EFFECT OF TRANSPLANTING DATE ON THE GROWTH AND YIELD OF INBRED AND HYBRID RICE VARIETIES IN T. *AMAN* SEASON

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DEDICATED

TO

MY BELOVED PARENTS

CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF TRANSPLANTING DATE ON THE GROWTH AND YIELD OF INBRED AND HYBRID RICE VARIETIES IN T. *AMAN* SEASON "** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207 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 **MIR MD. MONIRUZZAMAN KABIR**. Registration No. 05-1610 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2011

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(Prof. Dr. Md. Hazrat Ali)
Supervisor

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EFFECT OF TRANSPLANTING DATE ON THE GROWTH AND YIELD OF INBRED AND HYBRID RICE VARIETIES IN T. *AMAN* SEASON

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ABSTRACT

A field experiment was carried out at Agronomy Experiment Field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from June 2010 to February 2011 to study the Effect of transplanting date on the growth and yield of inbred and hybrid rice varieties in T**.**Aman season**.** The experiment consisted of two level of treatments viz. variety and transplanting time. Two inbred variety viz.BR11(Mukta) and BRRI dhan39 and two hybrid variety viz. ACI 1 and ACI Shera. Four different transplanting date viz. 20th July, 4th August, 19th August and 3rd September were observed for this study as a treatment. The experiment was laid out in Randomized Complete Block Design (RCBD) two factors with three replications. Experimental result showed that variety had significant effect on all the agronomic parameters where as transplanting date had little effects on panicle length, grain yield, straw yield, biological yield and harvest index. Combined effect also showed significant variation except number of total tillers m^{-2} at 90 DAT, LAI at 15 and 30 DAT, Number of effective and non effective tillers, panicle length and harvest index. The variety BR11(Mukta) at 4th August transplanting gave early flowering and maturity compared to other varieties and transplanting dates. Inbred variety BR11(Mukta) at 4th August transplanting required for 88.92 and 119.17 days for flowering and maturity respectively which took 10 and 12.5 days less time for flowering and maturity at 4th August transplantation than that of ACI Shera. Similar variety and transplanting date produced maximum number of total tillers $hill^{-1}$ (42.00) and LAI (9.10) at 75 days after transplanting. The maximum number of effective tiller m^{-2} (502.70) and total grain $panicle^{-1}$ (296.70) were found from 4th August transplanting with BR11(Mukta). The highest 1000-seed weight (29.82 g), grain yield (6.57 t ha^{-1}), straw yield (7.68 t ha^{-1}), biological yield (14.25 t ha^{-1}) were obtained from BR11(Mukta) with 4th August transplanting. However, lowest performance was recorded at 3rd September transplanting with the hybrid variety ACI Shera in respect of all the morphological and yield contributionary characteristics except harvest index.

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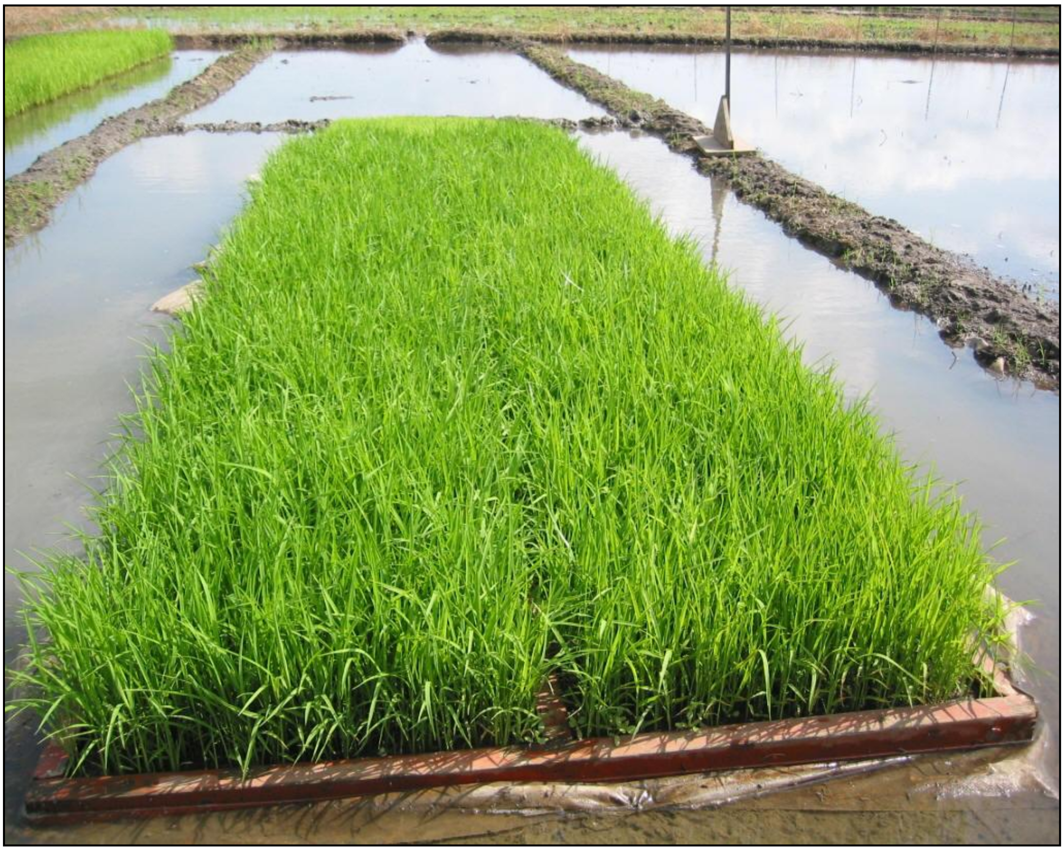
LIST OF ACRONYMS

%	Percentage
°C	Degree Centigrade
AEZ	Agro-Ecological Zone
Anon.	Anonymous
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
cm	Centi-meter
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAE	Department of Agricultural Extension
DAS	Days After Sowing
DAT	Days After Transplanting
e.g.	*exempli gratia* (L), for example
et al.	And associates
etc.	Etcetera
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
TSP	Triple Super Phosphate
MOP	Murate of Potash
IRRI	International Rice Research Institute
Kg	Kilogram (s)
LSD	Least Significant Difference
M.S.	Master of Science
m^{-2}	Per squares meter
No.	Number
NS	Non significant
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource and Development Institute
$t\ ha^{-1}$	Ton per hectare
UNDP	United Nations Development Programme
var.	Variety

CHAPTER I

INTRODUCTION



CHAPTER I
INTRODUCTION

Rice (*Oryza sativa*) is the staple food for more than three billion people that is over half of the world's total population (FAO, 2010). Rice is the most important source of the food energy for more than half of the human population. Rice is grown in 114 countries across the world on an area of about 150 million hectares with annual production of over 525 million tones, constituting nearly 11 per cent of the world's cultivated land (Rai, 2006). According to the Food and Agriculture Organization (FAO) of the UN 80% of the world rice production comes from 7 countries (UAE/FAO, 2012). However, if we talk about world rice production 2009-2010, the worldwide rice production by countries-infact, the top ten countries of world counted for their rice production is China(32.7%), India(26.0%),Indonesia(10.2%),Bangladesh(7.5%),Vietnam(6.8%),Thailand(5.3%),Myanmar(4.8%), Philippines (2.8%), Brazil(2.0%) and Japan (1.9%) (UAE/FAO, 2012).

In Bangladesh, about 80% of the total lands are used for rice cultivation. Rice contributes 91.1% of the total grain production and covers 74% of the total calorie intake for the people of Bangladesh(MOA, 2010). Area under Bangladesh is the 5th largest country of the world with respect to rice cultivation(BBS, 2010).

T. *Aman* (wet season) is one of the most important rice crops period which might suffer from high temperature at the different growth stages from germination to maturity (BRRI, 2007). A study showed that most Asian countries will not be able to feed their projected populations without irreversibly degrading their land resources, even with high levels of management inputs (Beinroth *et al*. 2001). There is no opportunity to increase rice area consequently, much of the additional rice required will have to come from higher average yield on existing land. Clearly, it will require adoption of new technology such as high management package as like as optimum date of sowing on modern and high yielding inbred and hybrid varieties. T. *Aman* (wet season) is one of the most important rice crops period which might suffer from high temperature at different growth stages from germination to maturity (BRRI, 2007).

In Bangladesh, the rice varieties grown in Transplanted Aman (T. *Aman*) i.e. in wet season are mostly photoperiod sensitive. When these varieties were transplanted in the late season during September-October their sensitivity of flowering in the months of October-December mostly depends on the planting dates. Though these varieties are photosensitive but their phenological events also depend on the particular air temperature. BRRI (1989) and Yoshida (1993) reported that rice plants require a particular temperature for its phenological affair such as panicle initiation, flowering, panicle exsertions from flag leaf sheath and maturity and these are very much influenced by the planting dates during T. *Aman*. Deviation from the optimum planting time may cause incomplete and irregular panicle exsertion, increase spikelet sterility BRRI (1991). The optimum planting time of T. *Aman* rice is in August (De-Datta, 1981). But sometimes transplanting is delayed due to various physical and socio-economic factors (Gomosta *et al*. 1989). This late planting exposes the reproductive phase as well as phenological events of crop in an unfavorable temperature regime thereby causing high spikelets sterility and poor growth of the plant (BRRI, 1989). Informations regarding phenological events of these varieties to temperature are not adequate. Therefore, this study was under taken to find out the effect of planting dates on phenological development and to determine the degree of sensitivity of cultivars to air temperature. The reason for such low yield is mainly associated with cultural technologies (Barari, 2005). Transplanting rice in the optimum period of time is critical to achieve high grain yield. However, optimum rice planting dates are regional and vary with location and genotypes (Bruns and Abbas, 2006; Sha and Linscombe, 2005). BRRI and Yoshida reported that rice plants require a particular temperature for its phonological affair such as panicle initiation; flowering, panicle exertions from flag leaf sheath and maturity and these are very much influenced by the planting dates during rainy season.

The time of transplanting has a great influence on the growth, yield and yield contributing characters of rice (Islam *et al.* 1999). Sometimes transplanting in optimum time is not possible due to untimely rainfall or delay recession of floodwater. Moreover, due to genetic variability, the potentiality of the genotypes expressed differently due to planting in different dates. The early planted photoperiod sensitive rice varieties passed lag vegetative phase which increased tallness as well as biomass that prone to lodge during grain filling stage. Thus, by adjustment of transplanting time, the plant can take advantage of natural conditions favourable for its growth (BRRI, 2004). Chowdhury *et al.* (2000) reported that grain and straw yields gradually decreased after 10 August plantation. Islam (1986) concluded that time between 15 July and 20 August is the optimum for transplanting of Aman rice especially in case of photosensitive rice varieties. Based on the above propositions, the present study was undertaken to find out the optimum planting time and to select the inbred and hybrid genotypes having high yield potential to increase production in Aman season.

Timely transplanting of rice results in earlier harvest and allows timely planting of the next wheat or other crops. The rice-wheat system productivity was nearly 12 tones per hectare when about 25 days old rice seedlings were transplanted before end of June. The total system productivity is reduced by more than 40 per cent when field were planted after 15 August (Rai, 2006). Timely transplanting of rice crop is also found favorable climatic condition and also increase the rain water use efficiency as compared to the delayed planting.

Keeping in view the above facts, the present investigation entitled “Effect of Transplanting date on the growth and yield of inbred and hybrid rice varieties in T. *Aman* season” has been planned and was carried out at the Sher-e-Bangla Agricultural University Experiment Field, Sher-e-Bangla Nagar, Dhaka-1207, during the T. *Aman* season 2010-11 with the following objectives:

- Compare the production potential of inbred and hybrid rice at T. *Aman* season.
- Find out the optimum transplanting time to ensure the maximum growth and higher yield of rice genotypes.
- Interaction between inbred and hybrid rice with transplanting dates in T. *Aman* season.

CHAPTER II

REVIEW OF LITTERATURE

CHAPTER II
REVIEW OF LITERATURE

Research information regarding the growth and yield of different inbred and hybrid rice varietes in Bangladesh with different transplanting date of July, August and September are reviewed here in this chapter.If so, many scientists of Agriculture are now applying different transplanting time to find out the optimum transplanting time of most favourable climatic condition which will ensure the maximum growth and greater yield. In view of this, the present experiment was undertaken to assess the effect of different inbred and hybrid varieties with different transplanting time on the yield performance of inbred variety viz. BRRI dhan39 and BR11(Mukta) and hybrid variety ACI 1 and ACI Shera. Two inbred and hybrid variety performance was also investigated with this study. Many research works on different aspects of rice cultivation have been done at home and abroad for the improvement of rice yield. So, some related information pertaining to this study is reported in the following headings-

2.1 Effect of dates of planting on growth characters

2.1.1 Number of total tillers

Ali *et al*. (2012) conducted a field experiment on new four rice varieties (Oryza sativa L.) at Rice research and training center (RRTC), Sakha, Kafr-El sheikh, governorate, Egypt to investigate dates of planting.Sakha 106, Sakha 105, G.Z 7576, G.Z. 9057 and G.Z. 9362 under five sowing dates April 1st, April 10th, April 20th, May 1st and may 10th.Results showed that sowing date at April 1st gave the highest value on number of days from sowing up to maximum tillering and also no. of tillers/hill at PI and number of tillers m^{-2} at maturity stage.

Faghani(2011) conducted an experiment to study the effects of seedling age and planting date on yield and yield components of rice (*Oryza sativa*) in the field of Qaemshahr Azad University.They reported that the planting date in 23 May and 12 June some agronomical traits such as total tiller number, fertile tiller number were measured. Results showed that the effect of planting date on total tiller number was significant at 0.01 probability level. Also planting date had a significant effect on fertile tiller number at 0.05 probability levels. Seedling had a significant effect on fertile tiller at 0.05 probability level.

Bashir *et al*. (2010) conducted an experiment to evaluate the effect of different sowing dates on yield and yield components of the direct sown coarse rice where 20th June sowing gave maximum number of productive (panicle bearing) tillers and benefit-cost ratio.

Akbar *et al*. (2010) studied on the response of yield and yield components of direct seeded fine rice (*Oryza sativa* L.) against different sowing dates during 2008 at Agronomic Research Area, University of Agriculture Faisalabad.In the study comprised six different sowing dates that is 31st May, 10th June, 20th June, 30th June, 10th July and 20th July. The crop sown on 20th June produced the maximum number of productive tillers per meter square.

Recently Khalifa (2009) in Egypt carried out a field experiment for physiological evaluation of four hybrid rice varieties under six different sowing dates. Results indicated that early date of sowing was the best time of sowing for important properties such as maximum tillering, number of tillers m^{-2}.
Mannan *et al*. (2009) studied to determine the optimum time of planting and to find out the genotypes having high yield potential. Crop planted from 7 August to 7 September gave more number of tillers per m^{-2}. The growth duration of the genotypes decreased with the advancement of planting date.

Effective tillers $hill^{-1}$ was significantly higher at BRRI dhan 46 than and BRRI dhan31 in late transplanted conditions (Nahar *et al*. 2009).

Khalifa (2009) found that number of days from sowing up to maximum tillering and heading date was significant affected by different sowing dates.

Yadav (2007) conducted a field experiment during *Kharif* seasons of 2005 and 2006 to investigate the effect of dates of planting, plant geometry and number of seedlings per hill in hybrid rice 'PHB 71' where planting the crop on 15th July recorded significantly more total (317.59) and productive (246.86) tillers m^{-2}

Akram *et al*. (2007) found out the effect of different planting dates from July, 1 to 31 with 10 days interval on six rice varieties (98801, PK-5261-1-2-1, 97502, 98409, Basmati-385 and Super Basmati). Maximum number of tillers was significantly affected.

Yield components like tillers number m^{-2} was found in the decreasing in trend from the seeding of 15 June onward. June 15 seeding had the highest tillers number m^{-2} where as the lowest in July 29 seeding (Shah and Bhurer, 2005).

Ghosh *et al*. (2004) conducted a experiment at Kalyani, India to determine the effect of two planting dates and four fertilizer levels on different aromatic rice cultivars during the dry seasons of 1995/96 and 1996/97, while nine cultivars were evaluated during the wet seasons of 1996 and 1997. Delayed planting (23 February) significantly reduced the amylose content by 0·5% and duration by 10 days; but increased the summed heliothermal units (17806 *v*. 18505). Thus, the cultivars became less efficient (27%) in heat use with delay in planting from 2 to 23 February.

Pandey *et al.* (2001) noted that rice hybrid ‘PA 6201’ gave significantly higher productive tillers per hill of the crop transplanted on 20 July and 4 August than that the crop transplanted on 20 August.

Patel (1999) recorded maximum number of total tillers (482 per m^{-2}) when the crop was transplanted on 15 July, which decreased significantly with delayed planting on 30 July and 14 August.

Islam *et al.* (1999) conducted a field experiment to find out the optimum planting date for two advanced mutants rice varieties along with two check varieties in *Aman* season in 1997. The mutants were BINA115 and BINA163 and the check varieties were Binasail and BR22. There were three planting dates starting from July, with an interval of 30 days. Number of tillers per hill showed significant variation among the dates of planting.

Kumar *et al.* (1998) reported that productive tillers per m^{-2} significantly decreased due to delay in transplanting from 25 July to 15 August in hybrid rice (‘PA 103’, ‘APHR 2’ and ‘DRRH 1’).

Singh *et al.* (1997) conducted an experiment at Kanpur and observed that 20 July planting gave significantly higher rice recovery by 0.85 and 0.30 per cent than crop planting on 5 July on 4 August, respectively. They further observed that protein content of the grain was significantly decreased with subsequent delay in planting by 1.62 and 1.05 per cent from 5 July to 20 July and 20 July to 4 August planting, respectively.

Singh *et al.* (1997) observed that rice planted on 15 June gave more productive tillers per m^{-2}.

Singh *et al.* (1997) conducted a field experiment at Kanpur found that total tiller of the crop transplanted on 5 July was more than that of the crop transplanted on 20 July and 4 August.

Om *et al.* (1997) found, in an experiment with rice hybrids 'PHB 71', 'PMS2A/IR 31802', 'PMS10A/PR 106' and 'HKR 126', that the productive tillers per m^2 was highest in the crop transplanted on 25 June fallowed by 5 July, 15 July and 25 July.

Krishnan and Nayak (1997) conducted a field trial with four rice cultivars named JET 12875, Lunisree, CR 629-256 and CR 683-175 in conjunction with three transplanting dates viz., 15 July, 30 July and 14 August. They reported that the effective tillers $hill^{-1}$was greater when transplanting was done on 30 July compared with 15 July or 14 August transplanting.

Singh *et al.* (1996) reported that total tillers per plant of the crop transplanted on 16 May and 31 May was significantly more than that of the crop transplanted on 16 June.

Parihar (1995) conducted a field experiment at Bilaspur revealed that higher plant height 84.63 cm and 83.75 cm in 1991 and 1992, respectively and significantly more number of effective tillers of 15 July planting as compared to both early (30 June) and late planting (30 July).

Reddy and Reddy (1992) found that the productive tillers per m^{-2} and productive tillers per hill were significantly more when the crop was transplanted on 29 August than that of the crop transplanted on 14 August and 30 July.

Lin and Huang (1992) carried out an experiment in 1991, rice cv. 1 aichungsen 10 and Taichungsen 10, transplanted on 5 August and 20 August. They observed that late transplanting increased grain protein content.

Ali *et al.* (1991) observed that optimum transplanting dates of rice cv. Basmati-385 and Basmati-370 were normally in the first half of July when 30 day old seedlings were used. The best transplanting dates were 1 and 16 July for Basmati-370 and Basrmiti-385 respectively.

Dhaliwal *et al.* (1986) reported that late transplanting reduced head rice recovery and grain length breath ratio. It was further observed that crude protein content in grain was not affected by transplanting dates but was increased by late transplanting. In experiment reports under All India Coordinated Rice Improvement Programme on scented rice (1991) and showed that the hulling and milling per cent were more with the early planting on 15 July, however, the head recovery, was maximum (38.8%) with late planting on 4 August (AICRIP, 1991).

The protein content of rice was studied on cv. Kashmir Basmati, crop was transplanted on 24 May, 8 June and 24 June or 8 July did not affect the protein content of grain (Akram *et al.* 1985). Mejos and Pava (1980) stated that the number of effective tillers was not significantly affected by transplanting date in kharif season.

BRRI (1985) reported that while Nizersail was transplanted on 10 September, 25 September and 10 October, number of tillers produced on three different dates was about similar.

2.1.2 Dry matter content

Yao Yi *et al*. (2011) conducted a field experiment to study the matter production and yield formation of direct seeding rice under the conditions of different sowing dates. The dry matter accumulation increased at jointing stage but reduced at heading and maturity stages, the harvest index descended, and the population growth rate at various stages showed a significant decreasing trend. Yet, from the view point of the security for reproduction, the medium-maturing medium japonica cultivars should be planted no later than June 30, the late-maturing medium japonica varieties no later than June 25, and the early-maturing late japonica varieties no later than June 20.

A field experiment was conducted by Yadav (2007) to study the effect of dates of planting. Planting the crop on 15th July recorded significantly the highest dry weight per hill (34.36g).

El-Khoby (2004) showed that delaying sowing date sharply decreased the dry matter production and chlorophyll content.

Nayak *et al.* (2003) conducted a field experiment on hybrid rice 'PA 6201', reported that early planting of 16 July exhibited the maximum total and effective dry matter accumulation than that planting on 31 July and 16 August. One month delay in planting from 16 July reduced dry matter accumulation by 18 per cent.

Pandey *et al.* (2001) noted that rice hybrid 'PA 6201' gave significantly higher dry matter accumulation per plant of the crop transplanted on 20 July and 4 August than that the crop transplanted on 20 August.

Singh *et al.* (1997) conducted a field experiment at Kanpur found that dry matter accumulation of the crop transplanted on 5 July was more than that of the crop transplanted on 20 July and 4 August.

Om *et al.* (1997) found, in an experiment with rice hybrids 'PHB 71', 'PMS2A/IR 31802', 'PMS10A/PR 106' and 'HKR 126', that the dry matter accumulation was highest in the crop transplanted on 25 June fallowed by 5 July, 15 July and 25 July.

Dhiman *et al.* (1995) observed that higher plant height and dry matter accumulation per plant in earlier planting on 15 July than in delayed planting on 25 July and 5 August.

Vandana *et al.* (1994) conducted an experiment with three rice cultivars, which were transplanted on three different dates viz. 13 June, 27 June and 13 July in 1991. They stated that dry matter accumulation in leaves decreased in all three cultivars, with the later transplanted dates.

Reddy (1994) reported that maximum dry matter accumulation per m^2 and per hill was recorded when planting was done on 29 August which was significantly higher than that of the crop planted on 30 July and 14 August.

Ghadekar *et al.* (1988) observed that the rice transplanting on 9 July recoded highest dry matter accumulation (18.22 $gplant^{-1}$) than the transplanting on 25 July.

Mandal *et al*. (1984) reported that dry matter accumulation decreased with delay transplanting in kharif season.

2.1.3 Plant height

Faghani *et al*. (2011) reported that the planting date in 23 May and 12 June where results showed the effect of planting date on plant height was significant at 0.01 probability level.

Mannan *et al*. (2009) studied to determine the optimum time of planting and to find out the genotypes having high yield potential. Fine rice genotypes Basmati PNR, Basmati 370, Basmati 375, and Basmati D were transplanted from 22 July and continued up to 7 October at an interval of 15 days both in 1999 and 2000. The tallest plant was found in the early-planted crop at maturity.

Khalifa (2009) in Egypt carried out field experiment for physiological evaluation of four hybrid rice varieties under six different sowing dates. Results indicated that early date of sowing was the best time of sowing for important properties such as maximum plant height.

Yadav (2007) conducted a field experiment during *Kharif* seasons of 2005 and 2006 to study the effect of dates of planting. Planting the crop on 15^{th} July recorded significantly tallest plant height (105.77 cm).

Akram *et al*. (2007) find the effect of different planting dates from July, 1 to 31 with 10 days interval on six rice varieties (98801, PK-5261-1-2-1, 97502, 98409, Basmati-385 and Super Basmati).

Akhter *et al*. (2007) conducted an experiment on twelve rice promising lines i.e., 98801, 98410, 98316, 99417, 97502, 99512, 98410, 99513, 98506, 98408, 5261-1-2 along with Super Basmati as check variety were transplanted on six different dates (16May to 1st August) with an interval of fifteen days to test the basmati behavior with new strains. Super Basmati in all the six dates flowered in the last week of September and first week of October irrespective of its time of transplanting. Super Basmati showed a remarked increase in plant height in first date (138 cm) and 2nd date (127cm) due to prolonged vegetative period while it showed a considerable decrease in plant height in last date (101cm) due to reduced vegetative phase. New strains 98316, 99417and 98408 reflected the same behavior and appeared to be true basmati strains. Whereas rest of the strains performed equally good in all the dates and remained unaffected by the different transplanting dates and appeared to be non-basmati strains.

Naher *et al.* (1999) observed in year round rice transplanting experiment in Bangladesh, that the transplanting dates showed significant differences in plant height. May to August planting showed taller plants whereas October and November planting produced smaller plant.

Islam *et al.* (1999) conducted a field experiment at the experimental farm of BINA, Mymensingh to find out the optimum planting date for two advanced mutants of rice along with two check varieties in *Aman* season. There were three planting dates starting from July, with an interval of 30 days. The plant height showed significant variation among the dates of planting.

Singh *et al.* (1997) conducted a field experiment at Kanpur found that plant height of the crop transplanted on 5 July was more than that of the crop transplanted on 20 July and 4 August.

Om *et al.* (1997) found, in an experiment with rice hybrids ‘PHB 71’, ‘PMS2A/IR 31802’, ‘PMS10A/PR 106’ and ‘HKR 126’, that the plant height was highest in the crop transplanted on 25 June fallowed by 5 July, 15 July and 25 July.

Paliwal *et al.* (1996) found that early transplanting on 25 July produced significantly higher plant height (107.4 cm) than delayed transplanting on 10 and 25 August.

Sahu (1994) conducted a field trial with rice *cv.* ‘Mahalaxmi’ observed that plant height was significantly higher at all the growth stages under 12 July planting among all the planting dates (12 and 22 July, 1 and 11 August).

Mejos and Pava (1980) stated that the number of days to heading, flowering, maturity and plant height was reduced with delay transplanting. Number of effective tillers, seeds panicle seed weight and seed yield was not significantly affected by transplanting date in kharif season.

2.1.4 Leaf area index

Ali *et al*. (2012) reported that the lowest leaf area index at Panicle Initiation stage was the lowest value. While may 10^{th} gave the lowest value for all preview attributes.

Yao Yi *et al*. (2011) conducted a field experiment to study the matter production and yield of direct seeded rice under the conditions of different sowing dates. With the delay of sowing date, the grain yields of the three rice cultivars decreased significantly, but the decrements varied. Under the delay of sowing date, the whole period of growth and development shortened notably, the growth dynamics of stems and tillers became not smooth and intensified as the sowing date further delayed, the leaf area index increased gradually at early growth stage but relatively declined at the middle and late growth stages.

Khalifa (2009) in Egypt carried out field experiment for physiological evaluation of four hybrid rice varieties under six different sowing dates. Results indicated that early date of sowing is the best sowing time for important properties such as maximum leaf area index.

A field experiment was conducted by Yadav (2007) to study the effect of dates of planting. Planting the crop on 15^{th} July recorded significantly the maximum number of functioning leaves per hill (63.54) than 30^{th} July and 14^{th} August planting.

Ghosh *et al*. (2004) investigated two important factors influencing growth, yield and quality of aromatic rice (*Oryza sativa* L.). The study was conducted at Kalyani, India to determine the effect of two planting dates and four fertilizer levels on different aromatic rice cultivars during the dry seasons of 1995/96 and 1996/97, while nine cultivars were evaluated during the wet seasons of 1996 and 1997. Thermal and photoperiodic conditions significantly influenced the vegetative (leaf area index and light extinction co-efficient) growth of the crop.

El-Khoby (2004) showed that delaying sowing date sharply decreased the leaf area index. In addition, delaying sowing date up to June 15^{th} significantly reduced the period from sowing to heading.

Dixit *et al.* (2004) observed that rice crop planting on 25 June showed significantly more number of leaves at 60 DAS than that crop planting on 5, 10 and 15 June.

Nayak *et al.* (2003) conducted a field experiment on hybrid rice 'PA 6201', reported that early planting of 16 July exhibited the maximum total and effective LAI than that planting on 31 July and 16 August. One month delay in planting from 16 July reduced LAI 13 per cent.

Samdhia (1996) found from an experiment conducted at Bhubaneswar taking rice hybrid 'PA 6201' and *cv.* 'Lalat', that LAI declined gradually as the planting was delayed beyond 15 July and maximum LAI of 4.64 was recorded at 60 DAP.

Sahu (1994) conducted a field trial with rice *cv.* 'Mahalaxmi' observed that leaf area index was significantly higher at all the growth stages under 12 July planting among all the planting dates (12 and 22 July, 1 and 11 August).

Kumar and Subramaniam (1991) reported that gradual decrease in LAI with delay in planting beyond 15 July in coastal Andhra Pradesh.

Mandal *et al*. (1984) reported that leaf area index generally decreased with delay transplanting in kharif season.

2.2 Effect of dates of planting on yield and yield contributing characters

2.2.1 1000 seed weight

Faghani *et al*. (2011) reported that the planting date in 23 May and 12 June showed that the effect of planting date on 1000 grains weight was significant at 0.01% probability level and 12 June gave the highest 1000 grains weight. When date of planting is delayed 1000 grains weight decreased.

Bashir *et al*. (2010) conducted an experiment to evaluate the effect of different sowing dates on yield and yield components of the direct sown coarse rice where 20th June sowing gave the maximum 1000-grain weight.

Simialr study was also conducted by Khalifa (2009) who reported that the early date of sowing is the best time of sowing for 1000 grain weight (g).

Islam *et al*. (2009) reported that the BRRI dhan3l had higher 1000-grain weight than BRRI dhan31 in 2001. In 2002, Sonarbangla I had the highest 1000 grain weight followed by BRRI dhan31.

Yadav (2007) studied on the different dates of planting, plant geometry and number of seedlings per hill in hybrid rice 'PHB 71' where 15^{th} July recorded significantly more 1000-grain weight (22.07g) than 30^{th} July and 14^{th} August planting.

Akram *et al*. (2007) found the effect of different planting dates from July, 1 to 31 with 10 days interval on six rice varieties (98801, PK-5261-1-2-1, 97502, 98409, Basmati-385 and Super Basmati).Minimum sterility was observed in rice planted on 21st July followed by July 1, 11 and 31.

Shah and Bhurer (2005) reported that the decreasing trend was found in the seeding of 15 of June onward of 1000-grain weight. June 15 seeding had the highest 1000-grain weight and decreased as sowing delayed.

Islam *et al.* (1999) used mutants BINA 115 and BINA 163 and the check varieties Binasail and BR22 to investigate 1000 grain weight where the 1000-grain weight showed significant variation among the dates of planting.

Halder *et al*. (1995) observed that the filled grains/panicle increased with the increase in the frequency of weedings. In case of 1000-grain weight, no significant different was found among the treatments.

Gangwar and Ahamedi (1990) recommended planting of rice with in June or latest by first week of July when yield attributes and grain yield increased, and delay in planting after first week of July decreased drastically the 1000 grain weight.

BRRI (1988) reported that grain yield reduced in all the varieties/lines in 18 September planting compared to 2 September plantings. Reduction in yield was due to reduction in spikelet number panicle^{-1}, increased sterility and reduction in 1000-grain weight.

2.2.2 Panicle

Ali *et al*. (2012) conducted a field experiment to study five new rice varieties, Sakha 106, Sakha 105, G.Z 7576, G.Z. 9057 and G.Z. 9362 under five sowing dates April 1st, April 10th, April 20th, May 1st and may 10th.Results induced that sowing date at April 1st gave the highest value on number of days from sowing up to panicle initiation and flowering dates. And also panicle length (cm) was the lowest value.

Faghani *et al*. (2011) reported that the planting date in 23 May and 12 June where panicle number m^{-2} was significant at 0.01% probability level.

Nahar *et al*. (2009) reported that the BRRI dhan46 had significantly higher values of panicles hill^{-1}, panicle length and spikelets panicle^{-1} than the BRRI dhan31 in late transplanted conditions.

Mannan *et al*. (2009) studied to determine the optimum time of planting and to find out the genotypes having high yield potential. The tallest plant was found in the early-planted crop at maturity. Crop planted from 7 August to 7 September gave more number of panicles per m^{-2} which resulted in higher grain yield. The growth duration of the genotypes decreased with the advancement of planting date.

Khalifa (2009) in Egypt carried out field experiment for physiological evaluation of four hybrid rice varieties under six different sowing dates where, early date of sowing is the best time of sowing for important properties such as number of grains per panicle, panicle length (cm), number of panicles m^{-2}.

Khalifa (2009) in Egypt carried out field experiment for physiological evaluation of four hybrid rice varieties under six different sowing dates. Results indicated that early date of sowing is the best time of sowing for important properties such as maximum panicle initiation, heading date, number of days to panicle initiation and heading date.

Islam *et al*. (2009) conducted an experiments to compare the growth and yield behaviour of hybrid and inbred rice varieties under controlled condition.BRRI dhan-3l had higher panicles/plant than Sonarbangla 1. BRRI dhan31 gave the highest number of panicles/plant followed by Sonarbangla I.

Halder *et al*. (2004) investigated that due to late planting the panicle initiation, heading and maturity of all the cultivars were slowed with decreasing air temperature and solar radiation. Nizersail and BR11 did not complete flower beyond October 01 and September 01 planting, respectively while BR11 completed flowering in all the planting dates. Eighty three to 94% tillers of Nizersail produced fully exserted panicles upto October 01 planting while for BR11 it was 21-92% up to September 15 planting but in BR22 it was about 86-97% in all planting dates.

Balaswamy *et al.* (2001) conducted a field experiment comprising four dates of transplanting (25 July, 10 August, 25 August and 10 Sept) in conjunction with four rice cultivars in India. More number of panicles m^{-2}, panicle length and filled grains $panicle^{-1}$ was recorded on 25 July planting.

Sharief *et al*. (2000) studied the effect of sowing dates (April 25th. May 10th, May 25th and June 10th) on yield and yield components of rice. They found that early sowing dates (May 10) had marked effect on number of panicles m^{-2} as compared with the planting in April 25th, however, late planting in May 25th or June 10 significantly reduced the panicles.

Islam *et al.* (1999) conducted experiment on mutants BINA 115 and BINA 163 and the check varieties Binasail and BR22 to the study panicle length where the panicle length showed significant variation among the dates of planting.

Krishnan and Nayak (1997) observed that the panicle length was greater when transplanting was done on 30 July compared with 15 July or 14 August transplanting.

In a field experiment at Waraseoni (MP), Paliwal *et al.* (1996) found that significant reduction in panicle length and grain yield due to delay in transplanting beyond 25 July.

Halder *et al*. (1995) conducted two field experiments to find out the effect of time and frequency of hand weeding on the yield and yield components of transplanted Aman (T. *Aman*) rice at BRRI RS, Sonagazi, Feni. The panicles m^{-2} increased with the increase in the frequency of weedings.

Reddy and Ghosh (1989) reported that delay in planting beyond 13 July resulted in decreased panicle length.

BRRI (1989) reported that rice plants require a particular temperature for its phonological affairs such as panicle initiation, flowering, panicle exsertion from flag leaf sheath and maturity and these are much influenced by the planting dates during T. *Aman* season. Deviation from the optimum planting time may cause incomplete and irregular panicle exertion, increased spikelet sterility.

2.2.3 Seed or grain yield

Ali *et al*. (2012) reported that the lowest number of grains $panicle^{-1}$ and grains yield ha^{-1} except light penetration it was the lowest value. As Sakha surpassed other varieties under study to all previous attributes who ever G.Z. 9362 gave the lowest value.

Faghani *et al*. (2011) reported that the planting date in 23 May and 12 June where results showed that the 12 June produced the highest grain yield. When date of planting is delayed grain yield decreased because the 1000 grains weight decreased.

Prabhakar and Reddy (2010) conducted a field experiment to study the effect of different dates of dry seeding and staggered nursery sowing on growth and yield of *Kharif* rice. The experimental results showed no difference among the methods of stand establishment in terms of yield. However, among the dates of sowing the delay in sowing beyond 30th July significantly reduced the grain yield and returns per rupee invested. It has been concluded that the rice crop may be established either by direct seeding or by transplanting nurseries but the sowing of the respective cultures should be done by the end of July for obtaining maximum yield and profits.

Bashir *et al*. (2010) conducted an experiment to evaluate the effect of different sowing dates on yield and yield components of the direct sown coarse rice during the Kharif season at Agronomic Research Area, University of Agriculture, Faisalabad. Experiment comprised of six sowing dates i.e. 31st May, 10th June, 20th June, 30th June, 10th July and 20th July. Data on agronomic parameters and economics of coarse rice were recorded. Results revealed that direct seeded rice sown on 20th June proved to be the best for obtaining maximum grain yield and net return.

Vange and Obi (2009) studied the effect of sowing date on grain yield of rice. Five upland rice varieties were sown in a randomized complete block design with three replications on 15 June, 30 June, and 15 July.Result showed significant difference in yields for sowing dates, but interaction effect of sowing dates and variety were statistically insignificant. The sowings on 30 June resulted in the highest yield of 3.32 Mg/ha at Otobi, while the sowings on 15 July gave the least yield of 1.46 Mg/ha at Makurdi. The regression of sowing date and yield showed a declining yield trend with delay in sowing dates for both locations. The Makurdi location had its predicted maximum yield with sowing on 15 June with yield of 2.70 Mg/ha. At Otobi the highest yield of 3.30 Mg/ha was on 23 June. The comparison between estimated and observed yield for both years for Otobi and Makurdi were not significant. A 12-day delay in sowing beyond optimum sowing date resulted in a 5% decrease in predicted yield at Makurdi while at Otobi, a delay of 15 days resulted in a 5% decline in yield. These results enforce the need to rice farmers in Benue State to sow in June.

Six different sowing dates were investigate where, the maximum number of grains per panicle and grain yield (t ha^{-1}) is the best at early date of sowing (Khalifa, 2009).

Nahar *et al*. (2009) reported that the BRRI dhan46 had significantly higher values of yields than the BRRI dhan31 in late transplanted conditions. There were significant reductions in yield attributes and yields after delayed transplanting. Yield reduction of BRRI dhan46 due to late transplanting at 10 September, 20 September and 30 September were 4.44, 8.88 and 15.55%, respectively compared to 01 September transplanting. In case of BRRI dhan31 the reduction was more significant which were 6.12, 20.48 and 36.73%, respectively.

Mannan *et al*. (2009) studied to determine the optimum time of planting and to find out the genotypes having high yield potential.Crop planted from 7 August to 7 September gave more number of grains per panicle which resulted in higher grain yield. The growth duration of the genotypes decreased with the advancement of planting date.

Mannan *et al*. (2009) studied to determine the optimum time of planting and to find out the genotypes having high yield potential. Compared to the 22 August planting, grain yield decreased by 11, 10, 10, 26, and 61%, respectively, when the crop was planted at 22 July, 7 August, 7 September, 22 September, and 7 October, respectively. Among the genotypes, Basmati PNR gave maximum grain yield followed by Basmati-D. Thus, fine rice Basmati PNR and Basmati-D were most suitable to obtain higher grain yield when planted within 17-21 August.

Yadav and Tripathi (2008) conducted a field experiment to find out the effect of hybrid rice 'PHB 71' to 3 dates of planting (15 July, 30 July and 14 August), 4 plant geometry (15 × 15cm, 20 × 15cm, 25 × 15cm and 30 × 15 cm) and 2 seedling rates (1 and 2 seedlings hill^{-1}). Hybrid rice planted on 15 July recorded significantly more grain yield (62.82 q ha^{-1}), which declined by 7.6 and 20.6% due to 15 and 30 days delay in planting, respectively. Planting the crop with a closer plant geometry of 15 × 15 cm produced significantly highest grain yield (59.18 q ha^{-1}) than wider plant geometry of 20 × 15 cm, 25 × 15 cm and 30 × 15 cm. Planting of 2 seedlings hill^{-1} was beneficial with yield advantage of 8.2% over 1 seedling hill^{-1}.

Yadav (2007) conducted a field experiment during *Kharif* season to study the effect of dates of planting, plant geometry and number of seedlings per hill in hybrid rice 'PHB 71' where planting the crop on 15th July recorded significantly more filled grains per panicle

(202.33) than 30th July and 14th August planting. The hybrid rice planted on 15 July registered also significantly more grain yield (62.82 qha^{-1}).

Akram *et al*. (2007) found the effect of different planting dates from July, 1 to 31 with 10 days interval on six rice varieties (98801, PK-5261-1-2-1, 97502, 98409, Basmati-385 and Super Basmati). Maximum number of grains per spike was found significantly. Basmati-385 and Super Basmati produced maximum paddy yield (5655 and 5612 $kgha^{-1}$) when planted on July, 11 and 1, respectively. Minimum sterility was observed in rice planted on 21st July followed by July 1, 11 and 31.

Akhter *et al*. (2007) conducted an experiment on twelve rice promising lines i.e., 98801, 98410, 98316, 99417, 97502, 99512, 98410, 99513, 98506, 98408, 5261-1-2 along with Super Basmati as check variety were transplanted on six different dates (16May to 1st August) with an interval of fifteen days to test the basmati behavior of new strains. Super Basmati in all the six dates flowered in the last week of September and first week of October irrespective of its time of transplanting. Most of the promising lines gave good yield when transplanted from 1st July to 16th July. 99512 and 99513 behaved differently, paddy yield of these genotypes reduced when transplanted late.

Vange and Obi (2006) investigated the effect of planting dates on grain yield and some agronomic characters by early seeding (June 15 and June 30) and late seeding (July 15 and July 30). These indicated that planting date affected the performance of these traits significantly. Grain yield (tha^{-1}) and plot yield (g) were highest on July 30 planting.

Dongarwar *et al.* (2005) reported that early transplanting on 15 and 30 July resulted significantly higher grain yield 31.29 and 32.61 qha^{-1}, respectively than late transplanting on 15 August (28.40 qha^{-1}).

Verma *et al.* (2004) studied the response of hybrid rice ‘PA 6201’ to date of planting and found that early planting on 20 July produced significantly higher grain yield than late planting on 5 and 20 August.

Singh *et al.* (2004) carried out a field experiment on hybrid rice ‘PRH 10’ at New Delhi and reported that delay on transplanting significantly reduced the yield and yield attributes, timely transplanting on 3 July led to 8.4 and 19.1 per cent higher grain yield than transplanting on 10 and 17 July, respectively.

Linscombe *et al*. (2004) conducted an experiment to determine the number of days from seedling emergence to 50% panicle emergence. The interaction of cultivar by planting date for days required reaching 50% panicle emergence and rough rice grain yield was not significant. However, planting date had a major effect on days required to reach 50% panicle emergence and grain yield. Grain yield at one location in southwest Louisiana was highest (8.60 tha^{-1}) when rice was planted in late March, and grain yield decreased linearly as planting was delayed until early June (6.50 tha^{-1}).

Dixit *et al.* (2004) conduced a experiment on rice hybrid 'Sahyadri' at Maharashtra and observed that 25 June planting showed significantly highest grain yield (53.22 qha^{-1}) than that planting on 5, 10 and 15 June.

Roy *et al*. (2003) investigated to find out the transplanting effects on growth and yield of five modern varieties and to identify suitable varieties for late T. *Aman* season.Early September was the suitable transplanting time of modern varieties for higher grain yield. The results indicated that the varieties like BR23, BRRI dhan37 and BRRI dhan 38 could easily be transplanted up to the 4th week of September with a reasonably higher yield of about 3 t ha^{1} in the southern region (tidal non-saline area) of Bangladesh.

Qin Yang (2003) conducted an experiment using 6 rice varieties as test materials, three sowing-dates were performed and the effects of sowing-date on yield and yield component of rice plants were analyzed. The result indicated that when varieties Shennong 315 and Liaojing 454 were sowed on April 23 and transplanted on Jun 2, grain yields of them could be as high as usual.

Nayak *et al.* (2003) conducted a field experiment at Bhubaneshwar during wet season to find out the response of hybrid rice 'PA 6201' to dates of planting (16, 31 July and 16 August) and reported that a fortnight delay in planting from 16 July reduced the grain yield by 7.6 and 4.5 per cent during first year and second year, respectively. One month delay in planting from 16 July reduced the grain yield by 24.3 per cent.

Reddy (2002) reported that highest grain yield were recorded on 16 August transplanting and which was significantly superior to 1 and 16 Sept. transplanting.

Khatun *et al*. (2002) conducted an experiment at net house of the department of Agronomy, Bangladesh Agril. Univ., Mymensingh using four seedling ages 30, 45, 60 and 75 days, for transplant rice during July to November in transplant Aman (T. *Aman*) season in Boro season. The highest grain yield was obtained from 45-days old seedlings in both seasons. Regression models prepared for T. *Aman* and Boro seasons separately could explain the yield variations 77.1% and 68%, respectively due to seedling age.

Planting on 35 or 45 day old seedlings produced significantly higher grain yields, grain weight and number of filled grains per panicle compared to 25 days old seedlings. When transplanting was delayed to the second fortnight of August, the performance of both 35 and 45 days old' seedlings was greater than that of 25 days old seedlings. In general, there" was 'a drastic reduction in yield when planting was done in the first fortnight of September (Pattar *et al.* 2001).

Pandey *et al.* (2001) observed that early planting on 20 July resulted significantly higher grain yield than with delayed planting on 5 and 20 August.

BRRI (2001) conducted a field experiment with five modem varieties named BRRI dhan 30, BRRI dhan31, BRRI dhan32, BRRI dhan33 and JR 33380. Seedlings were transplanted at 15 days interval from 15 July to 30 September. Result showed that all the varieties- gave considerable higher grain yield when planted between 30 July and 15 September.

Biswas and Salokhe (2001) reported that the 15^{th} July transplanting of mother crop and collected vegetative tillers and re-transplanting on 15 August showed significantly high grain yield (3·8 tha^{-1}). The photoperiod-insensitive variety RD23 gave higher yield (3·8 tha^{-1}) than the photoperiod-sensitive variety KDML105 (3·0 tha^{-1}).

Balaswamy *et al.* (2001) conducted a field experiment comprising four dates of transplanting (25 July, 10 August, 25 August and 10 Sept) in conjunction with four rice cultivars in India. They stated that the highest grain yield of 3.67 tha^{-1} was recorded when planted on 25 July. A linear reduction in grain yield was observed with every 15 days delay in planting from 25 July to 10 Sept. More number of panicles m^{-2}, panicle length and filled grains $panicle^{-1}$ was recorded on 25 July planting.

Singh *et al.* (2000) conducted an experiment where four rice cultivars named Sugandha, Basmati.370, Pusa Basmati 1 and Brio were transplanted in two dates (7 and 22 July). They observed that timely transplanted (7 July) crop gave 17.2, 18.7, 18.8 and 14.4% higher grain yield, respectively.

Sherief *et al.* (2000) studied the effect of sowing dates (April 25^{th}, May 10^{th}, May 25^{th} and June 10^{th}) on yield and yield components of rice. They found that early sowing dates (May 10) had marked effect on number of filled grains $panicle^{-1}$, grain and yields fed^{-1}.

Mahal *et al.* (1999) observed from a field study at Ludhiana reported that planting on 19 July gave significantly higher grain yield as compared to planting on 5 July and 2 August.

Islam *et al.* (1999) reported that the grain yield varied significantly among the varieties irrespective of planting dates. The last planting date September produced the highest grain yields, 4.5 and 4.04 tha^{-1} given by Binasail and BINA163 respectively.

An year round experiment conducted by Naher *et al.* (1999) in Bangladesh with cv 'BR 11' and 'BR 14' revealed that the transplanting dates showed significant differences in grain yield. July planted crop produced higher grain yield than the crop planted in August and September. Patel (1999) found significantly more grain yield with early planting on 15 July than with delayed planting on 30 July and 14 August.

Kumar *et al.* (1998) observed from 2-year field study with rice hybrids 'PA 103', 'APHR 2' 'DRRH1' reported significantly higher grain yield (5.1 tha^{-1}) due to early planting on 25 July than the delayed planting on 5 and 15 August during both the year.

A field experiment was conducted by Om *et al.* (1997) at Kaul in *Kharif* season with hybrids 'ORI 161' (PHB 71), 'PMS 2A/IR 31802' and 'PMS 10A/PR 106' revealed that higher panicle weight and grain yield were recorded on 25 June transplanting. They reported that 10, 3 and 43 per cent, and 11, 5 and 78 per cent increased in grain yield with 25 June transplanting over 15 June, 5 and 25 July in Transplanting respectively.

Singh *et al.* (1997) observed that rice planted on 15 June gave 20.5 per cent higher grain yield than planted on 29 June (27.37 qha^{-1}) owing to 17.8 per cent more productive tillers per m^{-2}, 20 per cent filled grain per panicle and 29 per cent grain weight per panicle.

Krishnan and Nayak (1997) reported that the grain weight was greater when transplanting was done on 30 July compared with 15 July or 14 August transplanting.

Gangwar and Sharma (1997) obtained maximum grain yield by transplanting on 1^{st} to 16^{th} July compared to 31^{st} July and 16^{th} August. The most serious yield limiting factor associated with early transplanted crop is sterility.

Experiment conducted at CSAUA&T, Kanpur on traditional scented rice varieties in different dates of planting showed that time of planting significantly influenced the grain yield and 5 July planting produced significantly higher grain yield of 36.97 q/ha. The per cent reduction in grain yield of 4.86 and 16.20 were recorded under 20 July and 4 August planting as compared to the yield levels reported under 5 July planting (Singh *et al.* 1997).

Denish *et al.* (1997) conducted a field experiment with 12 Basmati rice varieties to evaluate the effect of planting date on grain yields. Dates of planting were 25 July 1991, 5 September in 1991, 25 July in 1992 and 11 August in 1992. They observed that grain yields were significantly higher for the 25 July planting. When planted late, four varieties gave higher yields, five gave lower yields and three gave similar yields.

A field experiment conducted at CRRI, Cuttack in 1996-97 showed that rice hybrids 'PA 103,' 'VRH 4', 'KMRH 2', and DRRH 1, planted on 22 July recorded significantly more grain yield of 3.78 tha^{-1} than that planted on 1 August (3.33 tha^{-1}) and 11 August (3.27 tha^{-1}) (CRRI, 1997).

Paliwal *et al.* (1996) found that significant reduction in grain yield due to delay in transplanting beyond 25 July.

Gohain and Saiki (1996) observed that in field experiment, average grain yie1d of rice was 4.0, 4.17, 3.65 and 2.3 t ha^{-1} when transplanted on 20 July, 5 August, 20 August and

20 Sept, respectively.They concluded that dierent transplanting dates significantly influenced the grain yield of transplant *Aman* rice. They repeated that the reduction in yield was about 50 % when planting was delayed from 20 July to 5 September.

Halder *et al*. (1995) were observed that the filled grains/panicle and grain yield increased with the increase in the frequency of weedings. Two weddings, one at two weeks after transplanting (WAT) and another at five WAT were enough to get the significantly higher grain yield.

Bali *et al.* (1995) studied the effect of transplanting dates on rice and observed that delay in transplanting decreased grain yield significantly. These results were also supported by Dhiman *et al.* (1995).

Bali and Uppal (1995) observed from a field experiment with Basmati rice, reported earlier transplanting on 10 July gave higher grain yield of 5 and 8.6 percent in 1989 and 1991, respectively as compared to 30 July transplanting.

Bali and Uppal (1995) carried out a field trial with two rice cultivars, which were transplanted on 10 and 30 July. The cultivars that transplanted on 10 July had reduced 9.4% higher grain yield than the cultivars transplanted on 30 July in 1989 a 1991, respectively.

Ali *et al.* (1993) planted two sets of rice varieties for early and late sowing. They recommended BR-11 for early while BR22 and BR23 for late sowing.

BRRI (1992) reported from an experiment with BR22 and BR23 that transplanting 30 days old seedlings of both the varieties of 1 August to 7 October at 15 days interval up to 15 September and then at 7 days intervals, both the variety gave the highest yield BR22 (4 52 tha^{-1}) and BR23 (3 97 tha^{-1}) when planted on 1 August. After that the yield was decreased gradually.

Gangwar and Ahamedi (1990) recommended planting of rice with in June or latest by first week of July when yield attributes and grain yield increased, and delay in planting after first week of July decreased drastically the number of grains per panicle and grain yield. Experiment conducted at DRR, Hyderabad on traditional scented rice varieties in different dates of planting showed that time of planting significantly influenced the grain yield, 2 July planting produced significantly higher grain yield of 3.30 tha^{-1}.

Li *et al.* (1989) studied photosynthetic characteristics of the plant population of rice hybrid Shanyou 63, they were reported that early planting received more amount of light and yield was closely correlated with amount of light received. Reddy and Ghosh (1989) reported that delay in planting beyond 13 July resulted in decreased grain yield.

Planting dates, years and combinations IE of these two factors had significant effect on grain yield of all the entries. The first planting date was found to be suitable for best performance of all the varieties. Good yield of Binasail in late planting makes it suitable for late cultivation in the flood prone areas (Azam *et al*. 1988).

Ghadeker *et al.* (1988) reported that transplanting on 9 July recorded highest yield (51.02 qha^{-1}) than that transplanting on 25 June

BRRI (1988) reported that grain yield reduced in all the varieties/lines in 18 September planting compared to 2 September plantings. Reduction in yield was due to reduction in spikelet number $panicle^{-1}$, increased sterility and reduction in 1000-grain weight.

Babu (1988) worked out with four rice cultivars, transplanted on 30 July, 15, August, 30 August, 1 5 September and 30 September. He obtained average grain yields of 3.6, 3.4, 2.6, 2.2 and 1.4 tha^{-1} respectively. The result showed that the yield gradually decreased with delayed transplanting and Magor observed that the effect of time of transplanting on yield was the least with Nizersail and most pronounced with Pajam. The reduction in yield of Pajam, by delaying transplanting from August 10 to August 20 was 175 kg ha^{-1} by delaying from August 31 to September 10, it was 1.4 tha^{-1} for Nizersail, the respective reduction in yield 5 $kgha^{-1}$ and 290 $kgha^{-1}$.

Islam (1986) reported that the time between 15 July and 15 August was the best for transplantation of high yielding varieties of transplant Aman rice concluded that early sowing at low temperature prolonged the growth cycle and reduced grains $panicle^{-1}$.

BRRI (1985) conducted an experiment with BR4, BRI 1 and seven advance lines taking Nizersail as check at Comilla Station of BRRI to determine the suitable date for late planting in the transplant *Aman* season. Results showed that all the lines and test varieties gave an optimum yield when planted at 15 August. None but Nizersail and BR11 followed when planted on 30 September and those two varieties gave about 18 to 41 % and 60% to 80 % lower grain yield respectively. But while Nizersail was transplanted on 10 September, 25 September and 10 October, number of tillers produced on three different dates was about similar but number on panicle and grain weight was reduced as 10 October planting.

Akram *et al.* (1985) conducted an experiment with Kashmir Basmati, a photoperiod-sensitive variety on 24 May, 8 June, 24 June or 8 July and found that transplanting on 8 June gave the significant yield but 8 July transplanting did not reach maturity due to low temperature during its growing period.

Grain yield generally decreased with delay transplanting in kharif season reported by Mandal *et al*. (1984).

Mejos and Pava (1980) stated that the number of seeds per panicle, seed weight and seed yield was not significantly affected by transplanting date in kharif season.

2.2.4 Number of spikelet per panicle and length

Results showed that the effect of planting date total sterile spikelet per panicle, was significant at 0.01 probability level (Faghani *et al*. 2011). When date of planting was delayed total strile spikelet per panicle increased.

Bashir *et al*. (2010) conducted an experiment to evaluate the effect of different sowing dates on yield and yield components of the direct sown coarse rice where 20th June sowing also gave the maximum number of spikelet per panicle.

Akbar *et al*. (2010) studied the response of yield and yield components of direct seeded fine rice (*Oryza sativa* L.) to six different sowing dates that is 31st May, 10th June, 20th June, 30th June, 10th July and 20th July. The crop sown on 20th June produced the maximum number of kernel per panicle (94.47).

Akbar *et al*. (2010) recorded that the maximum 1000-kernel weight (18.82 g) was obtained from 20th June direct seeding of super basmati rice in term of entire yield and yield components.

Nahar *et al*. (2009) reported that the BRRI dhan46 had significant highest spikelets panicle^{-1} than the BRRI dhan31 in late transplanted conditions.

Mannan *et al*. (2009) studied to determine the optimum time of planting and to find out the genotypes having high yield potential where more number of panicles and lower percentage of spikelet sterility was found in Basmati 370 irrespective of planting date due to lower number of panicles and high percentage of spikelet sterility.

Khalifa (2009) in Egypt carried out field experiment for physiological evaluation of four hybrid rice varieties under six different sowing dates. Results indicated that early date of sowing was the best time of sowing for important properties such as maximum spikelets/leaf area ratio.

Sherief *et al*. (2000) studied the effect of sowing dates (April 25th, May 10th, May 25th and June 10th) on yield and yield components of rice. They found that early sowing dates (May 10) had marked effect on straw yields fed^{-1}.

Hari *et al.* (1999) conducted a field experiment comprising four dates of transplanting (15 June, 25 June, 5 July and 25 July) in conjunction with four rice cultivars in India. Spikelet sterility was the maximum in 25 July and minimum in 25 June transplanted crop.

2.2.5 Yield

Islam *et al*. (2009) investigated to find out the effect of nitrogen levels and transplanting dates on the yield and yield components of aromatic rice cv. *Kalizira*. Four (0, 50, 100, and 150 kg N ha^{-1}) levels of nitrogen and three transplanting dates (10 August, 22 August and 04 September, 2007) along with the basal doses of triple super phosphate (TSP), murate of potash (MoP) and gypsum were used in this study. The study revealed that most of the straw yields (5.14 t ha^{-1}) were found in N control treatment with transplanting date of 04 September.

2.3 Interaction Effect of Inbred and Hybrid Rice

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, 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 (Islam *et al*. 2009).

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 (Islam *et al*. 2009).

Islam *et al*. (2009) was conducted an experiment to compare the growth and yield behaviour of hybrid and inbred rice varieties under controlled condition.BRRI dhan3l had about 10-15% higher plant height at all days after transplanting (DAT) compared to Sonarbangla-1.

In 2002, BRRI dhan31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhanl had the highest plant height (Islam *et al*. 2009).

CHAPTER III

MATERIALS AND METHOD

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted at the Research Field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from June,2010 to February,2011.

3.1 Site Description

3.1.1 Geographical Location

The experimental area was situated at $23^{O}77\ ^{O}N$ latitude and $90\ ^{O}33\ ^{O}E$ longitude at an altitude of 8.6 meter above the sea level (Anon. 2004).

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of “The Modhupur Tract”, AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain.

3.1.3 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.1-6.3 and had organic matter 1.29%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. Soil samples were analyzed for both physical and chemical properties in the laboratory of the SRDI, Farmgate, Bangladesh. The properties studied included pH, organic matter, total N, available P and exchangeable K. The soil was analyzed following standard methods. Particle-size analysis of soil was done by Hydrometer method and soil pH was measured with the help of a glass electrode pH meter using soil water suspension of 1:2.5. The physico-chemical properties of the soil are presented in Appendix I.

3.1.4 Climate

The area has sub tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season and scanty rainfall associated with moderately low temperature during the Rabi season. Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix II.

3.2 Details of the Experiment

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

Factor A: Variety - 4

V_1= BR11 (Mukta) V_2= BRRI dhan39

V_3= ACI 1 V_4= ACI Shera

Factor B: Transplanting period (4)

T_1= 20th July (1st transplanting)

T_2= 4th August (2nd transplanting)

T_3= 19th August (3rd transplanting)

T_4= 3rd September (4th transplanting)

3.3 Experimental Design

The experiment was laid out in two factors RCBD with three replications. There were 16 treatment combinations. The total numbers of unit plots were 48. The size of unit plot was 4.0m by 3.0 m. The distances between plot to plot and replication to replication were 1 m and 1.5 m, respectively. The layout of the experiment has been shown in Plate 4.

3.4 Crop Management

3.4.1 Seed Collection

Seeds of BR11(Mukta) and BRRI dhan39 were collected from BRRI, Joydebpur, Gazipur, and the hybrid rice seed was collected from ACI Seed Company.

3.4.2 Seed Sprouting

Seeds were selected by following specific gravity method. Seeds were immersed into water in a bucket for 24 hours. These were then taken out of water and kept tightly in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.4.3 Preparation of Seedling Nursery

A common procedure was followed in raising seedlings in the seedbed. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Selected inbred and hybrid variety of rice seeds were sown in the nursery seedbed 30 days before transplanting. Weeds were removed and irrigation was gently provided to the bed as and when necessary.

3.4.4 Soil Sample Preparation

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.5 Preparation of Experimental Land

The experimental field was first ploughed on June, 2010 with the help of a tractor drawn disc plough, later on July, 2010 the land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor drawn plough and subsequently leveled by laddering.

3.6 Fertilizer Application

The experimental area was fertilized with 120, 80, 80, 20 and 5 $kgha^{-1}$ of N, P_2O_5, K_2O, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum and zinc sulphate respectively. The entire amount of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at final land preparation. Urea was top-dressed in three equal installments i.e., after seedling recovery, during the vegetative stage and at 7 days before panicle initiation.

3.7 Direct Seed Sowing, Uprooting and Transplanting of Seedlings

For nursery seedlings, seeds of each inbred and hybrid cultivars were sown on June to July, 2010 in nursery bed and seedlings were uprooted carefully on 20th July, 4th August, 19th August and 3rd September and at the same days these were transplanted in to the research field. The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. Seedlings were then transplanted as per BRRI and ACI recommendation.

3.8 Intercultural Operations

3.8.1 Thinning and Gap Filling

After transplanting the seedlings in the research field, gap filling was done whenever it was necessary using the seedling.

3.8.2 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Two hand weeding were done first at 15 days after transplanting followed by second 15 days after first weeding. Weeds were removed mechanically with the help of Japanese rice wider.

3.8.3 Application of Irrigation Water

Irrigation water was added to each plot according to the recommended treatments of inbred and hybrid cultivar by their originated characteristics. Partial amount of water was applied to keep the soil moist, and it was even allowed to dry out for 2 to 4 days during tillering. This was done to keep the soil well aerated, to allow better root growth. From panicle initiation (PI) to hard dough stage, a thin layer of water (2-3 cm) was kept on the plots. Again water was drained from the plots during ripening stage.

3.8.4 Plant Protection Measures

Plants were infested with rice stem borer (*Scirphophaga incertolus*) and leaf hopper (*Nephotettix nigropictus*) to some extent which were successfully controlled by applying Diazinone @ 10 ml/10 liter of water for 5 decimal lands. Crop was protected from birds and rats during the grain filling period. Field trap and fox toxin poisonous bait was used to control the rat. For controlling the birds watching was done properly, especially during morning and afternoon.

3.8.5 Harvesting and Post Harvest Operation

Maturity of crop was determined when 80-90% of the grains become golden yellow in color. The harvesting of inbred variety BRRI dhan39 and BR11(Mukta) were done on January 23 and January 26, respectively. On the other hand, hybrid variety ACI 1 and ACI Shera were harvested at February 02 and February 11. m^{-2} areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done using pedal thresher. The grains were cleaned and sun dried to a moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were determined and converted to ton ha^{-1}.

3.9 Recording of Data

A. Crop growth and Plant characters

- Plant height (cm)
- Number of tillers $hill^{-1}$
- Leaf area index (LAI)
- Dry matter weight (g)
- Days to flowering
- Days to maturity

B. Yield contributing characters

- Number of effective tillers m^{-2}
- Number of noneffective tillers m^{-2}
- Panicle length (cm)

Number of fertile spikelets (filled grains) panicle^{-1}

Number of sterile spikelets (unfilled grains) panicle^{-1}

Weight of 1000- grain (g)

C. Yield

Grain yield (t ha^{-1})

Straw yield (t ha^{-1})

Biological yield (t ha^{-1})

Harvest index (%)

3.10 Experimental measurements

Experimental data collection began at 15 days after transplanting, and continued till harvest. The necessary data on agronomic characters were collected from ten selected hills from each plot in the field at 15 days interval and at harvest.

Plant height

Plant height was measured at 15 days interval and continued up to harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before heading, and to the tip of panicle after heading.

Number of tillers hill^{-1}

Number of tillers hill^{-1} were counted at 15 days interval up to harvest from pre selected hills and finally averaged as their number hill^{-1}. Only those tillers having three or more leaves were considered for counting.

Leaf area index (LAI)

Leaf area index was estimated measuring the length and width of leaf and multiplying by a factor of 0.75 followed by Yoshida (1993).

Dry weight of plant

The sub-samples of 5 hills plot^{-1} uprooting from Second line were oven dried until a constant level from which the weight of above ground dry matter were recorded at 30 days interval up to harvest.

Days to flowering

Days to flowering was recorded when about 50% of the plants within a plot flower emerged.

Days to maturity

Days to maturity was recorded when the panicles were turned yellow before harvest.

Number of effective tillers m^{-2}

The panicles which had at least one grain was considered as effective tiller. The number of effective tillers of 10 hills was recorded and expressed as effective tillers number m^{-2}.

Number of noneffective tillers m^{-2}

The tiller having no panicle was regarded as ineffective tiller. The number of ineffective tillers 10 hills^{-1} was recorded and was expressed as ineffective tiller number m^{-2}.

Panicle length

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 10 panicles.

Number of fertile spikelets (filled grains) panicle^{-1}

Spikelet was considered to be fertile if any kernel was present there in. The number of total fertile spikelets present on each panicle was recorded.

Number of sterile spikelets (unfilled grains) panicle^{-1}

Sterile spikelet means the absence of any kernel inside in and such spikelets present on each panicle were counted.

Weight of 1000-grain

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight were expressed in gram.

Grain yield

Grain yield was determined from the m^{-2} of the plot and expressed as t ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

Straw yield

Straw yield was determined from the m^{-2} of each plot. After threshing, the sub-sample was oven dried to a constant weight and finally converted to t ha^{-1}.

Biological yield

The biological yield was calculated with the following formula-

Biological yield= Grain yield + Straw yield

Harvest index (%)

It denotes the ratio of economic yield to biological yield and was calculated with following formula

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

3.11 Statistical Analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using MSTAT-C package and the mean differences were adjudged by Least Significance Difference at 5% Level of Significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

The experimental results were studied on the effect of different transplanting date of inbred and hybrid rice genotypes and their relations on morpho-physiological characters, yield and yield contributing characters. The overall results, observation, discussion and findings of the study were presented in this chapter with some tables, figures and appendices. A general view of the experimental plots and treatments has been shown in plates which were presented after appendices.

4.1 Crop growth characters

4.1.1 Plant height (cm)

4.1.1.1 Effect of variety

Plant height was affected significantly by different rice genotypes of inbred and hybrid at different days after transplanting (DAT) were shown in Appendix III and Table 1. The plant height data was recorded at 15 days interval from 15 DAT to 90 DAT. From the observation of table 1, inbred variety V_1 produced the tallest plant (29.08 cm) and hybrid variety V_4 formed the shortes(26.17 cm) plant at 15 days after transplanting. At 30 DAT, the tallest(50.42 cm) plant and the shortest(46.17 cm) plant were also gave the inbred variety V_1 and hybrid cultivar V_4, respectively. Similar variety also gave the tallest(73.33 cm) plant and shortest(67.17 cm) plant at 45 DAT. At 60 DAT, the tallest(91.33 cm) plant was recorded from the inbred cultivar V_1 and the shortest (84.17 cm) was observed from the hybrid genotype V_4. On the other hand, inbred cultivar V_1 further gave the tallest(96.33 cm) plant and hybrid variety V_4 formed the shortest(86.17 cm) plant at 75 days after transplanting. However, at 90 DAT, the tallest plant (108.33 cm) and the shortest(91.17 cm) plant were also found from the inbred variety V_1 and hybrid cultivar V_4, respectively. Table 1 also showed that at early stages of growth the hybrid variety V_3 produced the statistically similar results (28.50, 49.50, 72.50 and 90.50 cm) with V_1 at 15, 30, 45 and 60 DAT respectively.

The results revealed that the plant height was rapidly increasing up to 60 days after transplanting whereas the plant height was increased slowly up to 90 DAT and at harvest its increasing possibility was bunged. So, it is clear that the plant height was increase rapidly at vegetative stage and the rate of increase gradually reduce at reproductive stage. From the above observation it was also found that the inbred variety showed the better performance than hybrid variety in case of plant height. Similar result was also observed by Rahman (2001) who observed that the tallest plant in the inbred variety and shortest plant height in hybrid variety.

Table 1: Effect of different inbred and hybrid varieties on plant height at different days after transplanting

Variety	Plant height (cm)					
	15	**30**	**45**	**60**	**75**	**90**
V_1	29.08	50.42	73.33	91.33	96.33	108.33
V_2	26.50	46.50	68.50	85.50	87.50	99.50
V_3	28.50	49.50	72.50	90.50	94.50	98.50
V_4	26.17	46.17	67.17	84.17	86.17	91.17
$LSD_{0.05)}$	**0.985**	**1.179**	**1.209**	**1.684**	**1.784**	**1.704**
CV (%)	**4.29**	**2.94**	**2.06**	**2.30**	**2.35**	**2.06**

V_1= BR11(Mukta), V_2= BRRI dhan39 V_3= ACI 1; V_4= ACI Shera

4.1.1.2 Effect of transplanting date

Plant height was significantly affected due to the different transplanting date at 15, 30, 45, 60, 75 and 90 DAT (Table 2). Among the four transplanting date, the plant transplanting on 4^{th} August produced the tallest plant (34.58 cm) and 3^{rd} September gave the shortest plant height (22.08 cm) at the initial period of data recording. Similarly, 4^{th} August transplanting plant gave the tallest plant (55.08 cm) and the transplanting plant of 3^{rd} September also gave the shortest plant (42.58 cm) at 30 DAT. On the other hand, the tallest plant (77.33 cm) and the shortest plant (64.83 cm) were recorded from 4^{th} August and 3^{rd} September transplanting plant, respectively at 45 DAT. At 60 DAT, the tallest plant (94.83 cm) also produced from the 4^{th} August and the shortest plant (82.33 cm) was observed from 3^{rd} September transplanting plant. However, the tallest plant (98.08 cm) and the shortest plant (85.58 cm) were found from 4^{th} August and 3^{rd} September transplanting plant, respectively at 75 DAT. At the final period of data recording before harvest, the tallest plant (106.33 cm) also formed from the 4^{th} August transplanting plant whereas the shortest plant (93.83 cm) was found at 3^{rd} September transplanting plant. From the above results, the maximum tallest plant (106.33 cm) was found at 90 DAT and the top minimum shortest plant (22.08 cm) was recorded at 15 DAT from 4^{th} August and 3^{rd} September transplanting plant respectively. These results revealed that the optimum planting time of T. *Aman* rice is in August for the better plant growth. It is obvious that the gradually increase in plant height was attributed to the reason that late planting had shorter growing period due to photoperiodic response. Longer growing season of August planted crop produced taller plants and higher dry matter production as compared to the rest planting dates. These results are in line with Khakwani *et al*. (2006); Paraye and Kandalkar (1994) who reported that plant height is significantly affected by sowing dates.

Table 2: Effect of transplanting date on plant height at different days after transplanting (DAT)

Date of transplanting	Plant height (cm) at15 days interval					
	15	**30**	**45**	**60**	**75**	**90**
T_1	29.58	50.33	72.58	90.08	93.33	101.58
T_2	34.58	55.08	77.33	94.83	98.08	106.33
T_3	24.00	44.58	66.75	84.25	87.50	95.75
T_4	22.08	42.58	64.83	82.33	85.58	93.83
$LSD_{0.05)}$	**0.985**	**1.179**	**1.209**	**1.684**	**1.784**	**1.704**
CV (%)	**4.29**	**2.94**	**2.06**	**2.30**	**2.35**	**2.06**

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.1.1.3 Interaction effect of varieties and transplanting date

A significant variation was found due to the combined effect of different inbred and hybrid genotypes of rice on plant height at different days after transplanting (Appendix III). Plant height data was collected at 15 days interval from 15 DAT up to 90 DAT whereas vegetative stage was up to 60 DAT and reproductive stage was 75 and 90 DAT. At vegetative stage of data recording, 4th August transplanting plant showed the tallest plant 36.33, 57.33, 80.33 and 98.33 cm inbred variety BR11 (Mukta) followed by the second highest (35.67, 56.67, 79.67 and 97.67 cm) at similar treatment in combination with hybrid variety ACI 1 and it was statistically similar. The shortest plant (20.67, 40.67, 61.67 and 78.67 cm) was recorded from 3rd September transplanting plant of ACI Shera at 15, 30, 45 and 60 DAT, respectively. At the reproductive stage, second transplanting at 4th August produced the tallest plant (103.30 and 115.30 cm) and fourth transplanting plant at 3rd September gave the shortest plant (80.67and 85.67 cm) at 75 and 90 DAT, respectively (Table 3).

Table 3: Interaction effect of different varieties and their transplanting date on plant height at different days after transplanting (DAT)

Interaction	Plant height (cm)					
	15	**30**	**45**	**60**	**75**	**90**
V_1T_1	30.67	52.67	75.67	93.67	98.67	110.7
V_1T_2	36.33	57.33	80.33	98.33	103.3	115.3
V_1T_3	25.67	47.00	69.67	87.67	92.67	104.7
V_1T_4	23.67	44.67	67.67	85.67	90.67	102.7
V_2T_1	28.67	48.67	70.67	87.67	89.67	101.7
V_2T_2	33.33	53.33	75.33	92.33	94.33	106.3
V_2T_3	23.00	43.00	65.00	82.00	84.00	96.00
V_2T_4	21.00	41.00	63.00	80.00	82.00	94.00
V_3T_1	30.67	51.67	74.67	92.67	96.67	100.7
V_3T_2	35.67	56.67	79.67	97.67	101.7	105.7
V_3T_3	24.67	45.67	68.67	86.67	90.67	94.67
V_3T_4	23.00	44.00	67.00	85.00	89.00	93.00
V_4T_1	28.33	48.33	69.33	86.33	88.33	93.33
V_4T_2	33.00	53.00	74.00	91.00	93.00	98.00
V_4T_3	22.67	42.67	63.67	80.67	82.67	87.67
V_4T_4	20.67	40.67	61.67	78.67	80.67	85.67
$LSD_{0.05)}$	**1.970**	**2.359**	**2.419**	**3.368**	**3.568**	**3.409**
CV (%)	**4.29**	**2.94**	**2.06**	**2.30**	**2.35**	**2.06**

V_1= BR11(Mukta), V_2= BRRI dhan39; V_3= ACI 1; V_4= ACI Shera

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.1.2 Number of tillers hill^{-1}

4.1.2.1 Effect of variety

The analysis of variance and data regarding the number of total tillers hill^{-1} is given in Appendix IV and Table 4. It is evident from the data that number of total tillers hill^{-1} was affected significantly by the different inbred and hybrid genotypes in T. *Aman* season at different days after transplanting. Among the cultivars, inbred variety BR11 (Mukta) formed the maximum number of total tiller hill^{-1} in the whole data recording period viz. 15 DAT (4.58), 30 DAT (9.58), 45 DAT (17.58), 60 DAT (28.50), 75 DAT (39.08) and 90 DAT (34.58) whereas the minimum number of total tiller hill^{-1} (3.50, 7.50, 14.50, 23.50, 31.75 and 27.42) was recorded from the hybrid cultivar ACI Shera at 15, 30, 45, 60, 75 and 90 DAT, respectively. It was revealed that the inbred variety was greater than hybrid variety on number of total tillers hill^{-1}.

Table 4: Effect of different inbred and hybrid varieties on number of total tillers hill^{-1} at different days after transplanting (DAT)

Variety	Number of total tillers hill^{-1}					
	15	30	45	60	75	90
V_1	4.58	9.58	17.58	28.50	39.08	34.58
V_2	3.75	7.75	14.75	23.75	32.00	27.67
V_3	4.08	9.08	17.08	27.08	36.83	31.50
V_4	3.50	7.50	14.50	23.50	31.75	27.42
$LSD_{0.05)}$	**0.372**	**0.570**	**1.294**	**1.327**	**0.8933**	**1.537**
CV (%)	**11.24**	**5.05**	**4.28**	**6.04**	**4.56**	**6.09**

V_1= BR11(Mukta), V_2= BRRI dhan39; V_3= ACI 1; V_4= ACI Shera

4.1.2.2 Effect of transplanting date

Number of total tillers hill^{-1} was significantly influenced by the various transplanting dates (Appendix IV and Table 5). The data concerning the number of total tillers hill^{-1} was recorded at 15 days after transplanting from 15 DAT up to 90 DAT which variance results was present in Table 5. Among the four transplanting treatment, second treatment (T_2) at 4th August showed the maximum number of tillers hill^{-1} (5.25, 9.75, 17.25, 26.92, 37.00 and 33.00) at their whole data recording period (15, 30, 45, 60, 75 and 90 DAT, respectively) and Treatment of 3rd September (T_4) transplanting plant produced the minimum number of tillers hill^{-1} (2.83, 7.33, 14.83, 24.58, 33.08 and 28.25) at 15, 30, 45, 60, 75 and 90 DAT, respectively. Above investigation observed that the number of total tiller hill^{-1} gradually increase up to 75 days after transplanting whereas number of total tillers hill^{-1} decreased at 90 DAT. Among the DAT, at 4th August transplanting plant produced the maximum (37.00) at 75 DAT and 3rd September formed the minimum (2.83) at 15 DAT. All the remaining treatments were also statistically different from each other. Among yield components, productive tillers are very important because the final yield is mainly a function of the number of panicles bearing tillers per unit area. This increase of fertile tillers hill^{-1} at 4th August transplanting was attributed to favorable environmental conditions which enabled the plant to improve its growth and development as compared to other sowing dates. These results are similar to that of Pandey and Agarwal, 1991 and they indicated that different sowing dates had significant effect on number of tillers meter square.

Table 5: Effect of transplanting date on number of total tillers hill^{-1} at different days after transplanting (DAT)

Date of transplanting	Number of total tillers hill^{-1}					
	15	**30**	**45**	**60**	**75**	**90**
T_1	4.58	9.08	16.58	26.33	35.58	30.75
T_2	5.25	9.75	17.25	26.92	37.00	33.00
T_3	3.25	7.75	15.25	25.00	34.00	29.17
T_4	2.83	7.33	14.83	24.58	33.08	28.25
$LSD_{0.05)}$	**0.373**	**0.570**	**1.294**	**1.327**	**0.893**	**1.537**
CV (%)	**11.24**	**5.05**	**4.28**	**6.04**	**4.56**	**6.09**

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.1.2.3 Interaction of varieties and transplanting date

A significant variation was found on number of total tillers hill^{-1} due to the effect of different genotypes of BRRI inbred and ACI hybrid rice at different days after transplanting except 90 DAT whereas number of total tillers hill^{-1} did not vary significant difference (Appendix IV and Table 6). Among the inbred and hybrid variety, inbred cultivar BR11 (Mukta) produced the maximum number of total tiller hill^{-1} (6.00, 11.00, 19.00, 29.67, 42.00 and 40.00) was recorded at 4th August transplanting plant at their whole data recording period (15, 30, 45, 60, 75 and 90 DAT, respectively). On the other hand, maximum results closely followed by the same inbred variety to 15 DAT (5.33), 30 DAT (10.33), 45 DAT (18.33), 60 DAT (29.33), 75 DAT (40.33) and 90 DAT (35.00) by the 20th July transplanting and hybrid variety at 15 DAT (5.33), 30 DAT (10.33), 45 DAT(18.33), 60 DAT (28.33) by 4th August transplanting plant where it was statistically similar to inbred variety BR11 (Mukta) and hybrid variety ACI 1 (Table 6). However, the minimum results on number of tillers hill^{-1} (2.33, 6.33, 13.33, 22.33, 30.33 and 26.67) was found from the hybrid variety ACI Shera with 3rd September transplanting plant at 15, 30, 45, 60, 75 and 90 DAT respectively.

Table 6: Interaction of varieties and different transplanting date on number of total tillers hill^{-1} at different days after transplanting (DAT)

Variety × Treatments	Number of total tillers hill^{-1}					
	15	30	45	60	75	90
V_1T_1	5.333	10.33	18.33	29.33	40.33	35.00
V_1T_2	6.000	11.00	19.00	29.67	42.00	40.00
V_1T_3	3.667	8.667	16.67	27.67	37.67	32.33
V_1T_4	3.333	8.333	16.33	27.33	36.33	31.00
V_2T_1	4.333	8.333	15.33	24.33	32.33	28.00
V_2T_2	5.000	9.000	16.00	25.00	34.00	29.67
V_2T_3	3.000	7.000	14.00	23.00	31.00	26.67
V_2T_4	2.667	6.667	13.67	22.67	30.67	26.33
V_3T_1	4.667	9.667	17.67	27.67	37.67	32.33
V_3T_2	5.333	10.33	18.33	28.33	38.33	33.00
V_3T_3	3.333	8.333	16.33	26.33	36.33	31.00
V_3T_4	3.000	8.000	16.00	26.00	35.00	29.67
V_4T_1	4.000	8.000	15.00	24.00	32.00	27.67
V_4T_2	4.667	8.667	15.67	24.67	33.67	29.33
V_4T_3	3.000	7.000	14.00	23.00	31.00	26.67
V_4T_4	2.333	6.333	13.33	22.33	30.33	26.00
$LSD_{0.05)}$	**0.746**	**0.713**	**1.140**	**2.589**	**2.654**	**3.074**
CV (%)	**11.24**	**5.05**	**4.28**	**6.04**	**4.56**	**6.09**

V_1= BR11 (Mukta), V_2= BRRI dhan 39; V_3= ACI 1; V_4= ACI Shera

T_1= 20th July (1st transplanting)
T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting)
T_4= 3rd September (4th transplanting)

These results raveled that the number of total tiller hill^{-1} increased progressibly at vegetative stage up to 75 DAI whereas it was decreased at 90 DAT. This increase of fertile tillers m^{-2} at 4th August transplanting plant which will ensure favorable environmental conditions, relative humidity and soil moisture and it will improve plant growth and development as compared to other transplanting dates. These results are similar to that of Rakesh and Sharma (2004) who are of the opinion that delay in planting resulted in significant decrease in number of productive tillers per meter square and ultimately the paddy yield. Pandey *et al.* (2001) and Lu and Cai (2000) also reported that the number of fertile tillers per square meter was found in decreasing trend from the seeding of late transplanting (Shah and Bhurer, 2005).

4.1.3 Leaf area index (LAI)

4.1.3.1 Effect of variety

Main effect of variety significantly influenced ($P<0.01$) on leaf area index at different days after transplanting (Appendix V). The results on leaf area index were also present in Table 7. From the Table 7, it was clear that the highest leaf area index (1.62) was found from the hybrid variety ACI 1 which was statistically similar to inbred variety BR11 (Mukta) (1.60) at 15 days after transplanting. At 30 DAT, the highest leaf area index (4.30) was also found by inbred cultivar BR11 (Mukta) and it was statistically similar to hybrid cultivar ACI 1 (4.24). Inbred variety BR11 (Mukta) also produced the highest leaf area index at 45 DAT (5.93), 60 DAT (7.01), 75 DAT (8.65) and 90 DAT (2.30) which was statistically similar to hybrid variety ACI 1 (5.35, 6.96, 8.57 and 2.24) at 45, 60, 75 and 90 DAT, respectively. On the other hand, the lowest leaf area index (1.30, 3.92, 5.21, 5.63, 7.25 and 1.92) was found from the hybrid variety ACI Shera. These results indicate that the leaf area index gradually increase up to 75 DAT or vegetative stage but rapidly decrease at 90 days after transplanting (Table 7). This might be due to the production of tillers relatively lower at hybrid variety than the inbred variety which accordingly decreased the number of leaves plant^{-1} as well as leaf area index. Takeda *et al.* (1983) observed that hybrid rice varieties had higher LAI.

Table 7: Effect of inbred and hybrid varieties on leaf area index (LAI) at different days after transplanting (DAT)

Variety	Leaf area index (LAI)					
	15	**30**	**45**	**60**	**75**	**90**
V_1	1.60	4.30	5.93	7.01	8.65	2.30
V_2	1.407	4.01	5.30	5.74	7.34	2.01
V_3	1.62	4.24	5.35	6.96	8.57	2.24
V_4	1.30	3.92	5.21	5.63	7.25	1.92
$LSD_{0.05)}$	**0.142**	**0.142**	**0.362**	**0.216**	**0.201**	**0.070**
CV (%)	**11.56**	**3.63**	**7.97**	**4.09**	**3.04**	**3.83**

V_1= BR11 (Mukta), V_2= BRRI dhan 39, V_3= ACI 1; V_4= ACI Shera

4.1.3.2 Effect of transplanting date

Leaf area index is significantly affected by different transplanting dates at different days after transplanting (Appendix V and Table 8). Among the transplanting dates, 4th August transplanting produced the maximum leaf area index (1.86) while minimum leaf area index (1.22) was produced by 3rd September at 15 days after transplanting. Similarly, second transplanting date at 4th August gave the maximum leaf area index (4.48) and at 3rd September formed the minimum leaf area index (3.83) at 30 DAT. Among the DAT, 45 DAT was significantly maximum on leaf area index (5.96) at 4th August transplanting plant which was closely followed by control (5.61) and the minimum leaf area index (3.83) was found at 3rd September transplanting plant. However at 60 DAT, the maximum leaf area index (8.32) was recorded at 4th transplanting plant (T2) and the minimum leaf area index (4.90) was observed at 3rd September transplanting plant. Transplanting plant of 4th August also produced the maximum leaf area index (8.32 and 2.48) and 3rd September gave the minimum leaf area index (7.67 and 1.83) at 75 and 90 days after transplant, respectively. Late sowing, shortened the growth period of the plant, leaf and other physiological growth which reduced the leaf area, length of panicle and number of kernels per panicle than early sowing. These are in line with the findings of Shah and Bhurer (2005). He reported that more number of filled grains per panicle was visualized in the early seeding and declined gradually in the successive seeding dates. Leaf area index was found in the decreasing trend from the seeding of 15 of June onward (Mahmood *et al.* 1995; Saikia *et al.* 1989). Leaf area showed better response with early sowing (Biswas and Salokhe, 2001).

Table 8: Effect of transplanting date on leaf area index (LAI) at different days after transplanting (DAT)

Variety	Leaf area index (LAI)					
	15	**30**	**45**	**60**	**75**	**90**
T_1	1.54	4.23	5.61	6.45	8.07	2.23
T_2	1.86	4.48	5.96	6.70	8.32	2.48
T_3	1.31	3.92	5.32	6.14	7.75	1.92
T_4	1.22	3.83	4.90	6.05	7.67	1.83
$LSD_{0.05)}$	**0.142**	**0.142**	**0.362**	**0.216**	**0.201**	**0.070**
CV (%)	**11.56**	**3.63**	**7.97**	**4.09**	**3.04**	**3.83**

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.1.3.3 Interaction of varieties and transplanting date

Combined effect of inbred and hybrid variety significantly influenced at 45, 60, 75 and 90 days after transplanting(Appendix V and Table 9). The maximum number of leaf area index (2.13) was found from the inbred variety BR11 (Mukta) which was statistically to hybrid variety (2.09) at the similar treatment (4th August transplanting) at 15 days after transplanting. At 30 DAT, inbred variety BR11 (Mukta) produced the maximum leaf area index (4.77) at 4th August transplanted plant followed by the same treatment with hybrid variety ACI 1 (4.71) which was statistically identical. Transplanted plant of inbred variety BR11 (Mukta) at 4th August also produced the maximum leaf area index (6.40) which was closely followed by the same inbred variety at control (6.04) and hybrid ACI 1 at 4th August (6.03) at 45 days after transplanting. At 60 and 75 DAT, sprouted plant of BR11 (Mukta) produced the maximum leaf area index (7.47 and 9.10, respectively) when it was transplant at 4th August followed by the same transplanting date with hybrid variety ACI 1 (7.43 and 6.05, respectively) which was statistically same. At the 15, 30, 45, 60 and 75 DAT, the minimum leaf area index (1.08, 3.71, 4.81, 5.42 and 7.05, respectively) was found from hybrid variety ACI Shera at 3rd September transplanted plant. At 90 DAT, the leaf area was reduced rapidly according to inbred and hybrid variety as well as the treatment combinations where the reduced maximum leaf area index (2.77) was found from the inbred variety BR11 (Mukta) at 4th August transplanted plant. Hybrid variety ACI Shera showed the minimum leaf area index (1.71) at the same DAT. Fourth August transplanted plant of the hybrid variety required lower duration to complete their life cycle and hence it produced lower leaf area index at whole data recording period including harvest period compare to inbred variety as well as BR11(Mukta).

Table 9: Interaction of varieties and different transplanting date on leaf area index (LAI) at different days after transplanting (DAT)

Variety × Treatments	Leaf area index (LAI)					
	15	30	45	60	75	90
V_1T_1	1.477	4.423	6.037	7.143	8.757	2.423
V_1T_2	2.133	4.767	6.400	7.467	9.100	2.767
V_1T_3	1.460	4.090	5.720	6.793	8.423	2.090
V_1T_4	1.317	3.937	5.557	6.650	8.303	1.937
V_2T_1	1.490	4.100	5.390	5.823	7.433	2.100
V_2T_2	1.710	4.313	5.733	6.043	7.647	2.313
V_2T_3	1.240	3.830	5.113	5.573	7.163	1.830
V_2T_4	1.187	3.777	4.963	5.520	7.110	1.777
V_3T_1	1.737	4.347	5.703	7.070	8.680	2.347
V_3T_2	2.093	4.713	6.030	7.427	9.047	2.713
V_3T_3	1.387	4.000	5.410	6.720	8.333	2.000
V_3T_4	1.277	3.900	4.250	6.610	8.233	1.900
V_4T_1	1.440	4.063	5.327	5.773	7.397	2.063
V_4T_2	1.513	4.137	5.670	5.847	7.470	2.137
V_4T_3	1.143	3.763	5.027	5.477	7.097	1.763
V_4T_4	1.083	3.713	4.813	5.417	7.047	1.713
$LSD_{0.05)}$	**0.284**	**0.247**	**0.723**	**0.432**	**0.402**	**0.140**
CV (%)	**11.56**	**3.63**	**7.97**	**4.09**	**3.04**	**3.83**

V_1= BR11(Mukta), V_2= BRRI dhan39, V_3= ACI 1; V_4= ACI Shera
T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.1.4 Dry weight of plant (g m^{-2})

4.1.4.1 Effect of variety

Dry weight of plant significantly influenced due to the effect of different variety at different days after transplanting (Appendix VI). The significant variation data on plant dry weight at 30, 60, 90 and at harvest was present in Table 10. Among the DAT, the high yielding inbred variety BR11 (Mukta) produced the highest dry weight of plant (315.50 g m^{-2}) followed by hybrid variety ACI 1 (294.92 g m^{-2}) where the lowest dry weight (207.42 g m^{-2}) was found from the hybrid variety ACI Shera. At 60 and 90 DAT, the inbred variety BR11 (Mukta) produced the highest dry weight (778.50 and 1467.17 g m^{-2}, respectively) followed by the hybrid variety ACI 1 (757.83 and 1447.33 g m^{-2}, respectively) where they are statistically identical. On the other hand, the lowest dry weight of plant (669.58 and 1359.08 g m^{-2}) was found from the hybrid variety ACI Shera at 60 and 90 DAT, respectively. However, at harvest, inbred variety produced the highest dry weight of plant (1859.33 g m^{-2}) which was closely followed by the hybrid variety ACI 1 (1840.25 g m^{-2}) where the lowest dry weight of plant (1751.25 g m^{-2}). Above results indicate that the inbred variety was better on dry matter production of plant to compare with hybrid variety.

Table 10: Effect of dry weight (g) at different days after transplanting (DAT)

Variety	Dry weight of plant (g m^{-2})			
	30	60	90	At harvest
V_1	315.50	778.50	1467.17	1859.33
V_2	226.42	687.33	1376.83	1769.42
V_3	294.92	757.83	1447.33	1840.25
V_4	207.42	669.58	1359.08	1751.25
$LSD_{0.05)}$	**11.28**	**30.23**	**42.01**	**83.60**
CV (%)	**5.18**	**5.01**	**3.56**	**5.56**

V_1= BR11(Mukta), V_2= BRRI dhan39, V_3= ACI 1; V_4= ACI Shera

4.1.4.2 Effect of transplanting date

Dry weight of plant data was recorded at 30 days interval from 30 days up to 90 days and at harvest period. Dry matter production data was significantly influenced by the different days after planting due to the effect of different transplanting date (Appendix VI and Table 11). At 30 and 60 DAT, the highest dry weight of plant (361.33 and 793.75 g m^{-2}, respectively) was recorded at 4th August transplanting (T_2) which was closely followed by 20th July transplanting (334.08 and 793.75 g m^{-2}, respectively) whereas, the lowest dry weight of plant (128.33 and 591.75 g m^{-2}, respectively) was recorded at 3rd September transplanting. At the same treatment (T_2) also produced the highest dry weight of pant (1513.75 g m^{-2}) at 90 DAT where 20th July gave the identically similar results (1483.75 g m^{-2}) at the same DAT. However, the highest dry weight of plant (1906.33 g m^{-2}) was found at 4th August transplanting which was statistically same to 20th July transplanting at harvest. At the similar DAT, 3rd September showed the lowest dry weight of plant (1673.50 g m^{-2}).

Table 11: Effect of transplanting date on total dry weight (g) at different days after transplanting (DAT)

Variety	**Dry weight of plant (g m^{-2})**			
	30	**60**	**90**	**At harvest**
T_1	334.08	793.75	1483.75	1875.92
T_2	361.33	824.75	1513.75	1906.33
T_3	220.50	683.00	1372.00	1764.50
T_4	128.33	591.75	1280.92	1673.50
$LSD_{0.05)}$	**11.28**	**30.23**	**42.01**	**83.60**
CV (%)	**5.18**	**5.01**	**3.56**	**5.56**

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.1.4.3 Interaction of varieties and transplanting date

Combined effect of two BRRI released high yielding inbred and ACI released two hybrid varieties with 4 types of transplanting date at T. *Aman* season showed significant variation on dry matter production at different days after transplanting (AppendixVI). The significant variation result was also present in Table 12. From the table 12, it was clear that BRRI released high yielding inbred variety BR11 (Mukta) produced the highest with 4th August transplanting and ACI released hybrid variety ACI Shera showed the lowest with 3rd September transplanting on dry weight of plant at their whole data recording period. At 30 DAT, 4th August transplanting showed the highest dry weight (415.3 g m^{-2}) was found from BR11 (Mukta) and it was closely followed by the ACI 1 (396.30 g m^{-2}) at the same treatment (T_2). Similarly, the highest dry weight (877.70g m^{-2}) was found with the inbred variety BR11 (Mukta) which was statistically similar to ACI 1 (858.70 g m^{-2}) when they are transplant at 4th August. At the similar trend, the maximum dry weight (1567.0 g m^{-2}) was also found from the BR11 (Mukta) with 4th August transplanting (V_1T_2) which was closely followed by ACI 1 (1548.0 g m^{-2}) with same treatment (V_3T_2) at 90 DAT. However at harvest, the highest dry weight (1959.0 g m^{-2}) was obtained from the 4th August transplanting of inbred variety BR11 (Mukta) which was statistically identical with the same transplanting (1940.0 g m^{-2}) date of hybrid variety ACI 1 and also with 20th July transplanting (1928.0 g m^{-2}) of the inbred variety BR11 (Mukta). On the other hand, the lowest dry weight (74.33, 536.70, 1227.0 and 1619.0 g m^{-2}) was recorded at 3rd September transplanting of ACI Shera at 30, 60, 90 DAT and at harvest, respectively.

Table 12: Interaction of varieties and different transplanting date on total dry weight (g) at different days after transplanting (DAT)

Interaction	Total dry weight (g)			
	30	60	90	At harvest
V_1T_1	385.7	847.0	1537.0	1928.0
V_1T_2	415.3	877.7	1567.0	1959.0
V_1T_3	276.0	738.7	1428.0	1820.0
V_1T_4	185.0	650.7	1337.0	1730.0
V_2T_1	305.3	758.7	1449.0	1842.0
V_2T_2	322.3	789.0	1478.0	1871.0
V_2T_3	185.7	647.0	1336.0	1727.0
V_2T_4	92.33	554.7	1245.0	1637.0
V_3T_1	364.7	827.3	1517.0	1910.0
V_3T_2	396.3	858.7	1548.0	1940.0
V_3T_3	257.0	720.3	1409.0	1803.0
V_3T_4	161.7	625.0	1315.0	1708.0
V_4T_1	280.7	742.0	1432.0	1823.0
V_4T_2	311.3	773.7	1463.0	1855.0
V_4T_3	163.3	626.0	1315.0	1708.0
V_4T_4	74.33	536.7	1227.0	1619.0
$LSD_{0.05)}$	**22.56**	**6.46**	**84.02**	**167.20**
CV (%)	**5.18**	**5.01**	**3.56**	**5.56**

V_1= BR11(Mukta), V_2= BRRI dhan39, V_3= ACI 1; V_4= ACI Shera
T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.1.5 Days to flowering and maturity

4.1.5.1 Effect of variety

Days to flowering significantly influenced due to the effect of inbred and hybrid variety when about 50% of the plants flower emerged (Appendix VII). Different inbred and hybrid variety required variation days for flowering and maturity due to the effect of varietal characteristics where the minimum time for flowering (88.92 days) and maturity (119.17 days) were required for inbred variety BR11 (Mukta) and hybrid variety ACI Shera took the longer time for flowering (98.92 days) and maturity (131.67 days) (Table 13). The variation in days for flowering and maturity where high yielding inbred variety BR11(Mukta) was earlier for flowering and maturity (10.0 and 12.50 days, respectively) than the hybrid variety ACI Shera which variety perform the lowest on growth characteristics as well as yield.

Table 13: Effect of inbred and hybrid variety on days to flowering and maturity

Variety	Days to flowering	Days to maturity
V_1	88.92	119.17
V_2	96.17	127.25
V_3	93.08	123.67
V_4	98.92	131.67
$LSD_{0.05)}$	**4.140**	**4.048**
CV (%)	**5.27**	**3.87**

V_1= BR11 (Mukta), V_2= BRRI dhan39 V_3= ACI 1; V_4= ACI Shera

4.1.5.2 Effect of transplanting date

Different transplanting date significantly affected on days to flowering at 1% level of probability (Appendix VII). Among the transplanting date, 4th August transplanting required the shortest time for flowering (90.33 days) and maturity (120.00 days) in case of favourable environment where 3rd September need the longer period for flowering (99.50 days) and maturity (130.83 days) for unfavourable environment. Among the transplanting date, 4th August gave the 6.58 days earlier to flowering and 10.83 days to maturity than 3rd September. Different transplanting date are fully affected on flowering as well as maturity in case of favourable environmental factor viz. temperature, relative humidity, rainfall etc. fulfilled earlier photoperiodic facts by sympathetic times of the season of any crops (Table 14). These results are in agreement with that of Maiti and Sen (2003) who found that the growth duration exhibited an increasing trend of early planted crop and decreasing trend of late planted crop.

Table 14: Effect of transplanting date on days to flowering and maturity

Variety	Days to flowering	Days to maturity
T_1	92.92	124.33
T_2	90.33	120.00
T_3	94.33	126.58
T_4	99.50	130.83
$LSD_{0.05)}$	**4.140**	**4.048**
CV (%)	**5.27**	**3.87**

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.1.5.3 Interaction of varieties and transplanting date

Combined effect of different inbred and hybrid variety with different transplanting time showed significant difference which analysis of variance table was present in Appendix VII. Fourth August transplanting of inbred variety BR11(Mukta) required the minimum time for flowering (84.33 days) and maturity (114.0 days). Similarly, 3rd September transplanting of hybrid variety ACI Shera need the maximum time for flowering (105.0 days) and maturity (139.3 days) (Table 15).August transplanting showed the better performance for flowering and maturity in case of favourable environmental which may shorten the period for flowering and maturity of inbred variety BR11(Mukta).

Table 15: Interaction of varieties and different transplanting date on days to flowering and maturity

Variety × Treatments	Days to flowering	Days to maturity
V_1T_1	88.00	118.7
V_1T_2	84.33	114.0
V_1T_3	89.67	121.0
V_1T_4	93.67	123.0
V_2T_1	94.67	125.7
V_2T_2	93.00	122.7
V_2T_3	96.00	128.0
V_2T_4	101.0	132.7
V_3T_1	91.67	123.7
V_3T_2	89.00	118.0
V_3T_3	93.33	124.7
V_3T_4	98.33	128.3
V_4T_1	97.33	129.3
V_4T_2	95.00	125.3
V_4T_3	98.33	132.7
V_4T_4	105.0	139.3
$LSD_{0.05)}$	**8.280**	**8.090**
CV (%)	**5.27**	**3.87**

V_1= BR11(Mukta), V_2= BRRI dhan39 V_3= ACI 1; V_4= ACI Shera

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.2 Yield contributing characters

4.2.1 Number of effective tillers m^{-2}

4.2.1.1 Effect of variety

Different varieties showed significant variation on number of effective tillers m^{-2} (Appendix VII). Number of effective tillers hill^{-1} was significantly the maximum (424.08) was observed from the inbred variety BR11(Mukta) followed by the hybrid variety ACI 1(414.25) which was statistically identical. Similarly, the minimum number of effective tillers hill^{-1} (250.38) was found from the hybrid variety ACI Shera where as inbred variety BRRI dhan39 showed the statistically similar results (314.25) (Table 16). These results indicate that inbred variety was the superior variety for the tillers effectiveness in case of genetic constituents of the varieties which might be increase production. Anon.(1992) reported that the proportion of effective tillers was more or less similar in inbred variety and hybrid variety. However,experiment suggested that the high yielding variety had more bearing tillers m^{-2} greater than the low yielding hybrid variety.

4.2.1.2 Effect of transplanting date

Transplanting date of inbred and hybrid variety significantly influenced on the number of effective tillers m^{-2} (Appendix VII). The maximum number of effective tillers m^{-2} (405.88) was obtained from the transplanted plant of 4th August which was closely followed by 20th July (384.67) and 19th August (321.67) transplanting where inbred variety BRRI dhan39 and hybrid variety ACI 1 was statistically more or less similar on the production of effective tillers m^{-2}. On the other hand, the minimum number of effective tillers m^{-2} (290.75) was observed from 3rd September transplanting (Table 17). Among yield components, productive tillers are very important because the final yield is mainly a function of the number of panicles bearing tillers (productive tillers) per unit area. This increase of effective tillers m^{-2} at 4th August transplanting was attributed to favorable environmental conditions which enabled the plant to improve its growth and development as compared to other transplanting dates. Our results are in alignment with the findings of Pandey *et al.* (2001), Lu and Cai (2000) and Paraye and Kandalkar (1994). Number of effective tillers m^{-2} was found in decreasing trend from the seeding of 15th June onward (Shah and Bhurer, 2005). These results are similar to that of Pandey and Agarwal, 1991 and they indicated that different sowing dates had significant effect on number of fertile tillers per meter square. These results are also in line with Rakesh and Sharma (2004) who are of the opinion that delay in planting resulted in significant decrease in number of productive tillers per meter square and ultimately the paddy yield.

4.2.1.3 Interaction of varieties and transplanting date

Combined effect of different inbred and hybrid variety did not vary significant on the number of effective tillers m^{-2} (Appendix VII and Table 18). Among the different inbred and hybrid variety, inbred variety BR11(Mukta) produced the maximum number of effective tillers (502.70) and it was statistically more or less similar with the hybrid variety ACI 1 (492.0) when both are transplanting at 4^{th} August. However, the minimum number of effective tillers m^{-2} (205.0) was recorded from the hybrid variety ACI Shera when it was transplanting at 3^{rd} September.

4.2.2 Number of non effective tillers m^{-2}

4.2.2.1 Effect of variety

Number of non effective tillers m^{-2} was significantly influenced due to the effect of different inbred and hybrid variety (Appendix VII) and the significantly variation data are present in Table 16. Among the inbred and hybrid variety, high yielding inbred variety BR11 (Mukta) gave the maximum number of non effective tillers m^{-2} (424.08) which was statistically more or less similar with hybrid variety ACI 1 (414.25). However, another hybrid variety ACI Shera produced the minimum number of non effective tillers m^{-2} (250.38) and it was also more or less similar with inbred variety BRRI dhan39 (314.25) to produce the non effective tillers m^{-2}.

4.2.2.2 Effect of transplanting date

Number of non effective tillers m^{-2} showed significant difference due to the effect of different transplanting data and the analysis of variance (ANOVA) at 1% level of probability are presented in Appendix VII. Beside the significant variation results was also present in Table 17. From the table 17, the maximum number of non effective tillers m^{-2} (27.67) was found from the 4^{th} August transplanting whereas 20^{th} July also produced the statistically similar (24.25) number of non effective tillers m^{-2}. However, the minimum number of non effective tillers m^{-2} (14.17) was recorded from 3^{rd} September transplanting where 19^{th} August transplanting showed the statistically similar (19.08) (Table 17).

4.2.2.3 Interaction of varieties and transplanting date

Number of non effective tillers m^{-2} did not vary significant variation due to the combined effect of different inbred and hybrid variety with their different transplanting date (Appendix VII and Table 18). Among the DAT, 4^{th} August transplanting of inbred variety

BR11 (Mukta) showed the maximum number of non effective tillers m^{-2} (31.67) followed by the hybrid variety ACI 1 (30.67) where they are statistically similar. However, the minimum number of non effective tillers m^{-2} (10.67) was observed from the hybrid variety ACI Shera. These results indicate that the more number of effective tillers produced the more effective and non effective tillers but statistically they produced significant production. Beside more number of effective tillers produced more production of grain which will ensure the higher grain yield where non effective tillers effect was not sufficient (Table 18).

Table 16: Effect of different inbred and hybrid varieties on number of effective and non effective tillers m^{-2}

Variety	Number of effective tillers m^{-2}	Number of non effective tillers m^{-2}
V_1	424.083	24.917
V_2	314.250	19.333
V_3	414.250	23.833
V_4	250.379	17.083
$LSD_{0.05)}$	**0.7216**	**42.37**
CV (%)	**14.49**	**4.15**

V_1= BR11(Mukta), V_2= BRRI dhan39, V_3= ACI 1; V_4= ACI Shera

Table 17: Effect of transplanting date on number of effective and non effective tillers m^{-2}

Transplanting date	Number of effective tillers m^{-2}	Number of non effective tillers m^{-2}
T_1	384.667	24.250
T_2	405.879	27.667
T_3	321.667	19.083
T_4	290.750	14.167
$LSD_{0.05)}$	**0.7216**	**0.4237**
CV (%)	**14.49**	**4.15**

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

Table 18: Interaction of varieties and transplanting date on effective and non effective tillers m^{-2}

Interaction	Number of effective tillers m^{-2}	Number of non effective tillers m^{-2}
V_1T_1	448.0	28.00
V_1T_2	502.7	31.67
V_1T_3	386.0	22.67
V_1T_4	359.7	17.33
V_2T_1	340.0	22.00
V_2T_2	391.7	25.67
V_2T_3	276.0	17.00
V_2T_4	249.3	12.67
V_3T_1	440.3	27.00
V_3T_2	492.0	30.67
V_3T_3	375.7	21.67
V_3T_4	349.0	16.00
V_4T_1	310.3	20.00
V_4T_2	237.2	22.67
V_4T_3	249.0	15.00
V_4T_4	205.0	10.67
$LSD_{0.05)}$	**1.443**	**84.74**
CV (%)	**3.28**	**14.49**

V_1= BR11(Mukta), V_2= BRRI dhan39 V_3= ACI1; V_4= ACI Shera

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.2.3 Number of total grain panicle^{-1}

4.2.3.1 Effect of variety

Total number of grain panicle^{-1} showed the significant variation due to the effect of different inbred and hybrid variety (Appendix VIII). Significant variation results was also present in Fig. 1 where, the maximum number of grain panicle^{-1} (278.00) was obtained from the inbred variety BR11 and the minimum number of grain panicle^{-1} (226.58) was recorded from the hybrid variety ACI Shera (Fig. 1). Total number of grains panicle^{-1} is the largest part of yield characteristics which contributes towards the grain yield. As a result, more grain panicle^{-1} produced the more yield or production. Varietals effect also showed significant on number of grains panicle^{-1}. Hossain and Alam (1991) reported the varietal variation in number of grains panicle^{-1}

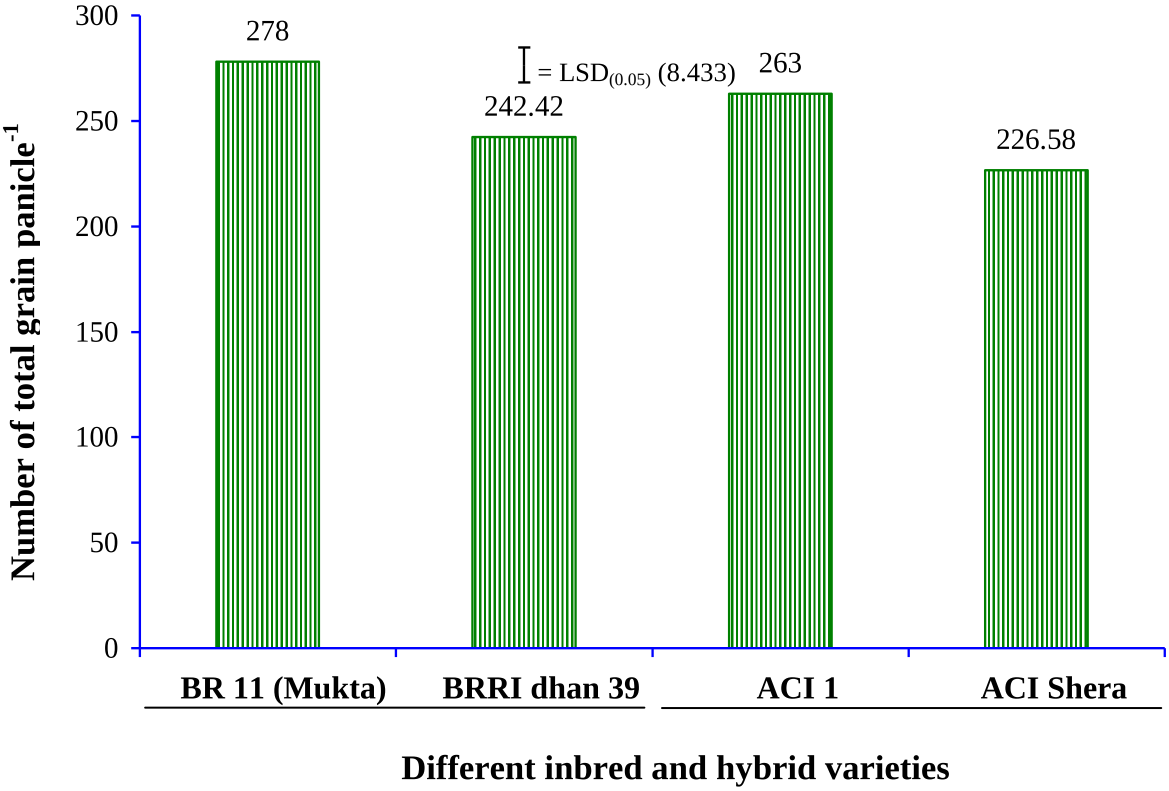


Fig. 1. Effect of different inbred and hybrid varieties on number of total grain panicle^{-1}. Vertical bar represent LSD at 5% level of probability

4.2.3.2 Effect of transplanting date

The total number of grains panicle^{-1} was significantly affected by the different transplanting time (Appendix VIII). The maximum number of total grains panicle^{-1} (272.17) was obtained from the 4th August transplanting that was closely followed by 20th July transplanting (258.92) and the lowest number of grains panicle^{-1} (233.17) was recorded from 3rd September transplanting (Fig. 2). These results are similar to that of Akram *et al*. (2007); Kameswara and Jackson (1997) who reported that number of kernels per panicle were significantly affected as sowing date is delayed. However these results are contrary to that of Habibullah *et al.* (2007), who reported that sowing date had no significant effect on number of grains per panicle.

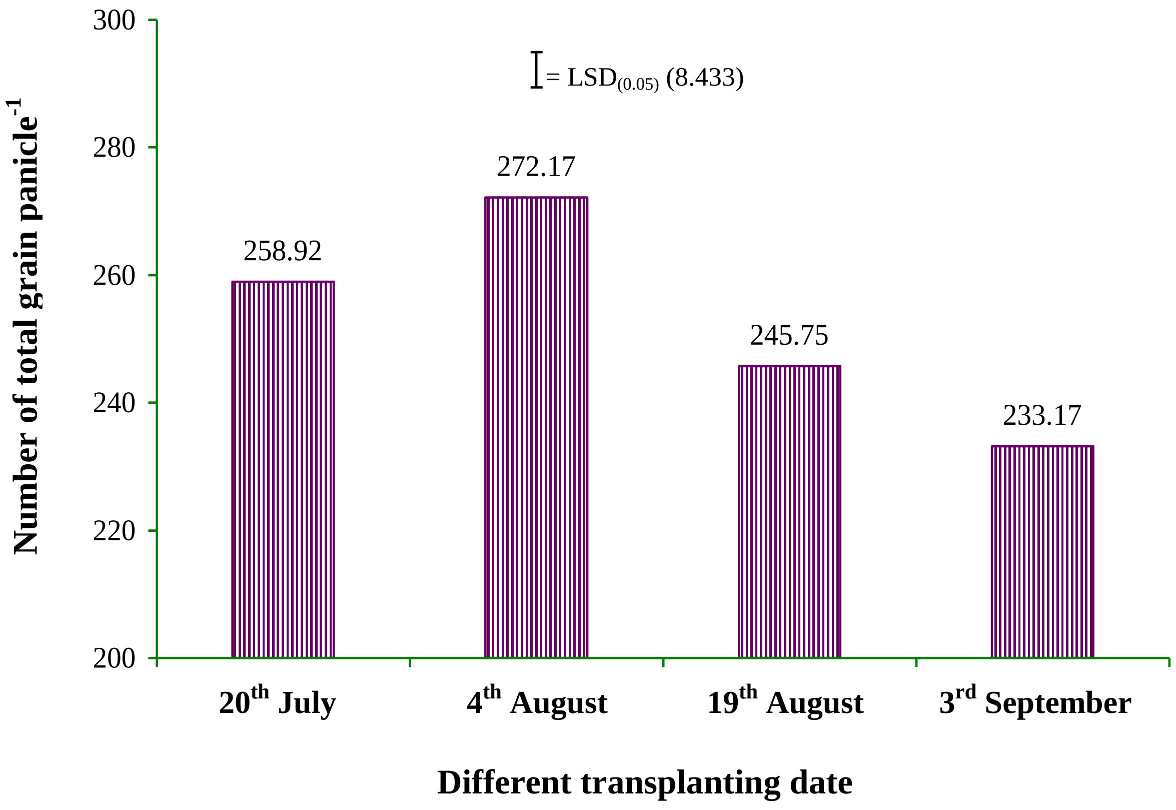


Fig. 2. Effect of different transplanting date on number of total grain panicle^{-1}. Vertical bar represent LSD at 5% level of probability

4.2.3.3 Interaction of varieties and transplanting date

A significant variation was found due to the combined effect of different inbred and hybrid varieties and their various transplanting time at T. *Aman* season (Appendix VIII and Table 19). The maximum number of total grains panicle^{-1} (296.70) was found from the 4th August transplanting of the high yielding inbred variety BR11 which was closely followed (282.30) by the similar variety at 20th July transplanting. However, the minimum number of total grains panicle^{-1} (205.30) was obtained from 3rd September transplanting of the hybrid variety ACI Shera. Similar variety also produced the more or less similar (218.0) results by the 19 August transplanting and 3rd September transplanting of BRRI dhan39 also produced the statistically same results (219.70).

4.2.4 Panicle length (cm)

4.2.4.1 Effect of variety

Length of panicle showed significant variation due to the effect of high yielding inbred and hybrid variety of aman rice at T. *Aman* season (Appendix VII). Among the high yielding inbred and hybrid varieties, high yielding BR11 (Mukta) produced the longest (27.48 cm) and hybrid variety ACI Shera gave the shortest (25.41 cm) panicle. However, the length of panicle was taken from the inbred variety BRRI dhan39, 25.89 cm and hybrid variety ACI 1 26.92 cm (Fig. 3). This variation of the length of panicle might be due to the genetic make-up or characteristics of the varieties which findings was similar with the Babiker (1986). Who observed that panicle length differed due to the varietal variation.

4.2.4.2 Effect of transplanting date

Length of panicle did not vary significantly due to the effect of different transplanting time (Appendix VII). The longest (26.88 cm) and shortest (25.99 cm) panicle were observed from 4th August and 3rd September transplanting, respectively.(Fig. 4).

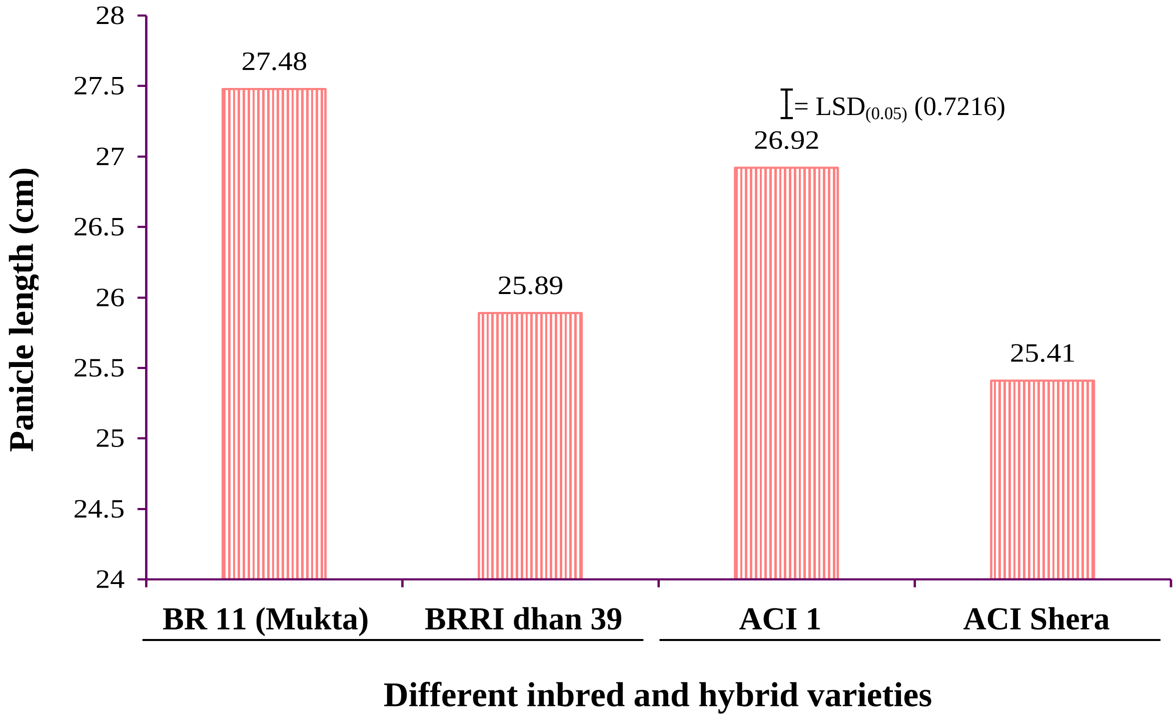


Fig. 3. Effect of different inbred and hybrid varieties on panicle length (cm). Vertical bar represent LSD at 5% level of probability

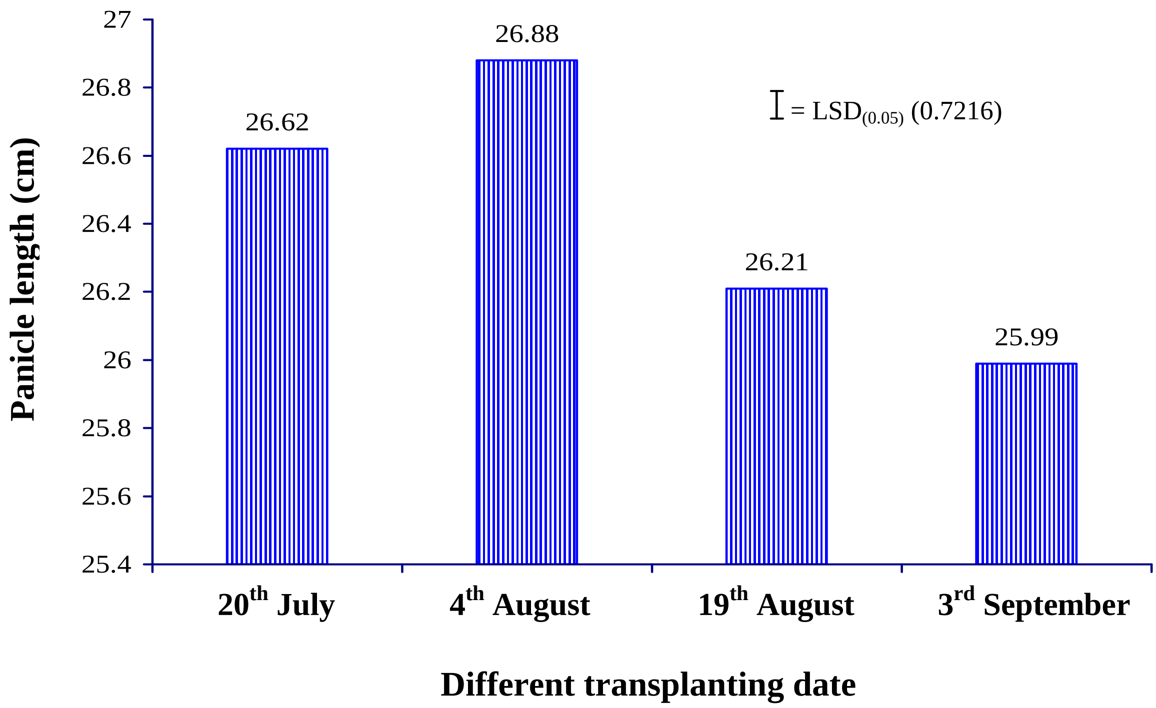


Fig. 4. Effect of different transplanting date on panicle length (cm). Vertical bar represent LSD at 5% level of probability

4.2.4.3 Interaction of varieties and transplanting date

Panicle length was not significant difference due to the combined effect of different inbred and hybrid varieties at different days of transplanting (Appendix VIII) and the results were also present in Table 19. where BR11(Mukta) produced the longest (28.26 cm) panicle at 4th August transplanting and it was followed by the hybrid variety ACI 1 (27.77 cm) at 4th August transplanting where 3rd September transplanting of hybrid variety ACI Shera showed the shortest (24.83 cm) panicle.

4.2.5 Number of filled grains panicle^{-1}

4.2.5.1 Effect of variety

Number of filled grains panicle^{-1} differed significantly due to the effect of different inbred and hybrid variety (Appendix VIII). The maximum number of fertile/filled grains panicle^{-1} (234.25) was obtained from the inbred variety BR11(Mukta) followed by the hybrid variety ACI 1 (224.33) where the minimum number of fertile/filled grains panicle^{-1} (196.25) was found from the hybrid variety ACI Shera (Fig. 5).

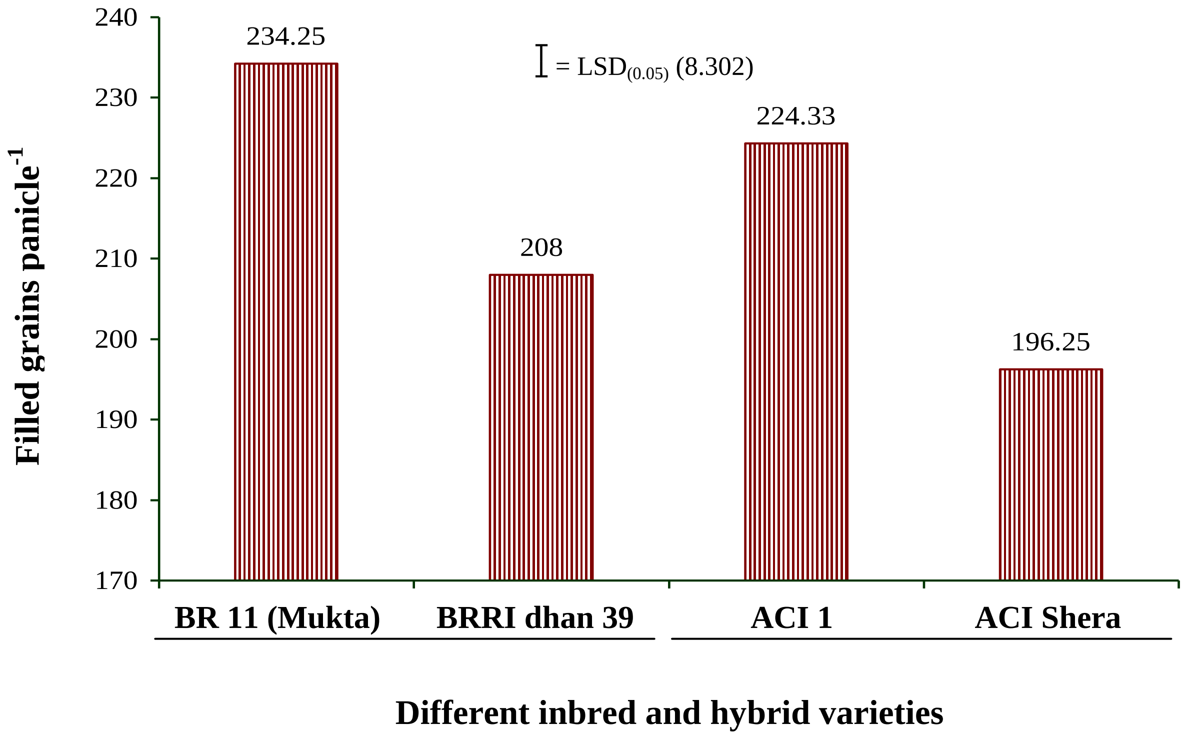


Fig. 5. Effect of different inbred and hybrid varieties on filled grains panicle^{-1}. Vertical bar represent LSD at 5% level of probability

4.2.5.2 Effect of transplanting date

Different transplanting date of T. *Aman* season showed significant variation in respect of filled grains panicle^{-1} (Appendix VIII). The significant variation data was also present in Fig. 6 where the maximum filled grains panicle^{-1} (227.00) was recorded at 4th August transplanting and the lowest filled grains panicle^{-1} (205.33) was found at 3rd September transplanting(Fig 6).

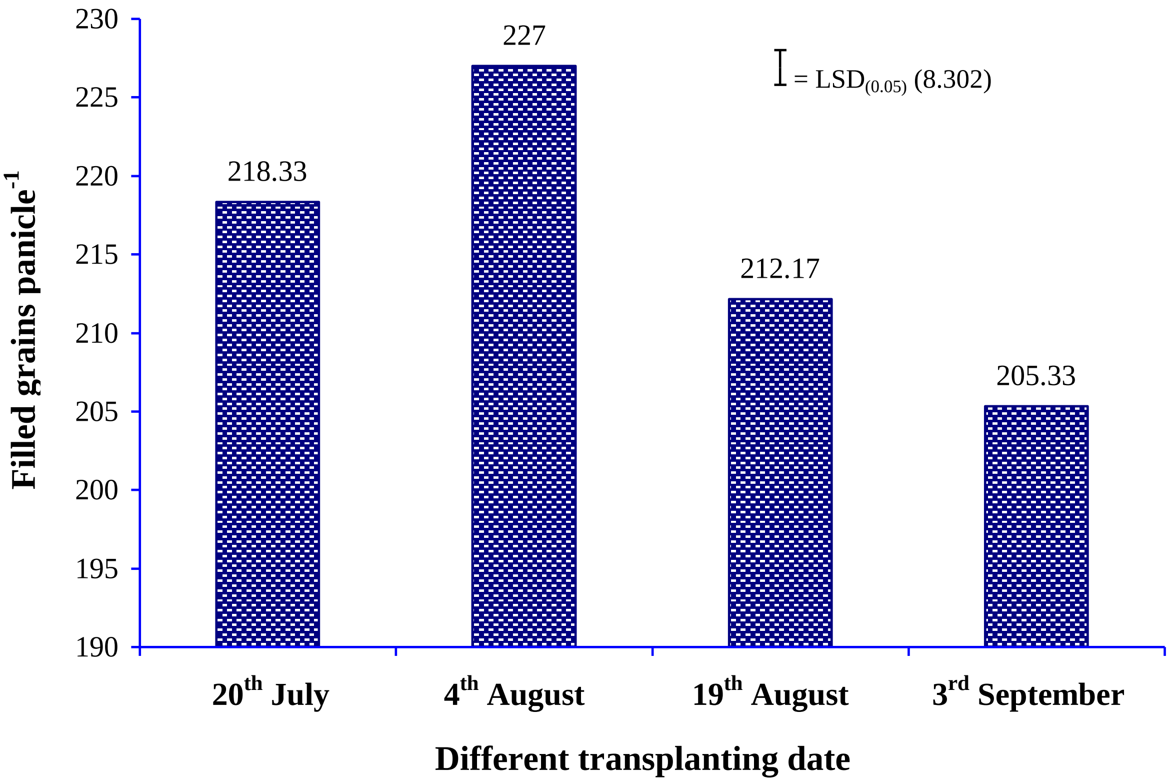


Fig. 6. Effect of different transplanting date on filled grains panicle^{-1}. Vertical bar represent LSD at 5% level of probability

4.2.5.3 Interaction of varieties and transplanting date

A highly significant difference was found due to the effect between the inbred and hybrid varieties with their transplanting date of T. *Aman* season on fertile/filled grains panicle^{-1} (Appendix VIII and Table 19). From the Table 19, the maximum number of fertile/filled grains panicle^{-1} (244.70) was obtained at 4th August transplanting of inbred variety BR11 (Mukta) whereas it was closely followed by the similar variety at 20th July transplanting (235.70). However, hybrid variety ACI Shera produced the minimum number of fertile/filled grains panicle^{-1} (183.00) at 3rd September transplanting (Table 19).

4.2.6 Number of sterile/unfilled grains panicle^{-1}

4.2.6.1 Effect of variety

The unfilled grains panicle^{-1} was significantly differed between the high yielding inbred and hybrid variety (Appendix VIII). The maximum number of unfilled grains panicle^{-1} (43.75) was recorded from the inbred variety BR11 (Mukta) and it the minimum number of unfilled grains panicle^{-1} (30.33) was found from the hybrid variety ACI Shera (Fig. 7).

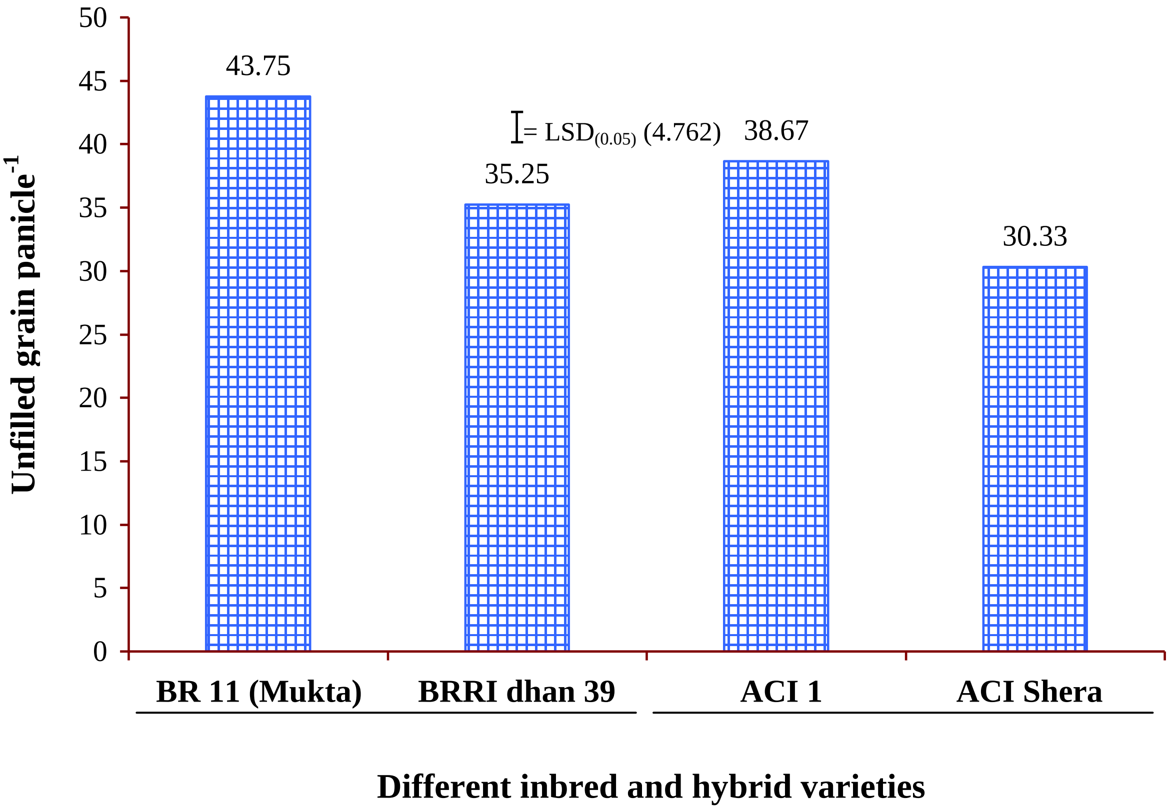


Fig. 7. Effect of different inbred and hybrid varieties on unfilled grain panicle^{-1}. Vertical bar represent LSD at 5% level of probability

4.2.6.2 Effect of transplanting date

A highly significant variance was found due to the effect of different transplanting time. Analysis of variance data was present in Appendix VIII and the variation result was also present in Fig. 8. Among the transplanting date, 4th August produced the maximum number of unfilled grain panicle (46.00) and 3rd September showed the minimum number of unfilled grain panicle (27.83).

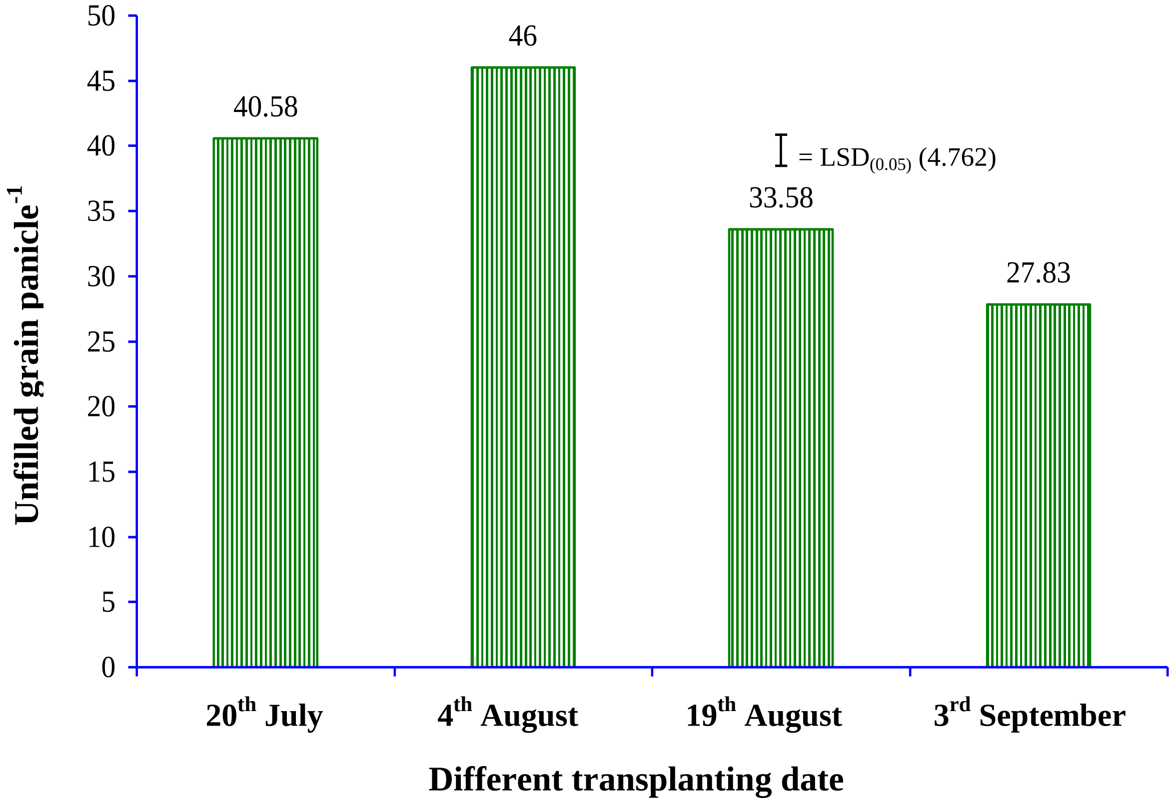


Fig. 8. Effect of different transplanting date on unfilled grain panicle^{-1}. Vertical bar represent LSD at 5% level of probability

4.2.6.3 Interaction of varieties and transplanting date

Unfilled grains panicle^{-1} showed significant variation due to the combined effect of different inbred and hybrid variety with their different transplanting time at T. *Aman* season (Appendix VIII). The maximum (52.00) number of unfilled grains panicle^{-1} was obtained from the inbred variety BR11 (Mukta) at 4th August transplanting which was closely followed by the similar inbred variety at 20th July transplanting. On the other hand, the minimum (22.33) number of unfilled grains panicle^{-1} was observed from the hybrid variety ACI Shera at 3rd September transplanting (Table 19).

Table 19: Interaction of varieties and transplanting date on filled and unfilled grains panicle^{-1}

Variety × Treatments	Number of total grain panicle^{-1}	Panicle length (cm)	Fertile/filled grain panicle^{-1}	Sterile/unfilled grain panicle^{-1}
V_1T_1	282.3	27.65	235.0	47.33
V_1T_2	296.7	28.26	244.7	52.00
V_1T_3	271.7	27.07	230.3	41.33
V_1T_4	261.3	26.93	227.0	34.33
V_2T_1	250.3	26.43	212.0	38.33
V_2T_2	263.3	25.23	220.3	46.33
V_2T_3	236.3	26.07	205.3	31.00
V_2T_4	219.7	25.84	194.3	25.33
V_3T_1	268.0	26.94	225.3	42.67
V_3T_2	280.7	27.77	234.0	46.67
V_3T_3	257.0	26.61	221.0	36.00
V_3T_4	246.3	26.37	217.0	29.33
V_4T_1	235.0	25.45	201.0	34.00
V_4T_2	248.0	26.28	209.0	39.00
V_4T_3	218.0	25.10	192.0	26.00
V_4T_4	205.3	24.83	183.0	22.33
$LSD_{0.05)}$	16.87	1.443	**16.60**	**9.525**
CV (%)	4.01	3.28	**4.62**	**15.44**

V_1= BR11(Mukta), V_2= BRRI dhan39 V_3= ACI 1; V_4= ACI Shera

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.3.1 Weight of 1000- grains (g)

4.3.1.1 Effect of variety

The weight of 1000-grains was significantly influenced by the effect of variety at 5% level of probability (Appendix VIII and Table 20). Among the inbred and hybrid varieties, high yield characteristics inbred variety BR11(Mukta) produced the highest 1000-grains weight (27.47 g) which was statistically more or less similar results with the hybrid variety ACI 1 (26.47 g). Similarly, the lowest 1000-grains weight (23.05 g) was obtained from the hybrid variety ACI Shera (Table 20). These differences results of inbred and hybrid rice genotypes on 1000-grains weight might be due to the genetic constituents.

4.2.4.2 Effect of transplanting date

A significant variation was also found on weight of 1000-grains weight due to the effect of different transplanting time of T. *Aman* season (Appendix VIII and Table 21). Among the different transplanting date of T. *Aman* season, 4^{th} August transplanting (T_2) gave the highest weight of 1000-grains weight (27.69 g) where 3^{rd} September produced the lowest weight of 1000-grains (22.74 g). All the remaining treatment, the second highest 1000-grains weight (26.52 g) was recorded from 20^{th} July transplanting (T^1) which was statistically similar to T_2 (4^{th} August transplanting) (Table 21). This indicated that the environmental conditions like temperature, humidity was most favorable for grain development during 4^{th} August as compared to other sowing dates. Similar findings have been reported by Biswas and Salokhe (2001). These results are in line with that of Tari *et al.* (2007) and they reported that effect of sowing date on 1000-kernel weight (g) was significant at 0.01 probability level.

4.2.4.3 Interaction of varieties and transplanting date

Combined effect of different inbred and hybrid varieties with their different transplanting data at T. *Aman* season was found significant variation in respect of weight of 1000-grains (Appendix VIII and Table 22). Among the genotypes, high yielding inbred varieties BR11 (Mukta) produced the highest 1000-grains weight (29.82 g) at 4^{th} August transplanting which was closely followed by the similar variety with 20^{th} July transplanting (V_1T_1) (28.61 g) and 4^{th} August transplanting of hybrid variety ACI 1 (V_3T_2) (28.81 g) where V_1T_1 and V_3T_2 were statistically more or less similar (Table 22).

4.3 Yield Characters

4.3.2 Grain yield (t ha^{-1})

4.3.1.1 Effect of variety

Grain yield was significantly influenced by the different inbred and hybrid variety (Appendix VIII and Table 20) where the highest grain yield (6.30 t ha^{-1}) was found from the BRRI released high yielding inbred variety BR11(Mukta) if so, hybrid variety ACI 1 also produced the statistically more or less similar results (5.36 t ha^{-1}). However the lowest grain yield (4.42 t ha^{-1}) was obtained from the hybrid variety ACI Shera. The high yielding inbred variety was better than hybrid variety in respect of grain yield because of the inbred variety produced the maximum productive tiller and filled grains compare to hybrid variety. As a result, more productive tiller and field grain ensure the more grain yield.

4.2.4.2 Effect of transplanting date

Different transplanting time of T. *Aman* season did not vary significant variation in respect of grain yield (Appendix VIII and table 21). Among the treatment of transplanting date, 4th August transplanting gave the highest grain yield (5.52 t ha^{-1}) and the lowest train yield (5.14). As a result, transplanting date effect did not vary on grain yield in case of favourable environmental was all transplanting period which will make sure the more or less same grain yield. The decreasing trend in the grain yield in delayed seeding might be associated with significantly lower number of productive tillers m-2, less number of filled grains/panicle and low 1000-grain weight. The higher paddy yield was attributed to more number of productive tillers, more number of kernels per panicle and increased 1000 grain weight. These results are also in line with the findings of Shah and Bhurer (2005) who reported that June 15 seeding recorded significantly the highest grain yield and decreased with the delay in sowing. Highest paddy yields (4530, 4030 and 4530 kg ha^{-1}) were obtained in early sown rice group (Khakwani *et al.* 2006). These results are in line with that of Iqbal *et al.* (2008) who reported that the highest yield (4-5 t ha^{-1}) was obtained when the rice crop was sown earlier in the season. Similarly, according to Baloch *et al.* (2006) among planting dates, June 20th planted crop gave highest paddy yield.

4.2.4.3 Interaction of varieties and transplanting date

Combined effect between the variety and their transplanting time showed significant variation (Appendix VIII). Significant variation results were also present in Table 22. From the table 22, the highest grain yield (6.57 t ha^{-1}) was obtained from the 4th August transplanting of inbred variety BR11(Mukta) which was closely followed by the same inbred variety at 20th July transplanting (6.42 t ha^{-1}). On the other hand, 3rd September transplanting of hybrid variety ACI Shera gave the lowest grain yield (4.30 g ha^{-1}). Productions of any crops directly related on grain yield in case of more grain yield confirm the highest production. More grain yield depends on varietals performance and their sowing date also. So, grains yield an important character for promoting the yield which will make sure the biological yield and harvest index.

4.3.3 Straw yield (t ha^{-1})

4.3.1.1 Effect of variety

Straw yield showed significant variation in case of the main effect of variety (Appendix VIII and Table 20). The highest yield of straw (7.24 t ha^{-1}) was obtained from the inbred variety BR11(Mukta) where the lowest straw yield (4.84 t ha^{-1}) was found from the hybrid variety ACI Shera. However, the second highest of straw yield (5.99 t ha^{-1}) was taken from the hybrid variety ACI 1 which was statistically similar result with the inbred variety BRRI Dhan39 (5.85) (Table 20). Inbred varieties produced the maximum yield of straw to compare hybrid varieties. This might be due to the highest plant height and higher number of tillers $hill^{-1}$ of the inbred variety than the hybrid one. Akbar (2010) reported that inbred variety produced higher straw yield than the hybrid varieties.

4.2.4.2 Effect of transplanting date

A highly significant variation was found on straw yield due to the effect of different transplanting date (Appendix VIII). The result on straw yield data was present in table 21 where the highest straw yield (6.34 t ha^{-1}) was obtained from 4th August transplanting and the lowest straw yield (5.72 t ha^{-1}) was taken from 3rd September transplanting. Among the transplanting date, transplanting date at 19th August (5.85 t ha^{-1}) and 3rd September (5.72 t ha^{-1}) were statistically similar.

4.2.4.3 Interaction of varieties and transplanting date

Combined effect of different varieties and their transplanting date showed significant variation in respect of straw yield (Appendix VIII and Table 22). The highest straw yield (7.68 t ha^{-1}) was obtained from the 4th August transplanting of inbred variety BR11(Mukta) which was statistically similar to 20th July transplanting of the similar variety (7.33 t ha^{-1}). However, the lowest straw yield (4.65 t ha^{-1}) was taken from the hybrid variety ACI Shera at 3rd September transplanting.

4.3.4 Biological yield (t ha^{-1})

4.3.1.1 Effect of variety

Main effect of different inbred and hybrid varieties in respect of biological yield showed significant variation at 5% level of probability (Appendix VIII and Table 20). Among the inbred and hybrid varieties, inbred variety BR11(Mukta) produced the highest biological yield (13.54 t ha^{-1}) and the lowest biological yield (9.26 t ha^{-1}) was noticed from the hybrid variety ACI Shera. Inbred variety BR11(Mukta) produced the maximum number of effective tillers and filled grains which make sure the more biological yield as well as the highest harvest index. This results are supported by the Rahman (2001) who reported that inbred variety BR11 (Mukta) produced the maximum biological yield to compare with hybrid variety Sonarbangla-1. This result also supported with Singh and Gangwer (1989).

Table 20: Effect of variety on different yield characters

Variety	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
V_1	27.47	6.30	7.24	13.54
V_2	24.34	5.22	5.85	11.03
V_3	26.46	5.36	5.99	11.34
V_4	23.05	4.42	4.84	9.26
$LSD_{0.05)}$	**0.421**	**0.4177**	**0.4169**	**0.8511**
CV (%)	**8.37**	**9.41**	**8.35**	**9.04**

V_1= BR11 (MUKTA), V_2= BRRI dhan39; V_3= ACI 1; V_4= ACI Shera

4.2.4.2 Effect of transplanting date

Main effect of different transplanting date at T. *Aman* rice did not vary significant variation on biological yield (Appendix VIII). The highest biological yield (11.82 t ha^{-1}) was found at 4th August transplanting which was closely followed by 20th July transplanting (11.39 t ha^{-1}). However, the lowest biological yield (10.87 t ha^{-1}) was recorded from the 3rd September transplanting. These results indicted that the effect of different date of transplanting at T. *Aman* season was favourable on environment to make sure the similar yield of grains and straw as well as biological yield (Table 21).

Table 21: Main effect of transplanting date on different yield characters

Treatments	1000 grain weight (g)	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Biological yield (tha^{-1})
T_1	5.381	5.38	6.01	11.39
T_2	5.516	5.52	6.34	11.82
T_3	5.255	5.26	5.85	11.10
T_4	5.142	5.14	5.72	10.87
$LSD_{0.05)}$	**0.421**	**0.418**	**0.417**	**0.851**
CV (%)	**8.37**	**9.41**	**8.35**	**9.04**

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.2.4. Interaction of varieties and transplanting date

Combined effect between the varieties and different transplanting time at T. *Aman* season showed significant variation on biological yield (Appendix VIII). Significant variation results were also found in Table 22 where the highest biological yield (14.25 t ha^{-1}) was recorded from the inbred variety BR11(Mukta) at 4th August transplanting which was closely followed by the same inbred variety at 20th July transplanting (13.75 t ha^{-1}). However, the lowest biological yield (8.95 t ha^{-1}) was taken from the hybrid variety ACI Shera at 3rd September transplanting.

Table 22: Combined effect of varieties and different transplanting date on different yield characters

Variety × Treatments	1000 grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)
V_1T_1	28.61	6.417	7.333	13.75
V_1T_2	29.82	6.573	7.680	14.25
V_1T_3	26.49	6.163	7.047	13.21
V_1T_4	24.98	6.033	6.907	12.94
V_2T_1	25.49	5.233	5.837	11.06
V_2T_2	26.67	5.340	6.133	11.34
V_2T_3	23.38	5.203	5.773	10.98
V_2T_4	21.82	5.100	5.653	10.75
V_3T_1	27.61	5.433	6.037	11.47
V_3T_2	28.81	5.600	6.397	12.00
V_3T_3	25.48	5.260	5.827	11.09
V_3T_4	23.97	5.133	5.690	10.82
V_4T_1	24.38	4.440	4.830	9.270
V_4T_2	25.46	4.550	5.130	9.680
V_4T_3	22.17	4.393	4.747	9.140
V_4T_4	20.20	4.300	4.647	8.947
$LSD_{0.05)}$	**3.537**	**0.8354**	**0.8338**	**1.702**
CV (%)	**8.37**	**9.41**	**8.35**	**9.04**

V_1= BR11 (Mukta), V_2= BRRI dhan39 V_3= ACI 1; V_4= ACI Shera

T_1= 20th July (1st transplanting) T_2= 4th August (2nd transplanting)
T_3= 19th August (3rd transplanting) T_4= 3rd September (4th transplanting)

4.3.5 Harvest index (%)

4.3.1.1 Effect of variety

The data regarding the harvest index did not vary significant due to the effect of different inbred and hybrid varieties (Appendix VIII and Fig. 9). The data range of harvest index was 46.72 to 47.39% which indicate that the varietals affect on harvest index with each others are statistically more or less similar. If so, the highest harvest index 47.39% was noticed from the hybrid variety ACI Shera and the lowest harvest index 46.72% was found from the inbred variety BR11(Mukta). But they and other variety were statistically similar in case they did not show any significant variation (Fig. 9).

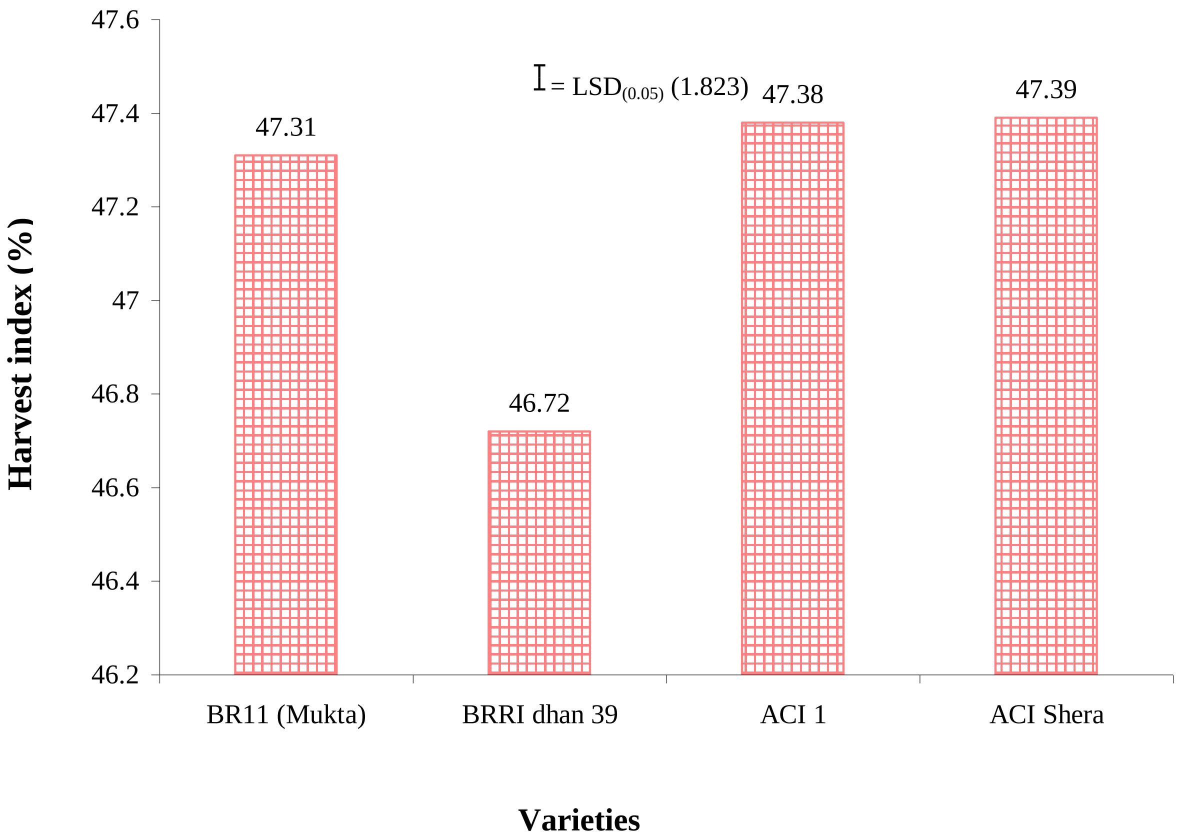


Fig. 9. Effect of variety on harvest index (%). Vertical bar represent LSD at 5% level of probability

4.2.4.2 Effect of transplanting date

The data regarding the harvest index (%) are given in Figure 10 where the harvest index range was 46.517 to 47.755%. It is observed from Fig. 10 that all the treatments results are closest with each in that case the harvest index (%) did not affect significantly by different transplanting dates. The crop sown on 3rd September produced the highest (47.755%) harvest index where 20th July (T_1) gave the lowest harvest index 46.517%.

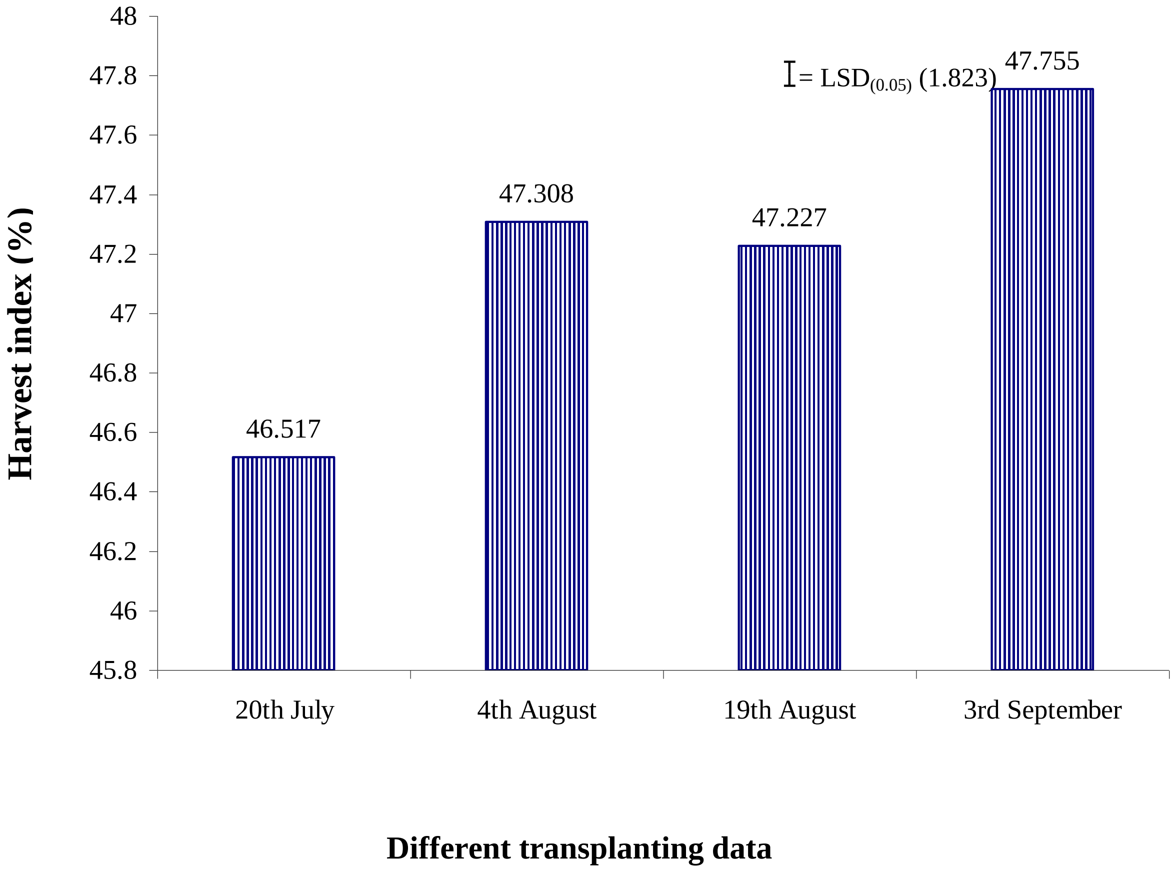


Fig. 10. Effect of different transplanting date on harvest index (%). Vertical bar represent LSD at 5% level of probability

4.2.4. Interaction of varieties and transplanting date

Harvest index did not vary significantly due to the combined effect of different inbred and hybrid varieties with their transplanting date (Appendix VIII and Fig. 11). The harvest index range was 46.13 to 48.06% where the highest harvest index was found from the hybrid variety ACI Shera at both 19th August and 3rd September transplanting and the lowest harvest index was recorded from the inbred variety BR11(Mukta) at 4th August transplanting.

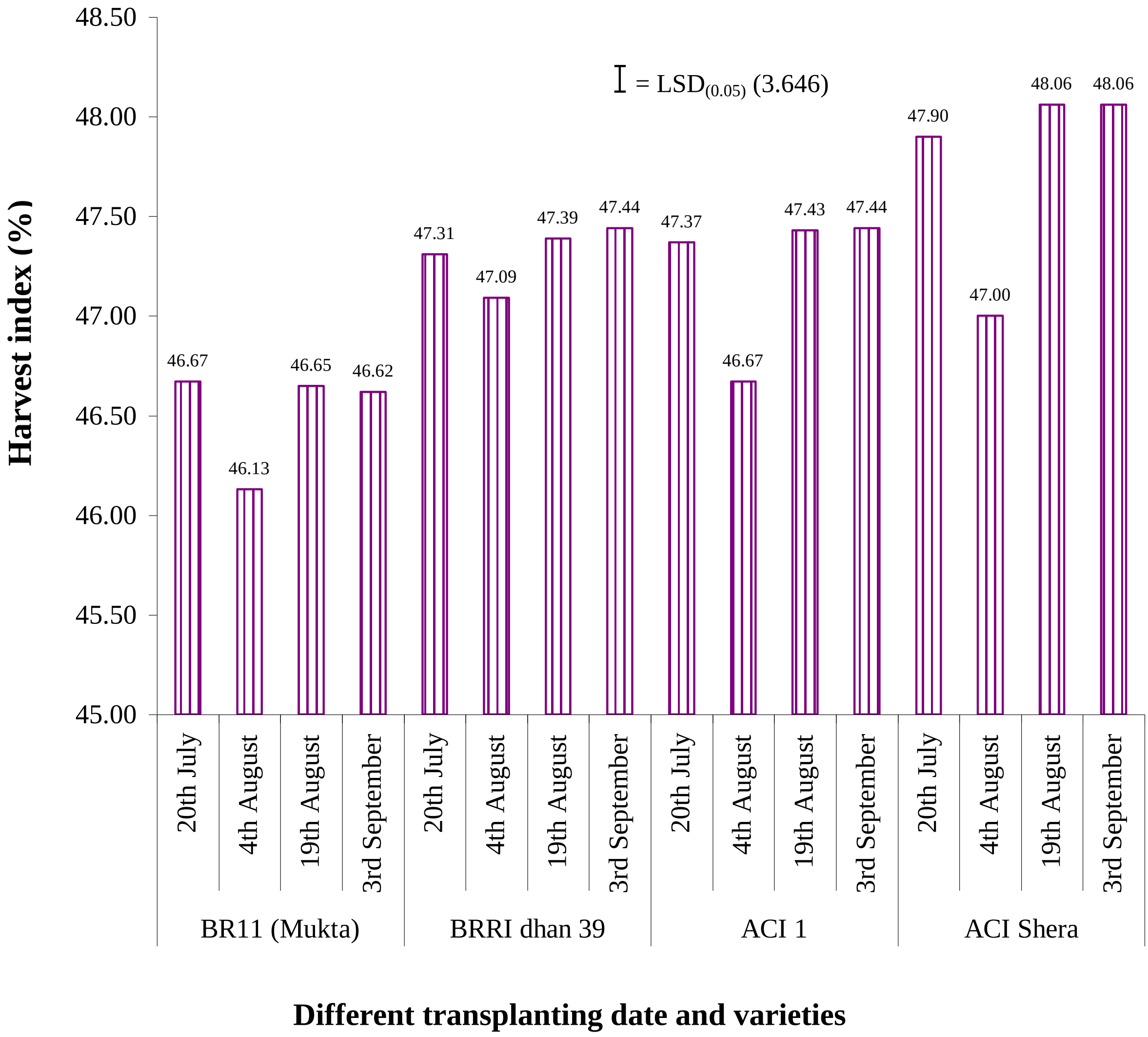


Fig. 11. Combined effect of varieties and different transplanting date on harvest index (%). Vertical bar represent LSD at 5% level of probability

CHAPTER V

SUMMARY AND CONCLUSION

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The present study was conducted at Experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from June, 2010 to February, 2011 to assess the growth yield performance effect of different inbred and hybrid rice varieties with different transplanting time.The experiment compared with two different group of rice genotypes viz. high yielding inbred (BR11 and BRRI Dhan39) and hybrid (ACI 1 and ACI Shera) varieties which were collected from BRRI and ACI Seed Ltd. with different transplanting date viz. T_1: 20th July, T_2: 4th August, T_3: 19th August and T_4: 3rd September on growth and yield performance. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Effect of variety showed significant difference on the whole morphological and yield characteristics except harvest index.Inbred variety BR11(Mukta) (V_1) showed the better performance on morphological and yield contributing characteristics comparison to another inbred and hybrid varieties.ACI 1 showed the best result in respect of leaf area index (1.62) at 15 DAT whereas, lowest (1.30) was observed with hybrid variety ACI Shera.Hybrid variety ACI Shera (V_4) showed the poor performance at every stage of data recording. Plant height was the maximum (108.33 cm) and the minimum (91.17 cm) at 90 DAT which were obtained from BR11(Mukta) and ACI Shera, respectively. At 75 DAT the inbred variety BR11(Mukta) produced the highest number of total tillers hill^{-1} (39.08) and leaf are index (8.65) whereas the lowest results (31.75 and 7.25, respectively) was found from ACI Shera.

Total dry matter weight was the highest (1859.33 gm $^{-2}$) at harvest from the variety BR11(Mukta) and the lowest (1751.25 gm $^{-2}$) was found from ACI Shera.The minimum days was required for BR11(Mukta) to flowering (88.92 days) and maturity (119.17 days) whereas, the maximum number of effective tillers m $^{-2}$ (424.08) and non effective tillers m^{-2} (24.92) were found from the similar variety (V_1). Inbred variety BR11(Mukta) also produced the better results on number of total grain panicle^{-1} (278.0), panicle length (27.48 cm), filled grain (234.25), unfilled grain (43.75), 1000-seed yield (27.47 g), grain yield (6.30 t ha^{-1}), straw yield (7.24 t ha^{-1}), Biological yield (13.54 t ha^{-1}) and harvest index (47.31%) whereas, the lower results were obtained from the hybrid variety ACI

Shera (226.58, 24.41 cm, 196.25, 30.33, 23.05 g, 4.42 t ha^{-1}, 4.84 t ha^{-1}, 9.26 t ha^{-1} and 47.39%, respectively).

Different transplanting date on panicle length, grain yield, biological yield and harvest index did not show significant variation whereas, all othet chracters showed significant difference.Transplanting at 4th August (T_2) produced the superior results on morphological, yield contributing and yield characters than any another transplanting date whereas, the maximum plant height (106.33 cm) and highest dry weight (1906.33 gm $^{-2}$) were recorded at 90 DAT and at harvest respectively. The shortest plant height (22.08 cm) and lowest dry weight (128.33gm $^{-2}$) were recorded at 3rd September transplanting at 15 DAT. At 75 DAT, the maximum tillers m^{-2} (37.0) and leaf area index (8.32) were found at 4th August transplanting whereas 15 DAT produced the minimum tillers m^{-2} (2.83) and leaf area index (1.22) at 3rd September transplanting. Similarly, 4th August transplanting took the minimum days for flowering (90.33 days) and maturity (120.00 days) whereas, the maximum time for flowering (99.50 days) and maturity (130.83 days) was recorded at 3rd September transplanting. However, the maximum number of effective tillers m^{-2} (405.88) and non effective tillers m^{-2} (27.67) were found at 4th August transplanting (T_2). Similar treatment (T_2) also produced the highest number of total grain $panicle^{-1}$ (272.17), panicle length (26.88 cm), filled grain (227.00), unfilled grain (46.00), 1000-seed weight (27.69 g), grain yield (5.52 t ha^{-1}), straw yield (6.34 t ha^{-1}) and Biological yield (11.82 t ha^{-1}) whereas the lowest were also found at 3rd September transplanting (233.17, 25.99 cm, 205.33, 27.83, 22.74 g, 5.14 t ha^{-1},5.72 t ha^{-1} and 10.87 t ha^{-1}, respectively).Highest harvest index (47.75%) was found at 3rd September transplanting but lowest HI (46.51%) was observed at 20 July transplanting.

Combination effect of different inbred and hybrid varieties and their transplanting dates showed significant variation except number of total tillers m^{-2} at 90 DAT, leaf area index at 15 and 30 DAT, number of effective and non effective tillers m^{-2}, panicle length at harvest.Among the interaction effect, inbred variety BR11(Mukta) at 4th August transplanting showed the superior performance in all respect.At 90 DAT, the tallest plant (115.30 cm) was found from the BR11(Mukta) at 4th August transplanting whereas 15 DAT showed the shortest plant (20.67 cm) at 3rd September transplanting of hybrid variety ACI Shera.The maximum number of total tillers m^{-2} (42.0) and leaf area index

(9.10) were obtained from 4th August transplanting with BR11(Mukta) at 75 DAT whereas the minimum (2.33 and 1.08, respectively) was obtained from the hybrid variety ACI Shera at 3rd September transplanting at 15 DAT. At harvest, inbred variety BR11 (Mukta) also produced the maximum dry weight (1959 gm $^{-2}$) at 4th August transplanting whereas the minimum (74.33gm $^{-2}$) was recorded from ACI Shera at 3rd September transplanting at 30 DAT. Inbred variety BR11(Mukta) took minimum time for flowering (84.33 days) and maturity (114.0 days) at 4th August transplanting and ACI Shera at 3rd September required the maximum time (105.0 and 139.30 days, respectively). Among the varieties, inbred variety BR11(Mukta) also performed best results on number of effective tillers m^{-2}, non effective tillers m^{-2}, number of total grain panicle^{-1}, panicle length, filled grain, unfilled grain, 1000-seed yield, grain yield, straw yield and biological yield (502.7, 31.67, 296.70, 28.26 cm, 244.70, 52.00, 29.82 g, 6.57 t ha^{-1}, 7.68 t ha^{-1} and 14.25 t ha^{-1}, respectively) at 4th August transplanting whereas the lowest (205.0, 10.67, 205.30, 24.83 cm, 192.0, 26.00, 22.17 g, 4.30 t ha^{-1}, 4.65 t ha^{-1} and 8.95 t ha^{-1}, respectively).

From the above results it could be concluded that the high yielding inbred variety BR11(Mukta) at 4th August transplanting individually and also their combination effect produced the better results than other varieties and transplanting dates in respect of morpho-physiological and yield contributing characters of assigned inbred and hybrid rice genotypes. Considering the above observation 4th August transplanting date ensured maximum growth and yield with the inbred variety BR11(Mukta) in T.*Aman* season. So in this study 4th August transplanting for BR11(Mukta) was found optimum transplanting time for maximum yield in T.*Aman* season. Therefore, This type of research work may be repeated to confirm this results with more number of varieties treatments on the different AEZ of the Bangladesh.

CHAPTER VI

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REFERENCES

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CHAPTER VII

APPENDICES

APPENDICES

Appendix I: Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological and chemical characteristics of the experimental field

Lab No.	Sample No	pH effect	Organic matter (%)	Total Nitrogen (%)	Potassium mM 100 g^{-1} soil	Phosphorus	Ghondok	Boron	Tama	Iron	Dosta
						μg g^{-1} soil					
14058	T_0	5.3	1.21	0.061	0.11	19.3	3.38	0.11	2.4	266	2.3
		MA	Low	OL	Low	P	OL	OL	OH	OH	OH
14059	T_1	4.9	0.94	0.047	0.19	29.0	24.46	2.20	2.4	294	17.2
		LA	OL	OL	Medium	OH	P	OH	OH	OH	OH
14060	T_2	5.6	1.28	0.064	0.15	23.6	7.46	0.17	2.4	318	5.3
		LA	Low	OL	Low	High	OL	Low	OH	OH	OH
14061	T_3	6.0	0.94	0.047	0.11	19.4	3.95	0.04	2.6	336	4.2
		LA	OL	OL	Low	P	OL	OL	OH	OH	OH
14062	T_4	5.8	0.54	0.027	0.12	20.3	7.33	0.15	2.6	326	4.6
		MA	OL	OL	Low	P	OL	OL	OH	OH	OH
14063	T_5	5.4	1.55	0.078	0.13	21.1	5.50	0.12	2.61	290	4.0
		MA	Low	OL	Low	High	OL	OL	OH	OH	OH
14064	T_6	5.0	1.08	0.054	0.24	40.6	17.56	2.02	2.6	286	8.4
		MA	Low	OL	Medium	OH	Medium	OH	OH	OH	OH
14065	T_7	5.4	0.61	0.031	0.14	24.5	6.81	0.52	2.6	280	14.9
		MA	OL	OL	Low	High	OL	P	OH	OH	OH
14066	T_8	5.4	1.48	0.074	0.13	23.5	13.39	1.73	2.42	292	6.5
		MA	Low	OL	Low	High	Low	OH	OH	OH	OH
14067	T_9	5.3	1.21	0.061	0.15	22.9	12.22	5.90	2.6	282	7.2
		MA	Low	OL	Low	High	Low	OH	OH	OH	OH
14068	Soil	5.3	0.87	0.044	0.19	27.7	24.06	0.22	2.0	1.82	4.6
		MA	OL	OL	Medium	OH	P	Low	OH	OH	OH

MA= More acidity, LA= Less acidity, OL= Over low, L= Low, P= Perfect, OH= Over high

B. Physical properties of the initial soil

Soil sample no.	Soil ** sample	Sand	Silt	Clay
T_0	Silt loam	25.60	53.91	20.49
T_1	Silt loam	26.60	54.00	19.40
T_2	Silt loam	25.67	53.86	20.47
T_3	Silt loam	26.37	54.22	19.41
T_4	Silt loam	26.40	55.12	18.48
T_5	Silt loam	25.96	53.49	20.55
T_6	Silt loam	26.00	54.00	20.00
T_7	Silt loam	26.40	54.17	19.43
T_8	Silt loam	26.38	55.00	18.62
T_9	Silt loam	25.49	54.11	20.40
Soil	Silt loam	25.65	53.84	20.51

Appendix II: Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from October 2010 to March 2011

Date/Week	Air temperature		Relative humidity (%)	Rainfall (mm) (Total)
	Maximum	Minimum		
October, 2010	26.11	18.05	77	19
November, 2010	25.82	16.04	78	00
December, 2010	22.40	13.50	74	00
January, 2011	24.50	12.40	68	00
February, 2011	27.10	16.70	67	30
March, 2011	31.40	19.60	54	11

* Monthly Average

Source: Bangladesh Meteorological Dept (Climate and Weather Division), Agargoan, Dhaka- 1207

Appendix III: Analysis of variance (mean square) for plant height

Source of variation	Degrees of freedom	Mean square on plant height (cm) at					
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Replication	2	105.063	126.646	129.438	165.813	172.313	172.313
Factor A	3	25.076**	54.465**	108.306**	152.972**	304.972**	593.639**
Factor B	3	384.354**	386.188**	388.583**	388.583**	388.583**	388.583**
AB	9	0.169**	0.076**	0.065**	0.065**	0.065**	0.065**
Error	30	1.396	2.001	2.104	4.079	4.579	4.179

Appendix IV: Analysis of variance (mean square) for number of total tillers hill^{-1}

Source of variation	Degrees of freedom	Mean square on number of total tillers hill^{-1} at					
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Replication	2	4.333	6.583	16.333	47.521	49.333	64.021
Factor A	3	2.632**	12.299**	29.965**	73.583**	158.278**	140.139**
Factor B	3	15.299**	15.299**	15.299**	14.472**	35.944**	51.917**
AB	9	0.058**	0.058**	0.058**	0.046**	1.148**	5.083ns
Error	30	0.200	0.183	0.467	2.410	2.533	3.399

Appendix V: Analysis of variance (mean square) for leaf area index (LAI)

Source of variation	Degrees of freedom	Mean square on leaf area index at					
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Replication	2	0.116	0.155	0.124	8.063	7.308	0.072
Factor A	3	0.295**	0.407**	1.278**	6.800**	6.933**	0.407**
Factor B	3	0.996**	1.068**	2.440**	1.054**	1.049**	1.068**
AB	9	0.042ns	0.024ns	0.179**	0.024**	0.022**	0.024**
Error	30	0.029	0.022	0.188	0.067	0.058	0.007

*= Significant at 5% level of probability; **= Significant at 1% level of probability NS=Non Significant

Appendix VI: Analysis of variance (mean square) for dry matter weight

Source of variation	Degrees of freedom	Mean square on total dry matter weight (g) at			
		30 DAT	60 DAT	90 DAT	At harvest
Replication	2	2957.813	15562.750	29242.333	103285.688
Factor A	3	32751.021**	33674.688**	33308.854**	33399.576*
Factor B	3	138594.521**	136739.188**	137130.021**	136920.410**
AB	9	38.391**	19.780**	13.576**	16.095**
Error	30	183.101	1314.306	2529.000	10055.021

Appendix VII: Analysis of variance (mean square) for days to flowering and maturity, panicle length and effective, non effective and total number of tillers m^{-2}

Source of variation	Degrees of freedom	Mean square on				
		Days to flowering	Days to maturity	Panicle length (cm)	Number of effective tiller m^{-2}	Number of non effective tiller m^{-2}
Replication	2	495.146	405.063	0.531	3190.004	8.271
Factor A	3	221.021**	338.188**	10.659**	83266.326**	164.583**
Factor B	3	178.743**	244.854**	1.926ns	34541.621**	420.139**
AB	9	1.132**	4.595**	0.754ns	2813.551ns	0.861ns
Error	30	24.657	23.574	0.749	2582.582	0.782

Appendix VIII: Analysis of variance (mean square) for yield and yield contributing characters

Source of variation	Degrees of freedom	Filled grain	Unfilled grain (g)	1000-seed yield (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Replication	2	1540.646	651.938	49.685	2.620	1.856	10.957	105.390
Factor A	3	3424.917**	383.389**	48.221**	7.095**	11.650**	36.994**	3.145ns
Factor B	3	1018.306**	758.167**	58.280**	0.312ns	0.839*	2.007ns	1.240ns
AB	9	19.583**	3.852**	0.043**	0.017**	0.017**	0.086**	0.076ns
Error	30	99.157	32.626	4.499	0.251	0.250	1.042	4.781

*= Significant at 5% level of probability; **= Significant at 1% level of probability NS=Non Significant

PLATES

Plate 1 : Site View of Experimental Field

Plate 2 : Panicale Initiation stage at Plot

Plate 3 : Harvesting stage at Plot

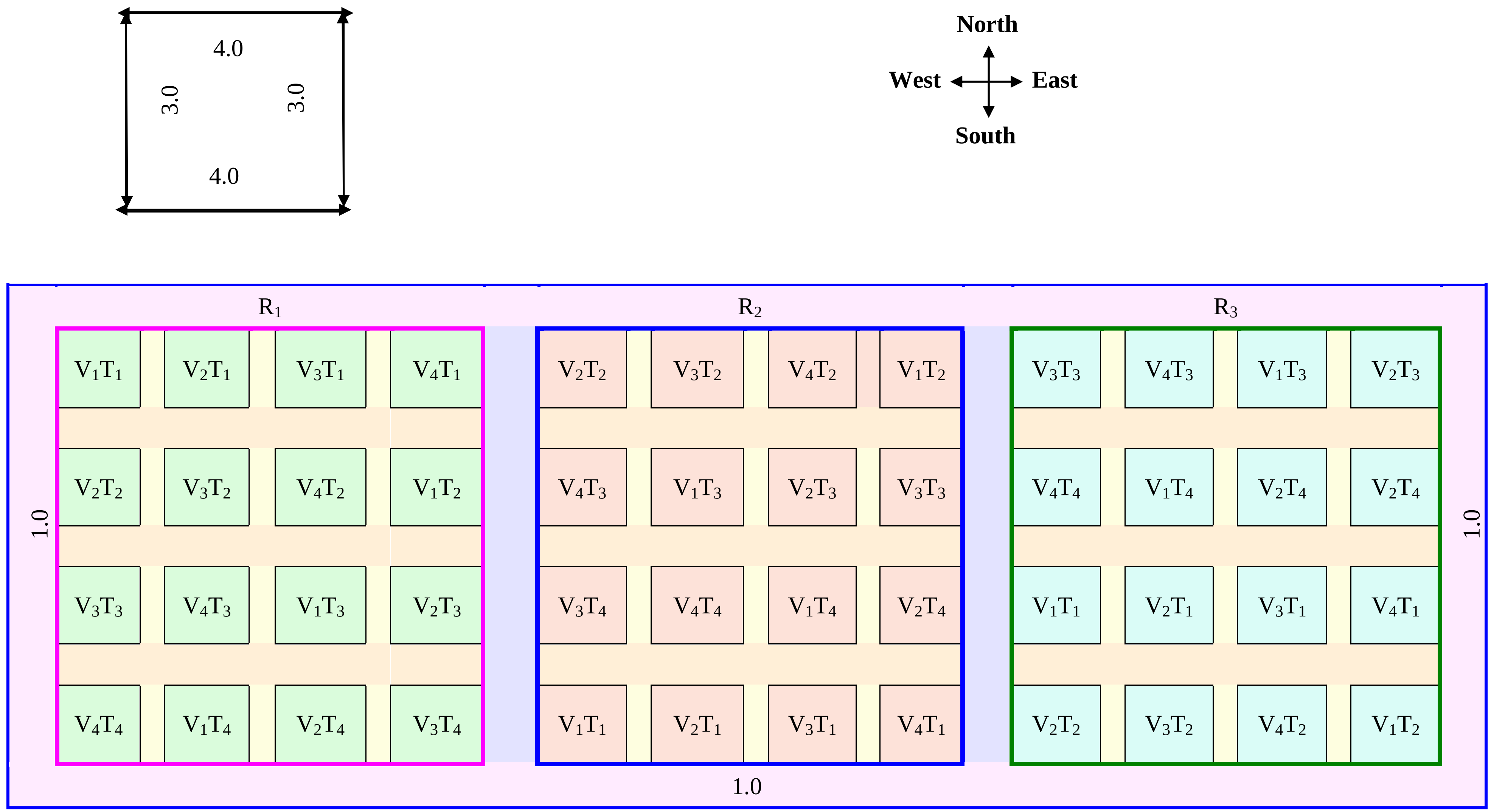

Plate 4: Layout of the experimental plot