EFFECT OF PLANTING TIME ON MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF HYBRID RICE VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of planting time on morpho-physiological and yield attributes of hybrid rice varieties**" submitted to the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of **Master of Science (MS)** in **AGRICULTURAL BOTANY**, embodies the result of a piece of *bonafide* research work carried out by **MOCHA. SABINA KHATUN**, Registration No. **11-04608** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2017

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Dedicated To

My Beloved Parents

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The Author

EFFECT OF PLANTING TIME ON MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF HYBRID RICE VARIETIES

ABSTRACT

The experiment was carried out during the period from October 2016 to May 2017 to find out the effect of planting time on morpho-physiological and yield attributes of hybrid rice varieties at the research field in the department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207. Two planting times *viz.* 15 December and 15 January and five different varieties *viz*. Heera 4, Tia, Aloron, BRRI hybrid 3 and BRRI dhan 29 were used. The experiment was laid out in Randomized Complete Block Design with three replications. Data on different yield contributing characters and yield were recorded. Different varieties showed significant variation on different parameters. Variety, V_1 (Heera 4) showed the best performance on plant height (93.16 cm), number of leaves hill^{-1} (76.80), highest number of tillers hill^{-1} (18.37), dry weight hill^{-1} (9 50.09 g), leaf length (33.97 cm), leaf breadth (1.57 cm), SPAD value (42.93), panicle length (23.75 cm), number of filled grains panicle^{-1} (121.30), grain yield (5.78 t ha^{-1}), straw yield (7.50 t ha^{-1}), biological yield (13.26 t ha^{-1}) and the highest harvest index (43.45%). The planting time, T_1 (Transplanting at 15 December) also provided the highest plant height (98.75 cm), number of leaves hill^{-1} (68.40), number of tillers hill^{-1} (15.13) and dry weight hill^{-1} (49.99 g), leaf length (31.94 cm), leaf breadth (1.49 cm), SPAD value (44.89), panicle length (23.51 cm), number of filled grains panicle^{-1} (121.42), the highest 1000 grain weight (27.12 g), the highest number of grains panicle^{-1} (137.33), the highest grain yield (5.63 t ha^{-1}), the highest straw yield (7.80 t ha^{-1}), biological yield (13.43 t ha^{-1}) and harvest index (41.66%). The combination of planting time, T_1 (Transplanting at 15 December) with variety, V_1 (Heera 4) also showed the best performance on number of tillers hill^{-1} (19.80), dry weight hill^{-1} (54.54 g), leaf length (35.10 cm), leaf breadth (1.58 cm), SPAD value (45.66) and panicle length (24.27 cm), number of filled grains panicle^{-1} (132.20), the highest number of grains panicle^{-1} (144.60), the highest grain yield (6.60 t ha^{-1}), the highest straw yield (8.18 t ha^{-1}), the highest biological yield (14.78 t ha^{-1}) and the highest harvest index (44.65%).

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ABBREVIATIONS AND ACRONYMS

%	=	Percentage
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
Ca	=	Calcium
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan’s Multiple Range Test
e.g.	=	exempli gratia (L), for example
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
GM	=	Geometric mean
i.e.	=	id est (L), that is
K	=	Potassium
Kg	=	Kilogram (s)
L	=	Litre
LSD	=	Least Significant Difference
M.S.	=	Master of Science
m^2	=	Meter squares
mg	=	Milligram
ml	=	Milli litre
NaOH	=	Sodium hydroxide
No.	=	Number
^oC	=	Degree Celsius
P	=	Phosphorus
SAU	=	Sher-e-Bangla Agricultural University
USA	=	United States of America
var.	=	Variety
WHO	=	World Health Organization
μg	=	Microgram

CHAPTER I

INTRODUCTION

Rice is the most important food crop of the world and the staple food of more than 3 billion people of the world's population. Rice is grown in more than a hundred countries with a total harvested area of about 160 million hectares, producing more than 700 million tons every year (IRRI, 2013).

The population of Bangladesh is still growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 57.26 million tons of rice for the year 2020 (BRRI, 2011). To reach the goal, it is necessary either to increase the crop area or to increase yield per unit area. But due to high population pressure, horizontal expansion of land is not possible. Therefore, increasing yield per unit area is the only means. 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, 2016).

In Bangladesh, there are three diverse growing seasons of rice namely, Aus, Aman and Boro. Among different rice groups of Bangladesh boro is the most important that covers an area of 4.72 million hectares with a production of 13.73 million tons of grains (BBS, 2011). Variety is one of the most important factors to be considered for getting increased rice production. Use of high yielding varieties and hybrid varieties in Bangladesh has been increased remarkably in recent years and the country has almost reached a level of self sufficiency in rice production.

Selection of potential variety, planting in appropriate method and application of optimum amount of plant nutrients and optimum insistence can play important role in increasing yield and national income. In Bangladesh about 4.065 million ha land is under boro rice cultivation of which modern high yielding varieties (MV) cover about 96% (BBS, 2015).

Hybrid rice technology is one of the alternative means to meet the challenge of food security for the increasing population in Bangladesh. Hybrid rice has higher seedlings dry matter content, thicker leaves, larger leaf area and longer root system (BRRI, 2000). Hybrid rice can give 10-15% yield advantage over modern inbred varieties through vigorous growth, extensive root system, efficient and greater sink size, higher carbohydrate translocation from vegetative parts to spikelets and larger leaf area index during the grain filling stage (Peng *et al.*, 1998).

During vegetative growth, hybrid rice accumulates more dry matter which results in higher spikelets panicle^{-1}, whereas inbred rice depends basically on the accumulation of assimilates after heading (Yan, 1988). The main reason for higher yield of hybrid rice is vigorous seedlings with tillers. The tillers that emerge in the seedbed produce more spikelets panicle^{-1} than the tillers that emerge after transplanting (Wen, 1990). Dry matter production at different growth stages shows different patterns for hybrid and inbred rice. While hybrid rice has more dry matter accumulation in the early and middle growth stages, inbred rice has more in the late growth stages (Yan, 1988). High grain yield of hybrid rice is attributed to high vegetative biomass production, high leaf area, large panicles and high tillering capacity in some cases (Peng *et al.*, 1998).

The rice seedlings lose much of their growth potential if they are transplanted more than 15 days after they emerge in the nursery (Manjunatha *et al*., 2010). Sowing and transplanting at the optimum time is important for obtaining high paddy yield. Too early or too late transplanting causes yield reduction due to crop sterility and lower number of productive tillers, respectively (Nazir, 1994). Vandana *et al*., (1994) reported that dry matter accumulation in leaves decreased with later transplanting dates. They further observed that delayed transplanting reduced seedling dry matter with least accumulation of dry matter in leaves.

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) reported that rice plants require a particular temperature for its phenological affairs such as panicle initiation; flowering, panicle exertions from flag leaf sheath and maturity and these are very much influenced by the planting dates during *T. Aman* and *Boro* season.

The present study was undertaken to evaluate the growth and yield behaviour of a few selected hybrid and inbred rice varieties in *Boro* season under field condition. Based on above proposition, this research work is designed to find out the effect of planting time on morpho-physiological and yield attributes of high yielding hybrid rice varieties with the following objectives:

1. To find out the effect of planting times on growth and yield of hybrid rice varieties.
2. To identify the yield contributing characters responsible for high yield in hybrid rice varieties compared to the inbred.
3. To investigate the yield variation among the hybrid rice varieties.

CHAPTER II

REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief and relevant review of literature in relation to the effect of planting time on morpho-physiological and yield attributes of hybrid rice varieties. Related review regarding growth and yield components in this chapter have been described under the following headings:

Effect of varieties on growth, yield of *Boro* rice

Murshida *et al*. (2017) conducted an experiment to examine the effect of variety and water management system on the growth and yield performance of boro rice. The experiment consisted of three varieties (cv. BRRI dhan28, BRRI dhan29 and Binadhan-14) and four water management systems (viz. Traditional flooding, non-flooded rice straw mulching, non-flooded water hyacinth mulching and non-flooded no mulching). Results revealed that at 100 DAT, the highest plant height, maximum number of tillers hill^{-1}, dry matter of shoot hill^{-1} and dry matter of root hill^{-1}were obtained from BRRI dhan29 and the lowest values were found in Binadhan-14. Variety had significant effect on all the crop characters under study except 1000-grain weight. The highest grain yield was obtained from BRRI dhan29 and the lowest value was recorded from Binadhan-14. The interaction of variety and water management system showed that BRRI dhan29 with non-flooded rice straw mulching resulted in the highest grain yield. The result of the experiment suggests that BRRI dhan29 can be grown economically with non-flooded rice straw mulching treatment.

Chamely *et al*. (2015) conducted an experiment study the effect of variety and rate of nitrogen on the performance of Boro rice. The experiment comprised three varieties *viz*., BRRI dhan28 (V_1), BRRI dhan29 (V_2) and BRRI dhan45 (V_3); and five rates of nitrogen *viz*., control (N_0), 50 kg (N_1), 100 kg (N_2), 150 kg (N_3) and

200 kg (N_4) N ha^{-1}. The growth analysis results indicate that the tallest plant (80.88 cm) and the highest number of total tillers $hill^{-1}$ (13.80) were observed in BRRI dhan29 at 70 DATs and the highest total dry matter (66.41 g m^{-2}) was observed in BRRI dhan45. The shortest plant (78.15 cm) and the lowest number of tillers $hill^{-1}$ (12.41) were recorded from BRRI dhan45 and the lowest dry matter (61.24 g) was observed in BRRI dhan29. The highest number of tillers $hill^{-1}$ (15.14) was obtained from BRRI dhan29 with 50 kg N ha^{-1}. The harvest data reveal that variety had significant effect on total tillers $hill^{-1}$, effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, panicle length, grain yield, straw yield and harvest index. The highest grain yield (4.84 t ha-1) was recorded from BRRI dhan29.

Wiangsamut *et al.* (2015) found that the plant height of RD14 rice genotype was significantly taller than San-pah-tawng1 rice genotype. Grain yield of RD14 rice genotype was significantly higher than San-pah-tawng1 rice genotype; mainly due to RD14 rice genotype having had higher filled grain number $panicle^{-1}$ and harvest index.

Roy *et al.* (2014) evaluated 12 indigenous *Boro* rice varieties where the plant height and tillers $hill^{-1}$ at different DAT varied significantly among the varieties up to harvest. At harvest, the tallest plant (123.80 cm) was recorded in Bapoy and the shortest (81.13 cm) in GS. The maximum tillers $hill^{-1}$ (46.00) was observed in Sylhety *Boro* and the minimum (19.80) in Bere Ratna. All of the parameters of yield and yield contributing characters differed significantly at 1% level except grain yield, biological yield and harvest index. The maximum effective tillers $hill^{-1}$ (43.87) was recorded in the variety Sylhety *Boro* while Bere ratna produced the lowest effective tillers $hill^{1}$ (17.73). The highest (110.57) and the lowest (42.13) filled grains $panicle^{-1}$ was observed in the variety Koijore and Sylhety *Boro*, respectively. Thousand grain weight was the highest (26.35 g) in Kali *Boro* and the lowest (17.83 g) in GS one. Grain did not differ significantly among the varieties but numerically the highest grain yield (5.01 t ha^{-1}) was found in the variety Koijore and the lowest in GS one (3.17 t ha^{-1}).

Haque *et al.* (2015) evaluated the two popular indica hybrids (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrid varieties out yielded the inbred. However, the hybrids and inbred varieties exhibited statistically identical yield in late planting. Filled grain (%) declined significantly at delayed planting in the hybrids compared to elite inbred due to increased temperature impaired- inefficient transport of assimilates. Results suggest that greater remobilization of shoot reserves to the grain rendered higher yield of hybrid rice varieties.

Hossain *et al.* (2014b) conducted an experiment at the research farm of SAU on the yield and yield attributes of exotic hybrid rice varieties. Significantly longer panicle was recorded from Heera2 (24.70 cm) which was statistically identical with Aloron (24.52 cm). Both hybrid rice varieties Heera2 (119.8) and Aloron (111.8) produced the highest spikelets $panicle^{-1}$ than that of BRRI dhan48 (105.5). In BRRI dhan48, the highest filled spikelets $panicle^{-1}$ (79.53) was recorded. This was may be due to lower sensitiveness of BRRI dhan48 to high temperature and low sunshine hour at grain filling stage compared to test hybrid varieties. The highest spikelet filling percent was recorded from BRRI dhan48 (74.43%) due to favorable environmental condition at grain filling stage. Aloron produced heavier grain size than that of Heera2 and BRRI dhan48. BRRI dhan48 gave significantly higher grain yield 3.51 t ha^{-1} over the tested hybrid varieties Heera2 (3.03 t ha^{-1}) and Aloron (2.77 t ha^{-1}). Biological yield did not varied significantly among studied hybrid and inbred rice varieties. The highest HI was obtained from BRRI dhan48 while it was lowest in Aloron.

Hossain *et al.* (2014a) evaluated the five rice cultivars (one hybrid: WR96, three modern: BR16, BR26, and BRRI Dhan27 and one local: Pari). Most of the yield-contributing characters examined and showed wide variations among the cultivars whereas modern cultivar BR16 produced the highest panicle length, number of grain panicle^{-1} and grain yield ha^{-1}. At the same time as local cultivar Pari generated the lowest number of tiller plant^{-1}, panicle length, grain number panicle^{-1} and grain yield ha^{-1}. Moreover, hybrid cultivar WR96 produced the highest percentage of spotted grain panicle^{-1}.

Sokoto and Muhammad (2014) conducted a pot experiment to determine the effect of water stress and variety on productivity of rice. The results indicated significant ($P < 0.05$) differences among genotypes. Faro 44 differed significantly from others in plant height, number of leaves plant^{-1}, harvest index and grain yield. FARO 44 differed significantly from NERICA 2 and FARO 15 at all the parameters under study.

Shiyam *et al.* (2014) conducted an experiment to evaluate the performance of four Chinese hybrid rice varieties where it was showed comparative superiority of FARO 15 to the hybrids in all growth and yield components assessed. FARO 15 was taller (140 cm) with more productive tillers (11.0), higher spikelets plant^{-1} (166.0), higher filled grains panicle^{-1} (156.17), higher filled grains (92.17%), highest 100-grain weight of 2.63 g and the higher paddy yield (5.021 t ha^{-1}) than others. Despite the comparative poor performance of the hybrids, Xudao151came close to FARO 15 with grain yield of 2.987 t ha^{-1}.

Akter (2014) investigated the growth, yield and nutrient content of 15 *Boro* rice cultivars. BR 15, BRRI dhan29 and BRRI dhan28 were the three rice cultivars having high potentials for grain and straw production during *Boro* season. The highest yield was recorded 5.26 t ha^{-1} which is still very low compared to other rice growing countries of the world. Chola *Boro* and Sada bore are two local land races having potentials for producing higher number of effective tillers and higher 1000 grain weight. Sada *Boro* and Chola *Boro*, two local cultivars were found very high in grain nitrogen content compared to other test cultivars.

Sarker *et al.* (2013) found that the BRRIdhan 28 was shorter in plant height, having more tillering capacity, higher leaf number which in turn showed superior growth character and yielded more than those of the local cultivars. The HYV BRRIdhan 28 produced higher grains panicle^{-1} and bolder grains resulted in higher grain yield over the local cultivars. The BRRIdhan 28 produced higher grain yield (7.41 t ha^{-1}) and Bashful, Poshurshail and Gosi yielded ha^{-1}, respectively. Among the local rice cultivars, Gosi showed the higher yielding ability than Bashful and Poshursail.

Islam *et al.* (2013) found that the highest plant height (116.00 cm) was found in the variety Morichsail and the lowest in the variety Khaskani. Filled grains panicle^{-1} was found highest (100) with the variety Khaskani and the lowest was recorded in the variety Raniselute. Raniselute produced the highest 1000-grain weight (32.09 g) and the lowest (13.32 g) was recorded from the variety Kalijira. The variety Morichsail produced the highest grain yield (2.53 t ha^{-1}) followed by Kachra (2.41 t ha^{-1}), Raniselute (2.13 t ha^{-1}) and Badshabhog (2.09 t ha^{-1}) and the lowest grain yield (1.80 t ha^{-1}) was obtained from Kalijira.

Hossaina *et al.* (2013) reported that the evaluated five rice cultivars showed wide variations regarding most of the yield-contributing characters. Modern cultivar BR16 produced the highest panicle length, number of grain panicle^{-1} and grain yield ha^{-1}. At the same time as local cultivar Pari generated the lowest number of tiller plant^{-1}, panicle length, grain number panicle^{-1} and grain yield ha^{-1}.

Garba *et al.* (2013) studied on the effects of variety, seeding rate and row spacing on growth and yield of rice. Variety Ex-China produced significantly ($P<0.05$) higher numbers of tillers plant^{-1} and spikes hill^{-1}. However, NERICA-1 produced significantly ($P<0.05$) higher numbers of spikelets spike^{-1}, seeds spike^{-1}, weight of seed spike^{-1}, weight of seed hill^{-1}, 1000 grain weight and yield in kg ha^{-1} than Ex-China.

Yao *et al.* (2012) found insignificant difference in grain yield between the cv.

AWD and CF. On average, YLY6 produced 21.5% higher yield than HY3 under AWD conditions. Like grain yield, YLY6 showed consistently higher water productivity and physiological nitrogen use efficiency than HY3. Both total dry weight and harvest index contributed to higher grain yield of YLY6.

Sritharan and Vijayalakshmi (2012) evaluated the physiological traits and yield potential of six rice cultivars *viz.,* PMK 3, ASD 16, MDU 3, MDU 5, CO 47 and RM 96019. The plant height, total dry matter production and the growth attributes like leaf area index, crop growth rate and R:S ratio were found to be higher in the rice cultivar PMK 3 that showed significant correlation with yield. Yield and yield components like number of productive tillers, fertility co-efficient, panicle harvest index, grain weight and harvest index were found to be higher in PMK 3.

Panwar *et al.* (2012) studied to evaluate the performance of rice varieties. Growth parameters *viz.* plant height (cm), No. of tillers m , leaf area index and dry matter accumulation (g) was highest in JGL-3844 over rest of varieties. The effective tillers m^{-2} (331.6), panicle length (25.63), grains $panicle^{-1}$ (68.23), sterility percent (12.1%), grain yield (60.9 q ha^{-1}) and straw yield (92.58 q ha^{-1}) yield were also highest in variety JGL-3844.

Oka *et al.* (2012) assessed the agronomic characteristics of 15 selected indigenous and newly introduced hybrid rice varieties in Ebonyi State, Nigeria. Significant variation ($P<0.05$) was detected among the 20 rice varieties for all the traits evaluated. The results showed that plant height ranged between 144.01 cm in "Mass (I)" and 76.00 cm in "Chinyeugo". Cv. "E4197" had the highest value of 38±0.02 cm for panicle length and "Chinyereugo" had the highest value of 6.3g ± 0.03 for panicle weight. Leaf area showed the highest value of 63.8cm^2 ± 0.01 in "Mass (I)". Cv. "Co-operative" had high number of seeds $panicle^{-1}$ (139 ± 0.19). "Chinyereugo" had the highest value of 25.9g ±1.4 for 1000-grains weight. The grain of "E4314" was the longest (8.00 mm ± 0.89) of the varieties studied.

Mannan *et al.* (2012) reported that the Badshabhog and Kalijira showed taller plants and Chinigura was shorter while Chinigura produced the greatest tillers at early, mid and at later growth stages and the lower tillers was observed in Badshabhog. Chinigura produced the highest amount of DM and while least amount of DM was observed in Kataribhog. The Chinigura produced significantly the highest panicles but it was statistically identical with Kalijira, while, Kataribhog exhibited lower number of panicles but number of grains panicle^{-1} was found more in Badshabhog. The heaviest grain was found in Kataribhog while the light grain was observed in Badshabhog. The grain yield of Chinigura and Kalijira was almost identical. Lower grain yield was found in Kataribhog which may be attributed to the lower number of panicles and grain panicle^{-1}.

Alam *et al.* (2012) found that the cultivar BRRI dhan33 gave significantly the tallest plant (113.17 cm), while the shortest plant was found in BRRI dhan32 cultivar (105.07 cm). Among the cultivars, BR11 produced the maximum total tillers hill^{-1} (12.33), maximum fertile spikelets panicle^{-1} (103.83) while lowest fertile spikelets panicle^{-1} (102.10) and minimum total tillers hill^{-1} (10.17) were found in BRRI dhan32. BR11 also produced the highest 1000-grain weight (23.79g) and highest grain yield (5.92 t ha^{-1}) while BRRI dhan33 produced the lowest 1000-grain weight (21.69 g) and grain yield. The cultivar BR11 produced the highest grain yield, it might be due to the highest number of total tillers hill^{-1}, number of effective tillers hill^{-1} and 1000-grain weight and lowest number of sterile spikelets panicle^{-1}.

Mahamud *et al.* (2013) showed that rice cultivars differed significantly in all growth characters, such as plant height, tillers number, chlorophyll content and dry matter weight of different plant parts, panicle length, filled grain, unfilled grain, filled grain percentage, 1000-grain weight, grain yield and straw yield.

Khushik *et al.* (2011) studied to assess the performance of rice hybrid and other varieties planted in rice growing areas of Sindh and Balochistan. The results revealed that average yield of hybrid rice was 195 mds ha^{-1}, followed by IRRI-6 (151 mds ha^{-1}), B-2000 (91 mds ha^{-1}) and Rosi (94 mds ha^{-1}). This indicates that the yield of hybrid rice was higher by 29% than the major variety IRRI-6.

Islam (2011) conducted a field experiment at BINA, Mymensingh on five aromatic rice genotypes viz., BRRIdhan34, Ukunimadhu, RM-100/16, KD5 18-150 and Kalozira by at BINA, Mymensingh. Among the varieties, KD5 18-150 showed higher grain yield, total dry matter $plant^{-1}$ and harvest index under temperature stress.

Baset Mia and Shamsuddin (2011) reported that the aromatic rice cultivars showed tallest plant stature, profuse tillers $hill^{-1}$, panicle $hill^{-1}$ and larger panicle but smaller grain, higher grain yield, lowest straw yield and harvest index compare modern rice. Modern rice cultivars generally had higher TDM, LAI, LAR, CGR, RGR whereas aromatic cultivars resulted in higher NAR. The highest grain yield of modern rice cultivars was due to the higher harvest index. Poor yield in aromatic rice cultivars was due to lower translocation of assimilates.

Islam *et al.* (2010) found that the rice cultivar 1R76712H produced the highest grain yield (7.7 t ha^{-1}) followed by 1R75217H and Magat (7.6 t ha^{-1}) in WS; in DS, 1R79118H produced the highest grain yield (9.17 t ha^{-1}) followed by 1R73855H (8.9 t ha^{-1}) and SL-8H (8.8 t ha^{-1}) due to high harvest index. Hybrid produced higher spikelets $panicle^{-1}$ and 1000-grain weight than inbred rice. Spikelet filling percent was higher in inbred than hybrid rice.

Islam *et al.* (2009b) reported that the genotype BINAdhan 5 and BINAdhan 6 showed similar performance in respect of most of the parameters but BINA dhan 6 produced the highest grain yield (40.26 g $hill^{-1}$) compared to BINA dhan 5 (35.54 g $hill^{-1}$) and Tainan 3 (33.90 g $hill^{-1}$).

Islam *et al.* (2009a) reported that BRRI dhan-3l had about 10-15% higher plant height, very similar tillers plant^{-1}, 15-25% higher LA at all DAT compared to Sonarbangla-1 in 2001. Sonarbangla-1 had about 40% higher DM production at 25 DAT but had very similar DM production at 50 and 75 DA. BRRI dhan-3l had higher panicles plant^{-1} than Sonarbangla-1, but Sonarbangla-1 had higher grains panicle^{-1}, 1000-grain weight and grain yield than BRRI dhan-31. In 2002, BRRI dhan-31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhan-l had the highest plant height. Sonarbangla-1 had the largest LA at 25 and 50 DAT while BRRI dhan-31 had the largest LA.

Sohel *et al.* (2009) found that BRRI dhan41 produced higher grain yield (4.7 t ha^{-1}) which was the contribution of higher number of grains panicle and heavier grain weight. Lower yield (4.51 t ha^{-1}) was recorded in BRRI dhan 40.

Razzaque *et al.* (2009) studied on salt tolerant genotypes PVSB9, PVSB19, PNR381, PNR519, Iratom24 and salt sensitive genotype NS15 along with one standard check salt tolerant rice cultivar Pokkali. The different morphological characters studied include plant height, total number of tillers, Root Dry Weight (RDW), Shoot Dry Weight (SDW) and Total Dry Matter (TDM) content of the selected rice genotypes in view to evaluate their response at different salinity levels. The genotypes Pokkali, PVSB9, PVSB19 showed significantly higher values and the lowest value of all these characters were recorded in NS15.

Jeng *et al.* (2009) found that the cultivar Tainung 67 had greater yield (7.2 mg ha^{-1}) than SA419 (6.2 mg ha^{-1}). The greater yield of SA419 than Tainung 67 in autumn was due to its higher net assimilation rate and better dry matter partitioning during grain filling. Significant panicle branch effects on the distribution pattern of grain weight were also found between Tainung 67 and SA419 with greater variation for the former than the latter.

Ashrafuzzaman *et al.* (2009) reported that the Kalizira was the tallest (107.90 cm) while it was shortest (93.40 cm) in Chiniatop and was identical to Kataribhog (95.30 cm) due to genetic makeup of the cultivar, but the environmental factors also influence it. There was also significant difference on 1000-grains weight among the cultivars whereas the highest 1000-grains weight was recorded in BR38 (20.13 g) and the lowest was recorded in BR34 (12.17 g). BR34 produced the maximum grain yield and Basmati produced the lowest. The highest harvest index was recorded from BR34 (34.94%) and the lowest harvest index was obtained from Basmati (31.51%).

Alam *et al.* (2012) found that the cultivar BRRI dhan33 gave significantly the tallest plant (113.17 cm), while the shortest plant was found in BRRI dhan32 cultivar (105.07 cm). Among the cultivars, BR11 produced the maximum total tillers hill^{-1} (12.33), maximum fertile spikelets panicle^{-1} (103.83) while lowest fertile spikelets panicle^{-1} (102.10) and minimum total tillers hill^{-1} (10.17) were found in BRRI dhan32. BR11 also produced the highest 1000-grain weight (23.79g) and highest grain yield (5.92 t ha^{-1}) while BRRI dhan33 produced the lowest 1000-grain weight (21.69 g) and grain yield. The cultivar BR11 produced the highest grain yield, it might be due to the highest number of total tillers hill^{-1}, number of effective tillers hill^{-1} and 1000-grain weight and lowest number of sterile spikelets panicle^{-1}.

Masum *et al.* (2008) reported that that Nizershail produced the taller plant height than BRRI dhan44 at different DAT. Total tillers hill^{-1} was significantly influenced by variety at all stages. At 30 and 60 DAT, Nizershail had significant by higher amount of DM (35.46% higher at 30 DAT and 18.01% higher at 60 DAT) than BRRI dhan44 but at harvest BRRI dhan44 had significantly higher amount of DM (39.85 g hill^{-1}) that was 18.42% higher than Nizershail. BRRI dhan44 produced higher (4.85 t ha^{-1}) grain yield than Nizershail (2.46 t ha^{-1}). Nizershail produced higher (7. 22 t ha^{-1}) straw yield compared to BRRI dhan44

(6.34 t ha^{-1}).

Hossain *et al.* (2008) reported that all the yield contributing characters differed significantly due to cultivar. The tallest plant was observed in Chinigura (162.8 cm) which statistically similar to Kataribhog. Kalizira produced the maximum number of grains $panicle^{-1}$ (135.90). Among the cultivars, BRRI dhan 38 gave the maximum grain yield (4.00 t ha^{-1}). Five varieties were evaluated by Ndaeyo *et al.* (2008). Among the varieties, the variety WAB224-8-HB produced the highest grain yield (4.73 and 4.40 t ha^{-1}) followed by WAB189-B-B-B-8-HB (4.37 and 4.20 t ha^{-1}) for both years.

Akram *et al.* (2007) studied on fifteen rice hybrids where two hybrids viz., MK Hybrid 111 and 27P72 produced more productive tillers than KS 282. All most all the hybrids produced more number of grains $panicle^{-1}$ and higher 1000-grain weight. Yield advantage of the hybrids over the commercially grown rice variety ranges between 4.59-21.33% except RH-257 and GNY-40. These two hybrids were low yielder by 4.20 % and 14.95%, respectively, than the check variety.

Khan *et al*. (2006) reported that the variety Rachna showed the highest yield of 4009.590 kg ha^{-1} followed by Basmati-385, Shaheen and Super with the production of 3678.983, 2939.257 and 2175.303 kg ha^{-1}, respectively. However, the plant height (cm) of Rachna was at 2nd position (125.400 cm) after Basmati-385 at 129.767 cm. The maximum tiller $plant^{-1}$ (18) was obtained by variety Rachna, which significantly differ from variety Super that produced 10 tillers $plant^{-1}$. The maximum spike $plant^{-1}$ 18 were shown by variety Rachna and the number of tiller $plant^{-1}$ produced by Rice variety Basmati-385 i.e., 17. The highest yield of Rachna variety was due to the best performance in terms of tillers $plant^{-1}$, spike $plant^{-1}$ and weight of 1000 grains.

Amin *et al.* (2006) studied on traditional and modern rice cultivars at BSMRAU, Salna, Gazipur. Cultivar KK-4, a high yielding variety out yielded (4772 kg ha^{-1})

the indigenous varieties Jharapajam (4150 kg ha^{-1}), Lalmota (3628 kg ha^{-1}) and Bansful Chikon (3575 kg ha^{-1}).

George *et al.* (2005) evaluated the 12 aromatic rice varieties/cultivars where pooled analysis of the yield data indicates that 'Pusa Basmati-1' had the highest grain yield of 2777 kg ha^{-1}. But it was statistically at par with that of 'Jeerakasala' (2743 kg ha^{-1}) and IET-12606 (2610 kg ha^{-1}), implying the suitability of these three varieties for cultivation in Wayanad district.

2.1 Effect of planting time

Shabana *et al*. (2016) conducted an experiment assigning three transplanting dates (25 May, 10 and 25 June) with four cultivars of rice (Jhelum, Shalimar rice^{-1}, SKAU-341 (SR-2) and SKAU-382 (SR-3). The crop planted on 25 May produced the highest yield of 74.0 and 79.0 q ha^{-1} during 2011 and 2012 respectively over 10 June (57.3 and 57.1 q ha^{-1}) and 25 June (31.1 and 32.2 q ha^{-1}). Spikelet sterility was 19.08 and 18.18, 20.21 and 20.62, 29.67 and 33.84 with 25 May, 10 June and 25 June transplanting during 2011 and 2012 respectively. Yield attributes like grains panicle^{-1}, spikelet's panicle^{-1} and test weight were recorded highest with 25 May transplanting and lowest in 25 June transplanting. Variety Jhelum recorded highest grain yields. The superiority of variety Jhelum over Shalimar rice^{-1}, SKAU-341 and SKAU-382 was 3.9, 9.1 and 15.9 per cent, respectively during 2011 and corresponding values for year 2012 were 1.7, 8.5 and 14.7 per cent, respectively.

Mishri and Rambaran (2001) conducted a field experiment to find out the alternate management practices to compensate the loss in the grain yield due to flood. Irrespective of the varieties and transplanting dates, age of seedlings had no effect on grain yield of rice. But transplanting dates had significant effect on grain and grain contributing characters. The yield of rice transplanted at 1 Sept was 25.6 and 37.5% less in 1998/99 and 1999/00 respectively as compared to rice grain yield of

14 July transplanting. Radha 11 registered the highest grain yield of 4086 kg ha^{-1} in 1999/00 and 2662 $kgha^{-1}$ in 1998/99, which was at par to the yield obtained by Sabitri at the same year. The interaction effect of the age of seedlings, transplanting dates and varieties were found significant in both the years. 25 days old seedlings transplanted on 14 July in 1999/00 of rice varieties Masuli and Radha 11, produced statistically the similar yield. Radha 11 was the best among the tested varieties. 25 days old seedlings of Masuli, Basmati, Sabitri and Radha 11 can be recommended to transplant as late as Sept 1.

The time between July 15 and August 15 is the best for transplantation of high yielding cultivars of transplant *Aman*rice in Bangladesh. However, better results are obtained from early transplanting than late transplanting (Hedayetullah *et al.*, 1994). It was revealed that mildly photoperiod-sensitive cultivars had a reduced likelihood of encountering low temperature compared with photoperiod-insensitive cultivars. The benefits of photoperiod sensitivity include greater sowing flexibility and reduced water use as growth duration is shortened when sowing is delayed (Farrell *et al*., 2006).

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

The vegetative stage of rice may be extended due to low temperature (Vergera and Chang, 1985). In November planting of BR3 when the temperature was cool, the vegetative phase was extended by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast with planting in July when the temperature was high, the relative tillering rate reached the highest value within 15 to 25 days after transplanting. In most cases, tillering rate decreases because of low temperature. So, appropriate planting time and the use of photoperiod-sensitive cultivars can be advantageous in a region in avoiding low temperature damage during reproductive development.

Gohain and Saikia (1996) reported that earlier planting of high yielding varieties of rice around mid-July was the best. Late planting might have exposed the crop to relatively more adverse condition in terms of water stagnation at the tillering phase and low temperature at the reproductive phase which might have pulled down the yield compared to earlier planting.

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

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

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

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

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

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

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

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

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2016 to May 2017. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and their analysis.

3.1 Site description

The study was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The location of the site is 23°74′ N latitude and 90°35′ E longitude with an elevation of 8.2 meter from sea level (Appendix I).

3.2 Climate and weather

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

3.3 Soil

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

3.4 Plant materials

In this research work, four samples of hybrid and one inbreed rice varieties were used as plant materials. The rice varieties used in the experiments were Heera 4, Tia, Aloron, BRRI hybrid dhan 3 and BRRI dhan 29. The seeds were collected from Siddique bazaar, Dhaka.

3.5 Experimental details

3.5.1 Treatments

Two factors experiment was conducted to evaluate the performance of some hybrid rice varieties in *Boro* season. The test varieties those were used in the present study with different planting times were as follows:

Factor A: Planting time

1. T_1= 15 December, 2016
2. T_2= 15 January, 2017

Factor B: variety

1. V_1= Heera 4 (Hybrid)
2. V_2=Tia (Hybrid)
3. V_3=Aloron (Hybrid)
4. V_4= BRRI hybrid 3 (Hybrid)
5. V_5= BRRI dhan 29 (Inbreed)

3.5.2 Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the variety. There were 30 plots of size 1.4 m × 3 m in each of 3 replications. The treatments of the experiment were assigned at random into each replication following the experimental design. Seedlings were sown in seed bed and age of transplanted seedling was 21 days. Line to line distance was 25 cm where hill to hill distance was 15 cm. Two seedlings $hill^{-1}$ were used during transplanting. The layout of the experiment field is presented in Appendix IV.

3.6. Seed sprouting

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

3.7 Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed @ 70 g m^{-2} on 22 November, 2016 and 28 December, 2016 in order to have seedlings of 21 days at both the sowing date.

3.8 Preparation of the main field

The plot selected for the experiment was opened in 8 December 2016 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed for puddling several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.9 Fertilizers and manure application

The following doses of different manures and fertilizers were used:

1. Cowdung : 10 t ha^{-1}
2. Urea (N) : 220 kg ha^{-1}
3. TSP (P_2O_5) : 165 kg ha^{-1}
4. MP (K_2O) : 180 kg ha^{-1}
5. Gypsum : 70 kg ha^{-1}
6. Zinc : 10 kg ha^{-1}

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

3.10 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. Firstly, seedlings were uprooted on December 14, 2016 from the seed sown of 22 November, 2016 seed bed to maintain seedling age (21 days) on definite sowing time. Secondly, seedlings were uprooted on January 14, 2017 from the seed sown of 28 December, 2016 seed bed to maintain also seedling age (21 days). Seedlings were uprooted without causing much mechanical injury to the roots.

3.11 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on December 15, 2016 and January 15, 2017 and the rice seedlings were transplanted in lines each having a line to line distance of 25 cm and plant to plant distance was 15 cm for all test varieties in the well prepared plot.

3.12 Cultural operations

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

3.12.1 Irrigation and drainage

Recommended amount of irrigation was provided for crop production.

3.12.2 Gap filling

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

3.12.3 Weeding

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

3.12.4 Plant protection

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

3.13 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80-90% of the grains become golden yellow in colour. Ten pre-selected hills per plot from which different data were collected and 1 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Dry weight of grain and straw were recorded plot wise. Finally the weight was adjusted to a moisture content of 12%. The yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.14 Data recording

3.14.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 40, 70 and 100 DAT (days after transplanting). Data were recorded as the average of same 10 hills selected at random from the outer side rows (started after 2 rows from outside) of each plot. The height was measured from the ground level to the tip of the plant.

3.14.2 Leaves hill^{-1}

The number of leaves hill^{-1} was recorded at 40, 70 and 100 DAT (days after transplanting) and by counting total leaves as the average of same 5 hills pre-selected at random from the inner rows of each plot.

3.14. 3 Tillers hill^{-1}

The number of tillers hill^{-1} was recorded at 40, 70 and 100 DAT (days after transplanting) by counting total tillers as the average of same 5 hills preselected at random from the inner rows of each plot.

3.14.4 Leaf area

Leaf length (cm)

The length of leaf was measred by using a meter scale. The measurement was taken from base to tip of the leaf . Average length of leaves was taken from five random selected plants. Average was expressed in centimeter (cm).

Leaf breadth (cm)

The average breadth of leaves was taken from five random selected plants from each plot. Average was expressed in centimeter (cm).

3.14.6 Dry weight of leaves plant^{-1}

Ten plants were collected randomly from each plot at harvest. Those were the segmented into leaves. The leaves were oven dried 72 hours at 70º C and the dry weight of leaves plant^{-1} was determined by using the following formula:

Dry weight of leaves plant^{-1} = $\frac{\textbf{Dry weight (g)}}{\textbf{Number of plants}}$

3.14.7 Dry weight of stem plant^{-1}

Ten plants were collected randomly from each plot at harvest. Those were the segmented into stem. The sample plants were oven dried 72 hours at 70º C and the dry weight of stem plant^{-1} was determined by using the following formula:

Dry weight of stem plant^{-1} = $\frac{\textbf{Dry weight (g)}}{\textbf{Number of plants}}$

3.14.8 Dry weight of root plant^{-1}

Ten plants were collected randomly from each plot at harvest with the help of a shovel in such a way that root had minimum damage and was intact. Those were then washed in running water and the soil was removed and the roots were then segmented from the plant. The sample parts were oven dried 72 hours at 70º C and the dry weight of root plant^{-1} was determined by using the following formula:

Dry weight of root plant^{-1} = $\frac{\textbf{Dry weight (g)}}{\textbf{Number of plants}}$

3.14.9 SPAD value

Rice plants were selected at experimental field. Upper, middle and lower leaves were used for SPAD readings. For each leaf average of three readings were taken. Finally the SPAD value was taken from the average of three readings leaf^{-1} basis.

3.14.10 Length of panicle

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

3.14.11 Filled grain panicle^{-1}

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

3.14.12 Unfilled grains panicle^{-1}

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

3.14.13 Grains panicle^{-1}

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

3.14.14 Weight of 1000 grains

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

3.14.15 Grain yield

The central 1 m^2 from each plot were harvested, threshed, dried, weighed and finally converted to t ha^{-1} basis.

3.15 Statistical Analysis

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

CHAPTER IV

RESULTS AND DISCUSSIN

The results obtained from the present study considering the effect of planting time on morpho-physiological and yield attributes of hybrid rice varieties have been presented and discussed in this chapter under the following headings.

4.1 Plant height

Plant height of rice was recorded due to different planting times at different growth stages (Figure 1 and Appendix V). Data represented that the tallest plant (40.11, 64.16 and 98.75 cm at 40, 70 and 100 DAT, respectively) was recorded from T_1 (Transplanting at 15 December), whereas the shortest plant (34.19, 54.58 and 78.71 cm at 40, 70 and 100 DAT, respectively) was recorded from T_2 (Transplanting at 15 January). Probably delayed planted crop prevailed lesser time in favor of growing environment which might have shorten the plant height of the variety. This result is in agreement with that of Murshida *et al*. (2017), Chamely *et al*. (2015), Hedayetullah *et al.* (1994) and they reported that plant height reduced with delayed transplanting of rice.

Significant variation was noted for plant height affected by different varieties of rice at different growth stages (Fig. 2 and Appendix V). Results indicated that V_1 (Heera 4) showed the tallest plant (39.00, 63.80 and 93.16 cm at 40 70 and 100 DAT, respectively). The competition on plant height among the different varieties, V_5 (BRRI dhan 29) showed the shortest plant (35.37, 57.71 and 85.51 cm at 40 70 and 100 DAT, respectively) which was significantly different from all other varieties followed by V_3 (Aloron) and V_4 (BRRI hybrid 3). The results obtained from other findings by Shabana *et al*. (2016), Bisne*et al.* (2006), BINA (1993) and Hossain and Alam (1991 a) was similar and they stated that plant height significantly differed among different varieties.

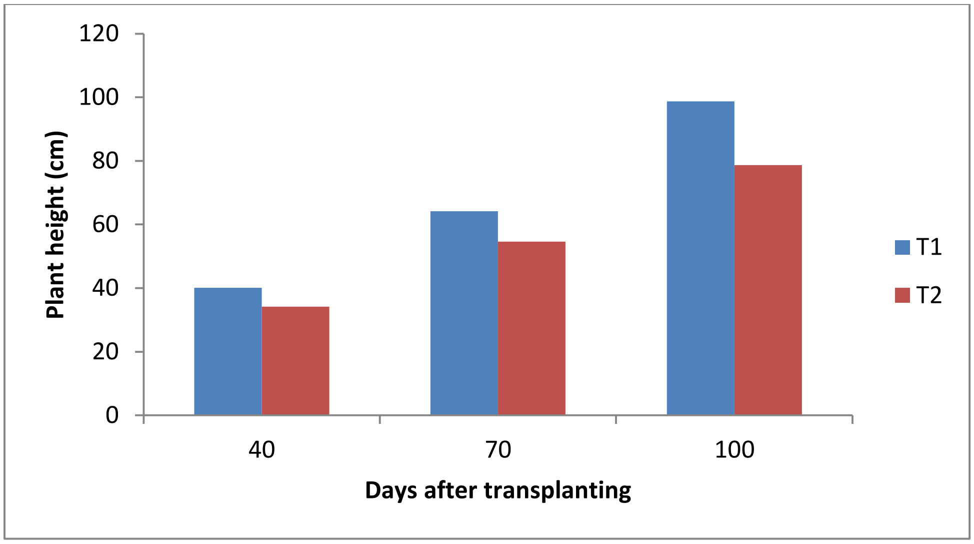

Fig. 1. Effect of different planting times on plant height of rice

T_1 = 15 December, T_2 = 15 January

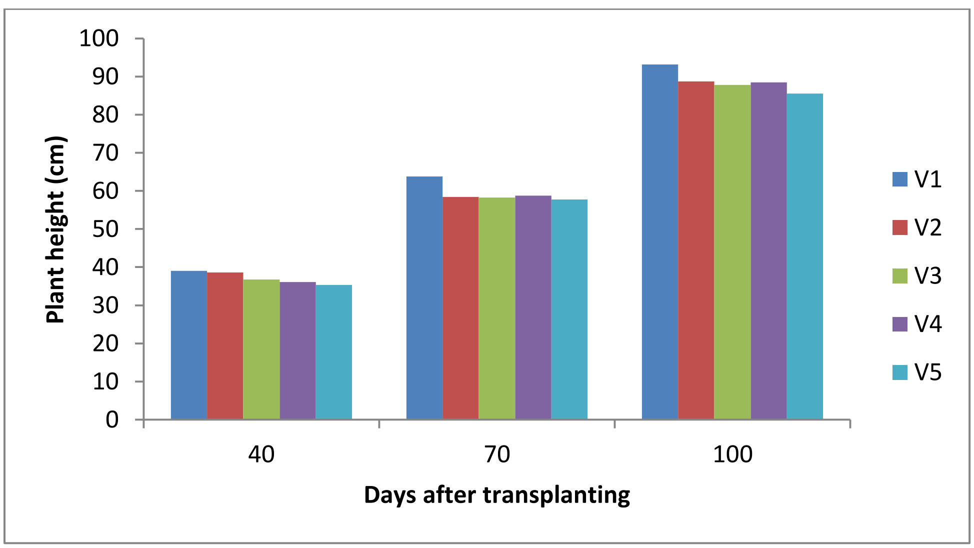

Fig. 2. Effect of different varieties on plant height of rice

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

Interaction effect of planting times and varieties significantly influenced the plant height at different growth stages of Boro rice (Table 1 and Appendix V). It was noted that the longest plant (42.32, 66.78 and 106.50 cm at 40 70 and 100 DAT, respectively) was with T_1V_1, which was significantly different from all other treatment combinations followed by T_1V_2, T_1V_3, T_1V_4 and T_1V_5. The lowest plant height (31.66, 52.04 and 74.54 cm at 40 70 and 100 DAT, respectively) was obtained from the treatment combination of T_2V_5. The results obtained from all other treatments combinations at different growth stages on plant height showed significantly different results.

Table 1. Combined effect of planting times and varieties on plant height of rice at different days after transplanting

Treatment	Plant height (cm)		
	40 DAT	70 DAT	100 DAT
T_1V_1	42.32 a	66.78 a	106.5 a
T_1V_2	39.54 c	63.14 b	97.17 b
T_1V_3	38.55 cd	63.95 b	96.00 b
T_1V_4	41.08 b	63.58 b	97.62 b
T_1V_5	39.07 c	63.37 b	96.48 b
T_2V_1	35.68 e	60.82 c	79.81 c
T_2V_2	37.67 d	53.64 d	80.28 c
T_2V_3	34.92 e	52.52 e	79.59 c
T_2V_4	31.04 f	53.88 d	79.31 c
T_2V_5	31.66 f	52.04 e	74.54 d
$LSD_{(0.05)}$	0.95	0.96	2.99
CV (%)	6.15	8.31	11.71

T_1 = 15 December, T_2 = 15 January

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

4.2 Number of leaves $hill^{-1}$

Variation in number of leaves $hill^{-1}$ at different growth stages was found at different planting times of rice (Figure 3 and Appendix VI). It was observed that at 40, 70 and 100 DAT, the maximum number of leaves $hill^{-1}$ (40.46, 62.70 and 68.40 respectively) was found from T_1 (Transplanting at 15 December), while the minimum number of leaves $hill^{-1}$ (39.05, 58.86 and 68.40, respectively) was from T_2 (Transplanting at 15 January).

Significant influence was found in terms of number of leaves $hill^{-1}$ for different rice varieties at different growth stages (Figure 4 and Appendix VI). Results revealed that at 40 70 and 100 DAT, the DAT the maximum number of leaves $hill^{-1}$ (68.89 and 76.80, respectively) was recorded from V_1 (Heera 4) which was significantly different from all other varieties followed by V_4 (BRRI hybrid 3) where the minimum number of leaves $hill^{-1}$ (33.95, 51.12 and 63.88, respectively) was obtained from V_5 (BRRI dhan 29). Such results on number of leaves $hill^{-1}$ might be due to cause of genotypic characters of varieties and proper nutrient availability from soil.

Number of leaves $hill^{-1}$ at different growth stages showed significant variation due to the combined effect of different planting times and rice varieties (Table 2 and Appendix VI). It was found that the maximum number of leaves $hill^{-1}$ (44.92, 73.41 and 80.61 at 40 70 and 100 DAT, respectively) were found from the treatment combination of T_1V_1, whereas the minimum number of leaves $hill^{-1}$ (33.64, 50.43 and 55.80 at 40 70 and 100 DAT, respectively) was recorded from treatment combination of T_2V_5 which was statistically identical with T_2V_3 at 100 DAS.

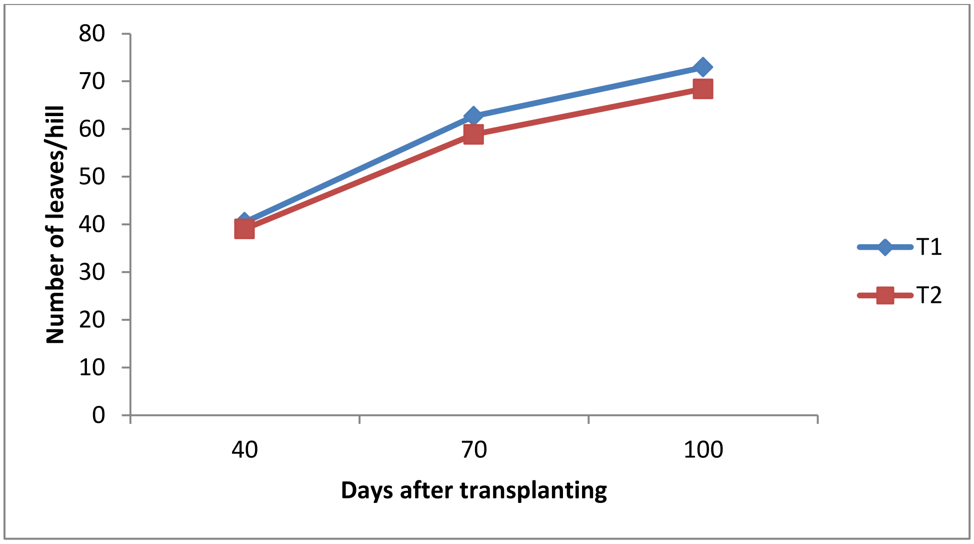

Fig. 3. Effect of different planting times on number of leaves hill^{-1} of rice

T_1 = 15 December, T_2 = 15 January

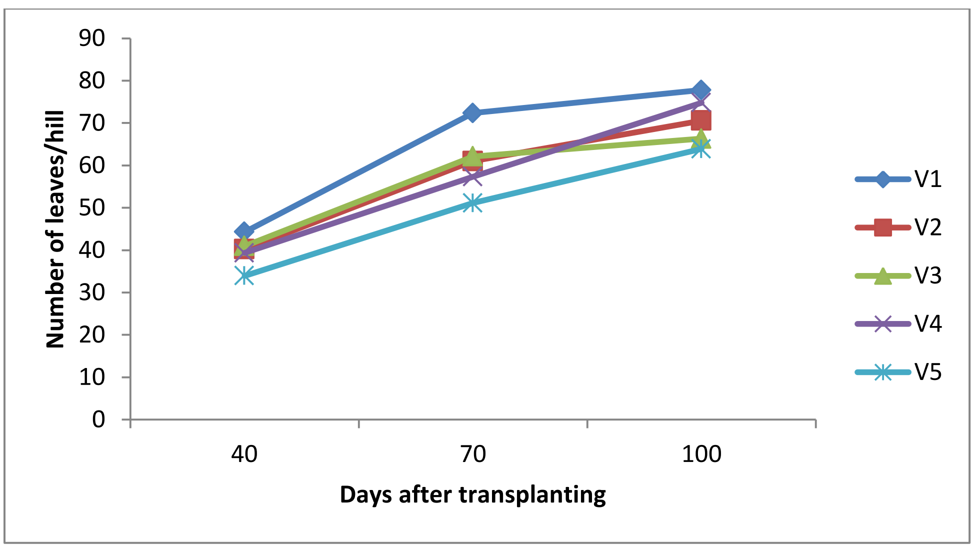

Fig. 4. Effect of different varieties on number of leaves hill^{-1} of rice

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

Table 2. Combined effect of planting times and varieties on number of leaves hill^{-1} of rice at different days after transplanting

Treatment	Number of leaves hill^{-1}		
	40 DAT	70 DAT	100 DAT
T_1V_1	44.92 a	73.41 a	80.61 a
T_1V_2	38.28 e	55.19 d	64.71 d
T_1V_3	40.27 d	60.84 c	73.86 bc
T_1V_4	37.52 e	53.03 de	73.55 bc
T_1V_5	34.26 f	51.81 e	71.96 c
T_2V_1	43.68 b	71.27 a	74.99 bc
T_2V_2	42.14 c	66.84 b	76.43 b
T_2V_3	41.67 c	63.38 c	58.77 e
T_2V_4	41.15 cd	61.58 c	76.02 b
T_2V_5	33.64 f	50.43 e	55.80 e
LSD $_{(0.05)}$	0.97	2.98	2.99
CV (%)	8.05	10.66	10.39

T_1 = 15 December, T_2 = 15 January

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

4.3 Number of tillers hill^{-1}

The recorded data on number of tillers hill^{-1} at different growth stages was varied due to different planting times (Figure 5 and Appendix VII). Results revealed that, the highest number of tillers hill^{-1} (7.07, 15.04 and 15.13 at 40, 70 and 100 DAT, respectively) was found from T_1 (Transplanting at 15 December) where the lowest number of tillers hill^{-1} (6.84, 15.93 and 14.51 at 40, 70 and 100 DAT, respectively) was from T_2 (Transplanting at 15 January). The number of tiller per hill decreased rationally irrespective of all transplanting times after peak as tiller survival was negatively correlated to the maximum tiller number (Sarkar and Reddy, 2006). Similar results were also observed by Shabana *et al*. (2016) and Mishri and Rambaran (2001).

Significant influence was observed on number of tillers hill^{-1} at different growth stages of rice influenced by different varieties (Figure 6 and Appendix VII). It was observed that, the highest number of tillers hill^{-1} (8.02, 18.53 and 18.37 at 40, 70 and 100 DAT, respectively) was found from V_1 (Heera 4) which was statistically identical with V_3 (Aloron) at 40 DAT where the lowest number of tillers hill^{-1} (4.99, 12.92 and 10.11 at 40, 70 and 100 DAT, respectively) was from V_5 (BRRI dhan 29) which was significantly different from all other variety. The other findings by Murshida *et al*. (2017), Chamely *et al*. (2015), Bisne *et al.* (2006), Chowdhury *et al.* (1993) and Hossain and Alam (1991) were similar with the present finding.

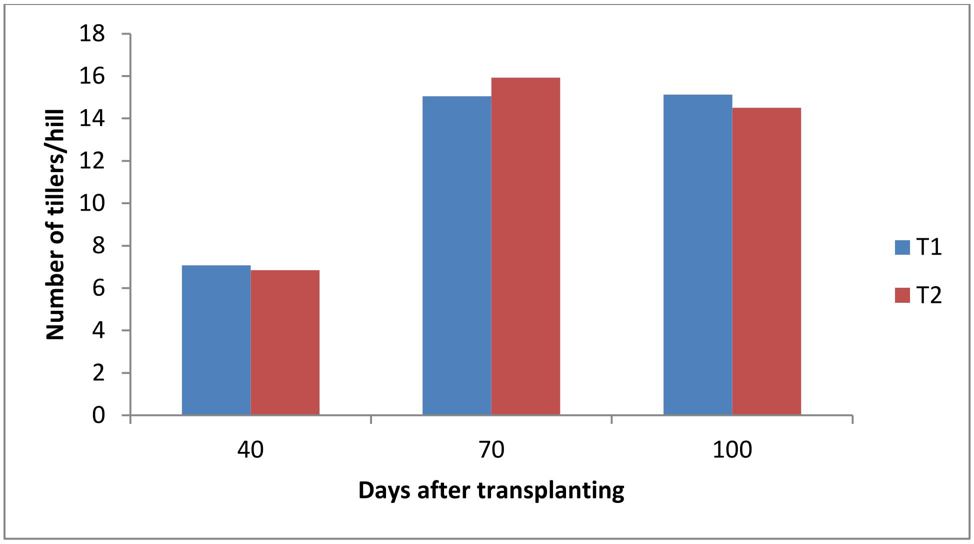

Fig. 5. Effect of different varieties on number of tillers hill^{-1} of rice

T_1 = 15 December, T_2 = 15 January

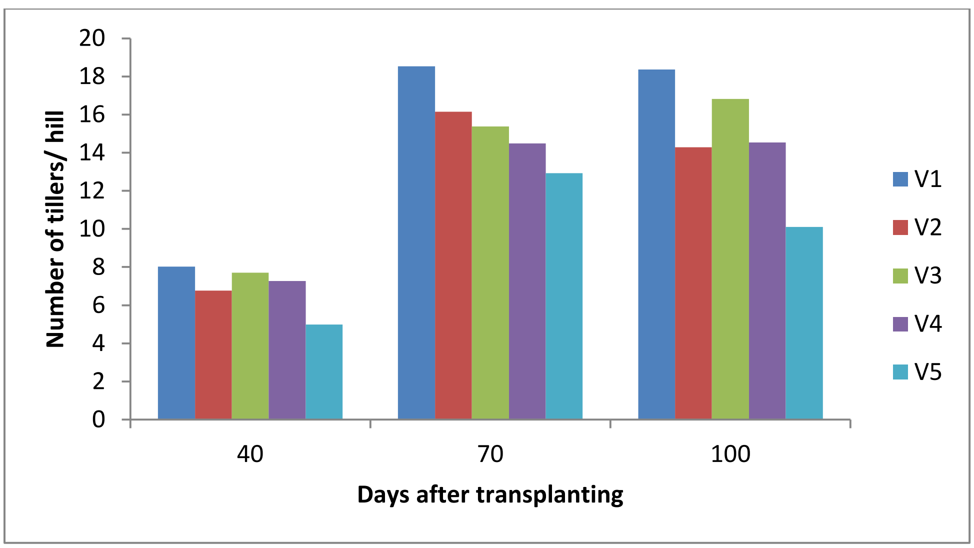

Fig. 6. Effect of different varieties on number of tillers hill^{-1} of rice

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

Combined effect of different planting times and varieties had significant influence on number of tillers hill^{-1} at different growth stages (Table 3 and Appendix VII). Results indicated that the highest number of tillers hill^{-1} (8.32, 18.64 and 19.80 at 40, 70 and 100 DAT, respectively) was found from the treatment combination of T_1V_1 which was statistically identical with T_2V_1 at 70 DAT but significantly different from all other treatment combinations followed by the treatment combination of T_1V_3. The lowest number of tillers hill^{-1} (4.88, 12.75 and 9.93 at 40, 70 and 100 DAT, respectively) was from the treatment combination of T_2V_5 which was statistically identical with the treatment combination of T_1V_5.

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

Treatment	Number of tillers hill^{-1}		
	40 DAT	70 DAT	100 DAT
T_1V_1	8.32 a	18.64 a	19.80 a
T_1V_2	7.10 d	15.20 d	15.83 d
T_1V_3	8.14 ab	14.31 e	17.70 b
T_1V_4	6.68 e	13.97 e	12.03 f
T_1V_5	5.10 f	13.09 f	10.28 g
T_2V_1	7.72 c	18.42 a	16.93 c
T_2V_2	6.44 e	17.08 b	12.73 e
T_2V_3	7.28 d	16.42 c	15.93 d
T_2V_4	7.86 bc	14.98 d	17.03 c
T_2V_5	4.88 f	12.75 f	9.93 g
LSD $_{(0.05)}$	0.35	0.39	0.46
CV (%)	4.72	6.82	9.31

T_1 = 15 December, T_2 = 15 January

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

4.4 Dry weight hill^{-1}

The recorded data on dry weight hill^{-1} at different growth stages was varied due to different planting times (Figure 7 and Appendix VIII). It was observed that, the highest dry weight hill^{-1} (49.32, 41.22 and 49.99 g at 40, 70 and 100 DAT, respectively) was found from T_1 (Transplanting at 15 December) where the lowest dry weight hill^{-1} (7.51, 34.86 and 38.48 g at 40, 70 and 100 DAT, respectively) was from T_2 (Transplanting at 15 January). Hundal*et al*. (2005) observed the significant linear and exponential relationships between aboveground biomass and yield of rice and planting time had direct influence on above attributes. Late planting might have exposed the crop to relatively more adverse growing environment including low temperature at reproductive phase which might pulled down the dry matter accumulation compared to those of earlier plantings (Gohain and Saikia, 1996).

Significant variation was remarked on dry weight hill^{-1} at different growth stages of rice affected by different varieties (Figure 8 and Appendix VIII). It was observed that, the highest dry weight hill^{-1} (9.91, 40.70 and 50.09 g at 40, 70 and 100 DAT, respectively) was found from V_1 (Heera 4) which was significantly different from all other varieties followed by V_3 (Aloron). The lowest dry weight hill^{-1} (6.10, 35.09 and 39.44 g at 40, 70 and 100 DAT, respectively) was from V_5 (BRRI dhan 29) which was also significantly different from all other varieties. Similar results also reported by Murshida *et al*. (2017), Amin *et al*. (2006) and Son *et al*. (1998) from their earlier experiment in rice.

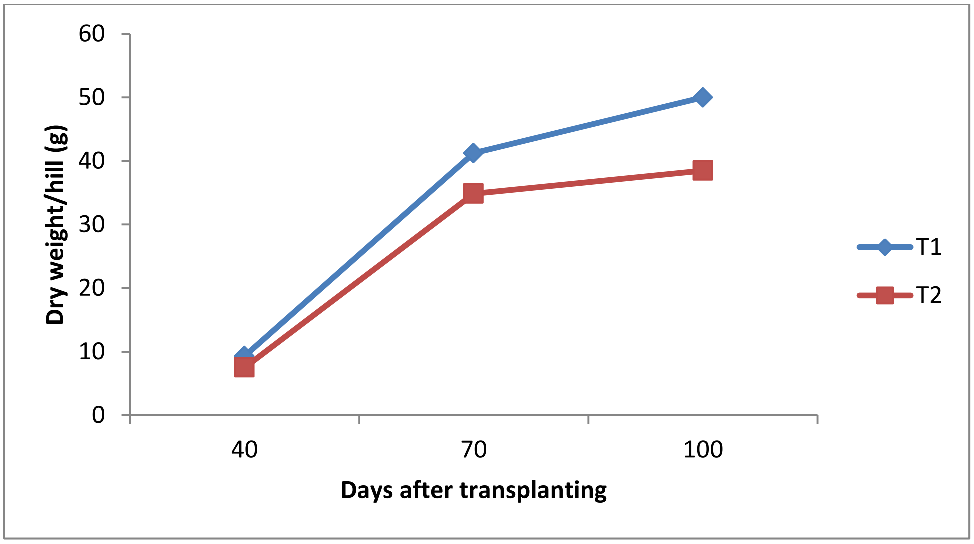

Fig. 7. Effect of different planting times on dry weight hill^{-1} of rice

T_1 = 15 December, T_2 = 15 January

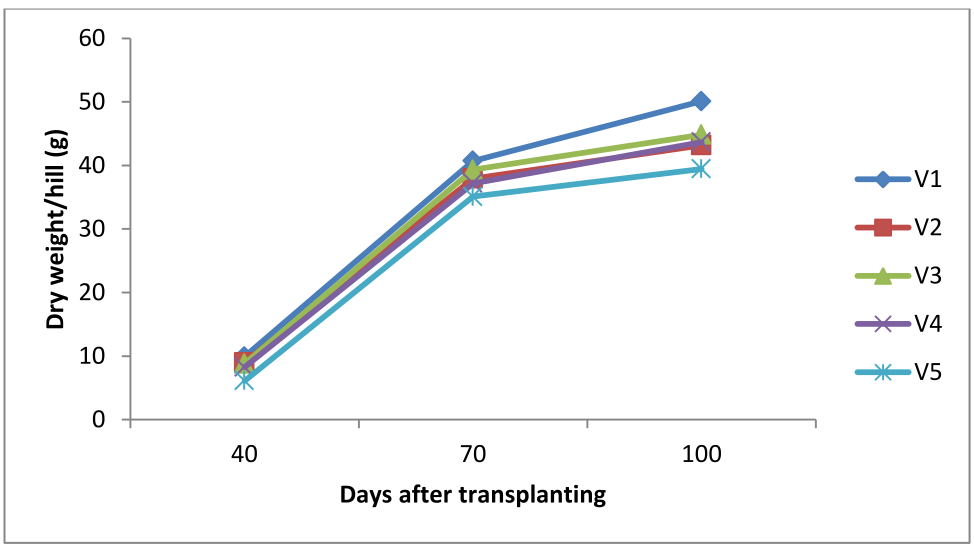

Fig. 8. Effect of different varieties on dry weight hill^{-1} of rice

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

Remarkable variation was found for dry weight hill^{-1} at different growth stages influenced by combined effect of different planting times and varieties (Table 4 and Appendix VIII). It was observed that, the highest dry weight hill^{-1} (11.20, 43.72 and 54.54 g at 40, 70 and 100 DAT, respectively) was found from the treatment combination of T_1V_1 which was significantly different from all other treatment combinations followed by T_1V_3 and T_1V_4. The lowest dry weight hill^{-1} (5.67, 31.66 and 32.37 g at 40, 70 and 100 DAT, respectively) was from the treatment combination of T_2V_5 which was also significantly different from all other treatment combinations but close to T_2V_4 and T_2V_2.

Table 4. Combined effect of planting times and varieties on dry weight hill^{-1} of rice at different days after transplanting

Treatment	Dry weight hill^{-1} (g)		
	40 DAT	70 DAT	100 DAT
T_1V_1	11.20 a	43.72 a	54.54 a
T_1V_2	9.08 c	40.66 b	48.67 bc
T_1V_3	9.37 c	41.42 b	49.69 b
T_1V_4	10.40 b	41.80 b	50.57 b
T_1V_5	6.53 f	38.52 c	46.50 c
T_2V_1	8.58 de	37.67 c	45.64 c
T_2V_2	8.92 cd	35.20 d	37.68 de
T_2V_3	8.24 e	37.21 c	39.96 d
T_2V_4	6.12 fg	32.54 e	36.76 e
T_2V_5	5.67 g	31.66 e	32.37 f
LSD $_{(0.05)}$	0.46	1.74	2.99
CV (%)	5.76	8.22	9.82

T_1 = 15 December, T_2 = 15 January

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

4.5 Leaf area

Leaf area (leaf length × leaf breadth) was recorded due to different transplanting times of rice (Table 5 and Appendix IX). Results indicated that the highest leaf area (leaf length = 31.94 cm and leaf breadth = 1.49 cm) was found from T_1 (Transplanting at 15 December) where the lowest leaf area (leaf length = 26.57 cm and leaf breadth = 1.45 cm) was from T_2 (Transplanting at 15 January).

Significant variation was observed on leaf area (leaf length × leaf breadth) of rice influenced by different varieties (Table 5 and Appendix IX). It was noted that, the highest leaf area (leaf length = 33.97 cm and leaf breadth = 1.57 cm) was found from V_1 (Heera 4) followed by V_2 (Tia), V_3 (Aloron) and V_4 (BRRI hybrid 3) where the lowest leaf area (leaf length = 24.76 cm and leaf breadth = 1.38 cm) was obtained from V_5 (BRRI dhan 29).

There was significant influence on leaf area (leaf length × leaf breadth) of rice affected by combined effect of different planting times and varieties (Table 5 and Appendix IX). Results signified that, the highest leaf area (leaf length = 35.10 cm and leaf breadth = 1.58 cm) was found from the treatment combination of T_1V_1 which was significantly different from all other treatment combinations followed by T_1V_2. The lowest leaf area (leaf length = 23.39 cm and leaf breadth = 1.35 cm) was from the treatment combination of T_2V_5 which was close to the treatment combination of T_2V_2.

Table 5. Effect of different planting times and varieties and also their combination on leaf area (leaf length × leaf breadth) of rice at harvest

Treatment	Leaf length at harvest (cm)	Leaf breadth at harvest (cm)
Effect of planting time		
T_1	31.94 a	1.49 a
T_2	26.57 b	1.45 b
LSD $_{(0.05)}$	1.31	0.03
CV (%)	7.86	2.51
Effect of variety		
V_1	33.97 a	1.57 a
V_2	29.03 b	1.47 b
V_3	29.25 b	1.50 b
V_4	29.28 b	1.45 b
V_5	24.76 c	1.38 c
LSD $_{(0.05)}$	0.95	0.05
CV (%)	7.86	2.51
Combined effect of planting time and variety		
T_1V_1	35.10 a	1.58 a
T_1V_2	33.31 b	1.52 c
T_1V_3	32.65 c	1.50 c
T_1V_4	32.52 c	1.44 de
T_1V_5	26.13 d	1.40 f
T_2V_1	32.83 c	1.55 b
T_2V_2	24.74 e	1.42 ef
T_2V_3	25.85 d	1.49 c
T_2V_4	26.03 d	1.46 d
T_2V_5	23.39 f	1.35 g
LSD $_{(0.05)}$	1.31	0.03
CV (%)	7.86	2.51

T_1 = 15 December, T_2 = 15 January

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

4.6 SPAD value

Different SPAD value in rice leaf was recorded due to different planting times (Table 6 and Appendix IX). Results revealed that the highest SPAD value (44.89) was found from T_1 (Transplanting at 15 December) where the lowest SPAD value (38.95) was from T_2 (Transplanting at 15 January).

Significant variation was observed on SPAD value of leaf influenced by different varieties (Table 6 and Appendix IX). Results exposed that, the highest SPAD value (42.93) was found from V_1 (Heera 4) which was significantly different from all other varieties followed by V_2 (Tia) and V_4 (BRRI hybrid 3). The lowest SPAD value (41.03) was found from V_5 (BRRI dhan 29) which was statistically identical with V_3 (Aloron).

Combined effect of different planting times and varieties showed significant variation on SPAD value (Table 6 and Appendix IX). Results signified that, the highest SPAD value (45.66) was found from the treatment combination of T_1V_1 which was statistically identical with T_1V_4 and statistically similar with T_1V_2. The lowest SPAD value (38.01) was found from the treatment combination of T_2V_5 which was statistically identical with T_2V_3.

Table 6. Effect of different planting times and varieties and also their combination on SPAD value of rice at harvest

Treatment	SPAD value
Effect of planting time	
T_1	44.89 a
T_2	38.95 b
LSD $_{(0.05)}$	1.39
CV (%)	9.39
Effect of variety	
V_1	42.93 a
V_2	42.40 b
V_3	41.06 c
V_4	42.21 b
V_5	41.03 c
LSD $_{(0.05)}$	0.25
CV (%)	9.39
Combined effect of planting time and variety	
T_1V_1	45.66 a
T_1V_2	45.05 ab
T_1V_3	44.51 bc
T_1V_4	45.20 a
T_1V_5	44.05 c
T_2V_1	40.20 d
T_2V_2	39.74 de
T_2V_3	37.60 f
T_2V_4	39.22 e
T_2V_5	38.01 f
LSD $_{(0.05)}$	0.61
CV (%)	9.39

T_1 = 15 December, T_2 = 15 January

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

4.7 Panicle length

Panicle length was recorded due to different planting times of rice (Table 7 and Appendix X). Results indicated that the highest panicle length (23.51 cm) was found from T_1 (Transplanting at 15 December) where the lowest panicle length (22.41 cm) was from T_2 (Transplanting at 15 January).

Significant variation was observed on panicle length of rice influenced by different varieties (Table 7 and Appendix X). It was noted that, the highest panicle lengthh (23.75 cm) was found from V_1 (Heera 4) followed by V_2 (Tia), V_3 (Aloron) and V_4 (BRRI hybrid 3) where the lowest panicle length (22.05 cm) was from V_5 (BRRI dhan 29). Devaraju *et al.* (1998 b), BINA (1993) and Chowdhury *et al.* (1993) achieved similar results from different experiment with different rice varieties.

There was significant influence on panicle length of rice affected by combined effect of different planting times and varieties (Table 7 and Appendix X). Results signified that, the highest panicle length (24.27 cm) was found from the treatment combination of T_1V_1 which was statistically similar with T_1V_4 where the lowest panicle length (20.53 cm) was from the treatment combination of T_2V_5 which was close to the treatment combination of T_1V_5, T_2V2_4, T_2V_3 and T_2V_4.

4.8 Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} was recorded due to different planting times of rice (Table 7 and Appendix X). Results showed that the highest number of filled grains panicle^{-1} (121.42) was found from T_1 (Transplanting at 15 December) where the lowest number of filled grains panicle^{-1} (103.58) was from T_2 (Transplanting at 15 January).

Significant variation was observed on number of filled grains panicle^{-1} of rice influenced by different varieties (Table 7 and Appendix X). It was found that, the highest number of filled grains panicle^{-1} (121.30) was found from V_1 (Heera 4) which was significantly different from others followed by V_3 (Aloron) where the lowest number of filled grains panicle^{-1} (104.60) was from V_5 (BRRI dhan 29) followed by V_2 (Tia) and V_4 (BRRI hybrid 3). Murthy *et al.* (2004) recorded different number of filled spikelets for different variety.

Significant influence on number of filled grains panicle^{-1} of rice was marked as affected by combined effect of different planting times and varieties (Table 7 and Appendix X). It was observed that, the highest number of filled grains panicle^{-1} (132.20) was found from the treatment combination of T_1V_1 which was significantly different from all other treatment combinations followed by T_1V_4. The lowest number of filled grains panicle^{-1} (95.60) was found from the treatment combination of T_2V_5 which was significantly different from all other treatment combinations followed by T_2V_4.

4.9 Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} was recorded due to different planting times of rice (Table 7 and Appendix X). Results showed that the highest number of unfilled grains panicle^{-1} (22.88) was found from T_2 (Transplanting at 15 January) where the lowest number of unfilled grains panicle^{-1} (15.91) was from T_1 (Transplanting at 15 December).

Significant variation was observed on number of unfilled grains panicle^{-1} of rice influenced by different varieties (Table 7 and Appendix X). It was found that, the highest number of unfilled grains panicle^{-1} (30.42) was found from V_5 (BRRI dhan 29) which was significantly different from others followed by V_3 (Aloron) where the lowest number of unfilled grains panicle^{-1} (12.35) was from V_1 (Heera 4) followed by V_2 (Tia) and V_4 (BRRI hybrid 3).

Significant influence on number of unfilled grains panicle^{-1} of rice was marked as affected by combined effect of different planting times and varieties (Table 7 and Appendix X). It was observed that, the highest number of unfilled grains panicle^{-1}

(41.26) was found from the treatment combination of T_2V_5 which was significantly different from all other treatment combinations followed by T_2V_3. The lowest number of unfilled grains panicle^{-1} (11.99) was found from the treatment combination of T_1V_1 which was statistically similar with T_1V_2 and T_2V_1.

4.10 Number of grains panicle^{-1}

Number of grains panicle^{-1} was recorded due to different planting times of rice (Table 7 and Appendix X). Results showed that the highest number of grains panicle^{-1} (137.33) was found from T_1 (Transplanting at 15 December) where the lowest number of grains panicle^{-1} (126.45) was from T_2 (Transplanting at 15 January).

Significant variation was observed on number of grains panicle^{-1} of rice influenced by different varieties (Table 7 and Appendix X). It was found that, the highest number of grains panicle^{-1} (139.20) was found from V_3 (Aloron) followed by V_1 (Heera 4) and V_5 (BRRI dhan 29) where the lowest number of grains panicle^{-1} (124.80) was from V_2 (Tia) which was statistically identical with V_4 (BRRI hybrid 3). Supporting results were achieved by Bhowmick and Nayak (2000), Chowdhury *et al.* (1993), Hossain and Alam (1991).

Significant influence on number of grains panicle^{-1} of rice was marked as affected by combined effect of different planting times and varieties (Table 7 and Appendix X). It was observed that, the highest number of grains panicle^{-1} (144.60) was found from the treatment combination of T_1V_1 which was statistically identical with T_1V_4 and T_2V_3. The lowest number of grains panicle^{-1} (110.80) was found from the treatment combination of T_2V_4 followed by T_2V_2.

4.11 Weight of 1000 grains

Weight of 1000 grains was significantly different due to different planting times of rice (Table 7 and Appendix X). Results showed that the highest 1000 grain weight (27.12 g) was found from T_1 (Transplanting at 15 December) where the lowest 1000 grain weight (25.62 g) was from T_2 (Transplanting at 15 January). Alim *et al.* (1993) reported that better results are obtained from early transplanting than late transplanting.

Significant variation was observed on 1000 grain weight of rice influenced by different varieties (Table 7 and Appendix X). It was found that, the highest 1000 grain weight (27.43 g) was found from V_3 (Aloron) which was statistically identical with V_4 (BRRI hybrid 3) where the lowest 1000 grain weight (24.19 g) was from V_5 (BRRI dhan 29). Bhowmick and Nayak (2000), Mishra and Pandey (1998) and Chowdhury *et al.* (1993) found almost similar results in respect of 1000 grain weight at different varieties of rice.

Significant influence on 1000 grain weight of rice was marked as affected by combined effect of different planting times and varieties (Table 7 and Appendix X). It was observed that, the highest 1000 grain weight (28.70 g) was found from the treatment combination of T_1V_3 which was statistically identical with T_1V_4. The lowest 1000 grain weight (23.80 g) was found from the treatment combination of T_2V_5 followed by T_1V_5.

Table 7. Effect of different planting times and varieties and also their combination on yield contributing parameters of rice at harvest

Treatment	Yield contributing parameters				
	Panicle length (cm)	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of grains panicle^{-1}	1000 grain weight (g)
Effect of planting time					
T_1	23.51 a	121.42 a	15.91 b	137.33 a	27.12 a
T_2	22.41 b	103.58 b	22.88 a	126.45 b	25.62 b
LSD $_{(0.05)}$	0.43	3.12	1.07	3.09	0.37
CV (%)	6.36	11.43	5.32	12.07	8.63
Effect of variety					
V_1	23.75 a	121.3 a	12.35 d	133.7 b	26.76 b
V_2	22.89 b	110.4 c	14.36 c	124.8 c	26.20 c
V_3	23.05 b	114.5 b	24.69 b	139.2 a	27.43 a
V_4	23.07 b	111.6 c	15.16 c	126.8 c	27.28 a
V_5	22.05 c	104.6 d	30.42 a	135.1 b	24.19 d
LSD $_{(0.05)}$	0.33	2.63	0.97	3.00	0.35
CV (%)	6.36	11.43	5.32	12.07	8.63
Combined effect of planting time and variety					
T_1V_1	24.27 a	132.2 a	11.99 f	144.6 a	27.04 b
T_1V_2	23.25 c	116.5 d	12.41 ef	131.2 d	26.82 b
T_1V_3	23.55 bc	120.4 c	14.56 d	134.9 bc	28.70 a
T_1V_4	23.93 ab	124.4 b	18.33 c	142.7 a	28.48 a
T_1V_5	22.57 d	113.7 d	19.58 c	133.2 cd	24.58 e
T_2V_1	23.24 c	110.5 e	12.29 ef	122.8 e	26.48 bc
T_2V_2	22.52 d	104.3 f	14.03 de	118.4 f	25.56 d
T_2V_3	22.56 d	108.6 e	34.81 b	143.4 a	26.37 bc
T_2V_4	22.21 d	98.84 g	14.68 d	110.8 g	25.86 cd
T_2V_5	20.53 e	95.60 h	41.26 a	136.9 b	23.80 f
LSD $_{(0.05)}$	0.53	2.99	1.69	3.27	0.65
CV (%)	6.36	11.43	5.32	12.07	8.63

T_1 = 15 December, T_2 = 15 January

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

4.12 Grain yield

Grain yield was recorded due to different planting times of rice (Table 8 and Appendix XI). Results showed that the highest grain yield (5.63 t ha^{-1}) was found from T_1 (Transplanting at 15 December) where the lowest grain yield (4.19 t ha^{-1}) was from T_2 (Transplanting at 15 January). Singh *et al.*, 1995; Patel and Desai, 1987 reported that grain yield of rice markedly declined with delayed planting.

Significant variation was observed on grain yield of rice influenced by different varieties (Table 8 and Appendix XI). It was found that, the highest grain yield (5.78 t ha^{-1}) was found from V_1 (Heera 4) which was significantly different from all others where the lowest grain yield (3.65 t ha^{-1}) was found from V_5 (BRRI dhan 29) followed by V_2 (Tia) and V_4 (BRRI hybrid 3). The present finding was conformity with Bisne *et al.* (2006), Patel (2000), Devaraju *et al.* (1998 b), Dwivedi (1997) and Chowdhury *et al.* (1993).

Significant influence on grain yield of rice was marked as affected by combined effect of different planting times and varieties (Table 8 and Appendix XI). It was observed that, the highest grain yield (6.60 t ha^{-1}) was found from the treatment combination of T_1V_1 which was statistically identical with T_1V_4 followed by T_1V_2 and T_1V_3. The lowest grain yield (3.18 t ha^{-1}) was found from the treatment combination of T_2V_5 which was statistically identical with T_2V_4 followed by T_1V_5.

4.13 Straw yield

Straw yield was recorded due to different planting times of rice (Table 8 and Appendix XI). Results showed that the highest straw yield (7.80 t ha^{-1}) was found from T_1 (Transplanting at 15 December) where the lowest straw yield (6.42 t ha^{-1}) was from T_2 (Transplanting at 15 January).

Significant variation was observed on straw yield of rice influenced by different varieties (Table 8 and Appendix XI). It was found that, the highest straw yield (7.50 t ha^{-1}) was found from V_1 (Heera 4) which was statistically identical with V_2 (Tia) and V_3 (Aloron). The lowest straw yield (6.33 t ha^{-1}) was obtained from V_5 (BRRI dhan 29) which was close to V_4 (BRRI hybrid 3).

Significant influence on straw yield of rice was marked as affected by combined effect of different planting times and varieties (Table 8 and Appendix XI). It was observed that, the highest straw yield (8.18 t ha^{-1}) was found from the treatment combination of T_1V_1 which was statistically identical with T_1V_2, T_1V_3 and T_1V_4. The lowest straw yield (5.78 t ha^{-1}) was found from the treatment combination of T_2V_5 which was statistically identical with T_2V_4.

4.14 Biological yield

Biological yield was recorded due to different planting times of rice (Table 8 and Appendix XI). Results showed that the highest biological yield (13.43 t ha^{-1}) was found from T_1 (Transplanting at 15 December) where the lowest biological yield (10.61 t ha^{-1}) was from T_2 (Transplanting at 15 January).

Significant variation was observed on biological yield of rice influenced by different varieties (Table 8 and Appendix XI). It was found that, the highest biological yield (13.26 t ha^{-1}) was found from V_1 (Heera 4) which was significantly different from all others followed by V_2 (Tia) and V_3 (Aloron) where the lowest biological yield (9.98 t ha^{-1}) was from V_5 (BRRI dhan 29) followed by V_4 (BRRI hybrid 3).

Significant influence on biological yield of rice was marked as affected by combined effect of different planting times and varieties (Table 8 and Appendix XI). It was observed that, the highest biological yield (14.78 t ha^{-1}) was found from the treatment combination of T_1V_1 which was statistically identical with T_1V_4 followed by T_1V_2 and T_1V_3. The lowest biological yield (8.96 t ha^{-1}) was found from the treatment combination of T_2V_5 which was statistically identical with T_2V_4.

4.15 Harvest index

Harvest index was recorded due to different planting times of rice (Table 8 and Appendix XI). Results showed that the highest harvest index (41.66%) was found from T_1 (Transplanting at 15 December) where the lowest harvest index (39.14%) was from T_2 (Transplanting at 15 January).

Significant variation was observed on harvest index of rice influenced by different varieties (Table 8 and Appendix XI). It was found that, the highest harvest index (43.45%) was found from V_1 (Heera 4) followed by V_3 (Aloron) where the lowest harvest index (36.47%) was from V_5 (BRRI dhan 29).

Significant influence on harvest index of rice was marked as affected by combined effect of different planting times and varieties (Table 8 and Appendix XI). It was observed that, the highest harvest index (44.65%) was found from the treatment combination of T_1V_1 which was statistically identical with T_1V_4 followed by T_2V_1 and T_2V_3. The lowest harvest index (35.49%) was found from the treatment combination of T_2V_5 which was statistically identical with T_1V_5 and T_2V_4.

Table 8. Effect of different planting times and varieties and also their combination on yield parameters of rice at harvest

Treatment	Yield parameters			
	Grain yield t ha^{-1} (t)	Straw yield ha^{-1} (t)	Biological yield ha^{-1} (t)	Harvest index (%)
Effect of planting time				
T_1	5.63 a	7.80 a	13.43 a	41.66 a
T_2	4.19 b	6.42 b	10.61 b	39.14 b
LSD $_{(0.05)}$	0.21	0.31	0.57	0.61
CV (%)	5.05	6.12	8.31	7.37
Effect of variety				
V_1	5.780 a	7.500 a	13.26 a	43.45 a
V_2	5.020 c	7.480 a	12.52 b	40.07 c
V_3	5.200 b	7.260 a	12.45 b	41.79 b
V_4	4.900 c	6.990 b	11.89 c	40.24 c
V_5	3.650 d	6.330 c	9.980 d	36.47 d
LSD $_{(0.05)}$	0.16	0.27	0.33	0.65
CV (%)	5.05	6.12	8.31	7.37
Combined effect of planting time and variety				
T_1V_1	6.60 a	8.18 a	14.78 a	44.65 a
T_1V_2	5.36 b	7.85 a	13.21 b	40.58 bc
T_1V_3	5.55 b	7.96 a	13.51 b	41.08 bc
T_1V_4	6.52 a	8.12 a	14.64 a	44.54 a
T_1V_5	4.12 e	6.88 bc	11.00 e	37.45 d
T_2V_1	4.96 c	6.78 cd	11.74 c	42.25 b
T_2V_2	4.68 d	7.15 b	11.83 c	39.56 c
T_2V_3	4.84 cd	6.55 d	11.39 d	42.49 b
T_2V_4	3.28 f	5.85 e	9.13 f	35.93 d
T_2V_5	3.18 f	5.78 e	8.96 f	35.49 d
LSD $_{(0.05)}$	0.25	0.31	0.34	1.91
CV (%)	5.05	6.12	8.31	7.37

T_1 = 15 December, T_2 = 15 January

V_1 = Heera 4, V_2 = Tia, V_3 = Aloron, V_4 = BRRI hybrid 3, V_5 = BRRI dhan 29

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Research field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2016 to May 2017 to find out the effect of planting times on morpho-physiological and yield attributes of hybrid rice varieties in *Boro* season. Two factors experiment was conducted to evaluate the performance of some hybrid and HYV rice varieties in *Boro* season. In this experiment, the treatment consisted of two planting dates *viz*. T_1 = 15 December 2016 and T_2 = 15 January 2017 and five different varieties (four hybrid and one inbreed) *viz*. V_1 = Heera 4 (hybrid), V_2 = Tia (hybrid), V_3 = Aloron (hybrid), V_4 = BRRI hybrid 3 (hybrid) and V_5 = BRRI dhan 29 (inbreed). The experiment was laid out in two factors Randomized Complete Block Design with four replications. Data on different yield contributing characters and yield were recorded and analyzed with MSTAT-C Computer Package program. Results revealed that planting time, variety and their combination had significant effect on different parameters.

In terms of planting date, the highest plant height (40.11, 64.16 and 98.75 cm at 40 70 and 100 DAT, respectively), number of leaves hill^{-1} (40.46, 62.70 and 68.40 respectively), number of tillers hill^{-1} (7.07, 15.04 and 15.13 at 40, 70 and 100 DAT, respectively) and dry weight hill^{-1} (49.32, 41.22 and 49.99 g at 40, 70 and 100 DAT, respectively) were found from T_1 (Transplanting at 15 December). The highest leaf length (31.94 cm), leaf breadth (1.49 cm), SPAD value (44.89), panicle length (23.51 cm), number of filled grains panicle^{-1} (121.42), 1000 grain weight (27.12 g), number of grains panicle^{-1} (137.33), grain yield (5.63 t ha^{-1}), straw yield (7.80 t ha^{-1}), biological yield (13.43 t ha^{-1}) and harvest index (41.66%) were also found from T_1 (Transplanting at 15 December). The lowest plant height (34.19, 54.58 and 78.71 cm at 40, 70 and 100 DAT, respectively), number of leaves hill^{-1} (39.05, 58.86 and 68.40, respectively), number of tillers hill^{-1} (6.84, 15.93 and 14.51 at 40, 70 and 100 DAT, respectively) and dry weight hill^{-1} (7.51, 34.86 and 38.48 g at 40, 70 and 100 DAT, respectively) were recorded from T_2 (Transplanting at 15 January). The lowest leaf length (26.57 cm), lowest leaf breadth (1.45 cm), the lowest SPAD value (38.95), lowest panicle length (22.41 cm), lowest number of filled grains panicle^{-1} (103.58), lowest 1000 grain weight (25.62 g), the lowest number of grains panicle^{-1} (126.45), lowest grain yield (4.19 t ha^{-1}), lowest straw yield (6.42 t ha^{-1}), lowest biological yield (10.61 t ha^{-1}) and lowest harvest index (39.14%) were also recorded from T_2 (Transplanting at 15 January). The highest and lowest number of unfilled grains panicle^{-1} (22.88 and 15.91 respectively) was found from T_2 (Transplanting at 15 January) and T_1 (Transplanting at 15 December) respectively.

Regarding varietal performance, the highest plant height (39.00, 63.80 and 93.16 cm at 40 70 and 100 DAT, respectively), number of leaves hill^{-1} (44.30, 68.89 and 76.80 at 40 70 and 100 DAT, respectively), highest number of tillers hill^{-1} (8.02, 18.53 and 18.37 at 40, 70 and 100 DAT, respectively) and highest dry weight hill^{-1} (9.91, 40.70 and 50.09 g at 40, 70 and 100 DAT, respectively) were found from V_1 (Heera 4). Again, the leaf length (33.97 cm), leaf breadth (1.57 cm), SPAD value (42.93), panicle length (23.75 cm), number of filled grains panicle^{-1} (121.30), grain yield (5.78 t ha^{-1}), straw yield (7.50 t ha^{-1}), biological yield (13.26 t ha^{-1}) and highest harvest index (43.45%) were also found from V_1 (Heera 4) but the highest 1000 grain weight (27.43 g) was found from V_3 (Aloron) and number of grains panicle^{-1} (139.20) was found from V_3 (Aloron). The lowest plant height (35.37, 57.71 and 85.51 cm at 40 70 and 100 DAT, respectively), number of leaves hill^{-1} (33.95, 51.12 and 63.88, at 40, 70 and 100 DAT, respectively) was obtained from V_5 (BRRI dhan 29), number of tillers hill^{-1} (4.99, 12.92 and 10.11 at 40, 70 and 100 DAT, respectively) and dry weight hill^{-1} (6.10, 35.09 and 39.44 g at 40, 70 and 100 DAT, respectively) were obtained from V_5 (BRRI dhan 29). Again, the lowest leaf length (24.76 cm), leaf breadth (41.38 cm), SPAD value (41.03), panicle length (22.05 cm), lowest number of filled grains panicle^{-1} (104.60), 1000 grain weight (24.19 g), grain yield (3.65 t ha^{-1}), straw yield (6.33 t ha^{-1}), biological yield (9.98 t ha^{-1}) and harvest index (36.47%) were also obtained from V_5 (BRRI dhan 29) but the lowest number of grains panicle^{-1} (124.80) was from V_2 (Tia). The highest and lowest number of unfilled grains panicle^{-1} (30.42 and 12.35 respectively) were found from V_5 (BRRI dhan 29) and V_1 (Heera 4) respectively.

In case of combined effect of planting times and varieties, The highest plant height (42.32, 66.78 and 106.50 cm at 40 70 and 100 DAT, respectively), number of leaves hill^{-1} (44.92, 73.41 and 80.61 at 40 70 and 100 DAT, respectively), number of tillers hill^{-1} (8.32, 18.64 and 19.80 at 40, 70 and 100 DAT, respectively) and dry weight hill^{-1} (11.20, 43.72 and 54.54 g at 40, 70 and 100 DAT, respectively) were found from the treatment combination of T_1V_1. Again, the highest leaf length (35.10 cm), leaf breadth (1.58 cm), SPAD value (45.66) and panicle length (24.27 cm), number of filled grains panicle^{-1} (132.20), the highest number of grains panicle^{-1} (144.60), the highest grain yield (6.60 t ha^{-1}), the highest straw yield (8.18 t ha^{-1}), the highest biological yield (14.78 t ha^{-1}) and the highest harvest index (44.65%) were also achieved from the treatment combination of T_1V_1 but the highest 1000 grain weight (28.70 g) was found from the treatment combination of T_1V_3 where the highest number of unfilled grains panicle^{-1} (41.26) was found from the treatment combination of T_2V_5.

The lowest plant height (31.66, 52.04 and 74.54 cm at 40 70 and 100 DAT, respectively), number of leaves hill^{-1} (33.64, 50.43 and 55.80 at 40 70 and 100 DAT, respectively), number of tillers hill^{-1} (4.88, 12.75 and 9.93 at 40, 70 and 100 DAT, respectively) and dry weight hill^{-1} (5.67, 31.66 and 32.37 g at 40, 70 and 100 DAT, respectively) were found from the treatment combination of T_2V_5. Again, the lowest leaf length (23.39 cm), leaf breadth (1.35 cm) SPAD value (38.01), panicle length (20.53 cm), number of filled grains panicle^{-1} (95.60), 1000 grain weight (23.80 g), grain yield (3.18 t ha^{-1}), straw yield (5.78 t ha^{-1}), biological yield (8.96 t ha^{-1}) and harvest index (35.49%) were also found from the treatment combination of T_2V_5. But the lowest number of grains $panicle^{-1}$ (110.80) was found from the treatment combination of T_2V_4 and lowest number of unfilled grains $panicle^{-1}$ (11.99) was found from the treatment combination of T_1V_1.

From the above results it can be concluded that-

1. Heera 4 provided better yield than the other test varieties.
2. Planting at 15 December provided the best yield for most of the varieties
3. Combination of Variety, Heera 4 with planting date 15 December gave the best results on yield performance. So, this treatment combination may be considered as the best compared to others

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

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

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

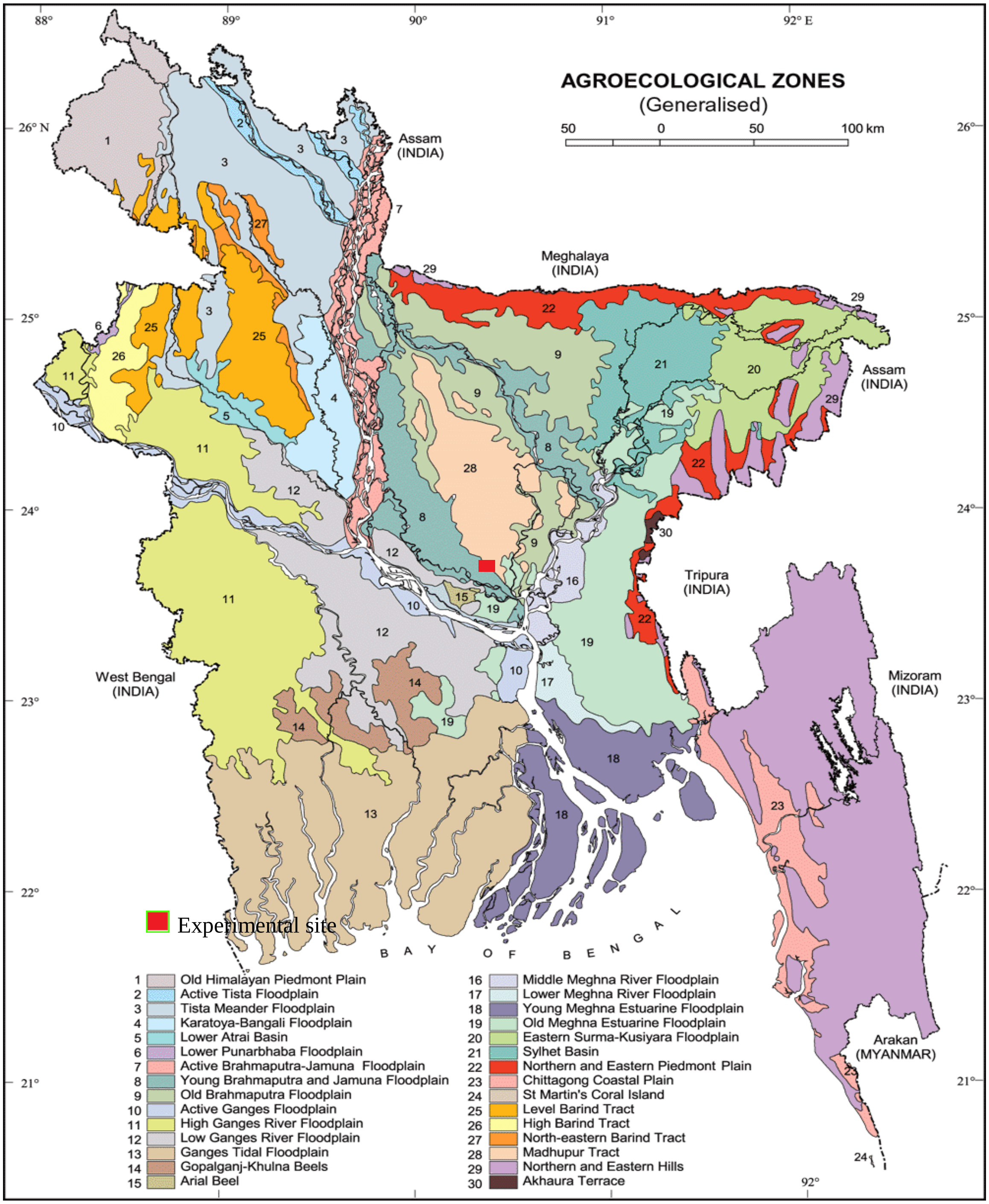


Fig. 9. Experimental site

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from October, 2016 to May, 2017

Month and year	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
October, 2016	68.48	30.42	16.24	23.33	52.60
November, 2016	56.75	28.60	8.52	18.56	14.40
December, 2016	54.80	25.50	6.70	16.10	0.0
January, 2017	46.20	23.80	11.70	17.75	0.0
February, 2017	37.90	22.75	14.26	18.51	0.0
March, 2017	52.44	35.20	21.00	28.10	20.4
April, 2017	65.40	34.70	24.60	29.65	165.0
May, 2017	68.30	32.64	23.85	28.25	182.2

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

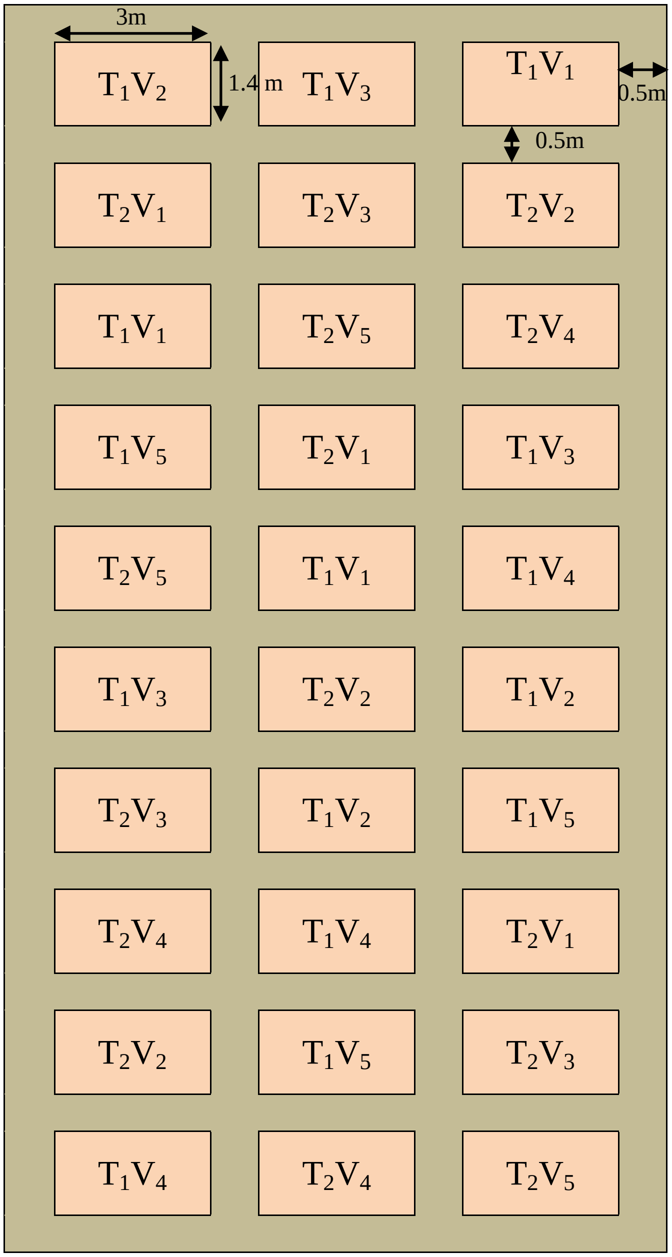
Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Layout of the experiment field



Treatments

Factor A: Planting time

1. T_1= 15 December, 2016
2. T_2= 15 January, 2017

Factor B: variety

1. V_1= Heera 4
2. V_2=Tia
3. V_3=Aloron
4. V_4= BRRI hybrid 3
5. V_5= BRRI dhan 29

Fig. 10. Layout of the experimental field

Appendix V. Effect of different planting times and varieties and also their combination on plant height of rice at days after transplanting

Sources of variation	Degrees of freedom	Mean square of plant height (cm)		
		40 DAT	70 DAT	At harvest
Replication	2	0.312	1.453	2.052
Factor A	1	12.624*	15.84**	27.86*
Factor B	4	28.689*	26.58*	21.94**
AB	4	10.633**	12.66*	11.73**
Error	18	1.314	2.312	3.523

Appendix VI. Effect of different planting times and varieties and also their combination on Number of leaves hill^{-1} of rice at days after transplanting

Sources of variation	Degrees of freedom	Mean square of number of leaves hill^{-1}		
		40 DAT	70 DAT	At harvest
Replication	2	0.694	1.324	1.718
Factor A	1	12.40**	26.92*	23.75**
Factor B	4	21.561*	19.63*	17.62*
AB	4	4.033*	8.88*	8.89*
Error	18	1.053	2.047	3.024

Appendix VII. Effect of different planting times and varieties and also their combination on number of tillers hill^{-1} of rice at days after transplanting

Sources of variation	Degrees of freedom	Mean square of number of tillers hill^{-1}		
		40 DAT	70 DAT	At harvest
Replication	2	0.051	0.407	0.635
Factor A	1	6.300*	9.352**	12.117*
Factor B	4	10.039**	6.604*	21.063*
AB	4	3.151*	4.823*	7.405**
Error	18	0.532	1.018	2.716

Appendix VIII. Effect of different planting times and varieties and also their combination on dry weight hill^{-1} of rice at days after transplanting

Sources of variation	Degrees of freedom	Mean square of dry weight hill^{-1} (g)		
		40 DAT	70 DAT	At harvest
Replication	2	0.526	0.904	1.067
Factor A	1	7.847*	11.298*	14.84**
Factor B	4	11.96**	19.768*	26.97*
AB	4	3.371*	8.231*	9.826*
Error	18	0.539	1.283	3.071

Appendix IX. Effect of different planting times and varieties and also their combination on leaf area (leaf length × leaf breadth) and SPAD value of rice at harvest

Sources of variation	Degrees of freedom	Mean square of leaf area (leaf length × breadth)		Mean square of SPAD value
		Leaf length	Leaf breath	
Replication	2	0.316	0.018	0.356
Factor A	1	8.325*	0.427	14.234*
Factor B	4	12.055**	0.738*	10.222*
AB	4	5.319*	0.216*	6.218*
Error	18	0.422	0.018	1.271

Appendix X. Effect of different planting times and varieties and also their combination on yield contributing parameters of rice at harvest

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters				
		Panicle length (cm)	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	1000 grain weight (g)	Number of grains panicle^{-1} (g)
Replication	2	0.085	2.053	0.076	1.804	1.661
Factor A	1	8.016*	11.524*	1.887*	16.234	13.385 *
Factor B	4	4.624**	9.119*	5.624**	12.783*	9.563*
AB	4	4.229*	4.211*	2.736*	5.252*	15.088*
Error	18	1.066	1.312	0.036	1.371	1.314

Appendix XI. Effect of different planting times and varieties and also their combination on yield parameters of rice at harvest

Sources of variation	Degrees of freedom	Mean square of yield parameters			
		Grain yield ha^{-1} (t)	Straw yield ha^{-1} (t)	Biological yield ha^{-1} (t)	Harvest index (%)
Replication	2	0.752	0.825	1.034	1.277
Factor A	1	6.268*	9.689*	12.871 *	15.73*
Factor B	4	9.222*	18.09*	8.309*	10.84**
AB	4	14.07**	7.329*	6.376*	6.932*
Error	18	1.036	1.114	1.235	1.077