EFFECT OF TRANSPLANTING DATES ON GROWTH AND YIELD OF AROMATIC RICE VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF TRANSPLANTING DATES ON GROWTH AND YIELD OF AROMATIC RICE VARIETIES**" is being submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207 in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **MD. HASIBUL HASAN RABBI,** Registration No. **17-08258** under my supervision and guidance. The results embodied in this thesis have not been submitted to any other University or Institute for the award of any 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.

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Dedication

This thesis is dedicated to:

My family

Rahana Parvin
Sabina Yeasmin
Md. Habibur Rahaman
Md. Habibul Alam Refat

You have showed me what the true meaning of life really is.
You have showed me what it means to love, and to be loved.
You have helped make me who I am and continue to do so.
You the constant in my life, the thing that is there when I
close my eyes and is still there when I open them again.
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but let me try for the very first time-

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The author

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ABSTRACT

The experiment was conducted at experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from July to December, 2018 with a view to study the effect of transplanting dates on the growth and yield of aromatic rice varieties. The experiment consisted of two levels of treatments *viz.* (A) Two varieties- BRRI dhan34 and Chinigura; (B) Four transplanting dates: 14th, 21th, 28th August and 4th September 2018. The experiment was laid out in Randomized Complete Block Design with three replications. Varietal effect was significant based on all the recorded agronomic parameters whereas transplanting dates had little effect on plant height, number of total tillers hill^{-1}, dry matter production, filled grain panicle^{-1}, grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) of the crop. Combined effect showed significant variation on the growth and yield parameters like plant height, number of total tillers hill^{-1}, dry matter production (g hill^{-1}), number of effective tillers hill^{-1}, panicle length and weight, number of filled and unfilled grains panicle^{-1}, grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%). Between two varieties, BRRI dhan34 produced the highest grain yield (3.12 t ha^{-1}), number of effective tillers hill^{-1} (16.67), number of filled grains panicle^{-1} (147.35) while Chinigura produced highest plant height (125.94 cm), dry matter production (136.12 g) and straw yield (8.98 t ha^{-1}). As a variety, the lowest performance in terms of growth and yield-contributing characters, except straw yield, was recorded in Chinigura transplanted on 4th September. Among the interaction treatments, the 21th August showed the highest grain yield (3.92 t ha^{-1}) for BRRI dhan34. 21th August is appeared as a suitable time for transplanting of aromatic rice in transplanted aman season in Bangladesh.

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LIST OF ACRONYMS

Abbreviation	Full Word
%	Percentage
@	At a rate of
°C	Degree Celsius
AEZ	Agro-Ecological Zone
Anon.	Anonymous
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
CV	Coefficient of Variance
cv.	Cultivar
DAT	Days after Transplanting
e.g.	Example
et al.	And others
FAO	Food and Agriculture Organization
G	Gram
HI	Harvest Index
hr	Hour
IRRI	International Rice Research Institute
K_2O	Potassium Oxide
kg ha^{-1}	Kilogram per hectare
kg	Kilogram
LSD	Least Significant Difference
m	Meter
m^2	Square meter
mg	Miligram
MoP	Muriate of Potash
m ton	Metric tonne
N	Nitrogen
NS	Not Significant
OM	Organic matter
P_2O_5	Phosphorus Pennta Oxide
pH	Potential Hydrogen
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
Sig.	Significant
SRDI	Soil Resource Development Institute
t ha^{-1}	Ton per hectare
TDM	Total Dry Matter
TSP	Triple Super Phosphate
Var.	Variety
viz.	For example

Chapter 1

INTRODUCTION

Rice (*Oryza sativa* L.), belongs to Poaceae family, is the staple food of about 160 million people of Bangladesh which provides nearly about two-third of total calories supply and about one-half of the total protein intakes of an average person in the country. As a Bengali Nation different delicious recipe of rice viz. vat, muri, khai, biriani, polao, morog-polar, kacchi-biriani, payesh etc. are produced widely. Rice, in a true sense, is more than just an everyday food item. For many Bangladeshis, it signifies both life and culture. It is deeply ingrained in Bangladesh culture and even the words 'food' and 'rice' are synonymous in Bengali (Anonymous, 2018). Rice cultivation is the major source of livelihood and about 72% of the agricultural production comes from rice. It is the major source of cash income to the average Bangladesh farmers. Moreover, rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (BBS, 2018). In terms of rice production Bangladesh (7.5%) holds 4th position among 114 countries (FAO, 2016). Among the 150 different crops grown in Bangladesh, rice alone occupies about 77% of the total cultivated area and the total area and production of rice in Bangladesh is about 11.27 million hectare and 45.98 million ton, respectively (FAOSTAT, 2017). Average yield rate of aman for the Financial Year 2016-17 has been estimated 2.446 tons per hectare and total aman production of Financial Year 2016-17 has been estimated 1,36,56,054 tons (BBS, 2018).

Aromatic rice is a general term used for rice varieties that have flavor and aroma. Aroma of rice is due to certain chemicals present in the endosperm viz. 2-acetyl-1-pyrroline and 100 others volatile compounds (Singh *et al.*, 2000). They are generally medium to long-grained and have a light, fluffy texture when cooked. The aromatic rice rated best in quality and fetches much higher price in international market than high quality non-aromatic rice. Aromatic rice plays a vital role in international rice trading. Bangladesh has a bright prospect for export of fine rice thereby earning foreign exchange (Islam *et al.*, 2012). The demand of aromatic rice in this country is increasing due to its special appeal for aroma and acceptability although grain yield is low. Aromatic rice is the most highly valued rice commodity in Bangladesh Agricultural trade markets having small grain and pleasant aroma with soft texture upon cooking (Dutta *et al.*, 1998).

The supply of aromatic rice is not sufficient to fulfill the demand of the people in Bangladesh because of its low area coverage as well as lower yield. However, its higher price and low cost of cultivation generated higher profit margins captured to other varieties. Aromatic rice of Bangladesh has got the potential to enter the export trade and she exported 50-55 tones aromatic rice to Europe, the United States and the Middle East (Das and Baqui, 2000). There are 36 indigenous aromatic rice assents in BRRI germplasm from where Modhumala, Tulsimala, Kataribbog etc. were evaluated (BRRI, 1993). BRRI released aromatic rice variety BRRI dhan34 and Chinigura are the most highly valued commodity in Bangladesh agricultural trade market for having small grain and pleasant aroma. Chinigura was the predominant one that covered more than 70% farms in the northern districts and 30% of the rice lands were covered by aromatic rice cultivars during Aman season (Islam *et al.*, 2012). The average area devoted to aromatic rice production in the T. Aman season was 12.5%, with an average yield of 2.0 t ha^{-1} and the resultant total production of 1.42 million tons (Islam *et al.,* 1996).

Seeding and transplanting time can be influenced directly or indirectly by weather condition during land and seedbed preparation, method of seeding or transplanting, irrigation facilities, times of maturity of rice. Singh *et* al. (1997) described some factors which adversely affects aroma such as- transplanting date, hot weather during flowering and development, nitrogenous fertilizer, poor soil, heavy soil, delayed harvesting after maturity and mechanical dehulling. Late transplanting of photoperiod-sensitive Aman rice does not produce flower due to higher day length. Rice planted in mid-July gave the highest grain yield and with the advancement of planting dates yield decreased.

In Bangladesh, the transplanted Aman rainfed season is one of the most important rice-growing periods which might suffer from high temperature at the different growth stages of the crop from germination to maturity (BRRI, 2007). Rice varieties grown in the transplanted Aman season are mostly photoperiod-sensitive and influenced by daily sunshine hours. The sensitivity of flowering of these varieties mostly depends on the planting date when transplanted in the late season during September–October. Padalia (1981) reported that early transplanting of Aman rice in 1st July produced the higher grain yield 2.6 t/ha than other dates. The early-planted photoperiod-sensitive rice varieties go through a lag vegetative phase during which increases in their height as well as biomass make them prone to lodging during the grain-filling stage. Adjustment in the time of transplanting, therefore, enables the plants to take advantage of natural conditions favorable for growth. Yoshida (1983) reported that rice plants require a particular temperature for phenological responses such as panicle initiation, flowering, panicle exertion from flag leaf sheath and maturity, and these responses are very much influenced by the planting dates during the transplanted Aman season.

However, the price of fine rice, especially the aromatic rice is 2-3 times higher than that of coarse rice. In spite of low yielding of aromatic rice, it requires less input compared to coarse rice. Many researchers reported that the influence of time of transplanting on the yield and yield contributing characters of rice and obtained better results from early transplanting than late transplanting. So, selections of right type of variety and suitable date of transplantation are also most important factors for maximizing yield. Under the above circumstances, it was felt necessary to examine the performance of aromatic rice in different transplanting dates in Aman season. Nevertheless, appropriate planting date is required for higher yields with better quality of aromatic rice.

Considering the above facts, the present experiment was conducted to achieve the following objectives-

a) To compare yield performance of two aromatic rice varieties.

b) To determine optimum transplanting time of aromatic rice varieties.

c) To assess interaction effect of variety and different transplanting dates on growth and yield of aromatic rice.

Chapter 2

REVIEW OF LITERATURE

The performance of the aromatic rice is determined by the interactions of genetic potential with its environment to which it is grown (BRRI,1990). The genetic potential (yield) depends on cultural practices such as transplanting of rice in optimum time and the use of good varieties have considerable role on the growth and yield of rice. A number of experiments have been conducted in Bangladesh and also elsewhere in the world with these aspects to evaluate the performance of transplanted Aman rice by altering transplanting dates to find out the optimum time for aromatic rice cultivation during aman season.

In this chapter, an attempt has been made to review some of the remarkable findings of various researches at home and abroad related to the optimum time and variety on the performance of some transplanted aromatic rice varieties in aman season.

2.1 Effect of date of transplanting

A successful crop production depends on transplanting dates. Optimum time for transplanting is most important management practices for crop production. Transplanting date has a great influence on crop growth and yield. Variation of yield and other crop growth characters due to different transplanting dates are cited below:

Kabir *et al.* (2014) conducted a field experiment at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to determine the effect of transplanting dates on growth and yield of rice varieties grown in the rainfed season of 2011. In the experiment they manipulated transplanting dates using 2 HYV and 2 hybrid varieties. They reported that transplanting dates had a little effect on panicle length, grain yield straw yield, biological yield and harvest index. Early transplanting resulted in highest grain yield, biomass production. On the other hand, late transplanting showed lowest result in all varieties. They concluded that early transplanting brought a better result than late transplanting.

Mannan *et al.* (2012) conducted an experiment at the Bangladesh Rice Research Institute Farm, Gazipur, to determine the optimum planting date and to select the varieties having high yield potential. Traditional aromatic photoperiod sensitive fine rice varieties; Kalijira, Kataribhog, Chinigura and Badshabhog were transplanted from 10 August and continued up to 25 September, both in 2000 and 2001 years, at an interval of 15 days. Results exhibited that plant tallness, number of tillers and dry matter increased with the advancement of planting dates. On the contrary, the number of panicles, grains panicle^{-1}, panicle length, grain yield, straw yield and growth duration decreased with delaying of planting dates. The intermediate short stature plant type of Chinigura exhibited higher number of panicles and comparatively heavier individual grain, consequently gave higher grain yield planted with in December. However, in late planted situation in 10 September Kalijira exhibited higher number of panicles, grains panicle^{-1}, resulted higher grain yield than the rest of the varieties. Thus, cultivation of traditional aromatic fine rice Chinigura and Kalijira have the potentiality to produced higher grain yield when planted in early December.

Safder *et al.* (2008) conducted a field experiment to investigate the effect of various transplanting dates on the yield and yield related parameters as well as flowering behavior of fine rice grain rice genotypes. The experiment was conducted for three successive years from 2004 to 2006. Six transplanting dates *viz.* 16th May, 1st June, 16th June, 1st July, 16th July and 1st August were used for the experiment during each year. The 3 years average data showed that maximum number of fertile tiller hill^{-1} was recorded in 1st June transplanting date, whereas, plant height, grains panicle^{-1}, 1000 grain weight and paddy yield were highest in 16th July transplanting dates, irrespective of genotypes. However, minimum paddy yield was recorded in 1st August transplanting date. Therefore, 16th July was found to be the best date of transplanting.

Islam *et al.* (2008) was conducted a field experiment to find out the effect of nitrogen levels and transplanting dates on the yield and yield components of aromatic rice cv. Kalijira. The experiment was laid out in a randomized complete block design with three replications using three transplanting dates (10 August, 22 August and 04 September, 2007). The study revealed that most of the yield and yield contributing characters with few exceptions were significantly influenced by transplanting dates. They had significant positive effect on tillers hill^{-1}, tillers hill^{-1}, grains panicle^{-1} and straw yield. The highest grain and straw yield were observed in 10th August transplanting treatment and the lowest grain and straw yields were found in transplanting date of 4th September. They concluded that late transplanting reduce yield and yield contributing component.

BRRI (Bangladesh Rice Research Institute) conducted a number of researches on different rice varieties in aman season with manipulation of transplanting dates and they carried out some findings related to growth and yield contributing characters. In the year of 1988, BRRI was reported that three photosensitive varieties viz. BR4. BR10 and BR11 transplanted on 2 and 18 September and showed that the grain yield was reduced in all the varieties in 18 September transplanting compared to September 2 transplanting. Then in 1990, BRRI reported that the grain yield of photoperiod sensitive varieties decreased as the transplanting delayed beyond September at Gazipur area of Bangladesh. The rate of grain yield reduction was higher in the Northern regions compared to southern part of Bangladesh. In 1994, BRRI conducted an experiment and reported that the planting of Aman rice in September decreased grain yield and rate of yield reduction increased with the delaying of planting time. On the contrary, yield reduction was higher in weekly photoperiod sensitive varieties compared to strongly photoperiod sensitive rice. From 1999 to 2001, BRRI conducted another experiment to find out the best time of transplanting for Aman season. Under favorable condition, the optimum time of planting at modern Anion rice as recommended by BRRI is July to 15 August. Again in the same year, BRRI (2001) evaluated that most of the fine rice varieties are grown in the aman season. However, fine rice varieties can also be grown in boro season with the manipulation of planting date and the application of water. In another report, BRRI (2001) stated that under favorable condition transplant Aman rice performed best when planted between mid-July and the end of August. It was also reported that most of the fine rice varieties produced the higher grain yields planted in early September. In the year of 2003, BRRI reported that drastically yield reduction was observed when transplanting was done after mid-September from the result of an experiment.

Islam *et al.* (1999) conducted an experiment among different rice varieties and observed that agronomic characters of plan such as plant height, panicle hill^{-1} and panicle length were significantly affected by different planting dates. They observed that the grain yield of transplanting Aman rice decreased gradually with the delay of planting dates beyond August, because low temperature increase sterility in late planted rice.

Alam (1998) observed that traditional rice sometimes transplanting continued up to the end of September.

Krishnan and Nayak (1998) conducted an experiment and observed that transplanting during 15-25 July gave the highest grain yield, while delay in transplanting up to 4th August reduced grain yield by 38.9%. Rice planted in mid-July gave the highest grain yield and with the advancement of planting dates yield decreased. They also stated that pollen grains were desiccated by high temperature was significantly reduced by delayed transplanting.

Dhiman *et al.* (1997) showed that when transplanting became late the crop was attacked by insect or disease severely.

Dinesh *et al.* (1997) observed that basmati rice planted from July to September responded differently. Delayed planting (August) significantly decreased grain and straw yields of rice in India.

Gangwar and Sharma (1997) observed that the different rice varieties (Aromatic and non-aromatic) transplanted in different dates significantly influenced the grain yield and aroma content of rice. To achieve the full yield potential of traditional aromatic rice varieties, it is necessary to determine their optimum planting time in each season in specific location.

Haque (1997) reported that delayed transplanting led to increase in vegetative growth index, whereas duration of vegetative growth based on number of days until heading decreased. Changed in growth duration to various stages due to delayed transplanting were more pronounced for flowering and 80% panicle ripe indicating that these stages could he optimal for studying the response of rice plant to delayed transplanting. It is better to transplanting Aman rice such a way that. the reproductive phase takes place in good weather with declining temperature and high solar radiation for grain filling.

Singh *et al.* (1997) conducted an experiment and he showed that the rice seedlings planted early or late influence the growth and yield due to change in the climatic conditions. Thus, the growth and grain yields of rice depended on the genetic potentials of cultivars, environmental conditions and management practices.

Gohain and Saikia (1996) observed that scented rice varieties planting in mid-July (20 July) gave yield maximum grain yield and thereafter the yield was declined with delay in planting. The reduction of yield was about 50% when planting was delayed from 20 July to September.

Paliwal *et al.* (1996) observed that scented rice planting in early July gave the highest grain yield compared to mid-August planting in India. The normal time of transplanting of scanted rice is July to august but often its delayed due to late onset of the monsoon rains resulting low yield.

Rao *et al.* (1996) reported from an experiment with 4 Basmati type varieties of rice transplanted during 15-25 July gave the highest yield. While delay in transplanting up to 4 August reduced the grain yield by 38.9%.

Subbian *et al.* (1995) reported that the highest grain yield was recorded at 15 July transplanting which was significantly superior to both 30 June and 30 July planting in India. Crop transplanting 30 June experienced a greater number of cloudy days during panicle initiation and flowering stages and thereby had adverse effect on fertilization. This was reflected through number of grains panicle^{-1} which were significantly less than those under 15 July transplanting. However, late planted crop gave a smaller number of tillers and panicles consequently reduced grain yield.

Ghosh and Ganguly (1994) conducted an experiment with some modern and traditional rice varieties in different transplanting dates. In the experiment, they observed that modern variety in late planting caused reduction of grain yield while early planting of traditional variety failed to increase grain yield. They find out that it was happned due to premature lodging of the crop prior to flowering.

Om *et al.* (1993) in India reported that yields decreased with delay in transplanting. They further conducted that this was due to reduction in number of panicle hill^{-1} and grains panicle^{-1}.

Yoshida (1981) reported that rice plant required a particular temperature for phenological responses such as panicle initiation, flowering, panicle exertion from flag leaf sheath and maturity, and these responses are very much influenced by the planting dates during the transplanted aman season.

AICRIP (1992) reported that the yield and quantity of scanted rice was achieved by planting the crop at the optimum time at any specific location, which may vary from variety to variety.

Ali *et al.* (1991) observed that during wet season early or delay transplanting adversely affected milling recovery and cooking quality of scented basmati rice.

Miah *et al.* (1990) and Islam *et al.* (1999) reported that transplanting time influences the vegetative phase of a variety in Aman season. Rice seedling when planted late, it will get short period for its vegetative growth and thus its yield decreased.

Chandra and Manna (1988) reported that the day length of the vegetative phase determines the growth and ultimate grain yield. It has been found that the vegetative phase shorter by delayed planting and ultimately decreases the yield.

Babu (1987) reported that the yield and quantity of aromatic rice was accomplished by planting the crop at the ideal time at any exact location, which may vary from variety to variety.

Joseph and Havanagi (1987) reported that consideration of planting time of rice was the most important to obtain higher yield. The early or late planting of rice in Aman season influences the growth and yield due to change in the climatic condition.

Alim *et al.* (1986) reported that transplanting of Aman rice after 15 July decreasing grain yield. The critical transplanting date for transplanting date for transplanted Aman rice was 8 September. They further stated that the grain drastically reduced after 8 September planting.

Islam (1986) stated that the time between July 15 and August 15 was the best time for transplanting of high yield varieties of transplanted aman rice specially for photosensitive cultivars.

Yoshida (1981) reported that the flowering response to photoperiod sensitive varieties was markedly affected by the changes in day length. Rice growing in short day is sensitive to photoperiod thus long day can prevent or considerably delay flowering. However, photoperiod of most varieties is about 9-10 hours.

Mejos and Pava (1980) pointed out that the number of days to heading, flowering, maturity and plant height were reduced with delay in transplanting.

Zaman (1980) revealed that transplanting time in Aman season was very important to control the vegetative phase of a variety. In other words, early transplanting beyond the optimum enhanced excessive vegetative growth and late planting shortening the vegetative phase.

2.2 Effect of variety

The variety of crop is one of the basic ingredients of crop culture for successful production of the crop. Variety has a great influence on crop growth and yield. Variation of yield and other crop growth characters due to different varieties are cited below.

Debnath *et al.* (2012) observed that variety had significant effect on all the agronomic parameters except number of effective tillers, ineffective tillers, total tillers, grain straw ratio and biological yield. BRRI hybrid dhan2 produced the highest dry grain yield (5.92 t ha^{-1}) and the lowest straw yield (4.97 t ha^{-1}), whereas, BRRI dhan29 produced the lowest grain yield (4.16 t ha^{-1}) and the highest straw yield (6.70 t ha^{-1}).

Mannan *et al.* (2012) conducted an experiment at the Bangladesh Rice Research Institute Farm, Gazipur, to determine the optimum planting date and to select the varieties having high yield potential. Traditional aromatic photoperiod sensitive fine rice varieties; Kalijira, Kataribhog, Chinigura and Badshabhog were transplanted from 10 August and continued up to 25 September, both in 2000 and 2001 years, at an interval of 15 days. Results exhibited that the intermediate short stature plant type of Chinigura exhibited higher number of panicles and comparatively heavier individual grain, consequently gave higher grain yield planted with in September. Thus, cultivation of traditional aromatic fine rice Chinigura has the potentiality to produced higher grain yield.

Ashrafuzzaman *et al.* (2009) conducted an experiment and that was undertaken to evaluate the growth performance and grain quality of six aromatic rice varieties BR34, BR38, Kalizira, Chiniatop, Kataribhog and Basmati grown under rainfed conditions. The rice varieties differed significantly ($P<0.05$) with respect to leaf chlorophyll content, plant height, internode length, thousand grain weight and grain and straw yields. Varieties differed in morphological and yield and yield contributing traits. Thousand grain weight and grain yield both were highest in BR38. Basmati required shorter days to maturity and Kalizira longest days to maturity.

Hossian *et al.* (2008) conducted a field experiment to evaluate the effect of different nitrogen levels on the performance of four rice varieties in transplanted aman (monsoon) season. Aromatic rice varieties included BRRI dhan38, Kalizira, Badshabhog and Tulsimala, while nitrogen was applied at 30, 60, 90 and 120 kg ha-1. Performance of different varieties was different. All the yield contributing characters differed significantly due to variety. Kalijira produced the maximum number of grains per panicle (135.90). Among the varieties, BRRI dhan38 gave the maximum grain yield (4.00 t ha^{-1}). Different nitrogen rates also significantly affected the aromatic rice varieties. All the yield components were significantly increased up to 90 kg N ha^{-1}. Nonetheless, maximum grain yield (3.62 t ha^{-1}) was observed from 60 kg N ha^{-1}. The combination of varieties and nitrogen rates also affected the plant characters and yield components of aromatic rice, which ultimately affected the yield and it was observed that in combination the variety BRRI dhan38 was more responsive to nitrogen to produce better yield.

Safder *et al.* (2008) conducted a field experiment to investigate the effect of various transplanting dates on the yield and yield related parameters as well as flowering behavior of fine rice grain rice genotypes. The experiment was conducted for three successive years from 2004 to 2006. Rice genotypes viz. 98410, 98316, 99417, 99512, 99513, 98408, 00521-1, 98404, Basmati 385 and Super Basmati were used in the experiment and found that rice genotypes, 99417 produced highest plant height and 1000 grain weight but lowest paddy yield, whereas, 98408 and 99513 gave maximum values of productive tillers hill^{-1} and grains panicle^{-1} respectively. Fine grain rice genotype 99512 showed best yield performance by producing highest yield. Genotype 99512 showed best performance among all the genotypes studied. Flowering behavior showed that all genotypes were photoperiod sensitive except 98410 which showed that it was a non-basmati fine grain genotype.

Main *et al.* (2007) reported that there was no significant variation of effective tillers total grains panicle^{-1}, filled grains panicle, straw yield and harvest index observed between the two varieties but hybrid variety showed higher panicle, grain weight and grain yield compared to inbred variety. The variety Sonarbangla-1 gave the longer panicle (26.40 cm) compared to that of BR11 (25.66 cm). The higher weight of 1000 grains (28.32 g) was obtained from the hybrid variety and the lower (27.08 g) was obtained from the inbred variety. The higher grain yield (4.70 t ha^{-1}) was obtained from the hybrid variety Sonar bangla-1 and from inbred variety BR11 (4.43 t ha 1).

Obaiidullah (2007) specified that variety significantly influenced panicle length, number if total grains panicle^{-1}, filled grains panicle^{-1}, 1000 grains weight, grain yield and straw yield but not for effective tillers hill^{-1} and harvest index. The varietal effects on yield and other yield attributes where hybrid variety gave numerically maximum tillers hill^{-1} (10.08), and significantly highest panicle length (27.36 cm), grains panicle^{-1}(196.75), filled grains panicle^{-1} (156.84), 1000 grain weight (27.40 g) which eventually elevated the grain yield (5.58 t ha^{-1}). These parameters were 9.8, 25.17 cm, 112 83, 86.77, 20.09 g and 3.88 t had, respectively as lowest measurements from Inbred varieties.

Ashrafuzzaman (2006) detected that variety significantly influenced total spikelet panicle^{-1}, grains panicle^{-1}, 1000 grain weight, grain yield and harvest index. The higher number of spikelet panicle^{-1} (178.04) was obtained from the inbred variety BRRI dhan32 and the lower number of grains panicle^{-1} (155.49) was obtained from the hybrid variety sonarbangla-1. The inbred variety showed 14.50% higher number of total spikelet panicle compared to hybrid variety. The higher number of grains panicle^{-1} (147.59) was counted in the inbred variety and the lower (111.98) number were counted in the hybrid variety. The higher weight of 1000 grains (27.12 g) was obtained from the hybrid variety and the lower (21.89 g) from the inbred variety. The higher grain yield (5.46 t ha^{-1}) was obtained from the hybrid variety compared to that of inbred variety (4.45 t ha^{-1}). The grain yield was 20.26% higher in the hybrid variety than the inbred variety. The higher harvest index (47.53%) was found from the hybrid variety and the lowest harvest index (43.20%) was found in inbred variety. The harvest index was 10.07% higher in the hybrid variety compared to the inbred variety. Similar results were also reported by Cui *et al*. (2000).

Akbar (2004) stated that variety, seedling age and their interaction exerted significant influence on almost all the studied crop characters of rice. Among the varieties, BRRI dhan41 performed the best in respect of number of bearing tillers hill^{-1}, panicle length, total spikelet panicle^{-1} and no. of grains panicle^{-1}. BRRI dhan41 also produced the maximum grain and straw yields, Sonarbangla- 1 ranked first in respect of total tillers hill^{-1} and 1000 grain weight but produced the highest number of non-bearing tillers hill and sterile spikelet panicle^{-1}. BRRI dhan41 may be cultivated using 15-day-old seedlings in aman season following the SRI technique to better grain and straw yields.

Islam and Islam (2004) reported that grain yield of aromatic rice varieties was low but its high price and low cost of cultivation generates high profit compared to other varieties grown in the Northern region of Bangladesh.

BRRI (Bangladesh Rice Research Institute) conducted numerous researches on different rice varieties in aman season to carry out some findings related to growth and yield contributing characters. They are as follows-

BRRI (1991) reported that the number of effective tillers hill^{-1} was produced by transplant Aman rice varieties which ranged from 7-14. Number of effective tillers hill^{-1} significantly differed among the varieties. In the same year in another report, BRRI also reported that the number of total tillers hill^{-1} differed significantly among BR3, BR11, BR14, Pajam and Zagali varieties in boro season. In a report BRRI (1991) stated that weight of 1000-grain of Haloi, Tilockachari, Nizershail and Latishail were 26.5, 27.7. 19.6 and 25.0 g respectively.

BRRI (1994a) found from the result of an experiment that BRI4 produced the highest yield (3.75 t/ha) followed by Pajam and Tuishimala while 8R5 produced the lowest yield (2.61 t/ha). In the same year, BRRI (1994b) conducted another experiment to observe the performance of BR14, Pajam, BR5 and Tulsimala. They observed that Tulsimala produced the highest number of spikelets panicle^{-1} and BR14 produced the lowest number of spikelets panicle^{-1}.

After that, BRRI (1995) evaluated the varietals performance of BR4, BR10, BR11, BR22, BR23 and BR25 including two local checks Challisha and Nizershail. The results indicated that BR4. BR10. BR11, Challisha and Nizershail produced yields of 14.38, 3.12, 3.12. 3.12 and 2.70 t/ha respectively while BRRI (l995) in another trial observed that BR25 out yielded over BR22 and Nizershail.

BRRI (1997) stated that in local varieties namely Haloi, Tilockachari, Nizersail and Latishail, the number of effective tillers hill^{-1} were 9.7, 9.3, 10.8 and 9.0 respectively. In another report, BRRI (2000) reported that from different varieties Basmati, Kataribhog and BRRI dhan34 plant height differed significantly among the varieties. Result revealed that the tallest plant (126 cm) was recorded from Basmati and the shortest one (115 cm) was observed as a result of Kataribhog.

BRRI (1998) reported that the 1000-grain weight of Kuieha Binni, Leda Binni. Chanda Binni, Dudh Methi, Maraka Binni, Nizcrshail and one high yielding variety BR25 were 24, 22, 25, 20, 23, 18 and 17g respectively. In this year, in another report, BRRI found that 1000-grain weight of some aromatic rice varieties ranged from 12 g to 20 g and it differed significantly from variety to variety. It was also reported that three advanced lines BR4384-2B-2-2-4, BR4384-213-2-2-6 and BR4384-2B-2-2-HR3 and two local varieties namely Kataribhog and Khaskani showed 1000-grain weight values of 20, 16.5, 16.2, 15 and 12 g respectively.

In an experiment, BRRI (2000) observed the performance of three advanced lines BR438-213-2-2-2-4, BR4384-213-2-2-6 and BR4284-213-2-2-HR3 along with two standard checks and seven local checks in 11 locations. Kataribhog and Khaskani were used as standard check and Chinking, Basmat, Kalijira, Philippine Katari, Chinigura, Chiniatop and Bashful as local checks. From the results, it was reported that in Sonagazi and Bagura Sadar, the yield performances of advanced lines were excellent with more than 4.0 t/ha grain yield. About 30% higher yield was obtained from the advanced lines over the checks.

Alam (1998) observed that most of the native cultivated Aman rice varieties are photosensitive while the modem genotypes are insensitive to highly sensitive to photoperiod.

Ahmed *et al.* (1998) worked in Bangladesh during Aman season when natural disaster like flood and cyclone were more prevalent, when crop was planted late, the photosensitive varieties were reported to play a major role for boosting yield of rice.

Alam *et al.* (1996) conducted an experiment to evaluate the performance of different rice varieties. Among the varieties Kalijira produced the tallest plant which was followed by Pajam.

Chabder and Jitendra (1996) conducted an experiment and reported that the average productivity of aromatic rice is very low.

Islam (1995) in an experiment with four cultivars viz. BR10, BR11, BR22 and BR23 found that the highest number of non-bearing tillers hill^{-1} was produced by cultivar BR11 and the lowest number was produced by the cultivar BR10.

Chowdhury *et al.* (1993) observed that BR23 showed superior performance over Pajam regarding number of productive tillers/hill. They also observed that the variety Pajam produced significantly higher number of total spikelets in addition to unfilled spikelet panicle^{-1} than that of BR23.

Rao *et al.* (1993) found that the highest grain yield was obtained in the wet seasons by local variety Badshabhog (3.21 t/ha) than the other ones (cv. Kastui, Ranbir, Basmati and lET 8579) and mean yields varied from 2.22 - 2.58 t/ha.

Hossain and Alim (1991) reported that the growth characters like plant height, number of total tillers hill^{-1} and the number of grains panicle^{-1} differed significantly among BR3, BR14 and Pajam varieties in Boro season.

Idris and Matin (1990) conducted an experiment and found that panicle length differed among the varieties and it was greater in BR20 than that of any of the indigenous and high yielding varieties. They farther reported that total number of tillers hill^{-1} was identical among the tested varieties.

Kamal *et al.* (1988) stated that production of the number of grains panicle^{-1} in BR20 and Pajam were 107.6, 123.0 and 170.9 respectively.

Babiker (1986) reported that panicle length of rice cv. Gazi 171 and Gazi 180 different significantly among the varieties.

Alim *et al.* (1962) tested live fine rice cultivars namely Badshahhog, Basmati, Gohindhahhog and Radhunipagal for five years and found that Basmati showed the best performance followed by Gohindhabhog and Badshabhog. They also reported that Radshahhog and Hatishail yielded 2.6 t ha^{-1} and 2.69 t ha^{-1}, respectively.

Chapter 3

MATERIALS AND METHODS

The experiment was carried out during Aman season from August to December 2018 at the experimental field of Sher-e-Bangla Agricultural University to study the effect of transplanting dates on the performance of BRRI dhan34 and Chinigura. The details of material and methods applied and the experimental procedure adopted during the course of research are described below.

3.1 Description of the experimental site

3.1.1 Location of the experiment

The experiment was carried out at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from July to December 2018. The location belongs to the sub-tropical climate and AEZ No. 28 called "Madhupur Tract". It is situated at 23°46'14"N-23°46'14"N latitude and 90°22'35'E-90°22'36'E longitude with an elevation of 8.6 meter from the sea level (Appendix-I). It is characterized by high temperature accompanied by moderate high rainfall during Kharif season (April to September) and low temperature in the Rabi season (October to March).

3.1.2 Climate

The geographical situation of the experimental site was situated under subtropical climate, characterized by three distinct seasons, the monsoon or rainy season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October and also characterized by heavy precipitation during the month of May to August and scanty precipitation during the period from October to March. During Aman season in general there was sufficient rainfall for growing the crop. However, sometimes crop suffered from inadequate rainwater and then irrigation was applied. On the other hand, the temperature increased in the Aman season and gradually decreased with the advance of time from October to March. The bright sunshine hours were comparatively lower in the Aman season. Thus, the climatic factors were agreeable to grow the quality aromatic rice. Climatic data is presented in Appendix II. The record of air, temperature, humidity and rainfall during the period of experiment were recorded from the Bangladesh Metrological Department, Agargaon, Dhaka**.**

3.1.3 Soil

The experimental site was situated in the subtropical zone. The soil of the experimental site lays in Agro-ecological region of Madhupur Tract (AEZ no. 28) of Noda soil series. The soil of the experimental farm belongs to the general soil type (Shallow red brown trace Soil). The land was above flood level. Soil samples from *0-15* cm depth were collected from experimental field. The analysis was done at Soil Resources and Development Institute (SRDI), Dhaka. The soil was loam in texture. The experimental site was medium high land and the pH was 5.6 to 5.8 and organic carbon content was 0.82%. The physio-chemical properties of the soil are presented in Appendix III.

3.2 Growing of crops

3.2.1 Raising of seedlings

3.2.1.1 Seed collection

The two aromatic rice varieties (BRRI dhan34 and Chinigura) were used. One is BRRI released variety which was selected from local race Khashkani and other is a local variety. Chinigura was collected from a local farmer in Dinajpur and BRRI dhan34 was collected from Bangladesh Rice Research Institute (BRRI).

3.2.1.2 Seed sprouting

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

3.2.1.3 Preparation of seedling nursery bed and seed sowing

The seedlings of different varieties were raised in the separate seedbed in traditional way. As per BRRI recommendation seedbed was prepared with 1m wide and no fertilizer was applied in seedbed. Sprouted seeds were sown in beds by broadcast method. Nursery beds were irrigated as and when necessary. Seeds were sown in the seed bed on July 13, 2018; July 20, 2018; July 27, 2018 and August 3, 2018 in order to transplanting the seedlings in the main field.

3.2.2 Preparation of experimental land

The experimental land was prepared with the help of power tiller by three successive ploughing and cross-ploughing followed by laddering. The experimental plot was opened in the first week of July with a power tiller and was exposed to the sun for a weak. After a week the land was prepared by several ploughing and cross ploughing followed by laddering and harrowing with power tiller and country plough to bring about good tilth. This was carried out to manage weeds, provide good soil aeration and to obtain good seedling emergence and root penetration. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings. The final land preparation was done on 25 July, 2018. The experimental area was laid out according to the design of the experiment. The unit plot was leveled before transplanting.

3.2.2.1 Experimental design and layout

The experiment was laid out in two factor Randomized Complete Block Design with three replications. The layout of the experiment was prepared for distributing the combination of varieties and date of transplanting. There were 24 plots of size 3m x 2m in each of 3 replications. The 8 treatments combination of the experiment was assigned at random into 8 plots of each replication. Layout of the design is presented in Appendix IV.

3.2.2.2 Experimental treatments

Treatments included in the experiment were as follows:

A) Factor A: Variety

(i) V_1- BRRI dhan34

(ii) V_2- Chinigura

B) Factor B: Transplanting dates

(i) T_1- 14 August, 2018

(ii) T_2- 21 August, 2018

(iii) T_3- 28 August, 2018

(iv) T_4- 4 September, 2018

Treatments combinations:

➢ BRRI dhan48 (V_1)	x	14 August,2018 (T_1)
		21 August, 2018 (T_2)
		28 August, 2018 (T_3)
		4 September, 2018 (T_4)
➢ Chinigura (V_2)	x	14 August,2018 (T_1)
		21 August, 2018 (T_2)
		28 August, 2018 (T_3)
		4 September, 2018 (T_4)

3.2.2.3 Fertilizer management

The fertilizers N, P. K. S and B in the form of urea, TSP, MP, Gypsum and borax, respectively were applied. The entire amount of TSP, MP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Urea was applied in two equal installments at tillering and panicle initiation stage. The dose and method of application of fertilizer are shown in Table 1.

Table 1. Dose and method of application of fertilizers in rice field

Fertilizers	Dose (kg ha^{-1})	Application (kg ha^{-1})		
		Basal	1st installment	2nd installment
Urea	150	50	50	50
TSP	100	100	-	-
MoP	70	70	-	-
Gypsum	60	60	-	-
Borax	10	10	-	-
$ZnSO_4.7H_2O$	15	15	-	-

Source: Adunik Dhaner Chash (2018), BRRI, Joydebpur, Gazipur.

3.2.3 Transplanting of seedlings

30 days old seedlings were uprooted carefully for the transplantation and were kept in soft mud in shade. The seed beds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. In this way every 30 days old seedlings were uprooted and transplanted on the well puddled plots on 14th August, 21th August, 28th August and 4th September maintaining the standard spacing of 25 cm x 15cm with 2 seedlings per hill.

3.2.4 Intercultural operations

3.2.4.1 Gap filling

Gap filling was done after one week of transplanting using the seedlings from the same source.

3.2.4.2 Irrigation and drainage

Flood irrigation was given 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. The field was finally dried out 15 days before harvesting.

3.2.4.3 Weeding

Two hand weedings were done at 20 DAT and second weeding at 35 DAT to keep the crop weed free.

3.2.4.4 Plant protection measures

Crop was infested with nemic disease which was controlled by Furadan 5G 10 kg ha^{-1}. Crop was infested with rice bug with some extent in early transplanting which was controlled by Diazinon @2 ml $liter^{-1}$ of water. Crop was protected from birds and rats during the grain filling period. Filed trap and Fostoxin bait were used to control rat.

3.2.4.5 General observation of the experimental field

The field was monitored time to time to detect visual differences among the treatments and any kind of infestation by weeds, insects and diseases so that considerable losses by pest could be minimized. The field looked nice with normal green color plants. Incidence of stem borer, green leaf hopper, leaf roller and rice hispa were observed during tillering stage those were controlled properly. No bacterial and fungal disease was observed in the field.

3.3 Harvesting and post-harvest operation

Crop was harvested at maturity when 80% grains were matured. Harvesting was done in different dates due to the variation of planting dates and variation of life cycle of rice variety. Five hills were randomly select from middle portion of each plot for different morphological data collection and hills of $1m^2$ areas were separately harvested and bundle, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done by using paddle thresher. The grains were cleaned and sun dried to moisture content of 14%. Straw was also sun dried properly.

3.4 Recording of data

Experimental data were started to record after 30 DAT to 90 DAT for growth data with 15 days interval and harvest data was collected at 120 DAT. Dry weight of plant were collected by harvesting respective number of hills at different dates from the inner row by leaving border rows and harvest area for grain. The following data were recorded at harvest-

A. Crop growth characters

i. Plant height (cm)
ii. Number of tillers $hill^{-1}$
iii. Dry matter production (g)

B. Yield and yield contributing characters

i. Number of effective tillers $hill^{-1}$
ii. Number of non-effective tillers $hill^{-1}$
iii. Number of total tillers $hill^{-1}$
iv. Length of panicle (cm)
v. Weight of panicle (g)
vi. Number of filled grains $panicle^{-1}$
vii. Number of unfilled grains $panicle^{-1}$
viii. Number of total grains $panicle^{-1}$
ix. Weight of 1000 grain (g)
x. Grain yield (t ha^{-1})
xi. Straw yield (t ha^{-1})
xii. Biological yield (t ha^{-1})
xiii. Harvest index (%)

3.5 Detailed procedures of data recording

3.5.1 Crop growth characters

i. Plant height (cm)

Plant height was measured at 15 days interval starting from 30 days after transplantation and continued up to harvest from randomly preselected 5 hills per plot. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before heading and to the tip of panicle after heading.

ii. Total number of tillers hill^{-1}

Number of tillers hill^{-1} were counted at 15 days interval starting from 30 day after transplantation and up to harvest from preselected 5 hills/plot and finally the mean value was calculated as their number per hill. Only those tillers having three or more leaves were considered for counting.

iii. Dry matter production (g)

The sub-samples of 5 hills/plot uprooting the plant with root from 2nd line was oven dried until a constant level of weight was attained from which the weight of total dry weight was recorded at 15 days interval up to harvest.

3.5.2 Yield and yield contributing characters

i. Number of effective tillers hill^{-1}

The effective tillers from 5 hills were counted and mean value was calculated as per hill basis. The panicle which had at least one grain was considered as effective tillers.

ii. Number of non-effective tillers hill^{-1}

The non-effective tillers from 5 hills were counted and mean value was calculated as per hill basis. The panicle which had at least one grain was considered as non-effective tillers.

iii. Number of total tillers hill^{-1}

The panicle which had at least one grain was considered as non-effective tillers. The number of effective tillers plus the number of non-effective tillers gave the total number of tillers per hill.

iv. Length of panicle (cm)

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

v. Weight of panicle (g)

For panicle weight measurement panicle was taken from basal node of the rachis to apex and then measured weight by using digital weight machine.

vi. Number of filled grains panicle^{-1}

Number of filled grain panicle^{-1} was considered to be fertile if any kernel was present their in. The numbers of total filled grains present in each ten panicles was recorded and mean value was calculated.

vii. Number of unfilled grains panicle^{-1}

Number of unfilled spikelet panicle^{-1} means the absence of any kernel inside the floret after fertilization and such grains present in each panicle were counted.

viii. Number of total grains panicle^{-1}

Sum of the number of filled grain panicle^{-1} and the number of unfilled spikelet panicle^{-1} gave the total number of grain panicle^{-1}.

ix. Weight of 1000 grain (g)

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

x. Grain yield (t ha^{-1})

Grain yield was recorded from the central 1 m^2 undisturbed area of each plot was used to calculate grain yield rn^2 and then it was expressed as t ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

xi. Straw yield (t ha^{-1})

Straw yield was recorded from the central 1 m^2 undisturbed area of each plot was used to calculate straw yield m^2. After threshing, the sub-sample was oven to a constant wt. and finally convened to t ha^{-1}.

xii. Biological yield ($t\ ha^{-1}$)

Biological yield was calculated by using the following formula:

Biological yield= Grain yield + straw yield

xiii. Harvest index (%)

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

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

3.6 Statistical analysis

The data collected on different parameters were statistically analyzed to obtain the level of significance using the Statistix10 (analytical software) computer package program. Analysis of variance was done following two factors randomized complete block design. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

Chapter 4

RESULTS AND DISCUSSION

The experiment was conducted to find out the suitable transplanting dates to get highest grain yield through manipulation of transplanting dates of two aromatic rice varieties in aman season of Bangladesh. The result obtained from the study have been presented, discussed and compared in this chapter through tables, figures and appendices. The analysis of variance of data in respect of all growth and yield parameters have been shown in Appendix V-VIII. The result has been presented and discussed with the help of table and graphs and possible interpretations given below the following headings.

4.1 Plant growth characters

4.1.1 Plant height (cm)

4.1.1.1 Effect of variety

Plant height of the varieties were measured at 30, 45, 60, 75, 90 DAT and at harvest. Result exposed that varieties had significant influence on plant height at all growth stages (Figure 1). It was observed that plant height increased rapidly at the vegetative stage (linear phase) but was gradually reduced at the reproductive stage. Plant height increased rapidly up to 60 DAT and became slow after 75 DAT to harvest.

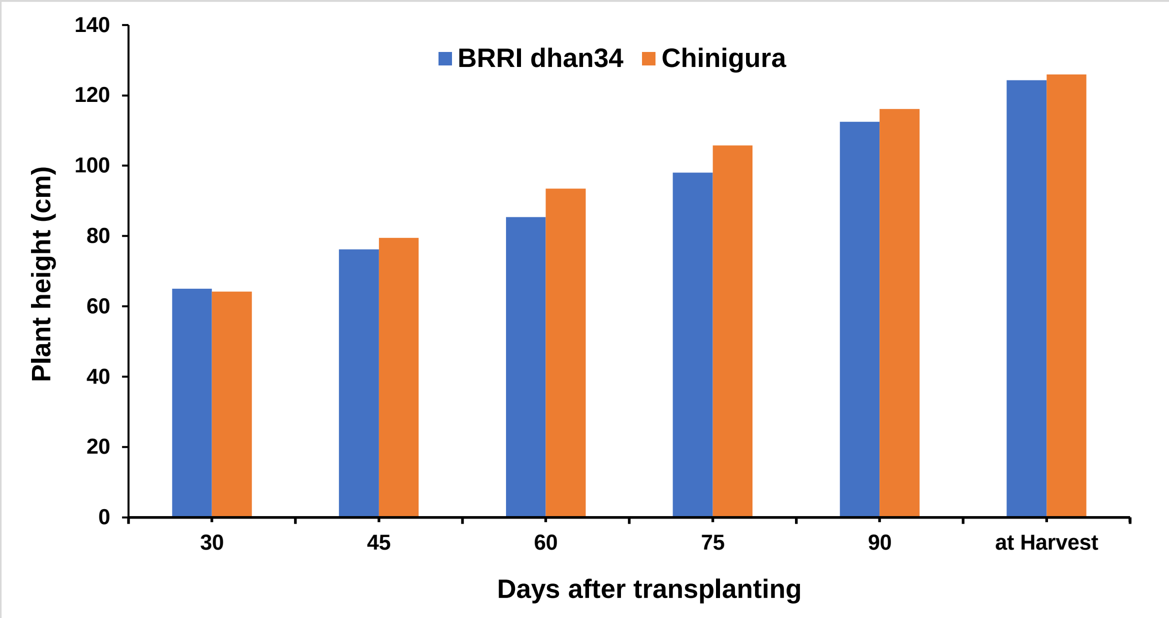
The tallest plant at all the growth stages were recorded from Chinigura and it was 125.94 cm at harvest. In contrast, the shortest plant was recorded from BRRI dhan34 (124.34 cm). Probably the genetic makeup of varieties was responsible for the variation in plant height. This confirms the reports of BINA (1992), BRRI (1991) and Shamsuddin et al. (1988) that plant height differed due to varietal variation. Plant height was collected from 24 plots and the average plant height of Chinigura and BRRI dhan34 were 125.94 cm and 124.31 cm respectively. The result agreed with BRRI (1995) that plant height of rice varieties in Aman season ranged from 95 cm-125 cm.

4.1.1.2 Effect of transplanting date

Plant height were measured at four transplanting dates; they are- 14th August, 21th August, 28th August, 4th September. Transplanting dates had significant effect on plant height at most of the growth stages. Plant height varied with different transplanting dates and it was affected significantly by transplanting dates. It is showed an increasing trend from 14th August from 21th August but after then a decreasing trend with the delayed transplanting starting from 28th August to 4th September (Figure 2).

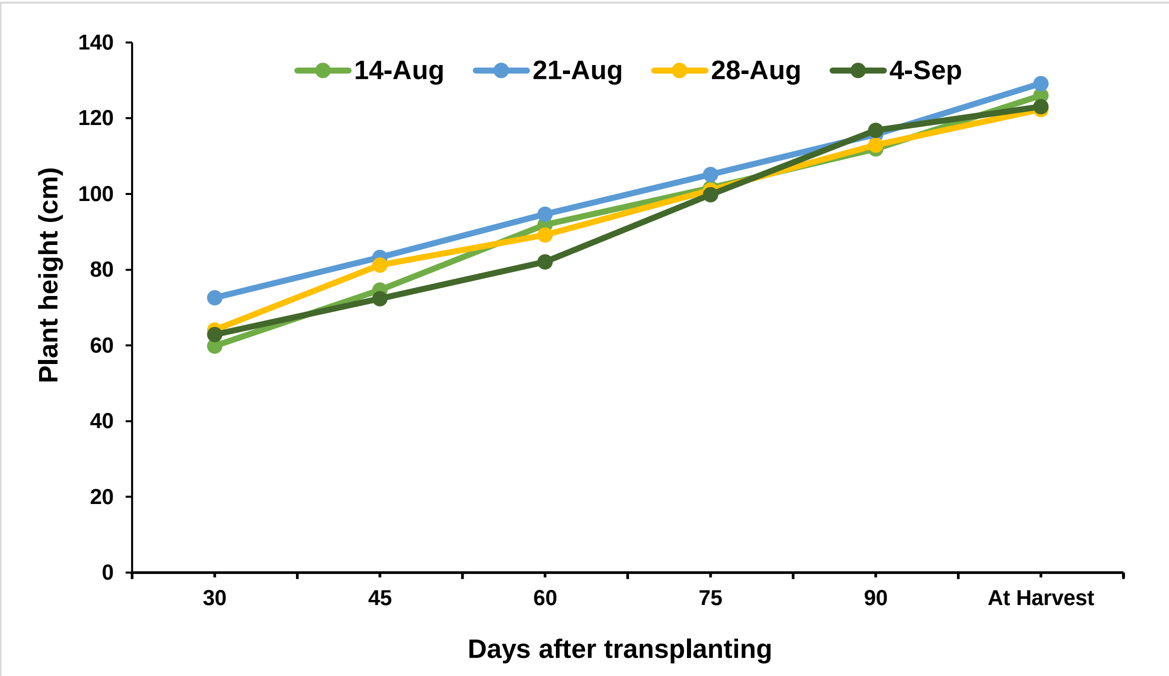
Among the four transplanting dates, transplanting on 21th August resulted in the tallest plant, while transplanting on 28th August gave the shortest plant height. The tallest plant (129.19 cm) was observed in the plots where crops transplanted on 21th August and the shortest plant (122.34 cm) was found in the plots where crops transplanted on 28th August. The consequences agree with Islam *et al.* (1999b) who reported that plant height significantly affected by planting date.

Plant height increased rapidly at the vegetative stage (linear phase) but was gradually reduced at the reproductive stage. Plant height increased rapidly up to 75 DAT, but slowly till harvest. This result agrees with Kabir *et al.* (2014) who described that different transplanting dates affect plant height and plant height increases rapidly at vegetative stage and slowly reduced at reproductive stage. The results also agree with the results of Majos and Pave (1980) who testified that plant height reduced with late transplanting. This might be due to the premature flowering because of high temperature sensitiveness of the variety which forced the plants to switch from vegetative stage to reproductive stage.



($LSD_{0.05}$ = 2.20, 5.54, 3.68, 3.27, 3.05, 2.91 at 30 DAT, 45 DAT, 60 DAT, 75 DAT, 90 DAT and harvest, respectively)

Figure 1. Effect of varieties on plant height (cm)



($LSD_{0.05}$ = 3.14, 7.84, 5.20, 4.62, 4.32, 4.11 at 30 DAT, 45 DAT, 60 DAT, 75 DAT, 90 DAT and harvest, respectively)

Figure 2. Effect of transplanting dates on plant height (cm)

4.1.1.3 Interaction effect

Plant height was significantly varied due to interaction effect of variety and transplanting dates at all growth stages (Table 2). The result showed that the best combination between date of transplanting and variety was 21th August transplanting with Chinigura (133.17 cm) and the second-best combination was obtained from 14th August transplanting with BRRI dhan34 (128.66 cm). The lowest plant height (121.00 cm) was obtained from the interaction between 4th September transplanting with BRRI dhan34. The result also indicates that the highest plant height at all growth stages was recorded from treatment combinations with Chinigura when transplanted on 21th August. In contrast the lowest plant height was recorded from the treatment combinations with BRRI dhan34 when transplanted on 4th September at all growth stages. So, from this result it is clear that indigenous variety was taller than inbreed variety. This result agrees with Kabir *et al.* (2014) which stated that inbreed and hybrid rice plant are shorter than indigenous rice varieties.

Table 2. Interaction effect of varieties and transplanting dates on plant height (cm)

Interaction	**Plant height (cm)**					
	30 DAT	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**	**At Harvest**
V_1T_1	66.23 **bc**	79.53 **bc**	89.14 **bc**	99.31 **bc**	110.49 **c**	128.66 **ab**
V_1T_2	69.49 **b**	75.75 **bc**	86.96 **c**	95.17 **c**	113.53 **bc**	125.21 **bc**
V_1T_3	64.62 **c**	79.53 **bc**	86.83 **c**	101.33 **bc**	112.46 **bc**	122.51 **c**
V_1T_4	59.97 **d**	70.41 **c**	78.60 **d**	96.40 **c**	113.64 **bc**	121.00 **c**
V_2T_1	53.49 **e**	70.22 **c**	94.69 **b**	103.95 **b**	113.37 **bc**	123.31 **bc**
V_2T_2	75.71 **a**	90.73 **a**	102.34 **a**	115.05 **a**	117.90 **ab**	133.17 **a**
V_2T_3	63.59 **cd**	82.87 **ab**	91.50 **bc**	100.62 **bc**	113.45 **bc**	122.16 **c**
V_2T_4	64.20 **cd**	74.75 **bc**	85.50 **cd**	103.32 **b**	119.91 **a**	125.11 **bc**
$LSD_{0.05}$	**4.44**	**11.09**	**7.36**	**6.53**	**35.61**	**5.81**
CV(%)	**3.92**	**8.13**	**4.70**	**3.66**	**18.46**	**2.65**

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date),
T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

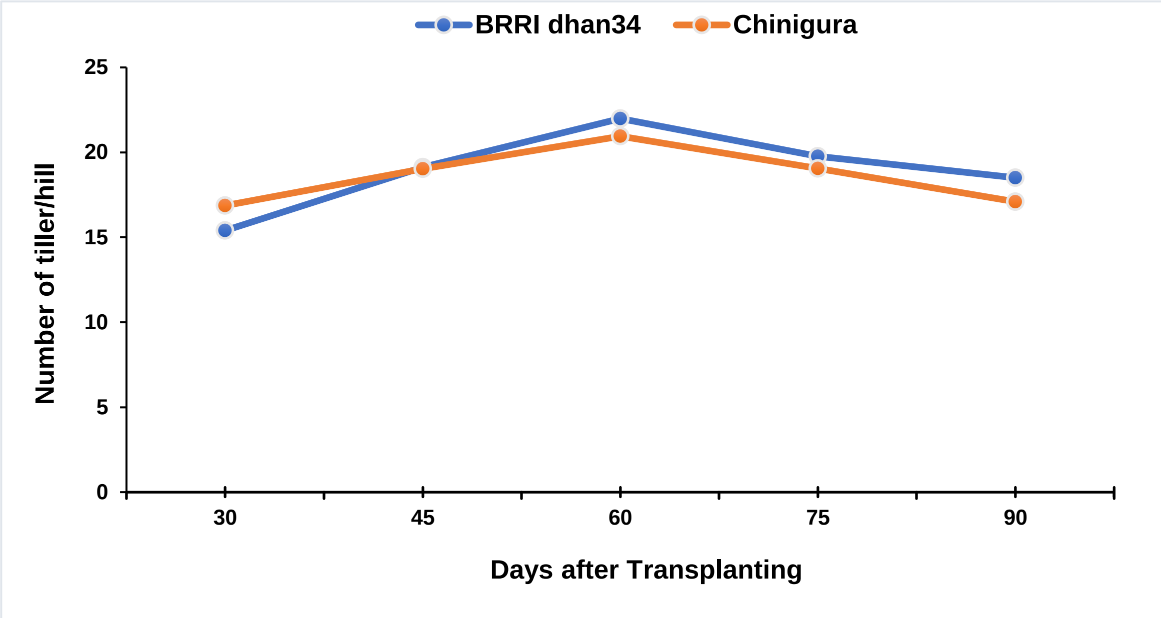
4.1.2 Number of tillers hill^{-1}

4.1.2.1 Effect of variety

Number of tillers hill^{-1} was influence by variety at all growth stages and it is observed among two rice varieties- BRRI dhan34 and Chinigura (Figure 3). It was observed from Figure 3 that number of tillers hill^{-1} increased progressively with the advancement of time and growth stages till 60 days after transplanting (DAT). Maximum (21.99 and 20.95) number of tillers hill^{-1} were produced by BRRI dhan34 and Chinigura respectively at 60 DAT. Minimum (15.4 and 16.7) number of tillers hill^{-1} were produced by BRRI dhan34 and Chinigura at 30 DAT. With the advancement of age, it declined up to maturity. The value decreased because some of the last emerged tillers died due to their failure in competing for light and nutrients which observed by Ishizuka (1963). Variable effect of varieties on number of tillers hill^{-1} was also reported by Hussain et al. (1989) and Idris and Matin (1990) observed that number of tillers hill^{-1} differed among the varieties.

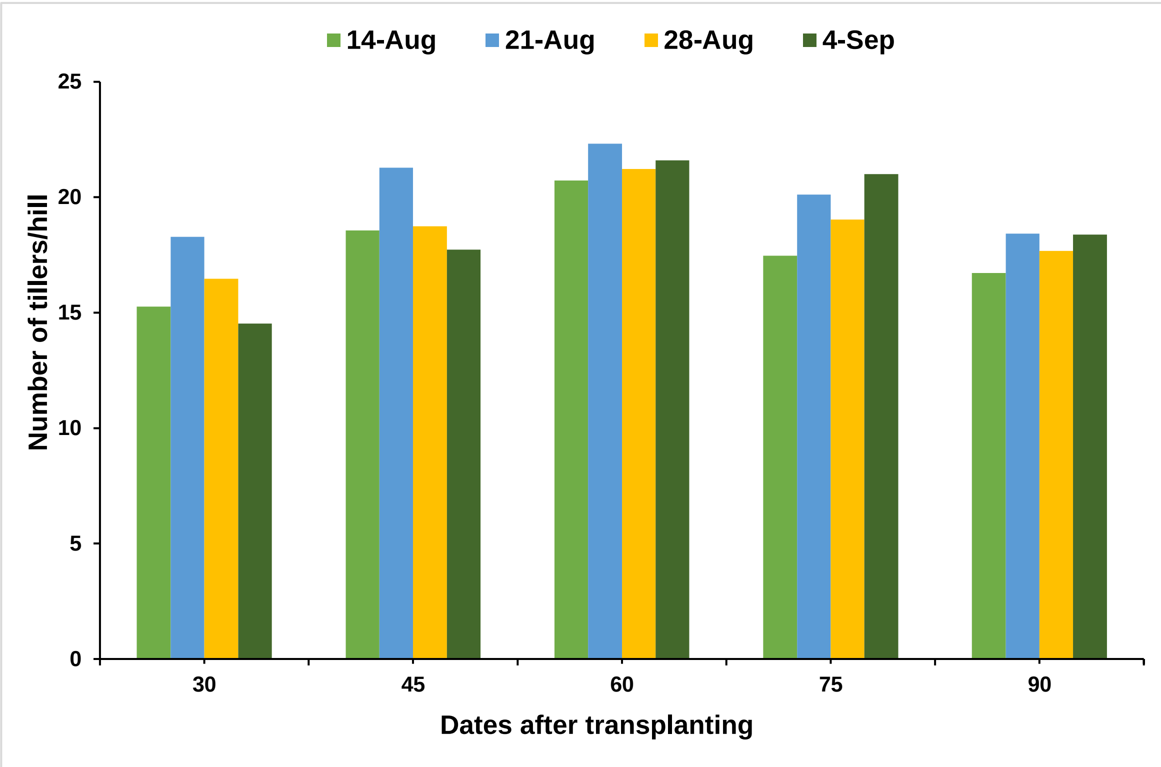
4.1.2.2 Effect of transplanting date

Number of tillers hill^{-1} was influence by transplanting dates at all growth stages and it is observed among four transplanting dates- 14th August, 21th August, 28th August and 4th September. Number of tillers hill^{-1} exerted significant variations due to different transplanting dates (Figure 4). Number of tillers hill^{-1} showed a decreasing trend with the advancement of age of the plants. The result indicates that 21th August transplanting dates showed the highest number of tillers hill^{-1}. The highest number of tillers hill^{-1} (22.32 at 60 DAT) was recorded from 21th August transplanting and the lowest number of tillers hill^{-1} (14.53 at 45 DAT) was recorded from 4th September transplanting. The results have the conformity with the results of Islam (1990) who reported that planting date affects number of tillers hill^{-1}.



LSD$_{0.05}$ = 0.98, 1.30, 1.39, 1.14, 1.28 at 30 DAT, 45 DAT, 60 DAT, 75 DAT and 90 DAT, respectively)

Figure 3. Effect of varieties on number of tiller hill^{-1}



(LSD$_{0.05}$ = 1.39, 1.84, 1.96, 1.61, 1.80 at 30 DAT, 45 DAT, 60 DAT, 75 DAT, 90 DAT, respectively)

Figure 4. Effect of transplanting dates on number of tiller hill^{-1}

4.1.2.3 Interaction effect

Number of tillers hill^{-1} was influence by transplanting dates at all growth stages and it is observed among two rice varieties- BRRI dhan34 and Chinigura due to varying with four transplanting dates- 14th August, 21th August, 28th August and 4th September. Number of tillers hill^{-1} was significantly varied due to interaction effect of variety and transplanting dates (Table 3). At all growth stages the highest number of tillers hill^{-1} (24.00) was recorded from treatment combination with BRRI dhan34 when transplanted on 21th August. In contrast the lowest number of tillers hill^{-1} (13.8) was recorded from the treatment combination with BRRI dhan34 when transplanted on 14th August.

Table 3. Interaction effect of varieties and transplanting dates on number of tillers hill^{-1}

Interaction	Number of tillers hill^{-1}				
	30 Days	45 Days	60 Days	75 Days	90 Days
V_1T_1	13.8 **c**	18.20 **c**	20.27 **b**	17.53 **c**	16.40 **bc**
V_1T_2	18.47 **a**	21.60 **a**	24.00 **a**	20.30 **ab**	18.07 **bc**
V_1T_3	15.13 **bc**	18.13 **c**	21.37 **ab**	18.23 **bc**	16.07 **c**
V_1T_4	14.20 **c**	18.60 **bc**	22.33 **ab**	20.13 **ab**	17.83 **abc**
V_2T_1	16.73 **ab**	18.93 **bc**	21.20 **b**	17.40 **c**	17.03 **abc**
V_2T_2	18.09 **a**	20.97 **ab**	20.63 **b**	19.83 **ab**	18.77 **ab**
V_2T_3	17.80 **a**	19.37 **abc**	21.10 **b**	19.83 **ab**	19.30 **a**
V_2T_4	14.87 **bc**	16.87 **c**	20.87 **b**	21.87 **a**	18.93 **ab**
$LSD_{0.05}$	**1.96**	**2.61**	**2.78**	**2.28**	**2.55**
CV(%)	**6.95**	**7.80**	**7.38**	**6.71**	**8.18**

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date),
T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

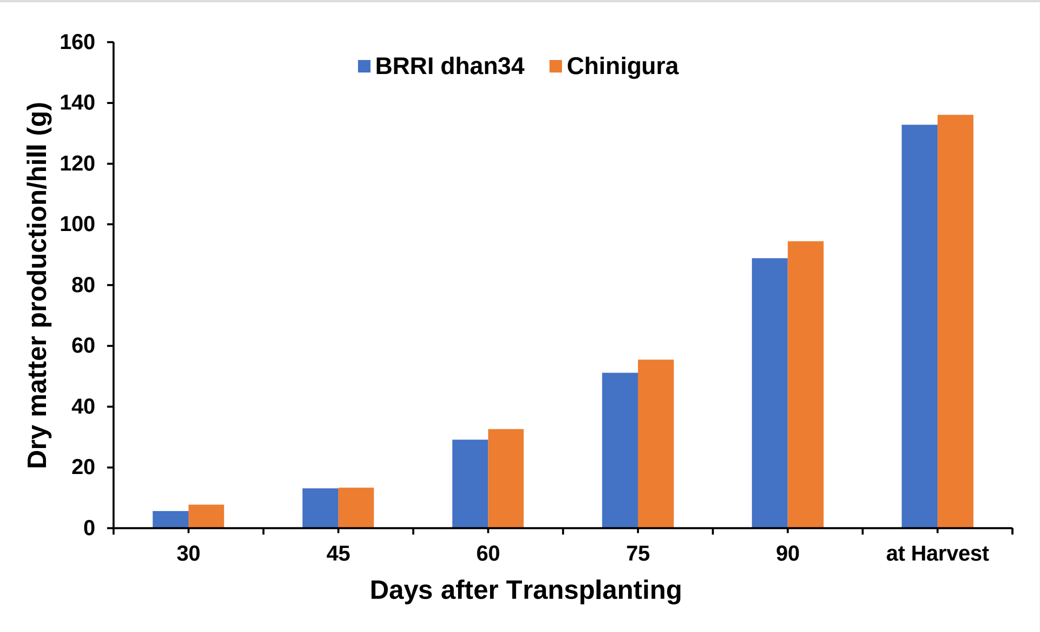
4.1.3 Dry matter production (g hill^{-1})

4.1.3.1 Effect of variety

Total dry matter production (g hill^{-1}) was significantly differed among the varieties at all growth stages (Figure 5). Result revealed that the total dry matter (TDM) production hill^{-1} gradually increased at all sampling dates from 30 to 90 DAT as well as at harvest. From 30-90 DAT the highest total dry matter hill^{-1} was recorded from BRRI dhan34 because of increased plant height and number of tillers hill^{-1} and also for higher spikelet filling percent. Amin *et al.* (2006) and Son *et al.* (1998) conducted an experiment and found that TDM production in rice is occurred due to genotypic variation of rice.

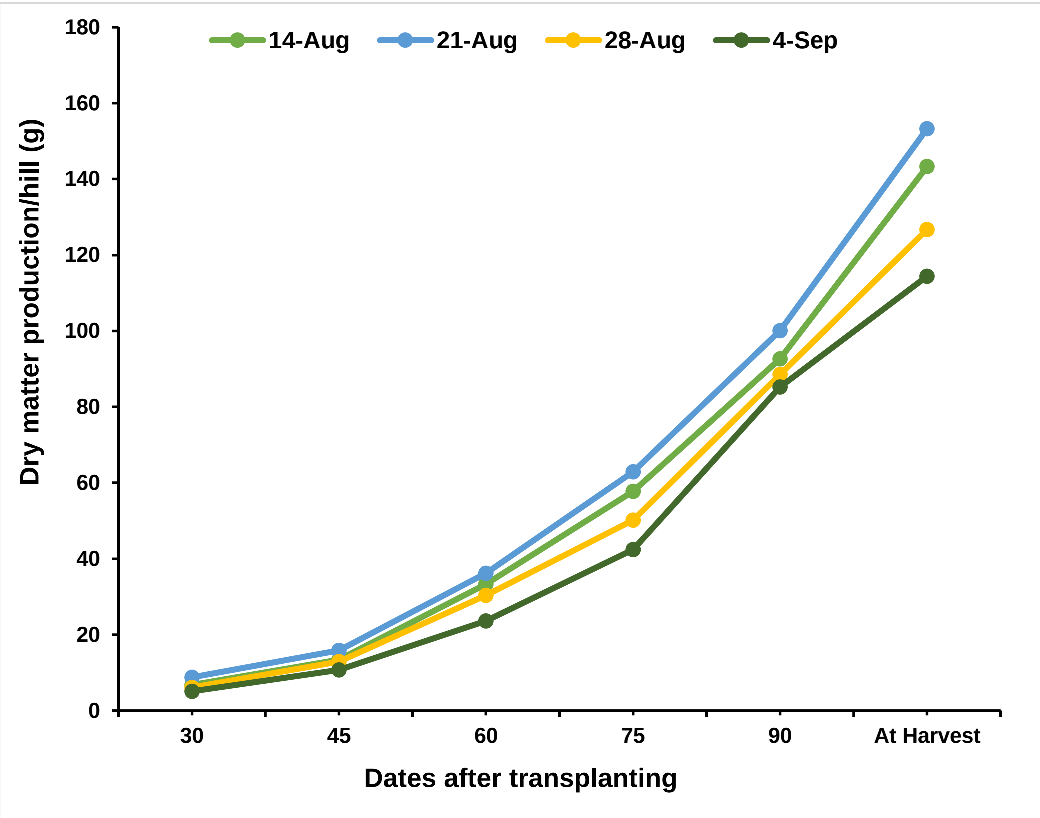
4.1.3.2 Effect of transplanting date

Total dry matter production (g hill^{-1}) was significantly differed as a result of transplanting dates at all growth stages (Figure 6). Results exposed that total dry matter production (TDM) showed a decreasing trend with the delayed transplanting starting from 28th August to 4th September. It was observed that total dry matter production (g hill^{-1}) increased progressively with the age till harvest. The highest total dry matter production (g hill^{-1}) at all growth stages was recorded when transplanted on 21th August followed by 14th August transplanting because of increased plant height, number of tillers hill^{-1} and for higher spikelet filling percent which indicates the more assimilation of dry matter than other dates of sowing. In contrast the lowest total dry matter production (g hill^{-1}) was recorded from 4th September transplanting followed by 28th August transplanting at all growth stages. The plants got less time for growth and development due to delayed transplanting. That is why, TDM was less in 28th August and 4th September transplanting.



($LSD_{0.05}$ = 0.32, 0.76, 2.14, 2.54, 1.17, 4.29 at 30 DAT, 45 DAT, 60 DAT, 75 DAT, 90 DAT and harvest, respectively)

Figure 5. Effect of varieties on dry matter production hill^{-1} (g)



($LSD_{0.05}$ = 0.45, 1.07, 3.03, 3.59, 2.42, 6.07 at 30 DAT, 45 DAT, 60 DAT, 75 DAT, 90 DAT and harvest, respectively)

Figure 6. Effect of transplanting dates on dry matter production hill^{-1} (g)

4.1.3.3 Interaction effect

Total dry matter production (g hill^{-1}) was significantly varied due to interaction effect of variety and transplanting dates at all growth stages (table 4). At 30-60 DAT the maximum total dry matter production (37.39 g hill^{-1}) was recorded from the treatment combination with Chinigura when transplanted on 21th August and at 75 and 90 DAT the highest total dry matter production (103.14 g hill^{-1}) was recorded from the treatment combination with the same combination of variety and transplanting date that is Chinigura at 21th August transplanting.

In contrast, from 30-60 DAT the minimum total dry matter production (23.17 g hill^{-1}) was recorded from the treatment combination with BRRI dhan34 when transplanted on 4th September and at 70 and 80 DAT the lowest total dry matter production (81.39 g hill^{-1}) was recorded from the same combination of varieties and transplanting date.

From the result, it is found that dry matter production varied from genotypic variation of the cultivar and transplanting dates. Late transplanting reduces the dry matter production because it can't get enough time for growth and development. Similar result was found by Kabir *et al.* (2014) who discovered that TDM affected by genotypic makeup of the cultivars and it also affected by plant height, total tiller number per hill. They also stated that late transplanting reduces the TDM of aman rice.

Table 4. Interaction effect of varieties and transplanting dates on dry matter production hill^{-1}

Interaction	Plant dry matter production (g)					
	30 Days	45 Days	60 Days	75 Days	90 Days	At Harvest
V_1T_1	5.66 **d**	12.60 **cd**	31.59 **b**	55.14 **b**	89.82 **c**	139.88 **c**
V_1T_2	7.03 **c**	15.02 **b**	35.02 **ab**	61.24 **a**	97.01 **b**	149.73 **ab**
V_1T_3	5.04 **de**	13.59 **bc**	26.60 **c**	47.53 **c**	87.13 **c**	129.15 **c**
V_1T_4	4.65 **e**	11.14 **de**	23.17 **c**	40.58 **d**	81.39 **d**	112.35 **f**
V_2T_1	7.89 **b**	14.18 **b**	34.99 **ab**	60.32 **a**	95.56 **b**	146.74 **bc**
V_2T_2	10.50 **a**	16.63 **a**	37.39 **a**	64.5 **a**	103.14 **a**	156.85 **a**
V_2T_3	7.17 **c**	12.27 **cd**	34.07 **ab**	52.82 **b**	90.01 **c**	124.36 **de**
V_2T_4	5.55 **d**	10.33 **e**	24.07 **c**	44.73 **cd**	89.15 **c**	116.51 **ef**
$LSD_{0.05}$	**0.63**	**1.5**	**4.29**	**5.09**	**3.43**	**8.58**
CV (%)	**5.42**	**6.54**	**7.94**	**5.45**	**2.13**	**3.65**

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

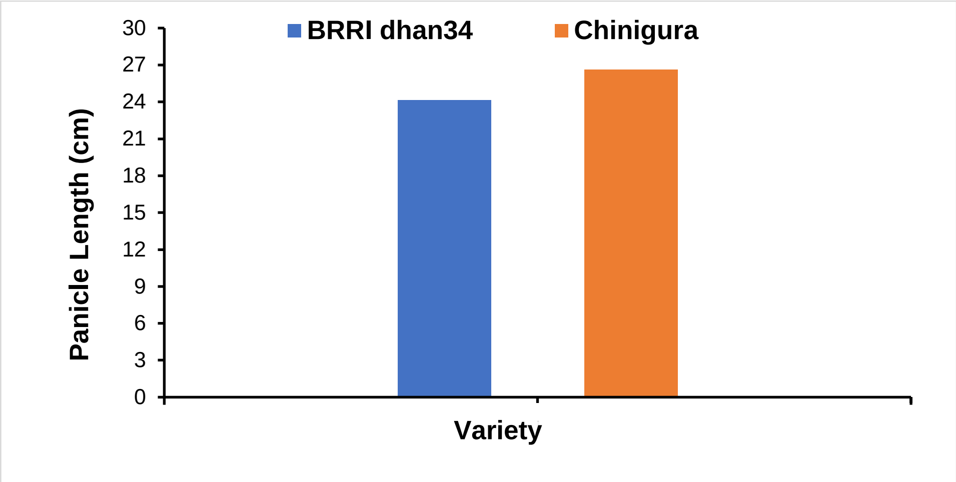
Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date), T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

4.2 Yield and yield contributing characters

4.2.1 Panicle length (cm)

4.2.1.1 Effect of variety

Length of panicle varied with varieties in the transplanted aman season (Figure 7). Between HYV and local variety, the local variety produced the longer panicle (26.63 cm). In contrast the lowest panicle length was recorded from BRRI dhan34 (24.13 cm). This confirms the report of Ahmed *et al.* (1998), Idris and Matin (1990) that panicle length was differed due to variety.

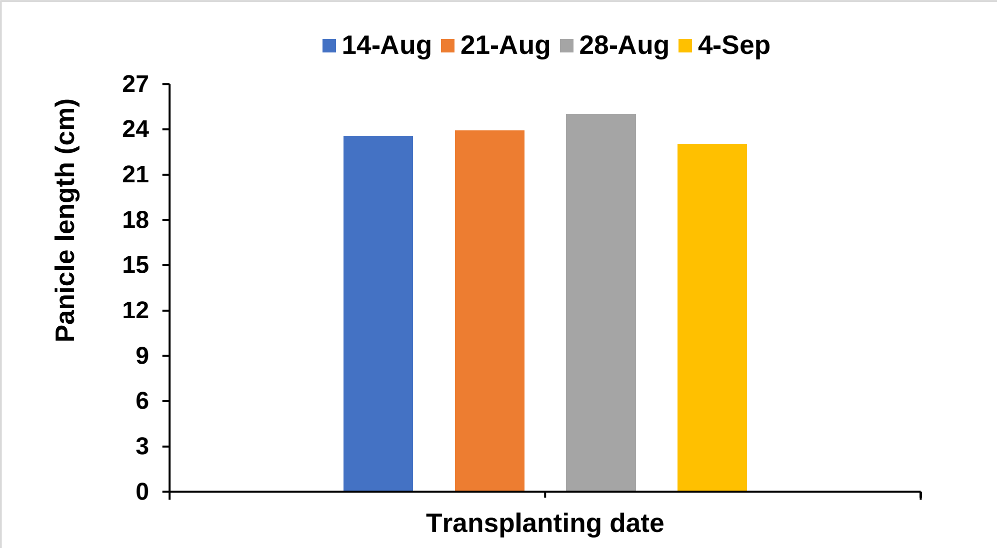


($LSD_{0.05}$ = 1.00)

Figure 7. Effect of varieties on panicle length (cm)

4.2.1.2 Effect of transplanting date

Date of transplanting had a significant effect on panicle length (cm) of rice during Aman season (Figure 8). Results showed that panicle length decreased with delayed transplanting in Aman season. The highest panicle length was recorded when transplanted on 28th August (25.02 cm) followed by 21th August (23.93 cm) transplanting. In contrast, the lowest panicle length was recorded from 4th September (23.03 cm) transplanting followed by 14th August (23.55 cm) transplanting. The results confirm the findings of Islam (1990) who reported the planting date affects the panicle length significantly.



($LSD_{0.05}$ = 1.42)

Figure 8. Effect of transplanting dates on panicle length (cm)

4.2.1.3 Interaction effect

The interaction of varieties and transplanting dates had significantly affected on panicle length of rice (Table 5). Results showed that higher panicle length was recorded from the treatment combination with BRRI dhan34 (25.41 cm) when transplanted on 28th August. In contrast the lowest panicle length was recorded from Chinigura (22.75 cm) when transplanted on 4th September.

Table 5. Interaction effect of varieties and transplanting dates on panicle length (cm)

Interaction	Length of panicle (cm)			
	T_1	T_2	T_3	T_4
V_1	24.05 **ab**	23.75 **ab**	25.41 **a**	23.31 **ab**
V_2	23.05 **b**	24.10 **ab**	24.63 **ab**	22.75 **b**
LSD (0.05)	2.00			
CV (%)	4.79			

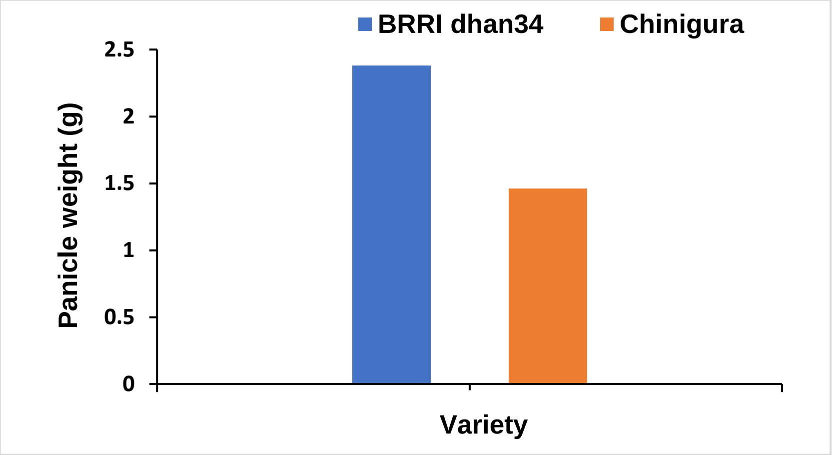
In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date),
T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

4.2.2 Panicle weight (g)

4.2.2.1 Effect of variety

Weight of panicle varied with varieties in the transplanted aman season (Figure 9). Between HYV and local variety, the HYV variety- BRRI dhan34 produced the higher panicle weight (2.38 g) and the lowest weight of panicle was recorded from Chinigura (1.46 g). This confirms the report of Ahmed *et al.* (1998), Idris and Matin (1990) that panicle weight was differed due to variety.

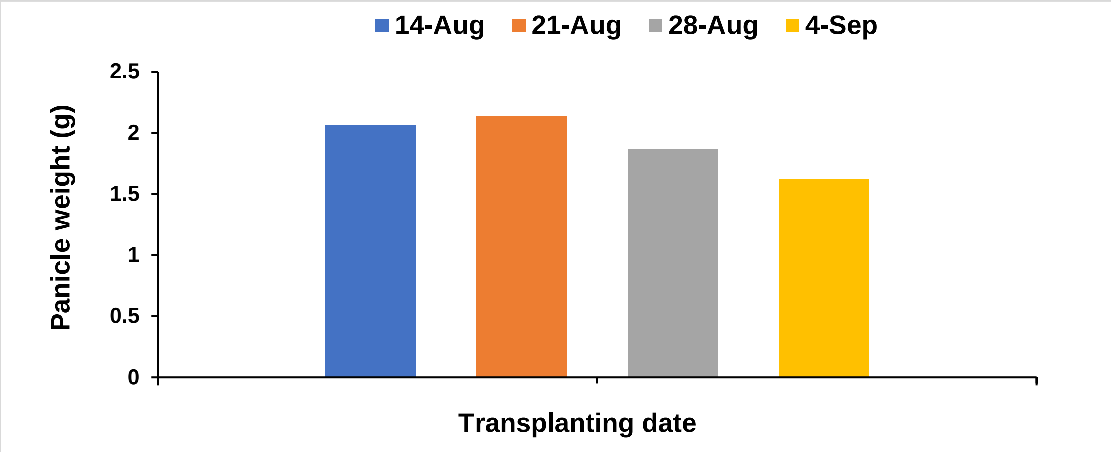


($LSD_{0.05}$ = 0.16)

Figure 9. Effect of varieties on panicle weight (g)

4.2.2.2 Effect of transplanting date

Date of transplanting had a significant effect on panicle weight (g) of rice during Aman season (Figure 10). Results showed that panicle weight decreased with delayed transplanting in Aman season. The highest panicle weight was recorded when transplanted on 21th August (2.14 g) and the lowest panicle weight was recorded from 4th September (1.625 g). The results confirm the findings of Islam *et al.* (1990) who reported the planting date affects the panicle weight.



($LSD_{0.05}$ =.23)

Figure 10. Effect of transplanting dates on panicle weight (g)

4.2.2.3 Interaction effect

The interaction of varieties and transplanting dates had significantly affected panicle weight of aromatic rice (Table 6). Results showed that higher panicle weight was recorded from the treatment combination with BRRI dhan34 (2.81g) when transplanted on 21th August. In contrast the lowest panicle length was recorded from Chinigura (1.33 g) when transplanted on 4th September.

Table 6. Interaction effect of varieties and transplanting dates on panicle weight (g)

Interaction	Weight of Panicle (g)			
	T_1	T_2	T_3	T_4
V_1	2.47 **b**	2.81 **a**	2.32 **b**	1.91 **c**
V_2	1.64 **cd**	1.47 **d**	1.42 **d**	1.33 **d**
LSD (0.05)	0.32			
CV (%)	9.47			

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date),
T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

4.2.3 Number of grains panicle^{-1}

4.2.3.1 Interaction effect of varieties and transplanting dates on number of grains panicle^{-1}

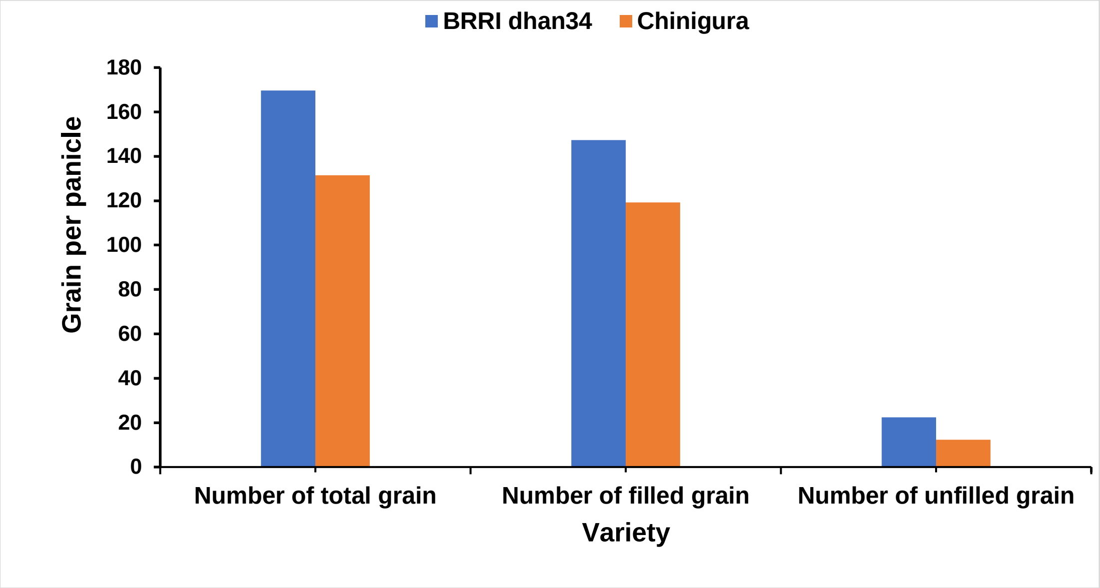
Total number of grains per panicle significantly affected by different transplanting dates in the different varieties. The interaction between varieties and transplanting dates had significantly affected total number of grains per panicle of aromatic rice (Table 7). The maximum number of total grains per panicle was obtained from the 21th August transplanting of BRRI dhan34. On the other hand, the minimum number of grains per panicle was recorded from Chinigura at 4th September transplanting dates. This confirms the report of Kabir *et al.* (2014) that total grains per panicle was varied with variety. The result also said that Plant which have long growth duration produced optimum number of tillers. The result agreed with Subbain *et al.* (1995) who reported that late planted crop gave a smaller number of tillers and panicles.

4.2.3.2 Interaction effect of varieties and transplanting dates on number of filled grains panicle^{-1}

Highly significant differences in fertile/filled grains per panicle were found between varieties and their transplanting dates (Table 7). The maximum number of filled grains per panicle was obtained from the 21th August transplanting of BRRI dhan34. Then again, the minimum number of filled grains per panicle was recorded from Chinigura at 4th September transplanting dates. This confirms the report of Kabir *et al.* (2014) that filled grains per panicle was varied with variety.

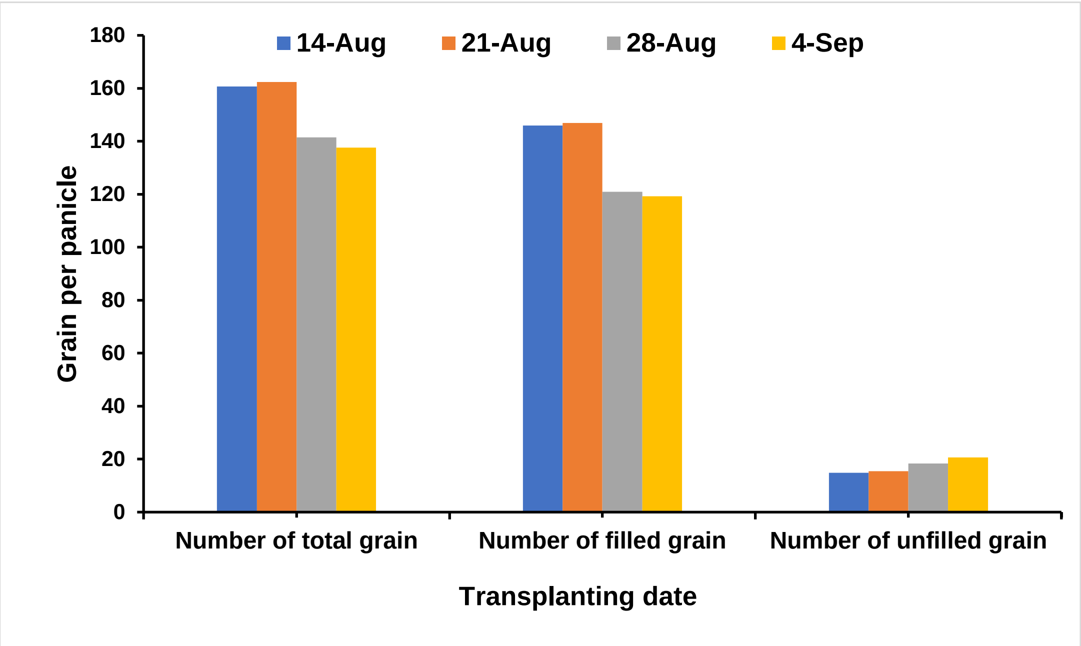
4.2.3.3 Interaction effect of varieties and transplanting dates on number of unfilled grains per panicle^{-1}

Highly significant differences in sterile/unfilled grains per panicle were found of varieties and their transplanting dates (Table 7). The maximum number of unfilled grains per panicle was obtained from the 21th August transplanting of BRRI dhan34. Then again, the minimum number of unfilled grains per panicle was recorded from Chinigura at 4th September transplanting dates. This confirms the report of Kabir *et al.* (2014) that unfilled grains per panicle was varied with variety.



($LSD_{0.05}$ =3.82, 2.97 and 3.03 for total grain, filled grain and unfilled grain, respectively)

Figure 11. Effect of varieties on filled and unfilled grain panicle^{-1}



($LSD_{0.05}$ =5.39, 4.20 and 4.28 for total grain, filled grain and unfilled grain, respectively)

Figure 12. Effect of transplanting dates on filled and unfilled grain panicle^{-1}

Table 7. Interaction effect of varieties and transplanting dates on number of filled and unfilled grains panicle^{-1}

Interaction	Number of total grains panicle^{-1}				Number of filled/fertile grains panicle^{-1}				Number of unfilled/sterile grains panicle^{-1}			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
V_1	168.05 **b**	184.08 **a**	163.91 **b**	162.72 **b**	150.39 **b**	165.06 **a**	137.00 **c**	136.94 **c**	17.67 **bc**	19.02 **b**	26.91 **a**	25.78 **a**
V_2	153.38 **c**	140.67 **d**	119.17 **e**	112.58 **e**	141.40 **c**	128.89 **d**	104.78 **e**	101.58 **e**	11.98 **cd**	11.78 **cd**	14.39 **bcd**	11.00 **d**
$LSD_{.05}$	**7.63**				**5.94**				**6.05**			
CV (%)	**2.90**				**2.55**				**19.96**			

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date), T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

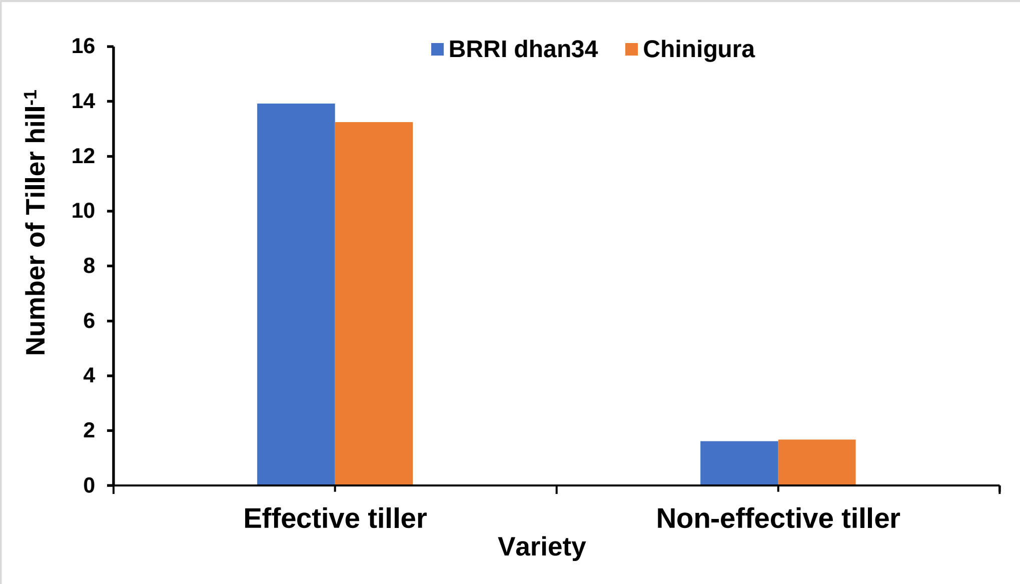
4.2.4 Number of effective & non-effective

4.2.4.1 Number of effective tillers

Transplanting date and varieties had significant influence on the number of effective tillers per hill (Table 8). The maximum effective tillers hill^{-1} (16.67) recorded from BRRI dhan34 21th August transplanting and the lowest effective tillers hill^{-1} (11.00) was recorded from Chinigura and 4th September transplanting. The result revealed that early transplanting showed the highest number of effective tillers hill^{-1} than delayed transplanting. These might be due to delayed transplanted crops get shorter period for their vegetative growth compared with earlier transplanted crops. Plant that have short growth duration do not enough have time to produce enough tillers while the plant that have long growth duration produced optimum number of tillers. The result agreed with Subbain *et al.* (1995) who reported that late planted crop gave a smaller number of tillers and panicles. The differences in tillers number among the varieties might be due to the difference of genetic makeup of the varieties. BRRI (1991) reported similar opinions that the number of effective tillers differed among different varieties.

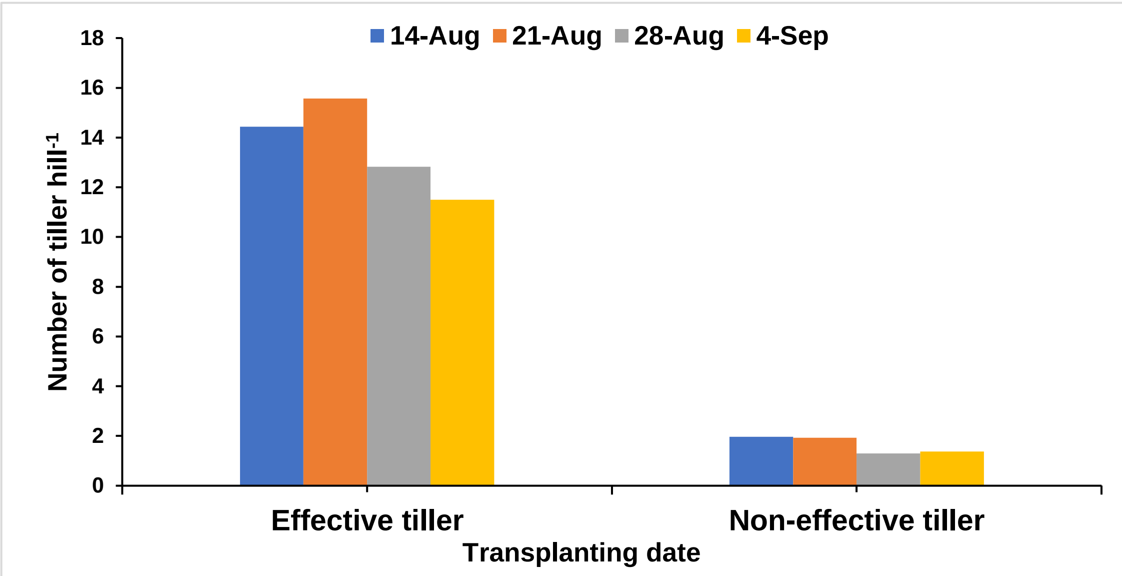
4.2.4.2 Number of non-effective tillers

From the result it is said that, there had no significant difference of non-effective tillers per hill among different transplanting dates and varieties (Table 8). The both highest (2.47) and lowest number (1.27) of non-effective tiller was found in the same variety and that was BRRI dhan34 but in different transplanting dates 21th August and 4th September respectively and they both are statistically similar. In 1991, BRRI arranged an experiment which showed that number of effective and non-effective tiller depends on its genetic makeup.



($LSD_{0.05}$ = 0.42 and 0.69 of effective and non-effective tillers $hill^{-1}$, respectively)

Figure 13. Effect of varieties on number of effective and non-effective tillers $hill^{-1}$



($LSD_{0.05}$ = 0.59 and 0.98 of effective and non-effective tillers $hill^{-1}$, respectively)

Figure 14. Effect of transplanting dates on number of effective and non-effective tillers $hill^{-1}$

Table 8. Interaction effect of varieties and transplanting dates number of effective and non-effective tillers $hill^{-1}$

Interaction	Number of effective tillers per hill				Number of non-effective tillers per hill			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
V_1	13.60 **c**	16.67 **a**	13.40 **c**	12.00 **d**	1.50 **a**	2.47 **a**	1.20 **a**	1.27 **a**
V_2	15.27 **b**	14.47 **b**	12.27 **d**	11.00 **e**	2.40 **a**	1.40 **a**	1.40 **a**	1.47 **a**
LSD $_{(0.05)}$	**0.84**				**1.39**			
CV (%)	**3.51**				**48.41**			

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date), T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

4.2.5 1000 grain weight (g)

4.2.5.1 Effect of variety

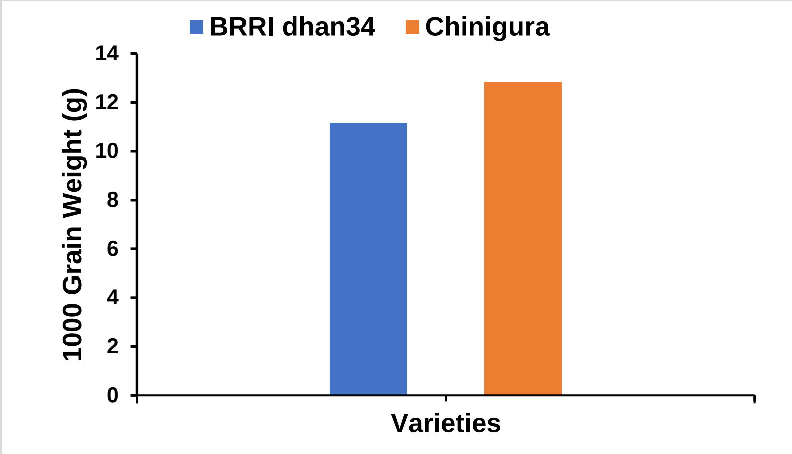
1000 grain weight showed statistically significant variation among aromatic varieties (Figure 15). Between two varieties Chinigura produced highest 1000 grain weight (15.08 g) and the lowest weight of 1000 seeds (11.16 g). This result is in agreement with the finding of Rafey *et al.* (1989) and Shamsuddin *et al.* (1988) who stated that weight of 1000-grain differed due to the varietal differences.

4.2.5.2 Effect of transplanting dates

A significant variation in 1000-grain weight was also found to be due to the effect of different transplanting dates (Figure 16). Transplanting on 14th August (13.37 g) produce highest 1000 grain weight which is statistically similar with 21th August (13.12 g) transplanting dates. The lowest 1000 grain weight was obtained from 28th August transplanting (11.25 g). A similar result was found Kabir *et al.* (2014) who stated that different transplanting dates are responsible for 1000 grain weight variation.

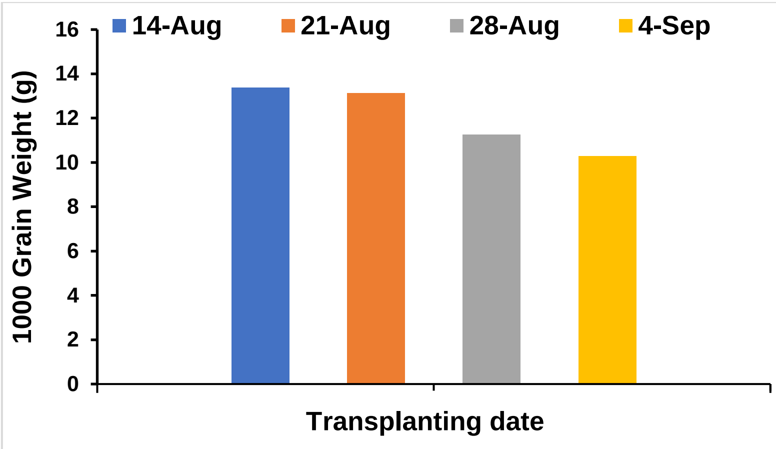
4.2.5.3 Interaction effect

Statistically significant variation was recorded due to interaction effect of varieties and transplanting dates of 1000-grain weight (Table 9). The maximum weight of 1000 grain (15.08 g) was recorded from the treatment combination for Chinigura and 14th August transplanting date. In contrast, the minimum weight of 1000 seeds (9.90 g) was recorded from the treatment combination for BRRI dhan34 and 4th September transplanting date. This result is found similarity with Kabir *et al.* (2014) who stated that aromatic rice varieties and transplanting dates had significantly affected 1000-grain weight.



($LSD_{0.05}$ = 0.26)

Figure 15. Effect of varieties on 1000 grain weight (g)



($LSD_{0.05}$ = 0.59)

Figure 16. Effect of transplanting dates on 1000 grain weight (g)

Table 9. Interaction effect of varieties and transplanting dates 1000 grain weight (g)

Interaction	1000 grain weight (g)			
	T_1	T_2	T_3	T_4
V_1	11.66 **d**	12.73 **c**	10.35 **ef**	9.90 **f**
V_2	15.08 **a**	13.51 **b**	12.15 **d**	10.67 **e**
LSD (0.05)	**0.52**			
CV (%)	**2.48**			

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date),
T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

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

4.2.6.1 Effect of variety

Grain yield is a function of interplay of various yield components such as number of productive tillers hill^{-1}, number of filled grains panicl^{-1} and 1000-grain weight (Hossain *et al*. 2008). In present study variety had significant effect on the grain yield (t ha^{-1}) of rice (Figure 17). The highest grain yield of rice was recorded from BRRI dhan34 (3.12 t ha^{-1}). In contrast the lowest grain yield of rice was recorded from Chinigura (2.02 t ha^{-1}). Grain yield differed due to varieties were reported by IRRI (1978), Suprithatno and Sutaryo (1992), Alam (1998), Singh and Singh (2000), Rahman (2002), Mondal *et al.* (2005) and Yeasmin (2005) who recorded variable grain yield among tested varieties. The probable reason for variation in yield may be due high temperature high temperature and low sunshine hours which causes spikelet sterility. This confirms the report of Krishnan and Nayak (1998), stated that pollen grains were desiccated by high temperature.

4.2.6.2 Effect of transplanting date

Transplanting dates exerted significant effect on grain yield (t ha^{-1}) (Figure 18). Results showed that grain yield decreased with delayed transplanting. Among four different transplanting dates, the highest grain yield was recorded when transplanted on 21th August (3.01 t ha^{-1}). In contrast the lowest grain yield was recorded from 4th September (1.93 t ha^{-1}). It might be due to shorter vegetative phase and climatic conditions. The results agreed with the findings of Chandra and Manna (1988), Ali *et al* (1991), Ghosh and Ganguly (1994), BRRI (1998), Chowdhury and Guha (2000), Assaduzzaman (2006), BINA (2006) and Kabir *et al.* (2014) who stated that delayed transplanting reduces grain yield of rice due to shorter vegetative phase.

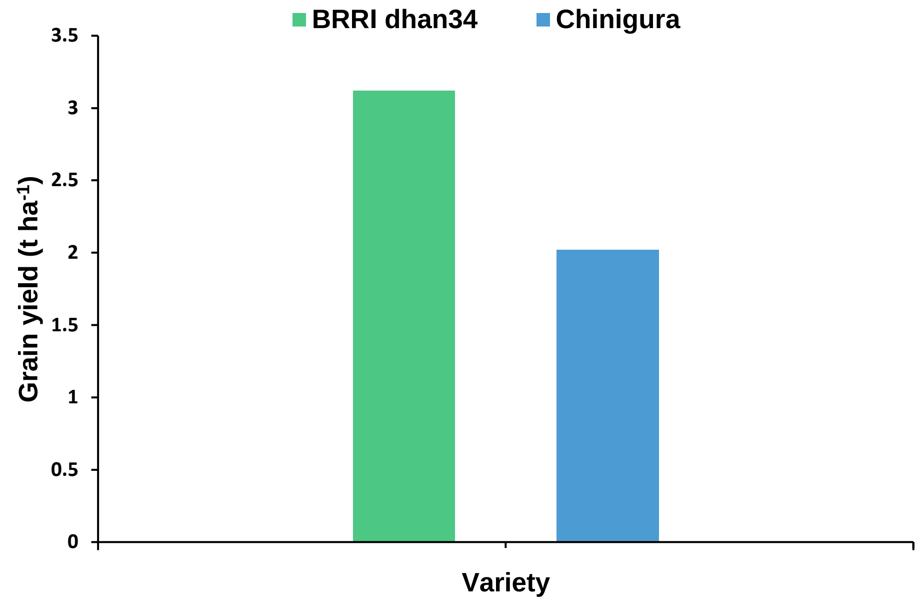


Figure 17. Effect of varieties on grain yield (t ha^{-1})

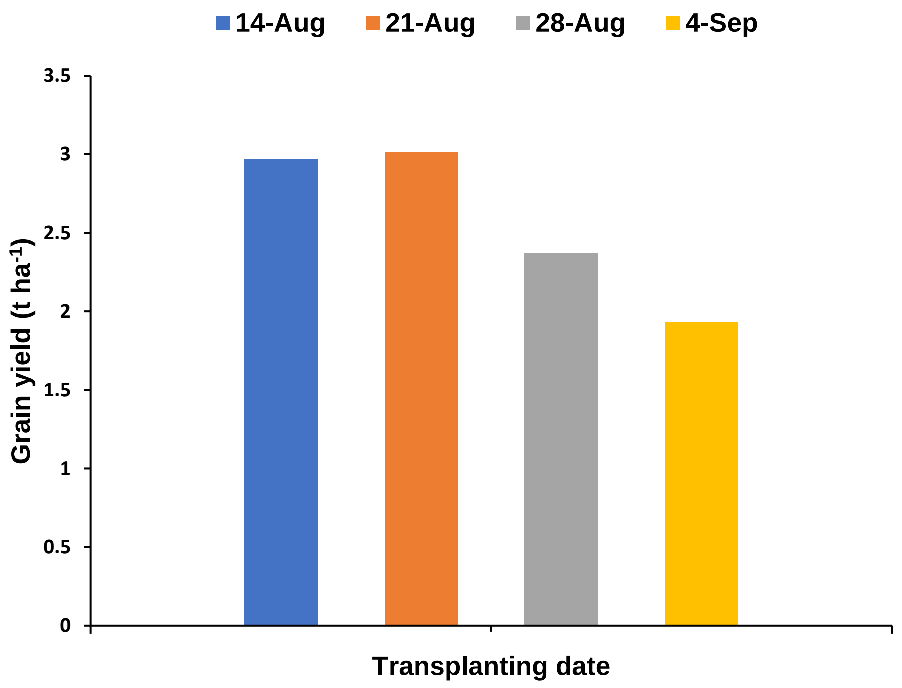


Figure 18. Effect of transplanting date on grain yield (t ha^{-1})

4.2.6.3 Interaction effect

Interaction of transplanting date and variety showed significant variations in respect of grain yield (Table 10). In general, combination of BRRI dhan34 and 21th August transplanting interaction produced the highest yield (3.92 t ha^{-1}). On the other hand, the lowest grain yield (1.53 t ha^{-1}) recorded from BRRI dhan34 and 4th September interaction treatment. Yield decreases more rapidly in BRRI dhan34 from early transplanting date to late transplanting date than other Chinigura.

Table 10. Interaction effect of varieties and transplanting dates on grain yield (t ha^{-1})

Interaction	Grain yield (t ha^{-1})			
	T_1	T_2	T_3	T_4
V_1	3.39 **b**	3.92 **a**	2.83 **c**	2.33 **de**
V_2	2.55 **cd**	2.10 **ef**	1.91 **f**	1.53 **g**
LSD $_{(.05)}$	**0.31**			
CV (%)	**6.82**			

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date), T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

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

4.2.7.1 Effect of variety

Straw yield varied significantly among the varieties (Figure 19). The highest straw yield (8.37 t ha^{-1}) was recorded in Chinigura. Its provided vegetative growth and highest tiller number than other varieties. The lowest straw yield was obtained from BRRI dhan34 (8.37 t ha^{-1})

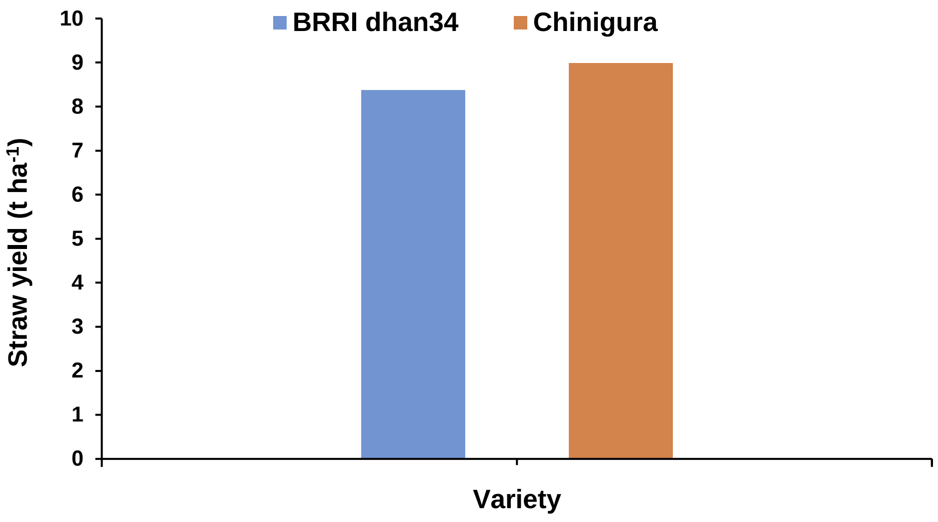


Figure 19. Effect of varieties on straw yield (t ha^{-1})

4.2.7.2 Effect of transplanting dates

Transplanting dates exerted significant effect on grain yield (t ha^{-1}) (Figure 20). The highest straw yield (11.44 t ha^{-1}) was recorded on combination of Chinigura and 21th August transplanting and combination of Chinigura and 4th September transplanting produced the lowest straw yield (6.89 t ha^{-1}).

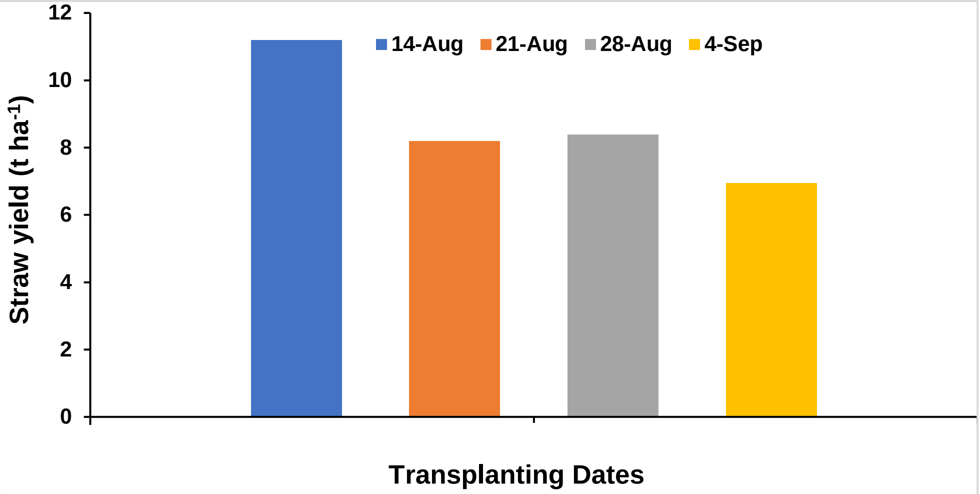


Figure 20. Effect of transplanting date on straw yield (t ha^{-1})

4.2.7.3 Interaction effect

Interaction of transplanting date and variety showed significant variations in respect of straw yield (Table 11). In general, combination of Chinigura and 14th August transplanting interaction produced the highest straw yield (11.44 t ha^{-1}). On the other hand, the lowest straw yield (6.89 t ha^{-1}) recorded from Chinigura and 4th September interaction treatment. Yield decreases more rapidly in BRRI dhan34 from early transplanting date to late transplanting date than other Chinigura.

Table 11. Interaction effect of varieties and transplanting dates on straw yield (t ha^{-1}) of aromatic rice on different transplanting dates

Interaction	Straw yield (t ha^{-1})			
	T_1	T_2	T_3	T_4
V_1	10.93 **a**	7.74 **c**	9.84 **c**	6.99 **d**
V_2	11.44 **a**	8.65 **b**	8.96 **b**	6.89 **d**
LSD $_{(.05)}$	0.71			
CV (%)	4.65			

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date),
T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

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

4.2.8.1 Effect of variety

Biological yield exerted significant variation among the varieties (Figure 21). Like grain BRRI dhan34 maintained its superiority by producing higher biological yield (11.49 t ha^{-1}) over the promising Chinigura (11.00 t ha^{-1}).

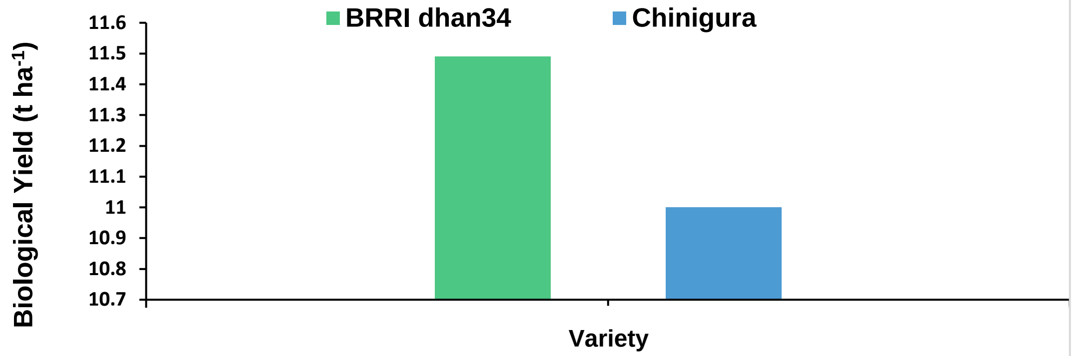


Figure 21. Effect of varieties on biological yield (t ha^{-1})

4.2.8.2 Effect of transplanting dates

The date of transplanting was found highly significant in case of biological yield (Table 22). The highest biological yield (14.16 t ha^{-1}) was produced in 14th August transplanting and the lowest (8.87 t ha^{-1}) was obtained with 4th September transplanted crops. Biological yield slightly decreased from 14th August to 4th September transplanting. The 2nd and 3rd transplanting date showed statistically similar and significantly higher biological yield than delayed transplanting which may be attributed the higher straw and grain yield. Zaman

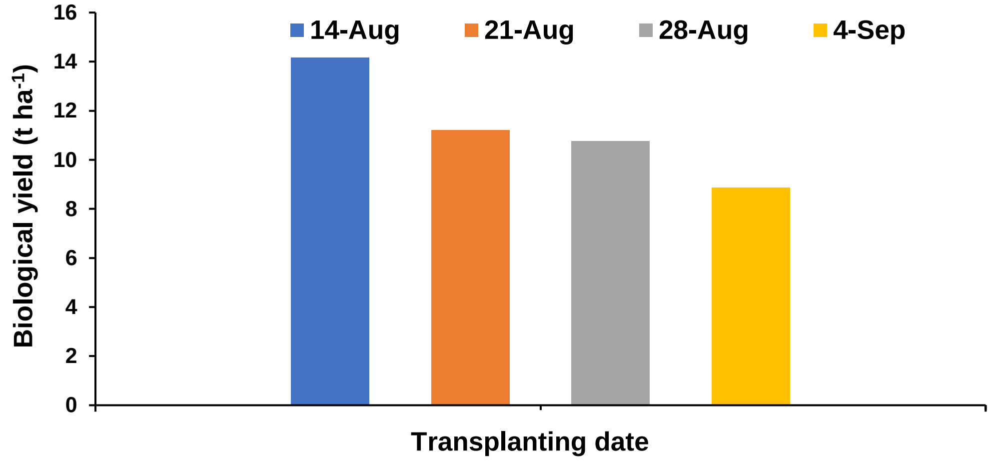


Figure 22. Effect of transplanting date on biological yield (t ha^{-1})

(1980) expressed similar views that late transplanting reduced biological yield of rice.

4.2.8.3 Interaction effect

Biological yield significantly influenced by the interaction of transplanting date and variety (Table 12). The trend of biological yield similar as observed in grain yield and straw yield i.e. early transplanting showed the highest biological yield than late transplanting. The highest biological yield (14.32 t ha^{-1}) was produced in treatment combination of BRRI dhan34 which was statistically similar with treatment combination of Chinigura and 14th August transplanting. The lowest biological yield (8.42 t ha^{-1}) was obtained in treatment combination of Chinigura and 4th September transplanted crops. Zaman (1980) expressed similar views that late transplanting reduced biological yield of rice

Table 12. Interaction effect of varieties and transplanting dates on biological yield (t ha^{-1})

Interaction	Biological yield (t ha^{-1})			
	T_1	T_2	T_3	T_4
V_1	14.32 **a**	11.67 **b**	10.67 **d**	9.33 **d**
V_2	13.99 **a**	10.75 **c**	10.86 **bc**	8.42 **e**
LSD $_{(0.05)}$	**0.86**			
CV (%)	**4.38**			

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date),
T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

4.2.9 Harvest Index (%)

4.2.9.1 Effect of variety

Harvest index showed significant variation among the varieties (Figure 23). BRRI dhan34 showed the highest harvest index (27.21%) and Chinugura produced the lowest harvest index (18.38%).

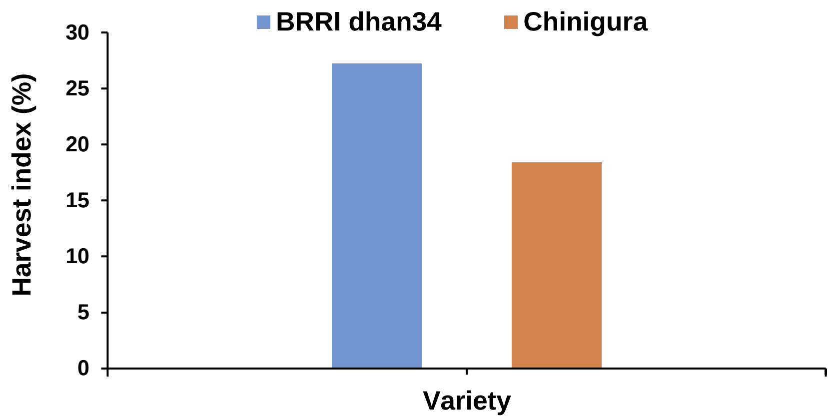


Figure 23. Effect of varieties on harvest index (%)

4.2.9.2 Effect of date of transplanting

Harvest index was significantly affected by date of transplanting (Figure 24). 21th August showed the highest harvest index (26.03%) and 14th August transplanting date showed the lowest harvest index (20.95%) and which was statistically similar 28th August (22.03%) and 4th September (21.57%).

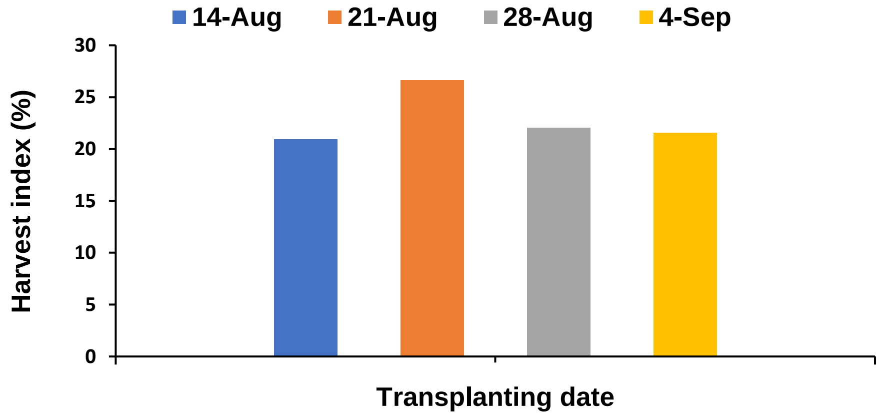


Figure 24. Effect of transplanting date on harvest index (%)

4.2.9.3 Interaction effect

Harvest index had significant effect in combination with date of transplanting and variety (Table 13). From interaction table, BRRI dhan34 and 21th August produced the highest harvest index (33.68%). The lowest harvest index (17.56%) found in the interaction between Chinigura and 28th August which was statistically similar with others three Chinigura and transplanting dates combination.

Table 13. Interaction effect of varieties and transplanting dates on harvest index

Interaction	Harvest index (%)			
	T_1	T_2	T_3	T_4
V_1	23.65 **a**	33.68 **a**	26.51 **b**	25.01 **bc**
V_2	18.25 **d**	19.59 **d**	17.56 **d**	18.14 **d**
LSD $_{(0.05)}$	2.25			
CV (%)	5.63			

In the column means having similar letter(s) are statistically similar and those having dissimilar letter(s) are differ significantly by $LSD_{0.05}$ level of significant.

Note: V_1= BRRI dhan34, V_2= Chinigura;
T_1= 14 August (1st transplanting date), T_2= 21 August (2nd transplanting date),
T_3=28 August (3rd transplanting date) and T_4= 4 September (4th transplanting date)

Chapter 5

SUMMARY AND CONCLUSION

To find out the effect of different date of transplanting on growth and yield of two aromatic rice varieties, a field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Dhaka, throughout the Aman season in July to December, 2018. The experiment be made up of two level of treatment such as- (A) Two aromatic rice varieties: BRRI dhan34 (V_1) and Chinigura (V_2); (B) Four transplanting date: 14th August (T_1), 21th August (T_2), 28th August (T_3) and 4th September (T_4). The experiment was laid out in Randomized Complete Block Design (RCBD) design with three replications. The unit plot size was (3 x 2) m^2. The land was fertilized with 150, 100, 70, 60, 10 and 15 kg ha^{-1} N, P_2O_5, KCl, S, B and Zn respectively. The total amount fertilizers except urea were applied in the field during final land preparation. The urea was applied in three equal splits where first application was at final land preparation with other fertilizers, second dose at tillering stages and final dose was applied at panicle initiation stage. 30 days old seedlings were transplanted in the plots with row to row and plant to plant spacing of 20 cm and 25 cm respectively. All intercultural operations were given as when required.

The data on crop growth characters (plant height, number of tillers $hill^{-1}$ and dry weight of plant) were recorded in the field from 30 DAT to 90 DAT with 15 days interval. The data on crop yield as well as yield contributing characters (number of effective and non-effective tillers, panicle length, panicle weight, number of total grains $panicle^{-1}$, number of filled grain $panicle^{-1}$, number of unfilled grains $panicle^{-1}$, 1000-grain weight, grain and straw yield, biological yield and harvest index) were noted after harvest and data was analyzed by using the Statisyix10 analysis package software. The mean difference among treatments were compared by least significant difference test at 5% level of significant.

Results of the experiment showed that growth parameters viz. plant height and dry matter production were significantly affected by varieties and the maximum values was obtained from Chinigura (V_2) for plant height and dry matter production while maximum number of tillers was shown at BRRI dhan34 (V_1). It revealed that Chinigura showed singnificantly taller plant throughout the growth stage while BRRI dhan34 showed lowest result in relation to plant height. The highest plant height was 125.34 cm which obtained from Chinigura (V_2) and lowest plant height was 124.31 cm which obtained from BRRI dhan34 (V_1). BRRI dhan34 produce the highest number of total tiller hill^{-1} while Chinigura (V_2) produced the lowest. The lowest number of non-effective tillers hill^{-1} was produced by BRRI dhan34 (V_1). Maximum total grain penical^{-1} was found in BRRIdhan34 (V_1) and minimum was found in Chinigura (V_2). The maximum number of filled grain and unfilled grain were found also in BRRI dhan34 (V_1) variety and lowest on Chinigura (V_2). For panicle length and weight, result showed that the highest panicle length was found in Chinigura (V_2) but weight of the panicle was highest in BRRI dhan34 (V_1). On the other hand, lowest value of panicle length and weight was found BRRI dhan34 (V_1) and Chinigura (V_2) respectively. Chinigura (V_2) produced maximum (12.85 g) 1000-grain weight while BRRI dhan 34 (V_1) produced the lowest (11.16) which are statistically different from each other. BRRI dhan34 produced the highest grain yield (3.12 t ha^{-1}) and lowest grain yield (2.02 t ha^{-1}) recorded from Chinigura (V_2). Straw yield was the highest (8.98 t ha^{-1}) in Chinigura (V_2) and lowest (8.37 t ha^{-1}) in BRRI dhan34 (V_1). Like grain yield, BRRI dhan34 (V_1) maintained its superiority by producing highest biological yield (11.49 t ha^{-1}) over the promising Chinigura (V_2) (11.00 t ha^{-1}). BRRI dhan34 maintained its superiority by producing highest harvest index (27.21%).

Results of the experiment showed that growth parameters viz. plant height and dry matter production, were significantly affected by transplanting dates. Numerical values of these characters were the highest for early transplanting and the lowest for late transplanting. Highest plant height (129.19 cm) was found T_2 transplanting and lowest height (122.34) was obtained from T_3. Number of tillers hill^{-1} was maximum in T_3 transplanting dates and the minimum was found in T_3 transplanting date. Effective tillers hill^{-1} were affected significantly by the transplanting dates but non-effective tillers hill^{-1} were not significantly affected by transplanting dates. The highest effective tillers hill^{-1} (15.57) was obtained from T_2 transplanting date and lowest from T_4 transplanting. On the other hand, there was no statistically different of non-effective tillers hill^{-1} which produce all four transplanting dates. From the result, it can be said that production of total tillers hill^{-1} was the highest in early transplanting dates than delayed transplanting dates with decreasing trends. Length and weight of panicle was significantly affected by transplanting dates and T_3 transplanting showed highest length (25.02 cm) while T_2 produced highest weight (2.14 g) of panicle. In contrast, T_4 transplanting showed lowest height (23.03 cm) and lowest weight (1.62 g) both. As T_2 produced height length, T_2 also produced maximum number of filled grains panicle^{-1} (146.97) while T_1 produced lowest number of unfilled grains (14.28). In contrast, T_4 produced lowest number (119.26) of filled grain and highest number (20.65) of unfilled grain. Highest 1000 grain weight was found at T_1 (13.37 g) and lowest was at T_3 (11.25 g). T_2 transplanting produced the highest grain yield (3.01 t ha^{-1}) and lowest grain yield (1.93 t ha^{-1}) recorded from T_4. Straw yield was the highest (11.19 t ha^{-1}) in T_1 and lowest (6.94 t ha^{-1}) at T_4 transplanting dates. Late transplanting reduced grain and straw yield. T_1 transplanting date produced highest biological yield (14.16 t ha^{-1}) over T_4 (8.87 t ha^{-1}). Like grain yield, T_2 maintained its superiority by producing highest harvest index (26.63%) while T_1 produced lowest (20.95%) harvest index.

Interaction of transplanting dates and varieties significantly affects in plant height, dry matter production and total tiller hill^{-1}. The highest values of these characters were observed in early transplanting with all varieties and the lowest was recorded from delayed transplanting. Interaction effect of V_2T_2 was provided highest plant height (133.17 cm) and V_1T_4 was provided lowest plant height (121.00 cm) which was statistically similar with V_2T_3 (122.16) and V_1T_4 (122.51). Plant produced highest dry matter was recorded from interaction of V_2T_2 (156.85 g) and lowest dry matter was recorded from V_1T_4 (112.35 g). Interaction effect of varieties and transplanting dates are significantly affected total number of tillers hill^{-1} up to 75 DAT from 30 DAT while 90 DAT shows no significant difference among the interaction of varieties and transplanting dates. Highest tiller number hill^{-1} (18.07) was obtained from V_1T_2 and lowest tiller number hill^{-1} (16.07) from V_1T_3 and both are statistically similar. For effective tiller hill^{-1} V_1T_2 produced the highest (16.67) where V_2T_4 produced the lowest (11.00) number of effective tiller hill^{-1}. When it is about non-effective tiller, there is no significant difference between the interaction of varieties and transplanting dates. Panicle length and weight are affected significantly by the interaction of varieties and transplanting dates. V_1T_3 showed the highest panicle length

(25.41 cm) while V_2T_4 showed lowest panicle length (22.75 cm). Weight of panicle was highest (2.81 g) at V_1T_2 and lowest (1.33 g) at V_2T_4. So, it can be said that length and weight of panicle was reduced at late transplanting. Maximum total grain penical^{-1} was found in V_1T_2 and minimum was found in V_2T_4 and maximum filled grain penicle^{-1} (184.08) was found in V_1T_2 and minimum was recorded in V_2T_4. Number of filled grains panicle also showed decreasing trends from early transplanting to delayed transplanting. Maximum (26.9) number of unfilled grains was obtained from V_1T_3 and lowest (11.00) at V_2T_4. 1000 seed weight was affected significantly by the interaction of varieties and transplanting dates. Highest 1000 grain weight (15.08 g) was found in V_2T_1 and lowest (9.90 g) was found V_1T_4. Grain yield was highest (3.92 t ha^{-1}) in the interaction of V_1T_2 gave the highest and the lowest grain yield (1.53 t ha^{-1}) was observed from V_2T_4 interaction treatment. Straw yield was the highest (11.44 t ha^{-1}) in V_2T_2 and highest biological yield (14.32 t ha^{-1}) produced in V_1T_1 interaction. On the other hand, both straw yield and biological yield was lowest in V_2T_4 interaction. Harvest Index was also significantly affected by transplanting date and variety. Harvest index was the highest (33.68%) in V_1T_2 interaction and lowest in V_2T_3 interaction.

Based on the result of the present study, the conclusion may be drawn as-

- Crop transplanted on 21th August produced the highest grain yield (3.01 t ha^{-1}) but delayed transplanting (4th September) producing the lowest grain yield (1.93 t ha^{-1}).
- Between the two aromatic varieties (BRRI dhan34 and Chinigura), BRRI dhan34 produced higher grain yield (3.12 t ha^{-1}).
- BRRI dhan34 x 21th August transplanting produced the highest grain yield (3.92 t ha^{-1}).
- Transplanting the varieties on 21th August showed significantly higher yields and yields was decreased with delayed transplanting in all combination.

Recommendation

Bearing in mind the above observation of the present study further investigation in the following areas may be recommended:

- Further study may be required in changed Agro-Ecological Zones (AEZ) of Bangladesh for rational adaptability.
- More number of treatments with different transplanting dates and other aromatic rice varieties may be chosen to study such effect.

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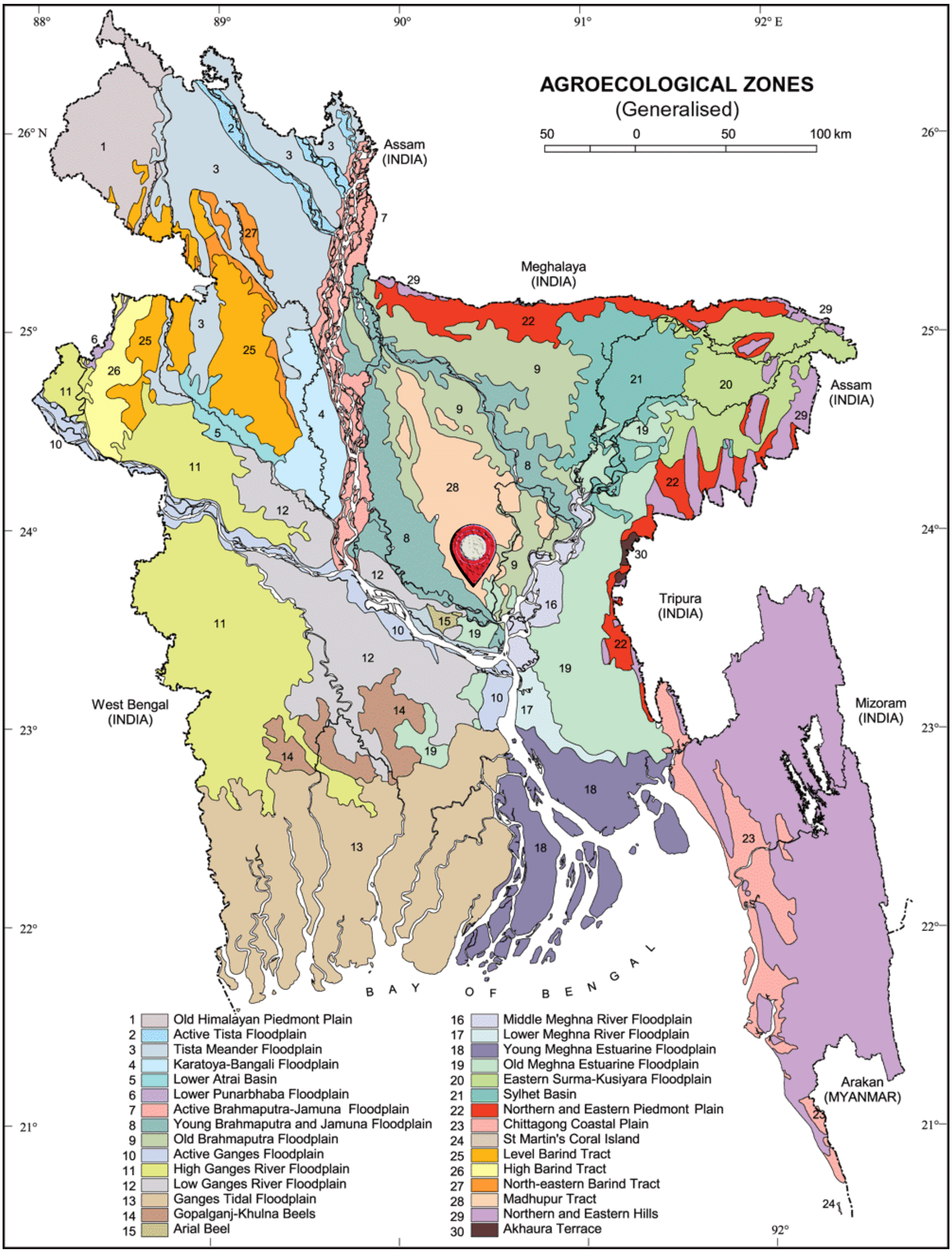
APPENDICES

Appendix I. Map showing the experimental site under the study



 The experimental site under the study

Appendix II. Monthly average temperature, average relative humidity and total rainfall and average sunshine of the experimental site during the period from June, 2018 to December, 2018

Month	Average Temperature (ºC)		Average Relative Humidity (%)	Rainfall (mm)	Average sunshine (hr)
	Minimum	Maximum			
June, 2018	23.2	35.5	78	312	5.4
July, 2018	24.5	36.0	83	563	5.1
August, 2018	23.5	36.0	81	319	5.0
September, 2018	24.4	34.5	81	279	4.4
October, 2018	25	32	79	175	6
November, 2018	21	30	65	35	8
December, 2018	15	29	74	15	9

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

Appendix III: Characteristics of soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of soil of the experimental field

Morphological features	Characteristics
Location	Agronomy field, SAU, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	Medium-high land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical composition of the soil

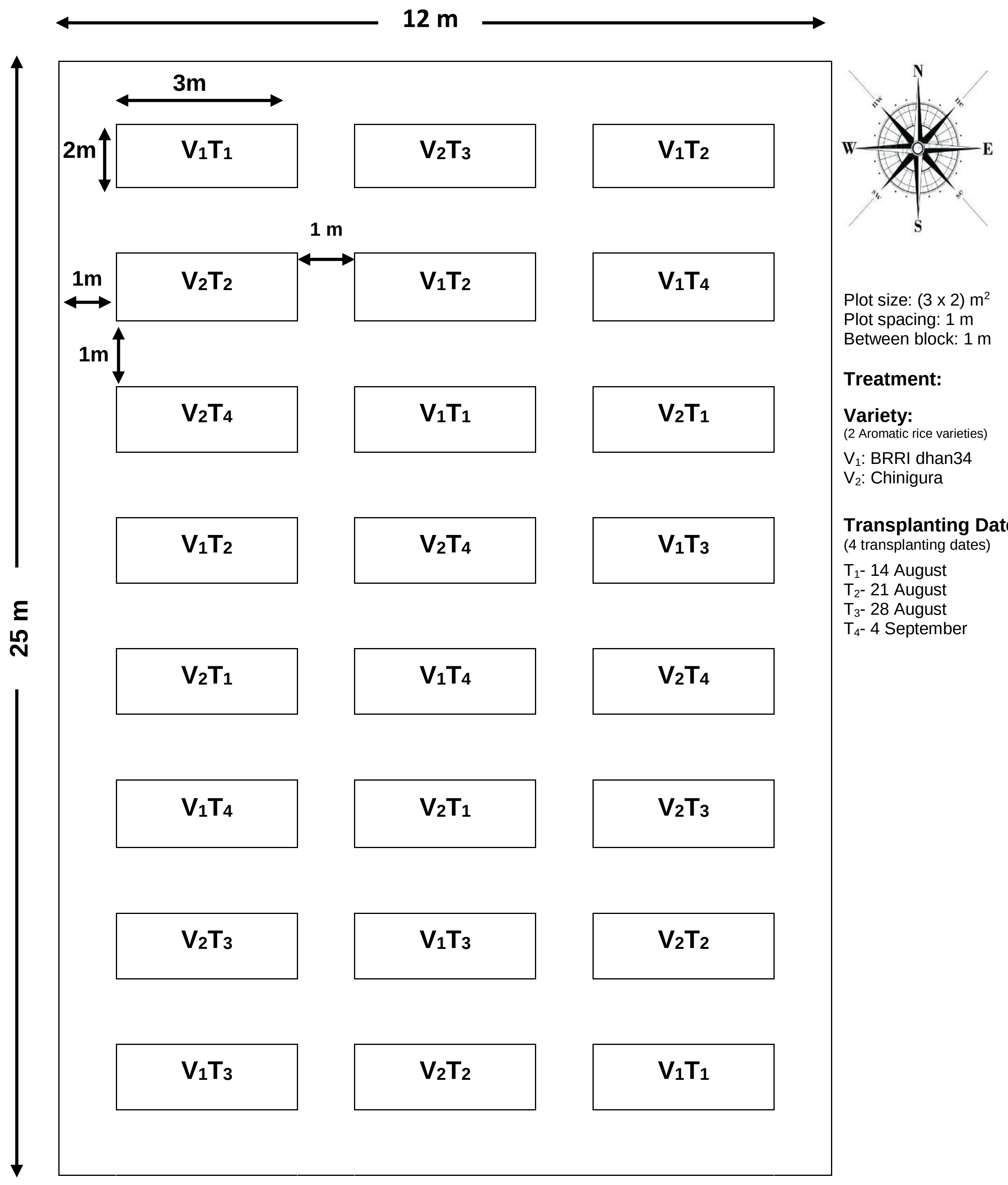
Soil separates	%	Methods employed
Sand	26	Hydrometer method (Day, 1915)
Silt	45	Do
Clay	29	Do
Texture class	Silty loam	Do

C. Chemical composition of the soil

Sl. No.	Soil characteristics	Analytical data	Methods employed
1	Organic carbon (%)	0.45	Walkley and Black, 1947
2	Total N (%)	0.03	Bremner and Mulvaney, 1965
3	Total S (ppm)	225.00	Bardsley and Lanester, 1965
4	Total P (ppm)	840.00	Olsen and Sommers, 1982
5	Available N (kg/ha)	54.00	Bremner, 1965
6	Available P (ppm)	20.54	Olsen and Dean, 1965
7	Exchangeable K (me/100 g soil)	0.10	Pratt, 1965
8	Available S (ppm)	16.00	Hunter, 1984
9	pH (1:2.5 soil to water)	5.6	Jackson, 1958
10	CEC	11.23	Chapman, 1965

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

Appendix IV: Layout of the design of the experiment



Plot size: (3 x 2) m^2
Plot spacing: 1 m
Between block: 1 m

Treatment:

Variety:
(2 Aromatic rice varieties)

V_1: BRRI dhan34
V_2: Chinigura

Transplanting Date:
(4 transplanting dates)

T_1- 14 August
T_2- 21 August
T_3- 28 August
T_4- 4 September

Appendix V. Analysis of variance (ANOVA) of plant height at different days after transplanting for aromatic rice varieties

ANOVA for Plant height @30 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	21.88	10.94		
Treatment	1	4.10	4.10	0.64	0.437
Date	3	558.22	186.07	28.92	0.000
Treatment*Date	3	325.57	108.52	16.87	0.000
Error	14	90.06	6.43		
Total	23	999.86			
Grand Mean	**64.664**				
CV	**3.92**				

ANOVA for Plant height @45 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	32.00	16.001		
Treatment	1	65.87	65.869	1.64	0.220
Date	3	485.05	161.685	4.03	0.029
Treatment*Date	3	428.10	142.700	3.56	0.042
Error	14	561.06	40.076		
Total	23	1572.08			
Grand Mean	**77.862**				
CV	**8.13**				

ANOVA for Plant height @60 DAT

Source	DF	SS	MS	F	P
Replication	2	21.83	10.91		
Treatment	1	396.09	396.09	22.42	0.000
Date	3	527.70	175.90	9.96	0.000
Treatment*Date	3	109.05	36.34	2.06	0.152
Error	14	247.32	17.66		
Total	23	1301.99			
Grand Mean	**89.444**				
CV	**4.70**				

ANOVA for Plant height @75 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	115.31	57.65		
Treatment	1	354.29	354.29	25.47	0.000
Date	3	92.29	30.76	2.21	0.132
Treatment*Date	3	343.75	114.58	8.24	0.002
Error	14	194.74	13.91		
Total	23	1100.39			
Grand Mean	**101.89**				
CV	**3.66**				

Appendix V. (Cont'd)

ANOVA for Plant height @90 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	1269.2	634.61		
Treatment	1	858.2	858.25	2.08	0.171
Date	3	1621.5	540.49	1.31	0.311
Treatment*Date	3	1008.6	336.20	0.81	0.507
Error	14	5788.5	413.46		
Total	23	10546.1			
Grand Mean	**110.18**				
CV	**18.46**				

ANOVA for Plant height @HARVEST

Source	DF	SS	MS	F	Sig.
Replication	2	122.757	61.37		
Treatment	1	15.232	15.23	1.38	0.259
Date	3	175.748	58.58	5.32	0.011
Treatment*Date	3	148.257	49.41	4.49	0.020
Error	14	154.208	11.01		
Total	23	616.202			
Grand Mean	**125.14**				
CV	**2.65**				

Appendix VI. Analysis of variance (ANOVA) of plant Dry matter production at different days after transplanting for aromatic rice varieties

ANOVA for Dry weight @30 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	0.0140	0.0070		
Treatment	1	28.5798	28.5798	217.62	0.0000
Date	3	43.1986	14.3995	109.64	0.0000
Treatment*Date	3	4.9735	1.6578	12.62	0.0003
Error	14	1.8386	0.1313		
Total	23	78.6046			
Grand Mean	**6.6863**				
CV	**5.42**				

ANOVA for Dry weight @45 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	1.574	0.7869		
Treatment	1	0.408	0.4082	0.55	0.4719
Date	3	78.391	26.1303	34.99	0.0000
Treatment*Date	3	10.821	3.6069	4.83	0.0164
Error	14	10.455	0.7468		
Total	23	101.648			
Grand Mean	**13.220**				
CV	**6.54**				

ANOVA for Dry weight @60 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	4.558	2.279		
Treatment	1	75.013	75.013	12.50	0.0033
Date	3	522.199	174.066	29.02	0.0000
Treatment*Date	3	35.795	11.932	1.99	0.1620
Error	14	83.989	5.999		
Total	23	721.553			
Grand Mean	**30.864**				
CV	**7.94**				

ANOVA for Dry weight @75 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	18.16	9.082		
Treatment	1	112.49	112.493	13.33	0.0026
Date	3	1441.65	480.550	56.96	0.0000
Treatment*Date	3	5.02	1.675	0.20	0.8957
Error	14	118.11	8.436		
Total	23	1695.44			
Grand Mean	**53.288**				
CV	**5.45**				

Appendix VI. (Cont'd)

ANOVA for Dry weight @90 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	10.24	5.121		
Treatment	1	190.01	190.013	49.67	0.0000
Date	3	733.67	244.556	63.93	0.0000
Treatment*Date	3	18.52	6.173	1.61	0.2310
Error	14	53.56	3.826		
Total	23	1006.00			
Grand Mean	**91.650**				
CV	**2.13**				

ANOVA for Dry weight @Harvest

Source	DF	SS	MS	F	Sig.
Replication	2	14.16	7.08		
Treatment	1	66.83	66.83	2.78	0.1175
Date	3	5361.78	1787.26	74.40	0.0000
Treatment*Date	3	140.15	46.72	1.94	0.1688
Error	14	336.32	24.02		
Total	23	5919.23			
Grand Mean	**134.45**				
CV	**3.65**				

Appendix VII. Analysis of variance (ANOVA) of number of tiller hill^{-1} at different days after transplanting for aromatic rice varieties

ANOVA for number of tiller @30 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	4.123	2.0617		
Treatment	1	38.002	38.0017	13.51	0.0025
Date	3	73.218	24.4061	8.68	0.0017
Treatment*Date	3	2.205	0.7350	0.26	0.8520
Error	14	39.370	2.8121		
Total	23	156.918			
Grand Mean	**16.658**				
CV	**10.07**				

ANOVA for number of tiller @45 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	4.423	2.2117		
Treatment	1	18.727	18.7267	5.30	0.0372
Date	3	22.420	7.4733	2.11	0.1442
Treatment*Date	3	8.713	2.9044	0.82	0.5032
Error	14	49.470	3.5336		
Total	23	103.753			
Grand Mean	**18.183**				
CV	**10.34**				

ANOVA for number of tiller @60 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	1.375	0.6873		
Treatment	1	24.160	24.1603	7.35	0.0169
Date	3	86.906	28.9687	8.81	0.0016
Treatment*Date	3	7.225	2.4083	0.73	0.5496
Error	14	46.016	3.2869		
Total	23	165.682			
Grand Mean	**17.887**				
CV	**10.14**				

ANOVA for number of tiller @75 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	0.9100	0.4550		
Treatment	1	13.2017	13.2017	8.89	0.0099
Date	3	22.5650	7.5217	5.06	0.0140
Treatment*Date	3	4.0317	1.3439	0.90	0.4636
Error	14	20.7967	1.4855		
Total	23	61.5050			
Grand Mean	**18.475**				
CV	**6.60**				

ANOVA for number of tiller @90 DAT

Source	DF	SS	MS	F	Sig.
Replication	2	7.5033	3.75167		
Treatment	1	0.3267	0.32667	0.10	0.7513
Date	3	4.8333	1.61111	0.52	0.6784
Treatment*Date	3	4.2733	1.42444	0.46	0.7176
Error	14	43.7767	3.12690		
Total	23	60.7133			
Grand Mean	**16.817**				
CV	**10.52**				

Appendix VIII. Analysis of variance (ANOVA) of yield data

A. ANOVA for Panicle length (cm)

Source	DF	SS	MS	F	Sig.
Replication	2	6.8193	3.40963		
Treatment	1	1.4900	1.49002	1.14	0.3041
Date	3	12.8284	4.27614	3.27	0.0532
Treatment*Date	3	1.5799	0.52665	0.40	0.7536
Error	14	18.3265	1.30903		
Total	23	41.0441			
Grand Mean	**23.882**				
CV	**4.79**				

B. ANOVA for Panicle weight (g)

Source	DF	SS	MS	F	Sig.
Replication	2	0.01710	0.00855		
Treatment	1	5.01420	5.01420	151.39	0.0000
Date	3	0.94935	0.31645	9.55	0.0011
Treatment*Date	3	0.43811	0.14604	4.41	0.0221
Error	14	0.46370	0.03312		
Total	23	6.88246			
Grand Mean	**1.9213**				
CV	**9.47**				

C. ANOVA for Filled grain panicle^{-1}

Source	DF	SS	MS	F	Sig.
Replication	2	14.29	7.15		
Treatment	1	4765.80	4765.80	414.11	0.0000
Date	3	4179.98	1393.33	121.07	0.0000
Treatment*Date	3	750.30	250.10	21.73	0.0000
Error	14	161.12	11.51		
Total	23	9871.50			
Grand Mean	**133.26**				
CV	**2.55**				

D. ANOVA for Unfilled grain panicle^{-1}

Source	DF	SS	MS	F	Sig.
Replication	2	115.19	57.593		
Treatment	1	607.12	607.121	50.83	0.0000
Date	3	133.09	44.362	3.71	0.0373
Treatment*Date	3	83.08	27.694	2.32	0.1199
Error	14	167.23	11.945		
Total	23	1105.70			
Grand Mean	**17.315**				
CV	**19.96**				

E. ANOVA for Effective tiller hill^{-1}

Source	DF	SS	MS	F	Sig.
Replication	2	0.4433	0.2217		
Treatment	1	2.6667	2.6667	11.73	0.0041
Date	3	57.3533	19.1178	84.08	0.0000
Treatment*Date	3	12.1867	4.0622	17.87	0.0000
Error	14	3.1833	0.2274		
Total	**23**	**75.8333**			
Grand Mean	**13.583**				
CV	**3.51**				

Appendix VIII (Cont'd)

F. ANOVA for Non-effective tiller hill^{-1}

Source	DF	SS	MS	F	Sig.
Replication	2	0.5433	0.27167		
Treatment	1	0.0150	0.01500	0.02	0.8797
Date	3	2.2983	0.76611	1.21	0.3415
Treatment*Date	3	2.9383	0.97944	1.55	0.2455
Error	14	8.8433	0.63167		
Total	23	14.6383			
Grand Mean	**1.6417**				
CV	**48.41**				

G. ANOVA for 1000 Grain yield (t ha^{-1})

Source	DF	SS	MS	F	Sig.
Replication	2	0.0071	0.0035		
Treatment	1	17.1873	17.1873	193.58	0.0000
Date	3	39.7647	13.2549	149.29	0.0000
Treatment*Date	3	7.0030	2.3343	26.29	0.0000
Error	14	1.2430	0.0888		
Total	23	65.2051			
Grand Mean	**12.007**				
CV	**2.48**				

H. ANOVA for Grain yield (t ha^{-1})

Source	DF	SS	MS	F	Sig.
Replication	2	0.0267	0.01336		
Treatment	1	7.1832	7.18320	233.79	0.0000
Date	3	4.8153	1.60510	52.24	0.0000
Treatment*Date	3	1.0659	0.35529	11.56	0.0004
Error	14	0.4301	0.03072		
Total	23	13.5213			
Grand Mean	**2.5713**				
CV	**6.82**				

I. ANOVA for Straw yield (t ha^{-1})

Source	DF	SS	MS	F	Sig.
Replication	2	0.0432	0.0216		
Treatment	1	2.1962	2.1962	13.46	0.0025
Date	3	57.7532	19.2511	117.99	0.0000
Treatment*Date	3	1.3004	0.4335	2.66	0.0889
Error	14	2.2842	0.1632		
Total	23	63.5772			
Grand Mean	**8.6800**				
CV	**4.65**				

J. ANOVA for Biological yield (t ha^{-1})

Source	DF	SS	MS	F	Sig.
Replication	2	0.0043	0.0021		
Treatment	1	1.4357	1.4357	5.91	0.0291
Date	3	85.9956	28.6652	117.98	0.0000
Treatment*Date	3	1.2739	0.4246	1.75	0.2032
Error	14	3.4016	0.2430		
Total	23	92.1111			
Grand Mean	**11.251**				
CV	**4.38**				

Appendix VIII (Cont'd)

K. ANOVA for Harvest index (t ha^{-1})

Source	DF	SS	MS	F	Sig.
Replication	2	4.699	2.350		
Treatment	1	467.691	467.691	283.43	0.0000
Date	3	121.220	40.407	24.49	0.0000
Treatment*Date	3	64.919	21.640	13.11	0.0002
Error	14	23.101	1.650		
Total	23	681.630			
Grand Mean	**22.797**				
CV	**5.63**				

PLATES

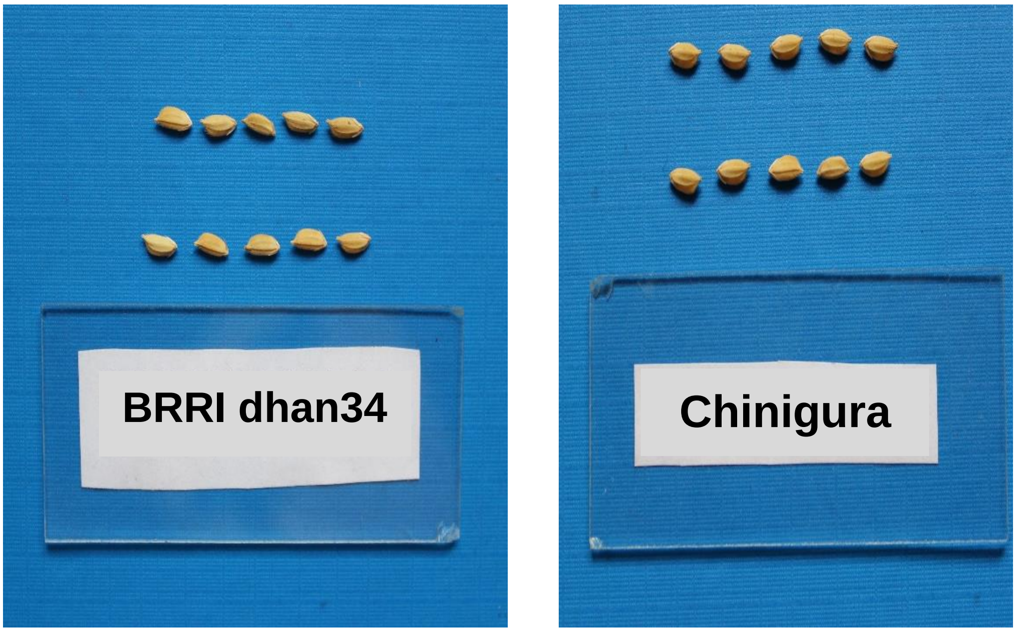


Plate 1. Pictorial view of collected two rice varieties seeds

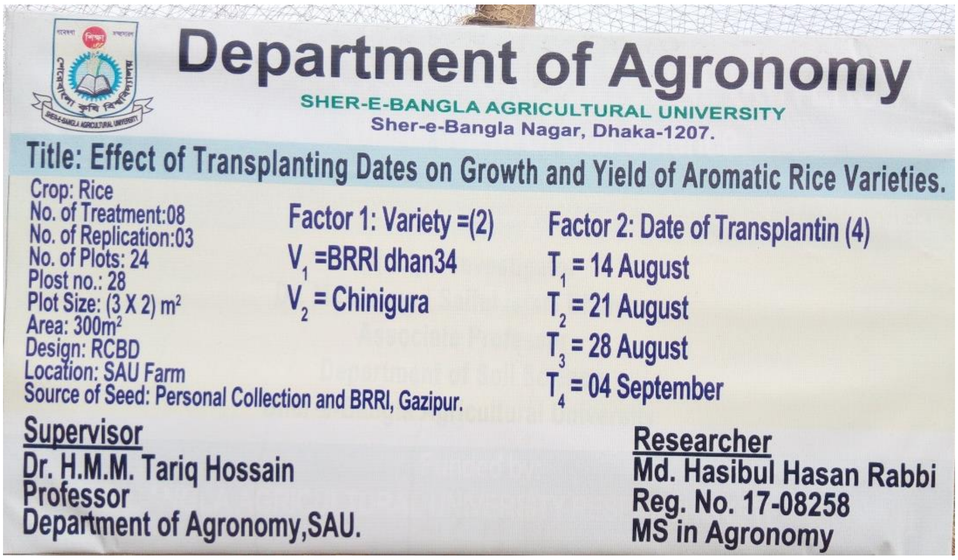


Plate 2. Pictorial view of signboard of the experiment

Plate 3. Pictorial view of transplanting of 30 days seedling

Plate 4. Field view after transplanting


Plate 5. Preparation of irrigation channel and irrigation facility of experiment field

Plate 6. Performing intercultural operation

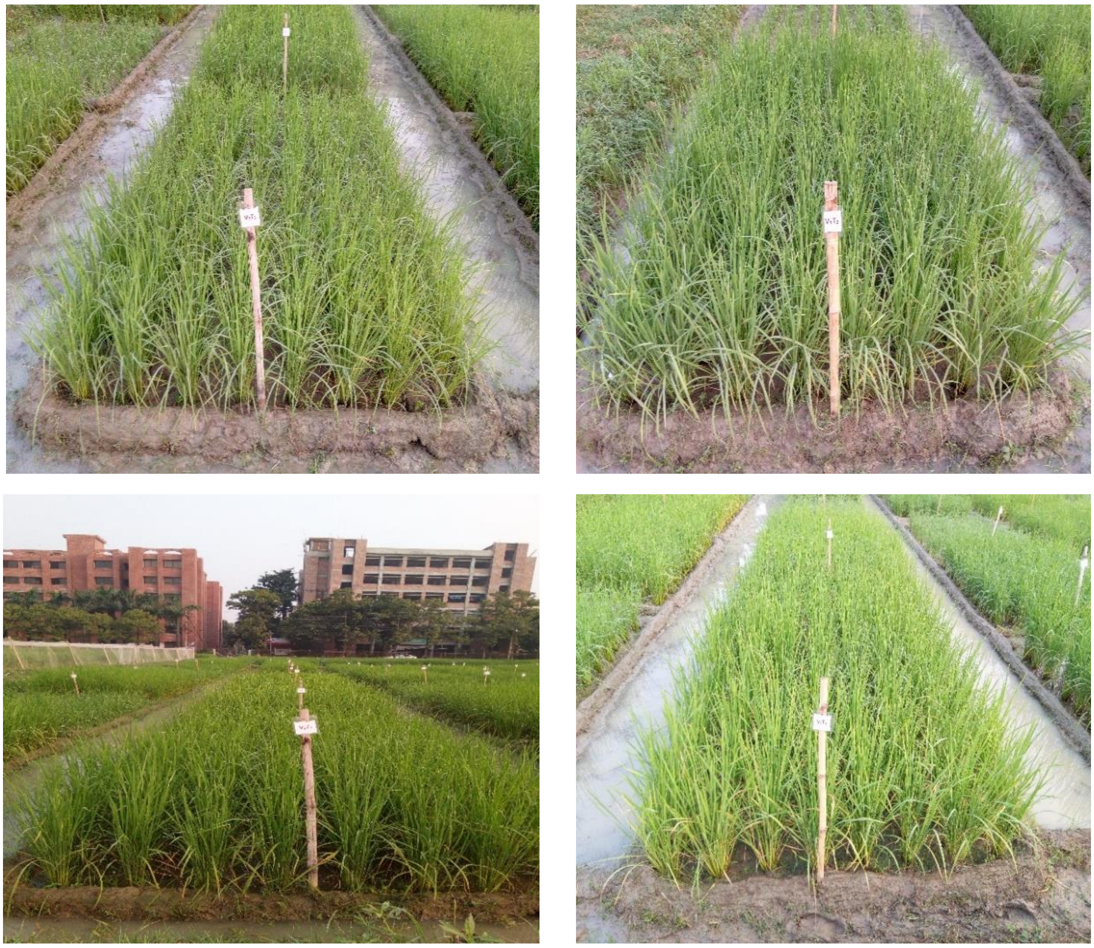


Plate 7. Field view after tagging

Plate 8. Data collection

Plate 9. Collected sample for dry weight

Plate 10. Overhead crop netting at ripening stage

Plate 11. Field view of crop at different stages

Plate 12. Collecting harvested crop from field

Plate 13. Sun drying harvested grain

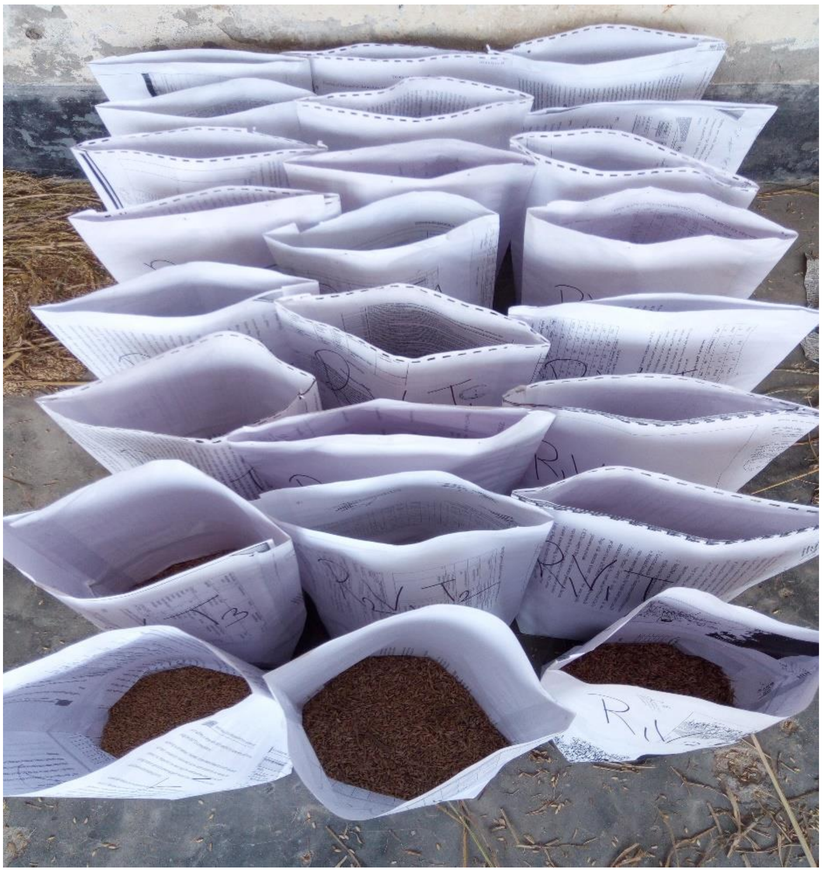


Plate 13. Bagging for storing after balancing