EFFECT OF DATE OF TRANSPLANTING ON GROWTH AND YIELD OF HYBRID RICE IN *BORO* SEASON

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

MASTER OF SCIENCE (MS)
IN
AGRICULTURAL BOTANY
Semester: July – December, 2010

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To my father, Md. Mosharaf Hossain,

Without whose inspiration
this thesis would not have been possible.

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF DATE OF TRANSPLANTING ON GROWTH AND YIELD OF HYBRID RICE IN *BORO* SEASON"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURAL BOTANY**, embodies the results of a piece of bonafide research work carried out by **MD. MOSHREFUL HASAN**, Registration number: **04-01359** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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ACKNOWLEDGEMENTS

*All praises are due to **Almighty Allah**, the Great, Gracious and Merciful, Whose blessings enabled the author to complete this research work successfully.*

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

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

The author expresses his heartfelt thanks to all the teachers of the Department of Agricultural Botany, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

*The author thanks to all his seniors and friends, especially **Alif, Apurbo, Champa, Chamili, Mukul, Nahar, Reza, and Sudip** for their help, encouragement and moral support towards the completion of the degree.*

*Last but not least, the author expresses his heartfelt gratitude and indebtedness to his beloved father **Md. Mosharaf Hossain**, mother **Mrs. Marjina Begum**, brother and sisters for their inspiration, encouragement and blessings that enabled him to complete this research work.*

The Author

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ABSTRACT

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during December 2010 to May 2011 with a view to investigate the effect of date of transplanting on the growth and yield of hybrid rice varieties in *Boro* season. The experiment included two hybrid and one inbred rice varieties *viz*. Aloron, BRRI hybrid dhan2, and BRRI dhan45, and three transplanting dates *viz*. 30 December, 15 January and 31 January. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The studied hybrid rice varieties differed significantly from inbred BRRI dhan45 in respect of growth, yield and yield contributing attributes. BRRI hybrid dhan2 produced the maximum number of tillers hill^{-1} (16.42) at 70 days after transplanting (DAT) in 30 December followed by Aloron (12.96) at 70 days after transplanting in 30 December. At 90 DAT, the highest total dry matter (32.22 g plant^{-1}) was achieved from BRRI hybrid dhan2 followed by Aloron (31.74 g plant^{-1}), regardless of transplanting date. BRRI hybrid dhan2 gave the highest grain yield (4.25 t ha^{-1}), irrespective of transplanting dates. Among the three transplanting dates, 30 December transplanting exhibited the highest grain yield (4.55 t ha^{-1}). The significant highest grain yield (5.38 t ha^{-1}) was found from the combination of BRRI hybrid dhan2 and 30 December transplanting while the lowest (2.88 t ha^{-1}) from Aloron at 31 January transplanting. This higher grain yield was attributed by the higher number of effective tillers hill^{-1} and filled grain panicle^{-1}, and heavier grain size of the BRRI hybrid dhan2. So, hybrid dhan2 is suitable for early *Boro* season.

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CHAPTER I

INTRODUCTION

Rice is the second most important cereal in the world. It is the staple food for about half of the world's population. Rice is extensively grown in Bangladesh There are three rice growing seasons in Bangladesh namely, *Aus, Aman* and *Boro*, which covers 80% of the total cultivable area of the country (AIS, 2011). In Bangladesh total rice cultivable land is 90, 98,460 hectare. The total production of rice in the year of 2011 is 3, 35, 41,099 metric ton. Hybrid rice is cultivated 6, 53,000 hectare of land and total production is 28, 82,000 metric ton in the year of 2010-2011.On the other hand, High yielding variety (HYV) is cultivated 40, 67, 000 hectare land and the total production of rice is 1, 56,32,000 metric ton. The average rice production of hybrid rice variety is 4.41 metric t ha^{-1} and HYV is 3.84 metric t ha^{-1} in the year of 2010 to 2011 (DAE, 2012).

Yield is the cumulative effect of inherent characteristics of a variety as well as management practices under where it is grown. Variety is the most significant factor for increasing rice production. Inbred rice varieties in Bangladesh have longer growth period of 150 to 160 days in *Boro* season with a lower yield, while higher yield we get from hybrid rice varieties, because of its higher dry matter accumulation ability in both vegetative and reproductive stages (Julfiquar *et al*., 1998). By Cultivating hybrid rice varieties, crop duration can be reduced 20 to 40 days, which can facilitate a massive change in our cropping system.

In each and every year we need more production of rice. The additional rice production has to come from either an expansion of the planting area or an increasing yield, or both of them. The land area under rice production is actually declining due to the pressure of urbanization, industrialization, crop diversification and other economic factors. In this point of view, horizontal expansion of rice area is not possible in Bangladesh. So, the only avenue left is to increase production of rice by vertical means, that is, management practices and introduction of higher yielding hybrid varieties.

Variety is a genetic factor which contributes a lot in producing yield and yield components of hybrid rice in *Boro* season. Yield components are directly related with variety, date of transplanting and other environmental factors in where it is grown. In the time of heading and post heading stages, hybrid rice varieties are very much sensitive to temperature compared to inbred. It is therefore, essential to generate adequate information on planting time of hybrid varieties to exploit its better growth and productivity over inbred.

Keeping all the points in mind mentioned above, the present piece of research work was undertaking with the following objectives:

i. to compare the performance of hybrid rice and inbred rice varieties in *Boro* season.
ii. to determine the effect of transplanting date on the growth and yield of BRRI hybrid dhan2 and Aloron in *Boro* season.
iii. to investigate the interaction effects of variety and transplanting date on the yield and yield attributes of afore-mentioned hybrid rice varieties.

CHAPTER II

REVIEW OF LITERATURE

Several research works have been carried out throughout the world on the effect of transplanting date on growth and yield of hybrid rice varieties in *Boro* (dry) season. Some of the relevant findings have been reviewed and showed in this chapter:

2.1 Effect of variety

Variety is the genetic factors which have enormous effect on the yield and yield contributing characters of hybrid rice production in *Boro* season.

Julfiquar *et al.* (1998) reported that BRRI evaluated twenty three hybrid rice variety along with three standard check variety during *Boro* season 1994-95 as preliminary yield trial at Gazipur and it was reported that five hybrids (IR 58025A/IR 54056, IR 54883, PMS 8A/IR 46R) out yielded over the check varieties (BR 14 and BR 16) with significant yield difference. Julfiquar *et al.* (1998) also reported that thirteen hybrid rice varieties were evaluated in three locations of BADC farm during the *Boro* season of 1995-96. Two hybrids out yielded over the check variety of same duration by more than 1 t ha^{-1}.

Wang *et al.* (2006) studied the effects of plant density and row spacing on the yield and yield components of hybrids and conventional cultivars of rice. Compared to the conventional cultivars, the hybrids had larger panicle, heavier seeds, resulting in an average yield increase of 7.27%.

Swain *et al.* (2006) also reported that the control cultivar IR 64, with high translocation efficiency and 1000 grain weight and lowest spikelet sterility recorded a grain yield of 5.6 t ha^{-1} that was at par with hybrid PA 6201.

Molla (2001) reported that Pro-agro 6201 (hybrid) was a significant higher yield than IET 4786 (HYV), due to more mature panicle m^{-2}, higher number of filled grains $panicle^{-1}$ and more seed weight.

BRRI (1998) reported that three modern upland rice varieties namely, BR 20, BR 21, BR 24 was suitable for high rainfall belts of Bangladesh. Under proper management, the grain yield was 3.5 ton for BR 20, 3.0 ton for BR 21 and 3.5 ton for BR 24 ha^{-1}.

Pruneddu and Spanu (2001) conducted an experiment with 18 varieties to know the varietal performance of rice. They classified them into five groups according to grain properties and the highest yield was obtained from the long-grained varieties (9.1 t ha^{-1}), while the lowest was recorded in aromatic rice variety (3.15 t ha^{-1}).

Mondal *et al*. (2005) conducted an experiment with 17 modern varieties of rice in north region of Bangladesh and reported that BRRI dhan36 produced the highest grain yield (5.30 t ha^{-1}) due to superior yield components. Further, Rahman (2002) studied seven fine grain rice (Ukunimadhu, Bullet, Hetkumra, Ghunshi, Bojromuri, Hoglapata and Binashail) to assess their yield and yield contributing characters and reported that Binashail produced the highest grain yield (5.36 t ha^{-1}) due to the production of maximum effective tillers m^{-2}, filled grains $panicle^{-1}$, and better partitioning; while Hetkumra, an aromatic rice, produced the lowest (2.70 t ha^{-1}).

2.2 Effect of transplanting time

Planting time for successful hybrid rice cultivation widely depends on genotype, growth duration, sensitivity to photoperiod, temperature, rainfall and other environmental factors. Some related findings on planting times of hybrid and inbred rice varieties are reviewed under the following headings:

If photosensitive varieties are transplanted in early period, their vegetative growth stage extended and resulted more plant height and leafy growth. Due to increased plant height, such varieties lodge badly when transplanted early. As a result, the grains yield from such hybrid rice varieties are reduced drastically. On the other hand, when transplanting is delayed, underdeveloped grains production increased, which ultimately cause of poor grains yield (Kainth and Mehra, 1985).

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 of the cases, tillering rate decreased because of low temperature. So, appropriate planting time and the use of proper sun light, cultivars can be advantageous to avoiding low temperature damages during reproductive development. Gohain and Saikia (1996) reported that earlier planting of high yielding rice varieties in mid-July was the best grains yield. Later 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 case of hybrid rice production, the optimum leaf area index (LAI) at flowering and crop growth rate (CGR) at panicle initiation stages have 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. Thakur and Patel (1998) reported that dry matter production, leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) and relative growth rate (RGR) are ultimately reflected in higher grains yield of hybrid rice. Crop growth rate is the most critical growth attributes for hybrid 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 and effective tillers hill^{-1}, leaf area index, dry matter accumulation, relative growth rate, fertile spikelet panicle^{-1}, 1000 grain weight and straw yield (Nayak, *et al.*, 2003). Hundal *et al.* (2005) observed the significant linear and exponential relationships between leaf area index and above ground biomass and yield of rice. Planting time had directlly influenced on above attributes.

Yield components like panicle plant^{-1}, grains panicle^{-1} and 1000 grain weight increased yield in modern rice varieties (Saha Ray *et al.*, 1993). Haque *et al.* (1991) reported negative association of 1000 grain weight and yield plant^{-1} in traditional varieties but positive association of yield plant^{-1} with the number of panicle plant^{-1} in modern varieties. Other reports revealed that number of panicle hill^{-1}, 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 attributes which affecting the rice yields. Number of panicle hill^{-1} and number of spikelet's panicle^{-1} had negatively direct effects on grain yield (Padmavathi *et al.*, 1996). Surek *et al.* (1998) found that biological yield of rice had direct effect on grain yield followed by harvest index and 1000 grain weight. (Hussain *et al.*, 1989) stated that grains panicle^{-1} had the maximum positive direct effect on yield of rice followed by 1000 grain weight, panicle length and number of panicle hill^{-1}.

The highest grains yield of rice was obtained from transplanting at July15. The highest grain yield was obtained due to cumulative effect of longer panicle, highest number of grains panicle^{-1} and 1000 grain weights (Salam *et al.*, 2004). Similar result was also reported by Rahman (2003). Islam *et al.* (2008) reported that wet seeded rice produced 10% higher grain yield than the transplanted rice pland on 31 December wet seeded rice produced the highest grain yield. Rice transplanted on 01 December, significantly reduced the grains panicle^{-1} and on 31 January, planted rice significantly reduced the panicle per unit area.

Yield and yield parameters like, number of tillers hill^{-1}, grains panicle^{-1}, 1000 grain weight and sterility were significantly affected by transplanting time. Basmati-385 and Super Basmati produced more when transplanted on 01 July and 11 July, respectively. Minimum sterility were 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 01 July, 11 July and 31 July (Akram *et al.*, 2004). Spikelet sterility was higher in rice transplanted on June 30 as compared with transplanted on 15 June due to reduced growth phases and low temperature during reproductive phase.

Due to heat stress, germination percentage is reduced and that causes seed setting rate decreased, ultimately 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 an hour exposure to 33.7^{0}C at anthesis caused sterility. In IR64, spikelet fertility was reduced about 7% by degree^{-1} 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). Number of filled grains panicle^{-1} reduced significantly under the high temperature (day mean temperature 30^{0}C). The highest temperature also increased the chalkiness score, and reduced milled rice, amylase content, alkali value, eating and aroma scores, and gel consistency (Xu *et al.*, 2006).

Low temperature is a cause for spikelet sterility of hybrid rice production during panicle development stage. Since the susceptibility of rice plants to low temperature often changes according to its physiological status during sensitive stages. Low water temperature (below 20^{0}C) during vegetative growth significantly increased the sterility. 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 suggested that temperatures before panicle initiation stage change the susceptibility of a rice plant to low temperatures during panicle development which results in spikelet sterility.

(Patel *et al.,* 1987) also reported that grain yield of rice markedly declined with delayed transplanting.

Ali *et al*. (1995) transplanting of hybrid rice ((BR-1, BR-3, BR-14) in *Boro* season at first week of January, February and March; reported that February planting is the best for yield attributes and grain yield in all the varieties.

BRRI (1998) evaluated the performance of four promising lines under different dates of transplanting (25 December, 10 January and 10 February) and reported that all the tested lines performed the best when transplanted on 10 January. We may conclude from the above reviews that the varietal differences and time of transplanting has considerable effects on total production in *Boro* season.

2.3 Combined effect of variety and transplanting time

An experiment was conducted by Yeasmin (2006) during the period from November to June to study the performance of hybrid rice varieties in Boro season as affected by date of transplanting. The experiment comprised four hybrid rice varieties in *Boro* season viz. Hira2, Aftab, Jagorini and BRRI dhan29 and five dates of transplanting viz. 17 December, 01 January, 16 and 31 and 15 February. The author reported that the highest grain yield (5.93 t ha^{-1}), biological yield (13.02 t ha^{-1}) and harvest index (45.55%) were produced by the variety of Jagorini. This variety produced maximum number of effective tillers $hill^{-1}$, number of grains $panicle^{-1}$ and 1000 grain weight. On the other hand, BRRI dhan29 produced the lowest values form the said parameters.

A field experiment was set by BINA (2006) with three promising rice mutants (TNBD-100, Y-1281 and RD-25-56) along with one check variety (BRRI dhan28) to know the performance under of planting four dates (01 and 15 January; 01 and 15 February) during *Boro* season and reported that TNDB-100 produced the highest grain yield where BRRI dhan28 produced the lowest grain yield.

CHAPTER III

MATERIALS AND METHOD

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh, during December 2010 to May 2011 with a view to investigate the effect of date of transplanting on growth pattern and yield of hybrid rice in *Boro* season. The details of the materials and method have been presented below:

3.1 Description of the experimental site

3.1.1 Location

This research work was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka 1207. The location of the site is $23^{0}74'$N latitude and $90^{0}35'$E longitude with an elevation of 8.2 meter from sea level.

3.1.2 Soil

The soil belongs to "The Modhupur Tract", AEZ 28 (Appendix I). Top soil is silty clay in texture with distinct dark yellowish brown mottles in colour. The soil pH is 5.6 and has organic carbon 0.45%. The experimental area is flat having available irrigation and drainage system. The selected plot is medium high land. The details have been presented in Appendix III.

3.1.3 Climate

The geographic 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, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix II.

3.2 Test crop and their characteristics

BRRI dhan45: This inbred variety was developed by Bangladesh Rice Research Institute (BRRI), Gazipur, it is released as a variety in the year of 2005. It is recommended for *Boro* season (November to February). Average plant height of the variety is 100 cm at the ripening stage. The grains are medium fine and white in color. It requires about 145 days on an average for completing its life cycle with an average grain yield is 6.5 t ha^{-1} (BRRI, 2010).

Aloron: It is a hybrid rice variety and developed in China and marketed in Bangladesh by ACI Ltd. The variety has the ability to produce grain yield 8.5 to 9.5 t ha^{-1}, growth duration 104 to 130 days, plant height is semi dwarf (100 to 120 cm) , and suitable in irrigated soil.

BRRI hybrid dhan2: It is another hybrid rice variety developed by the Bangladesh Rice Research Institute (BRRI), Gazipur. It was recommended for *Boro* season (November to February). The grains are medium fine and white in color. It requires about 145 days on an average for completing its life cycle with an average grain yield of 8.0 t ha^{-1} (DAE-2012).

3.3 Experimental details

3.3.1 Treatments

This experiment comprised of two factors. These are:

Factor A: Variety

i. Aloron
ii. BRRI Hybrid dhan2
iii. BRRI dhan45

Factor B: Three transplanting date

i. 30 December
ii. 15 January
iii. 31 January

3.3.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The layout of the experiment was prepared for distributing the combination of variety and transplanting date. Thus there were thirty six unit plots. The nine treatments were assigned randomly at nine plots of each block, where each blocks representing a replication.

3.4 Crop growing

3.4.1 Raising seedlings

3.4.1.1 Seed collection

The seed of the crops i.e. Aloron, BRRI Hybrid dhan2 and BRRI dhan45 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur.

3.4.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method, and then soaked the seeds into water for 24 hours and after that separated seeds from water, kept tightly in gunny bags. Seeds were started sprouting after 48 hours and sown after 72 hours.

3.4.1.3 Preparation of seedling nursery bed and seed sowing

As per BRRI recommendation, seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seedbed on 10 November, 25 November, and 10 December in order to transplant the seedlings in the main field.

3.4.2 Preparation of the field

The field was opened in the first week of December, 2010 with a power tiller, and was exposed to the sun for a week, after that the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.4.3 Fertilizers and manure application

Cowdung was applied to the plot @ 8.0 t ha^{-1} just 15 days before of land preparation. Urea, TSP, MP, Gypsum and Borax were applied to supply N, P, K, S and B. The entire amount of TSP, MP, Gypsum, Zinc Sulphate and Borax were applied during the final land preparation. Urea was top dressed in two equal installments at tillering and panicle initiation stages. The dose and method of application of fertilizers are shown in Table 1.

Table 1. Dose and methods of fertilizers application

Fertilizers	Dose ha^{-1}	Application (%)		
		Basal	1st installment	2nd installment
Urea	120 kg	--	50	50
TSP	100 kg	100	--	--
MP	100 kg	100	--	--
Gypsum	60 kg	100	--	--
Borax	10 kg	100	--	--

Source: Adunik Dhaner Chash, 2010, BRRI, Joydevpur, Gazipur

3.4.4 Uprooting of seedlings

The nursery bed was made by application of water one day before uprooting of the seedlings. The seedlings were uprooted on 29 December, 14 January, and 30 January for transplant to the respective plots on 30 December, 15 January, and 31 January without causing much mechanical injury to the roots.

3.4.5 Transplanting of seedlings

On the scheduled dates as per experiment, the seedlings were transplanted in lines each having a line to line distance was 25 cm and plant to plant distance was 15 cm in the well prepared plots.

3.4.6 After care

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

3.4.6.1 Irrigation and drainage

Flood irrigation was provided to maintain a constant level of standing water up to 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering and weed growth. The field was finally dried out at 15 days before harvesting.

3.4.6.2 Gap filling

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

3.4.6.3 Weeding

Weeding was done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at tillering stage and at panicle initiation stage by mechanical means.

3.4.6.4 Top dressing

After basal dose, the remaining doses of urea were top dressed in 2 equal installments at tillering and panicle initiation stages.

3.4.6.5 Plant protection

Furadan 5G was applied at the time of final land preparation and later on other insecticides were applied when necessary.

3.5 Harvesting, threshing and cleaning

The crop was harvested depending upon the maturity of plant and harvesting was done manually from the central 6 m^2 undisturbed areas of each unit plots. The harvested plants of each plot was bundled separately, properly tagged and brought to threshing floor. Paddle thresher was used for separating grains. However, enough care was taken during harvesting, threshing, cleaning and drying of rice grains and straw. Finally grain moisture content was adjusted to 14%.

3.6 Data collection

3.6.1 Plant height

The height of the plant was recorded in centimeter (cm) at the 50, 70, 90 days after transplanting (DAT). Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the tiller.

3.6.2 Tillers hill^{-1}

The number of tillers hill^{-1} was estimated at the 30, 50, 70 and 90 DAT by counting total tillers hill^{-1}. Data were recorded as the average of 5 hills selected at random from the inner rows of each plot.

3.6 Plant sampling and measurement of dry matter accumulation

Plants were sampled at the 30, 50, 70 and 90 days after transplanting, sequentially. At each sampling, 5 plants were uprooted sequentially from a single row of each unit plot. The hills were separated into leaf blade, stem (culm + leaf sheath), and panicles (if present).The separated plant samples were kept in separate envelopes after proper recording and was oven dried at 70^{o}C for 72 hours. Then, Leaf dry matter plant^{-1}, stem (culm + leaf sheath) dry matter plant^{-1} and panicle dry matter plant^{-1} were recorded using a digital balance. Finally total dry matter (TDM) was calculated adding the dry matter of different plant parts.

3.6.7 Panicle length

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

3.6.8 Filled grain panicle^{-1}

The number of filled grains was recorded at random from selected 5 plants of each plot and then average number of filled grains panicle^{-1} was recorded.

3.6.9 Unfilled spikelet panicle^{-1}

The number of unfilled spikelet was collected at random from selected 5 plants in each plot and then average number of unfilled spikelet panicle^{-1} was recorded.

3.6.10 Thousand seed weight

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

3.6.11 Grain yield ha^{-1}

Grain yield was taken from the afore-mentioned 6 m^2 area of each unit plots and then converted to t ha^{-1}.

3.6.12 Straw yield ha^{-1}

Straw obtained from the afore-mentioned 6 m^2 area each unit plots were recorded and finally converted to t ha^{-1}.

3.6.13 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.6.14 Harvest index (%)

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

$$\text{HI (\%)} = \frac{\text{Grain weight}}{\text{Biological yield}} \times 100$$

3.7 Statistical Analysis

The data obtained for different characters were statistically analyzed. The significant difference among the treatments means was estimated by the Duncan's Multiple Range Difference (DMRT) test at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

RESULTS AND DISCUSSION

The results of the present study have been presented and discussed in this chapter under the following heading:

4.1 Plant height

Plant height was significantly influenced by variety at all the sampling dates (Figure 1). Irrespective of varieties, height of the plants increased rapidly from tillering to heading stage. BRRI hybrid dhan2 produced the tallest plant (78.33 cm, 91.39 cm and 103.11 cm) at the 50, 70 and 90 DAT, respectively while Aloron gave the shortest plant. The variation of plant height among the varieties might be due to their inherent characters, which is in agreement with the reports of BINA (1992), BRRI (1991) and Shamsuddin *et al.* (1988).

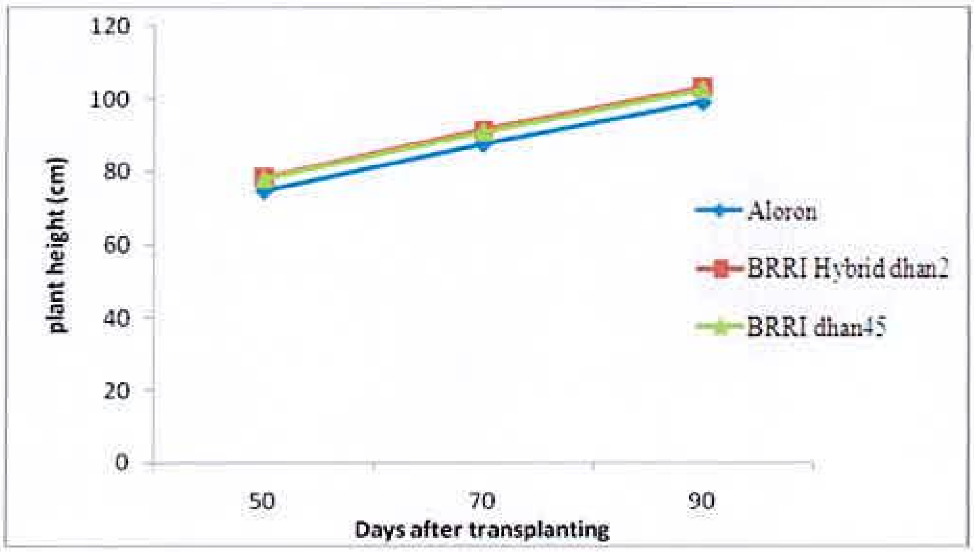

Figure 1. Effect of variety on plant height of hybrid and inbred rice varieties in *Boro* season

Plant height of rice showed that statistically significant differences at 50, 70 and 90 DAT due to the different planting dates. The tallest plant was recorded (79.19 cm, 94.05 cm and 103.72 cm) at 50, 70 and 90 DAT, respectively at 30 December transplanting, while the shortest plants (75.39 cm, 87.11 cm and 98.44 cm) was observed at 50, 70 and 90 DAT, respectively in the 31 January transplanting (Fig. 2).

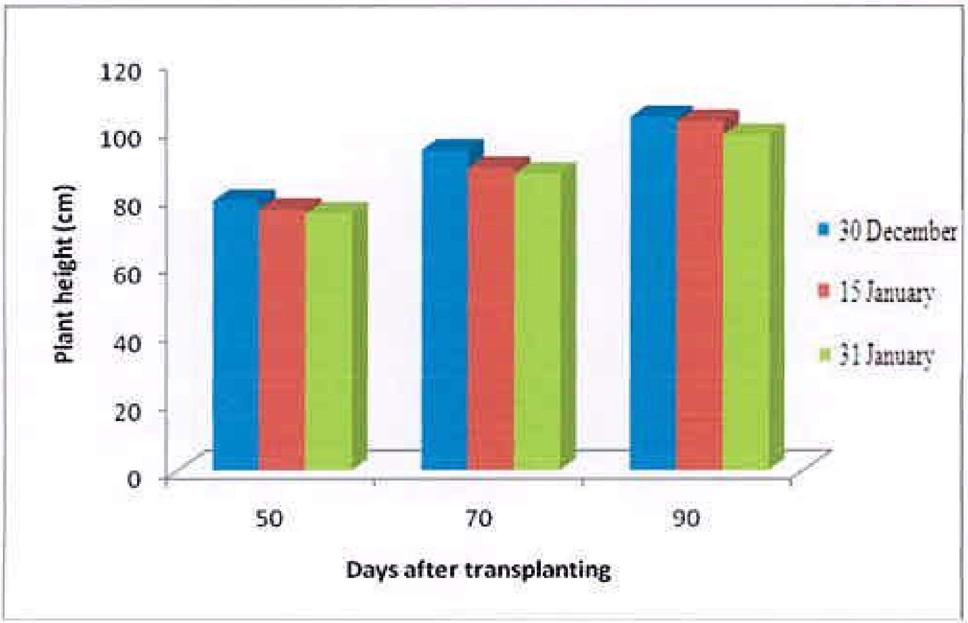

Figure 2. Effect of transplanting date on plant height of hybrid and inbred rice varieties in *Boro* season

Delayed transplanted hybrid rice was subjected to the higher temperature during vegetative growth which might have shortened the plant height. Plant height at different days after transplanting was significantly affected by the interaction between variety and planting date (Table 2). The tallest plant height was recorded from BRRI hybrid dhan2 at 30 December transplanting and the shortest plant height was recorded from variety of Aloron at 31 January transplanting.

Table 2. Interaction effect of variety and transplanting date on plant height of hybrid and inbred rice varieties in *Boro* season

Variety x Transplanting date	Plant height (cm)		
	50 DAT	70 DAT	90 DAT
Aloron x 30 Dec	5.85ab	8.08d	100.70b
Aloron x 15 Jan	5.53ab	9.39bc	103.20a
Aloron x 31 Jan	4.30b	9.75b	93.33c
BRRI Hybrid dhan2 x 30 Dec	6.87a	11.23a	104.7a
BRRI Hybrid dhan2 x 15 Jan	5.64ab	9.69b	103.50a
BRRI Hybrid dhan2 x 31 Jan	6.04ab	9.39bc	101.20b
BRRI dhan45 x 30 Dec	4.79ab	9.28bc	103.30a
BRRI dhan45 x 15 Jan	5.01ab	8.85c	103.30a
BRRI dhan45 x 31 Jan	6.24ab	8.84c	100.80b
$LSD_{(0.05)}$	2.14	0.51	1.91
CV	10.10	9.36	5.00

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

4.2 Tillers hill^{-1}

The number of tillers hill^{-1} was significantly influenced by variety indifferent days after transplanting (DAT) (Figure 3). Varietal effects on the number of tillers hill^{-1} at different days after transplanting are shown in Figure 3. BRRI hybrid dhan2 exhibited the maximum tillers hill^{-1} which is 9.07, 13.74, 14.11 and 12.947 at 30, 50, 70 and 90 DAT, respectively, whereas Aloron provided the minimum tillers hill^{-1} 5.31, 10.59, 10.72 and 9.92 at 30, 50, 70 and 90 DAT, respectively. Variable effect of variety on number of tillers hill^{-1} was also reported by Hussain *et al.* (1989) who noticed that the number of tillers hill^{-1} differed among the varieties

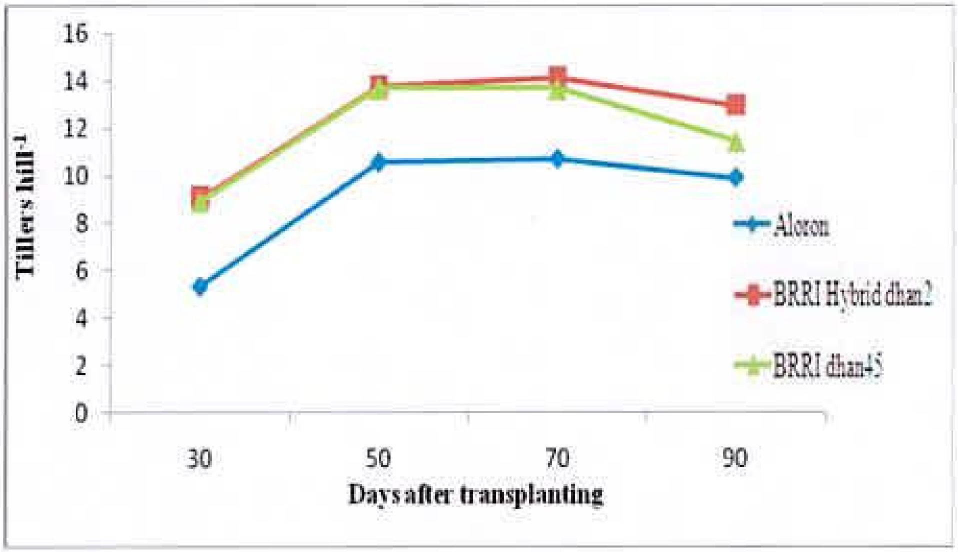

Figure 3. Effect of variety on tillers hill^{-1} of hybrid and inbred rice varieties in *Boro* season

Statistically significant variation was recorded from the number of tillers hill^{-1} at 30, 50, 70 and 90 DAT among the different planting dates. The maximum number of tillers hill^{-1} was obtained (8.40, 12.72, 13.92 and 12.22) at 30, 50, 70 and 90 DAT, respectively at 30 December transplanting, while the minimum number was recorded 7.11, 12.03, 12.17 and 10.54 at 30, 50, 70 and 90 DAT, respectively at 31 January transplanting (Figure 4). The number of tillers hill^{-1} decreased rationally irrespective of all transplanting date after peak as tillers survival was negatively correlated to the maximum tillers number (Schnier *et al.*, 1990) and mutual shading of the crop tillering rate reached its peak at 40 to 50 days after transplanting.

In contrast with Vergara and Chang (1985) reported that in November planting of BR3 when the temperature was cool, the vegetative phase was extended by 50 days and the relative planting date in July when the temperature was high, the relative tillering rate reached the highest value within 15 to 25 days after transplanting.

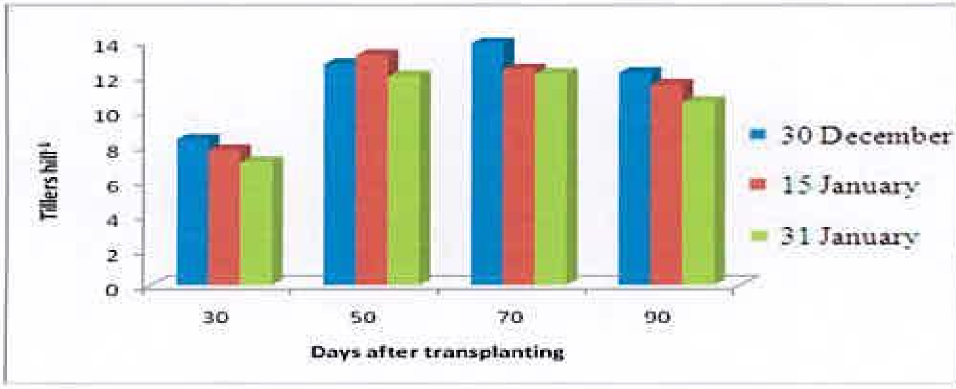

Figure 4. Effect of transplanting date on tillers hill^{-1} of hybrid and inbred rice varieties in *Boro* season

The interaction effect of variety and planting date on the number of tillers hill^{-1} was statistically significant at different days after transplanting (Table 3).The maximum tillers hill^{-1} 10.58, 14.67, 16.42 and 14.08 at 30, 50, 70 and 90 DAT, respectively were found in BRRI hybrid dhan2 at 30 December transplanting and the minimum tillers hill^{-1} 4.42, 8.17, 9.58 and 7.88 at 30, 50, 70 and 90 DAT, respectively from Aloron with transplanting at 31 January.

Table 3. Interaction effect of variety and transplanting date on tillers hill^{-1} of hybrid and inbred rice varieties in *Boro* season

Variety x Transplanting date	Tillers hill^{-1}			
	30 DTA	50 DTA	70 DTA	90 DTA
Aloron x 30 Dec	6.21d	12.92b	12.96de	10.96b
Aloron x 15 Jan	5.29de	10.67c	10.63ef	10.92b
Aloron x 31 Jan	4.42e	8.17d	9.58f	7.88c
BRRI Hybrid dhan2 x 30 Dec	10.58a	14.67a	16.42a	14.08a
BRRI Hybrid dhan2 x 15 Jan	8.34bc	14.08ab	12.75cd	12.34b
BRRI Hybrid dhan2 x 31 Jan	7.88c	13.25b	13.17bcd	12.42b
BRRI dhan45 x 30 Dec	8.84bc	12.96b	12.59cd	11.34b
BRRI dhan45 x 15 Jan	9.33ab	13.42ab	14.71b	11.67b
BRRI dhan45 x 31 Jan	9.0bc	13.88ab	13.75bc	11.33b
LSD $_{(0.05)}$	1.26	1.24	1.58	1.34
CV	9.37	9.24	10.26	10.7

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

4.3 Stem dry matter

Hybrid and inbred rice varieties differed significantly in respective of stem dry matter at all sampling dates (Figure 5). BRRI hybrid dhan2 produced higher amount of stem dry matter which was 2.07 g plant^{-1}, 7.81 g plant^{-1}, 10.70 g plant^{-1} and 17.03 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively. Aloron produced lower amount of stem dry matter g plant^{-1}.

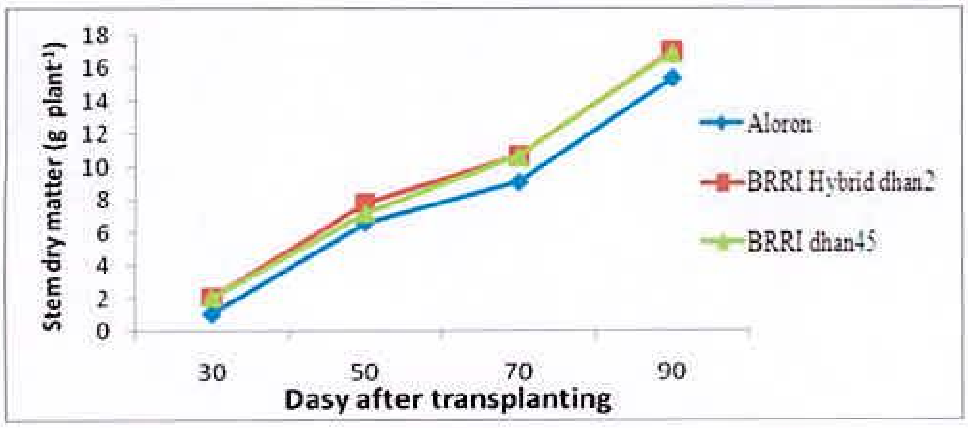

Figure 5. Effect of variety on stem dry matter of hybrid and inbred rice varieties in *Boro* season

The maximum amount of stem dry matter was obtained (1.96 g plant^{-1}, 8.30 g plant^{-1}, 10.89 g plant^{-1} and 17.43 g plant^{-1}) at the 30, 50, 70 and 90 DAT, respectively when transplanted at 30 December and the minimum amount was recorded (1.49 g plant^{-1}, 6.57, g plant^{-1} 9.05 g plant^{-1} and 14.89 g plant^{-1}) at 30, 50, 70 and 90 DAT, respectively at 31 January transplanting (Figure 6).

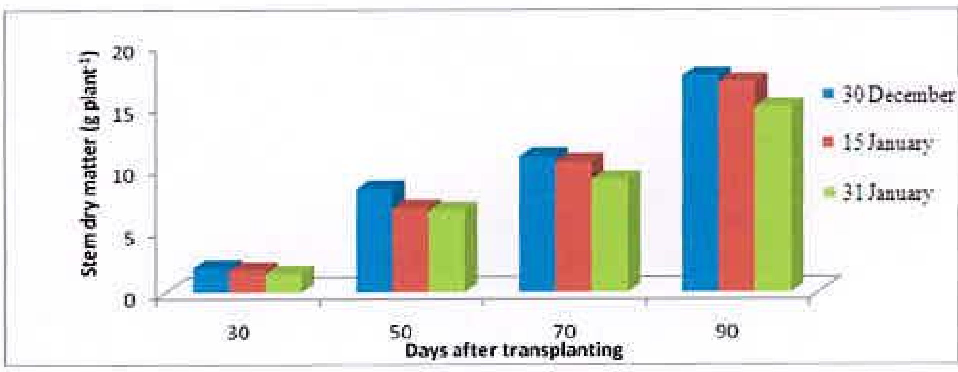

Figure 6. Effect of transplanting date on stem dry matter of hybrid and inbred rice varieties in *Boro* season

The effect of variety and planting date on dry matter of stem were significant at different days after transplanting (Table 4). The maximum stem dry matter 2.58 g plant^{-1}, 9.1 g plant^{-1}, 11.5 g plant^{-1} and 18.46 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively was found in BRRI hybrid dhan2 at 30 December transplanting and the minimum dry matter of stem 0.77 g plant^{-1}, 4.81 g plant^{-1}, 6.45 g plant^{-1} and 11.96 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively from Aloron at 31 January transplanting.

Table 4. Interaction effect of variety and transplanting date on stem dry matter of hybrid and inbred rice varieties in *Boro* season

Variety x Transplanting date	Stem dry matter (g)			
	30 DTA	50 DTA	70 DTA	90 DTA
Aloron x 30 Dec	1.07cd	1.07cd	11.43a	16.91ab
Aloron x 15 Jan	1.43bcd	1.43bcd	9.28ab	17.16ab
Aloron x 31 Jan	0.77d	4.81d	6.45b	11.96c
BRRI Hybrid dhan2 x 30 Dec	2.58a	9.10a	11.50a	18.46a
BRRI Hybrid dhan2 x 15 Jan	1.62bcd	1.62bcd	11.30a	17.23ab
BRRI Hybrid dhan2 x 31 Jan	1.99ab	1.99ab	9.30ab	14.99b
BRRI dhan45 x 30 Dec	1.79abc	1.79abc	9.92ab	15.45ab
BRRI dhan45 x 15 Jan	1.86abc	1.86abc	10.57a	17.92ab
BRRI dhan45 x 31 Jan	2.573a	2.573a	11.39a	17.72ab
LSD $_{(0.05)}$	0.80	0.80	3.33	2.84
CV	8.36	8.36	12.02	10.00

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

4.4 Leaves dry matter

Hybrid and inbred rice varieties differed significantly in respect of leaves dry matter plant^{-1} at all sampling dates, irrespective of transplanting dates (Figure 7). BRRI hybrid dhan2 showed the significant higher amount of leaves dry matter which was 1.59 g plant^{-1}, 4.61g plant^{-1}, 6.65 g plant^{-1} and 7.21 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively. The lowest amount of dry matter of leaves was 0.86 g plant^{-1}, 4.20 g plant^{-1}, 5.43 g plant^{-1} and 6.26 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively recorded from Aloron.

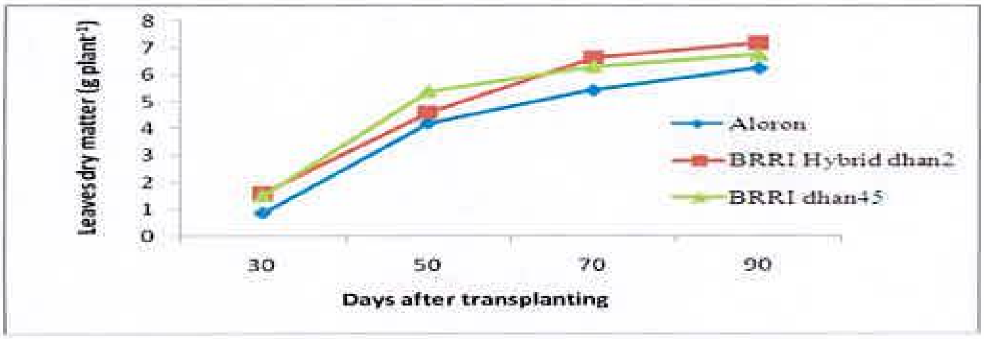

Figure 7. Effect of variety on leaves dry matter of hybrid and inbred rice varieties in *Boro* season

Statistically non-significant variation was recorded for dry matter of leaves at 30, 50, 70 and 90 DAT. The maximum dry matter of leaves was obtained (1.53 g plant^{-1}, 5.26 g plant^{-1}, 9.05 g plant^{-1} and 7.21 g plant^{-1}) at 30, 50, 70 and 90 DAT, respectively at 30 December transplanting while the minimum amount was recorded 1.21 g plant^{-1}, 4.48 g plant^{-1}, 5.64 g plant^{-1} and 6.26 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively at 31 January transplanting (Figure 8).

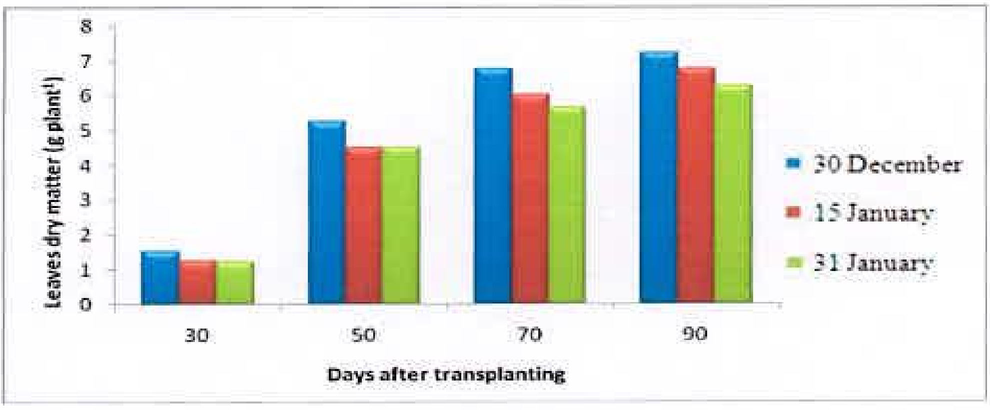

Figure 8. Effect of transplanting date on leaves dry matter of hybrid and inbred rice varieties in *Boro* season

The effect of variety and planting date on dry matter of leaves were statistically significant at different days after transplanting (Table 5). The maximum dry matter of leaves 2.02 g plant^{-1}, 6.46 g plant^{-1}, 7.72 g plant^{-1} and 8.07 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively was achieved from BRRI hybrid dhan2 at 30 December planting and the minimum dry matter of leaves 0.51 g plant^{-1}, 3.28 g plant^{-1}, 4.43 g plant^{-1} and 4.72 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively from Aloron at 31 January transplanting.

Table 5. Interaction effect of variety and transplanting date on leaves dry matter of hybrid and inbred rice varieties in *Boro* season

Variety x Transplanting date	Leaves dry matter (g)			
	30 DTA	50 DTA	70 DTA	90 DTA
Aloron x 30 Dec	0.91b	4.09bcd	6.13ab	6.72abc
Aloron x 15 Jan	1.14ab	5.23bc	5.74ab	7.33abc
Aloron x 31 Jan	0.51b	3.28d	4.43b	4.72d
BRRI Hybrid dhan2 x 30 Dec	2.02a	6.46a	7.72a	8.07a
BRRI Hybrid dhan2 x 15 Jan	1.31ab	4.92bc	6.82a	7.95ab
BRRI Hybrid dhan2 x 31 Jan	1.21ab	4.83bc	6.00ab	5.82cd
BRRI dhan45 x 30 Dec	1.44ab	4.43bcd	5.73ab	6.12bcd
BRRI dhan45 x 15 Jan	1.42ab	4.08cd	6.14ab	6.52abcd
BRRI dhan45 x 31 Jan	1.91a	5.33b	6.50ab	7.42abc
LSD $_{(0.05)}$	0.83	1.10	1.93	1.67
CV	10.36	10.49	18.16	14.37

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

4.5 Panicle dry matter

The studied hybrid and inbred varieties significantly differed at all sampling dates, irrespective of planting dates (Figure 9). BRRI hybrid dhan2 had significant higher amount of dry matter of panicle 1.24 g plant^{-1} and 6.40 g plant^{-1} at 70 and 90 DAT, respectively. Lower amount of panicle dry matter 0.92 g plant^{-1} and 5.94 g plant^{-1} at 70 and 90 DAT, respectively was achieved from Aloron.

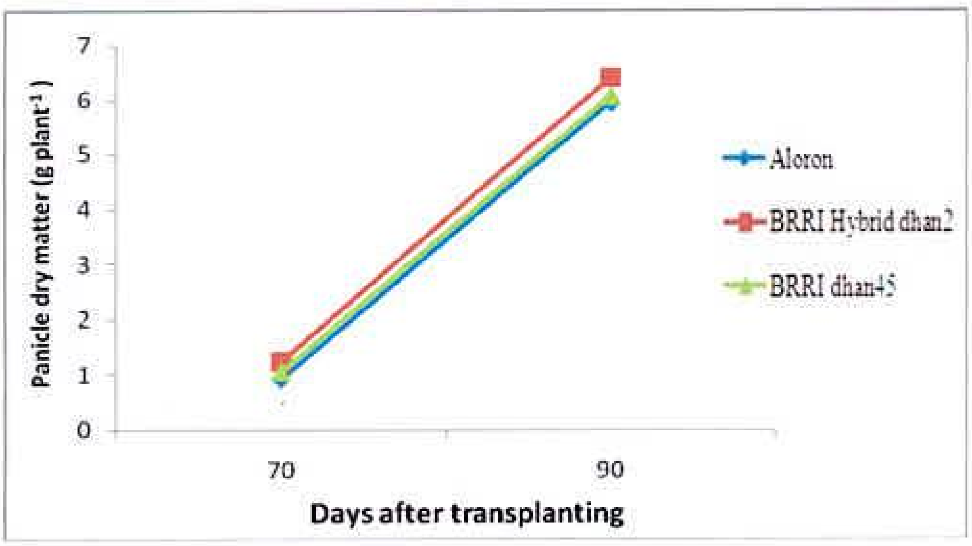

Figure 9. Effect of variety on panicle dry matter of hybrid and inbred rice varieties in *Boro* season

Statistically non significant variation was recorded for panicle dry matter at 70 and 90 DAT. The maximum dry matter of panicle was obtained 1.14 g plant^{-1}, and 6.82 g plant^{-1} at 70 and 90 DAT, respectively transplanting at 30 December, while the minimum number was recorded 0.95 g plant^{-1} and 5.19 g plant^{-1} at 70 and 90 DAT, respectively at 31 January transplanting (Figure 10).

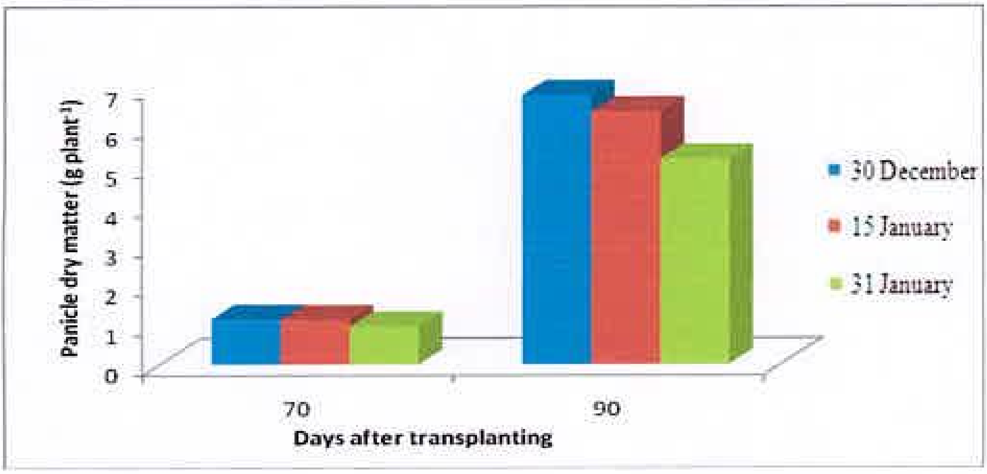

Figure 10. Effect of transplanting date on panicle dry matter of hybrid and inbred rice varieties in *Boro* season

Table 6. Interaction effect of variety and transplanting date on panicle dry matter of hybrid and inbred rice varieties in *Boro* season

Variety x Transplanting date	Panicle dry matter (g)	
	70 DAT	90 DAT
Aloron x 30 Dec	1.04abc	6.84a
Aloron x 15 Jan	1.11abc	6.48a
Aloron x 31 Jan	0.60c	3.73b
BRRI Hybrid dhan2 x 30 Dec	1.61a	7.25a
BRRI Hybrid dhan2 x 15 Jan	0.98bc	7.03a
BRRI Hybrid dhan2 x 31 Jan	1.16abc	5.69a
BRRI dhan45 x 30 Dec	0.8bc	5.85b
BRRI dhan45 x 15 Jan	1.31ab	6.16a
BRRI dhan45 x 31 Jan	1.04abc	6.84a
LSD $_{(0.05)}$	1.11abc	6.48a
CV	0.59c	3.73b

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

The effect of variety and planting date on panicle dry matter were statistically significant at different days after transplanting (Table 6). The maximum dry matter of panicles 1.61 g plant^{-1} and 7.25 g plant^{-1} at 70 and 90 DAT, respectively was found in BRRI hybrid dhan2 at 30 December transplanting and the minimum dry matter of panicle 0.60 g plant^{-1} and 3.73 g plant^{-1} at 70 and 90 DAT, respectively from Aloron at 31 January transplanting.

4.6 Total dry matter

Total dry matter (TDM) production indicates the yield potential of a crop. A high TDM production is the first perquisite for high yield. TDM of studied varieties significantly varied at all sampling dates, regardless of transplanting dates. Figure 5, showed that BRRI hybrid dhan2 produced the significantly higher amount of dry matter 3.67 g plant^{-1}, 13.21 g plant^{-1}, 18.52 g plant^{-1} and 30.29 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively. The lowest amount of dry matter 1.94 g plant^{-1}, 10.81 g plant^{-1}, 15.40 g plant^{-1} and 27.54 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively were recorded from Aloron. This result confirms the reports of Amin *et al.* (2006) and Son *et al.* (1998) that total dry matter production differed due to the interaction of variety and environment.

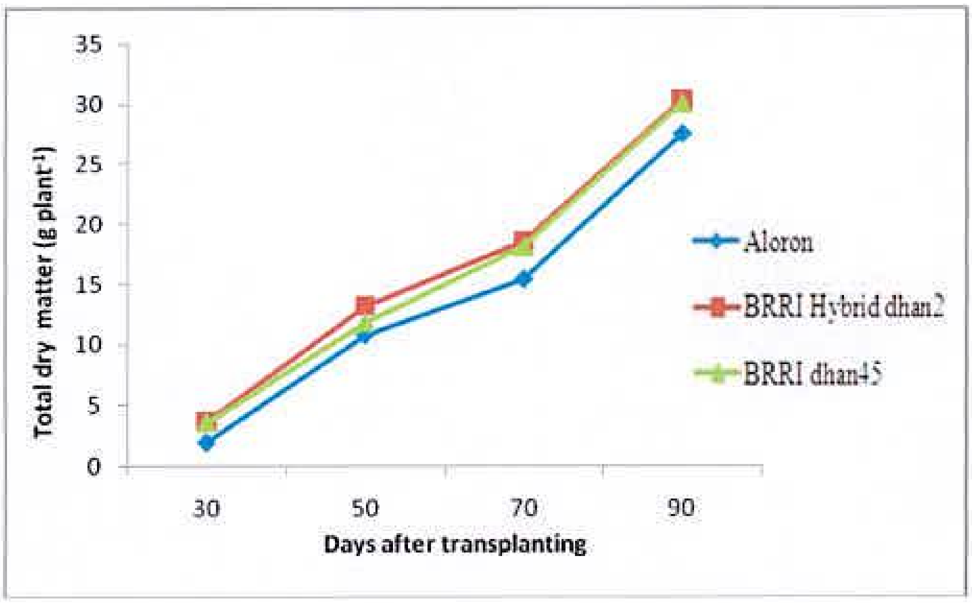

Figure 11. Effect of variety on total dry matter accumulation of hybrid and inbred rice varieties in *Boro* season

Different planting date showed significant influence on the dry matter accumulation of studied varieties (3.49 g plant^{-1}, 13.56 g plant^{-1}, 18.35 g plant^{-1} and 32.04 g plant^{-1}) in 30, 50, 70 and 90 DAT, respectively at 30 December transplanting, whereas the lowest amount was observed 2.713 g plant^{-1}, 11.05 g plant^{-1}, 15.81 g plant^{-1} and 26.07 g plant^{-1} at 31 January transplanting (Figure 12). Late planting might have exposed the crop to relatively more adverse growing environment including rising temperature at reproductive phase which might pulled down the dry matter accumulation compared to those of earlier plantings (Gohain and Saikia, 1996). Hundal *et al.* (2005) observed the significant linear and exponential relationships between above ground biomass and yield of rice and planting time had direct influence on above attributes.

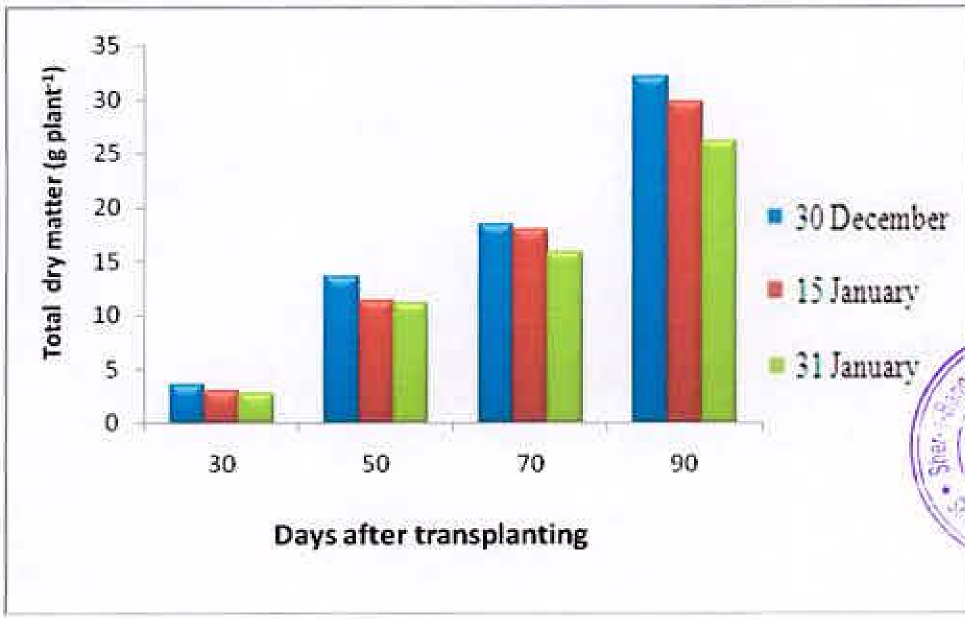

Figure 12. Effect of transplanting date on total dry matter accumulation of hybrid and inbred rice varieties in *Boro* season

The effect of variety and transplanting date on total dry matter were statistically significant (Table 7). The maximum dry matter 4.60 g plant^{-1}, 15.41 g plant^{-1}, 19.60 g plant^{-1} and 32.22 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively were found from BRRI hybrid dhan2 at 30 December transplanting and the minimum dry matter were 1.29 g plant^{-1}, 8.09 g plant^{-1}, 11.47 g plant^{-1} and 20.41 g plant^{-1} at 30, 50, 70 and 90 DAT, respectively from Aloron at 31 January transplanting.

Table 7. Interaction effect of variety and transplanting date on total dry matter accumulation of hybrid and inbred rice varieties in *Boro* season

Variety x Transplanting date	Total dry matter (g)			
	30 DTA	50 DTA	70 DTA	90 DTA
Aloron x 30 Dec	1.98cd	10.01e	18.61a	30.47ab
Aloron x 15 Jan	2.56cd	14.33ab	16.13ab	31.74ab
Aloron x 31 Jan	1.29d	8.09f	11.47b	20.41c
BRRI Hybrid dhan2 x 30 Dec	4.60a	15.41a	19.60a	32.22a
BRRI Hybrid dhan2 x 15 Jan	2.93bc	12.20cd	19.31a	31.46ab
BRRI Hybrid dhan2 x 31 Jan	3.19abc	12.03cde	16.47ab	26.51b
BRRI dhan45 x 30 Dec	3.23abc	11.51cde	16.46ab	27.43ab
BRRI dhan45 x 15 Jan	3.29abc	10.95de	18.45a	32.15a
BRRI dhan45 x 31 Jan	4.49ab	13.04bc	19.50a	31.30ab
$LSD_{(0.05)}$	1.46	1.89	4.89	4.81
CV	10.21	9.18	11.00	9.49

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

4.7 Panicle length and filled grains

The panicle length varied significantly among the studied hybrid and inbred rice varieties (Table 8). It was observed that BRRI hybrid dhan2 produced longer (25.48 cm) panicle than Aloron (23.05 cm). This finding confirms the report of Ahmed *et al.* (1997) and Idris and Matin (1990) that panicle length was varied due to varietal difference. Table 8, showed that the cultivars significantly affected the number of filled grains panicle^{-1} i.e. grains panicle^{-1}. BRRI hybrid dhan2 gave significantly higher number (97.81) of grains panicle^{-1} than that of Aloron (94.33). BRRI (1995) reported that the number of filled grains panicle^{-1} significantly differed due to variety.

Table 8. Effect of variety on yield components of hybrid and inbred rice varieties in *Boro* season

Variety	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled spikelets panicle^{-1}	1000 grain weight (g)
Aloron	23.05b	94.33b	153.09a	26.18b
BRRI hybrid dhan2	25.48a	97.81a	93.28b	27.26a
BRRI dhan45	23.00b	96.24ab	130.26ab	25.96c
$LSD_{(0.05)}$	1.25	2.96	38.79	0.91
CV	5.33	10.37	13.34	5.36

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

Planting dates did not exerted significant effect on panicle length. However, the longest panicle was recorded 24.45 cm at 30 December transplanting and the shortest panicle was observed 23.67 cm at 31 January transplanting (Table 9).

Table 9. Effect of transplanting date on yield components of hybrid and inbred rice varieties in *Boro* season

Transplanting date	Panicle length (cm)	Filled grains $Panicle^{-1}$	Unfilled spikelets $Panicle^{-1}$	1000 grain Wt. (g)
30 Dec	24.45	97.71b	104.07b	27.08
15 Jan	24.4	97.44b	129.15ab	26.75
31 Jan	23.67	92.73a	143.42a	26.18
$LSD_{(0.05)}$	NS	2.96	38.79	NS
CV	5.33	10.37	13.34	5.36

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, NS = non-significant

The different planting dates did not exert significant influence on the number of filled grains $panicle^{-1}$. However, the maximum number of filled grains $panicle^{-1}$ was recorded (97.71) at 30 December transplanting and the minimum number was found (92.73) at 31 January transplanting (Table 9).

Table 10. Interaction effect of variety and transplanting date on yield components of hybrid and inbred rice varieties in *Boro* season

Variety x Transplanting date	Panicle length (cm)	Filled grains $panicle^{-1}$	Unfilled spikelets $panicle^{-1}$	1000 grain weight (g)
Aloron x 30 Dec	24.83 ab	94.53 c	87.48 cde	26.87
Aloron x 15 Jan	24.23 ab	97.07 c	174.60 a	27.07
Aloron x 31 Jan	22.30 c	83.4d	197.20 a	24.93
BRRI Hybrid dhan2 x 30 Dec	25.03 a	102.50 a	77.17 e	27.80
BRRI Hybrid dhan2 x 15 Jan	24.47 ab	94.47 c	138.00 b	26.67
Hybrid dhan2 x 31 Jan	24.73 ab	99.73 b	113.10 bcd	26.73
BRRI dhan45 x 30 Dec	24.20 ab	96.07 c	84.99 de	26.60
BRRI dhan45 x 15 Jan	23.80 b	100.80 ab	117.70 bc	26.53
BRRI dhan45 x 31 Jan	24.00 ab	95.07c	139.80 b	26.60
$LSD_{(0.05)}$	0.97	2.44	28.96	0.60
CV	5.33	10.37	13.34	5.36

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

Panicle length was markedly influenced by the interaction of variety and planting date (Table 10). The highest panicle length (25.03 cm) was observed from hybrid rice variety Aloron when transplanted at 30 December. Interaction effect of variety and transplanting date was found significant on filled grains panicle^{-1} (Table 10). From the Table 10, it was observed that the highest (102.5) filled grains panicle^{-1} was achieved from the combination of BRRI hybrid dhan2 and 30 December transplanting. The lowest (83.4) filled grains panicle^{-1} was found from the combination of Aloron and 31 January transplanting.

4.8 Unfilled spikelets

Among the traits, unfilled spikelet panicle^{-1} plays a vital role in yield reduction. Results showed that the hybrid and inbred rice varieties exhibited significant difference in respect of the unfilled spikelets panicle^{-1} (Table 8). BRRI hybrid dhan2 produced the minimum (93.29) unfilled spikelets panicle^{-1} and Aloron produced the maximum (153.09) unfilled spikelets panicle^{-1} and this variation might be due to genetic makeup. BINA (1993) and Chowdury *et al.* (1993) also reported differences of unfilled spikelets panicle^{-1} due to varietal differences. The number of unfilled spikelets panicle^{-1} varied significantly for different transplanting dates. The minimum number of unfilled spikelets panicle^{-1} was found 104.07 at 30 December transplanting and the maximum number was recorded 143.43 at 31 January transplanting (Table 9). Interaction of variety and transplanting date exerted significant effect on the unfilled spikelets panicle^{-1} (Table 10). From the Table 10, it was observed that the minimum (77.17) unfilled spikelets panicle^{-1} was found from BRRI hybrid dhan2 at 30 December transplanting and the maximum (197.2) unfilled spikelet panicle^{-1} from BRRI hybrid dhan2 at 31 January transplanting.

4.9 Thousand grain weight

Variety had significant effect on 1000 grain weight (Table 8). Thousand grain weight of BRRI hybrid dhan2 was much higher (27.26 g) than that of Aloron (26.18 g), this result is in agreement with the findings of Rafey *et al.* (1989) who stated that weight of 1000 grain differed due to the varietal differences. The highest weight of 1000 grain was 27.08 g observed from 30 December transplanting, while the lowest weight was recorded 26.18 g, which was statistically identical at 31 January transplanting (Table 8). Ali *et al.*, (1995) reported that better results are obtained from early transplanting than the late transplanting. Interaction of variety and transplanting dates showed significant effect on 1000 grain (Table 10). From the Table 10, it was found that the minimum thousand seed weight (24.93 g) was observed from Aloron at 31 January transplanting, and the maximum (27.8 g) thousand seed weight from BRRI hybrid dhan2 at 30 December transplanting.

4.10 Grain yield

Grain yield is a function of various yield components such as number of productive tillers, grains panicle^{-1} and 1000 grain weight (Hussan *et al.*, 1989). In the present experiment, variety had significant effect on grain yield (Table 11). It was evident from (Table 11) that BRRI hybrid dhan2 produced higher amount (4.25 t ha^{-1}) of grains yield than that of Aloron (3.50 t ha^{-1}), which was contributed by the higher number of effective tillers hill^{-1}, higher number of grains panicle^{-1} and heavier individual grain size of the former. Grain yield differences due to varieties were reported by Suprithatno and Sutaryo (1992), Alam (1988) and IRRI (1978) who recorded variable grains yield among hybrid and inbred varieties.

Table 11 Effect of variety on yield and harvest index of hybrid and inbred rice varieties in *Boro* season

Variety	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Aloron	3.50b	4.98	8.92ab	39.36c
BRRI hybrid dhan2	4.25a	5.89	10.11a	42.00a
BRRI dhan45	3.64b	5.56	9.07b	40.66b
$LSD_{(0.05)}$	0.50	4.34	1.05	0.01
CV	10.38	10.10	9.36	9.15

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

Grain yield hectare^{-1} of rice varied significantly for different planting dates. The highest grain yield (4.55 t ha^{-1}) was recorded from 30 December transplanting whereas the lowest yield (2.94 t ha^{-1}) was obtained from 31 January transplanting (Table 12). Patel *et al.*, 1987 reported that grain yield of rice markedly declined with delayed planting.

Table 12. Effect of transplanting date on yield and harvest index of hybrid and inbred rice varieties in *Boro* season

Transplanting date	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
30 Dec	4.55a	6.39b	9.53	47.32a
15 Jan	3.91b	5.39ab	9.33	43.18b
31 Jan	2.94c	4.98a	9.31	31.51c
LSD $_{(0.05)}$	0.50	1.37	NS	0.01
CV	10.38	10.10	9.36	9.15

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, NS = non-significant.

Table 13 showed that the interaction of variety and transplanting date did not significantly affect the grain yield. The significant highest (5.38 t ha^{-1}) grain yield was achieved from the combination of BRRI hybrid dhan2 and 30 December transplanting and the lowest (2.88 t ha^{-1}) from Aloron and 31 January transplanting.

Table 13. Interaction effect of variety and transplanting date on yield and harvest index of hybrid and inbred rice varieties in *Boro* season

Variety x Transplanting date	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
Aloron x 30 Dec	3.78c	5.85ab	8.08d	46.52c
Aloron x 15 Jan	3.86c	5.53ab	9.39bc	41.69f
Aloron x 31 Jan	2.88e	4.33b	9.75b	28.71i
BRRI Hybrid dhan2 x 30 Dec	5.38a	6.88a	11.23a	48.28a
BRRI Hybrid dhan2 x 15 Jan	4.04c	5.64ab	9.69b	42.78e
BRRI Hybrid dhan2 x 31 Jan	3.35d	6.04ab	3.51bc	28.71g
BRRI dhan45 x 30 Dec	4.48b	4.79ab	9.28bc	47.25b
BRRI dhan45 x 15 Jan	3.84c	5.01ab	8.85c	45.08d
BRRI dhan45 x 31 Jan	2.60f	6.24ab	8.84c	29.88h
LSD $_{(0.05)}$	0.25	2.14	0.51	0.005
CV	10.38	10.10	9.36	9.15

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

4.11 Straw yield

Straw yield was differed significantly among the studied hybrid and inbred rice variety (Table 11). BRRI hybrid dhan2 produced the higher amount of straw yield (5.89 t ha^{-1}) compared to Aloron (4.98 t ha^{-1}). The variety BRRI hybrid dhan2 was taller and produced higher amount of straw compared to Aloron. Different transplanting dates showed statistically significant differences in the straw yield $hectare^{-1}$. The highest straw yield (6.39 t ha^{-1}) was recorded at 30 December transplanting. On the contrary, the lowest yield (4.98 t ha^{-1}) was obtained from 31 January transplanting (Table 12). Interaction effect of varieties and transplanting dates was observed significant on the straw yield (Table 13). The highest amount of straw yield (6.88 t ha^{-1}) was found from the combination of BRRI hybrid dhan2 and 30 December transplanting and the lowest amount (4.33 t ha^{-1}) from the combination of hybrid variety Aloron and 31 January transplanting.

4.12 Biological yield

The tested hybrid and inbred rice varieties differed significantly among themselves regarding biological yield (Table 11). It was found that BRRI hybrid dhan2 produced the higher amount (10.11 t ha^{-1}) of biological yield than that of Aloron (8.93 t ha^{-1}). Higher grain yield was attributed by the higher biological yield. (Singh and Ganger, 1989). Biological yield $hectare^{-1}$ was not affected due to the different planting dates. However, the highest biological yield (9.53 t ha^{-1}) was observed from 30 December transplanting and the lowest yield (9.31 t ha^{-1}) was found from 31 January transplanting (Table 12). Kainth and Mehra, 1985, reported that delayed transplanting causes the poor grain development which results huge quantity of underdeveloped grains and ultimately severe reduction of biological yield. Biological yield was affected significantly due to the interaction of variety and transplanting date. The maximum (11.23 t ha^{-1}) biological yield was obtained from the combination of BRRI hybrid dhan2 and 30 December transplanting and the minimum (3.51 t ha^{-1}) from BRRI hybrid dhan2 and 31 January transplanting (Table 13).

4.13 Harvest Index

The variety had significant effect on harvest index (Table 11). BRRI hybrid dhan2 showed the highest (42.00%) harvest index compared to Aloron (39.36%). Significant difference was recorded in terms of harvest index for different transplanting dates. The highest harvest index was found (47.32%) at 30 December transplanting, while the lowest was found (31.51%) at 31 January transplanting (Figure 12). There was significant effect on harvest index by the interaction of variety and transplanting date. The maximum harvest index (48.28%) was achieved from the combination of BRRI hybrid dhan2 and 30 December transplanting while the minimum was obtained (28.71%) from the combination of BRRI hybrid dhan2 and 31 January transplanting.

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University (SAU), during December 2010 to May 2011 to investigate the effect of date of transplanting on the growth and yield of hybrid and inbred rice varieties in *Boro* season. The experimental included three rice varieties *viz.* Aloron, BRRI hybrid dhan2 and inbred BRRI dhan45, and three transplanting date *viz.* 30 December, 15 January and 31 January. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The whole field was divided into four blocks each containing nine plots. The treatments were at random assigned to each unit plot. The size of the unit plot was 4 m x 3 m. Seedlings were transplanted with 25 cm and x 15 cm spacing. Intercultural operation, such as gap filling, weeding, water management and pest management were done when necessary. Maturity of crop was determined when 90% of the grains become yellowish in color. The harvesting was done on ten pre-selected hills from which data were collected and 6 mid lines from each plot was separately harvested, bundled, properly tagged and than brought to the threshing floor. Threshing was done by pedal thresher. The grains were cleaned and dried sun to under moisture keep content of 14 %.

The data on crop growth attributes, like plant height, tillers hill^{-1} and dry mater were recorded at different days after transplanting in the field, yield and yield contributing characters, like number of effective tillers hill^{-1}, panicle length, filled grains panicle^{-1} and unfilled spikelets panicle^{-1} and 1000-grain weight were recorded during harvesting period. Finally, grain yield and straw yield plot^{-1} were recorded and converted to t ha^{-1} and data were analysed using MSTAT statistical package program. The mean differences among the treatments were compared by least significant difference (LSD) test at 5 % level of significance.

It is revealed from this research work that the tallest plant height was recorded from BRRI hybrid dhan2 with transplanting at 30 December and the shortest plant height was found from Aloron at 31 January transplanting. Maximum tillers $hill^{-1}$ was found from BRRI hybrid dhan2 at 30 December transplanting and the minimum tillers $hill^{-1}$ from Aloron at 31 January transplanting. The maximum stem dry matter 18.46 g $plant^{-1}$ at 90 DAT was found in BRRI hybrid dhan2 at 30 December transplanting. The maximum dry matter of leaves 2.02 g $plant^{-1}$, 6.46 g $plant^{-1}$, 7.72 g $plant^{-1}$ and 8.07 g $plant^{-1}$ at 30, 50, 70 and 90 DAT, respectively was found from BRRI hybrid dhan2 at 30 December transplanting and the minimum dry matter of leaves 0.51 g $plant^{-1}$, 3.28 g $plant^{-1}$, 4.43 g $plant^{-1}$ and 4.72 g $plant^{-1}$ at 30, 50, 70 and 90 DAT, respectively from Aloron and 31 January transplanting. The maximum dry matter $plant^{-1}$ 4.60 g $plant^{-1}$, 15.41 g $plant^{-1}$, 19.60 g $plant^{-1}$ and 32.22 g $plant^{-1}$ at 30, 50, 70 and 90 DAT, respectively were found from BRRI hybrid dhan2 at 30 December transplanting and the minimum dry matter were 1.29 g $plant^{-1}$, 8.09 g $plant^{-1}$, 11.47 g $plant^{-1}$ and 20.41 g $plant^{-1}$ at 30, 50, 70 and 90 DAT, respectively from Aloron at 31 January transplanting. BRRI hybrid dhan2 gave significantly higher number (97.31) grains $panicle^{-1}$ than Aloron (94.33). The maximum filled grains $panicle^{-1}$ was recorded (97.71) from 30 December transplanting and the minimum (92.73) from the 31 January transplanting. The highest (102.5) filled grains $panicle^{-1}$ was found from the combination of BRRI hybrid dhan2 and 30 December transplanting. The lowest (83.4) filled grains $panicle^{-1}$ was found from the combination of Aloron and 31 January transplanting. The minimum thousand seed weight (24.93 g) was recorded from Aloron at 31 January transplanting, and the maximum (27.8 g) thousand seed weight from BRRI hybrid dhan2 at 30 December transplanting. The highest grain yield (5.38 t ha^{-1}) was achieved from the combination of BRRI hybrid dhan2 and 30 December transplanting and the lowest (2.88 t ha^{-1}) from Aloron and 31 January transplanting. Maximum biological yield (11.23 t ha^{-1}) was obtained from the combination of BRRI hybrid dhan2 and 30 December transplanting, and the minimum (3.51 t ha^{-1}) from BRRI hybrid dhan2 and31 January transplanting. The maximum harvest index

(48.28%) was achieved from the combination of BRRI hybrid dhan2 and 30 December transplanting and the minimum was obtained (28.71%) from the combination of BRRI hybrid dhan2 and 31 January transplanting. Interaction effect of variety and transplanting date significantly influenced the growth, yield and yield contributing characters of hybrid rice varieties. The highest grain yield 5.38 (t ha^{-1}) was recorded from BRRI hybrid dhan2 at 30 December transplanting.

Considering the findings of the present experiment, it is concluded that-

i BRRI hybrid dhan2 is able to produce higher amount of dry matter at vegetative stage compared to BRRI dhan45 in *Boro* season

ii. BRRI hybrid dhan2 produces about 20% higher grain yield over the inbred BRRI dhan45 at 30 December transplanting in *Boro* season.

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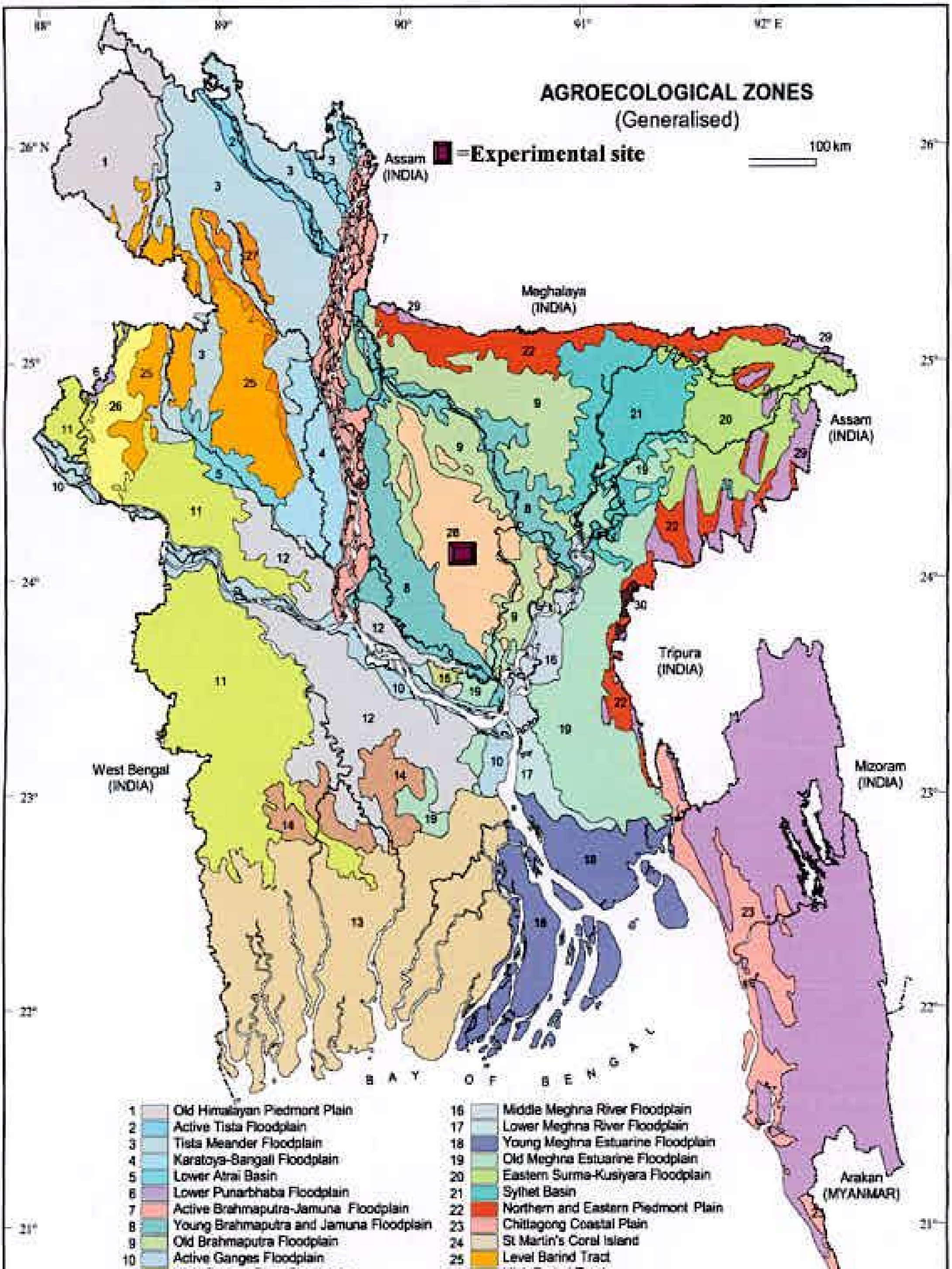
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological zones of Bangladesh



Appendix II. Monthly recorded air tempt., relative humidity, rainfall and sunshine of the experimental site during the period from Dec 10 to May 11

Month	*Air tempt. (°c)		*RH(%)	*Total Rainfall (mm)	*Sunshine (hrs)
	Max	Min.			
December	26.52	13.90	80.80	00.00	6.67
January	23.43	12.93	78.00	00.00	7.20
February	27.34	16.41	73.90	30.00	8.18
March	29.61	20.57	80.60	11.00	7.66
April	30.56	22.14	78.57	88.00	7.42
May	32.80	23.34	82.50	54.00	5.66

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka –1207

Appendix III. Physical and chemical properties of soil of the experimental plot

Properties	Value
A. Physical	
% Sand (0.2-0.02 mm)	26
% Silt (0.02-0.002 mm)	45
% Clay (< 0.002 mm)	29
Textural class	Silty clay
B. Chemical	
Soil pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus (µg/g soil)	22.08
Sulphur (µg/g soil)	25.98
Magnesium (meq/100 g soil)	1.00
Boron (µg/g soil)	0.48
Copper (µg/g soil)	3.54
Zinc (µg/g soil)	3.32
Potassium (µg/g soil)	0.30

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhak

Appendix IV. Analysis of variance of the data on plant height of hybrid and inbred rice varieties as influenced by variety and transplanting date in *Boro* season

Sources of Variance	Degrees of Freedom	Plant height (cm)		
		50 DAT	70 DAT	90 DAT
Replication	3	16.03	32.19	8.08
Factor A	2	35.19	37.19	43.03
Factor B	2	33.44	111.19	68.69
AB	4	58.97*	57.85*	12.72*
Error	24	16.68	27.03	25.82

* = Significant at 5% level of probability

Appendix V. Analysis of variance of the data on tillers plant^{-1} of hybrid and inbred rice varieties as influenced by variety and transplanting date in *Boro* season

Source of Variance	Degrees of Freedom	Tillers plant^{-1}			
		30 DAT	50 DAT	70 DAT	90 DAT
Replication	3	0.93	27.26	9.19	15.85
Factor A	2	40.95	29.28	30.64	20.61
Factor B	2	3.75	3.38	8.01	6.43
AB	4	2.57*	8.24*	5.90*	2.98*
Error	24	0.53	2.12	1.73	1.49

* = Significant at 5% level of probability

Appendix VI. Analysis of variance of the data on stem dry matter of hybrid and inbred rice varieties as influenced by variety and transplanting date in *Boro* season

Source of Variance	Degrees of freedom	Stem dry matter (g)			
		30 DTA	50 DTA	70 DTA	90 DTA
Replication	3	5.76	0.34	1.60	2.84
Factor A	2	4.97	1.48	3.36	3.57
Factor B	2	6.99	0.29	1.81	2.93
AB	4	0.31*	0.41*	2.42*	1.53*
Error	24	0.69	0.23	0.41	1.25

* = Significant at 5% level of probability

Appendix VII. Analysis of variance of the data on leaf and panicle dry matter of hybrid and inbred rice varieties as influenced by variety and transplanting date in *Boro* season

Source of Variance	Degrees of Freedom	Leaves dry matter (g)				Panicle dry matter (g)	
		30 DAT	50 DAT	70 DAT	90 DAT	70 DAT	90 DAT
Replication	3	0.76	0.29	3.81	7.37	0.11	3.21
Factor A	2	2.02	2.87	3.26	7.81	0.23	0.52
Factor B	2	7.84	0.49	8.15	8.31	0.09	6.37
AB	4	2.12*	0.55*	5.11*	8.23*	0.33*	3.10*
Error	24	0.94	0.21	0.72	3.71	0.09	0.89

* = Significant at 5% level of probability

Appendix VIII. Analysis of variance of the data on dry mater of hybrid and inbred rice varieties as influenced by variety and transplanting date in *Boro* season

Source of Variance	Degrees of Freedom	Total dry matter (g)		
		30 DAT	50 DAT	70 DAT
Replication	3	1.27	10.35	19.55
Factor A	2	8.47	13.3	25.55
Factor B	2	1.38	17.60	16.18
AB	4	1.89*	13.71*	19.57*
Error	24	0.71	1.20	8.00

* = Significant at 5% level of probability

Appendix IX. Analysis of variance of the data on panicle length, filled grains, unfilled spikelet of hybrid and inbred rice varieties as influenced by variety and transplanting date in *Boro* season

Sources of Variance	Degrees of Freedom	Filled grains Panicle^{-1}	Unfilled spikelets Panicle^{-1}
Replication	3	184.09	143.28
Factor A	2	20.49	8199.59
Factor B	2	70.57	3572.67
AB	4	138.17*	4277.36*
Error	24	99.00	280.32

* = Significant at 5% level of probability,

Appendix X. Analysis of variance of the data of 1000 seed weight, grain yield, straw yield, biological yield and harvest index of hybrid and inbred rice varieties as influenced by variety and transplanting date in *Boro* season

Source of Variance	Degrees of Freedom	1000 seed weight	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
Replication	3	6.564	4.164	6.218	15.446	2.0433
Factor A	2	1.391	1.444	0.56	3.436	0.2862
Factor B	2	2.333	5.871	4.709	0.128	11.1021
AB	4	1.524*	0.475*	1.115*	2.65*	0.3744*
Error	24	0.124	0.601	1.53	2.34	0.3764

* = Significant at 5% level of probability