR-2 was found to produce higher yield than DRRH-l.

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

Dwarfness may be one of the most important agronomic characters, because it is often accompanied by lodging resistance and thereby adapts well to heavy fertilizer application (Futsuhara and Kikuchi, 1984). Prasad *et al*. (2001) observed that days to flowering are negatively correlated with plant height. Grain yield is negatively correlated with plant height (Amirthadevarathinam, 1983). Patnaik *et al*. (1990) found that hybrids with intermediate to tall plant height having non-lodging habit could be developed gave more than 20% grain yield than the standard checks.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4 m^{-2}) and filled grains panicle^{-1} (111.0) than other varieties, whereas IR36 gave the highest 1000-grain weight (21.07 g) and number of panicles m^{-2} than other tested varieties. In a trial, varietal differences in harvest index and yield examined using 60 Japanese varieties and 20 high yielding varieties bred in Asian countries. It was reported that harvest index varied form 36.8% to 53.4%. Mean values of harvest index were 43.5% in the Japanese group and

48.8% in high yielding group. Yield ranged from 22.6 g plant^{-1} to 40.0 g plant^{-1}. The mean value of yield in Japanese group was 22.8 g plant^{-1}, and that in the high yielding group was 34.1 g plant^{-1}. They also reported that a positive correlation was found between harvest index and yield in the high yielding group (Cui *et al.*, 2000).

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

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

Om *et al.* (1999) conducted a field experiment with four varieties (3 hybrids: ORI 161, PMS 2A, PMS 10A and I inbred variety HKR 126) during rainy season and observed that hybrid ORI 161 exhibited superiority to other varieties in grain yield and straw yield.

Julfiquar *et al*. (1998) reported that BRRI evaluated 23 hybrids along with three standard checks during *boro* season 1994-95 as preliminary yield trial at Gazipur and it was reported that five hybrids (IR58025A/IR54056, IR54883, PMS8A/IR46R) out yielded the check varieties (BR14 and BR16) with significant yield difference. They also reported that thirteen rice hybrids were evaluated in three locations of

BADC farm during the boro season of 1995-96. Two hybrids out yielded the check variety of same duration by more than 1 t ha^{-1}.

Xu and Li (1998) observed that the maintainer lines were generally shorter than restorer line. Roy *et al*. (1989) observed that the plants, which needed more days for 50% flowering generally, gave more yield.

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

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

Mishra and Pandey (1998) evaluated standard heterosis for seed yield in the range of 44.7 to 230.9% and 42.4 to 81.4%, respectively. Plant height, panicles $plant^{-1}$, grains $panicle^{-1}$ and 1000 grain weight increase the yield in modern varieties.

Tac *et al.* (1998) conducted an experiment with two rice varieties, Akitakomachi and Hitombore in Tohoku region of Japan. It was found that Hitombore yielded the highest (7.10 g m^{-2}) and Akitakomachi yielded the lowest (660 g m^{-2}).

Associations of various yield components in rice (Padmavathi *et al.*, 1996) indicated that the plants with large panicles tend to have a high number of fertile grains. Similarly, a positive correlation was observed between number of panicle plant^{-1} and panicle length.

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

Dwivedi (1997) in a field experiment found that scented genotypes, Kamini and Sugandha gave higher grain and straw yields than four other cultivars RP615, Harban, Basmati and Kasturi with 60 kg N ha^{-1} under midupland sandy loam soil conditions of Agwanpur (Bihar).

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

BRRI (1995) conducted three experiments to find out the performance of different rice varieties. Results of the first experiment indicated that BR4, BR10, BR11, Challish and Nizersail produced grain yield of 4.38, 3.12, 3.12, 3.12 and 2.70 t ha^{-1}, respectively. Challish cultivar flowered earlier than all other varieties. BR22 and BR23 showed poor performance. Second experiment with rice cv. BR10, BR22, BR23 and Rajasail at three locations in aman season. It was found that BR23 yielded the highest (5.17 t ha^{-1}), and Rajasail yielded the lowest (3.63 t ha^{-1}). Growth duration of BR22, BR23 and Rajasail were more or less similar (152-155 days). Third experiment with BR22, BR23, BR25 and Nizersail during aman season at three locations-Godagari, Noahata, and Putia where BR25 yielded the highest and farmer preferred it due to its fine grain and desirable straw qualities.

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

Mallick (1994) carried out a pot experiment at the Institute of Postgraduate Studies in Agriculture (IPSA), Salna, Gazipur during the wet season, 1993 to evaluate the varietal differences in panicle characteristics, spikelet ripening, and special distribution of filled and unfilled spikelets within a panicle as influenced by tiller removal and double transplanting. The two varieties- Nizersail and BR 22 representing old and modern rice were taken as variables. Removal of tillers from the mother shoot and double transplanting increased panicle formation by about 10% in both the varieties. Tiller removal increased grain yield panicle^{-1} by 27% in Nizersail and 21% in BR 22. Double transplanting increased the number of spikelets panicle^{-1} in both the varieties. Tiller removal also increased spikelets but not as much as was in the double transplanted rice.

Ali and Murship (1993) conducted an experiment during July to December 1989 to determine suitable variety for late transplant aman rice. They reported that local variety Kumargoir significantly out yielded the modern rice cultivars BR23 and BR11.

BINA (1993) evaluated performance of four varieties-IRATOM 24, BR14, BINA dhan 13 and BINA dhan 9 and found that varieties differed significantly in respect of plant height, number of unproductive tillers hill^{-1}, panicle length and sterile spikelets panicle^{-1}.

Leenakumari *et al.* (1993) evaluated eleven hybrids of varying duration against controls Jaya, Rasi, IR20 and Margala, and observed that hybrid OR 1002 gave the highest yield (7.9 t ha^{-1}) followed by IR 1000 (6.2 t ha^{-1}).

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

BINA (1992) reported in a field experiment that under transplanting conditions the grain yield of BINA dhan 13 and BINA dhan 19 were 5.39 and 5.57 t ha^{-1} respectively and maturity of the above strains were 160 days and 166 days, respectively.

BRRI (1991) reported that the number of effective tillers produced by some transplant aman rice ranged from 7 to 14 hill^{-1} and it significantly differed with variety.

In a trial with six modern varieties in haor area during boro season, it was recorded that rice grain yield differed significantly where 4.59, 5.3, 5.73, 4.86, 3.75 and 4.64 t ha^{-1} of grain yield were recorded with BR3, BR11, BR14, IR8, Pajam and BRl6, respectively (Hossain *et al.*, 1991).

Hossain and Alam (1991) reported that the growth characters like plant height, total tillers hill^{-1} and number of grains panicle^{-1} differed significantly among BR3, BR11, BR4, Pajam and Jaguli varieties in boro season.

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

Patnaik *et al*. (1990) reported that in hybrids, yield was primarily influenced by effective tillers plant^{-1} and fertile grains panicle^{-1}, whereas in parents it was panicle length, maturity and effective tillers plant^{-1}. Number of effective tillers plant^{-1} and fertile grains panicle^{-1} remained constant and common in explaining heterosis for yield of most of the hybrids. The heterosis for grain yield was mainly due to the significant heterosis for the number of spikelets panicle^{-1}, test weight and total dry matter accumulation.

Shahidullah *et al.* (1989) conducted an experiment on retransplantation with 5 different transplanting dates and 5 transplant aman varieties. The fifty percent of each plot were disturbed by separating 50% of the total tillers hill^{-1} and subsequently retransplanted on mid-September in the field with 40 cm lower elevation (considered as flood affected field) than that of main field. They suggested that the total production might be increased through tiller separation and replanting and thereby the flood damaged transplant aman field could be recovered successfully.

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

Roy *et al.* (1989) conducted an experiment with variety BR11 at 4 to 5 seedlings hill^{-1}. After 35 days I, 3, 5 and 7 tillers were separated and replanted with 65 days old seedlings of the same variety as a control. They observed that number of panicles m^{-2} was higher with control and the lowest with 1 tiller hill^{-1}. Number of grains panicle^{-1} was significantly lower with control but no significant differences were observed with 1000 grain weight. Grain yield was significantly reduced compared with the control and 1 tiller planted hill^{-1} but there was no significant difference in grain yield with 3 to 7 tillers planted hill^{-1}.

Biswas *et al.* (1989) carried out experiment where 45 day old seedlings were transplanted and after 35 days I, 3, 5 and 7 tillers were detached from the mother crop replanted with 65 days old seedlings of the same variety as the control. They found that the highest yield (5.3 t ha^{-1}) was produced by retransplanting 3 to 5 tillers hill^{-1} but yield of the control was 3.8 t ha^{-1}.

BRRI (1985) reported that BR4 and BR10 were higher yielders than Rajasail and Kajalsail. Kamal *el al.* (1988) observed that among three rice varieties BR3 produced the highest grain yield and Pajam yielded the lowest. The superiority of promising line over the high yielding varieties in respect of grain yield was recorded by Bhuiyan and Saleque (1989).

Islam and Ahmed (1981) reported that the varieties Naizersail, Latishail, IR5 and IR20 differed significantly in respect of their performance. The two exotic cultivars of rice IR5 and IR20 independently gave significantly higher yield of grain than either of the other two local cultivars; and of the two exotic cultivars, IR5 was higher yielder (5188 kg ha^{-1}) though it was statistically identical with IR20 (5022 kg ha^{-1}) in respect of yield.

Luh (1980) reported that tillering and the production of leaves are the main visible activity during the vegetative phase of rice. In the tropics, maximum tiller and leaf number in rice occurred at 40 to 60 days after transplanting, depending upon the tillering capacity of the variety, the spacing used and the fertility level. The high yielding tropical varieties produced 25 to 30 tillers when grown as isolated plants.

Miller (1978) from a study of 14 rice cultivars observed that grain yields ranged from 5.6 to 7.7 t ha^{-1}. He also reported that grain yield was significantly influenced by rice cultivars. Kumber and Sonar (1978) also reported variable effects of rice varieties on grain yield.

Improvement of rice grain yield is the main target of breeding program to develop rice varieties for diverse ecosystems. However, grain yield is a complex trait, controlled by many genes and highly affected by environment (Jennings *et al.*, 1979). In addition, grain yield also related with other characters such as plant type, growth duration, and yield components (Yoshida, 1981). Rice yield is a product of number of panicles per unit area, number of spikelets $panicle^{-1}$, percentage of filled grains and weight of 1000 grains (Yoshida, 1981; De Datta, 1981). Improving rice (*Oryza sativa* L.) grain yield per unit land area is the only way to achieve increased rice production because of the reduction in area devoted to rice production (Cassman, 1999).

Chang and Vergara (1972) stated that the tillering pattern of rice varied with the varieties. In general, tall cultivars showed a tendency to have small number of tillers and shorts ones showed a large number. Tiller number and panicle number are positively correlated. Tall tropical and sub-tropical cultivars tend to have a low ratio of panicles to tillers. Japonica cultivars that produced few tillers under tropical conditions were vigorous and produced more tillers when grown under temperate conditions. Indica cultivars, which were vigorous under tropical conditions, showed few tillers under temperate conditions.

Yoshida (1972) reported two aspects of tiller as, spatial arrangement of tillers and tillering capacity. Medium tillering capacity considered desirable for a high yielding variety. Lower yield of rice varieties believed to be caused by faster growth rate and excessively large LAI beyond an optimum, which in turn were closely related to high tillering capacity.

Richharia *et al.* (1964) observed that twenty one, out of thirty varieties, exhibited differential response in increasing the grain yield by the simple process of separating the tillers three weeks after planting with a spacing of 15x15 cm^2 and replanting them with a closer spacing of 15.0x4.5 cm^2 with the same area. The plant height number and weight of grains $plant^{-1}$ and length of panicle were more in tiller plant than those in seed plants. They also showed some other advantages of tiller crop such as withstanding late planting by quicker establishment uniform stand, least mortality, reducing sterility and flowering about 10 days earlier. Above all an increased yield by more than 10% was obtained by vegetative propagation as compared to that of normal seedlings.

Richharia and Rao (1962) suggested that both hybrid and pure variety produced higher yield when propagated vegetatively and exploitation of hybrid vigor might be possible through the technique of clonal propagation.

Richharia (1960) stated that formation of tillers by activation of dormant buds was more pronounced in photoperiodically sensitive, long duration varieties than in insensitive ones. Probably prolongation of the vegetative phase provided in photosensitive varieties until the advent of the favorable season for initiation of the reproductive phase provided the opportunity for more abundant development of dormant buds. This method of vegetative propagation might prove useful in breeding genetical work and the multiplication of pure varieties.

Chapter 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during the period from June to October 2009 to find out the performance of some hybrid and inbred rice varieties in Aman season. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and their analysis.

3.1 Site description

The study was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. 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 (Appendix I).

3.2 Climate and weather

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

3.3 Soil

The soil belongs to “The Modhupur Tract”, AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix III.

3.4 Plant materials

Total fourteen samples of hybrid and inbred rice varieties were used as plant materials. Among them two varieties viz. BRRI dhan31 and BRRI dhan32 were used which were developed in BRRI that were used as local check. The fourteen hybrids and inbred rice varities were as follows:

(i) BRRI dhan31,
(ii) BRRI dhan32,
(iii) MHR- 1,
(iv) MHR- 2,
(v) MHR- 3,
(vi) MHR- 4,
(vii) MHR- 5,
(viii) MHR- 6,
(ix) MHR- 7,
(x) MHR- 8,
(xi) MHR- 9,
(xii) MHR- 10,
(xiii) MHR- 11 and
(xiv) MHR- 12

These fourteen varieties are recommended for Aman season.

3.5 Experimental details

3.5.1 Treatments

One factor experiment was conducted to evaluate the performance of some hybrid and inbred rice varieties in Aman season. The test varieties that were used in the present study were as follows:

(i) BRRI dhan31
(ii) BRRI dhan32
(iii) MHR- 1
(iv) MHR- 2
(v) MHR- 3
(vi) MHR- 4
(vii) MHR- 5
(viii) MHR- 6
(ix) MHR- 7
(x) MHR- 8
(xi) MHR- 9
(xii) MHR- 10
(xiii) MHR- 11
(xiv) MHR- 12

3.5.2 Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the variety. There were 42 plots of size 2.5 m × 4 m in each of 3 replications. The treatments of the experiment were assigned at random into each replication following the experimental design.

Seedlings were sown in seed bed and age of transplanted seedling was 21 days. Line to line distance was 25 cm where hill to hill distance was 15 cm. Two seedlings hill^{-1} were used during transplanting.

3.6 Growing of crops

3.6.1 Raising seedlings

3.6.1.1 Seed collection

The seeds of the test crops were collected from BRRI and ACI Seed Company. ACI introduced these 12 varieties from China to test the performance in Bangladesh for Aman season.

3.6.1.2 Seed sprouting

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

3.6.1.3 Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed @ 70 g m^{-2} on June 5, 2009 in order to have seedlings of 21 days.

3.6.2 Preparation of the main field

The plot selected for the experiment was opened in 18 June 2009 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.6.3 Fertilizers and manure application

The following doses were used of different manures and fertilizers:

(i) Cowdung : 10 t ha^{-1}

(ii) Urea (N) : 250 kg ha^{-1}

(iii) TSP (P_2O_5) : 150 kg ha^{-1}

(iv) MP (K_2O) : 180 kg ha^{-1}

(v) Gypsum (Sulpher) : 75 kg ha^{-1}

(vi) Zinc : 25 kg ha^{-1}

Whole amount of cowdung, TSP, MP, Gypsum and Zinc and one third of urea were applied at the time of final land preparation at broadcasting method. Half of the rest two third of urea was applied at 20 DAT and the rest amount of urea was applied at 45 DAT.

3.6.4 Uprooting seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on June 25, 2009 without causing much mechanical injury to the roots.

3.6.5 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on June 26, 2009 and the rice seedlings were transplanted in lines each having a line to line distance of 20 cm and plant to plant distance was 15 cm for all test varieties in the well prepared plot.

3.6.6 Cultural operations

The details of different cultural operations performed during the course of experimentation are given below:

3.6.6.1 Irrigation and drainage

Flood irrigations were given as and when necessary to maintain 3-5 cm water in the crop field.

3.6.6.2 Gap filling

Gap filling was done for all of the plots at 7-10 days after transplanting (DAT) by planting same aged seedlings.

3.6.6.3 Weeding

First weeding was done from each plot at 15 DAT and second weeding was done from each plot at 40 DAT. Mainly hand weeding was done from each plot.

3.6.6.4 Plant protection

Furadan 57 EC was applied at the time of final land preparation and Dimecron 50 EC was applied at 30 DAT.

3.7 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of plant and harvesting was done manually from each plot. For recording yield data plants of central six lines were harvested in each plot. Harvesting was started at 98 DAT and continued to 115 DAT. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}. Ten hills were harvested form each plot and tagged separately from outside.

3.8 Data recording

The following data were collected during the study period:

3.8.1 Data on growth parameters

1. Plant height (cm)
2. Tillers hill^{-1} (No.)
3. Leaves hill^{-1} (No.)
4. Dry weight hill^{-1} (g)

3.8.2 Data on yield and other parameters

1. Effective tillers hill^{-1} (No.)
2. Panicle length (cm)
3. Grains panicle^{-1} (No.)
4. Weight of 1000 grains (g)
5. Grain yield (t ha^{-1})
6. Straw yield (t ha^{-1})
7. Harvest index (%)

3.8.3 Procedure of recording data

3.8.3.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 20, 40, 60, 80 DAT (days after transplanting) and at harvest. Data were recorded as the average of same 10 hills selected at random from the outer side rows (started after 2 rows from outside) of each plot. The height was measured from the ground level to the tip of the plant.

3.8.3.2 Tillers hill^{-1}

The number of tillers hill^{-1} was recorded at 20, 40, 60, 80 DAT (days after transplanting) and at harvest by counting total tillers as the average of same 5 hills pre selected at random from the inner rows of each plot.

3.8.3.3 Leaves hill^{-1}

The number of leaves hill^{-1} was recorded at 20, 40, 60, 80 DAT (days after transplanting) and at harvest by counting total leaves as the average of same 5 hills pre selected at random from the inner rows of each plot.

3.8.3.4 Dry weight hill^{-1}

Total dry matter hill^{-1} was recorded at the time of 20, 40, 60, 80 DAT (days after transplanting) and at harvest by drying plant sample. Data were recorded as the average of 3 sample hill plot^{-1} selected at random from the outer rows of each plot leaving the boarder line and expressed in gram.

3.8.3.5 Length of panicle

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

3.8.3.6 Grains panicle^{-1}

The total number of grains was collected from the randomly selected 10 panicles in each plot and then average number of grains panicle^{-1} was calculated.

3.8.3.7 Weight of 1000 grains

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

3.8.3.8 Grain yield

The central 6 lines from each plot were harvested, threshed, dried, weighed and finally converted to t ha^{-1} basis.

3.8.3.9 Straw yield

The dry weight of straw of central 6 lines were harvested, threshed, dried and weighed and finally converted to t ha^{-1} basis.

3.8.3.10 Harvest index

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

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

3.9 Statistical Analysis

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

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The experimental results regarding the ‘growth, yield and yield contributing parameters of transplanted aman rice as influenced by some hybrid and inbred varieties in Aman season have been presented and discussed in this chapter. The effects of some hybrid and inbred varieties on growth, yield and yield contributing characters have been presented in this chapter.

4.1 Growth parameters

4.1.1 Plant height

Significant influence was remarked in terms of plant height with different hybrid and inbred varieties of transplanted aman rice (Table 1). It was also marked that a trend of gradual increase feature on plant height compared to one another among the test varieties was not achieved.

Results showed that at 20 and 40 DAT, MHR- 10 showed the highest plant height (77.33 and 90.87 cm, respectively), but at 60 and 80 DAT, MHR- 3 showed the highest plant height (115.30 and 115.60 cm, respectively). It was also evident that at the time of harvest the tallest plant was produced by MHR- 8 (123.00 cm) which was closely followed by MHR- 3, MHR- 4 and MHR- 5 (120.60, 120.30 and 120.70 cm) respectively. The competition in accordance with plant height among the test varieties, the shortest plant was observed with BRRI dhan32 (56.80, 74.13, 90.53, 91.07 and 99.40 cm at 20, 40, 60, 80 DAT and at harvest respectively) which was statistically similar with BRRI dhan31 and MHR- 11 at 20 and 40 DAT and BRRI dhan31 also showed lower plant height till to harvest.

The results corroborate with the findings of Islam*et al*. (2009), Bisne*et al.* (2006), Mishra and Pandey (1998), BINA (1993) and Hossain and Alam (1991) who observed various plant height due to different varieties.

Table 1: Performance of some hybrid and inbred varieties on plant height in Aman season

Variety	Days after transplanting (DAT) (cm)				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**At harvest**
BRRI dhan31	58.07 f	75.60 i	97.60 g	98.33 g	114.50 d
BRRI dhan32	56.80 f	74.13 i	90.53 h	91.07 h	99.40 e
MHR- 1	64.73 e	80.13 gh	111.00bc	111.50 c	118.30bc
MHR- 2	64.13 e	85.20 cd	110.30 c	110.60 c	116.50 cd
MHR- 3	66.73 d	84.20 de	115.30 a	115.60 a	120.60ab
MHR- 4	70.27 c	82.93 d-f	112.70 b	113.30 b	120.30ab
MHR- 5	64.40 e	79.20 h	100.50 f	101.10 f	120.70 ab
MHR- 6	70.07 c	87.33 bc	110.50 c	111.00 c	119.10bc
MHR- 7	70.93 c	82.13 e-g	107.50 d	108.50 d	116.80 cd
MHR- 8	74.20 b	88.27 b	112.40bc	112.30bc	123.00 a
MHR- 9	73.20 b	83.67 de	106.40 d	107.00 d	116.50 cd
MHR- 10	77.33 a	90.87 a	100.20 f	100.90 f	115.90 cd
MHR- 11	58.53 f	75.00 i	104.10 e	104.40 e	119.20 bc
MHR- 12	64.73 e	80.93 f-h	110.60 c	110.90 c	118.50bc
SE	2.650	**2.589**	**2.466**	**2.457**	**2.523**
CV (%)	**6.88**	**5.46**	**4.02**	**6.98**	**3.73**

4.1.2 Number of tillers hill^{-1}

The production of tillers hill^{-1} was significantly influenced by the tested different hybrid and inbred varieties (Table 2). The tiller number of the varieties increased with the advancement of growth stages. In some cases, finally (at harvest) reduced tiller number was observed than previous. MRH- 4, at all growth stages showed the highest tiller number hill^{-1} (8.93, 8.99, 9.87, 14.13 and 12.67 at 20, 40, 60, 80 DAT and at harvest, respectively) and the maximum tillers hill^{-1} (14.13) was obtained at 80 DAT and after that the tiller number hill^{-1} become reduced. At harvest, the highest tiller number hill^{-1} (12.67) was found in MRH- 4 which was statistically similar with MRH- 5.

The minimum tillers hill^{-1}at 20 and 40 DAT was found in MHR- 6 (5.73 and 5.87,respectively) and at 60 and 80 DAT it was found in MHR- 12 (6.13 and 7.00,respectively). But at the time of harvest the lowest number of tillers hill^{-1} (7.00) was found in MHR- 12 which was statistically identical with MHR- 11 (7.33).

Islam *et al*. (2009), Bisne *et al.* (2006), Chowdhury *et al*. (2005), Akbar (2004) and Bhowmick and Nayak (2000) reported similar trend of tillering habits with different varieties of rice.

Table 2: Performance of some hybrid and inbred varieties on number of tillers hill^{-1} in Aman season

Variety	Days after transplanting (DAT) (Number)				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**At harvest**
BRRI dhan31	3.40 c	7.42 c	9.00 b	11.20 de	9.13 bc
BRRI dhan32	2.60 e	6.67 ef	7.27 e	9.27 h	8.53 cd
MHR- 1	2.27 f	6.28gh	7.67 de	11.13 d-f	8.07 d
MHR- 2	2.27 f	6.53 e-g	7.67 de	10.80 ef	7.87 de
MHR- 3	4.53 b	8.56 b	7.53 de	11.53 cd	9.13 bc
MHR- 4	4.93 a	8.99 a	9.87 a	14.13 a	12.67 a
MHR- 5	3.20 cd	7.23 cd	10.03 a	12.27 ab	9.47 b
MHR- 6	4.73 g	5.87 i	8.07 cd	10.60 f	9.13 bc
MHR- 7	2.33 ef	6.47 fg	7.60 de	9.40 h	9.07 bc
MHR- 8	3.07 d	6.60 e-g	8.27 c	10.80 ef	9.53 b
MHR- 9	1.93 g	6.00 hi	8.47 bc	9.93 g	8.33 d
MHR- 10	2.60 e	6.87 de	8.47 bc	11.07 d-f	8.00 de
MHR- 11	2.47 ef	6.60 e-g	7.53 de	11.87 bc	7.33 ef
MHR- 12	2.93 d	7.07 cd	6.13 f	9.07 h	7.00 f
SE	**1.309**	**0.838**	**0.722**	**0.798**	**0.686**
CV (%)	**7.30**	**8.06**	**7.90**	**12.77**	**5.46**

4.1.3 Number of leaves hill^{-1}

Significant variation was marked in terms of number of leaves hill^{-1} at different growth stages of rice among the test varieties (Table 3). Gradually increased number of leaves was found of different growth stages till to 40 DAT but after that decreased trend was observed till to harvest.

Results showed that the highest number of leaves hill^{-1} was produced from BRRI dhan32 (36.00, 40.00, 35.93, 35.73 and 32.65 at 20, 40, 60, 80 DAT and at harvest, respectively) which was statistically similar with MHR- 3 at 60 DAT, 80 DAT and at harvest. The highest leaves hill^{-1} (40.00) was obtained at 40 DAT and after that the leaf numbers hill^{-1} become reduced gradually till to harvest.

A sequential trend was not also found in terms of minimum number of leaves hill^{-1}. The lowest number of leaves hill^{-1} was found in MHR- 1 (18.73 at 20 DAT) and MHR- 12 (26.27 at 40 DAT) but at 60, 80 DAT and at harvest the lowest number of leaves hill^{-1} was found in MHR- 6 (23.73, 22.93 and 20.02, respectively). At the time of harvest, MHR- 9 was also showed lower number of leaves hill^{-1}which was statistically similar with MHR- 6 (20.36).

The results substantiate with the findings of Luh (1980) who observed highest tiller and leaf number in rice occurred at 40 to 60 days after transplanting, depending upon the tillering capacity of the variety, the spacing used and the fertility level.

Table 3: Performance of some hybrid and inbred varieties on number of leaves hill^{-1} in Aman season

Variety	Days after transplanting (DAT) (Number)				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**At harvest**
BRRIdhan31	27.33 d	33.93 cd	29.60 b	29.30 b	26.48 b
BRRIdhan32	36.00 a	40.00 a	35.93 a	35.73 a	32.65 a
MHR- 1	18.73 f	29.60 f	25.67 d-f	25.07 ef	22.12 f
MHR- 2	23.80 e	30.87 ef	26.40 de	25.17 ef	22.27 ef
MHR- 3	27.67 d	32.73 c-e	35.18 a	34.13 a	31.18 a
MHR- 4	24.27 e	29.47 f	26.93 de	27.07 c-e	24.16 c-e
MHR- 5	27.80 d	37.80 b	27.07 de	28.80 bc	25.75 bc
MHR- 6	30.93 b	33.87 cd	23.73 g	22.93 g	20.02 g
MHR- 7	26.73 d	34.40 cd	25.63 e-g	25.33 ef	22.41 ef
MHR- 8	28.27 cd	34.67 c	29.07 bc	28.53 bc	25.48 b-d
MHR- 9	27.13 d	34.53 cd	24.27 fg	23.73 fg	20.36 g
MHR- 10	30.40 bc	32.33 c-e	27.47 cd	26.40 de	23.62 d-f
MHR- 11	22.27 e	32.20 de	26.40 de	25.67 d-f	22.58 ef
MHR- 12	23.47 e	26.27 g	29.60 b	27.73 b-d	24.56 cd
SE	**3.406**	**3.348**	**2.776**	**2.276**	**1.740**
CV (%)	**10.80**	**17.55**	**9.32**	**8.14**	**10.11**

4.1.4 Dry matter weight hill^{-1} (g)

The dry matter weight was significantly varied due to varietal differences. The dry matter weight of the varieties was not similar at the begining of growth stage (20 DAT) and was also varied with the advancement of growth stage (Table 4).

At 80 DAT the highest dry matter (34.64 g) was observed in MHR- 4. The second highest dry matter weight (26.97 g) was observed in MHR- 7. Similar trend was also observed at the time of harvest. The highest dry matter weight (44.92 g) at harvest was obtained from MHR- 4. MHR- 4 also showed highest dry matter weight (16.35 g) at 40 DAT which was statistically similar with MHR- 8. But at very early growth stage (20 DAT) and mid growth stage (60 DAT) the highest dry matter weight was achieved from MHR- 9 (9.43 g) and MHR- 8 (23.48 g), respectively which was similar with MHR- 6 at 60 DAT.

In terms of dry matter weight hill^{-1} of the varieties was not similar at the begining of growth stage (20 DAT) but similar trend of dry weight with the advancement of growth stage. At 20 and 40 DAT the lowest dry matter weight were produced from MHR- 11 (3.46 g) and MHR- 5 (6.78 g), respectively. But at 60, 80 DAT and at harvest the lowest dry matter weight hill^{-1} (14.11, 18.05 and 25.75 g, respectively) was obtained from MHR- 10. Lower dry matter weight hill^{-1} was also achieved from BRRI dhan32, MHR- 9 and MHR- 11 at the time of harvest which showed lower varietal performance afterward.

The results uphold with the findings of Islam *et al*. (2009), Amin *et al.* (2006), Son *et al.* (1998) and Patnaik *et al*. (1990) who reported that dry matter accumulation capacity depends mainly on varietal performance.

Table 4: Performance of some hybrid and inbred varieties on dry matter weight hill^{-1} in Aman season

Variety	Days after transplanting (DAT)				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**At harvest**
BRRI dhan31	4.72 de	10.46 ef	21.56 bc	23.48 de	33.26 c
BRRI dhan32	7.31 b	11.39 d-f	17.06 e	18.79 hi	26.88 f
MHR- 1	4.70 de	11.30 d-f	18.47 d	23.63 c-e	30.52 d
MHR- 2	3.77 e	12.30 cd	21.26 c	22.84 de	32.29 cd
MHR- 3	5.43 cd	9.93 f	15.57 fg	24.03 cd	34.51 c
MHR- 4	4.43 de	16.35 a	20.54 c	34.64 a	44.92 a
MHR- 5	6.54 bc	6.78 g	16.69 ef	19.99 gh	30.10 d
MHR- 6	7.24 b	11.83 c-e	22.84 ab	22.33 ef	29.78 de
MHR- 7	6.34 bc	14.10 b	20.97 c	26.97 b	37.59 b
MHR- 8	6.33 bc	16.33 a	23.48 a	24.86 c	33.98 c
MHR- 9	9.43 a	13.27 bc	20.20 c	20.69 g	27.60 ef
MHR- 10	6.67 bc	12.72 b-d	14.11 h	18.05 i	25.75 f
MHR- 11	3.46 e	13.98 b	16.42 ef	18.08 i	27.11 f
MHR- 12	4.69 de	11.87 c-e	14.57 gh	20.97 fg	30.56 d
SE	**1.281**	**2.138**	**3.179**	**3.171**	**2.374**
CV (%)	**9.24**	**13.28**	**10.26**	**14.24**	**11.21**

4.2. Yield contributing parameters

4.2.1 Effective tillers hill^{-1}

Different varieties showed a significant variation on number of effective tillers hill^{-1} (Table 5). Results indicated that the highest number of effective tillers hill^{-1} (10.40) was found in MHR- 4 followed by MHR- 5 (10.33). The lowest number of effective tillers hill^{-1} (7.33) was obtained in MHR- 6 which was closely followed by BRRI dhan32, MHR- 7 and MHR- 9. The results designate that MHR- 4 produced 41.88%, 14.66% and 40.54% higher effective tillers hill^{-1} than MHR- 6, BRRI dhan31 and BRRI dhan32, respectively.

The results support the findings of Patnaik *et al*. (1990) and BRRI (1991) who observed effective tillers producing capacity depends on the performance of different varieties.

4.2.2 Panicle length

Panicle length was significantly influenced by different hybrid and inbred rice varieties under the present study (Table 5). Different length of panicle was observed due to its varietal performance. Results showed that the longest panicle length (28.05 cm) was produced by MHR- 4 which was closely followed by BRRI dhan31 (27.63 cm) and MHR- 9 (27.57 cm). On the other hand the shortest panicle length (24.17 cm) was found in MHR- 5 which was 13.83% less than longest panicle length. The panicle length obtained from MHR- 7, MHR- 11 and MHR- 12 showed lower performance but was significantly different from MHR- 5.

The results obtained under the present study was conformity with the findings of Wang *et al.* (2006), Chowdhury *et al*. (2005) and Akbar (2004).

4.2.3 Filled grains panicle^{-1}

Performance of test varieties under the present study showed a significant difference in respect of grains panicle^{-1} (Table 5). The highest number of filled grains panicle^{-1} (161.10) was observed in MHR- 4 which was significantly different from all other test varieties. BRRI dhan31 and BRRI dhan32 also showed better performance but significantly different from MHR- 4. MHR- 10 produced the lowest number of filled grains panicle^{-1} (34.57) which was significantly different from all other test varieties and 78.54% lower than MHR- 4. But MHR- 1, MHR- 5, MHR- 8 and MHR- 9 showed lower performance on number of filled grains panicle^{-1} which was 52.66%, 48.65% and 56.55%, respectively and also lower than MHR- 4.

The results obtained by Chowdhury *et al*. (2005), Murthy *et al.* (2004), Bhowmick and Nayak (2000) and Patel (2000) was in agreement with findings of present study.

4.2.4 Unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} was significantly influenced by test varieties under the present study (Table 5). Results showed that the highest number of unfilled grains panicle^{-1} (83.77) was observed in MHR- 10 which was significantly different from all other test varieties. On the other hand, the lowest number of unfilled grains panicle^{-1} (29.83) was achieved from BRRI dhan32 that was followed by MHR- 6 (30.93), and MHR- 2, MHR- 3, MHR- 4 and MHR- 8 also gave lower number of unfilled grains panicle^{-1} (39.57, 37.80, 37.40 and 36.37, respectively) but significantly different from MHR- 6. The results obtained by Chowdhury *et al*. (2005) was more or less similar with the present study.

4.2.5 Weight of 1000 grains

Significant influence of different varieties were observed on 1000 grain weight (Table 5). It is attained that the highest 1000 grain weight (27.34 g) was in MHR- 1 which was statistically similar with MHR- 7 (26.88 g) and MHR- 9 (27.25 g) and closely followed by MHR- 2 (26.24 g) and MHR- 8 (26.51 g). The lowest 1000 seed weight (21.09 g) was observed in BRRI dhan32 which was statistically similar with MHR- 10 (21.25 g). The result showed that MHR- 1 produced 29.63% and 28.66% higher grain weight than BRRI dhan32 and MHR- 10, respectively.

The results are in agreement with with the findings of Chowdhury *et al*. (2005) and Rahman *et al*. (2002) who observed varied 1000 grains weight among different varieties of rice.

Table 5: Yield contributing parameters of some hybrid and inbred varieties in Aman season

Variety	Number of effective tillers hill^{-1}	Panicle length (cm)	Number of filled grains panicle^{-1}	Number of unfilled grain panicle^{-1}	1000 grain weight (g)
BRRI dhan31	9.07 bc	27.63 ab	123.60 c	73.60 b	23.23 e
BRRI dhan32	7.40 de	27.13 bc	132.60 b	29.83 g	21.09 f
MHR- 1	8.87 bc	26.77 cd	76.27 i	56.67 c	27.34 a
MHR- 2	8.53 b-d	25.67 ef	102.10 de	39.57 f	26.24 ab
MHR- 3	9.60 ab	26.63 cd	104.50 d	37.80 f	24.04 de
MHR- 4	10.40 a	28.05 a	161.10 a	37.40 f	24.38 c-e
MHR- 5	10.33 a	24.17 h	44.27 k	75.07 b	23.48 e
MHR- 6	7.33 e	25.70 ef	89.17 g	30.93 g	25.47 bc
MHR- 7	7.53 de	25.27 fg	99.27 ef	50.37 d	26.88 a
MHR- 8	8.07 c-e	26.13 de	82.73 h	36.37 f	26.51 ab
MHR- 9	7.47 de	27.57 ab	70.00 j	59.40 c	27.25 a
MHR- 10	8.53 b-d	25.57 e-g	34.57 l	83.77 a	21.25 f
MHR- 11	9.07 bc	24.88 g	100.70 d-f	46.87 de	25.41 bc
MHR- 12	8.47 b-e	25.00 fg	96.97 f	45.83 e	24.76 cd
SE	**0.679**	**0.896**	**9.487**	**7.997**	**1.590**
CV (%)	**13.65**	**5.93**	**7.46**	**14.57**	**11.11**

4.3 Yield parameters

4.3.1 Grain yield

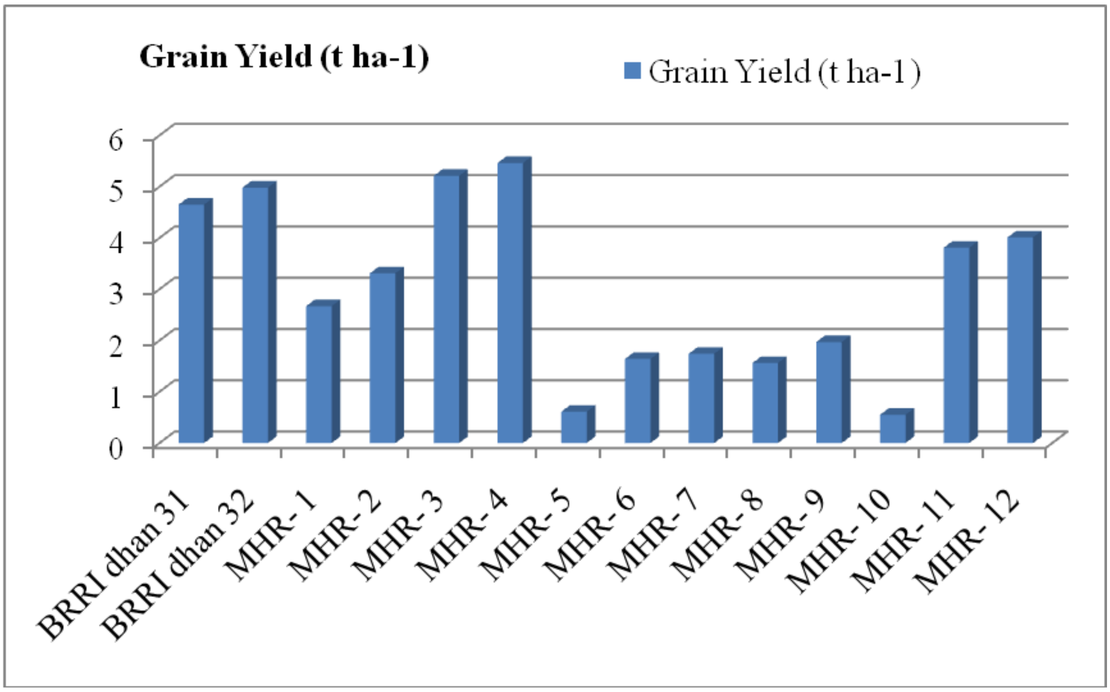

Figure 1. Performance of some hybrid and inbred varieties on grain yield in Aman season [SE = 0.108]

Different hybrid and inbred varieties significantly produced variable grain yield (Figure 1). Among the tested fourteen varieties MHR- 4 showed its superiority in producing highest grain yield (5.46 t ha^{-1}) which was closely followed by MHR- 3 (5.21 t ha^{-1}) that was the second highest grain yield and MHR- 4 yield was 4.80% higher than MHR- 3. BRRI dhan31, BRRI dhan32, MHR- 11 and MHR- 12 also gave comparatively higher grain yield which were 17.42%, 9.62%, 43.31% and 36.16%, respectively but statistically lower than MHR- 4. On the other hand, the lowest grain yield (0.55 t ha^{-1}) was obtained from MHR- 10 which was statistically similar with MHR- 5 (0.61 t ha^{-1}). MHR- 6, MHR- 7, MHR- 8 and MHR- 9 also gave lower grain yield but significantly higher than MHR- 10.

The results are in agreement with the findings of Islam *et al*. (2009), Bisne *et al.* (2006), Siddiquee *et al*. (2002) and Chowdhury *et al*. (2005) whose stated that grain yield differed significantly among the varieties.

4.3.2 Straw yield

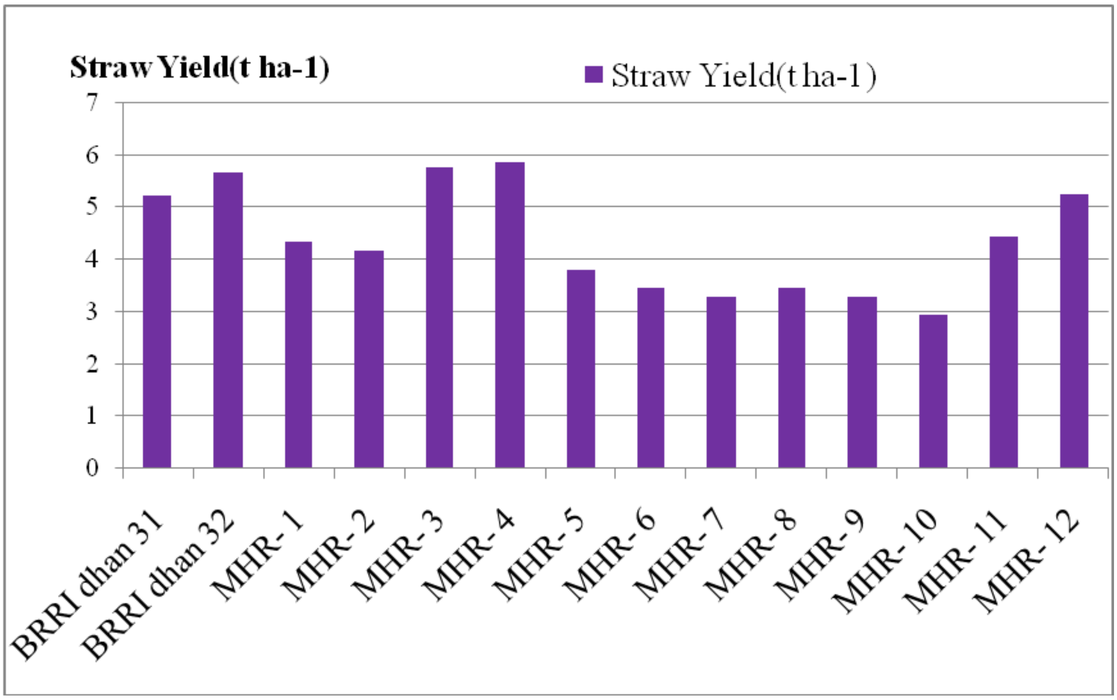

Figure 2. Performance of some hybrid and inbred varieties on straw yield in Aman season [SE = 0.261]

Straw yield differed significantly due to varietal differences (Figure 2). MHR- 4 gave the highest straw yield (5.86 t ha^{-1}) which was statistically similar with BRRI dhan31, BRRI dhan32, MHR- 3 and MHR- 12. The lowest straw yield was found in MHR- 10 (2.93 t ha^{-1}) which was closely followed by MHR- 7 and MHR- 9. The differences in straw yield among the varieties may be attributed to the genetic makeup of the varieties.

The results uphold with the findings of Chowdhury *et al*. (2005), Akbar (2004), Patel (2000) and Om *et al.* (1999) where they concluded that straw yield differed significantly among the varieties.

4.3.3 Harvest index

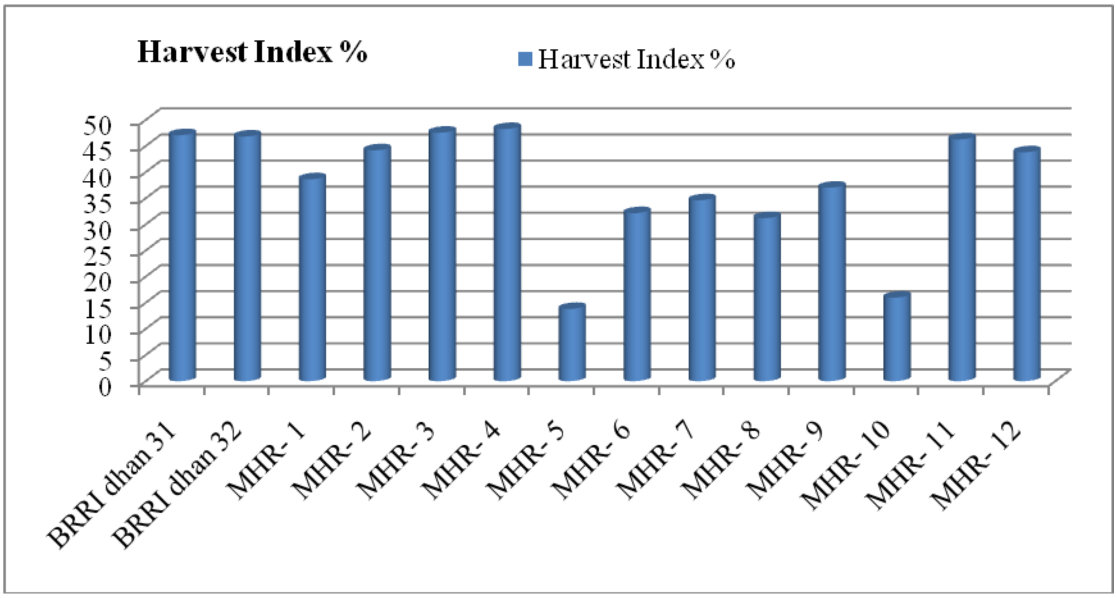

Figure 3. In T-Aman season performance of some hybrid and inbred varieties on Harvest index [SE = 1.239]

Harvest index was significantly influenced by different hybrid and inbred varieties under the present study (Figure 3). Results focused that the highest harvest index (48.27%) was observed in MHR- 4 which was statistically at par with BRRI dhan31, BRRI dhan32 and MHR- 3 and closely followed by MHR- 11. The lowest harvest index (13.82%) was found in MHR- 5. The result from MHR- 10 also gave lower harvest index (15.98%).

The results obtained under the present study was more or less similar with the findings of Cui *et al.*, (2000).

Chapter 5
Summary and Conclusion

CHAPTER 5
SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from June 2009 to October, 2009 to study the 'the performance of some hybrid and inbred rice varieties in Aman season'.

The experiment comprised of one factor 14 varieties viz. (i) BRRI dhan31, (ii) BRRI dhan32, (iii) MHR- 1, (iv) MHR- 2, (v) MHR- 3, (vi) MHR- 4, (vii) MHR- 5, (viii) MHR- 6, (ix) MHR- 7, (x) MHR- 8, (xi) MHR- 9, (xii) MHR- 10, (xiii) MHR- 11 and (xiv) MHR- 12.

There were 42 plots of size 4 m × 2.5 m having 14 treatments for the present study with three replications.

The treatments of the experiment were assigned at random into each replication following the experimental design. The experiment was laid out in Randomized Complete Block Design (RCBD). Seedlings of 21 days old were transplanted following line to line distance 20 cm and hill to hill distance 15 cm with 2 seedlings hill^{-1}.

Significant variation was recorded for data on growth, yield and yield contributing parameters of experimental materials. Data was collected on plant height (cm), number of tillers hill^{-1}, number of leaves hill^{-1}, dry weight hill^{-1} (g), number of effective tillers hill^{-1}, panicle length (cm), number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, 1000 grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}) and harvest index (%).

For growth parameters; the results were considered on plant height (cm), number of tillers hill^{-1}, number of leaves hill^{-1} and dry weight hill^{-1} (g).

Records on plant height at 20 and 40 DAT, MHR- 10 showed the highest plant height (77.33 and 90.87 cm, respectively) and at 60 and 80 DAT, MHR- 3 showed the highest plant height (115.30 and 115.60 cm, respectively). But at the time of harvest the longest plant was achieved by MHR- 8 (123.00 cm). The smallest plant was observed with BRRI dhan32 (56.80, 74.13, 90.53, 91.07 and 99.40 cm at 20, 40, 60, 80 DAT and at harvest, respectively).

In terms of tiller number hill^{-1}, the highest result (8.93, 8.99, 9.87, 14.13 and 12.67 at 20, 40, 60, 80 DAT and at harvest respectively) was achieved with MRH- 4. The minimum tillers hill^{-1}at 20 and 40 DAT was found in MHR- 6 (5.73 and 5.87, respectively) and at 60 and 80 DAT it was found in MHR- 12 (6.13 and 7.00, respectively). But at the time of harvest the lowest number of tillers hill^{-1}(9.07) was found in MHR- 9.

The results on number of leaves hill^{-1} at different growth stages, the highest number of leaves hill^{-1} was achieved from BRRI dhan32 (36.00, 40.00, 35.93, 35.73 and 32.65 at 20, 40, 60, 80 DAT and at harvest respectively). The lowest number of leaves hill^{-1} was found in MHR- 1 (18.73) at 20 DAT and in MHR- 12 (26.27) at 40 DAT but at 60, 80 DAT and at harvest the lowest number of leaves hill^{-1} was found in MHR- 6 (23.73, 22.93 and 20.02 respectively).

The highest dry matter weight hill^{-1}was found in MHR- 9 (9.43 g) at 20 DAT and in MHR- 8 (23.48 g) at 60 DAT. But at 40, 80 DAT and at harvest, the highest dry matter weigh hill^{-1} (16.35, 34.64 and 44.92 g, respectively) was observed in MHR- 4. The lowest dry matter weight was found in MHR- 11 (3.46 g) at 20 DAT and in MHR- 5 (6.78 g) at 40 DAT. But at 60, 80 DAT and at harvest the lowest dry matter weight hill^{-1} (14.11, 18.05 and 25.75 g, respectively) was obtained from MHR- 10.

Results on number of effective tillers hill^{-1}, the highest (10.40) was found in MHR- 4 where the lowest number of effective tillers hill^{-1} (7.33) was found in MHR- 6. The results designated that MHR- 4 produced 41.88%, 14.66% and 40.54% higher effective tillers hill^{-1} than MHR- 6, BRRI dhan31 and BRRI dhan32, respectively.

The highest panicle length (28.05 cm) was achieved by MHR- 4 where the lowest (24.17 cm) was found in MHR- 5 which was 13.83% less than highest panicle length.

Results showed that the highest number of filled grains panicle^{-1} (161.10) was observed in MHR- 4 where MHR- 10 produced the lowest number of filled grains panicle^{-1} (34.57), which was 78.54% lower than MHR- 4.

On the other hand, the highest number of unfilled grains panicle^{-1} (83.77) was observed in MHR- 10 where the lowest number of unfilled grains panicle^{-1} (29.83) was achieved by BRRI dhan32.

It is attained that the highest 1000 grain weight (27.34 g) was in MHR- 1 where the lowest (21.09 g) was observed in BRRI dhan32. The result showed that MHR- 1 produced 29.63% and 28.66% higher grain weight than BRRI dhan32 and MHR- 10, respectively.

Among the tested fourteen varieties MHR- 4 showed its superiority in producing highest grain yield (5.46 t ha^{-1}) where the lowest grain yield (0.55 t ha^{-1}) was obtained from MHR- 10. BRRI dhan31, BRRI dhan32, MHR- 11 and MHR- 12 also gave comparatively higher grain yield which were 17.42%, 9.62%, 43.31% and 36.16% respectively lower than MHR- 4.

In terms of straw yield and harvest index, MHR- 4 gave the highest results (5.86 t $ha^{-1}$and 48.27% respectively) where the lowest straw yield (2.93 t ha^{-1}) and harvest index (13.82%) were found in MHR- 10 and MHR- 5 respectively.

From the above summary of the study, it can be concluded that among the fourteen hybrid and inbred varieties, MHR- 4 demonstrated the best performance followed by MHR- 3. MHR- 5 and MHR- 10 showed lower performance regarding growth, yield and yield contributing characters. MHR- 6, MHR- 7, MHR- 8 and MHR- 9 also showed very poor performance. But BRRI dhan31, BRRI dhan32 and MHR- 12 also showed comparatively better performance in respect of yield.

So, MHR- 4 and MHR- 3 can be treated as the best varieties among the fourteen tested varieties from the present study.

Recommendation:

For wider acceptability the same experiment can be repeated at any other locations of the country.

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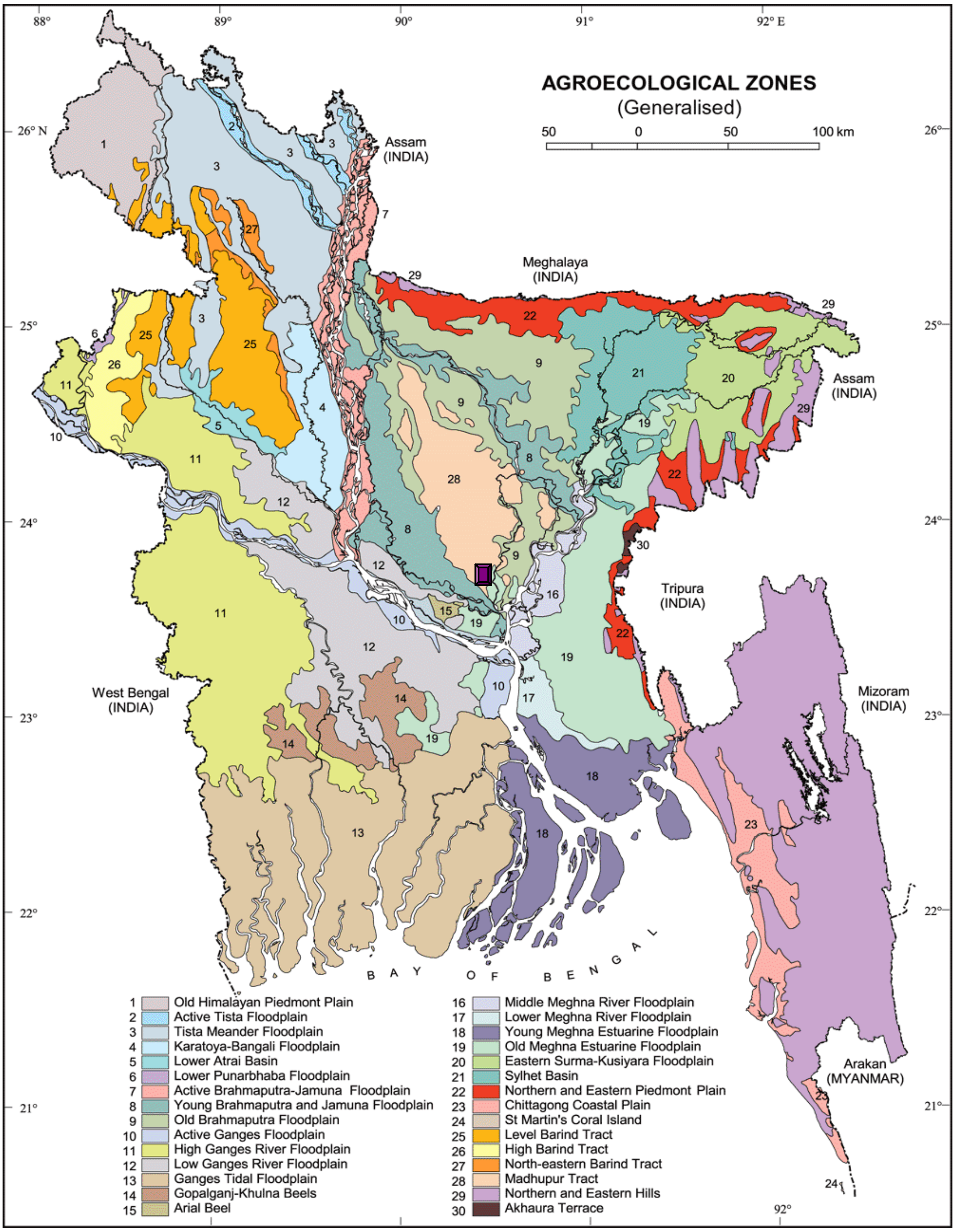
Appendices

APPENDICES

Appendix I. Map showing the experimental sites under study



The experimental site under study

Appendix II. Characteristics of soil of experimental site is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Field laboratory, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium 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, Farmgate, Dhaka.

Appendix III. Monthly average air temperature, rainfall, relative humidity of the experimental site during the period from June to October 2009

Month	Air temperature (ºc)		Relative humidity (%)	Total Rain fall (mm)
	Maximum	Minimum		
June	28.28	25.34	66.24	184
July	31.40	25.80	81	542
August	32.00	26.60	82	361
September	28.35	24.32	79	342
October	29.46	19.19	73.36	Terrace

* Monthly average,

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

Appendix IV: Performance of some hybrid and inbred varieties on plant height

Source of variance	Degrees of freedom	Mean square of plant height at different days after transplanting (cm)				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
Replication	2	22.607	5.580	37.412	36.523	2.377
Treatment	13	118.244	75.970	146.424	142.008	93.491
Error	26	1.071	2.118	1.253	1.117	3.100

Appendix V: Performance of some hybrid and inbred varieties on number of tillers hill^{-1}.

Source of variance	Degrees of freedom	Mean square of number of tillers hill^{-1} at different days after transplanting (number)				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
Replication	2	0.784	0.603	1.012	5.887	0.180
Treatment	13	2.527	2.037	3.183	8.629	3.634
Error	26	0.026	0.036	0.108	0.147	0.086

Appendix VI: Performance of some hybrid and inbred varieties on number of leaves hill^{-1}

Source of variance	Degrees of freedom	Mean square of number of leaves hill^{-1} at different days after transplanting				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
Replication	2	204.560	41.935	12.380	13.603	0.107
Treatment	13	73.803	35.956	27.577	40.455	40.213
Error	26	1.804	1.630	1.123	1.306	3.075