INFLUENCE OF TRANSPLANTING DATE ON TILLERING PATTERN AND YIELD OF HYBRID RICE VARIETIES IN *BORO* SEASON

BY

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CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF TRANSPLANTING DATE ON TILLERING PATTERN AND YIELD OF HYBRID RICE VARIETIES 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 result of a piece of bonafide research work carried out by *Mizanur Rahman* *Registration No. 04-01383,* under my supervision and guidance. As far as I know, this thesis has not been submitted for any other degree or diploma.

I further certify that any help or sources of information as has been availed of during the course of this inquire have been duly acknowledged and the contents & style of the thesis have been approved and recommended for submission.

Dated:

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Dedicated to

My

Beloved Parents

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during November 2008 to May 2009 to evaluate the effect of transplanting dates on the tillering pattern and yield of hybrid rice varieties. The experiment comprised of three hybrid rice varieties viz., Aloron, Tia and Taj and three transplanting dates viz., 15 December, 30 December and 15 January. The experiment was laid out in a split-plot design with transplanting date assigned to the main plot and variety to the sub-plot. The results showed that the maximum number of tillers hill^{-1} was produced in Tia at all transplanting dates. Plant height at harvest, number of non-bearing tillers hill^{-1}, panicle length, number of total spikelets panicle^{-1} and number of sterile spikelets panicle^{-1} were the maximum in Taj, whereas Tia produced the maximum number of total and effective tillers hill^{-1}. Number of grains panicle^{-1}, 1000- grain weight, grain yield, biological yield and harvest index were the highest in Aloron. Plants transplanted on 15 December produced the maximum number of tillers hill^{-1} compared to the plants transplanted on 30 December and 15 January. The values of all characters studied were the highest in 15 December, transplanting except number of non-bearing tillers hill^{-1} and number of sterile spikelets panicle^{-1}. The highest grain and straw yields were observed from 15 December transplanting. Aloron produced the highest grain and straw yields compared to Tia in all transplanting dates. Aloron should preferably be transplanted between 15 December and 30 December for better performance.

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Chapter 1

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops of Bangladesh. Almost 90 percent of the population of Bangladesh, Myanmar, Sri Lanka and Vietnam are rice eaters. There are 111 rice growing countries in the world those occupies about 146.5 million hectares, more than 90% of which is in Asia (Anon., 1999). To feed the fast increasing global population, the world's annual rice population must be increased to 760 million by the year 2020 (Kundu and Ladha, 1995). Rice plays a dominant role in the agriculture of Bangladesh. It is grown under diverse ecosystems subject to irrigated, rainfed and deep-water conditions in three distinct seasons, namely *Aus, Aman* and *Boro.* Unfortunately, the yield of rice is very low in Bangladesh (3.34 t ha^{-1}) compared to Australia (9.65 t ha^{-1}), Korean Republic (6.59 t ha^{-1}), Japan (6.70 t ha^{-1}) and Spain (6.59 t ha^{-1}), respectively (FAO, 2004). The successful development of hybrid rice is a major factor in rice breeding, providing an effective means to increase rice yields by a large margin. The average yield of hybrid rice is 6.6 t ha^{-1}. Hybrid rice varieties have the potential of yielding 14-28% more than the best inbred or pure line variety grown under similar environmental conditions (Siddiq, 1993).

China's experiences show that the expansion of hybrid rice area is the most efficient and economic way to meet the future rice demands of a growing population. From this we can roughly calculate that, if conventional rice is completely replaced by hybrid rice, the total rice production in the world would be doubled and could meet the food requirements of one billion more people. Therefore, acceleration of the cultivation of hybrid rice in the world would be very helpful in solving the starvation problem affecting human kind.

A number of hybrid rice varieties are now available in Bangladesh. Some commercial companies are marketing hybrid seeds imported from different countries. But the field performances of those varieties are not at all up to the mark as described by their marketing authorities. As a result farmers are loosing their interest in cultivating hybrid rice varieties. Therefore, there are vast scopes to conduct researches on the evaluation of the performances of the rice varieties available in the market and to prescribe the suitable variety(s) for cultivation.

The growing season of *Boro* rice is longer, extending from November to June. BRRI recommends seeding of short and long duration varieties between 15 and 30 November and 5 and 25 November, respectively (BRRI, 2007). To get appreciable good yield of hybrid rice, transplanting date is important. In general, late transplanting always reduces yields irrespective of varieties (BRRI, 1992). Therefore, a satisfactory yield of hybrid rice might be obtained through appropriate combination of hybrid rice variety and transplanting date.

The present study was, therefore, conducted with the following objectives:

i. To find out the appropriate date of transplanting for optimum growth and yield of rice.
ii. To investigate effect of cut off dates on tillering dynamics and yield of hybrid varieties.
iii. To analyze the interaction effect of variety and transplanting dates on the yield and yield components of these hybrid rice varieties.

Chapter 2

REVIEW OF LITERATURE

Growth and development of rice plants are greatly influenced by the environmental factors (i.e. day length or photoperiod, temperature etc.), variety used and agronomic practices (i.e. transplanting date, depth of transplanting, fertilizer etc.). Among the factors variety and times of transplanting are very important, especially for the production of hybrid rice. Information regarding the effects of transplanting date on the plant height, tiller production and yield of hybrid rice varieties are scarcely available in Bangladesh. However, some reviews related to the present study are presented in this chapter.

2.1 Effects of variety

Variety is an important factor for yield. Hybrid rice variety has greater yield potential. Recently, Bangladesh has imported some hybrid rice varieties with high yield potential to meet her increasing food demand. But limited research has been carried out with hybrid rice. Some research activities which are related to hybrid rice in respect to yield and yield traits are described in this section.

Yuan and Fu (1995) reported that the leading hybrid rice varieties generally being used commercially in China had about 150 spikelets panicle^{-1} (the maximum was over 200). The weight of 1000 grains was about 28 g.

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

Yuan and Fu (1995) recorded that hybrid rice had more than 30 per cent yield advantage over conventional pure line varieties in China. The average grain yield of hybrid rice grown in provinces of southern China was around 7.5 t ha^{-1} which was 20 per cent higher than that of the leading local varieties.

Katayama *et al.* (1990) carried out a field trail with eight F_1 hybrid rice cultivars viz., Nihonbare, Akenohoshi, CP 231, Tainung 67, Omachi, Hoyoku, Nishihomare and Suweon 258 using80, 140, or 220 kg N ha^{-1}and stated that yield of suweon 258

increased as N application rate increased, but yields of Akenohoshi, Nishihomare and others decrease at the highest N rate. High rates of N caused a large decrease in percentage of ripened grains in Akenohoshi and Nishihomare, but not in Suweon 258. Grain yield was highest in a Promising line BR-802-118-3-1 followed by BR14, BR3 and BR1.

Khan (1991) reported that grain yield was higher in cv. CSR4 than in BR6. Grain yield of BINA-13 and BINA-19 were 5.39 and 5.57 t ha^{-1}, respectively and maturity of the above strains was 160 days and 166 days, respectively under transplanted condition.

Chandra *et al.*(1992) conducted an experiment with hybrids derived from the CMS lines IR 62829 A and IR 58025 A and noticed that Hybrids of the latter out yielded the IR 62829 A hybrids and the control varieties Jaya, IR 36 and Hybrids IR 58025 A x IR 9761-19-IR and IR 58025 Ax IR 35366-62-1-2-2-3R.

Leenakumari *et al.* (1993) evaluated eleven hybrids of varying duration against local controls Jaya, Rasi, IR20 and Margala and concluded that hybrid OR1002 gave the highest yield (7.9 t ha^{-1}) followed by IR 1001 (6.2 t ha^{-1}).

2.2 Effects of transplanting date

Karim (2006) reported that planting time has profound effect on the performance of different cultivars as these vary, in most cases, in photo and thermo sensitivity. The vegetative development of photoperiod sensitive cultivars is in general, more affected by time of planting.

Sharma *et al.* (1991) stated that two cold susceptible varieties (Tella Hamsa and Pathana) were sown on mid November to mid January and they found higher spikelet sterility in Pathana than Tella Hamsa. Higher spikelet sterility was found in early sown crop, which experienced minimum temperature (less than 19.6 ^{0}c) before flowering.

In Brazil, four rice varieties viz. EEA-406, Lebonnet, Blue bells and P 798-B4-4-1T were sown on 3 November, 16 November, 1 December and 15 December. Higher grain yields were obtained from 3 November sown of EEA- 406 and Lebonnet and 16

November sown for the other varieties when sown from 3 November to15 December, the percentage of sterile spikelet increased from 7-38, 7-29 and 6- 15% in the varieties P 798-B4-4-1T, Lebonnet, Blue bells, respectively (Infeld, 2000).

In the farm of BRRI (2001), seeds of 22 varieties of rice were sown on 10 November and 30 December and transplanted on 19 November and 30 January, respectively to assess the cold injury. It was observed that early sowing reduced the number of spikelets plant^{-1} by producing sterile spikelets, through percentage of spikelet sterility differed with varieties. The low temperature which was critical at vegetative stage in some varieties and at the reproductive phase for others was responsible for producing sterile spikelets (BRRI, 2001).

Islam *et. al.* (1997) reported that hybrid rice varieties can be transplanted between the end of December to the end of January for the highest grain yield in Gazipur and other similar Agro-ecological zone of Bangladesh. Transplanting in 25 x 20 cm (20 hills/m^2) or 20 x 15 cm (33.34 hills/m^2) spacing with single seedling per hill is optimum for cultivation for IR69690H (BRRI hybrid dhan-1) for getting higher yield in the *T. Aman* season. BRRI proposed two rice hybrids IR68877H and IR69690H and one inbred check, BRRI dhan29 were evaluated in farmers' field varietal trial, (FFVT) at Bogail village under Bhanga Upazilla of Faridpur district during 2000-2001. Results revealed that the hybrid IR69690H took 158 days to maturity and the grain yield was 9.33 t/ha while the hybrid, IR68877H took 148 days and the grain yield was 8.33 t/ha in *Boro* season. However, the popular modern inbred variety BRRI dhan 29 took 165 days to maturity and the grain yield was 8.17 t/ha. The farmers of the locality expressed satisfaction with the hybrid IR69690H (BRRI hybrid dhan-1) as it exhibited duration and yield advantage over inbred and other hybrids.

In Brazil, Ishiy (2001) observed that among three planting dates (14 November, 13 December and 13 January) the late planted (13 January) rice crop produced higher spikelet sterility and reduced the length of the growth cycle.

Roy (1999) stated that between the two planting dates (13 November and 10 January) of rice late planting reduced plant height, filled grains panicle^{-1} and grain yield by 17, 18.5 and 39.5% respectively and increased the number of effective tillers hill^{-1} and

1000- grains weight. Low temperature was not critical in late planting but spikelet sterility percentage was higher with late transplanting.

Andrade *et al.* (1999) carried out field trials during 1995-1997 in Japan where eight rice cultivars were sown between November to January. They reported that late transplanting increase grain yield, but reduce the growth duration and plant height. The percentage of broken grains was found to increase from 32-42% with late transplanting.

Nehru *et al.* (2000) stated that during *Boro* season eight hybrids and five standard rice varieties were grown at spacing of 10cm x 15cm and they found that spikelet sterility in hybrids ranged from 18-30% and that of 50-68% in standard varieties.

Sharma *et al* (1991) observed that late sown crops showed reduction in plant height, panicle length and 1000-grains weight. While Shi *et al.* (1987) reported that the number of spikelets panicle^{-1} decreased with delay in transplanting during *Boro* season.

Reddy and Reddy (1986) also reported from an experiment that early transplanting gave significantly higher paddy yields than late transplanting in *Boro* season.

Guilani *et al.* (2003) studied on crop yield and yield components of rice cultivars (Anboori, Champa and LD183) in Khusestan, Iran, during 1997. Grain number panicle^{-1}was not significantly different among cultivars. The highest grain number panicle^{-1}was obtained with Anboori. Grain fertility percentages were different among cultivars. Among cultivars, LD183 had the highest grain weight.

Chapter 3

MATERIALS AND METHODS

The experiment was conducted at the experimental field of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, during November, 2008 to May, 2009.

3.1 Experimental site

The experiment was conducted at the Sher-e-Bangla Agricultural University, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28 during the *Boro* season of 2008-2009. The experimental area is situated at 23°41′N latitude and 90°22′E longitude at an altitude of 8.6 meter above sea level.

3.2 Climate

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity, and heavy rainfall with occasional gusty winds in *Kharif* season (April-September) and less rainfall associated with moderately low temperature during the *Rabi* season (October-March).

3.3 Experimental details

3.3.1 Treatment

Two factors included in the experiment were as follows:

A. Variety

i) Tia (hybrid)

ii) Aloron (hybrid)

iii) Taj (hybrid)

B. Transplanting date

i) 15th December 2008

ii) 30th December 2008

iii) 15th January 2009

3.3.2 Design and layout of the experiment

The experiment was laid out in a split-plot design with transplanting date assigned to main plot and variety to sub-plots. The whole experimental area was first divided into four blocks. Each block was then divided into three main plots to accommodate transplanting date treatments at random. Each main plot was then divided into three sub plots where the varieties were randomly distributed. The number of replications was four. The size of unit plot was 4m x 3m = 12 m^2 .The spaces between sub-plots, between main plots and between blocks were 50 cm, 75 cm and 1m, respectively. There were 36 unit plots in the experiment.

3.4 Conduction of the experiment

3.4.1 Seedling rising

3.4.1.1 Seed collection

Healthy seeds of hybrid rice varieties Tia and Taj were collected from Lalteer Seed Ltd. and seeds of Aloron were collected from BRAC.

3.4.1.2. Seed sprouting, preparation of seedling nursery and seed sowing

Healthy seeds were soaked in water in bucket for 24 hours. Then seeds were taken out of water and spread thickly on blotting paper and covered with wet gunny bags and straw. The seeds were sprouted after 48 hours. Seed beds for each variety were prepared by puddling the soil. In case of first planting, seeds were soaked 17 November and sprouted seeds of hybrid and inbred rice varieties were then sown on a well prepared wet nursery bed on 20 November. In case of second planting, seeds of hybrid and inbred rice varieties were soaked on 2 December and sown on a well prepared wet nursery bed on 5 December. In case of third planting, seeds of hybrid and inbred rice varieties were soaked on 17 December and sown on a well prepared wet nursery bed on 20 December. Proper care was taken to raise the seedlings in the nursery as the soil was fertile but water and pest management practices were followed in order to raise healthy seedlings.

3.4.2 Land preparation

The land was thoroughly ploughed on 16 November with a tractor driven disc plough followed by harrowing. Then the land was puddled thoroughly by ploughing and cross ploughing of four dates with country plough followed by two laddering in order

to level the soil was performed. Weeds and stubbles were removed from the field. The land was thus ready for transplanting of rice seedlings. The layout of the experimental field was done according to the design adopted on 14 December. Finally, individual plots were puddled with spade and leveled before transplanting of seedlings on different dates of planting.

3.4.3 Fertilizer application

The land was fertilized with 270, 150, 120, 110 and 15 kg ha^{-1} of urea, triple supper phosphate, murate of potash, gypsum and zinc sulphate respectively. The amount of each fertilizer for unit plot was calculated and the entire amount of triple super phosphate, murate of potash, gypsum and zinc sulphate were applied at the date of final land preparation. Urea was applied in three equal splits at 9 DAT, at 35 DAT and the other at the 10 days after panicle initiation.

3.4.4 Uprooting of seedling and transplantation

Seed beds were made wet by application of water on the previous day before uprooting the seedlings. Seedlings of 25 day old were uprooted from the seed bed and were transplanted on the well puddled plots on 15 December, 30 December and 15 January with two seedlings $hill^{-1}$ as per experimental specification. Transplanting was done by using 1 and 2 seedlings $hill^{-1}$ in the plot. The spacing was 20.00cm x 15.00cm.

3.4.5 Intercultural operations

3.4.5.1 Gap filling

Seedlings in some hills died off and those were replaced by gap filling on 25 December, 10 January and 25 January, respectively.

3.4.5.2 Weeding

Crops were infested with different weeds. In each transplanting weeding was done twice by hand pulling on 15 and 30 DAT.

3.4.5.3 Irrigation

Irrigation was done regularly with 7-10 days interval. The crop was irrigated by flood irrigation and steps were taken to maintain constant level of standing water up to 4-5

cm in the field. During tillering, the field was left to dry out for 2-4 days. The field was finally drained out before 10 days harvesting.

3.4.5.4 Plant protection measures

At tiller stage the plants were attacked by rice stem borer which was successfully controlled by applying Basudin 10 G at the rate of 20 kg ha^{-1}. At maximum tillering stage a few plants were attacked by sheath blight which was successfully controlled by applying Tilt 25 EC @ 1.00 liter ha^{-1} twice at 10 days interval.

3.4.6 Sampling, harvesting and processing

Maturity of crop was considered when 90% of the grains became golden yellow in color. Ten hills (excluding border hills) were selected randomly from each plot and uprooted before harvesting for recording of necessary data. After sampling the whole plot was harvested at maturity on different dates. The harvested crop of each plot was separately bundled, properly tagged and brought to the threshing floor. The harvested crops were threshed by pedal thresher and fresh weight of grains and straw were recorded plot wise. The grains were cleaned and dried to a moisture content of 14%.Straw were sun dried properly. Finally grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.5 Data collection

The data were collected on various dates as per experimental requirement.

3.5.1 Plant sampling

Five hills from each unit plot were selected randomly and tagged just after transplanting for counting tillers at 7 days intervals beginning from 7 DAT up to 56 DAT.

3.5.2 Tillering pattern

Tillers which had at least one leaf visible were counted from the selected hills at 7 days intervals beginning from 7 DAT up to 56 DAT.

3.5.3 Data collection at harvest

From the ten randomly selected hills of each unit plot at harvest the following data were collected:

a) Plant height, effective tillers and and non-bearing tillers hill^{-1}

i) Plant height (cm)

ii) Total tillers hill^{-1}

iii) Effective tillers hill^{-1}

iv) Non- bearing tillers hill^{-1}

b) Reproductive characters yield and yield components at harvest

i) Panicle length at maturity (cm)

ii) Grains panicle^{-1}

iii) Sterile spikelets panicle^{-1}

iv) Total spikelets panicle^{-1}

v) Weight of 1000 grains (g)

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

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

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

ix) Harvest index (%)

3.6 Procedure of data collection

A brief out line of the data collection procedure is given below-

Plant height at maturity: Plant height was measured from the ground level to the tip of the longest panicle.

Total tillers hill^{-1}: Tillers which had at least one leaf visible were counted. It included both effective and non-bearing tillers.

Effective tillers hill^{-1}: The panicles which had at least one grain were considered as effective tillers.

Non- bearing tillers hill^{-1}: The panicles which had no grain were regarded as non-bearing tillers.

Panicle length (cm): Panicle length was recorded from the basal node of the rachis to the apex of each panicle.

Grains panicle^{-1}: Presence of any food material in the spikelet was considered as grain and total number of grains present on each panicle was counted.

Sterile spikelets panicle^{-1}: Spikelet lacking any food material inside was considered as sterile spikelet and such spikelets present on the each panicle were counted.

Weight of 1000 grains (g): One thousand clean dried grains were counted from the seed stock obtained from each plot and weighed by using an electrical balance.

Grain yield: Grains obtained from each unit plot were sun dried and weighed carefully. The dry weight of grains of ten sample plants was added to the respective plot yield to record the final grain yield per plot. The grain yield was eventually converted to t ha^{-1}.

Straw yield: Straw obtained from each unit plot including the straw of ten sample plants of respective unit plot was dried in the sun and weighed to record the final straw yield per plot and finally converted to t ha^{-1}.

Biological yield: Grain yield and straw yield are altogether regarded as Biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield

Harvest index (%): It denotes the ratio of economic yield to biological yield and was calculated with the following formula (Gardner *et al.*, 1985).

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

3.7 Statistical analysis

Data obtained from the experiments for each parameter were analyzed following MSTAT-C package programme to obtain the level of significance. The differences between pairs of means were compared by Duncan's Multiple Range Test (DMRT) according to Gomez and Gomez (1984).

Chapter 4

RESULTS AND DISCUSSION

Results of the study on the effect of transplanting date on the growth and yield of three hybrid rice varieties (Aloron, Tia and Taj) have been presented and discussed in this chapter.

4.1 Tillering pattern

4.1.1 Number of tillers hill^{-1} at different DAT

4.1.1.1 Effects of variety

Variety influenced the number of tillers hill^{-1} at all sampling dates. At 7 DAT, the highest number of tillers hill^{-1} (3.90) was recorded in the hybrid variety (Tia). The lowest number of tillers hill^{-1} (3.38) was in (Taj) and this was statistically similar to that of Aloron. A similar trend was found at 49 DAT (Fig. 1and Appendix II). At 14 DAT, the highest number of tillers hill^{-1} (5.27) was recorded in the hybrid variety (Tia). The lowest number of tillers hill^{-1} was in (Taj). The variety Aloron was intermediate in respect of number of tillers hill^{-1}. Similar trend was observed at 21 and 56 DAT (Fig. I and Appendix II). At 28 DAT, the hybrid variety (Tia) produced the maximum number of tillers hill^{-1} (9.76). Aloron gave the minimum number of tillers hill^{-1} (8.07) identically followed by Taj (8.13). This trend was observed at 35 and 42 DAT also.

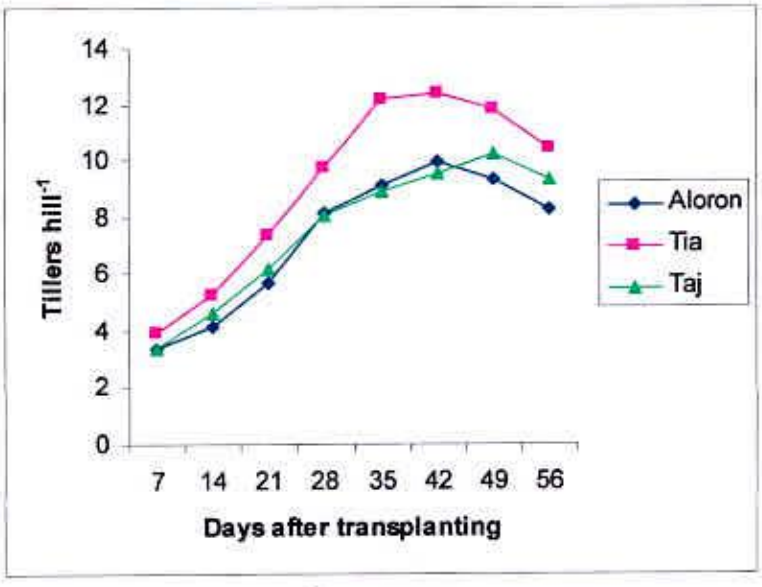

Fig. 1. Number of tillers hill^{-1} as influenced by variety at different DAT

4.1.1.2 Effects of transplanting date

Number of tillers hill^{-1} was significantly influenced by transplanting date at all dates of observation. At 7 DAT, a maximum number of tillers hill^{-1} (4.58) was observed in 15 December transplanting and it decreased gradually in 30 December transplanting and 15 January transplanting. Similar trend of number of tillers hill^{-1} was found at 14, 42, 49 and 56 DAT (Fig. 2 and Appendix III). At 21 DAT, the highest number of tillers hill^{-1} (7.42) was recorded from 15 January transplanting and lowest (5.02) from 30 January transplanting and 15 December transplanting was intermediate in respect of tiller production. At 28 DAT, the highest number of tillers hill^{-1} (9.74) was produced from 30 December transplanting and the lowest (7.54) from 30 January transplanting and 15 January transplanting was intermediate in respect of tiller production. A similar trend was found at 35 DAT.

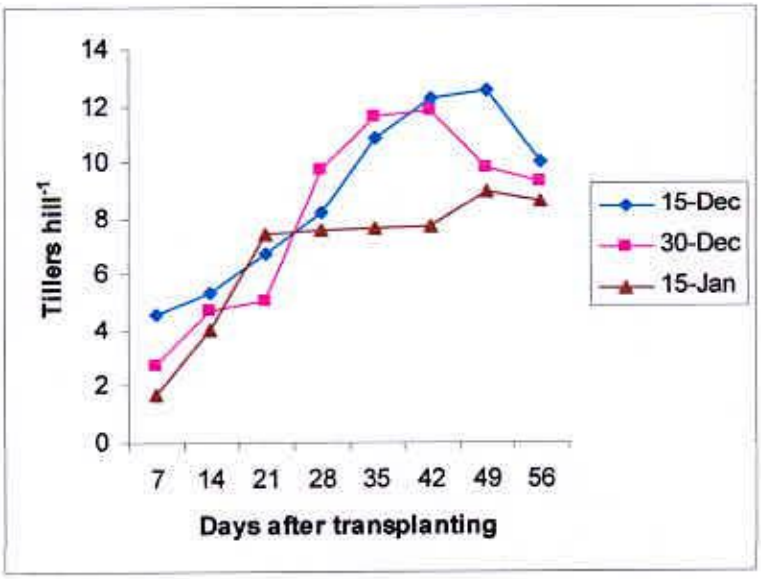

Fig. 2. No. of tillers hill^{-1} as influenced by transplanting date at different DAT

4.1.1.3 Effects of interactions

Interaction effect between variety and transplanting date on the number of tillers hill^{-1} was significant at 14, 21, 28, 35 and 42 DAT (Table 1). At 14 DAT, the highest number of tillers hill^{-1} (5.56) was recorded in Taj transplanted on 15 December which was statistically similar to those of Tia transplanted on 15 December, 30 December and 15 January. The lowest number of tillers hill^{-1} (3.27) was found in Aloron transplanted on 30 December which was statistically similar to that of Taj transplanted on 30 December (Table I). At 21 DAT, the maximum number of tillers hill^{-1}(8.46) was observed in Tia on 15 January transplanting. The minimum number of tillers hill^{-1} (4.33) was observed in Taj on 30 December transplanting which was statistically identical with that of Aloron on 30 December transplanting (Table I). At 28 DAT, the highest number of tillers hill^{-1} (11.13) was found in Tia transplanted on 30 December. The lowest number of tillers hill^{-1} (6.51) was observed in Aloron on 15 January transplanting which was statistically similar to those of Aloron on 15 December, Taj on 15 December, Taj on 30 December, Taj on 15 January and Tia on 15 January transplanting (Table I).The number of tillers hill^{-1}at 35 DAT was the highest (15.13) Tia on 30 December transplanting. The lowest number of tillers hill^{-1} (6.12) was found in Aloron on 15 January transplanting which was statistically similar to those of Taj on 15 January transplanting and Tia on January transplanting (Table I).

At 42 DAT, the highest number of tillers hill^{-1} (15.06) was found in Tia transplanted on 30 December. The lowest number of tillers hill^{-1} (6.60) was found in Taj transplanted on 15 January which was statistically similar to those of Tia and Aloron transplanted on 15 January (Table 1).

Table 1. Interaction effects between variety and transplanting dates on the number of tillers hill^{-1} at different DAT

Variety	Transplanting date	Number of tillers hill^{-1}							
		Days after transplanting							
		7	14	21	28	35	42	49	56
Aloron	15 December	5.01	5.02 bc	6.34 c	6.89 cd	9.26 c	10.64 cd	10.43	8.32
	30 December	3.09	3.27 e	4.46 d	8.3 b	9.3 c	9.73 de	8.35	7.25
	15 January	2.05	4.19d	6.34c	6.51d	6.12e	7.56f	7.27	6.77
Tia	15 December	5.26	5.40 ab	7.29 b	7.93 bc	12.09 b	13.23 b	13.68	9.65
	30 December	3.84	5.27 abc	6.42 c	11.13 a	15.13 a	15.06 a	10.43	9.47
	15 January	2.59	5.23 abc	8.46 a	7.51 bcd	7.42 de	7.06 f	9.56	8.98
Taj	15 December	5.26	5.56 a	6.63 c	7.01 cd	9.34 c	11.14 c	11.73	9.86
	30 December	3.13	3.52 e	4.33 d	7.1 bcd	8.53 cd	8.94 e	8.85	8.40
	15 January	3.3	4.77 c	7.63 b	7.39 bcd	6.76 e	6.60f	8.23	7.69
$S\bar{x}$		-	0.16	0.22	0.38	0.39	0.39	-	-
Level of significance		NS	0.01	0.01	0.01	0.01	0.01	NS	NS

Figures in a column having the same letter do no differ significantly as per DMRT.
NS = Not significantly differ at $p \leq 0$.

4.2 Plant height, effective tillers and non-bearing tillers hill^{-1}

4.2.1 Plant height

4.2.1.1 Effects of variety

Evidently, the varieties exhibited their differences in plant height. Table 2 shows that the tallest plant (106.40 cm) was produced by Taj which was identical with that of Aloron (103.70 cm). Tia produced the shortest plant (98.59 cm). These results were similar to those of BRRI (1992), which showed variability in plant height among hybrid varieties. This difference in plant height might be due to the genetic variation among the varieties.

4.2.1.2 Effects of transplanting date

Transplanting date had pronounced effect on plant height (Table 3). It is observed that plants attained the maximum height (111.05cm) when the crop was transplanted on 15 December. Plant height was progressively reduced when the crop was transplanted on 30 December (104.25 cm) and 15 January (99.57 cm), respectively. Many researchers reported a reduction in plant height due to delay in transplanting (Majid and Ahmed, 1975; Mejos and Pava, 1980; Theetharappan and Palanippan, 1984). It may be assumed that the shorter plant height associated with delayed transplanting was probably due to shorter vegetative growth period available for the crop before flowering.

4.2.2 Number of total tillers hill^{-1}

4.2.2.1 Effects of variety

Results presented in Table 2 show that the number of total tillers hill^{-1} ranged from 9.05 to 11.54.The highest number of total tillers hill^{-1} (11.54) was counted in Tia and lowest number (9.05) in Aloron. Variable effect of variety on the number of total tillers hill^{-1} was also reported by Hussain *et al.*(1989) who observed that number of total tillers hill^{-1}differed among the varieties. The variation in number of total tillers hill^{-1} might be due to variable characters.

4.2.2.2 Effects of transplanting date

The effective and non-bearing tillers hill^{-1} is altogether regarded as total tillers. The number of total tillers hill^{-1}was significantly influenced by the date of transplanting. The highest number of total tillers hill^{-1} (11.14) was produced from 15 December transplanting and the lowest one (9.51) from 15 January transplanting (Table 3).

Transplanted on 30 December was intermediate (10.11) in respect of number of total tillers hill^{-1} (Table 3).The results show that number of total tillers hill^{-1} decreased gradually with late transplanting.

4.2.3 Number of non-bearing tillers hill^{-1}

4.2.3.1 Effects of variety

Table 2 and Fig. 4 shows that non-bearing tillers hill^{-1}of three varieties followed in the descending order: Taj (3.03), Tia (2.57) and Aloron (2.10).All the varieties were statistically different in respect of number of non-bearing tillers hill^{-1}. Varietals difference regarding non-bearing tiller production hill^{-1}might is due to the differences in genetic make - up. BINA (1993) also reported that number of non-bearing tillers hill^{-1} was significantly influenced by variety.

4.2.3.2 Effects of transplanting date

Production of non-bearing tillers hill^{-1} was affected by the date of transplanting. A maximum number of non-bearing tillers hill^{-1} (2.12) was produced when transplanting was done on 30 December. Production of non-bearing tillers hill^{-1} was the minimum (1.83) when transplanting was done on 30 January. Transplanted on 30 December was intermediate (1.94) in respect of non-bearing tillers hill^{-1} (Table 3 and Fig. 2).

4.2.4 Straw yield

4.2.4.1 Effects of variety

The highest straw yield (6.84 t ha^{-1}) was found in Aloron and the lowest one (5.21 t ha^{-1}) in Taj. Tia was intermediate (6.03 t ha^{-1}) in respect of straw yield (Table 2 and Fig. 5). These results are in conformity with those observed by Chowdhury *et at.* (1993), who reported differences in straw yield among varieties.

4.2.4.2 Effects of transplanting date

Straw yield was reduced due to delay in transplanting (Table 3 and Fig. 6). The crop transplanted on 15 December produced the highest straw yield (6.83 t ha^{-1}) which was statistically identical with that of 30 December transplanting and the lowest straw yield (6.21 t ha^{-1}) was obtained from 15 January transplanting. Alim *et at.* (1992), reported that straw yield decreased due to delay in transplanting. The reduction in plant height and production of less tillers hill^{-1} due to late transplanting were mainly responsible for this reduction in straw yield.

Table 2. Effects of variety on the plant height, tiller number and straw yield

Variety	Plant height (cm)	Number of total tillers hill^{-1}	Number of non-bearing tillers hill^{-1}	Straw yield (tha^{-1})
Aloron	103.70 a	9.05 c	2.10 c	6.84 a
Tia	98.59 b	11.54 a	2.57 b	6.03 b
Taj	106.40 a	10.18 b	3.03 a	5.21 c
$S\bar{x}$	0.96	0.32	0.44	0.16
Level of significance	0.01	0.01	0.01	0.01

Figures in a column having the same letter do not differ significantly as per DMRT

Table 3. Effects of transplanting date on the plant height, tiller number and straw yield at harvest

Planting date	Plant height (cm)	Number of total tillers $hill^{-1}$	Number of non-bearing tillers $hill^{-1}$	Straw yield (tha^{-1})
15 December	111.05 a	11.14 a	1.94 b	6.83 a
30 December	104.25 b	10.11 b	2.12 a	6.73a
15 January	99.57 b	9.51 c	1.83 b	6.21b
$S\bar{x}$	1.78	0.22	0.05	0.15
Level of significance	0.01	0.01	0.01	0.05

Figures in a column having the same letter do not differ significantly as per DMRT

4.3 Reproductive characters, yield and yield components at harvest

4.3.1 Number of effective tillers hill^{-1}

4.3.1.1 Effects of variety

Variety had significant effect on the number of effective tillers hill^{-1}. The results indicate that the highest number of tillers hill^{-1} (9.97) was produced by Tia. The lowest number of effective tillers hill^{-1} (7.95) was produced by Aloron which was identically followed by Taj (Table 4 and Fig. 3).These findings corroborate with those reported by Chowdhury *et al.* (1993) who stated that effective tillers hill^{-1} varied with variety. The probable reason for difference in producing the effective tillers hill^{-1} is the genetic make-up of the variety which is primarily influenced by heredity.

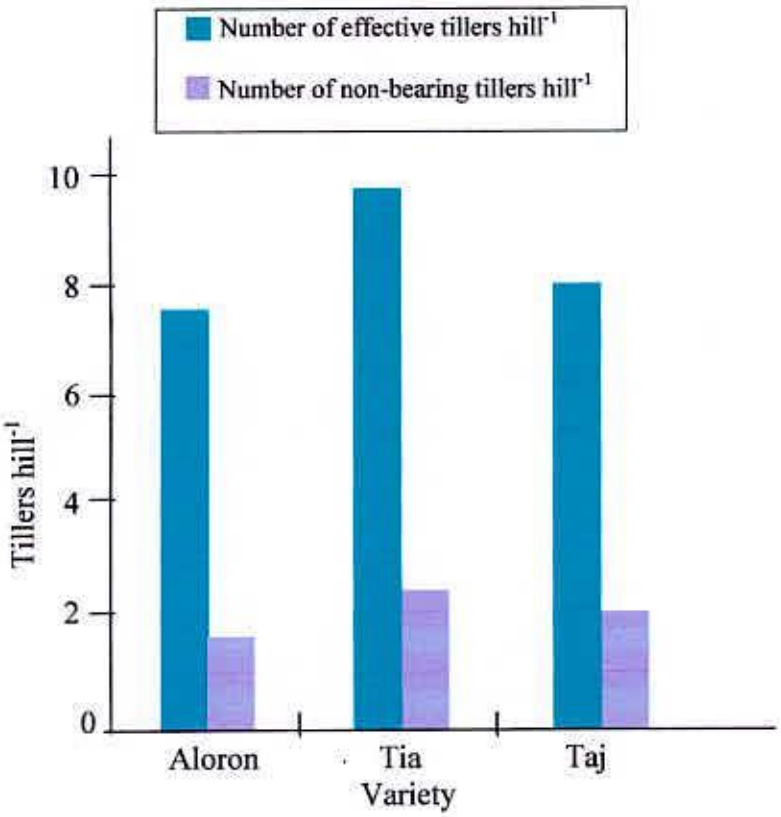

Fig. 3. Number of effective and non-bearing tillers hill^{-1} as influenced by variety

4.3.1.2 Effects of transplanting date

The number of effective tillers hill^{-1} was found to be significantly affected by the transplanting date. The highest number of effective tillers hill^{-1} (7.51) was produced in 15 December transplanting and there after the number of effective tillers hill^{-1} was progressively decreased with delayed transplanting and lowest number of effective tillers hill^{-1} (5.99) was produced transplanting was done on 15 January (Table 5 and Fig. 4). The reduction of effective tillers hill^{-1} was due to low temperature.

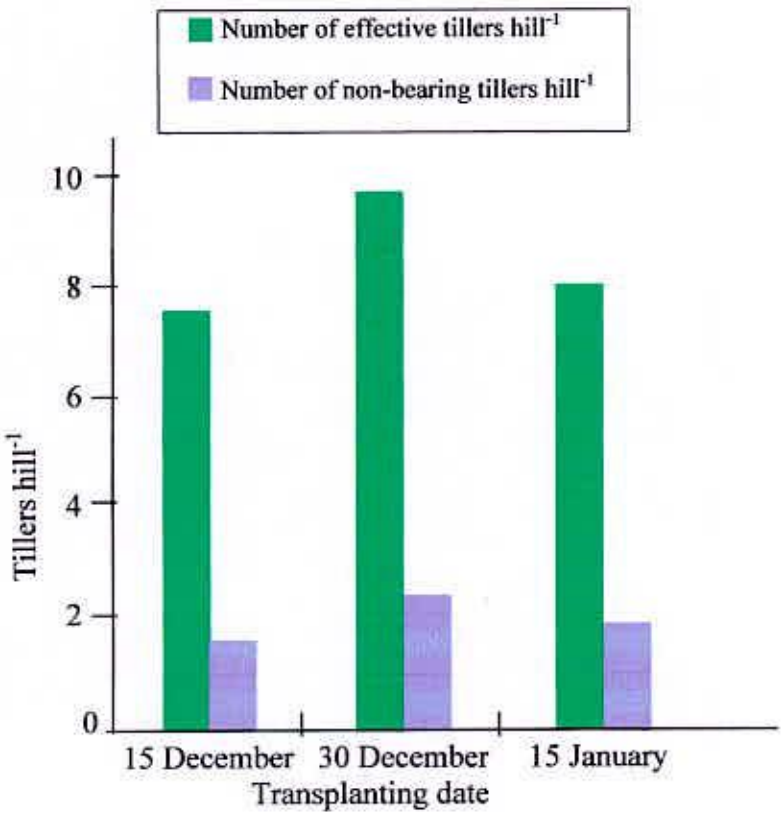

Fig. 4. Number of effective and non-bearing tillers hill^{-1} as influenced by transplanting date of different hybrid rice varieties

4.3.2 Panicle length

4.3.2.1 Effects of variety

Panicle length was found to be influenced by variety. The highest panicle length (22.84 cm) was recorded in Taj which was statistically similar to that of Aloron (22.85 cm) and the lowest one (22.26 cm) in Tia (Table 4). Similar results were also reported by Idris and Matin (1990) who reported that panicle length differed among the varieties. The variation as assessed might be mainly due to genetic characteristic of the variety which is primarily influenced by heredity.

4.3.2.2 Effects of transplanting date

Transplanting date significantly influenced the panicle length. Panicle length was progressively decreased from 15 December transplanting onwards and became the shortest (21.05 cm) in 15 January transplanting. Panicle length was the longest (23.69 cm) in 15 December transplanting (Table 5).

4.3.2.3 Effects of interactions

Panicle length was influenced by the interaction between variety and planting date. The highest panicle length (24.28 cm) was found in Tia on 15 December transplanting which was statistically similar to that of Taj on 15 December transplanting. The lowest panicle length (20.05 cm) was found in Tia on 15 January transplanting identically followed by Aloron on 15 January transplanting (Table 6).

4.3.3 Number of total spikelets panicle^{-1}

4.3.3.1 Effects of variety

The number of total spikelets panicle^{-1} ranged from 107.31 to 137.41 (Table 4). The highest numbers of total spikelets panicle^{-1} (137.41) was produced by Tia and the lowest spikelets panicle^{-1} (107.31) was found in Aloron. Differences in number of total spikelets panicle^{-1} were probably due to their differences in genetic make-up.

4.3.3.2 Effects of transplanting date

Number of total spikelets panicle^{-1} was affected by the transplanting date. The maximum number of total spikelets panicle^{-1} (127.63) was found when transplanting was done on 15 December which was similar to that of 30 December transplanting

and minimum one (113.96) on 15 January transplanting (Table 5). Shi *et al.* (1987) reported that number of total spikelets panicle^{-1} decreased with delay in transplanting.

4.3.3.3 Effects of interactions

From the data, it was observed that interaction between variety and transplanting date had pronounced effect on the number of total spikelets panicle^{-1}. A maximum number of total spikelets panicle^{-1} (146.73) was counted in Taj on 30 December transplanting and minimum one (98.53) in Tia on 15 January transplanting (Table 6).

4.3.4 Number of grains panicle^{-1}

4.3.4.1 Effects of variety

Variety differed in respect of number of grains panicle^{-1}. Table 4 shows that Aloron produced the maximum number of grains panicle^{-1} (104.03). The minimum number of grains panicle^{-1} (91.24) was produced in Taj which was statistically identical with that of Tia (91.56). Singh and Gangwer (1989) reported variable number of grains panicle^{-1} among varieties. Varietals differences regarding the number of spikelets panicle^{-1} might be due to their differences in genetic constituents.

4.3.4.2 Effects of transplanting date

Number grains panicle^{-1}was affected by transplanting date. Number of grains panicle^{-1} was followed decreasing trend with delayed transplanting. The maximum (101.12) and the minimum (92.99) number of grains panicle^{-1} were obtained from 15 December and 15 January transplanting, respectively (Table 5). Reduction in vegetative growth due to delay in transplanting was the main reason for this reduction in the number of grains panicle^{-1}. There are reports that the number of grains panicle^{-1} was reduced due to delay in transplanting (Shi *et al.* 1987).

4.3.5 Number of sterile spikelets panicle^{-1}

4.3.5.1 Effects of variety

Among the undesirable traits, number of sterile spikelets panicle^{-1} is the most significant and plays vital role in the field reduction. Effect of variety on the number of sterile spikelets panicle^{-1} was highly significant. Table 4 shows that Taj produced the highest number of sterile spikelets panicle^{-1} (45.67). The lowest number of sterile spikelets panicle^{-1} (15.85) was found in Taj. Chowdhury *et al.* (1993) and BINA

(1993) also reported differences in number of sterile spikelets panicle^{-1} due to varietals differences. This variation might be due to genetic characteristics of the varieties.

4.3.5.2 Effects of transplanting date

Number of sterile spikelets panicle^{-1} differed due to transplanting date. The highest number of sterile spikelets panicle^{-1} (28.42) was recorded at 30 December transplanting identically followed by that of 15 December transplanting and the lowest number of sterile spikelets panicle^{-1} (23.93) was recorded on 15 January transplanting (Table 5).

4.3.6 Weight of 1000 grains

4.3.6.1 Effects of variety

Varieties differed among themselves regarding weight of 1000 grains. Aloron was first (26.84 g) in respect of 1000 grains weight. Tia (21.01 g) and Taj (18.71 g) were second and third, respectively regarding 1000- grains weight (Table 4).

These results corroborate with the results reported by Shamsuddin *et al.* (1988) who recorded differences in 1000-grains weight among varieties. Chowdhury *et al.* (1993) also reported the same view.

4.3.7 Grain yield

4.3.7.1 Effects of variety

Evidently, the varieties exhibited their differences in grain yield. From the Table 4 and Fig. 5, it is evident that among three varieties tested Aloron and Taj gave the highest (7.63 t ha^{-1}) and the lowest (5.46 t ha^{-1}) grain yield, respectively. Tia was intermediate (6.57 t ha^{-1}) in respect of grain yield. Grain yield differences due to varieties were recorded by Leenakumari *et al.* (1993) who observed variable grain yield among varieties. The number of grains $panicle^{-1}$ and weight of 1000 grains were the main cause of highest grain yield in Aloron.

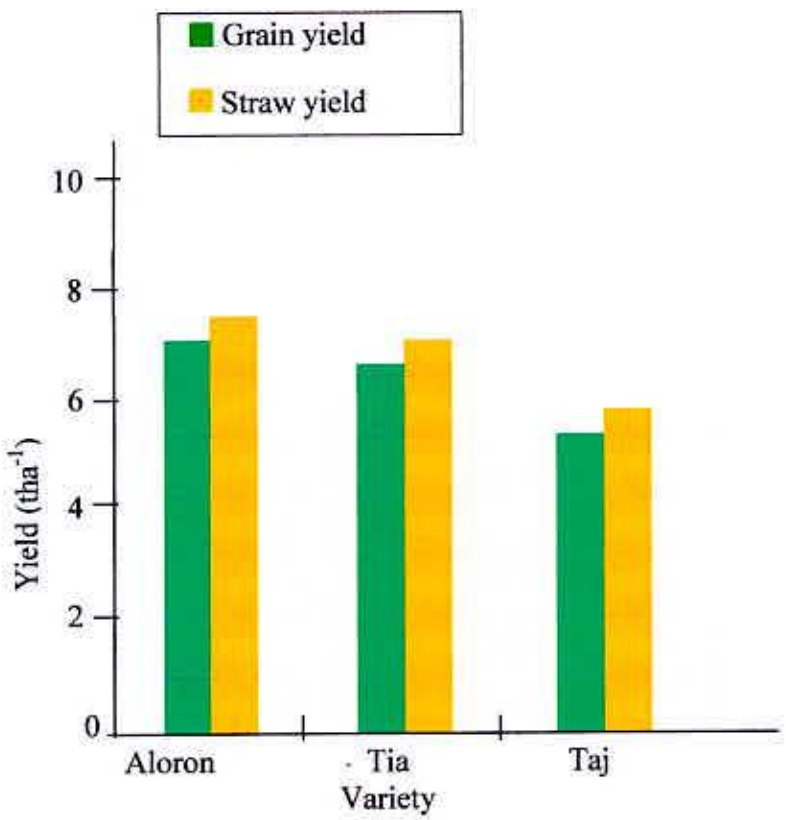

Fig. 5. Grain and straw yields as influenced by variety

4.3.7.2 Effects of transplanting date

Grain yield was found to be influenced by transplanting date. The results revealed that grain yield was progressively decreased from 15 December transplanting (6.46 t ha^{-1}) onwards and become the lowest (5.87 t ha^{-1}) when the crop was transplanted on 15 January (Table 5 and Fig. 6). The crop transplanted on 15 December and 30 December produced statistically similar and higher grain yields in comparison to late transplanted crop (15 January transplanting). The early transplanted crop produced the maximum plant height and number of total tillers (Table 3) which in turn contributed to improve reproductive growth in terms of increased number of effective tillers $hill^{-1}$, panicle length, number of grains $pnaicale^{-1}$ and weight of 1000 grains (Table 5).The improvement of component in early transplanted crop ultimately resulted in the enhancement of grain yield. Hedge (1993) reported early transplanted crop produced more grain yield.

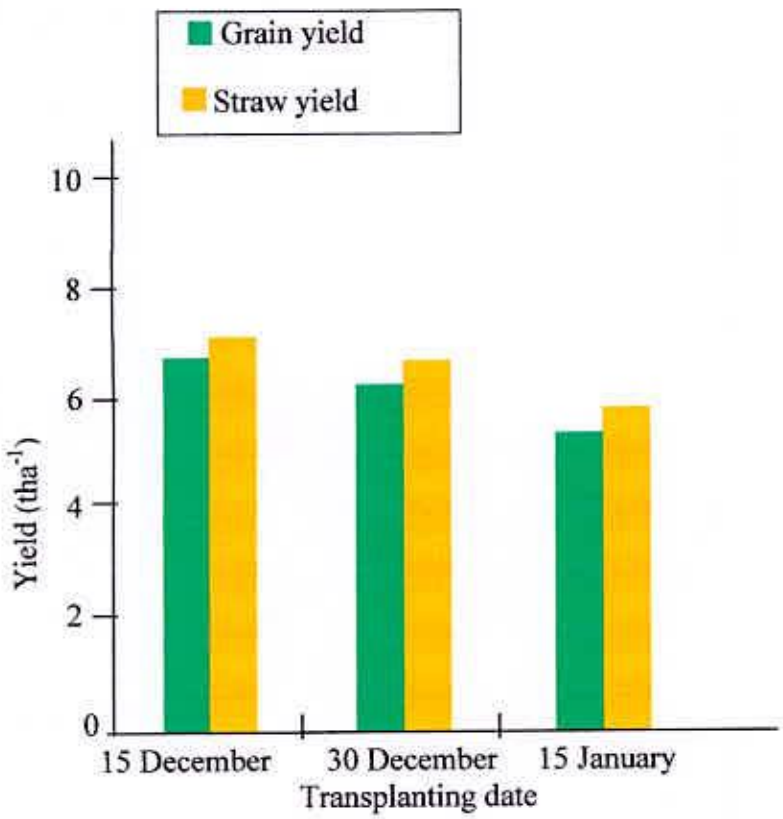

Fig. 6. Grain and straw yields as influenced by transplanting date of different hybrid rice varieties

4.3.8 Biological yield

4.3.8.1 Effects of variety

The varietals effect on biological yield was highly significant. Table 4 shows that the highest biological yield (12.08 t ha^{-1}) was recorded from Aloron and the lowest (8.17 t ha^{-1}) in Taj. Aloron produced the highest grain and straw yields which resulted in the highest biological yield.

4.3.8.2 Effects of transplanting date

Transplanting date showed an influence on biological yield. The highest biological yield (10.65 t ha^{-1}) was found on 15 December transplanting which was statistically similar (10.47 t ha^{-1}) to that of 30 December transplanting and the lowest biological yield (9.43 t ha^{-1}) was observed when the crop was transplanted on 15 January (Table 5). Similar results were found by Mohapatra (1989) who recorded that biological yield is decreased due to delay in transplanting.

4.3.9 Harvest index

4.3.9.1 Effects of variety

Varieties exerted an effect on harvest index. From the Table 4, it is evident that the highest harvest index (48.39%) was recorded from Aloron and the lowest one (45.62%) from Taj. Tia was intermediate (47.25%) in respect of harvest index. Higher grain-straw ratio in Aloron might be resulted in the highest harvest index.

Table 4. Effects of variety on the reproductive characters, yield and yield components at harvest of different hybrid rice varieties

Variety	Number of effective tillers hill^{-1}	Panicle length (cm)	Number of total spikelets panicle^{-1}	Number of grains panicle^{-1}	Number of sterile spikelets panicle^{-1}	Weight of 1000 grains (g)	Grains yield (tha^{-1})	Biological yield (tha^{-1})	Harvest index (%)
Aloron	7.95 b	22.65 ab	120.38 b	104.03 a	15.85 b	26.84 a	7.63 a	12.08 a	48.79 a
Tia	9.97 a	22.26 b	107.31 c	91.56b	16.41 b	21.01 b	6.57 b	10.20 b	47.25 b
Taj	8.15 b	22.84 a	137.41 a	91.24 b	45.67 a	18.71 c	5.46 c	8.17 c	45.02 c
$S\bar{x}$	0.32	0.09	1.48	0.58	1.10	0.19	0.17	0.33	0.23
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Figure in a column having the same letter do not differ significantly as per DMRT

Table 5. Effects of transplanting date on the reproductive characters, yield and yield components at harvest of different hybrid rice varieties

Planting date	Number of effective tillers hill^{-1}	Panicle length(cm)	Number of total spikelets panicle^{-1}	Number of grains panicle^{-1}	Number of sterile spikelets panicle^{-1}	Weight of 1000 grains (g)	Grains yield (tha^{-1})	Biological yield (tha^{-1})	Harvest index (%)
30 December	7.51 a	23.69 a	127.63 a	101.12 a	27.89 a	24.16	6.86 a	10.65 a	46.89
15 January	6.30 b	22.67 b	124.06 a	97.38 b	28.42 a	24.15	6.77 a	10.47 a	46.97
30 January	5.99 c	21.05 c	113.96 b	92.99 c	22.52 b	23.93	6.27 b	9.43 b	46.74
$s\bar{x}$	0.22	0.17	1.14	0.91	0.81	-	0.15	0.30	-
Level of significance	0.01	0.01	0.01	0.01	0.01	NS	0.05	0.05	NS

Figure in a column having the same letter do not differ significantly as per DMRT
NS = Not significantly differ at $p \leq 0.05$

Table 6. Interaction effects between variety and transplanting date on the reproductive characters, yield and yield components at harvest

Variety	Planting date	Number of effective tillers hill^{-1}	Panicle length (cm)	Number of total spikelets panicle^{-1}	Number of grains panicle^{-1}	Number of sterile spikelets panicle^{-1}	Weight of 1000 grains (g)	Grains yield (tha^{-1})	Biological yield (tha^{-1})	Harvest index (%)
Aloron	30 December	6.26	22.66 cd	127.08 c	107.82	18.59 cd	27.07	5.76	12.62	48.38 a
	15 January	5.77	21.89 d	120.35 d	103.47	16.20 de	26.92	5.41	11.97	48.15 a
	30 January	5.58	20.71 e	114.62 d	100.52	12.43 ef	27.17	5.24	11.69	47.98 a
Tia	30 December	9.10	24.28 a	118.17 d	95.23	22.22 c	21.35	4.45	10.39	46.59 b
	15 January	7.62	22.76 cd	106.17 e	88.98	16.52 de	21.32	4.42	10.37	46.36 b
	30 January	6.95	20.05 e	98.53 f	87.18	11.15 f	21.0	4.34	9.88	48.14 a
Taj	30 December	7.21	23.76 ab	137.68 b	94.37	42.64 b	19.03	3.64	8.87	45.69 b
	15 January	5.55	23.01 bc	146.73 a	93.76	52.30 a	19.17	3.77	8.99	46.38 b
	30 January	5.42	22.04 d	128.72 c	85.32	42.74 b	18.58	2.50	6.68	44.11 c
	$S\bar{x}$	-	0.29	1.97	-	1.40	-	-	-	0.40
Level of significance		NS	0.01	0.01	NS	0.01	NS	NS	NS	0.01

Figure in a column having the same letter do not differ significantly as per DMRT
NS = Not significantly differ at $p \leq 0.05$

Chapter 5

SUMMARY

The study was conducted at the experimental field of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from November 2008 to May 2009. The objective of this study was to evaluate the effect of transplanting dates on three selected hybrid varieties in *Boro* season. The experiment included two treatments as follows a. variety viz., Aloron (hybrid), Tia (hybrid) and Taj (hybrid); b. transplanting date viz., 15 December, 30 December and 15 January. The experiment was laid out in a split-plot design with four replications. The unit plot size was $12m^2$ (4m x 3m). The land was fertilized with urea, triple super phosphate (TSP), murate of potash (MP), gypsum and zinc sulphate @ 270, 150, 120, 110 and 15 kg ha^{-1}. The entire amount of TSP, MP, gypsum and zinc sulphate were applied as basal dose while urea was applied in three equal splits at basal application, 21 DAT and 42 DAT. During the study data were recorded under three broad heads viz., (i) tillering pattern (ii) effective and non-effective tillers $hill^{-1}$ and (iii) reproductive characters, yield and yield components at harvest. The recorded data were analyzed using the Analysis of Variance technique and mean differences were recognized by Duncan's Multiple Range Test (DMRT). The results showed that the maximum number of tillers $hill^{-1}$ was produced in Tia at all sampling dates. Aloron produced the lowest number of tillers $hill^{-1}$ at 7, 14, 21, 49 and 56 DAT while Taj produced the same at 28, 35 and 42 DAT. Significant differences in the production of tillers $hill^{-1}$ were observed in different transplanting dates at all dates of sampling. Interaction between variety and transplanting date showed significant effect on the number of tillers $hill^{-1}$ at 14, 21, 28, 35 and 42 DAT. At 28, 35 and 42 DAT, the maximum number of tillers $hill^{-1}$ was produced in Tia transplanted on 15 December. At 14 and 21 DAT, the maximum number of tillers $hill^{-1}$was produced in Aloron transplanted on 15 December and Tia transplanted on 15 January, respectively. Plant height, number of total tillers $hill^{-1}$, number of non-bearing tillers $hill^{-1}$ and straw yield were significantly affected by different planting dates. Plant height, number of total tillers $hill^{-1}$, number of non-bearing tillers $hill^{-1}$ and straw yield were found to decrease with the delay in transplanting. The highest values in plant height (111.05 cm), number of total

tillers hill^{-1} (11.14), number of non-bearing tillers hill^{-1} (1.94) and straw yield (6.83 tons ha^{-1}) were obtained from 15 December transplanting and the lowest from 15 January transplanting. The maximum (2.12) and the minimum (1.83) number of non-bearing tillers hill^{-1} were recorded on 15 January and 30 January transplanting, respectively. Variety had significant effect on number of effective tillers hill^{-1}, panicle length, number of total spikelets panicle^{-1}, number of grains panicle^{-1}, number of sterile spikelets panicle^{-1}, weight of 1000 grains, grain yield, biological yield and harvest index. The highest number of grains panicle^{-1}, weight of 1000 grains, grain yield, biological yield and harvest index were obtained from Aloron and the lowest from Taj. Panicle length and number of total spikelets panicle^{-1} were the maximum in Taj and the minimum in Tia. Taj and Aloron produced the maximum and the minimum number of sterile spikelets panicle^{-1}, respectively. Tia produced the highest effective tillers hill^{-1}and Aloron varied significantly from it. All other reproductive characters except 1000-grain weight were significantly affected by transplanting dates. Number of effective tillers hill^{-1}, panicle length, number of total spikelets panicle^{-1}, number of grains panicle^{-1}, number of sterile spikelets panicle^{-1}, weight of 1000 grains, grain yield, and biological yield were found to be reduced due to delay in transplanting. The highest values of those characters were observed on 15 December transplanting and lowest on 15 January transplanting. Number of sterile spikelets and harvest index were the maximum on 30 December transplanting and the minimum on 15 January transplanting. Panicle length, number of total spikelets panicle^{-1}, number of sterile spikelets panicle^{-1}, harvest index were significantly affected by the interaction between variety and transplanting dates. The highest number of sterile spikelets panicle^{-1} and panicle length were observed in Taj with 30 December transplanting and Tia with 15 December transplanting, respectively. Taj transplanted on 30 December produced the highest number of total spikelets panicle^{-1}and Tia transplanted on 15 January produced the lowest number of total spikelets panicle^{-1}. Harvest index was the maximum in Aloron transplanted on 15 December and the minimum in Taj transplanted on 15 January. The highest and the lowest numbers of grains panicle^{-1} were recorded in Aloron and Taj, respectively.

Conclusion and Recommendations

Among all studied hybrid varieties, Aloron is the best in respect of grain yield and it should preferably be transplanted between 15 and 30 December to have appreciable higher grain yield over inbred varieties.

For confirmation of these results, research work on transplanting dates should be carried out in different Agro-ecological zones of Bangladesh.

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Appendix I. Monthly record of air temperature, relative humidity and sunshine of the Experimental site during the period from October 2008 to July 2009

Year	Month	Air Temperature(°C)		Relative* Humidity (%)	Rainfall** (mm)	Sunshine** (hr)
		Maximum	Minimum			
	October	30.4	15.6	81	147	7.3
2008	November	32.3	16.3	79	0	7.9
	December	29.0	13.0	72	1	3.9
	January	28.1	11.1	55	1	5.7
	February	33.9	12.2	67	45	8.7
	March	34.6	16.5	65	88	7.3
2009	April	34.7	23.6	69	88	6.4
	May	34.9	25.9	70	90	7.8
	June	34.5	26.8	76	185	7.1
	July	32.2	26.1	73	213	6.3

*Monthly average ** Monthly total

Source: Bangladesh Meteorological Department (Climate & water division) Agargoan, Dhaka.

Appendix II. Effects of variety on the number of tillers hill^{-1} at different DAT

Variety	Number of tillers hill^{-1}							
	Days after transplanting							
	7	14	21	28	35	42	49	56
Aloron	3.38 b	4.13 c	5.66 c	8.13 b	9.09 b	9.91 b	9.28 b	8.24 c
Tia	3.90 a	5.27 a	7.34 a	9.76 a	12.20 a	12.38 a	11.83 a	10.41 a
Taj	3.57 b	4.59 b	6.15 b	8.07 b	8.86 b	9.49 b	10.20 b	9.28 b
$S\bar{x}$	0.065	0.08	0.04	0.16	0.14	0.23	0.46	0.22
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01

Figure in a column having the same letter do not differ significantly as per DMRT.

Appendix III. Effects of transplanting date on the number of tillers hill^{-1} at different DAT

Planting date	Number of tillers hill^{-1}							
	Days after transplanting							
	7	14	21	28	35	42	49	56
15 December	4.58 a	5.30 a	6.70 b	8.18 b	10.88 b	12.27 a	12.55 a	10.04 a
30 December	2.75 b	4.70 b	5.02 c	9.74 a	11.64 a	11.84 a	9.81 b	9.29 a
15 January	1.71 c	3.99 c	7.42 a	7.54 c	7.63 c	7.68 b	8.95 c	8.61 b
$s\bar{x}$	0.09	0.09	0.13	0.22	0.22	0.23	0.27	0.29
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Figure in a column having the same letter do not differ significantly as per DMRT.