# INFLUENCE OF TRANSPLANTING DATE ON GROWTH AND YIELD OF BORO RICE VARIETIES IN LALMAI-HILL AREA


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## *CERTIFICATE*

*This is to certify that thesis entitled, "**INFLUENCE OF TRANSPLANTING DATE ON GROWTH AND YIELD OF BORO RICE VARIETIES IN LALMAI-HILL AREA**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the result of a piece of bona fide research work carried out by **MD. NAYEB ALI KHAN** Registration No. **18-09240** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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**Place: Dhaka, Bangladesh**

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**Associate Professor**

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*Dedicated To*

*My Beloved Parents*
*Who Always*
*Inspired Me To*
*Continue My Study*

# LIST OF ABBRIVIATIONS

| Abbreviation | Full Word |
|---|---|
| **Agri** | Agricultural |
| **Agric** | Agriculture |
| **AEZ** | Agro-Ecological Zone |
| **BARD** | Bangladesh Academy for Rural Development |
| **BARI** | Bangladesh Agricultural Research Institute |
| **BBS** | Bangladesh Bureau of Statistics |
| **BINA** | Bangladesh Institute of Nuclear Agriculture |
| **BRRI** | Bangladesh Rice Research Institute |
| **cm** | Centi-meter |
| **CRD** | Completely Randomized Design |
| **cv.** | Cultivar |
| **CV%** | Percent coefficient of variance |
| **DAT** | Days after transplanting |
| **DF** | Degree of freedom |
| ***et al.*** | And others |
| **Etc.** | Etcetera |
| **FAO** | Food and Agricultural Organization |
| **g** | Gram |
| **ha** | Hectare |
| **HI** | Harvest Index |
| **HYV** | High yielding variety |
| **IRRI** | International Rice Research Institute |
| **kg** | Kilogram |
| **LAI** | Leaf area index |
| **LSD** | Least Significant Difference |
| **m** | Meter |
| **Mgmt** | Management |
| **MoP** | Muriate of Potash |
| **SRDI** | Soil Research and Development Institute |
| **t** | Ton |
| **TSP** | Triple Supper Phosphate |
| **viz.** | Namely |
| **%** | Percent |
| **$^0$C** | Degree Centigrade |

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**December, 2020** **The Author**

**SAU, DHAKA**

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## ABSTRACT

A field experiment was conducted in Lalmai-hill area of Cumilla with five recently BRRI released rice varieties during *boro* season (2018-2019) to evaluate their yield performance under different transplanting dates. Rice seedlings were transplanted on three different dates *viz.*, January 15 ($T_1$), January 30 ($T_2$) and February 14 ($T_3$) which were considered as transplanting date treatments. Five rice varieties *viz.*, BRRI dhan67 ($V_1$), BRRI dhan68 ($V_2$), BRRI dhan74 ($V_3$), BRRI dhan81 ($V_4$) and BRRI dhan86 ($V_5$) were considered as varietal treatments. Results showed that transplanting date had great impact on growth and yield of *boro* rice. Advancement of transplanting date or delaying of transplanting date decreased effective tillers, filled grains panicle$^{-1}$, total grains panicle$^{-1}$, thousand grain weight, grain yield, biological yield and harvest index. Compared to early-planted seedlings ($T_1$), late-planted seedlings ($T_3$) decreased effective tiller hill$^{-1}$, filled grains panicle$^{-1}$, grain yield and biological yield by 13, 14, 24 and 9%, respectively. Varietal variation also influenced the growth and yield of rice. The highest grain yield (5.95 t ha$^{-1}$) and biological yield (14.33 t ha$^{-1}$) were obtained from BRRI dhan74 compared with other varieties because of higher potentiality of its yield attributes. Combination of transplanting date and variety also influenced growth and yield of *boro* rice. The highest grain yield (6.67 t ha$^{-1}$) and yield return in terms of monetary advantages (Tk. 158765 ha$^{-1}$) were recorded from BRRI dhan74 when transplanted on January 15 whereas, lowest grain yield (3.36 t ha$^{-1}$) and yield return (Tk. 98350 ha$^{-1}$) were recorded from BRRI dhan86 when planted on February 14. Transplanting of all other varieties on January 15 confirmed higher yield and yield return compared with delayed transplanting (January 30 and February 14). However, transplanting of any *boro* rice seedling after January 30 decreased growth, yield and yield return in Lalmai-Hill area.

# CHAPTER 1
# INTRODUCTION

Rice is from the genus *Oryza* and family Poaceae, has 22 known species and has great economic importance (Bajaj and Mohanty, 2005). Rice, a staple food for more than half of the world's population, is grown in> 100 countries with 90% of the total global production from Asia. Although there are more than 110,000 cultivated varieties of rice that vary in quality and nutritional content, after In addition to calories, rice is a good source (Fukagawa and Ziska, 2019). It is the most important food crop of the world and the staple food of more than 3.5 billion people or more than half of the world's population (IRRI, 2010). Rice is the main food crop of an estimated 40% of the world’s population. Rice provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average per person in the country. Rice is adaptable to a variety climatic conditions. It can be cultivated in dry and wetland at low and high altitudes. Worldwide, rice is grown on 158 million hectare (M ha) with a production of 470 million ton (MT) milled rice is contributed by Asia with China and India as the major contributors and about 5000 L of water is required for each kilogram of irrigated rice (Fahad *et al.*, 2019).

Population growth rate in Bangladesh is two million people per year and the population will reach 233.2 million by 2050, going by the current trend. Bangladesh will require more than 55.0 MT of rice per year to feed its people by the year 2050. Bangladesh will require about 31.3 to 42.0 MT of rice for the year 2030 (BBS, 2012).

Rice is one of the most important food crop as it is the important source of calories for nearly 50% of the world’s population. The demand of rice as a food increasing day by day because of its popularity in ever growing population throughout the world (Asante, 2017). To feed the ever growing people and ensuring food security, it is important task for plant scientist to increase production of food crop including rice. As a rice eater and grower country Bangladesh should give more emphasis on rice production. Because rice is staple food and occupies 80% of total land area in our country (Kabir *et al.*, 2016). Although we showed some potentiality by surplus production (about 2 MT) of rice in 2014-15 by producing 34.4 million ton of clean rice in 2014 (Kabir *et al.*, 2015). But its demand will be reached to 44.6 MT of cleaned rice within 2050 because of overpopulation (BRRI, 2009 and Nath *et al*., 2016). In addition, increasing biotic and abiotic stress due to climatic hazards and decreasing resources' (like land, labor, water, soil health and water) because of growing economy and industrialization will be great challenge to feed the rice loving people (Kabir *et al*., 2015). Moreover, 'rice security' is the synonymous to 'food security' and important parameter for social stability in Bangladesh like many other rice growing country (Brolley, 2015). To ensure our food security, social stability as well as political stability we should increase our rice production. To do that, increasing rice cultivation area and yield per unit area may be important strategies. But regular shrinkage of agricultural land limits crop growing area including rice.

So, development of high yielding modern variety which are adapted to adverse climatic condition and expand them in new area might be important steps to increase rice production.

About 160 million peoples in Bangladesh depend on rice as main food and about 75.1% of agricultural land use to grow rice of which 42.40 was employed on *boro* crops (BBS, 2015). Boro is the single most crops in Bangladesh in the context of total volume of production. Although rice was considered as the main crop in Bangladesh and the country was ranked as the 3rd rice producer in the world (IRRI, 2020).

Although our agricultural land is declining @ 1% per annum (BBS, 2011), we have enough scope to increase rice production. We have increase our rice production from 3.74 to 4.5 t $ha^{-1}$ by 4 years (BRRI, 2017) through adapting advanced rice production technologies including cultivation of HYV rice. So we can increase rice production by adopting advanced technologies e.g. new released HYV. We can also increase our rice area. Because till we have a lot of cultivable waste land which can be bring under rice cultivation considering adaptability of rice variety of that area. We can also replace non profitable crop by HYV rice through ensuring high cost benefit ratio. Considering these points we discussed, Lalmai-Hill area might be a suitable location for introducing recently released HYV rice. To do that, we have to face challenges regarding planting time and methods as the cropping intensity of these area is high and the land occupied by other crops. To adjust with other crops and maintain or increase cropping intensity we have to select best planting time. In addition, weather variability is also a major factor for inter-annual variation of crop yield. Adjustment of specific crop growth stage with specific climatic conditions helps to ensure higher yield. Shifting of sowing and or planting date is the most important option for adjustment of specific crop growth stage with specific climatic conditions. Moreover, shifting planting date directly influences both thermo and photo period, and consequently have great effect on the phasic development and partitioning of dry matter (Patel *et al.*, 2019).

Introducing commercially competitive high yielding modern variety in Lamai-Hill area might be important steps to popularize specific rice variety as well as rice cultivation. Establishment of new variety in that area may increase the income of the rice grower. It may also create employment opportunity for agri-labor which can change the socio-economic condition. Higher rice production and profit might ensure socially and politically stable community.

Considering the problems and prospects we discussed, the present study was undertaken to meet the following objectives

- To find out the appropriate planting time of *boro* rice in Lalmai-Hill area.
- To identify the best performing *boro* rice varieties for Lalmai-Hill area, and
- To find out the cost-effective rice varieties for Lalmai-Hill area.

# CHAPTER 02
# REVIEW OF LITERATURE

## 2.1 Rice

Rice (*Oryza sativa L.*) is centre of lives of about half of world's population and it is possibly the oldest domesticated grain. It has two cultivated and 22 wild species among these two cultivated species *Oryza sativa* is grown all over the world but *Oryza glaberrima* has been cultivated in west of Africa *O. sativa* has two sub species *Indica* and *Japonica*. In Bangladesh *Indica* sub-species is mainly cultivated which prefers tropical warm climate (IRRI, 1992). Growing rice is the largest single use of land for producing food, covering 9% of the earth's arable land. It provides 21% of global human per capita energy and 15% of per capital protein. It is the principle energy source for 17 countries in Asia and the pacific, 9 countries in North and South America and 8 countries in Africa (FAOSTAT, 2012).

Rice is the principle food crop in Bangladesh. It is the staple food and it ranks first in respect of area and production among all food crops in Bangladesh. Due to the tropical climatic condition Bangladesh is suitable for rice cultivation and cultivated all over the country except southern-east hilly area. Rice is grown throughout the year in Bangladesh with three distinct seasons (*Aus*, *Aman* and *Boro*) and grown in four ecosystems namely irrigated (*Boro*), rainfed (transplanted *Aus* and *Aman*), rainfed upland (direct-seeded *Aus*) and deepwater (broadcast *Aman*) (Hussain, 2012).

## 2.2 Effect of transplanting date

The planting date of the rice crop is significant for three significant date. Initially, it guarantees that vegetative development happens during a time of good temperatures and elevated levels of sunlight based radiation. Furthermore, the ideal planting time for every cultivar guarantees the chilly touchy stage happens when the base night temperatures are verifiably the hottest. Thirdly, planting on time ensures that grain filling happens when milder harvest time temperatures are almost certain, henceforth great grain quality is accomplished (Farrell *et al.*, 2003).

### 2.2.1 Effect of transplanting date on growth of rice

Roy *et al.* (2019) conducted field experiment with five modern varieties viz., BRRI dhan28, BRRI dhan58, BRRI dhan67, BRRI dhan69 and BRRI dhan74 by transplanting on different dates viz., 15 December, 30 December, 15 January, 30 January and 15 February to find out the effect of variety, date of transplanting and its interaction on the growth and yield performance. The growth of plant varied with variation of transplanting date. Transplanting of all rice varieties at 15 January showed highest yield while transplanting at earlier or later than this date. However, the LAI and dry matter production hill-1 were highest in BRRI dhan69 when transplanted on 15 January whereas the lowest value was found in BRRI dhan28 when transplanted on 15 February.

Patel *et al.* (2019) reported that sowing and or transplanting date significantly influenced growth and yield of rice. Sowing and or transplanting at right time ensures optimum vegetative growth because of satisfactory temperatures and total sunshine hours.

Mannan *et al.* (2012) conducted a field experiment at BRRI farm Gazipur during boro season to understand the optimum transplanting date of locally available aromatic rice varieties Kalijira, Kataribhog, Chinigura and Badshabhog. They transplanted the rice variety from December 10 to January 25 with 15 days interval. They observed that plant height, tiller number and dry matter accumulation increased with advancement of transplanting date.

Mannan *et al.* (2009) reported that plant height, tillers number, and dry matter of varieties varied significantly due to variation of transplanting dates. The short plants, less tillers, and low dry matter observed in early planted (22 July) crop and characters increased successive with the advances of planting date until 7-22 September and again weakened thereafter irrespective of growth stages up to 60 DAT.

Nahar *et al.* (2009) described that low temperature causes various types of injuries in rice plants, but the most important one is spikelet sterility. Besides, filled grains production decreased significantly with the delay of transplanting which was due to happening of low temperature at anthesis and spikelet primordial formation.

Chopra *et al.* (2006) reported that delayed transplanting decreases the number of days from transplanting to maximum tillering. Delayed transplanting also significantly influenced flowering of rice.

### 2.2.2 Effect of transplanting date on yield and yield attributes of rice

Transplanting of *boro* rice on different dates showed variation on yield by different varieties in different districts of Bangladesh. Ali (2019) reported that transplanting at later dates shortened life cycle of *boro* rice. He also reported that yield of *boro* rice varieties Binadhan-10, Binadhan-14, BRRI dhan28 and BRRI dhan29 decreased while transplanted after 15 February at Mymensingh, Rangpur, Pabna and Cumilla districts. At Cumilla districts yield reduction started after transplanting of 21st January in case of all varieties. Yield reduction is 100% in case of BRRI dhan29 while transplanted at or after 30 March in Cumilla districts.

Roy *et al.* (2019) noted that transplanting date, variety and their interaction affect growth and yield of *boro* rice. They conducted the experiment with five modern varieties viz., BRRI dhan28, BRRI dhan58, BRRI dhan67, BRRI dhan69 and BRRI dhan74 by transplanting on different dates viz., 15 December, 30 December, 15 January, 30 January and 15 February. Results revealed that transplanted on 15 January gave best result while transplanting on earlier or later on that date. The highest number of effective tillers hill$^{-1}$ (12.81), number of grains panicle$^{-1}$ (131.20), 1000-grain weight (21.93 g), grain yield (5.36 t ha$^{-1}$) and straw yield (7.71 t ha$^{-1}$) was recorded while transplanted on 15 January. However, the highest grain (5.90 t ha$^{-1}$) and straw yields (7.87 t ha$^{-1}$) were recorded in BRRI dhan69 while transplanted on 15 January whereas the lowest results were recorded in BRRI dhan28 while transplanted on 15 February.

Patel *et al.* (2019) reported that yield of rice affected by sowing and or transplanting date. Transplanting and or sowing on proper time ensures grain filling during milder autumn when temperatures are more likely so that good grain quality is achieved. Results from different studies revealed that maximum yield of rice obtained when rice plants exposed to appropriate temperature range by controlling sowing and or transplanting time.

Kabir *et al.* (2017) reported that Rice is the staple food crop and it grows in three seasons in Bangladesh. The optimum transplanting time can satisfy its appropriate temperatures and solar radiation for vigorous vegetative growth and maximum grain yield. They selected two rice variety such as, BR11 and BRRI dhan39 and four transplanting dates (20th July, 4th August, 19th August and 3rd September). They showed that seedling transplanting on 4th August led to producing maximum grain yield, Also they produced maximum number of productive (panicle bearing) tillers, number of grains panicle$^{-1}$, and 1000-grain weight.

Kumar *et al.* (2017) revealed an experiment to observe the effects of date of transplanting on yield and quality of basmati rice (Pusa Basmati-1509). This experiment consisted of four transplanting dates (15 June, 5 July, 25 July and 15 August). Among the different date of transplanting they observed that the highest grain yield (4363 kg ha$^{-1}$) was recorded under 15 June and lowest the grain yield (4058 kg ha$^{-1}$) obtained under 5 July.

Haque *et al.* (2015) conducted two field experiment and noticed that late planting decreased grain yield both in hybrid and inbred varieties due to increased temperature impaired-inefficient transport of assimilates. Yield reduction was higher in hybrid varieties than inbred variety.

Variation in sowing date in Nepal showed variation in yield and yield attributes of rice. Sowing of rice in June 13 showed highest grain yield, straw yield harvest index as highest effective tiller and filled grain plant$^{-1}$ was observed in same date compared with May 29, June 28 and July 13 in Nepal (Dawadi and Chaudhury, 2013).

Mukesh *et al*. (2013) reported that early transplanting dates (25 June and 10 July) increase the grain yield (3.5 t ha$^{-1}$ and 3.4 t ha$^{-1}$) and yield contributing character of basmati rice (*Oryza sativa* L.) as compared to late planting (25 July).

Mannan *et al.* (2012) conducted field experiment during *boro* season with locally available aromatic rice varieties. They transplanted on December 10, December 25, January 10 and January 25. They reported that growth of aromatic rice increases with advancement of transplanting date but yield and yield attributes such as, the number of panicles, grains panicle$^{-1}$, panicle length, grain yield, straw yield and growth duration decreased with delaying of transplanting dates.

Late transplanting of rice after the optimum dates results lower yield. Delayed transplanting causes higher disease and insect incidence, tropical storm-related lodging. Late transplanting also causes possible heat or cold damage during heading, flowering and the grain filling stage (Reza *et al.*, 2011).

Hasan (2010) conducted an experiment in the research field at Sher-e-Bangla Agricultural University (SAU), Dhaka. During the period from November 2009 to June 2010 to study the effect of variety and date of transplanting on morpho-physiological characters, yield attributes and yields of hybrids and inbred rice varieties in *boro* season. The experiment comprised of three hybrid varieties *viz.*, Hira2, Moron and Tia along with an inbred variety, BRRI dhan29, and four dates of transplanting *viz.*, 01, 16 and 31 January and 15 February. Among the varieties Hira2 showed superiority in leaf area (LA), and total dry matter (TDM) production, straw yield and absolute growth rate which resulted the superior performance of yield attributes thereby increasing grain yield and lowest Tia was recorded when transplanted in mid-January.

Hossain *et al.* (2008) conducted an experiment to find out the effect of age of seedlings and date of transplanting on the performance of *boro* rice (cv. BRRI dhan29). They selected age of seedlings viz., 8- day old seedlings, 12- day old seedlings and 45- day old seedlings; and eight dates of transplanting *viz*., i) 1 December ii) 15 December iii) 30 December iv) 15 January v) 30 January vi) 15 February vii) 2 March and viii) 16 March. They showed that the highest grain yield (8.46 t ha$^{-1}$) was recorded when the crop was transplanted on 15 January but the lowest grain yield (1.64 t ha$^{-1}$) was produced when seedlings were transplanted on 16 March.

Safdar *et al.* (2008) carried out an 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. Rice genotypes viz., 98410, 98316, 99417, 99512, 99513, 98408, 00521-1, 98404, Basmati 385and Super Basmati were kept in 6 transplanting dates viz., 16th May, 1st June , 16th June, 1st July, 16th July and 1st August during each year. They found that maximum number of fertile tiller hill$^{-1}$ (19.1) was recorded in 1st June transplanting date, whereas, plant height (172.1 cm), grains panicle$^{-1}$ (119.3), 1000 grain weight (21.58) and paddy yield (3.95 t ha$^{-1}$) were highest in 16th July transplanting dates, irrespective of genotypes. 16th July was found to be the best date of transplanting and genotype 99512 showed best performance among all the genotypes studied.

Yeasmin *et al.* (2008) carried out an experiment to assess the effects of date of transplanting on growth of *boro* rice varieties under the System of Rice Intensification (SRI). They comprised of five transplanting dates with 15 days interval and four *boro* rice varieties. They showed the best performance on the transplanting date of 16 January and the lowest on December 17.

Akram *et al*. (2007) attempted to determine the studied on six rice varieties/lines Agronomic Research Institute, AARI, Faisalabad. Rice varieties/lines (98801, PK-5261-1-2-1, 97502, 98409, Basmati-385 and Super Basmati) were transplanted from July 1 to 31 with 10 days interval. The author showed that higher paddy yield in earlier transplanting dates compared with the late transplanting. They revealed that Super Basmati produced average maximum paddy yield (5121 kg ha$^{-1}$) while 98409 gave minimum (3536 kg ha$^{-1}$) irrespective of transplanting dates.

Ahmad *et al*. (2006) claimed that among various basmati strains tested, 98316 and Super Basmati gave better paddy yield in transplanting date of 16th July.

An experiment was conducted by Asaduzzaman (2006) at the field laboratory of Bangladesh Agricultural University, Mymensingh to study the effect of date of transplanting (5, 15 and 25 January, and 5 and 15 February) on the performance of *boro* rice cv. BRRI dhan29 and showed that date of transplanting had tremendous effect on growth and yield of rice. The author perceived that maximum yield was obtained when transplanted on 5 January while the lowest grain yield was observed on 15 February transplanting.

A field experiment was set by BINA (2006) with three promising rice mutants (TNBD-100, Y- 1281 and RD-25-56*)* along with one check variety (BRRI dhan28) under four dates of planting (01, 15, 30 January and 15 February) during *boro* season and find out that pooled grain yield was the highest when planted on 15 January due to improved number of effective tillers hill$^{-1}$. The lowest grain yield was observed when transplanted on 01 January.

Khalid (2006) carried out an experiment to know the effect of date of transplanting (10, 20, 30 January and 10, 20 February) of BRRI dhan28 during *boro* season of 2005-06 and observed that the grain yield was the highest when transplanted on 10 January.

BRRI dhan29, a high yielding inbred variety was grown by Shaon (2006) in *boro* season with five dates of transplanting viz., 01, 10, 20 and 30 January and 10 February in 2005-06 aimed at assessing the influence of date of transplanting on different crop characters and grain yield. The author concluded that grain yield of rice planted on 20 January was the highest (4.99 t ha$^{-1}$) followed by 30 January planting. The lowest grain yield was obtained from 10 February transplanting which was statistically similar to 01 January planting.

Yeasmin (2005) conducted an experiment during the period from November to June to study the performance *of boro* rice varieties as affected by date of transplanting. The experiment comprised of four *boro* rice varieties viz., Hiral, Aftab, Jagorini and BRRI dhan29 and five dates of transplanting viz., 17 December, 01, 16 and 31 January and 15 February. The author explained that grain and biological yield gradually increased up to 16 January transplanting followed by declined in all the varieties and 17 December transplanting recorded the lowest grain and straw yield.

Chowdhury and Guha (2000) carried out an experiment to know the effect of date of transplanting on five short duration varieties (Calturel. IRSO, Govind. China and Jagilu) and three medium duration (Joymati, Mala and Mahisur) varieties. The date of transplanting was 20 January, 05 and 20 February, 1998. Planting on 20 January produced the highest grain yield in all the cultivars except Mala. Mala performed best when planting on 5 February.

### 2.2.3 Effect of transplanting date on monetary advantage of Rice

Cheamuangphan *et al.* (2018) conducted research to find out the highest cost and benefit analysis of rice production between transplanting and direct seeded Method for Rice in Upper Northern Region. They suggested that encourage household members give more importance to rice production in order to increase the potential for rice production with transplanting method which will result in higher production efficiency and higher return.

## 2.3 Effect of varieties

Several researchers reported significantly different responses of different genotypes to various management variable and environments with respect to growth attributes due to inherent characteristics. It may be due to the genetic character of the variety and higher photosynthesis efficiency (Yang *et al.*, 2001).

### 2.3.1 Effect of variety on growth of rice

Roy *et al.* (2019) conducted a field experiment with five modern rice varieties viz., BRRI dhan28, BRRI dhan58, BRRI dhan67, BRRI dhan69 and BRRI dhan74 to understand the comparative performance. BRRI dhan69 showed better growth over other varieties in terms of plant height, tiller number, dry weight and LAI.

Dangi *et al.* (2017) conducted a field experiment at Rewa region with seven varieties viz., IET 23824, IET 24780, BPT 5204, Sahbhagi, Chittimuthyalu, Kalanamak and IR-64. The plant growth in terms of plant height, tiller number, leaf number was higher in IR-64 variety than other six varieties.

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

Hussain *et al.* (2014) conducted an experiment with four different rice varieties including IR-28, NERICA-4, Koshihikari and Nipponbare. They found that two Japonica varieties produced higher number of tillers, dry weight and LAI over NERICA-4 and IR-8.

Mahamud *et al*. (2013) conducted an experiment the experimental field of Sher-e-Bangla agricultural university during July to December 2010 to find out the dry matter production and yield performance of a modern inbred (BRRI dhan49) and four hybrid (BRRI hybrid dhan2, Heera, Tia and Aloron) transplant rice varieties. They found that rice cultivars differed significantly in all growth characters, such as plant height, tillers number, chlorophyll content and dry matter weight of different plant parts, panicle length, filled grain, unfilled grain, filled grain percentage, 1000-grain weight, grain yield and straw yield.

According to Islam *et al.* (2009), inbred rice BRRI dhan31 showed higher plant height and leaf area over hybrid rice Sonarbangla-1 in aman season. In pot experiment, they observed that BRRI dhan31 produced highest shoot dry weight over Sonarbangla-1 and BRRI hybrid dhan-1. They noticed that initially (at 35 DAT) photosynthetic rate was higher in inbred rice variety but in later stage (65 DAT) it was higher in hybrid variety.

BRRI (2008) conducted a comparative study of some promising lines with BRRI modern rice varieties to different nitrogen levels viz., 0, 30, 60, 90, 120 and 150 kg N $ha^{-1}$. It was said that tiller production with N @ 120 kg $ha^{-1}$ produced significantly higher tiller than those of lower N levels.

Xia *et al.* (2007) conducted an experiment to find out Potential growth of two widely-grown hybrid rice varieties in the Jinhua district of Zhejiang Province, China. They declared that the potential yield simulated with WOFOST were Shanyou63 variety gave the higher yield (12 t $ha^{-1}$) compared to Xieyou46 variety (10 t $ha^{-1}$). On the other hand, under farmers practice, current yield obtained about 7.5 t $ha^{-1}$ for Shanyou63 and 6.5 t $ha^{-1}$ for Xieyou46.

Amin *et al.* (2006) carried out a field experiment to find out the influence of variable doses of N fertilizer on growth, tillering and yield of three traditional rice varieties (viz., Jharapajam, Lalmota, Bansful Chikon) was compared with that of a modern variety (viz., KK-4) and stated that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

Swain *et al.* (2006) evaluated in a field experiment the performance of rice hybrids NRH1, NRH3, NRH4, NRH5, PA6111, PA6201, DRRH1, IR64, CR749-20-2 and Lalat conducted in Orissa, India during 1999-2000. Among the hybrids tested, PA 6201 recorded the highest leaf area index

### 2.3.2 Effect of variety on yield and yield attributes of rice

Varietal variation showed differences on yield in different districts of Bangladesh including Cumilla. Ali (2019) recorded different grain yield from Binadhan-10, Binadhan-14, BRRI dhan28 and BRRI dhan29 in Mymensingh, Rangpur, Pabna and Cumilla districts. In Cumilla districts, after transplanting within 15 February BRRI dhan29 showed highest yield over BRRI dhan28, Binadhan-14 and Binadhan-10.

Chowhan *et al.* (2019) conducted experiment with four high yielding rice varieties in combination with different seedlings number per hill. It is noted that Hybrid rice Shakti-2 gave highest grain and straw yield compared with BRRI dhan28, Binadhan-14 and Heera-1. Hybrid rice Shakti-2 also showed highest grain and straw yield in combination with three seedlings per hill.

A field experiment was conducted by Roy *et al.* (2019) to understand the comparative performance of BRRI dhan28, BRRI dhan58, BRRI dhan67, BRRI dhan69 and BRRI dhan74. The highest grain yield was observed in BRRI dhan69 compared with other test varieties because of its comparatively higher yield attributes. However, the number of effective tillers hill$^{-1}$ (11.80), number of grains panicle$^{-1}$ (130.90), 1000-grain weight (22.07 g), grain yield (4.96 t ha$^{-1}$) and straw yield (6.64 t ha$^{-1}$) were highest in BRRI dhan69 whereas corresponding lowest values were recorded in BRRI dhan28.

The high yielding variety IR-64 showed higher grain yield than other rice variety (IET 23824, IET 24780, BPT 5204, Sahbhagi, Chittimuthyalu, Kalanamak) because of the highest number of panicles m$^{-2}$, panicle weight, number of filled grain panicle$^{-1}$ in Rewa region of India (Dangi *et al.*, 2017).

Jewel *et al.* (2016) conducted an experiment to find out the effect of variety on yield performance of modern *boro* rice varieties. They selected four rice varieties viz., BRRI dhan28, Hera hybrid2, Bina dhan-14 and BRRI dhan58. They reported that BRRI dhan58 produced the highest number of filled grains panicle$^{-1}$ (85.74) and the lowest number of filled grains panicle$^{-1}$ (66.32) was produced by Hera hybrid2. The author revealed that that the highest weight of 1000-grain (29.92g) was obtained in Hera hybrid2 and the lowest weight was (21.87 g) in BRRI dhan28. The variation in 1000-grain weight might be due to differences of length and breadth of the grain. They found that The highest grain yield (4.59 t ha$^{-1}$ ) in BRRI dhan58 was mostly due to its higher grain panicle$^{-1}$ and heavier seed weight and lowest yield was found in Hera hybrid2 because of its lower effective tiller hill$^{-1}$ and lower number of grain panicle$^{-1}$. They also observed that the highest biological yield was obtained in BRRI dhan58 (10.04 t ha$^{-1}$) and the lowest was in BRRI dhan28 (8.85 t ha$^{-1}$).

Hossaina *et al.* (2016) conducted an experiment to evaluate performance of two rice varieties under different nutrient management practices in a saline soil at Kaligonj, Satkhira. They selected two *boro* rice varieties viz., Binadhan-10 and BRRI dhan28 and tested under 3 levels of nutrients ($T_1$= Recommended dose of N, P, K, S, Zn, $T_2$ = T1 + additional Gypsum @ 125 Kg ha$^{-1}$ and $T_3$ = $T_1$ + additional Gypsum @ 190 Kg ha$^{-1}$). They reported that among these two varieties Binadhan-10 showed better performance compared to BRRI dhan28 at saline condition.

Haque *et al.* (2015) reported that hybrid varieties BRRI hybrid dhan2 and Heera2 out yielded over inbred variety BRRI dhan45 in terms of crop growth rate, flag leaf chlorophyll content, photosynthetic rate and spikelet panicle$^{-1}$ and grain yield.

Chamely *et al.* (2015) An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November 2010 to May 2011 to study the effect of variety and rate of nitrogen on the performance of *Boro* rice. They selected three Rice varieties viz., BRRI dhan28, BRRI dhan29 and BRRI dhan45; and five rates of nitrogen viz., control, 50 kg, 100 kg, 150 kg and 200 kg ha$^{-1}$. Among three varieties BRRI dhan29 recorded the highest grain yield (4.84 t ha$^{-1}$).

Kader *et al.* (2015) conducted an experiment to find out the yield performance of transplant aman rice cv. BRRI dhan49 and *boro* rice cv. BRRI dhan29 under improved package of cultivation (TEGRA) as compared to farmers’ practice. They studied transplant aman season included two treatments on rice cultivation method viz., TEGRA package and farmers practice while in *boro* rice four treatments viz., TEGRA package, farmers practice with high inputs, farmers practice with medium inputs and farmers practice with low inputs. They obtained the benefit cost ratio of TEGRA package was much higher (1.35 and 2.20 during transplant aman rice and *boro* rice, respectively) compared to that of farmers’ practice (1.07 and 1.30).

According to Hussain *et al.* (2014) varietal variation showed differences in yield and yield contributing charaters. They found highest number of panicles $m^{-2}$, grain yield and straw yield from IR-8 variety compared with NERICA-4, Koshihikari and Nipponbare.

Roy *et al.* (2014) conducted a field experiment to evaluate the growth, yield and yield attributing characteristics of 12 indigenous *boro* rice varieties collected from South-Western regions of Bangladesh namely; Nayon moni, Tere bale, Bere ratna, Ashan boro, Kajol lata, Koijore, Kali boro, Bapoy, Latai balam, Choite boro, GS one and Sylhety boro. They observed that Grain did not differ significantly among the varieties but numerically the highest grain yield (5.01 t $ha^{-1}$) was found in the variety Koijore and the lowest in GS one (3.17 t $ha^{-1}$).

Dawadi and Chaudhury (2013) reported that rice variety Hadirnath-1 showed highest grain yield (3.09 t $ha^{-1}$) straw yield (6.09 t $ha^{-1}$) and harvest index (0.39) as it produced highest effective tiller and filled grain per plant compared with rice varieties Sabirti and Ram in Nepal.

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

Sarkar *et al.* (2013) attempted to determine the studied morphological, yield and yield contributing characters of four *boro* rice varieties of which three were local viz., Bashful, Poshursail and Gosi; another one was a high yielding variety (HYV) BRRIdhan 28. Among those varieties BRRIdhan 28 were significantly superior among the cultivars studied. The highest grain yield (7.41 t $ha^{-1}$) was recorded from BRRI dhan28. Among the local rice cultivars, Gosi showed the higher yield than Bashful and Poshursail.

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

Saeed *et al*. (2012) also reported significant differences among the varieties for grain yield. They selected six varieties viz., Bakhtawar-92, Fakhar-e-Sarhad, Ghaznavi-98, Nowshera-96, Chakwal, and Khyber-87 and were randomly planted in skip and solid row geometries. The accumulative effects of superior growth and yield attributes were finally mirrored in terms of higher grain yield. The authors showed that performance of the two wheat varieties, Fakhar-e-Sarhad and Ghaznavi-98 was better as compared to other four varieties of wheat i.e., Bakhtawar-92, Nowshera-96, Chakwal and Khyber-87.

Khushik *et al*. (2011) conducted a survey to assess the performance of rice hybrid and other varieties planted in rice growing areas of Sindh and Balochistan during the year 2008-2009. They selected 100 rice growers and the results revealed that average yield of hybrid rice was 195 mds ha$^{-1}$, followed by IRRI- 6 (151 mds ha$^{-1}$), B–2000 (91 mds ha$^{-1}$) and Rosi (94 mds ha$^{-1}$). They showed that the yield of hybrid rice was higher by 29 percent than the major variety IRRI-6.

Islam (2011) showed a field experiment at BINA, Mymensingh on five aromatic rice genotypes viz., BRRI dhan34, Ukunimadhu, RM-100/16, KD5 18- 150 and Kalozira. Among the varieties, KD5 18-150 showed higher grain yield, total dry matter plant$^{-1}$ and harvest index under temperature stress.

In a pot experiment, inbred rice BRRI dhan31 showed highest grain yield hill$^{-1}$ compared with hybrid rice variety Sonarbangla-1 and BRRI hybrid dhan$^{-1}$ in aman season as inbred produced highest tiller and panicle hill$^{-1}$ (Islam *et al.*, 2009).

Jalota *et al.* (2009) a field experiments were conducted for 2 years (2006 and 2007) at Punjab Agricultural University Farm, Ludhiana on a deep alluvial loamy sand Typic Ustipsamment soils developed under hyper-thermic regime. They selected two Rice two cultivars (PR 118 inbred and RH 257 hybrid) and experiment set at three dates of transplanting (25 May, 10 June and 25 June). Among the varieties RH 257 hybrid showed the best result date of transplanting at 25 June.

Kamal *et al.* (2007) noted that Binadhan-5 produced highest grain yield over Binadhan-6, BRRI dhan28 and BRRI dhan29. The highest grain yield was found in Binadhan-5 due to the consequence of highest effective tillers, filled grain panicle$^{-1}$.

BINA (2006) finalized a statement with three promising rice mutants (TNBD-100, Y-1281 and RD-25-56) along with one check variety (BRRI dhan28) to know the performance under four dates of planting (01, 15, 30 January and 15 February) during *boro* season and described that TNDB-100 produced the highest grain yield where BRRI dhan28 produced the lowest grain yield.

Wang *et al.* (2006) studied the effects of plant density and row spacing (equal row spacing and one seedling hill$^{-1}$, equal row spacing and 3 seedlings hill$^{-1}$, wide-narrow row spacing and one seedling hill$^{-1}$, and wide-narrow row spacing and 3 seedlings hill$^{-1}$) on the yield and yield components of hybrids and conventional cultivars of rice. Compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%.

Yeasmin (2005) showed a result by an experiment during the period from November to June to study the performance of hybrid rice varieties in *boro* season as affected by the date of transplanting. The experiment included of four rice varieties viz., l-lira2, Aftab, Jagorini and BRRI dhan29 and five dates of transplanting in *boro* season viz., 17 December, 01, 16 and 31 January and 15 February. The author described that the highest grain yield (5.93 t ha$^{-1}$), biological yield (13.02 t ha$^{-1}$) and harvest index (45.55%) were produced by the variety, Jagoroni because of maximum number of effective tillers hill$^{-1}$, number of grains paniele$^{-1}$ and 1000-grain weight were obtained higher than other varieties.

Mondal *et al.* (2005) showed a result by an experiment with 17 modem varieties of rice in the northern region of Bangladesh and reported that BRRI dhan36 produced the highest grain yield (5.30 t $ha^{-1}$) due to superior yield components. Further, Rahman (2002) studied seven fine grain rice (likunimadhu, Bullet, Hetkurnra. Ohunshi. Bojromuri, Hoglapata and Binashail) to assess their yield and yield related traits and concluded that J3inashail produced the highest grain yield (5.36 t $ha^{-1}$) due to the production of higher number of effective tillers m 2, filled grains panicle and better partitioning (HI) while Hetkuznra, an aromatic rice, produced the lowest (2.70 t $ha^{-1}$).

Murthy *et al.* (2004) carried out an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti and observed that Mukti (5268 kg $ha^{-1}$) out yielded the other genotypes and recorded the maximum number of filled grains and had lower spikelet sterility (25.85%) compared to the others.

Sumit *et al.* (2004) worked with newly released four commercial rice hybrids (DRRH 1, PHB 71, Pro-Agro 6201, KHR 2, ADTHR 1, UPHR 1010 and Pant Sankar Dhan 1) and two high yielding cultivars (HYV) as controls (Pant Dhan 4 and Pant Dhan 12) and reported that KHR 2 gave the best yield (7.0 t $ha^{-1}$) among them.

Dongarwar *et al.* (2003) comprised an experiment to investigate the response of hybrid rice KJTRH-1 in comparison with 2 traditional cultivars, Jaya and Swarna, to 4 fertilizer rates, i.e. 100:50:50, 75:37.5:37.5, 125:62.5:62.5 and 150:75:75 kg NPK $ha^{-1}$ and stated that KJTRH-1 produced significantly higher yield (49.24 q $ha^{-1}$) than Jaya (39.64 q $ha^{-1}$) and Swarna (46.06 q $ha^{-1}$).

Nayak *et al.* (2003) noticed that late transplanting affect the growth of rice after conducting a field on hybrid rice 'PA 6201'. He reported that transplanting on16 July (early transplanting) results the highest total and effective tillers per $hill^{-1}$, LAI and dry matter accumulation than that of planting after 30 July (late transplanting). He found that delay transplanting (one month delay from 16 July) reduced total tillers number, LAI and dry matter accumulation by 38, 13 and 18%, respectively.

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

### 2.3.3 Effect of varieties on monetary advantages of Rice

Chanda *et al.* (2019) carried an experiment in the Sirajganj district during 2017, to compare the cost and revenue of Aus, Aman and *boro* rice, using benefit cost ratio technique. The Sirajganj district consists of nine upzilas. Ten farmers of each upzila were randomly selected and primary data were personally collected from the respondents through structural questionnaire. The data about Aus, Aman and *boro* rice and their cost as well as returns were collected in farmers' field. They reported that Aus rice benefit cost ration (BCR) was 1.61-2.22, Aman (HYV) rice 1.70-2.22, *Boro* (HYV) rice 1.70-2.22 and *Boro* (Hybrid) rice 2.10-2.36.

From a survey on cost benefit ratio of different rice varieties conducted by Sapkota and Sapkota (2019) in Kapilvastu district, Nepal to highlight the best results on that purposes where Gorakhnath, Radha-4, Ramdhan, and Sawa were used. For their survey purposes, they contacted 120 farmers and primary data were collected through household survey using interview schedule. After analyzing data, the average cost of production was amounted to NRs. 77,100 $ha^{-1}$ for all four rice varieties. Sawa variety had the highest gross return (NRs. 1,01,212.5 $ha^{-1}$). The benefit cost ratio was observed highest for Sawa (1.312) and lowest for Radha-4 variety (1.005).

Ahmad *et al.* (2015) conducted a survey in Malakand district, Pakistan to understand the best cost benefit ratio of different rice varieties. They contacted 50 farmers to collect data of different rice varieties namely, Fakhre Malakand, JP5, Basmati385, Sara Saila and Mardanai. Among the varieties Fakhre Malakand showed the best benefit cost ratio (3.24).

Hussain *et al.* (2008) conducted a survey in Swat district, Pakistan during 2007 to make comparative cost benefit analysis of per acre rice production of different rice varieties. They contacted 100 farmers to collect data of different rice varieties viz., JP-5, Basmati-385, Sara Saila, Dil Rosh-97, Swat-1 and Swat-2 and Fakhr-e- Malakand. Among the varieties the highest BCR (4.36) value was observed from variety of Fakhr-e- Malakand that is, indicted the most profitable variety.

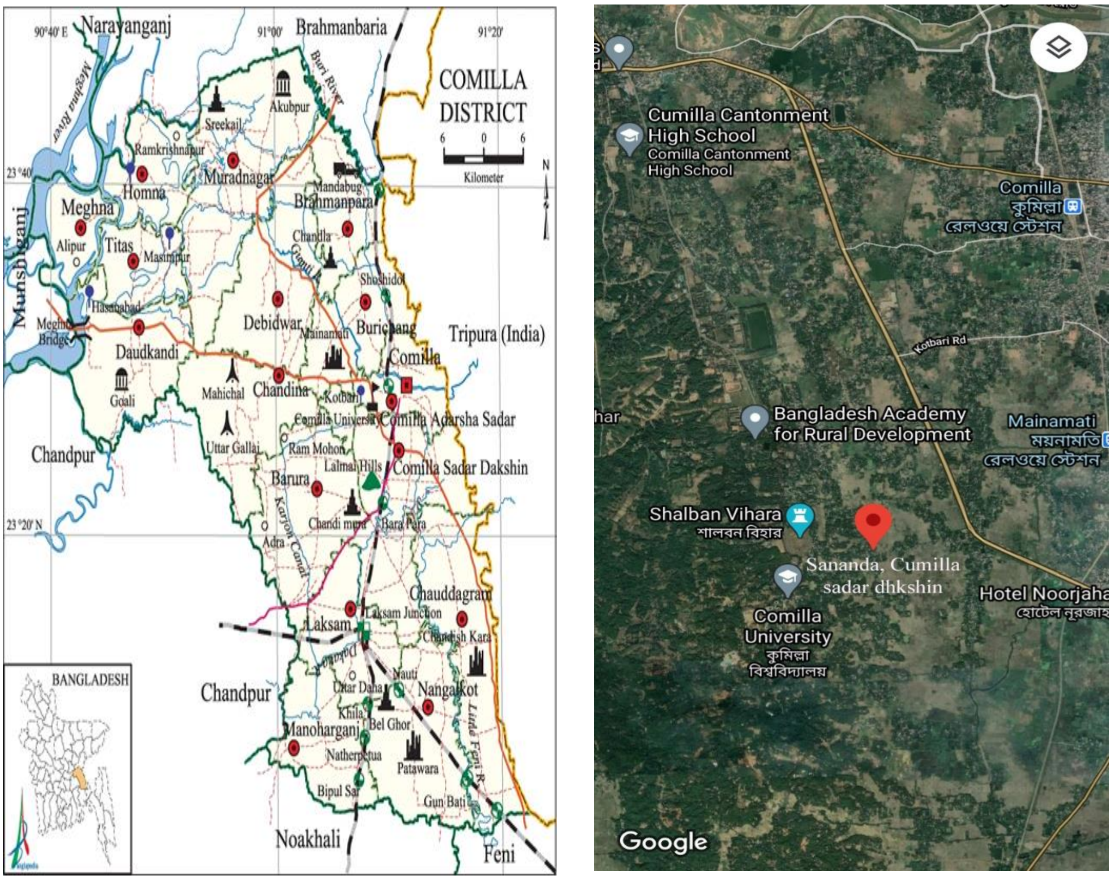
# CHAPTER 3
# MATERIALS AND METHODS

This chapter presenting a brief description of the experimental site, soil, climate, experimental design, treatments, cultural operations, data collection and data analysis of different parameters for present study. The experiment was conducted at Lalmai-Hill area in *boro* season during November 2018 to May 2019. During the study, five recently released rice varieties were selected. The rice variety was selected as per recommendation of fund providing authority (BARD). A concise description on experimental location, layout of that site, climate, soil, land preparation, layout of the experimental design, different intercultural operations, data collection and data analysis procedure are described below:

## 3.1 Experimental location, climatic condition and soil

The experiment was conducted in farmer's field in Lalmai-Hill area. It was located in Sanonda, Sudhonnopur and Gabtoli village under the Upazila of Cumilla Sadar (South). The participating farmer's were Md. Delowar Hosen, Md. Alek Hosen and Md. Jahangir Alam. Farmers were selected by the guidance of BARD. However, the experimental field was located at latitude 23° 27' 42.70" N longitude 91° 11' 6.11" E. The land was located at "Old Meghna Estuarine Floodplain" (AEZ 19). It lies on 17m above the sea level. The climate of the experimental area was subtropical. In winter, there is much less rainfall in Cumilla than in summer. The average temperature in Cumilla is 25.5 °C (78.0 °F). The annual rainfall is 2295 mm (90.4 inch). Average temperature and average rainfall were increasing after February to onward.

The soil of Cumilla hill area is composed of yellow to light brown, medium to very fine, moderately hard to lose sandstone, siltstone, silty clay, mudstone and shale with some conglomerates with clasts of petrified wood. The lithofacies of matrix supported conglomerate, trough cross bedded conglomerate, massive sandstone, trough cross bedded sandstone, planar cross bedded sandstone, ripple cross laminated sandstone-siltstone, flaser laminated sandstone-shale, lenticular laminated sandstone-siltstone-shale, and parallel laminated sandstone-siltstone, wavy laminated shale, parallel laminated blue shale, and mudstone are delineated within this formation.



(A) (B)

**Figure 1**. Study area: (A) Map of the area, (B) Satellite view of the research location.

### 3.2 Planting materials

BRRI dhan67, BRRI dhan68, BRRI dhan74, BRRI dhan81, BRRI dhan86 were used as planting materials for the present study purpose. Recently released these varieties were selected on the basis of their yield potentiality and growth duration. Growth duration of selected varieties are almost similar. The features of these five varieties are presented below:

**3.2.1 BRRI dhan67:** This variety is developed in 2014 by Bangladesh Rice Research Institute (BRRI) following crossing method. It's a high yielding variety, with plant height of 100 cm, grains are rice medium slender and white in colour, growth duration is 140-150 days and another important characteristics is salt tolerance.

**3.2.2 BRRI dhan68:** This variety is developed in 2014 by Bangladesh Rice Research Institute (BRRI) following Hybridization method. It's High yielding variety, with plant height of 95 cm, grains are rice medium broad, 1000 grain weight 27.4 g, growth duration 149 days. It has 7.7% protein content and 25.7% amylose content.

**3.2.3 BRRI dhan74:** This variety is developed in 2014 by Bangladesh Rice Research Institute (BRRI) following Hybridization method. It's a high yielding variety, with plant height of 92 cm, plant stout, not lodging, grains are rice medium broad and white in colour, growth duration 145-147 days. It is a zinc (Zn) enriched variety and has 8.3% protein content and 24.2% amylose content.

**3.2.4 BRRI dhan81:** This variety is developed in 2017 by Bangladesh Rice Research Institute (BRRI) following crossing method between Amol3 (Iranian rice variety) and BRRI dhan28. It's high yielding variety, plant stout, tiller dense on the base of plant, grains are medium slender, 1000 grain weight 20.3g, and growth duration 140-145 days.

**3.2.5 BRRI dhan86:** This variety is developed in 2017 by Bangladesh Rice Research Institute (BRRI) following anther culture method. It's high yielding variety, transplanted *boro,* strong and stout, lodging resistant, Grain long and slender, content of amylose is 25.0% and growth duration 140-142 days. Protein content is 10.1%. 1000 grain weight 23 g.

### 3.3 Experimental details

### 3.3.1 Treatments

There were two sets of experimental treatments. The treatments were as follows:

**Factor A: Transplanting dates (T)**

i. Transplanting on 15 January ($T_1$)
ii. Transplanting on 30 January ($T_2$)
iii. Transplanting on 14 February ($T_3$)

**Factor B: Variety (V)**

i. BRRI dhan67 ($V_1$)
ii. BRRI dhan68 ($V_2$)
iii. BRRI dhan74 ($V_3$)
iv. BRRI dhan81 ($V_4$)
v. BRRI dhan86 ($V_5$)

### 3.3.2 Experimental design and layout

The experiment was carried out in Lalmai-Hill area by following Randomized Complete block design (RCBD) with three replications. It was a factorial experiment. Three transplanting dates were in Factor A and selected five varieties were in Factor B. The number of total treatments were 15 and total number of plots were 45. The size of unit plot was 3m×3m. Plot to plot distance was 1m. [The rice seeds were supplied to three farmers and advised to transplant in specific date. Each farmer transplanted on January 15, January 30 and February 14. Fertilizers and other inputs were collected from specific sources and specific amounts were supplied to the farmers. All agronomic management were done as per recommendation].

## 3.4 Growing of crops

### 3.4.1 Seed collection

The seeds of the test crop BRRI dhan67, BRRI dhan68, BRRI dhan74, BRRI dhan81, BRRI dhan86 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur.

### 3.4.2 Seed sprouting and seed sowing

Healthy seeds were selected by specific gravity method and then soaked in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds sprouted for 72 hours and item were sown in wet nursery bed. For three transplanting dates, seeds were soaked on December 05, December 20 and January 05 respectively.

### 3.4.3 Preparation of the main field

The selected land for the experiment was opened with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good puddle condition. Weeds and stubble were removed, and finally obtained a desirable puddled condition of soil for transplanting of seedlings. The field was opened 15 days before final land preparation for each transplanting date.

### 3.4.4 Fertilizers and manure application

The field was fertilized with vermicompost, urea, TSP, MP, Gypsum and Zinc fertilizers as per recommendation of BRRI. The whole amount of vermicompost and all others fertilizers except urea were applied before final land preparation. Urea was top dressed in three equal splits at 15, 30 and 45 days after transplanting (DAT).

### 3.4.5 Uprooting and transplanting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The forty day's old seedlings were uprooted and transplanted without causing much mechanical injury to the roots. The rice seedlings were transplanted in main field by maintaining BRRI recommended spacing (25 cm×15 cm). Two to three seedlings were transplanted in each hill. However, for three different transplanting dates seedlings were uprooted and transplanted on January 15, January 30 and February 14 respectively.

## 3.5 Intercultural operations

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

### 3.5.1 Irrigation and drainage:

Irrigation was provided during the whole growth period of the crop for maintaining a constant water level in the field. Before top dressing of urea, water was drained off and weeding the plots. The plots were again irrigated after the application of urea. Additional water was drained out during the heavy rainfall. Before 15 days of harvest the field was finally drained out completely to enhance maturity.

### 3.5.2 Gap filling:

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

### 3.5.3 Weeding:

Two hand weeding was done for each plot and variety at 25 and 45 DAT.

### 3.5.4 Plant protection:

Furadan 57 EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

### 3.6 General Observation

The field was observed regularly to notice any alteration in plant characters, and it was observed that the general condition of the crop was good from transplanting to harvesting.

### 3.7 Harvesting of Crops

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80-90% of the grains become golden yellow in color. The matured rice crop was harvested on different dates as the seedlings were transplanted on three different dates. The harvest was done on April 25, May 08 and May 17 respectively, for transplanting date one, two and three. The matured rice plant was harvested keeping a cutting height of 15 cm from the ground level. However, ten pre-selected hills from each plot were kept separately for recording data of yield attributes. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. Finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw were recorded and converted to t $ha^{-1}$.

### 3.8 Data collection:

Data on the following growth yield and yield contributing characters of rice plants were collected:

i) Plant height

ii) Total number of tillers $hill^{-1}$

iii) Number of leaves $hill^{-1}$

iv) Number of effective tillers $hill^{-1}$

v) Number of non-effective tillers $hill^{-1}$

vi) Panicle length

viii) Number of filled grains $panicle^{-1}$

ix) Number of unfilled grains $panicle^{-1}$

x) Number of total grains $panicle^{-1}$

xii) 1000-grain weight

xiii) Grain yield

xiv) Straw yield

xvi) Harvest index

**3.9 Procedure of recording data**

**3.9.1 Plant height**

The height of plant was recorded in centimeter (cm) at 15, 30, 45, 60, 75 DAT (days after transplanting) and at the time of harvest. Data were recorded from 10 pre-selected hill of each plot. The height was measured from the ground level to the tip of the plant.

**3.9.2 Number of tillers hill$^{-1}$**

The number of tillers hill$^{-1}$ was recorded at 15, 30, 45, 60, 75 DAT and at harvest by counting total tillers as the average of same 10 pre-selected hills of each plot. Plants were selected from the inner rows of each plot. However, tillers which had at least one leaf visible were counted. It included both effective and non-effective tillers.

**3.9.3 Number of leaves hill$^{-1}$**

The number of leaves hill$^{-1}$ was recorded at 15, 30, 45, 60, 75 DAT and at harvest by counting total leaves as the average of same 10 pre-selected hills of each plot.

**3.9.4 Number of effective tillers hill$^{-1}$**

The panicle which had at least one grain was considered as effective tiller.

**3.9.5 Number of non-effective tillers hill$^{-1}$**

The panicle which had no grain was regarded as non-effective tiller.

**3.9.6 Panicle length**

Panicle length (cm) was recorded from the neck-node to the tip of each panicle and the average value was recorded.

**3.9.7 Number of filled grains panicle$^{-1}$**

Presence of any food material in the spikelet was considered as grain. Total number of grains combining with panicles per tiller was counted from each hill. Average mean of filled grains of these panicles was taken as number of filled grains panicle$^{-1}$.

### 3.9.8 Number of unfilled grains panicle$^{-1}$

Grains lacking any food material inside the grain was considered as sterile spikelet and such grains present on the each panicle were counted from each panicle of each hills.

### 3.9.9 Number of total grains panicle$^{-1}$

Sum of the both filled and unfilled grains per panicle considered as number of total grains per panicle and then average number of grains panicle$^{-1}$ was calculated.

### 3.9.10 1000-grain weight

One thousand clean dried filled grains were counted from the seed stock obtained from all plots and their weight (g) was taken by using an electric balance. This procedure was followed similarly for each variety.

### 3.9.11 Grain yield

Grains obtained from demarked area of each unit plot were sun-dried and weighed carefully and finally converted to t ha$^{-1}$. The central 9 m$^2$ from each plot were harvested, threshed, dried, and cleaned, weighed.

### 3.9.12 Straw yield

Straw obtained from each unit plot were weighed carefully and finally converted to t ha$^{-1}$. This procedure was followed for sun-dried straw. The dry weight of straw of central 9 m$^2$ were harvested, threshed, dried and weighed.

### 3.9.13 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot following the formulae given below and expressed in percentage.

$$\text{Harvest Index (HI) (\%)} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield ( total dry weight)}} \times 100$$

### 3.9.14 Monetary advantages

Total input cost and overhead cost were similar for all varieties and transplanting date as we provide similar inputs and management cost for all cases. So, cost effective variety were identified by considering monetary advantages. Monetary advantages of grain yield return and straw yield return were calculated by multiplying yield with market value of respective products. However, monetary advantages of grain yield return, straw yield return and total yield return were calculated using the following formula:

Monetary advantage from grain yield return
= Total Grain yield (t $ha^{-1}$) × Market price of rice grain (Tk. $t^{-1}$)

Market price of rice grain during harvest were as follows:

| Name of the variety | Market price (Tk. $t^{-1}$) |
|---|---|
| BRRI dhan67 | 21500 |
| BRRI dhan68 | 20100 |
| BRRI dhan74 | 18800 |
| BRRI dhan81 | 24150 |
| BRRI dhan86 | 18800 |

**Monetary advantage from straw yield return**
= Total straw yield (t $ha^{-1}$) × Market price of rice straw (Tk. $t^{-1}$)
The average market price of rice straw was 4000 Tk. $t^{-1}$ for all varieties.

**Monetary advantage from total yield return**
= [Total Grain yield (t $ha^{-1}$) × Market price of rice grain (Tk. $t^{-1}$) + Total straw yield (t $ha^{-1}$) × Market price of rice straw (Tk. $t^{-1}$)

### 3.10 Statistical Analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques using statistix 10 software and the mean values were separated using least significant differences (LSD) test at 5% level of significance.

# CHAPTER 4

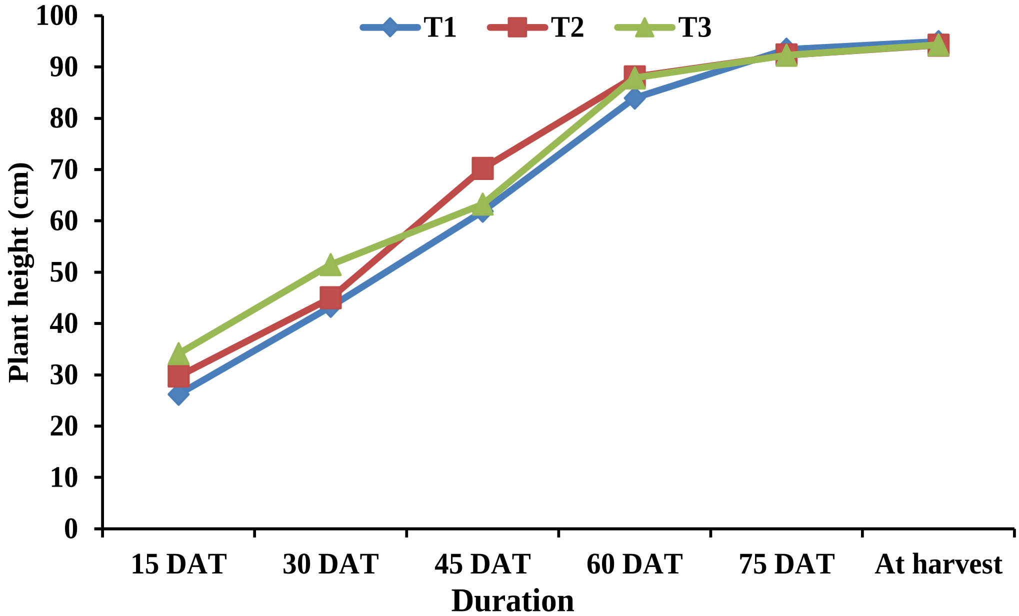
# RESULTS AND DISCUSSION

The present study was conducted to understand performance of recently released *boro* rice varieties under different transplanting date in Lalmai-Hill area. Different growth, yield and yield contributing parameters were observed in present study. The results observed in present study have been presented and discussed under the following headings.

## 4.1 Effect on growth parameters

### 4.1.1 Effect on plant height

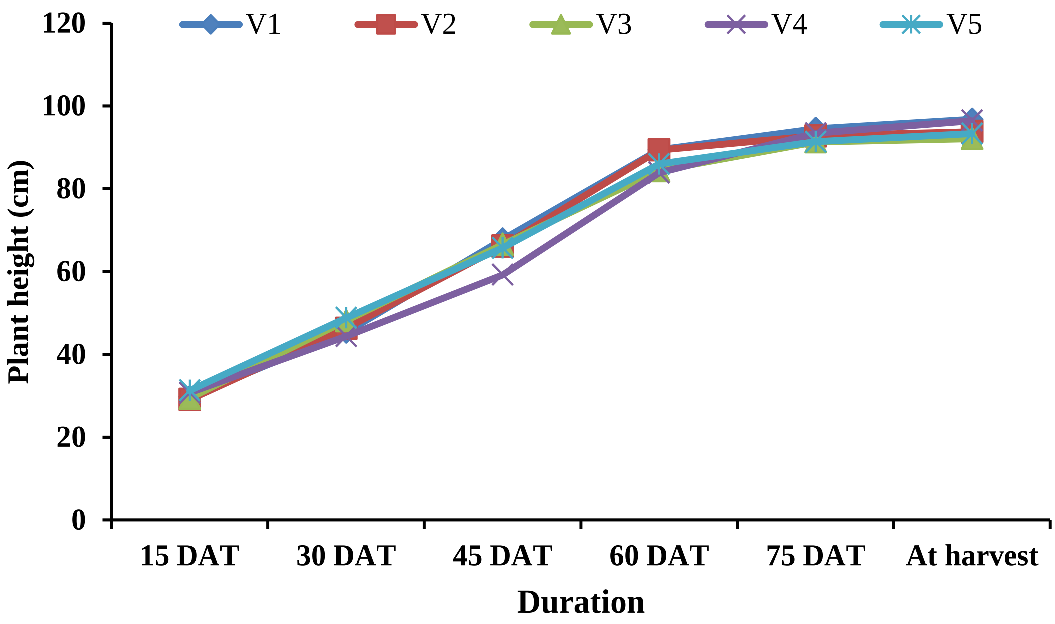
Plant height of rice increased with advancement of plant age. Plant height increment is rapid at initial stage and after certain stage gradually it become slow or stop at later stage. At initial stage of *boro* rice (upto 45 DAT) plant height varied with the variation of planting date (Figure 2 and Appendix 1). Transplanting of *boro* rice at 14 February provide longest plant upto 30 DAT compared with early transplanting. However, at later stage of *boro* rice especially after 45 DAT transplanting date have no effect on plant height.




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 2.** Effect of transplanting date on plant height of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 2.23, 2.66 and 3.27 at 15, 30 and 45 DAT, respectively].

Varietal variation has no effect on plant height throughout the life cycle except 45 DAT (Figure 3 and Appendix 1). AT 45 DAT, BRRI dhan67 produced longest plant (67.78 cm) which was statistically similar with all other varieties except BRRI dhan81.




Here,
$V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

**Figure 3.** Effect of variety on plant height of *boro* rice in Lalmai-Hill area.
[LSD $_{(0.05)}$ = NS].

Combined effect of transplanting date and variety have no effect on plant height throughout the life cycle except 45 DAT (Table 1 and Appendix 1). Transplanting of BRRI dhan68 at 30 January produced longest plant (73.01 cm) compared with all other combinations. Combination of BRRI dhan81 on 14 February produced shortest plant (52.72 cm).

### 4.1.2 Effect on number of leaves

Number of leaves of rice plant increased with advancement of plant age upto 60 DAT. Later on, the number of leaves decreased with advancement of plant age. However, variation in transplanting date affect number of leaves of *boro* rice in entire life cycle except 60 and 75 DAT (Figure 4 and Appendix 2). Transplanting of rice seedlings at 14 February produced highest number of leaves per hill upto 45 DAT compared with early transplanting of rice seedlings. At harvesting time, early transplanted seedlings produced highest number of leaves (81.03) compared with transplanting on 30 January and 14 February.

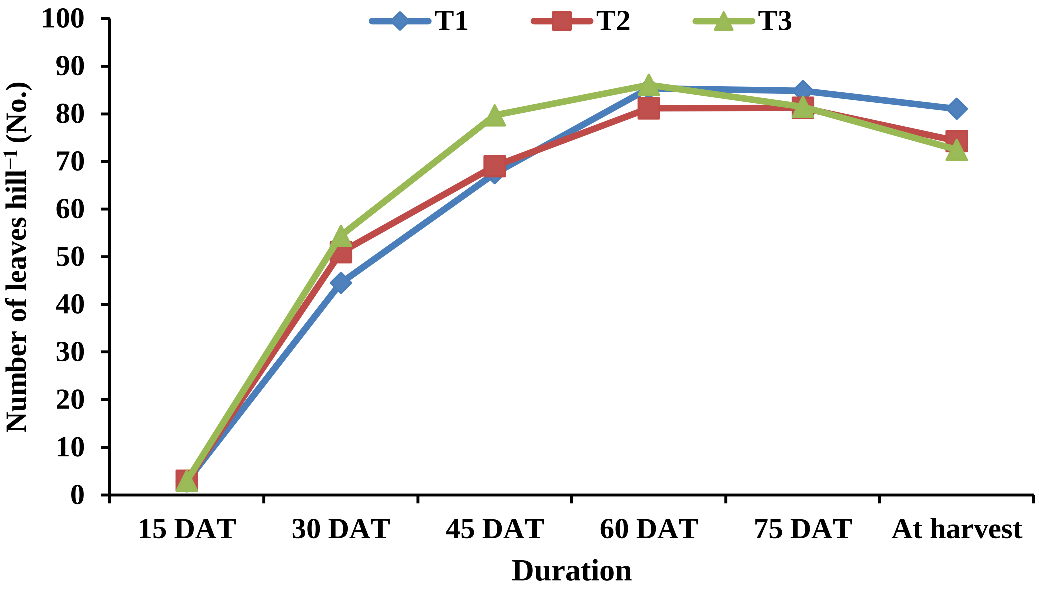
**Table 1.** Combined effect of transplanting date and variety on plant height of *boro* rice in Lalmai-Hill area

| **Treatments** | **Plant height (cm)** | | | | | |
|---|---|---|---|---|---|---|
| | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** | **75 DAT** | **At harvest** |
| **$T_1$ $V_1$** | 27.833 | 45.707 | 63.54 c-e | 86.240 | 95.16 | 97.47 |
| **$T_1$ $V_2$** | 24.633 | 43.200 | 63.51 c-e | 87.393 | 93.58 | 94.50 |
| **$T_1$ $V_3$** | 26.900 | 47.013 | 65.82 a-e | 82.683 | 91.96 | 92.41 |
| **$T_1$ $V_4$** | 23.700 | 36.800 | 54.58 fg | 79.610 | 93.49 | 96.79 |
| **$T_1$ $V_5$** | 27.900 | 43.837 | 61.65 ef | 83.750 | 93.04 | 93.53 |
| **$T_2$ $V_1$** | 27.980 | 43.167 | 69.04 a-d | 87.247 | 93.29 | 95.88 |
| **$T_2$ $V_2$** | 28.580 | 46.059 | 73.01 a | 91.817 | 92.97 | 93.71 |
| **$T_2$ $V_3$** | 29.063 | 44.947 | 67.48 a-e | 84.637 | 91.11 | 91.95 |
| **$T_2$ $V_4$** | 31.167 | 42.937 | 70.37 a-c | 89.377 | 93.15 | 95.96 |
| **$T_2$ $V_5$** | 31.973 | 47.757 | 71.08 ab | 87.213 | 91.00 | 93.68 |
| **$T_3$ $V_1$** | 33.320 | 47.197 | 70.76 a-c | 94.743 | 95.07 | 96.10 |
| **$T_3$ $V_2$** | 33.967 | 49.593 | 61.93 de | 88.863 | 91.83 | 93.25 |
| **$T_3$ $V_3$** | 32.160 | 52.390 | 66.44 a-e | 85.890 | 90.90 | 91.92 |
| **$T_3$ $V_4$** | 37.287 | 53.433 | 52.72 g | 82.723 | 93.49 | 96.61 |
| **$T_3$ $V_5$** | 33.947 | 54.833 | 64.40 b-e | 87.017 | 90.05 | 92.74 |
| **$LSD_{(0.05)}$** | NS | NS | 7.31 | NS | NS | NS |
| **CV** (%) | 9.96 | 7.62 | 6.72 | 6.05 | 4.60 | 4.48 |

Here

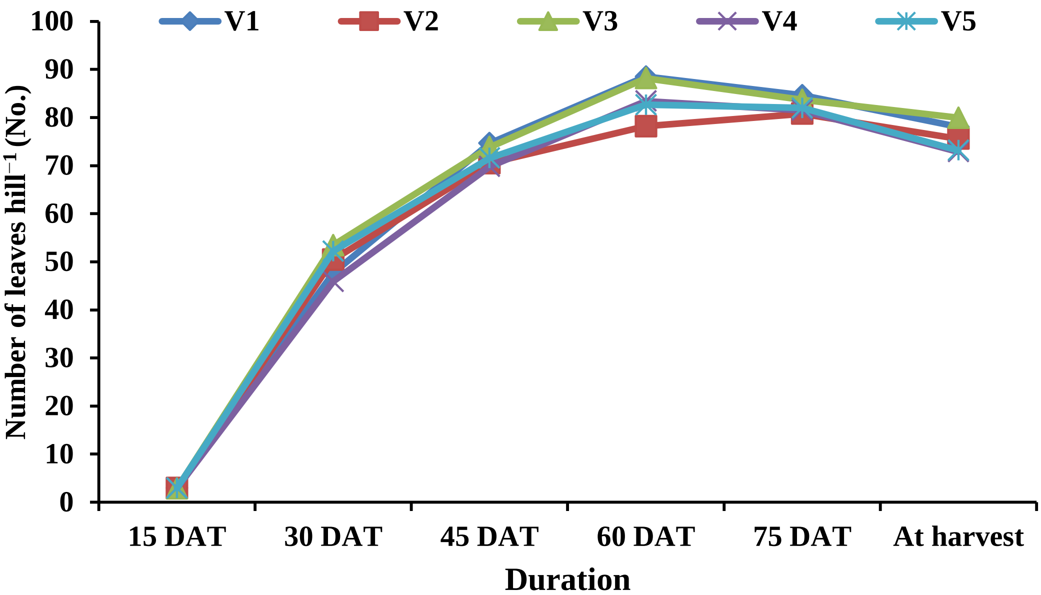
$T_1$= Transplanting of seedlings on 15 January — $V_1$= BRRI dhan67 — $V_4$= BRRI dhan81
$T_2$= Transplanting of Seedlings on 30 January — $V_2$= BRRI dhan68 — $V_5$= BRRI dhan86
$T_3$= Transplanting of seedlings on 14 February — $V_3$= BRRI dhan74

Number of leaves did not vary for the variation of variety at early stage of rice. During harvesting period varietal variation have effect on number of leaves hill$^{-1}$. At harvesting period BRRI dhan74 ($V_3$) produced highest number of leaves per plant compared with other varieties (Figure 5 and Appendix 2).




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 4**. Effect of transplanting date on number of leaves of *boro* rice in Lalmai-Hill area. [$LSD_{0.05}$=0.11, 6.73, 6.94 and 3.20 at 15, 30, 45 DAT and at harvest, respectively].




Here, $V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

**Figure 5.** Effect of variety on number of leaves of *boro* rice in Lalmai-Hill area. [$LSD_{(0.05)}$ =4.12 at harvest].

Combined effect of transplanting date and variety have no effect on number of leaves hill$^{-1}$ during entire growth period of rice except harvesting time (Table 2 and Appendix 2). Transplanting of BRRI dhan86 on 15 January produced highest number of leaves (85.72) during harvesting period compared with other combinations.

**Table 2.** Combined effect of transplanting date and variety on number of leaves hill$^{-1}$ of *boro* rice in Lalmai-Hill area

| **Treatments** | **Number of leaves hill$^{-1}$ (No.)** | | | | | |
|---|---|---|---|---|---|---|
| | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** | **75 DAT** | **At harvest** |
| **$T_1$ $V_1$** | 2.93 | 46.00 | 73.11 | 87.22 | 85.06 | 78.52 b-d |
| **$T_1$ $V_2$** | 2.87 | 43.67 | 56.67 | 75.11 | 74.86 | 73.33 d-f |
| **$T_1$ $V_3$** | 2.80 | 49.33 | 74.11 | 89.78 | 84.00 | 83.64 a-c |
| **$T_1$ $V_4$** | 2.80 | 37.67 | 67.61 | 87.89 | 89.89 | 83.94 ab |
| **$T_1$ $V_5$** | 2.80 | 45.78 | 66.00 | 86.67 | 90.33 | 85.72 a |
| **$T_2$ $V_1$** | 2.93 | 40.33 | 65.11 | 84.22 | 81.01 | 75.21 d-f |
| **$T_2$ $V_2$** | 2.87 | 55.00 | 81.44 | 76.67 | 87.28 | 78.17 b-d |
| **$T_2$ $V_3$** | 2.93 | 51.67 | 66.33 | 91.44 | 85.78 | 79.65 a-d |
| **$T_2$ $V_4$** | 3.00 | 51.67 | 67.67 | 77.89 | 78.39 | 68.84 fg |
| **$T_2$ $V_5$** | 2.93 | 56.00 | 64.44 | 75.56 | 73.81 | 69.62 e-g |
| **$T_3$ $V_1$** | 2.93 | 56.67 | 85.67 | 94.11 | 87.83 | 80.44 a-d |
| **$T_3$ $V_2$** | 2.93 | 52.67 | 73.44 | 82.78 | 80.22 | 75.27 d-f |
| **$T_3$ $V_3$** | 2.87 | 59.33 | 81.06 | 83.33 | 81.22 | 76.56 c-e |
| **$T_3$ $V_4$** | 3.07 | 48.43 | 74.11 | 84.50 | 76.33 | 65.83 g |
| **$T_3$ $V_5$** | 3.13 | 54.89 | 84.22 | 85.78 | 81.83 | 64.18 g |
| **LSD** $_{(0.05)}$ | NS | NS | NS | NS | NS | 7.14 |
| **CV** (%) | 5.20 | 18.03 | 12.88 | 10.13 | 7.49 | 5.63 |

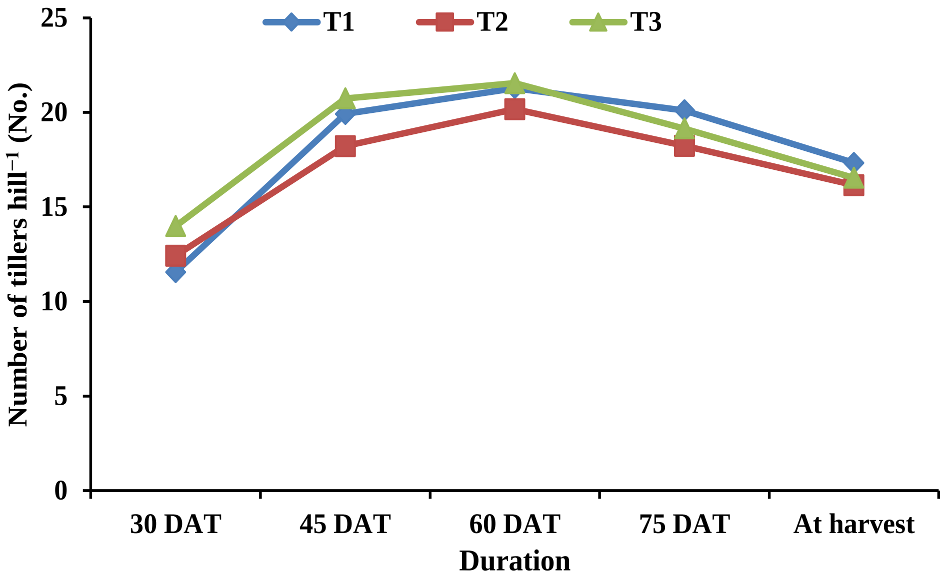
Here

| | | |
|---|---|---|
| $T_1$= Transplanting of seedlings on 15 January | $V_1$= BRRI dhan67 | $V_4$= BRRI dhan81 |
| $T_2$= Transplanting of Seedlings on 30 January | $V_2$= BRRI dhan68 | $V_5$= BRRI dhan86 |
| $T_3$= Transplanting of seedlings on 14 February | $V_3$= BRRI dhan74 | NS= Non significant |

### 4.1.3 Effect on number of tillers hill$^{-1}$

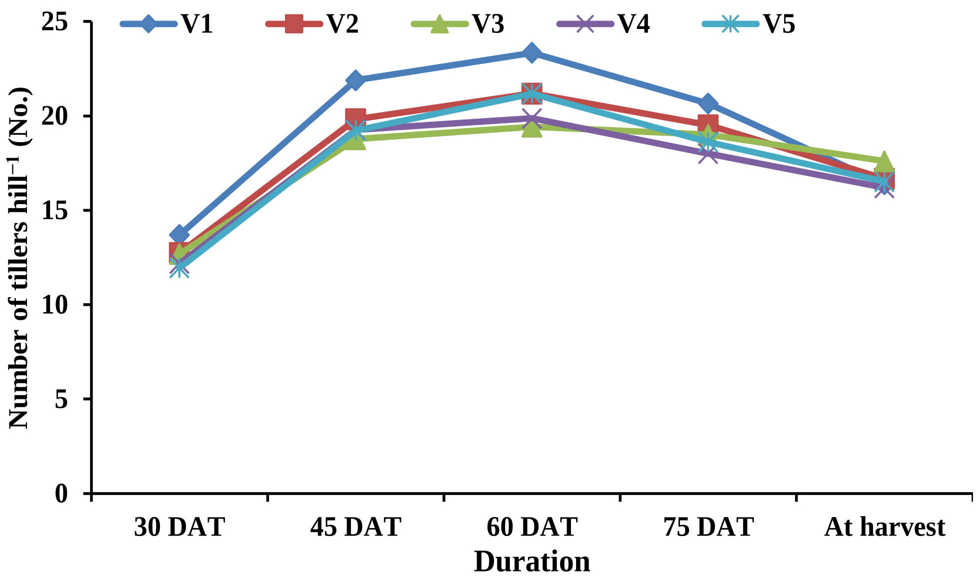
Number of tillers hill$^{-1}$ increased with advancement of plant age up to certain period. In later stage of rice plant tiller number decreased with advancement of plant age due to high mortality of tiller. However, variation of planting date did not affect tiller number per hill throughout the entire life of *boro* rice (Figure 6 and Appendix 3).

The number of tillers per hill did not affect for the variation of variety throughout the growth period (Figure 7 and Appendix 3).




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 6.** Effect of transplanting date on number of tillers hill$^{-1}$ of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = NS].




Here, $V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

**Figure 7.** Effect of variety on number of tillers hill$^{-1}$ of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = NS].

Combination of planting date and variety also have no effect on number of tillers hill$^{-1}$ throughout the life cycle of *boro* rice (Table 3 and Appendix 3).

**Table 3**. Combined effect of transplanting date and variety on number of tillers hill$^{-1}$ of *boro* rice in Lalmai-Hill area at different stages

| Treatments | Number of tillers hill$^{-1}$ (No.) | | | | |
|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 75 DAT | At harvest |
| $T_1 V_1$ | 11.43 | 24.5 | 25.17 | 23.07 | 17.53 |
| $T_1 V_2$ | 10.77 | 18.80 | 19.89 | 19.067 | 18.07 |
| $T_1 V_3$ | 13.20 | 20.20 | 20.61 | 20.34 | 18.21 |
| $T_1 V_4$ | 11.14 | 17.43 | 19.82 | 19.00 | 16.17 |
| $T_1 V_5$ | 11.20 | 18.63 | 20.91 | 19.07 | 16.67 |
| $T_2 V_1$ | 10.79 | 18.17 | 20.90 | 18.93 | 15.23 |
| $T_2 V_2$ | 12.47 | 21.10 | 21.60 | 20.58 | 16.50 |
| $T_2 V_3$ | 10.99 | 16.43 | 19.73 | 17.42 | 16.70 |
| $T_2 V_4$ | 13.47 | 19.37 | 18.93 | 16.87 | 15.90 |
| $T_2 V_5$ | 14.37 | 18.33 | 19.67 | 17.33 | 16.40 |
| $T_3 V_1$ | 14.31 | 22.97 | 23.97 | 19.97 | 16.37 |
| $T_3 V_2$ | 12.62 | 19.60 | 22.07 | 18.90 | 15.43 |
| $T_3 V_3$ | 13.88 | 19.67 | 17.93 | 19.26 | 17.89 |
| $T_3 V_4$ | 13.60 | 21.00 | 20.84 | 18.17 | 16.50 |
| $T_3 V_5$ | 15.53 | 20.73 | 22.96 | 19.47 | 16.50 |
| **LSD** (0.05) | NS | NS | NS | NS | NS |
| **CV** (%) | 23.47 | 23.63 | 23.38 | 24.54 | 15.83 |

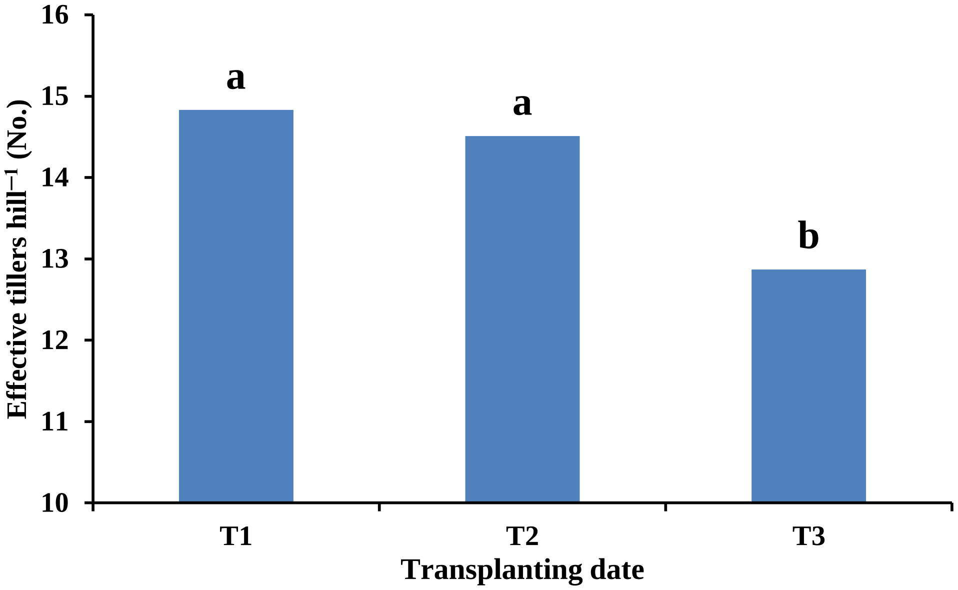
Here,

| | | |
|---|---|---|
| $T_1$= Transplanting of seedlings on 15 January | $V_1$= BRRI dhan67 | $V_4$= BRRI dhan81 |
| $T_2$= Transplanting of seedlings on 30 January | $V_2$= BRRI dhan68 | $V_5$= BRRI dhan86 |
| $T_3$= Transplanting of seedlings on 14 February | $V_3$= BRRI dhan74 | NS=Non-significant |

## 4.2 Effect on Yield contributing parameters

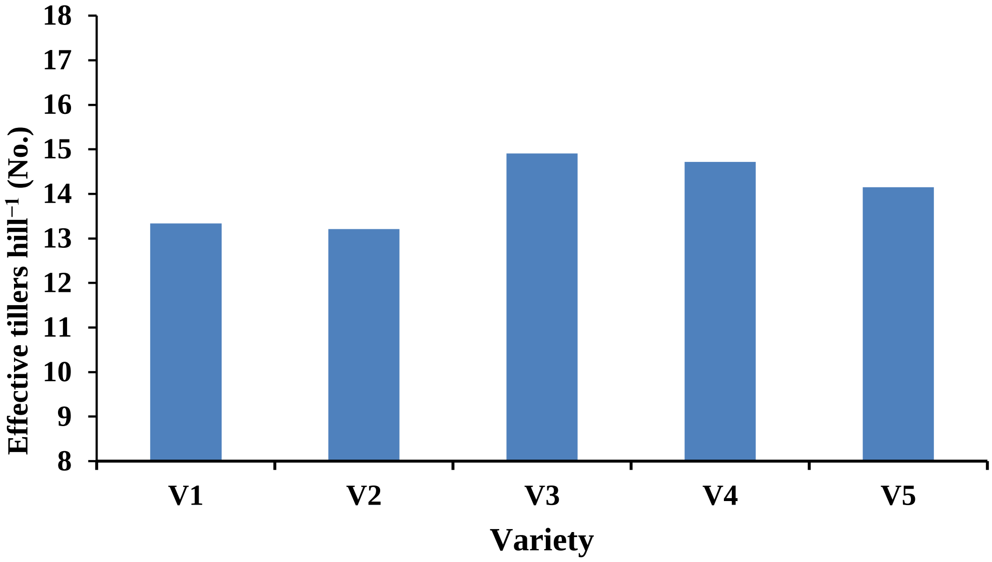
### 4.2.1 Effect on effective tillers hill$^{-1}$

Variation in transplanting date affect effective tillers hill$^{-1}$. Transplanting of rice seedlings on January 15 ($T_1$) produced highest number of effective tillers hill$^{-1}$ (14.83) which is statistically similar with transplanting of rice seedlings on January 30 (Figure 8 and Appendix 4). Lowest number of effective tillers (12.87) observed from late transplanting (Transplanting on February 14). Results revealed that early planting produced comparatively higher number of effective tillers and late planting produced lower effective tillers hill$^{-1}$. Late planting reduced effective tillers by increasing tiller mortality. Tiller mortality increased on late planting might be due to poor fertilization and partitioning. Poor fertilization and partitioning occurred on late planting due higher temperature during reproductive stage of late-planted seedlings.




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 8.** Effect of transplanting date on number of effective tillers hill$^{-1}$ of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ =1.44].




Here, $V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

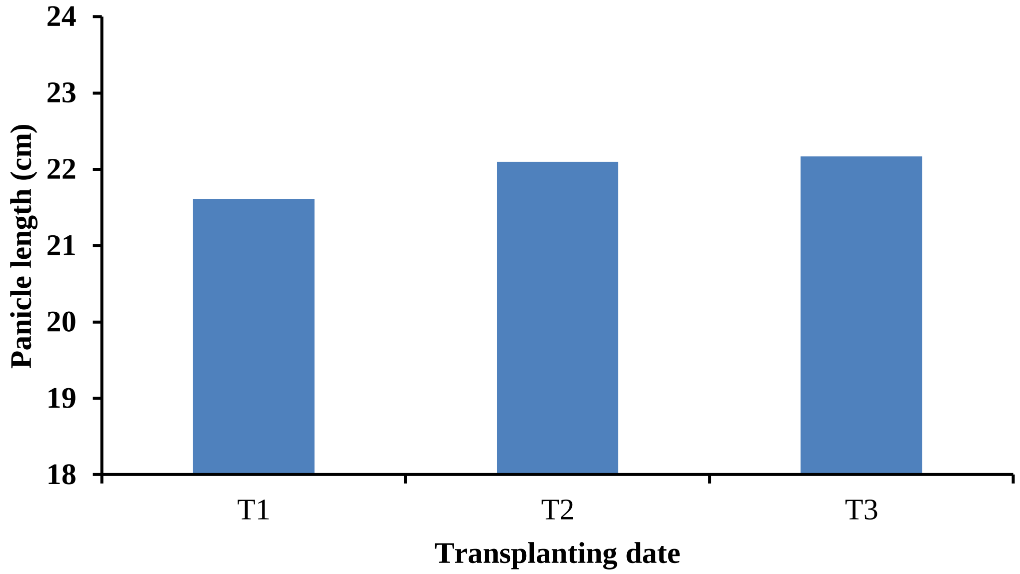
**Figure 9**. Effect of variety on number of effective tillers hill$^{-1}$ of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = NS].

Varietal variation did not affect the number of effective tillers hill$^{-1}$ (Figure 8 and Appendix 4). Statistically all varieties produced similar number of effective tillers hill$^{-1}$.

Combinations of transplanting date and variety also have no effect on the number of effective tillers hill$^{-1}$ (Table 4 and Appendix 4).

### 4.2.2 Effect on panicle length

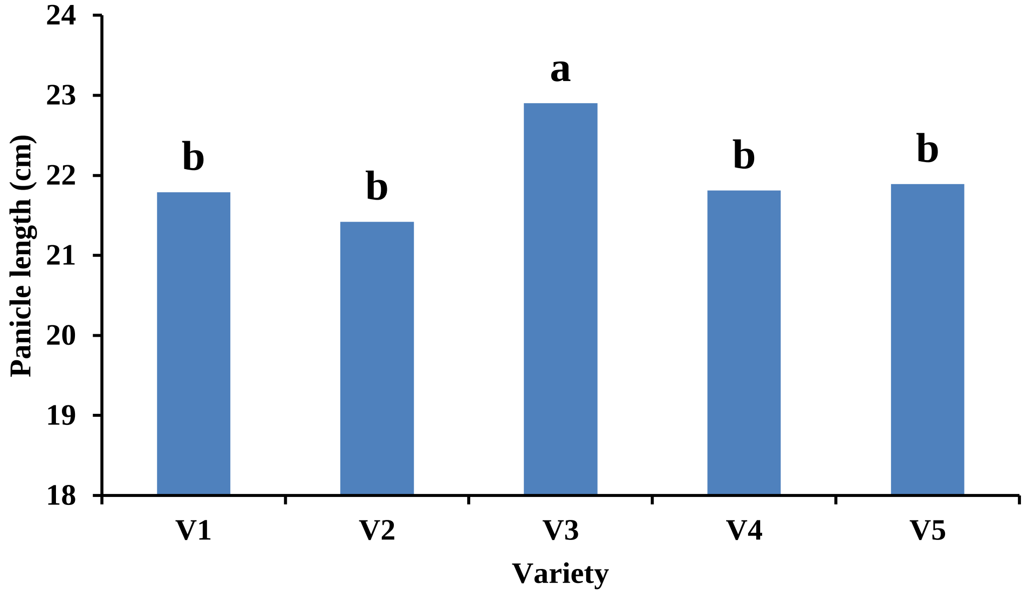
Transplanting date have no effect on panicle length (Figure 10 and Appendix 4). Variation of transplanting date of *boro* rice did not show any differences in panicle length.




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 10**. Effect of transplanting date on panicle length of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = NS].

Panicle length significantly influenced by varietal variation (Figure 11 and Appendix 4). The longest panicle (22.94 cm) produced by BRRI dhan74 ($V_3$). The shortest panicle (21.42 cm) produced by BRRI dhan68 ($V_2$) which was statistically similar with BRRI dhan67, BRRI dhan81 and BRRI dhan86.




Here, $V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

**Figure 11.** Effect of variety on number on panicle length of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 0.98].

There was no significant variation observed on panicle length for the combination of transplanting date and variety (Table 4 and Appendix 4). Combination of $T_2V_3$ numerically showed the longest panicle length and $T_1V_2$ produced the shortest panicle

### 4.2.3 Effect on filled grain panicle$^{-1}$

The number of filled grain panicle$^{-1}$ greatly influenced by variation of transplanting date. Early planting (Transplanting on January 15) produced highest number of filled grain panicle$^{-1}$ (102.51) and late planting (Transplanting on February 14) produced lowest number of filled grain panicle$^{-1}$ (Figure 12 and Appendix 4). In late-transplanted rice seedlings number of filled grain panicle$^{-1}$ decreased might be due to temperature.

In late-transplanted rice seedlings, reproductive and maturity stage exposed to later part of March and April when temperature is little higher than first half of March. Higher temperature caused poor fertilization and poor partitioning.

**Table 4.** Combined effect of variety and transplanting date on number of effective tiller, Panicle length, number of filled grain, unfilled grain total grain and thousand grain wt. of *boro* rice in Lalmai-Hill area

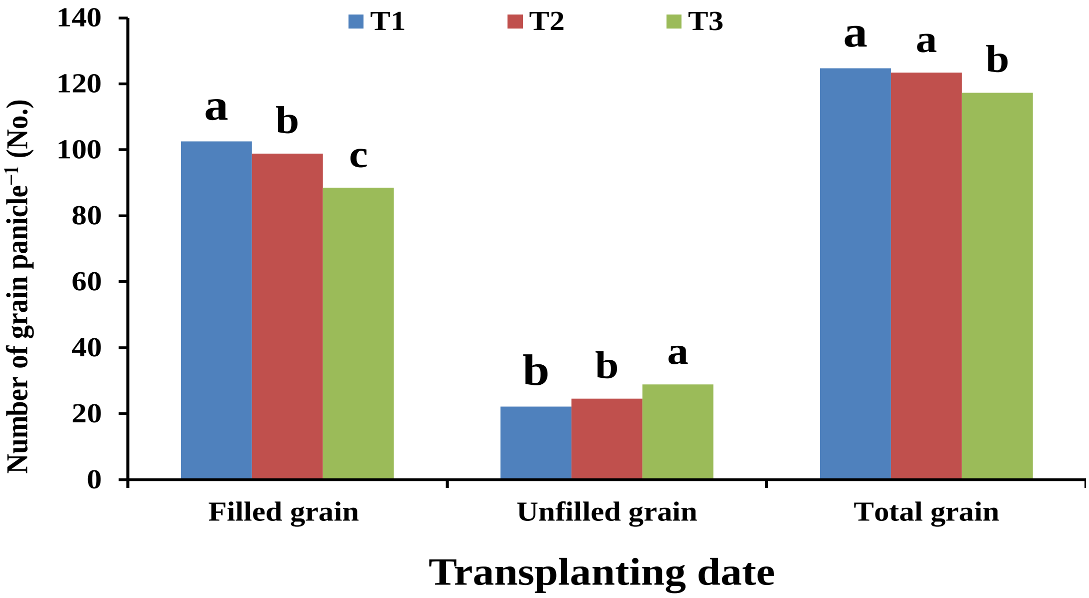
| Treatments | Effective tiller hill$^{-1}$ (No.) | Panicle length (cm) | Filled grain panicle$^{-1}$ (No.) | Unfilled grain panicle$^{-1}$ (No.) | Total grain panicle$^{-1}$ (No.) | 1000-grain wt. (g) |
|---|---|---|---|---|---|---|
| $T_1 V_1$ | 14.33 | 21.92 | 105.13 | 17.62 | 122.76 | 24.44 f |
| $T_1 V_2$ | 13.33 | 20.85 | 97.00 | 19.16 | 116.16 | 27.12 a |
| $T_1 V_3$ | 16.00 | 22.56 | 107.47 | 24.60 | 132.07 | 26.78 bc |
| $T_1 V_4$ | 15.63 | 21.38 | 105.84 | 20.76 | 126.60 | 20.03 j |
| $T_1 V_5$ | 14.87 | 21.35 | 97.13 | 28.76 | 125.88 | 21.45 h |
| $T_2 V_1$ | 13.41 | 21.50 | 101.08 | 21.94 | 123.03 | 24.73 e |
| $T_2 V_2$ | 13.71 | 21.68 | 95.34 | 19.46 | 114.80 | 26.80 b |
| $T_2 V_3$ | 15.23 | 23.69 | 103.54 | 25.99 | 129.53 | 26.40 d |
| $T_2 V_4$ | 15.43 | 21.65 | 99.97 | 24.50 | 124.46 | 20.05 j |
| $T_2 V_5$ | 14.73 | 21.98 | 94.19 | 30.87 | 125.06 | 21.26 h |
| $T_3 V_1$ | 12.28 | 21.93 | 88.84 | 26.72 | 115.56 | 23.95 g |
| $T_3 V_2$ | 12.59 | 21.74 | 83.82 | 26.26 | 110.08 | 26.58 cd |
| $T_3 V_3$ | 13.50 | 22.45 | 93.80 | 31.16 | 124.95 | 26.52 d |
| $T_3 V_4$ | 13.10 | 22.38 | 91.62 | 24.19 | 115.81 | 19.76 k |
| $T_3 V_5$ | 12.86 | 22.36 | 84.39 | 35.87 | 120.26 | 20.89 i |
| **LSD $_{(0.05)}$** | NS | NS | NS | NS | NS | 0.20 |
| **CV (%)** | 13.65 | 4.61 | 3.63 | 13.35 | 2.95 | 0.51 |

Here

$T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

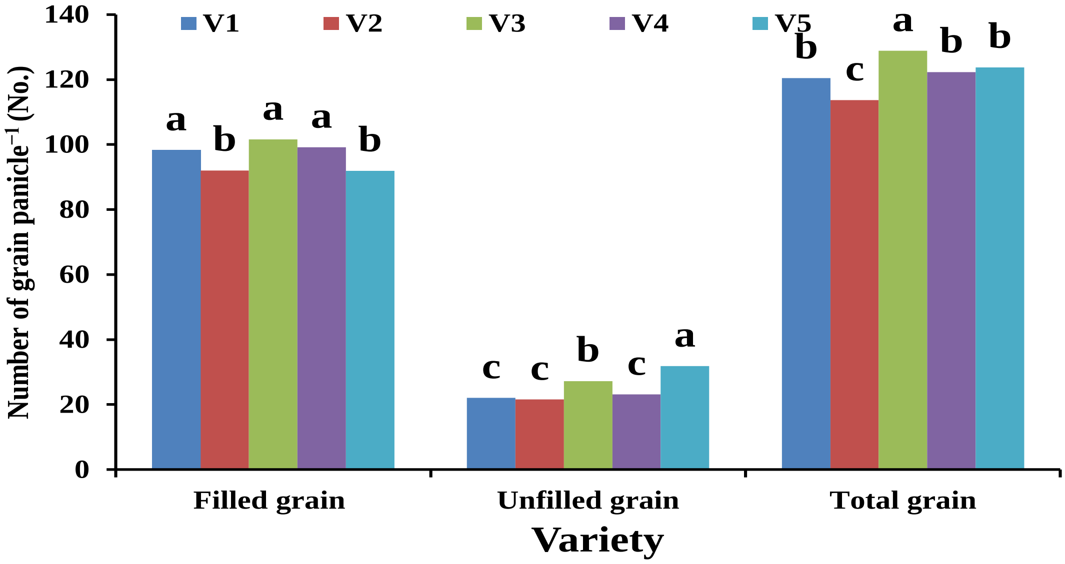
$V_1$= BRRI dhan67
$V_2$= BRRI dhan68
$V_3$= BRRI dhan74
$V_4$= BRRI dhan81
$V_5$= BRRI dhan86

Number of Filled grain panicle$^{-1}$ is considered as one of the most important yield contributing parameter. Our results revealed that, number of filled grain panicle$^{-1}$ influenced by varietal variation of *boro* rice (Figure 13 and Appendix 4). The highest number of filled grain panicle$^{-1}$ (103) produced by BRRI dhan74 which is statistically similar with BRRI dhan67 and BRRI dhan81. BRRI dhan86 produced the lowest number of filled grain panicle$^{-1}$ (92) which is statistically similar with BRRI dhan68.




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 12.** Effect of transplanting date on number of filled grain, unfilled grain and total grain of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 2.62, 2.51 and 2.68 for filled grain, unfilled grain and total grain, respectively]




Here, $V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

**Figure 13.** Effect of variety on number of filled grain, unfilled grain and total grain of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ =3.39, 3.24 and 3.47 for filled grain, unfilled grain and total grain, respectively]

Interaction of transplanting date and variety have no effect on number of filled grain panicle$^{-1}$ (Table 4 and Appendix 4). Combination of all transplanting date and variety statistically produced similar number of filled grain panicle$^{-1}$.

### 4.2.4 Effect on unfilled grain

Variation of transplanting date showed variation on the number of unfilled grain panicle$^{-1}$ (Figure 12 and Appendix 4). Late-planted seedlings (Transplanted on February 14) produced highest number of unfilled grain panicle$^{-1}$ (28.41). Early-planted seedlings (Transplanted on January 15) produced lowest number of unfilled grain panicle$^{-1}$ which is statistically similar with $T_2$ (Transplanting on January 30). Late planting increased unfilled grain panicle$^{-1}$ due to tropical-storm related lodging, heat damage during heading, flowering stage of rice (Reza *et al.*, 2011). In the present study, late-planted seedlings exposed its heading, flowering stage in later part of March and April. Temperature of April is higher than March and probability of tropical storm also high in April. That is why unfilled grain is higher in late-planted seedlings than early-planted seedlings.

The number of unfilled grain panicle$^{-1}$ influenced by varietal variation (Figure 13 and Appendix 4). The highest number (31.83) of unfilled grain panicle$^{-1}$ noticed in BRRI dhan86. The lowest number (21.62) of unfilled grain panicle$^{-1}$ observed in BRRI dhan68, which is statistically similar with BRRI dhan67 and BRRI dhan81.

Interaction of Transplanting date and variety have no influence on unfilled grain panicle$^{-1}$ (Table 4 and Appendix 4)

### 4.2.5 Effect on the number of total grain panicle$^{-1}$

The number of total grain panicle$^{-1}$ significantly influenced by transplanting date. Variation of transplanting date changes the number of total grain panicle$^{-1}$ (Figure 12 and Appendix 4). Early-planted seedlings (Transplanted on January 15) produced highest number of total grain panicle$^{-1}$ (124.69) which is statistically similar with

$T_2$ (Transplanting of seedlings on January 30). The lowest number of total grain panicle$^{-1}$ was recorded from late-planted seedlings (Transplanted on February 14).

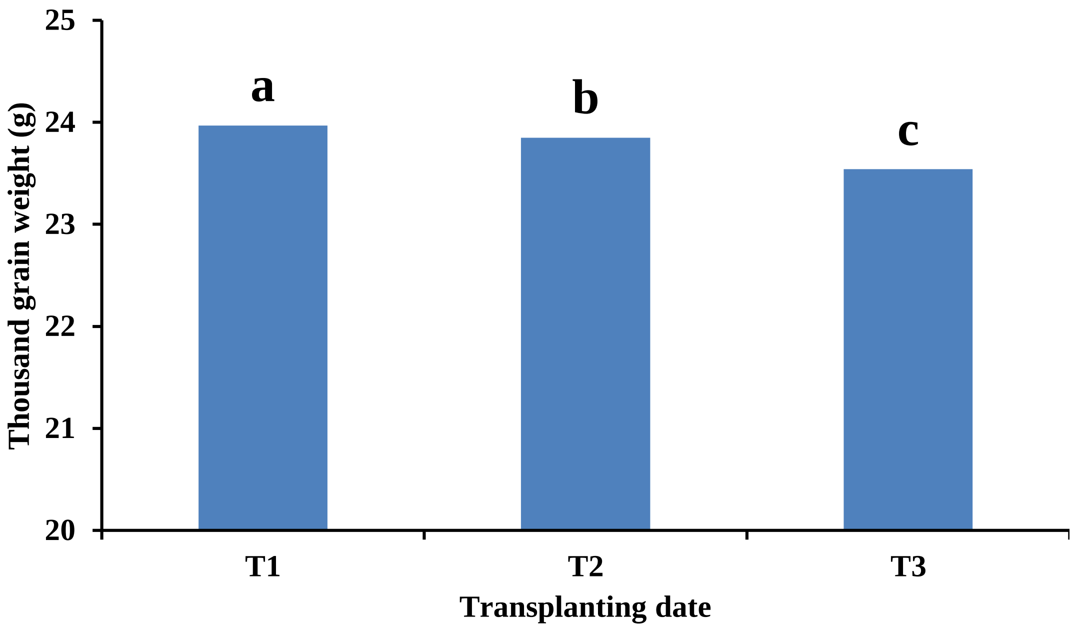
Varietal variation has effect on the total number of grain panicle$^{-1}$ (Figure 13 and Appendix 4). The highest number of total grain panicle$^{-1}$ (128.85) recorded from BRRI dhan74 and the lowest number of total grain panicle$^{-1}$ (113.68) recorded from BRRI dhan68.

Combination of transplanting date and variety have no impact on the number of total grains panicle$^{-1}$ (Table 4 and Appendix 4).

### 4.2.6 Effect on thousand grain weight

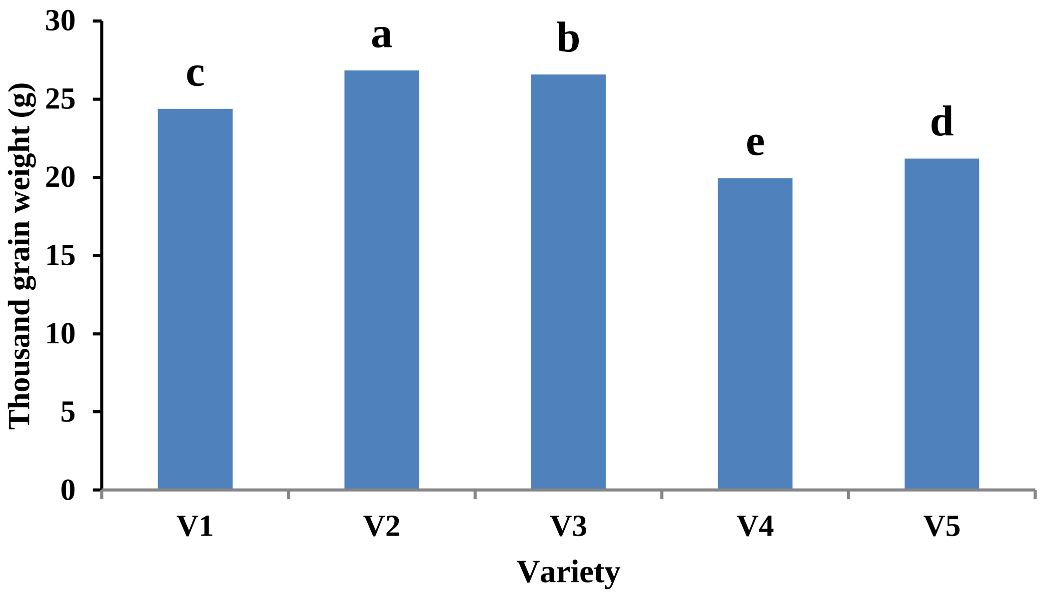
Transplanting date has significance on thousand grain weight. Thousand grain weight decreased with delaying of transplanting (Figure 14 and Appendix 4). The highest 1000-grain weight (23.97 g) was recorded from early–planted rice seedlings (Transplanted on January 15) and lowest 1000-grain weight (23.54 g) recorded from late-planted seedlings. Proper planting time ensure optimum temperature and sunshine ours during flowering, heading and dough stage which increased fertilization and partitioning (Patel *et al.*, 2019). Early-planted seedlings (Transplanting of rice seedlings on January 15) exposed the panicle initiation, booting, heading and flowering stage exposed to second half of February which conforms optimum temperature for proper fertilization and partitioning. Consequently, filled grain panicle$^{-1}$ and thousand grain weight increased in early-planted seedlings.

Thousand grain weight usually varied from variety to variety due to differences on individual seed size and weight. Our results revealed that thousand grain weight influenced by varietal variation (Figure 15 and Appendix 4). The highest 1000-grain weight (26.84 g) recorded in BRRI dhan68 and the lowest grain weight (21.20 g) recorded in BRRI dhan81.




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 14.** Effect of transplanting date on thousand-grain weight of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 0.09].




Here,
$V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

**Figure 15**. Effect of variety on thousand-grain weight of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 0.12].

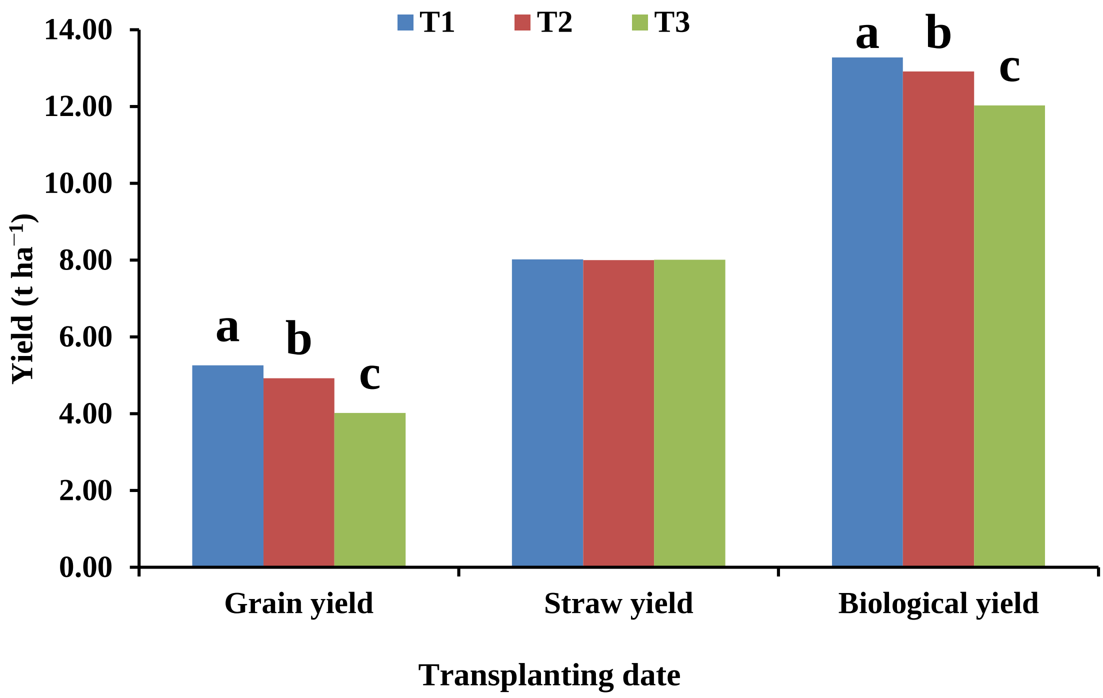
Combination of transplanting date and variety greatly influenced 1000-grain weight of *boro* rice (Table 4 and Appendix 4). The highest 1000-grain weight (27.12 g) recorded from $T_1V_2$ combination and lowest 1000-grain weight (19.76 g) recorded from $T_3V_4$ combination.

### 4.3 Effect on yield

#### 4.3.1 Effect on grain yield

Grain yield of rice significantly affected by planting date (Figure 16 and Appendix 5). The highest grain yield (5.26 t ha$^{-1}$) obtained from early-planted seedlings (Transplanted on January 15) and lowest grain yield from late-planted seedlings (Transplanted on February 14). Delayed transplanting decreased grain yield because of lower filled grain panicle$^{-1}$, 1000-grain weight. Chopra *et al.* (2006) reported that maximum yield of rice obtained when rice plants exposed to appropriate temperature range by controlling sowing and or transplanting time. Proper planting time ensure optimum temperature and sunshine ours during flowering, heading and dough stage which increased fertilization and partitioning (Reza *et al.,* 2011 and Patel *et al.*, 2019). Delayed transplanting causes higher disease and insect incidence, tropical storm-related lodging. Late transplanting also causes possible heat or cold damage during heading, flowering and the grain filling stage (Reza *et al.,* 2011). Our results revealed that early-planted seedlings confirmed higher grain yield and late-planted seedlings confirmed lower grain yield. These results in agreement with previous studies (Mannan *et al.,* 2012 and Roy *et al.,* 2019). These results are also in agreement with Ali *et al.* (2019) who reported that, at Cumilla districts yield reduction started after transplanting of 21$^{st}$ January in case of different *boro* rice varieties.

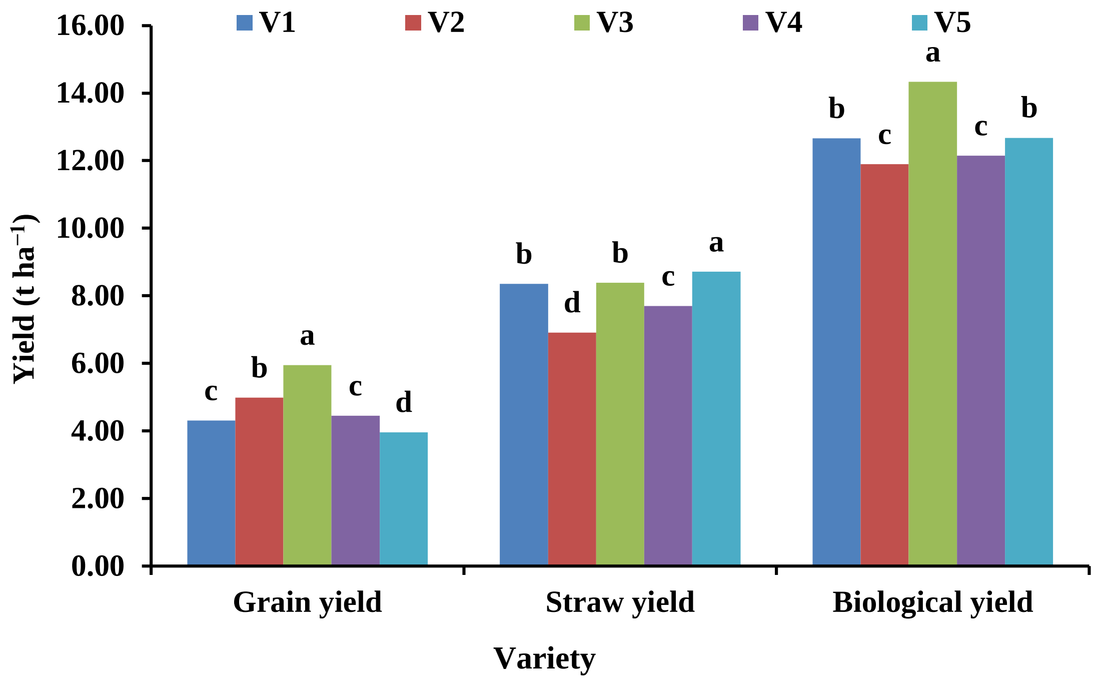
Grain yield of *boro* rice influenced by varietal variation (Figure 17 and Appendix 5). The highest grain yield (5.95 t ha$^{-1}$) obtained from BRRI dhan74 ($V_3$) and lowest grain yield (3.96 t ha$^{-1}$) from BRRI dhan86 ($V_5$). BRRI dhan74 produced the highest grain yield compared with others as it also produced highest effective tillers and filled grain compared with others. It is the consequence of higher effective tiller per hill and higher filled grain and total grain per panicle. Our results supported by several previous studies (Kamal *et al*., 2007; Mannan *et al.,* 2012 and Hussain *et al.*, 2014). They reported that different varieties showed different grain yield by showing differences in effective tillers hill$^{-1}$, filled grain panicle$^{-1}$ and 1000-grain weight. Similar results also reported by Chowhan *et al.* (2019) and Ali *et al.* (2019) who stated that varietal variation showed different yield in different locations.




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 16.** Effect of transplanting date on grain yield, straw yield and biological yield of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 0.13 and 0.20 for grain yield and biological yield, respectively].

Combined effect of transplanting date and variety influenced grain yield of *boro* rice. The highest grain yield (6.67 t ha$^{-1}$) recorded from BRRI dhan74 by transplanting on January 15 (Table 5 and Appendix 5). From our results, we observed that BRRI dhan74 has higher potentiality in higher grain yield production by producing highest number of effective tillers hill$^{-1}$ and number of grain panicle$^{-1}$. Early-planted seedlings also showed potentiality in production of effective tillers hill$^{-1}$, grain panicle$^{-1}$ and consequently grain yield. The lowest grain yield (3.34 t ha$^{-1}$) recorded from BRRI dhan86 when planted on February 14 as late-transplanted seedling showed lower filled grain per panicle, lower effective tillers hill$^{-1}$.




Here,

$V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

**Figure 17.** Effect of variety on grain yield, straw yield and biological yield of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 0.17 and 0.21 and 0.26 for grain yield and straw yield, and biological yield, respectively].

### 4.3.2 Effect on straw yield

Transplanting *boro* rice seedlings in different date did not affect straw yield (Figure 16 and Appendix 5). Early- and late-planted seedlings almost showed similar potentiality in production of straw.

Varietal variation significantly influenced straw yield of *boro* rice. Different variety showed difference in straw yield (Figure 17 and Appendix 5). The highest straw yield (8.71 t ha$^{-1}$) recorded from BRRI dhan86 and lowest (6.91 t ha$^{-1}$) from BRRI dhan68.

Interaction of transplanting date and variety have no influenced on straw yield of *boro* rice (Table 5 and Appendix 5).

### 4.3.3 Effect on Biological yield

Variation in transplanting date influenced biological yield (Figure 16 and Appendix 5). Early-transplanted seedlings ($T_1$) confirmed highest biological yield (13.28 t ha$^{-1}$) and late-planted seedlings (Transplanted on February 14) confirmed lowest biological yield (12.03 t ha$^{-1}$). Highest biological yield obtained from early-planted seedlings because highest grain yield also from early-planted seedlings. Similar results also reported by Mannan *et al.* (2012) who reported that the number of panicles, grains panicle$^{-1}$, panicle length, grain yield and straw yield and growth duration decreased with delaying of transplanting dates.

**Table 5.** Combined effect of variety on grain yield, straw yield, biological yield and harvest index of *boro* rice in Lalmai-Hill area

| Treatments | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index |
|---|---|---|---|---|
| **$T_1$ $V_1$** | 4.79 ef | 8.45 | 13.236 b | 0.36 cd |
| **$T_1$ $V_2$** | 5.63 c | 7.08 | 12.705 c | 0.44 a |
| **$T_1$ $V_3$** | 6.67 a | 8.38 | 15.039 a | 0.44 a |
| **$T_1$ $V_4$** | 4.86 e | 7.71 | 12.562 c-e | 0.39 b |
| **$T_1$ $V_5$** | 4.37 gh | 8.46 | 12.834 bc | 0.35 e |
| **$T_2$ $V_1$** | 4.34 gh | 8.32 | 12.658 cd | 0.34 de |
| **$T_2$ $V_2$** | 5.29 d | 6.81 | 12.096 fg | 0.44 a |
| **$T_2$ $V_3$** | 6.26 b | 8.49 | 14.752 a | 0.42 a |
| **$T_2$ $V_4$** | 4.52 fg | 7.63 | 12.145 e-g | 0.37 bc |
| **$T_2$ $V_5$** | 4.18 hi | 8.77 | 12.953 bc | 0.32 ef |
| **$T_3$ $V_1$** | 3.80 j | 8.28 | 12.079 fg | 0.31 f |
| **$T_3$ $V_2$** | 4.03 ij | 6.84 | 10.876 h | 0.37 bc |
| **$T_3$ $V_3$** | 4.94 e | 8.26 | 13.201 b | 0.37 bc |
| **$T_3$ $V_4$** | 3.98 ij | 7.75 | 11.731 g | 0.34 e |
| **$T_3$ $V_5$** | 3.34 k | 8.91 | 12.244 d-f | 0.27 g |
| **LSD** (0.05) | 0.29 | NS | 0.45 | 0.02 |
| **CV** (%) | 3.72 | 3.72 | 2.09 | 3.18 |

Here,

$T_1$= Transplanting of seedlings on 15 January; $V_1$= BRRI dhan67; $V_4$= BRRI dhan81

$T_2$= Transplanting of seedlings on 30 January; $V_2$= BRRI dhan68; $V_5$= BRRI dhan86

$T_3$= Transplanting of seedlings on 14 February; $V_3$= BRRI dhan74; NS= Non-significant

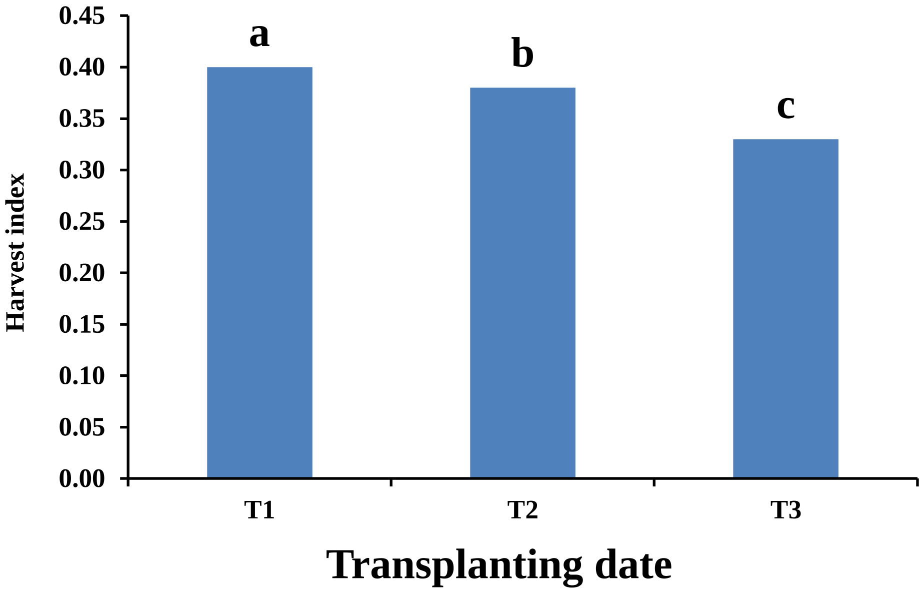
Varietal variation significantly influenced biological yield of *boro* rice (Figure 17 and Appendix 5). The highest biological yield (14.33 t ha$^{-1}$) recorded from BRRI dhan74 and lowest biological yield (11.89 t ha$^{-1}$) recorded from BRRI dhan68. These results in agreement with Roy *et al*. (2019) who noted that different variety showed different grain yield, straw yield and biological yield indifferent varieties.

Interaction of transplanting date and variety effect biological yield of *boro* rice (Table 5 and Appendix 5). The highest biological yield (15.04 t ha$^{-1}$) recorded from the BRRI dhan74 when transplanted on January 15. Similar results also found from $T_2V_3$

combination. The lowest biological yield recorded from BRRI dhan68 when transplanted on February 14.

### 4.3.4 Effect on harvest index

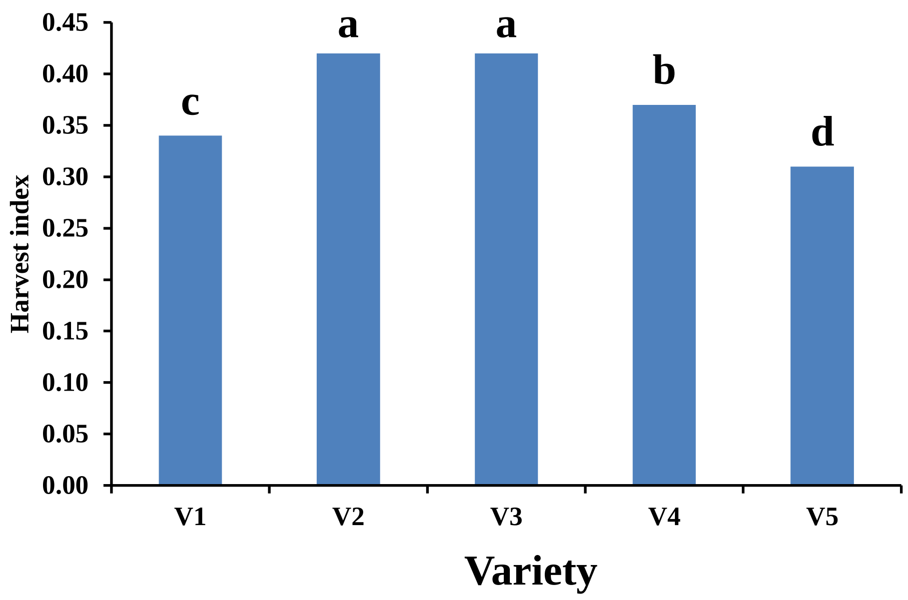
The harvest index of *boro* rice varied with the variation of transplanting date (Figure 18 and Appendix 5). The highest harvest index (0.40) recorded from early-planted seedlings and lowest (0.33) from late-planted seedlings. Grain yield of *boro* rice decreased with delaying of seedling transplanting which consequently influenced harvest index in similar way.




Here, $T_1$= Transplanting of seedlings on 15 January
$T_2$= Transplanting of seedlings on 30 January
$T_3$= Transplanting of seedlings on 14 February

**Figure 18**. Effect of transplanting date on harvest index of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 0.01].

Varietal variation also caused variation of harvest index (Figure 19 and Appendix 5). The highest harvest index (0.42) recorded from BRRI dhan68 and BRRI dhan74 and lowest harvest index (0.31) recorded from BRRI dhan86.




Here, $V_1$= BRRI dhan67, $V_2$= BRRI dhan68, $V_3$= BRRI dhan74, $V_4$= BRRI dhan81, $V_5$= BRRI dhan86

**Figure 19**. Effect of variety on harvest index of *boro* rice in Lalmai-Hill area. [LSD $_{(0.05)}$ = 0.01].

Combination of transplanting date and variety also significantly influenced harvest index of *boro* rice (Table 5 and Appendix 5). The highest harvest index recorded from $T_1V_2$, $T_1V_3$, $T_2V_2$ and $T_2V_3$ combinations. The lowest harvest index (0.27) recorded from BRRI dhan86 when planted on February 14.

### 4.3.5 Effect on monetary advantages

Transplanting dates have significant effect on yield monetary advantages as different transplanting date showed different grain yield return, straw yield return and total yield return (Grain yield + Straw yield) (Table 6 and Appendix 6). The highest grain yield return (Tk. 108159) recorded from early transplanted seedlings (Transplanted at January 15) as transplanting on this date also confirmed highest grain yield. Our findings revealed that, monetary advantage decreased gradually with advancement of transplanting date. This reduction of monetary advantages along with advancement of transplanting date due to gradual reduction of grain yield along with transplanting date. However, the lowest grain yield monetary advantages recorded from late transplanted seedlings (Transplanted on February 14).

**Table 6.** Effect of transplanting date and variety on monetary advantages of yield return in Lalmai-Hill area

| Treatments | Grain yield return (Tk. $ha^{-1}$) | Straw yield return (Tk. $ha^{-1}$) | Total yield return (Tk. $ha^{-1}$) |
|---|---|---|---|
| Transplanting date | | | |
| **$T_1$** | 108159 a | 32056 | 140214 a |
| **$T_2$** | 100990 b | 32015 | 133005 b |
| **$T_3$** | 82864 c | 32040 | 114904 c |
| **LSD** $_{(0.05)}$ | 2734.2 | NS | 2744.8 |
| **CV** (%) | 3.76 | 2.77 | 2.84 |
| Variety | | | |
| **$V_1$** | 92591 d | 33405 b | 125996 c |
| **$V_2$** | 100127 c | 27643 d | 127770 c |
| **$V_3$** | 111925 a | 33510 b | 145435 a |
| **$V_4$** | 107516 b | 30777 c | 138293 b |
| **$V_5$** | 74529 e | 34850 a | 109380 d |
| **LSD** $_{(0.05)}$ | 3529.8 | 858.36 | 3543.6 |
| **CV** (%) | 3.76 | 2.77 | 2.84 |

Here

$T_1$= Transplanting of seedlings on 15 January  $V_1$= BRRI dhan67  $V_4$=BRRI dhan81
$T_2$= Transplanting of Seedlings on 30 January  $V_2$= BRRI dhan68  $V_5$= BRRI dhan86
$T_3$= Transplanting of seedlings on 14 February  $V_3$= BRRI dhan74

Transplanting dates have no impact on straw yield return as straw yield return were not varied with transplanting date. Monetary advantages on total marketable yield also varied with the variation of transplanting date (Table 6 and Appendix 6). Late transplanting (Transplanting on February 14) showed lowest monetary advantages (Tk. 114904) for total marketable yield.

Varietal variation greatly influenced monetary advantages of grain yield return, straw yield return and total yield return (Table 6 and Appendix 6). The highest grain yield return (Tk. 111925) recorded from BRRI dhan74 and lowest monetary advantages (Tk. 74529) recorded from BRRI dhan86. The highest straw yield monetary advantages (Tk. 34850) recorded from BRRI dhan86 and lowest from BRRI dhan68. However, the highest marketable total yield monetary advantages (Tk.145435) recorded from BRRI dhan74 and lowest monetary advantages (Tk. 109380) from BRRI dhan86.

The combined effect of variety and transplanting date have great impact on monetary advantages of grain yield and total yield return (Table 7and Appendix 6).

**Table 7.** Combined effect of transplanting date and variety on monetary advantages of yield return in Lalmai-Hill area

| Treatments | Grain yield return (Tk. ha$^{-1}$) | Straw yield return (Tk. ha$^{-1}$) | Total yield return (Tk. ha$^{-1}$) |
|---|---|---|---|
| **$T_1$ $V_1$** | 102949 e | 33792 | 136741 cd |
| **$T_1$ $V_2$** | 113096 bc | 28313 | 141409 c |
| **$T_1$ $V_3$** | 125258 a | 33507 | 158765 a |
| **$T_1$ $V_4$** | 117264 b | 30827 | 148091 b |
| **$T_1$ $V_5$** | 82225 g | 33840 | 116065 f |
| **$T_2$ $V_1$** | 93210 f | 33292 | 126502 e |
| **$T_2$ $V_2$** | 106262 de | 27236 | 133498 d |
| **$T_2$ $V_3$** | 117713 b | 33964 | 151677 b |
| **$T_2$ $V_4$** | 109118 cd | 30507 | 139624 cd |
| **$T_2$ $V_5$** | 78647 g | 35077 | 113724 fg |
| **$T_3$ $V_1$** | 81614 g | 33131 | 114745 f |
| **$T_3$ $V_2$** | 81023 g | 27379 | 108402 g |
| **$T_3$ $V_3$** | 92803 f | 33059 | 125862 e |
| **$T_3$ $V_4$** | 96165 f | 30997 | 127163 e |
| **$T_3$ $V_5$** | 62717 h | 35633 | 98350 h |
| **LSD** (0.05) | 6113.8 | NS | 6137.6 |
| **CV** (%) | 3.76 | 2.77 | 2.84 |

Here,

$T_1$= Transplanting of seedlings on 15 January

$T_2$= Transplanting of seedlings on 30 January

$T_3$= Transplanting of seedlings on 14 February

$V_1$= BRRI dhan67 $V_4$=BRRI dhan81
$V_2$= BRRI dhan68 $V_5$= BRRI dhan86

$V_3$= BRRI dhan74

| Market price of grain | (Tk. t$^{-1}$) |
|---|---|
| BRRI dhan67 | 21500 |
| BRRI dhan68 | 20100 |
| BRRI dhan74 | 18800 |
| BRRI dhan81 | 24150 |
| BRRI dhan86 | 18800 |
| Market price of straw | 4000 |

Interaction of transplanting date and variety have no impact on straw yield monetary advantages. The highest grain yield monetary advantages (Tk. 125258) recorded from BRRI dhan74 when transplanted on January 15 and lowest monetary advantages (Tk. 62717) of grain yield BRRI dhan86 when transplanted on February 14. Similarly the highest monetary advantages (Tk. 158765) recorded from BRRI dhan74 when transplanted on January 15 and lowest advantages recorded from BRRI dhan86 when transplanted on February 14.

# CHAPTER 5
# SUMMARY AND CONCLUSIONS

Our experimental results suggested that transplanting of *boro* rice on January 15 confirmed higher effective tiller hill$^{-1}$, filled grain panicle$^{-1}$, 1000-grain weight, grain yield, biological yield, harvest index and monetary advantages than delayed-transplanted seedlings (Transplanted on January 30 and February 14). Delaying of transplanting date decreased effective tillers, filled grain panicle$^{-1}$, total grain panicle$^{-1}$, thousand grain weight, grain yield, biological yield, harvest index and monetary advantages. Varietal variation also shows variation on growth and yield of *boro* rice. The highest grain yield (5.95 t ha$^{-1}$) and biological yield (14.33 t ha$^{-1}$), monetary advantages for marketable yield return (Tk. 145435 t$^{-1}$) were recorded from BRRI dhan74 compared with other varieties. The lowest grain yield (3.96 t ha$^{-1}$) obtained from BRRI dhan86 following BRRI dhan74, BRRI dhan68, BRRI dhan81 and BRR dhan67. Transplanting of BRRI dhan74 on January 15 showed highest grain yield and monetary advantages, and transplanting of BRRI dhan86 on February 14 showed lowest grain yield. However, transplanting of any varieties after 15 January decreased grain yield and biological yield. Considering economic benefit BRRI dhan74 is the most cost-effective variety for Lalmai-Hill area.

# RECOMMENDATIONS

As we conducted our experiment with only five varieties, it is difficult to recommend the appropriate variety/varieties for study area. However, according to findings of our study we have the following recommendations:

1. Among the five varieties (BRRI dhan67, BRRI dhan68, BRRI dhan74, BRRI dhan81 and BRRI dhan86) BRRI dhan74 is best variety for Lalmai-Hill area.
2. Boro rice seedlings should be transplanted on or before 15 January.
3. However, more experiment should be conducted at different location of Lalmai-Hill area with more varieties and transplanting date.

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# RESEARCH PICTORIAL VIEWS

**Plate 1. Seed supply**

**Plate 2. Seedling Monitoring**

**Plate 3. Land preparation and Seedling Transplanting**

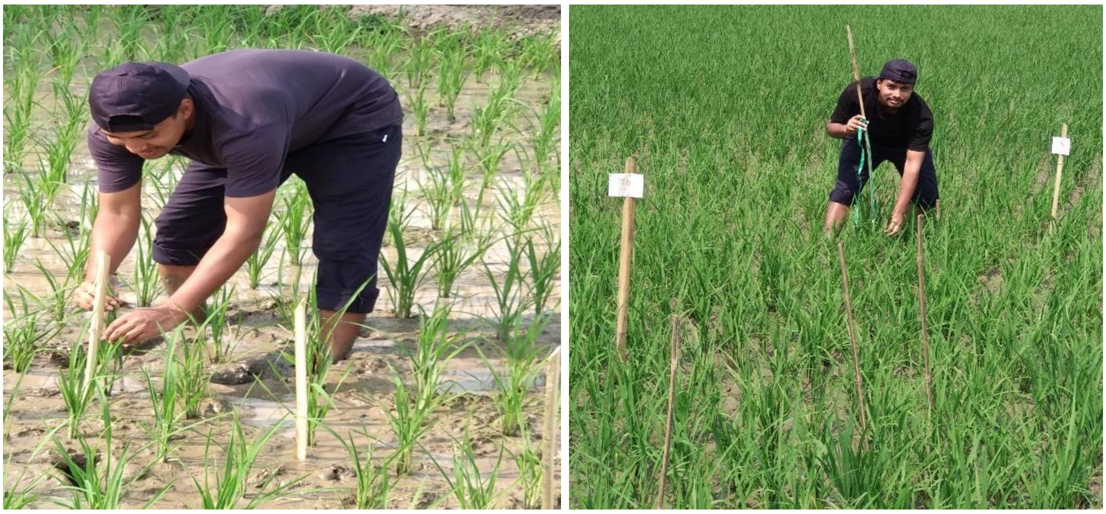

**Plate 4. Data Collection (Growth Stage)**

**Plate 5. Data Collection (Vegetative Stage)**

**Plate 6. Data Collection (Reproductive Stage)**

**Plate 7. Data Collection (Ripening Stage)**


**Plate 8. Experimental Field & Project Signboard**


**Plate 9. Field Day**

**Plate 10. Crop Harvesting**

**Plate 11. Crop Threshing and Cleaning**

**Plate 12. Data Collection (Laboratory)**

# APPENDICES

**Appendix 1. Mean sum square values of the data for plant height at different days after transplanting**

| Source of variation | DF | Mean Sum square values of plant height | | | | | |
|---|---|---|---|---|---|---|---|
| | | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** | **75 DAT** | **At harvest** |
| Replication | 2 | 3.37 | 0.917 | 31.381 | 6.05 | 14.47 | 9.21 |
| Transplanting date | 2 | 237.42** | 280.25** | 301.18** | 80.86 NS | 6.72NS | 2.27 NS |
| Variety | 4 | 7.86 NS | 30.85NS | 102.05* | 62.92 NS | 16.67NS | 37.51 NS |
| Transplanting date*Variety | 8 | 11.54 NS | 28.18 NS | 50.99* | 23.25 NS | 1.76 NS | 0.62 NS |
| Error | 28 | 8.92 | 12.608 | 19.144 | 27.46 NS | 18.15NS | 17.93 NS |
| Total | 44 | | | | | | |

* =Significance level is 0.05 ** =Significance level is 0.01 NS= Non significant

**Appendix 2. Mean sum square values of the data for number of leaves at different days after transplanting**

| Source of variation | DF | Mean Sum square values of leaf number | | | | | |
|---|---|---|---|---|---|---|---|
| | | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** | **75 DAT** | **At harvest** |
| Replication | 2 | 0.02 | 7.71 | 21.67 | 16.49 | 9.16 | 123.44 |
| Transplanting date | 2 | 0.08* | 379.29* | 663.95* | 106.22 NS | 60.01 | 305.62** |
| Variety | 4 | 0.017 NS | 87.87 | 39.38NS | 165.73 NS | 22.54 | 84.88** |
| Transplanting date*Variety | 8 | 0.023 NS | 68.04 | 176.32 NS | 66.79 NS | 118.15** | 107.49** |
| Error | 28 | 0.02 | 81.04 | 86.134 | 72.726 | 38.16 | 18.25** |
| Total | 44 | | | | | | |

* =Significance level is 0.05 ** = Significance level is 0.01 NS= Non significant

**Appendix 3. Mean sum square values of the data for tiller number at different days after transplanting**

| Source of variation | DF | Mean Sum square values of tillers hill$^{-1}$ | | | | |
|---|---|---|---|---|---|---|
| | | 30 DAT | 45 DAT | 60 DAT | 75 DAT | At harvest |
| Replication | 2 | 5.48 | 52.79 | 3.65 | 23.64 | 40.13 |
| Transplanting date | 2 | 22.95 NS | 16.92 NS | 8.09 NS | 13.26 NS | 5.44 NS |
| Variety | 4 | 4.10 NS | 13.59 NS | 20.98 NS | 8.98 NS | 2.71 NS |
| Transplanting date*Variety | 8 | 4.60 NS | 11.84 NS | 6.74 NS | 4.26 NS | 1.50 NS |
| Error | 28 | 9.0224 | 21.88 | 24.11 | 22.10 | 6.96 NS |
| Total | 44 | | | | | |

* =Significance level is 0.05 ** =Significance level is 0.01 NS= Non significant

**Appendix 4. Mean sum square values of the data for yield attributes such as effective tillers, panicle length, filled grain, unfilled grain, total grain and 1000-grain weight**

| Source of variation | DF | Mean Sum square values of yield attributes | | | | | |
|---|---|---|---|---|---|---|---|
| | | Effective tillers hill$^{-1}$ | Panicle length | Filled grain panicle$^{-1}$ | Unfilled grain panicle$^{-1}$ | Total grain panicle$^{-1}$ | 1000-grain weight |
| Replication | 2 | 4.44 | 0.26 | 4.91 | 20.35 | 6.32 | 0.017 |
| Transplanting date | 2 | 16.68* | 1.39 NS | 792.29** | 170.98** | 230.98** | 0.73** |
| Variety | 4 | 5.42 NS | 2.78* | 173.87** | 168.29** | 273.34** | 87.30** |
| Transplanting date*Variety | 8 | 0.54 NS | 0.63 NS | 3.37 NS | 7.08 NS | 4.47 | 0.10** |
| Error | 28 | 3.69 | 1.02 | 12.29 | 11.31 | 12.88 | 0.01 |
| Total | 44 | | | | | | |

* =Significance level is 0.05 ** =Significance level is 0.01 NS= Non significant

**Appendix 5. Mean sum square values of the data for grain yield, straw yield, Biological yield and harvest index**

| Source of variation | DF | Mean Sum square values of yield of *boro* rice | | | |
|---|---|---|---|---|---|
| | | Grain yield | Straw yield | Biological yield | Harvest index |
| Replication | 2 | 0.01 | 0.097 | 0.08 | 0.0001 |
| Transplanting date | 2 | 6.20** | 0.01 NS | 6.22** | 0.015** |
| Variety | 4 | 5.41** | 4.62 ** | 8.13** | 0.018** |
| Transplanting date*Variety | 8 | 0.15** | 0.07NS | 0.32** | 0.0002NS |
| Error | 28 | 0.03 | 0.05 | 0.07 | 0.00014 |
| Total | 44 | | | | |

* =Significance level is 0.05    ** =Significance level is 0.01    NS= Non significant

**Appendix 6. Mean sum square values of the data for grain yield monetary advantage, straw yield monetary advantage, and total marketable yield monetary advantage**

| Source of variation | DF | Grain yield return | Straw yield return | Total yield return |
|---|---|---|---|---|
| Replication | 2 | 5698408 | 1551797 | 5080106 |
| Transplanting date | 2 | 2.549E+09 ** | 6252.09 NS | 2.551E+09 ** |
| Variety | 4 | 1.951E+09 ** | 7.392E+07 ** | 1.690E+09 ** |
| Transplanting date*Variety | 8 | 4.444E+07 ** | 1176679 NS | 5.346E+07 ** |
| Error | 28 | 1.336E+07 | 790160 | 1.347E+07 |
| Total | 44 | | | |

* =Significance level is 0.05    ** =Significance level is 0.01    NS= Non significant