# EVALUATION OF GROWTH AND YIELD OF FOUR MORDERN RICE VARIETIES AS INFLUENCED BY SEEDLING AGE

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**EVALUATION OF GROWTH AND YIELD OF FOUR MORDERN RICE VARIETIES AS INFLUENCED BY SEEDLING AGE**

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*CERTIFICATE*

*This is to certify that the thesis entitled "**EVALUATION OF GROWTH AND YIELD OF FOUR MORDERN RICE VARIETIES AS INFLUENCED BY SEEDLING AGE**" submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (MS)** in Agricultural Botany, embodies the result of a piece of bona-fide research work carried out by **Md. Sajedul Islam** Registration No.**14-05914** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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**DEDICATED TO**

**MY**

**BELOVED PARENTS**

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# EVALUATION OF GROWTH AND YIELD OF FOUR MORDERN RICE VARIETIES AS INFLUENCED BY SEEDLING AGE

**Md. Sajedul Islam**

## ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka, during November-2019 to April 2020, to study the evaluation of growth and yield of four modern rice varieties as influenced by seedling age. The experiment consisted of two factors, and followed Randomized Complete Block Design (RCBD) with three replications. Factor A: Different rice varieties (4) *viz;* $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86, and $V_4$: BRRI dhan89and Factor B: Transplanting different age of seedling (3) *viz:* $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings. Data on different parameters were collected for assessing results for this experiment and showed significant variation in respect of growth, yield contributing characteristics and yield of *Boro* rice due to the effect of different rice variety, seedling age and their combinations. The highest number of tillers hill$^{-1}$was produced by BRRI dhan89 at all days after transplanting. The highest, number of effective tillers hill$^{-1}$ (16.86), panicle length (27.19 cm), filled grains panicle$^{-1}$ (152.75), 1000 grains weight (28.39 g), grain yield (6.69 t ha$^{-1}$), straw yield (7.74 t ha$^{-1}$), biological yield (14.42 t ha$^{-1}$) and harvest index (46.26 %) were recorded in BRRI dhan89variety ($V_4$). In case of seedling age, transplanting 25 days old seedling provided the highest number of tillers hill$^{-1}$ compared to transplanted 35- and 45-days old seedling. The values of all parameters studied were the highest in transplanting 25 days old seedling, except number of non-effective tillers hill$^{-1}$ and number of unfilled grainspanicle$^{-1}$. The height 1000 seeds weight (26.24 g), grain yield (6.92 t ha$^{-1}$), straw yield (8.29 t ha$^{-1}$), biological yield (15.19 t ha$^{-1}$) and harvest index (45.40 %) were recorded in transplanting 25 days old seedlings ($S_1$). In case of combined effect, BRRI dhan 89 along with transplanting at 25 days old seedling producedthe highest grain yield (7.86 t ha$^{-1}$) compared to other treatment combination. Thus, BRRI dhan89 and 25 days old seedling will be suitablefor optimum yield in respective edaphic-climatic conditions.

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# ABBREVIATIONS

| Full word | Abbreviations | Full word | Abbreviations |
|---|---|---|---|
| Agriculture | Agric. | Milliliter | mL |
| Agro-Ecological Zone | AEZ | Milliequivalents | Meqs |
| And others | et al. | Triple super phosphate | TSP |
| Applied | App. | Milligram(s) | Mg |
| Bangladesh Bureau of Statistics | BBS | Millimeter | Mm |
| Biology | Biol. | Mean sea level | MSL |
| Biotechnology | Biotechnol. | Metric ton | MT |
| Botany | Bot. | North | N |
| Centimeter | Cm | Nutrition | Nutr. |
| Cultivar | Cv. | Regulation | Regul. |
| Degree Celsius | °C | Research and Resource | Res. |
| Department | Dept. | Review | Rev. |
| Development | Dev. | Science | Sci. |
| Dry Flowables | DF | Silver nitrate | $AgNO_3$ |
| East | E | Soil plant analysis development | SPAD |
| Editors | Eds. | Soil Resource Development Institute | SRDI |
| Emulsifiable concentrate | EC | Technology | Technol. |
| Entomology | Entomol. | Tropical | Trop. |
| Environments | Environ. | Thailand | Thai. |
| Food and Agriculture Organization | FAO | United Kingdom | U.K. |
| Gram | G | University | Univ. |
| Horticulture | Hort. | United States of America | USA |
| International | Intl. | Wettable powder | WP |
| Journal | J. | Serial | Sl. |
| Kilogram | Kg | Percentage | % |
| Least Significant Difference | LSD | Microgram | µ |
| Liter | L | Number | No. |

## CHAPTER-I

# INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food crop and a primary food source for more than one-third of world's population (Sarkar *et al.,* 2017). Worldwide, rice provides 27% of dietary energy supply and 20% dietary protein (Kueneman, 2006). It constitutes 95% of the cereal consumed and supplies more than 80% of the calories and about 50% of the protein in the diet of the general people of Bangladesh (Yusuf, 1997). World's rice demand is projected to increase by 25% from 2001 to 2025 to keep pace with population growth (Maclean *et al.,* 2002), and therefore, meeting this ever-increasing rice demand in a sustainable way with shrinking natural resources is a great challenge. In Bangladesh, majority of food grains comes from rice. Rice has tremendous influence on agrarian economy of the country. Annual production of rice in Bangladesh is about 36.28 million tons from 11.52 million ha of land (BBS, 2018). According to the USDA report in 2021 rice production for the 2020-21 marketing year is expected to rise to 36.3 million tons in Bangladesh as further cultivation of hybrid and high yield variety plantings increase. The country is expected to import 200,000 tons of rice in the 2020-21 marketing year to ease food security tensions brought on by the COVID-19 pandemic (USDA, 2021).

There are three distinct growing seasons of rice in Bangladesh, according to changes in seasonal conditions such as *Aus, Aman* and *Boro*. More than half of the total production (55.50 %) is obtained in *Boro* season occurring in December–May, second largest production in *Aman* season (37.90 %) occurring in July-November and little contribution from *Aus* season (6.60 %) occurring in April-June (APCAS, 2016).

Recently, food security especially attaining self-sufficiency in rice production is a burning issue in Bangladesh. The average yield of rice is almost less than 50% of the world average rice grain yield. The national mean yield (2.60 t $ha^{-1}$) of rice in Bangladesh is lower than the potential national yield (5.40 t $ha^{-1}$) and world average yield (3.70 t $ha^{-1}$) (Pingali *et al.,* 1997).

In Bangladesh, BINA, BRRI, IRRI and diverse seed organizations has been presented high yielding rice varieties and it acquires positive monumentation in rice production for the particular three distinct growing seasons (Haque and Biswas, 2011). Now-a-day's different high yielding rice variety are available in Bangladesh which have more yield potential than different conventional varieties (Akbar, 2004). But still a wide gap between the potential yield and the actual yield exists in our country. Various efforts are being made in the country to narrow down this gap, of which the cultural methods and management practices are gaining importance.

Timely planting and use of appropriate aged seedlings for transplanting rice are important non cash inputs for realizing higher productivity in rice (Pattar *et al.,* 2001). An ideal age of seedlings for transplanting is governed by the duration of the variety and field conditions (Nandini and Singh, 2000).

Tillering in rice (*Oryza sativa* L.) is an important agronomic trait for panicle number per unit land area as well as grain production (Moldenhauer and Gibbons, 2003). The panicle-bearing tiller rate influences the grain yield of rice (Wang *et al*., 2007) and excessive tillering leads to high tiller abortion, poor grain setting, small panicle size, and further reduction in grain yield (Peng *et al*., 1994; Ahmad *et al*., 2005). For this reason excessive branching is often considered expensive (Dun *et al*., 2006), and formation of lowly productive tillers is considered an investment loss to the plant. Tillering characteristics can be altered by changes in environment and agronomic practices (Yoshida, 1973) and should be considered in relation to light intensity, temperature and carbohydrate metabolism. Higher panicle numbers per $m^2$ of direct-seeded rice are due to higher maximum tiller number per $m^2$ but not to higher panicle-bearing tiller rate (Huang *et al*., 2011). Tillering dynamics of the rice plant mainly depends on the age of seedling at transplanting (Pasuquin *et al.*, 2008). There is an in-built pattern of physiological development in the rice plant which puts out tillers regularly and sequentially which is described in terms of *phyllochrons.* Berkelaar (2001) reported that for maximum tillering, the plant has to complete as many *phyllochrons* as possible during its vegetative phase. Each tiller produces another two *phyllochrons* later under favorable growing conditions (Singh *et al.*, 2007). When a seedling is transplanted carefully at the initial growth stage, the trauma of root damage caused during uprooting is minimized following a rapid growth with short *phyllochrons*. Mobasser *et al.* (2007) observed that when seedlings stay for a longer period of time in the nursery beds, primary tiller buds on the lower nodes of the main culm become degenerated leading to reduced tiller production. When the seed is not planted too deep, tillering starts early in about fortnight from sowing in case of direct seeding. But, transplanted rice takes little longer time period to start tillering as it first needs more time to recover from transplanting shock. When rice seedlings are transplanted at the right time in terms of age, tillering and growth proceed normally and only fewer tillers are produced during vegetative period leading to poor yield if transplanting is delayed (Mobasser *et al.*, 2007). Many researchers have reported that grain yields increase by transplanting seedlings that are younger than 25 days (Nandini and Singh, 2000; Thanunathan and Sivasubramanian, 2002; Singh *et al.,* 2004; Manjunatha *et al.,* 2010 and (Sarwar *et al.,* 2011).

Generally, farmers raise rice nursery about a month earlier for normal planting, expecting timely availability of water. Of late, due to delay in the onset of monsoons and frequent drought, filling of reservoirs and tanks is delayed. This situation forces the farmers to wait for the water which leads to delayed transplanting of overages seedlings. Labour scarcity during the peak season of transplanting is another reason for late planting with overages seedlings. All the varieties will not perform equally, when transplanted with overages seedlings. Under these circumstances, suitable variety is required for getting higher yields.

Hence, the present investigation was taken up with the following objectives.

i. To compare the effect of seedling age on four modern rice varieties in relation to tillering, leaf area index, dry matter accumulationand yield.
ii. To evaluate the performance of aforesaid rice varieties under varying seedling age.

## CHAPTER II

# REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available regarding to study the effect of seedling age on growth and yield of four modern rice varieties in *Boro* season, to gather knowledge helpful in conducting the present piece of work.

### 2.1 Effect of rice variety

#### Plant height

Akter *et al.* (2018) carried out an experiment to evaluate the effect of integrated nitrogen (N) application on the yield of *Boro* rice and reported that BRRI dhan74 produced the taller plant (89.00 cm) than the BRRI dhan29 (81.10 cm). The varietal differences might be due to heredity or varietal character.

Chamely *et al.* (2015) reported that plant height is a varietal character and it is the genetic constituent of the cultivar, therefore, plant height was different among the cultivars.

Rahman, and Bulbul (2014) observed that the tallest plant(107.00cm) was found in BRRI hybrid2 theshortestplant (101.95cm) was found in BRRI dhan29. Variation in plant height might be due to the differences in the genetic make–up of the varieties.

Tyeb *et al.* (2013) reported that the variation in plant height due varietal differences. Varietal differences in plant height might be due to the heredity or varietal character.

Shamsuddin *et al.* (1998) reported that a variable plant height existed among the varieties.

#### Tillering in rice

A rice tiller is a specialized grain-bearing branch that is formed on the unelongated basal internode and grows independently of the mother stem (culm) by means of its own adventitious roots (Li, 1979). Tillering determines the plant architecture and canopy development for capture of incident light for primary production (Mohapatra and Kariali, 2008). It also depends on the genotypes and on the resources available for growth (Shahidullah *et al*., 2009). The mother culm is the source of nutrients for tiller buds inside the leaf sheath, but after the third leaf stage, tillers start their own photosynthesis and their mode of nutrition shifts to autotrophy from heterotrophy (Hanada, 1995). A tiller possesses its own independent entity after its emergence from the enclosure of the preceding leaf sheath (Sahu *et al*., 2004). In rice, a number of tiller types are usually formed, ranging from primary to quaternary and this depends on the type of culm from which a tiller emerges. Consequently, a primary tiller emerges from a main stem; a secondary tiller from a primary tiller, a tertiary tiller from a secondary tiller, and a quaternary tiller from a tertiary tiller. Tillers are further categorized into orders; tiller order referring to the ranking of tiller emergence from first to the last to emerge from a plant (Counce *et al*., 1996).

Verheye (2010) showed that direct seeding may result in two to five panicle bearing (productive) tillers while transplanted rice may have 5 to 30 productive tillers.

Sahu*et al*. (2004) reported that a late developed tiller may not be able to produce assimilates enough to sustain growth of the reproductive organs due to poorer photosynthetic area and older condition of the plant as a whole. Since each tiller has a different generation and development pattern, among the tillers, the pattern of panicle development is hierarchical, and grain yield becomes poorer in each subsequent productive tiller.

Moldenhauer and Slaton (2001) report that rice plants generally produce two to five panicle bearing tillers per plant compared to 10 to 30 tillers per plant in transplanted rice, where more space is available between plants. Yoshida (1981) reported that, tillers that do not bear panicles are called ineffective tillers. The number of ineffective tillers is a closely examined trait in plant breeding since it is undesirable in irrigated varieties, but sometimes an advantage in rainfed lowland varieties where productive tillers or panicles may be lost due to unfavorable conditions. A study by Chaudhry and Mclean (1963) also records that there are more productive tillers per plant under flooded than non-flooded (rainfed) conditions.

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

Akter *et al.* (2018) reported that higher (10.12) number of total tillers hill$^{-1}$ obtained by BRRI dhan74 than (9.70) number of total tillers hill$^{-1}$ reported by BRRI dhan29.

Wang *et al.* (2016) reported that the unequal distribution of photosynthetically active radiation (PAR) was the source of heterogeneity in individual tiller' yields, in that early emerging superior tillers pre-empted the uppermost light source, and shaded the late emerging tillers under limited light conditions.

Rahman, and Bulbul (2014) reported that that all the yield and yield contributing characters were significantly influenced by the variety. The highest number of total tillers hill$^{-1}$ (10.96) was found in BRRI hybrid2 and the lowest number of total tillers was found (10.63) in BRRI dhan29. The variation in number of total tillers hill-$^{1}$ might be due to varietal characteristics.

Kariali *et al*. (2012) reported that premature senescence of the newer tiller's limits grain yield by reduction of effective panicle number of the plant and number of grains on the newer tillers. Higher proportion of senescing tillers, will effect on grain yield.

Mohapatra *et al*. (2011) reported that increasing the number of later-initiated tertiary tillers does not contribute much to the final grain yield.

Huang *et al*. (2011) reported that increasing the panicle number is an effective approach to enhance rice yield for many breeding programs. Panicle number however, is largely determined by the number of tillers that develop during the vegetative stage.

Verheye (2010) reported that interaction of nutrients occurs within rice tillers, vascular bundles among main stem and tillers, and among main stem and early-emerging tillers can provide nutrients to the late-emerging tillers at tillering stage. Thus, the greater this interaction, the higher the rate of tiller survival, and hence effective mobilization and partitioning of photosynthetic assimilates, for optimum yield production. It should also be noted that, it is from the surviving tillers that the potential panicles per unit area are determined, which has an impact on yield.

Mohapatra and Kariali (2008) reports that, in rice, the manipulation of tiller number is important for grain yield, but the physiological basis of the regulation of tiller growth remains unclear.Fageria, (2007) shown that the number of tillers determined at the initiation of panicle growth stage and was more highly correlated with grain yield than at any other growth stages in lowland rice.Wang *et al*. (2007) report that excessive tillering leads to high tiller abortion, poor grain setting, small panicle size and further reduced grain yield. Variation in grain development and yield among tillers is variable over the varieties differing in tillering ability. Meanwhile, variation in grain yield and quality among tillers has been considered as a major factor affecting yield potential and quality for a given rice variety.

Counce and Keisling (1995) reported that grain yield and its components vary greatly with tiller type, and early initiated tillers produce more grains than late initiated ones.

Miller *et al.* (1991) reported that, the tillering ability of the rice plant had a great impact on panicle production, which was highly correlated with grain yield.

Chamely *et al*. (2015) showed that at all sampling dates except 25 DAT, variety BRRI dhan29 produced the highest number of total tillers hill$^{-1}$. The results indicate that tillering pattern of different varieties differed due to genetic potentiality of the varieties. Babikar (1986) reported the variation of tiller production due to cultivars.

Yoshida (1981) report that in high yielding semi-dwarf rice, early and high tillering capacity is considered beneficial for grain yield.

**Dry matter weight hill$^{-1}$**

Chamely *et al*. (2015) showed that among the varieties the highest total dry matter (66.41 g m$^{-2}$) was observed in BRRI dhan45 and the lowest dry matter (61.24 g) was observed in BRRI dhan29.

Ullah *et al.* (2016) carried out an experiment to determine the suitable nitrogen source for increasing the grain yield by reducing spikelet's sterility in *Boro* rice. The experiment comprised four nitrogen sources such as no nitrogen ($T_0$), BRRI recommended dose of prilled urea ($T_1$), Govt. approved dose of mixed NPK ($T_2$) and BARC recommended dose of USG ($T_3$), and four varieties viz. BRRI dhan29 ($V_1$), BRRI dhan58 ($V_2$), BADC SL8H ($V_3$) and Heera ($V_4$). Experiment result showed that among the varieties the maximum dry matter was found for $V_4$ (41.5g/hill)) whereas minimum from $V_1$ (37.0 g/hill) at 105 DAT respectively. Alam *et al.* (2009) found difference in total dry matter accumulation in different genotypes.

Sharma and Singh (1994) noticed a wide variability in photosynthetic rates exists in rice cultivars which may cause difference in dry matter accumulation.

**Effective tillers hill$^{-1}$**

Latif *et al.* (2020) showed that the highest number of effective tillers hill$^{-1}$ (17.64) was produced by BRRI dhan29 whereas the lowest values of respective effective tillers were found in BR14. The reduction of number of effective tillers hill$^{-1}$ in BR14 was due to tiller mortality in the vegetative stages. The probable reason of these results might be due to different genetic makeup of these varieties which are influence by heredity.

Akter *et al.* (2018) carried out an experiment to evaluate the effect of integrated nitrogen (N) application on the yield of *Boro*rice and revealed that all the yield and yield contributing characters except number of sterile spikelet panicle$^{-1}$ were significantly influenced by the variety. Performance of BRRI dhan74 was better compared to BRRI dhan29 in terms of all parameters. BRRI dhan74 produced maximum effective tillers hill$^{-1}$ (9.09) than the BRRI dhan29 (8.65). The varietal differences might be due to heredity or varietal character.

Chamely *et al*. (2015) observed significant differences among rice varieties. They reported that the highest number of effective tillers hill$^{-1}$ (11.07) was recorded in the variety BRRI dhan29 and the lowest one was observed in BRRI dhan45. The reasons for differences in producing bearing tillers hill$^{-1}$ might be due to the variation in genetic make-up of the variety that might be influenced by heredity.

**Non effective tillers hill$^{-1}$**

Rahman, and Bulbul (2014) revealed that all the yield and yield contributing characters were significantly influenced by the variety. The highest number of non-effective tillers (1.95) was found in BRRI dhan29 and the lowest number of non-effective tiller hill$^{-1}$ (1.85) was found in BRRI hybrid2. These differences occurred due to variations of genetic make-up among the varieties. Kamal *et al.* (2007) observed significant difference on non-effective tillers among the varieties. Among the different varieties BRRI dhan28 had the lowest number of effective tillers hill$^{1}$ (6.44) and lowest number of grains panicle$^{-1}$ (134.89) but the highest number of non-effective tillers hill$^{-1}$ (6.67) which contributed to the worst performance of this variety.

**Panicle length**

Hossain *et al.* (2016) revealed that different rice varieties and nutrient levels along with their interaction have significant effect on growth and yield of rice. It was observed that panicle length of the crop influenced by variety. Binadhan-10 produced longer panicle (24.60 cm) compared to BRRI dhan28 (20.97 cm).

Chamely *et al.* (2015) reported that the longest panicle (23.19 cm) was found in the variety BRRI dhan29 and the smallest one was observed in BRRI dhan45. The variation as assessed might be due to genetic characters of the varieties primarily influenced by the heredity. Diaz *et al.* (2000) also reported that panicle length varied among varieties.

**Filled grain panicle$^{-1}$**

Ullah *et al.* (2016) showed that among the varieties the maximum number of filled grain was for the Heera ($V_4$) (98.8/panicle) whereas minimum for BRRI dhan58 ($V_2$) (82.1/panicle) variety.

**Unfilled grain panicle$^{-1}$**

Afroz *et al.* (2019) showed that the highest number (81.20) of grains panicle$^{-1}$ and the lowest number (17.43) of sterile spikelet's panicle-$^{1}$ were observed in BRRI dhan29 cultivar. On the other hand, the lowest number (76.82) of grains panicle$^{-1}$ was recorded in BRRI dhan28 cultivar.

Akter *et al.* (2018) reported that numerically BRRI dhan29 gave the higher (6.32) number of sterile spikelet panicle-$^{1}$ than BRRI dhan74 (6.01).

Ullah *et al.* (2016) carried out an experiment to determine the suitable nitrogen source for increasing the grain yield by reducing spikelet's sterility in *Boro* rice. The experiment comprised four nitrogen sources such as no nitrogen ($T_0$), BRRI recommended dose of prilled urea ($T_1$), Govt. approved dose of mixed NPK ($T_2$) and BARC recommended dose of USG ($T_3$), and four varieties viz. BRRI dhan29 ($V_1$), BRRI dhan58 ($V_2$), BADC SL8H ($V_3$) and Heera ($V_4$). Experiment result showed that among the varieties the lowest number of unfilled grain was obtained from $V_1$ (7.5/panicle) while highest $V_2$ (13.7/panicle) variety.

**Grains panicle$^{-1}$**

Latif *et al.* (2020) indicated that among the varieties, BRRI dhan29 produced the highest number (111.0) of grains panicle$^{-1}$ and the lowest one (93.0) was recorded in BR14. Number of grains panicle$^{-1}$ differed significantly due to variety.

Akter *et al.* (2018) reported that higher (97.74) number of total grains panicle$^{-1}$obtained by BRRI dhan74 than (94.33) grains panicle$^{-1}$reported by BRRI dhan29.

Singh and Gangwar (1989) reported that variable numbers of grains panicle$^{-1}$ were found among the varieties. Varietal differences regarding the number of grains panicle$^{-1}$ might be due to differences in their genetic constituents.

**1000 grains weight**

Latif *et al.* (2020) reported that 1000 grains weight was significantly differ due to the varietal performance. The highest 1000-grain weight (26.33 g) was obtained in BR14 than BRRI dhan28 (22.60 g) and BRRI dhan29 (22.43 g).

Rahman *et al.* (2020) revealed that among the varieties the highest 1000-grain weight (26.65 g) was obtain in BRRI hybrid dhan3 while the lowest (21.43 g) was obtain in BRRI dhan28.

**Grain yield**

Latif *et al.* (2020) reported that BRRI dhan29 produced the highest grain yield (4.56 t ha$^{-1}$) than BRRI dhan28 (4.01 t ha$^{-1}$) and BR14 (3.77 t ha$^{-1}$). The probable reason of the different grain yields due to the different yield parameters (tillers hill$^{-1}$, grains panicle$^{-1}$, 1000-grain weight etc.) influenced by the genetic make-up of the variety.

Afroz *et al.* (2019) reported that the highest grain yield (5.17 t ha$^{-1}$) was recorded in BRRI dhan29 cultivar. This might be due to the fact of producing highest number of total and effective tillers hill$^{-1}$, highest number of grains panicle-$^{1}$, lowest number of sterile spikelet's panicle$^{-1}$ and heaviest 1000-grain weight of the cultivar BRRI dhan29. The lowest grain yield (3.89 t ha$^{-1}$) was found in BRRI dhan28 cultivar due to lowest number of total and effective tillers hill$^{-1}$, lowest number of grains panicle$^{-1}$, highest number sterile spikelet's panicle$^{-1}$ and lightest 1000-grain weight.

Hossain *et al.* (2016) reported that due to difference in variety, the grain yield of rice varied significantly. The highest grain yield (6.38 t $ha^{-1}$) produced by the variety Binadhan-10 where BRRI dhan28 produced 4.69 t $ha^{-1}$.

Rahman, and Bulbul (2014) reported that among the variety's performance the highest grain yield (5.64 t/ha) was achieved from BRRI hybrid2. The lowest grain yield (4.93t/ha) was achieved from BRRI dhan29. The highest yield occurred due to higher plant height, higher total tillers $hill^{-1}$ and lower number non-effective tiller $hill^{-1}$.

**Straw yield**

Chamely *et al*. (2015) observed that among the varieties the highest straw yield was observed in the variety BRRI dhan28. This was due to the higher total DM production in the cultivar BRRI dhan28.

**Biological yield**

Chowhan *et al.* (2019) reported that variety Shakti-2 ($V_4$) produced the highest biological yield (18.14 t/ha), whereas the lowest by BRRI dhan28 ($V_1$) (12.21 t/ha) and Binadhan-14 ($V_2$) (12.15 t/ha). It was observed that, varieties which had higher grain and straw yield ultimately obtained the highest biological yield.

Rahman, and Bulbul (2014) reported that among the variety's performance the highest biological yield (12.34$tha^{-1}$) was obtained from BRRI hybrid2 and the lowest one (10.76$tha^{-1}$) was obtained from BRRI dhan29.

**Harvest index**

Chowhan *et al.* (2019) found significant differences of harvest index among different rice varieties. From their experiment, they observed that Varieties Shakti-2 ($V_4$), Heera-1 ($V_3$) and BRRI dhan28 ($V_1$) had an identical harvest index of 50.9%, 48.5% and 47.9 respectively. OnlyBinadhan-14 ($V_2$) produced the harvest index (40.0%). It appears that hybrid rice maintained higher harvest index.

Akter *et al.* (2018) reported that harvest index was higher in BRRI dhan29 (42.86%) than BRRI dhan74 (39.28%). Kamal *et al.* (2007) showed that the highest harvest index (45.35%) was recorded from BRRI dhan28 and the lowest one (41.18%) was obtained form B1NADHAN-5.

## 2.2 Effect of seedling age

### Plant height

Pramanik and Bera (2013) reported that the increase in plant height from earlier transplanting seedlings might be due to more vigor, root growth and lesser transplant shock because of lesser leaf area during initial stages of crop growth, which stimulate increased cell division causing more stem elongation.

Sarker *et al.* (2013) conducted a study on the effect of age of seedlings on growth and yield of two modern rice varieties during *Boro* season and reported that plant height differed significantly among cultivars and increasing seedling age gradually decreasing plant height.

Krishna (2006) from Dharwad reported that 12 days old seedling performed better than 8-, 16- and 25-days old seedlings in terms of yield and yield attributes, B: C ratio, seed quality along with plant height, seedling dry weight and vigor index.

Gani*et al.* (2002) reported that young seedlings (7 or 14 days old) performed better than 21 days old seedlings. The plants of young seedlings were taller and they produced longer and heavier roots, a greater number of effective tillers and biomass.

### Tillers hill$^{-1}$

Krishna *et al.* (2009) conducted a experiment in Karnataka and revealed that the 12 days old seedling produced more number of tillers hill$^{-1}$ at harvest. The 8 days old seedling flowered and matured about four to five days early compared to 25 days old seedlings. The treatment combination of 12 days old seedling with wider spacing recorded maximum seed yield per hectare. Significantly higher seed yield (3.27 t ha$^{-1}$) and less spikelet sterility (16.72 per cent) recorded by 12 days old seedlings.

Sridevi and Hellmuth (2007) observed thatthe combination of single and young seedling per hill with square planting and cone-weeding gave highest tiller m$^{-2}$and grain yield than the normal seedling or multiple seedlings with rectangular planting and hand weeding.

Uthoff (2002a) also stated that transplanting of very young seedlings usually 8-10 days old and not more than 15 days will have better tillering and rooting and it was reduced if transplanting was done after the $4^{th}$phyllochron usually about 15 days after emergence.

**Dry matter weight hill$^{-1}$**

Ali *et al*. (2013) reported that the maximum dry matter production (211 g) was recorded from 15 days old seedlings and lowest (180 g) from 30 days old seedlings.

Mamun *et al.* (2013) reported that less dry matter production was noticed from 8 days old seedlings compared to 30-day old seedlings.

More *et al.* (2007) noticed that planting younger seedlings of 15 days age led to significant increase in dry matter production as compared to use of older seedlings of 20- and 28-days age and the extent of increase was 9.62 and 18.80%, respectively.

Mondal and Roy (1984) reported that seedling age affects dry matter accumulation. Crop raised with young seedling showed higher dry matter accumulation than older seedling.

**Effective tiller hill$^{-1}$**

Sultana *et al.* (2020) conducted a field experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from July 2016 to December 2016 to find out the effect of seedlings age and different nitrogen (N) levels on the yield performance of transplant Aman rice (cv. Binadhan-15). The experiment revealed that by using optimum seedling age at 15 DAT recorded the highest number of effective tillers plant$^{-1}$(8.29) at harvest respectively. The differences of non-effective tillers hill$^{-1}$ is the genetic makeup of the variety.

Rahman, and Bulbul (2014) also found similar result which supported the present finding and reported that all the highest number of non-effective tillers (1.95) was found in BRRI dhan29 and the lowest number of non-effective tiller hill$^{-1}$ (1.85) was found in BRRI hybrid2. These differences occurred due to variations of genetic make-up among the varieties.

Ali *et al.* (2013) reported more effective tillers/hill (24.9) when seedlings of 15 days age were transplanted while 30 days old seedlings gave minimum number of effective tillers (15.6).

Kavitha and Ganesharaja (2012) reported from Madurai that 14 days old seedling recorded significantly higher number of productive tillers ($m^{-2}$) over 18 and 22 days old seedlings under SRI.

Faghani *et al.* (2011) found the significant effect of seedlings age on tillering pattern, and concluded that the maximum tillers/ hill (16.3) was recorded by transplanting 25 days old seedlings while 35 days seedlings gave minimum tillers/hill (15.3).

Oteng and Anna (2003) from Ghana (South Africa) observed that 10-15 days old seedlings produced a greater number of effective tillers than those of 15-20 days and 20-25 days old seedlings under SRI practices.

**Panicle length**

Veeranna and Reddy (2010) found that panicle length did not vary significantly with transplanting different aged seedlings.

Pal and Mahunta (2010) found that longest panicle was observed with transplanting of 25 days old seedlings as compared to 35 days old seedlings. Faruk *et al.* (2009) reported that the panicle length was increased up to 4 weeks seedling age but beyond this, there was significant reduction in panicle length.

Singh *et al.* (2004) conducted an experiment at New Delhi during *kharif* season, with 21-, 31-, 41- and 51-days old seedlings and found that longest paniclewas produced by 21 days old seedlings whereas shortest panicle was produced by51 days old seedlings.

**Filled grain panicle$^{-1}$**

Pal and Mahunta (2010) reported that the number of filled spikelets per panicle did not differ significantly with different ages of seedlings.

Faruk*et al.* (2009) reported that transplanting of 3- and 4-weeks old seedlings produced maximum number of filled spikelets per panicle over crop planted with 2- and 5-weeks old seedlings.

Singh and Singh (1998) reported that transplanting of 25, 35, 45 days old seedlings responded significantly and found that number of filled spikelets per panicle decreased with increasing age of seedling.

**Unfilled grain panicle$^{-1}$**

Pattar *et al.* (2001) observed that number of sterile spikelet panicle$^{-1}$ was significantly highest in younger (25 days) seedlings than older seedlings used (45 days) in an experiment conducted during *kharif* season at Gangavathi.

Bhagat *et al.* (1991) observed that number of sterile spikelets per panicle increased significantly with each 10 days increase in the seedling age during transplanting.

**Grains panicle$^{-1}$**

Kavitha *et al.* (2011) observed that total number of spikelets per panicle were significantly higher with 14 days old seedlings as compared to 18 and 22 days old seedlings during *kharif* season.Singh *et al.* (2004) found that the highest number of spikelets was produced by the youngerseedlings (21 days old) and the lower number of spikelets per panicle was produced by the older seedlings (51 days old).

Patel (1999) conducted an experiment with 30-, 40- and 50-days old seedlings and found that the total number of spikelets panicle$^{-1}$ were highest in 30 days seedlings.

Yoshii *et al.* (1998) reported that transplanting of 10-, 15- and 20-days seedling showed significant variation with respect to yield components and 20 days seedling recorded the highest number of spikelets per unit area.

**1000 seed weight**

Pramanik and Bera (2013) carried out astudy to observed the Effect of seedling age and nitrogen fertilizer on growth, chlorophyll content, yield and economics of hybrid rice (*Oryza sativa* L.) and noticed that maximum 1000 grains weight 23.62 g was obtained from the transplanting of 10 days old seedling.Dahal and Khadka (2012) worked out of four aged of seedling group's viz.,8, 15, 22 and 29-days under SRI in Nepal. The results showed that 8-day-old seedlings produced significantly higher 1000-seed weight (21.10 g).Sarwa*et al.* (2011) conducted a study to investigate the impact of nursery seeding density, nitrogen, and seedling age on yield and yield attributes of fine rice and reported that younger seedlings of 10 days and 20 days oldregistered comparable higher 1000 grains weight of 21.43 g and

18.78 g respectively and its significantly superior over 30 (15.54 g) and 40days (14.8 g) old seedlings.

Tari *et al.* (2007) stated that appropriate time of transplanting resulted in higher 1000 grain weight.

Singh and Singh (1998) revealed that yield attributes viz 1000-grain weight significantly increased with transplanting of younger seedlings as compared to older seedlings.

**Grain yield**

Virk *et al*. (2020) carried out an experiment to identify the suitable seedling age of fine rice cultivars in transplanted rice systems under AWD and found that younger seedlings (20 days old) produced 14.69% and 13.36% longer panicle, 19.36% and 18% more filled grains panicle$^{-1}$ in both years (2017 and 2018) respectively as compared to the older seedlings (35 days old). Moreover, younger seedling (20 days) produced 22% and 22.92% kg ha$^{-1}$ more yield in comparison to (35 days) older seedling in both years, respectively.

Reuben *et al.* (2016), the study treatments adopted were three representing 8-, 12- and 15-days old seedlings. The rice variety tested was TXD 306 Super SARO, which was recommended by the ministry of Agriculture in Tanzania (United Kingdom).The yield for the three treatments was also investigated at the end of the season. No significant, differences was observed in rice yield in all the three treatments though 12 days has a slight higher yield compared to other rice ages. The rice yield were 8.4, 8.5 and 8.1 tones ha$^{-1}$ for 8, 12 and 15 days old transplanted seedlings respectively..

Patra and Haque (2011) reported from West Bengal, that transplantation of 10 days old seedling gave 18.66 per cent and 24.99 per cent more grain yield than 18- and 6-daysaged seedlings, respectively and also seen that for every day delay in transplanting beyond the age of 10 days caused reduction in grain yield to the extent of 4.5 per cent ha$^{-1}$ year$^{-1}$.

Krishna *et al.* (2009) conducted a experiment in Karnataka and revealed that the treatment combination of 12 days old seedling with wider spacing recorded maximum seed yield per hectare. Significantly higher seed yield (3.27 t ha$^{-1}$) and less spikelet sterility (16.72 per cent) recorded by 12 days old seedlings.Menete *et al*. (2008) reported that higher older seedling resulted in lesser grain yield *i.e*., 9.3, 8.6 and 7.8t ha$^{-1}$as against 10-, 20- and 30-days old seedlings, respectively.In Bhutan, Lhendup (2006) recorded maximum grain yield and other parameters with seedlings of 3-leaf stage with 30 cm x 30 cm spacing.

Porpavi *et al.* (2006) tested four rice varieties viz., ADT36, ADT43, ADT45and ADT47with using 14- and 25-days old seedlings under SRI. The performance of ADT43 and ADT47with 14 days seedling under SRI found better than 25 days aged seedling. The crop duration reduced by 5 to 6 days under system of rice intensification with14 days old seedlings as well.

Basu *et al.* (2003) opined that transplanting of 21-day old seedlings gave identical grain yield with direct sown crop and matured 8-10 days earlier. Hussain*et al.* (2003) obtained 7.7t ha$^{-1}$ grain yield with SRI (15 days old seedling) while it was 5.4 t ha$^{-1}$ in conventional practice with 36 days old seedling. Diechar *et al.* (2002) in Cambodia reported that 8-12 daysold seedlings performed better and had significantly higher yield potential then those of 15-20 days and 20-25 days old seedlings under SRI.Randriamiharisoa and Uphoff (2002) reported that young seedlingswere found tobe the most important practice in hesetrials, none could be discarded without some loss. With growing conditions controlled, using all SRI practices, young seedlings, one seedling hill$^{-1}$, aerated soil, and added compost gave yield increase of 140 to 245 per cent, compared to plot where only non-SRI practices -more mature seedlings, three seedling hill$^{-1}$, and saturated soil with NPK fertilizer used.

**Straw yield**

Panigrahi *et al*. (2014) conducted a field experiment during the kharif season of 2007 and 2008 at OUAT, Bhubaneswar on basmati rice varieties under system of rice intensification (SRI) that observed growth, yield and economics of basmati rice did not vary much between the crops planted with 10 and 15-day old seedlings.

Bagheri *et al.* (2011) noticed that the highest (635.8 g m$^{-2}$) straw yield was obtained from 20 days old seedlings over 30 and 40 days.Rajesh and Thanunathan (2003) reported that the seedling age had significant difference on straw yield. Planting of 40 day old seedlings found to be optimum to get significantly higher (5.63 t ha$^{-1}$) straw yield compared to 30 (5.09 t ha$^{-1}$) and 50 (4.76 t ha$^{-1}$) days old seedlings.Sharma and Ghosh (1998) stated that younger seedlings produced significantly higher straw (7.53 t ha$^{-1}$) yields as compared to older seedlings from their studieson hybrids rice.

**Biological yield**

Chakrabortty (2013) conducted a field experiment at the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2011 to May 2012 to study the growth and yield of *Boro* rice as affected by seedling age and planting geometry under System of Rice Intensification (SRI) and reported that seedling age varied biological yield of *Boro* rice and the maximum biological yield (9.84 t $ha^{-1}$ ) was recorded in 16 days old seedling and the minimum biological yield (8.73 t $ha^{-1}$ ) was found in 30 days old seedling.

Chandrapala *et al.* (2010) a fieldexperiment conducted during thekharifseason of 2007 and 2008 on sandy clay loam soil-havingpH 7.65 at Hyderabad. That observed that the transplanting of 12-day old seedling of rice (cv. Rassi) under SRI at a spacing of 25×25 cm, was recorded significantly higher biological yield over 25 days seedling under conventional transplanting at 20×15 cm and direct sowing of sprouted rice under un-puddled condition.

**Harvest index**

Islam *et al.* (2021) carried out an experiment in the Agriculture Field Laboratory, Noakhali Science and Technology University (NSTU) to evaluate the effects of age of seedlings on the yield and growth performance of transplanted Aus (T. *Aus*) rice variety from April 2019 to July 2019 and observed that the age of seedlings had significantly affected total tillers/hill, effective tillers/hill, panicle length in T. *Aus* rice variety. The highest harvest index (33.88%) was obtained from 22 days old seedlings. The lowest harvest index (30.467%) was obtained from 30 days old seedlings.

Pramanik and Bera (2013) reported that maximum harvest index of 45.19 and 47.00 was noticed from 10 days and 15 days old seedlings.

# CHAPTER III

# MATERIALS AND METHODS

This chapter presents a concise depiction about experimental period, site description, climatic condition, crop or planting materials that were being used in the experiment,

treatments, experimental design and layout, crop growing technique, fertilizers application, uprooting of seedlings, intercultural operations, data collection and statistical analysis.

## 3.1 Location of the experimental site

### 3.1.1 Geographical location

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar Agargaon, Dhaka, 1207. The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

### 3.1.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

## 3.2 Experimental Duration

The experiment was conducted during the period from November 2019 to April 2020 in Transplanting *Boro*season.

## 3.3 Soil characteristics of the experimental field

Soil of the experimental site was silty clay loam in texture belonging to Tejgaon series (Anon., 1988 a). The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8–6.5, ECE-25–28 (Anon., 1988 b). Soil samples from 0- 15 cm depths were collected from the experimental field. The analytical data of the soil sample collected from the experimental area were analyzed in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

### 3.4 Climate condition of the experimental field

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from March to August, but scanty rainfall associated with moderately low temperature prevailed during the period from March to August (Edris *et al*., 1979). The detailed meteorological data in respect of Maximum and minimum temperature, relative humidity and total rainfall were recorded by the meteorology centre, Dhaka for the period of experimentation have been presented in Appendix III.

### 3.5 Planting material

BRRI dhan84, BRRI dhan88, BRRI dhan86 and BRRI dhan89were being used as test crops for this experiment.

### 3.6 Seed collection and sprouting

BRRI dhan84, BRRI dhan88, BRRI dhan86 and BRRI dhan89 rice varieties seed were collected from BRRI (Bangladesh Rice Research Institute), Joydebpur, Gazipur. Healthy and disease free seeds were selected following standard technique. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hrs which were suitable for sowing in 72 hrs.

### 3.7 Raising of seedlings

A typical system was followed in raising of seedlings in the seedbed. The nursery bed was set up by puddling with continued ploughing followed by laddering. The sprouted seeds were planted as uniformly as possible. Irrigation was delicately given to the bed as and when required. No fertilizers were used in the nursery bed.

### 3.8 Preparation of experimental field

The experimental field was first opened on 17November, 2019 with the help of a power tiller, later the land was irrigated and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering, to have a good puddled field. Various kind of weeds and developments of pest crop were disposed of from the field. Final land preparation and the field layout was made on 24 November 2019. Each plotwas cleared in and finally leveled out with the help of wooden board.

### 3.9 Fertilizer management

The following doses of fertilizer were applied for cultivation of T. *Boro* rice (FRG, 2012).

| Fertilizers | Quantity (kg/ha) |
|---|---|
| Urea | 300 |
| TSP | 100 |
| MP | 120 |
| Gypsum | 60 |

Plant Macronutrients (*viz*. nitrogen, phosphorus, potash, sulfur) for rice were given through urea, triple super phosphate, muriate of potash, and gypsum, respectively. Plant micronutrients *viz*. Zinc and boron were as given through Zinc sulphate and boric acid according to the treatment requirements. All of the fertilizers except urea were applied as basal dose at the time of final land preparation. Urea (300 kg $ha^{-1}$) was applied in equal three splits.

### 3.10 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design having 3 replications. There were 12 treatment combinations and 36 unit plots. The unit plot size was 5.76 $m^2$ (2.4 m × 2.4 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively. The treatments were assigned in plot at random. The layout of the experimental field was shown in Appendix- IV.

### 3.11 Experimental details

**Seed bed preparation date**: 1 November 2019.

**Seed sowing date**: 1 November 2019.

**Spacing**: 25 cm × 15 cm

**Fertilizer apply date**: All the fertilizers were applied at 24 November 2019 during final land preparation except total urea

**Transplanting date**: 25 November, 5 December and 15 December

**Harvesting date**: 30 April 2020

### 3.12 Experimental treatments

The experiment consisted of two factors as mentioned below:

**Factor A**: *Boro* rice varieties (4) *viz.:*

$V_1$: BRRI dhan84

$V_2$: BRRI dhan88

$V_3$: BRRI dhan86

$V_4$: BRRI dhan89

**Factor B**: Seedling age (3) *viz.*

$S_1$: 25 days

$S_2$: 35 days and

$S_3$: 45 days old seedlings

### 3.13 Intercultural operations

#### 3.13.1 Gap filling

Died off seedlings in some hills, were replaced by vigor and healthy seedling from same source within 7 days of transplantation.

#### 3.13.2 Application of irrigation water

Irrigation water was added to each plot according to the critical stage. Irrigation was done up to 5 cm.

#### 3.13.3 Method of water application

The experimental plots were irrigated through irrigation channels. Centimeter marked sticks were installed in each plot which were used to measure depth of irrigation water.

#### 3.13.4 Weeding

Two hand weeding were done During plant growth period. First weeding was done at 40 DAT (Days after transplanting) followed by second weeding at 60 DAT.

### 3.13.5 Plant protection measures

The crop was attacked by yellow rice stem borer (*Scirpopagaincertulas*) at the panicle initiation stage which was successfully controlled with Sumithion @ 1.5 L $ha^{-1}$. Yet to keep the crop growth in normal, Basudin was applied at tillering stage @ 17 kg $ha^{-1}$ while Diazinon 60 EC @ 850 ml $ha^{-1}$ were applied to control rice bug and leaf hopper. Crop was protected from birds during the grain filling period by using net and covering the experimental field.

### 3.13.6 General observations of the experimental field

Regular observations were made to see the growth and visual different of the crops, due to application of different treatment were applied in the experimental field. In general, the field looked nice with normal green plants. Incidence of stem borer, green leaf hopper, leaf roller was observed during tillering stage and there were also some rice bug were present in the experimental field. But any bacterial and fungal disease was not observed.

### 3.13.7 Harvesting and post-harvest operation

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80-90% of the grains become golden yellow in colour.Five (5) pre-selected hills per plot from which different data were collected and 1.00 $m^2$ areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor.. Threshing was done by pedal thresher. The grains were cleaned and sun dried to moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were recorded and converted to t $ha^{-1}$.

### 3.14 Data collection

The data were recorded on the following parameters

i. Plant height
ii. Number of tillers $hill^{-1}$
iii. Leaf area index

iv. Above ground dry matter weight $hill^{-1}$
v. Number of effective tillers $hill^{-1}$
vi. Number of non-effective tillers $hill^{-1}$
vii. Panicle length
viii. Number of filled grains $panicle^{-1}$
ix. Number of unfilled grains $panicle^{-1}$
x. Number of total grains $panicle^{-1}$
xi. Weight of 1000- grain
xii. Grain yield
xiii. Straw yield
xiv. Biological yield
xv. Harvest index

**3.15 Relationship**

i. Functional relationship between tiller number and grain yield at harvest.

**3.16 Procedure of recording data**

**i) Plant height**

The height of the randomly selected 5 plant was determined by measuring the distance from the soil surface to the tip of the leaf at 15 DAT interval start at 30 DAT and harvest respectively.Mean plant height of rice plant were calculated and expressed in cm.

**ii) Number of tillers $hill^{-1}$**

Number of tillers $hill^{-1}$ were counted at 15 DAT interval start at 30 DAT up to harvest from pre-selected hills and finally averaged as their number $hill^{-1}$. Only those tillers having three or more leaves were considered for counting.

**iii) Leaf area index**

Leaf area index were estimated manually by counting the total number of leaves per plant and measuring the length and average width of leaf and multiplying by a factor of 0.75 (Kluen and Wolf, 1986). It was done at 30, 60 and 90 DAT.

$$\text{Leaf area index} = \frac{\text{Surface area of leaf sample } (\text{cm}^2) \times \text{Correction factor}}{\text{Ground area from where the leaves were collected}}$$

**iv) Above ground dry matter weight hill$^{-1}$**

Total above ground dry matter weight hill$^{-1}$ was recorded at 15 DAT interval start at 30 DAT and harvest respectively by drying plant sample. The sample plants were oven dried for 72 hours at 70°C and then data were recorded from plant samples hill$^{-1}$ plot$^{-1}$ selected at random from the outer rows of each plot leaving the border line and expressed in gram.

**v) Panicle length**

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Panicle length was measured with a meter scale from 5 selected panicles and average value was recorded.

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

The total number of effective tillers hill$^{-1}$ was counted as the number of panicle bearing tillers per hill. Data on effective tiller per hill were recorded from 5 randomly selected hill at harvesting time and average value was recorded.

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

The total number of non-effective tillers hill$^{-1}$ was counted as the tillers, which have no panicle on the head. Data on non-effective tiller per hill were counted from 5 pre-selected (used in effective tiller count) hill at harvesting time and average value was recorded.

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

The total number of filled grains was collected randomly from selected 5 plants of a plot and then average number of filled grains per panicle was recorded.

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

The total number of unfilled grains was collected randomly from selected 5 plants of a plot based on, no or partially developed grain in spikelet and then average number of unfilled grains per panicle was recorded.

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

The number of fertile grains panicle$^{-1}$ alone with the number of sterile grains panicle$^{-1}$ gave the total number of grains panicle$^{-1}$.

**xi) Weight of 1000-grain**

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

**xii) Grain yield**

Grain yield was adjusted at 14% moisture. Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central $1m^2$ area was measured and then record the final grain yield of each $plot^{-1}$ and finally converted to t $ha^{-1}$ in both locations.

**xiii) Straw yield**

After separating the grains, straw yield was determined from the central 1 $m^2$ area of each plot. After threshing the sub-samples were sun dried to a constant weight and finally converted to t $ha\text{-}^1$.

**xiv) Biological yield**

The summation of grain yield and above ground straw yield was the biological yield. Biological yield =Grain yield + straw yield.

**xv) Harvest index**

Harvest index was calculated on dry weight basis with the help of following formula.

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

Here, Biological yield = Grain yield + straw yield

**3.17 Data analysis technique**

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of computer package program name Statistix 10 data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to study the tillering dynamics and yield contributing characters and yield of hybrid rice in *Boro* season. The results have been discussed, and possible interpretations are given under the following headings.

### 4.1.1 Plant growth parameters

### 4.1.1 Plant height

**Effect of variety**

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach (Figure 1). From the experiment, result revealed that, plant height showed significant variation at different days after transplanting due to effect of different rice variety. Experimental result showed that the highest plant height (33.74, 47.85, 71.81, 84.20 and 93.63 cm) at 30, 45, 60, 75 DAT and at flowering respectively was recorded in $V_4$ (BRRI dhan89) treatment which was statistically similar with $V_2$ **(**VBRRI dhan88) treatment recorded plant height (45.04 and 92.76 cm) at 45 DAT and at flowering respectively. Whereas the lowest plant height (26.63, 37.48, 60.30, 71.44 and 83.98 cm) at 30, 45, 60, 75 DAT and at flowering respectively was recorded in $V_3$ (BRRI dhan86) treatment which was statistically similar with $V_1$ treatment recorded plant height (27.49, 40.47, 73.44 and 86.27 cm) at 30, 45, 75 DAT and at flowering respectively. The variation of plant height is probably due to the genetic make-up of the variety. Similar result also observed by Akter*et al.* (2018) and Chamely *et al.* (2015). They reported that plant height is a varietal character and it is the genetic constituent of the cultivar, therefore, plant height was different among the cultivars. Shamsuddin *et al.* (1998) also reported that a variable plant height existed among the varieties.

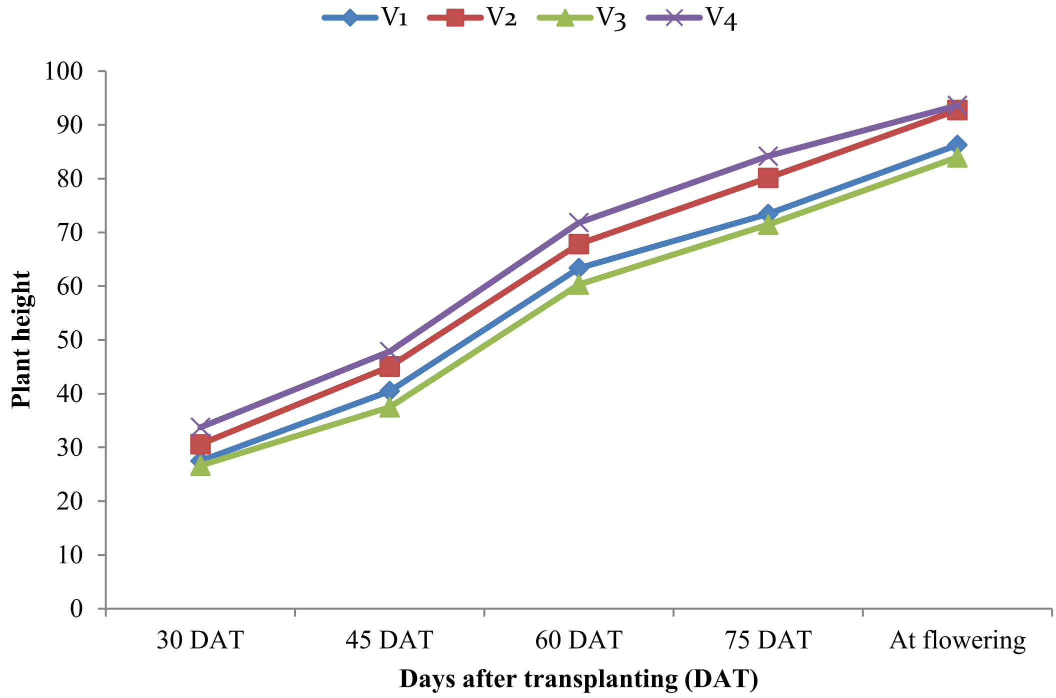


**Figure 1. Effect of variety on plant height of *Boro* rice at different DAT**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89]

**Effect of seedling age**

Different seedling age had significant effect on plant height of *Boro* rice at different days after transplanting (Figure 2). Experiment result revealed that, the height plant height (34.16, 47.12, 71.79, 83.35 and 95.27 cm) at 30, 45, 60, 75 DAT and at flowering respectively was recorded in 25 days old seedling ($S_1$). Whereas 45 days old seedling ($S_3$) recorded the lowest plant height (25.53, 37.60, 59.62, 71.07 and 81.85 cm) at 30, 45, 60, 75 DAT and at flowering respectively This might be due to the fact that optimum age of seedlings helped crop to complete its vegetative phase in favorable climatic conditions. The result obtained from the present study was similar with the findings of Pramanik and Bera (2013) and reported that the increase in plant height from earlier transplanting seedlings might be due to more vigour, root growth and lesser transplant shock because of lesser leaf area during initial stages of crop growth, which stimulate increased cell division causing more stem elongation.Sarker *et al.* (2013) also reported that plant height differed significantly among cultivars and increasing seedling age gradually decreasing plant height.

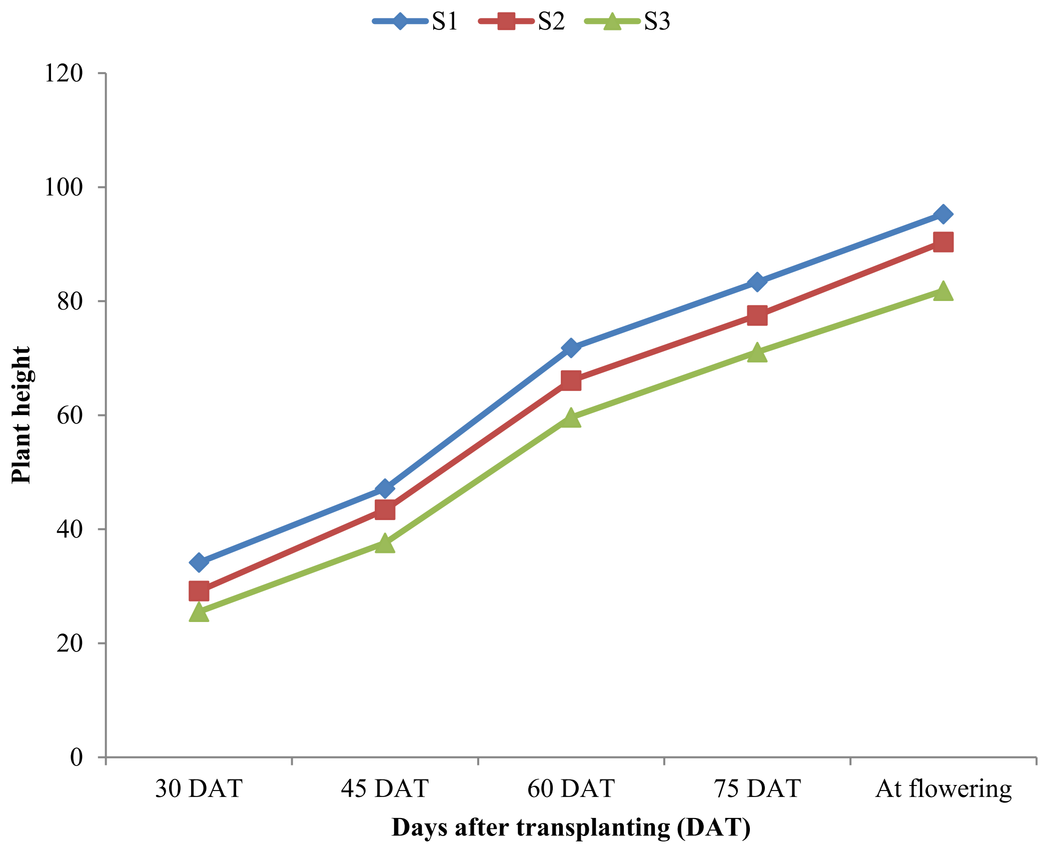


**Figure 2. Effect of seedling age on plant height of *Boro* rice at different DAT**[Here, $S_1$: 25 days , $S_2$: 35 days and $S_3$: 45 days old seedlings]

**Combined effect of variety and seedling age**

Plant height varied significantly due to combined effect of variety and seedling age at different days after transplanting (Table 1). Experimental result revealed that the highest plant height (38.78, 52.03, 81.02, 92.68 and 104.53 cm) at 30, 45, 60, 75 DAT and at flowering respectively was recorded in $V_4S_1$ treatment combination which was statistically similar with $V_2S_1$ treatment combination recorded plant height (35.78, 50.57, 77.01, 90.11 and 102.23 cm) at 30, 45, 60, 75 DAT and at flowering respectively whereas the lowest plant height (23.10, 32.05, 54.73, 64.70 and 76.75) at 30, 45, 60, 75 DAT and at flowering respectively was recorded in $V_3S_3$ treatment combination which was statistically similar with $V_1S_3$ (25.10 cm) and $V_3S_3$ (25.90 cm) treatment combination at 30 DAT; with $V_1S_3$ (34.07 cm) and $V_3S_3$ (36.95 cm) treatment combination at 45 DAT; and with $V_1S_3$ (56.93, 66.80 and 80.85 cm) treatment combination at 60, 75 DAT and at flowering respectively.

**Table 1. Combined effect of variety and seedling age on plant height of *Boro* rice at different DAT**

| Treatment combinations | Plant height at | | | | |
|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 75 DAT | At flowering |
| $V_1S_1$ | 31.18 cd | 42.44 cde | 65.99 bc | 75.19 bc | 86.31 c |
| $V_1S_2$ | 26.18 ef | 44.91 b-d | 67.14 bc | 78.33 bc | 91.66 b |
| $V_1S_3$ | 25.10 f | 34.07 f | 56.93 d | 66.80 de | 80.85 de |
| $V_2S_1$ | 35.78 ab | 50.57 ab | 77.01 a | 90.11 a | 102.23 a |
| $V_2S_2$ | 30.78 cd | 43.63 cd | 64.28 c | 77.77 bc | 91.44 b |
| $V_2S_3$ | 25.25 ef | 40.91 de | 62.23 c | 72.55 cd | 84.60 cd |
| $V_3S_1$ | 30.90 cd | 43.44 cd | 63.15 c | 75.41 bc | 88.00 bc |
| $V_3S_2$ | 25.90 ef | 36.95 ef | 63.02 c | 74.20 bc | 87.20 bc |
| $V_3S_3$ | 23.10 f | 32.05 f | 54.73 d | 64.70 e | 76.75 e |
| $V_4S_1$ | 38.78 a | 52.03 a | 81.02 a | 92.68 a | 104.53 a |
| $V_4S_2$ | 33.78 bc | 48.14 abc | 69.82 b | 79.70 b | 91.17 b |
| $V_4S_3$ | 28.66 de | 43.37 cd | 64.60 c | 80.21 b | 85.20 cd |
| $LSD_{(0.05)}$ | 3.53 | 5.81 | 4.95 | 6.40 | 4.61 |
| CV(%) | 7.05 | 8.04 | 4.44 | 4.89 | 3.05 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 $V_4$: BRRI dhan89and $S_1$: 25 days,$S_2$: 35 days and $S_3$: 45 days old seedlings.

### 4.1.2 Number of tillers hill$^{-1}$

**Effect of variety**

Rice tillers are special grain-bearing branch that is formed on the unelongated basal internode and grows independently of the mother stem (culm) by means of its own adventitious roots. In this experiment number of tiller number hill$^{-1}$significantly affected by different rice varieties at different days after transplanting (Figure 3). Experimental result revealed that, the highest number of tillers hill$^{-1}$ (5.80, 7.93, 15.59, 21.66 and 18.59) at 30, 45, 60, 75 DAT and at harvest, respectively, was recorded in $V_4$ (BRRI dhan89) treatment which was statistically similar with $V_2$ (BRRI dhan88) treatment recorded tillers number hill$^{-1}$ (7.89) at 45 DAT. Whereas the lowest number of tiller number hill$^{-1}$ (4.51, 6.47, 10.51, 17.05 and 13.77) at 30, 45, 60, 75 DAT and at harvest respectively was recorded in $V_3$ (BRRI dhan86) treatment. The variation of tiller number hill$^{-1}$ is probably due to the genetic make-up of the cultivars. Similar result also observed by Chamely *et al*. (2015). They showed that at all sampling dates except 25 DAT, variety BRRI dhan29 produced the highest number of total tillers hill$^{-1}$. The results indicate that tillering pattern of different varieties differed due to genetic potentiality of the varieties. Rahman, and Bulbul (2014) also reported that that all the yield and yield contributing characters were significantly influenced by the variety. The highest number of total tillers hill$^{-1}$ (10.96) was found in BRRI hybrid2 and the lowest number of total tillers was found (10.63) in BRRI dhan29. The variation in number of total tillers hill-$^{1}$ might be due to varietal characteristics.

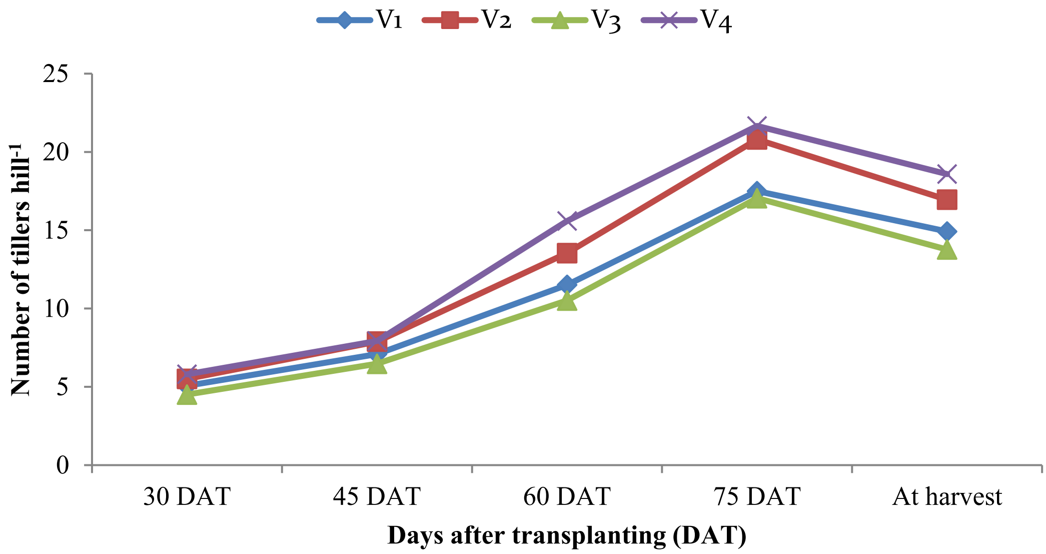


**Figure 3. Effect of variety on number of tillers hill$^{-1}$ of *Boro* rice at different DAT**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Number of tiller number hill$^{-1}$significantly affected by seedling age at different days after transplanting (Figure 4).Experimental result revealed that, the highest number of tillers hill$^{-1}$(5.75, 8.12, 14.33, 22.28 and 17.30) at 30, 45, 60, 75 DAT and at harvest, respectively, was recorded in transplanting 25 days old seedlings ($S_1$). Whereas the lowest number of tillers hill$^{-1}$(54.62, 6.48, 10.66, 16.85 and 14.18) at 30, 45, 60, 75 DAT and at harvest, respectively, was recorded in transplanting 45 days old seedlings ($S_3$).Overall younger seedlings produced higher numbers of tillers than older seedlings, which might be due to less root damage and minimum transplanting shock, as younger seedlings can more easily establish themselves after transplanting in the main field. The result obtained from the present study was similar with the findings of Uphoff (2002a) and stated that transplanting of very young seedlings usually have better tillering and rooting which influences the tillering number hill$^{-1}$.

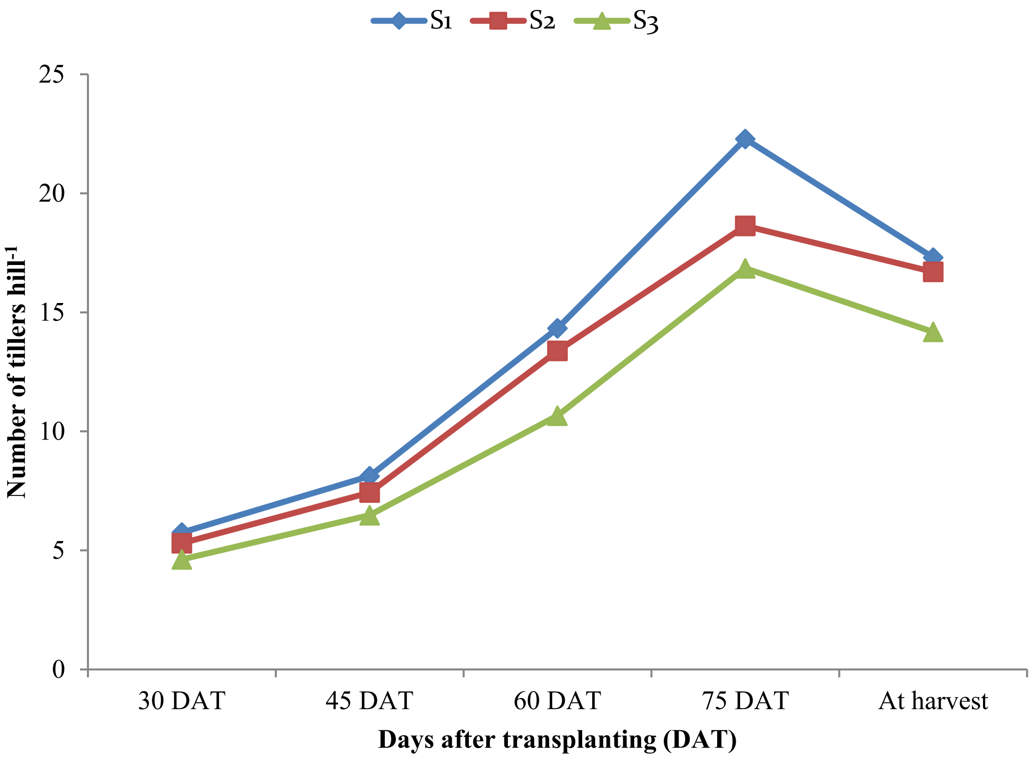


**Figure 4. Effect of seedling age on number of tillers hill$^{-1}$ of *Boro* rice at different DAT**[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Combined effect of variety and seedling age significantly influenced the number of tillers hill$^{-1}$ at different days after transplanting (Table 2). Experimental result revealed that, the highest number of tiller number hill$^{-1}$ (6.20, 9.13, 17.33, 24.30 and 20.10) at 30, 45, 60, 75 DAT and at harvest, respectively, was recorded in $V_4S_1$ treatment combination which was statistically similar with$V_2S_1$ (6.07), $V_4S_2$ (6.00 treatment combination at 30 DAT; with $V_2S_1$ (8.73) treatment combination at 45 DAT; with $V_4S_2$ (16.77) treatment combination at 60 DAT and with $V_2S_1$ (23.97) at 75 DAT. Whereas the lowest number of tiller number hill$^{-1}$ (4.07, 6.07, 9.20, 13.86 and 10.10) at 30, 45, 60, 75 DAT and at harvest, respectively, was recorded in $V_3S_3$ treatment combination which was statistically similar with$V_1S_3$ (4.20) treatment combination at 30 DAT; with $V_1S_3$ (6.20), $V_3S_2$ (6.47) and $V_2S_3$ (6.53) treatment combination at 45 DAT and with $V_3S_2$ (10.00) treatment combination at 60 DAT.

**Table 2. Combined effect of variety and seedling age on number of tillers hill$^{-1}$ of *Boro* rice at different DAT**

| Treatment combinations | Number of tillers hill$^{-1}$ at | | | | |
|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 75 DAT | At harvest |
| $V_1S_1$ | 5.73 bc | 7.73 c | 12.00 d | 20.76 b | 15.23 e |
| $V_1S_2$ | 5.27 de | 7.33 c-e | 12.20 d | 16.87 d | 15.43 e |
| $V_1S_3$ | 4.20 fg | 6.20 g | 10.33 e | 14.86 e | 14.10 f |
| $V_2S_1$ | 6.07 a | 8.73 ab | 15.67 b | 23.97 a | 18.10 bc |
| $V_2S_2$ | 5.47 cd | 8.40 b | 14.53 c | 19.10 c | 17.23 cd |
| $V_2S_3$ | 5.00 e | 6.53 fg | 10.42 e | 19.33 c | 15.53 e |
| $V_3S_1$ | 5.00 e | 6.87 ef | 12.33 d | 20.10 bc | 15.77 e |
| $V_3S_2$ | 4.47 f | 6.47 fg | 10.00 ef | 17.20 d | 15.43 e |
| $V_3S_3$ | 4.07 g | 6.07 g | 9.20 f | 13.86 e | 10.10 g |
| $V_4S_1$ | 6.20 a | 9.13 a | 17.33 a | 24.30 a | 20.10 a |
| $V_4S_2$ | 6.00 ab | 7.53 cd | 16.77 a | 21.33 b | 18.70 b |
| $V_4S_3$ | 5.20 de | 7.13 de | 12.67 d | 19.33 c | 16.97 d |
| $LSD_{(0.05)}$ | 0.32 | 0.58 | 0.85 | 1.28 | 0.94 |
| CV(%) | 3.62 | 4.69 | 3.90 | 3.93 | 3.45 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 $V_4$: BRRI dhan89and $S_1$: 25 days,$S_2$: 35 days and $S_3$: 45 days old seedlings.

### 4.1.3 Leaf area index

**Effect of variety**

The leaf area index (LAI) of the crop is crucial in the quantitative description of the canopy structure and photosynthetic processes. Since leaves are essential for photosynthesis and produce the bulk of biomass, the number of leaves and leaf area index will also influence yield.Leaf area index significantly affected by different rice varieties at different DAT (Figure5). Experiment result showed that $V_4$ treatment (BRRI dhan89) recorded the maximum leaf area index (0.92, 2.01 and 2.85) at 30, 45, and 60 DAT which was due to the varietal potentiality comparable to others rice varieties and it was statistically similar with BRRI dhan88 ($V_2$) at 45 and 60 DAT. While the BRRI dhan86 ($V_3$) variety recorded minimum leaf area index (0.77, 1.65and 2.25) at 30, 45 and 60 DAT. The variation in leaf area index was due to the effect of varietal differences.

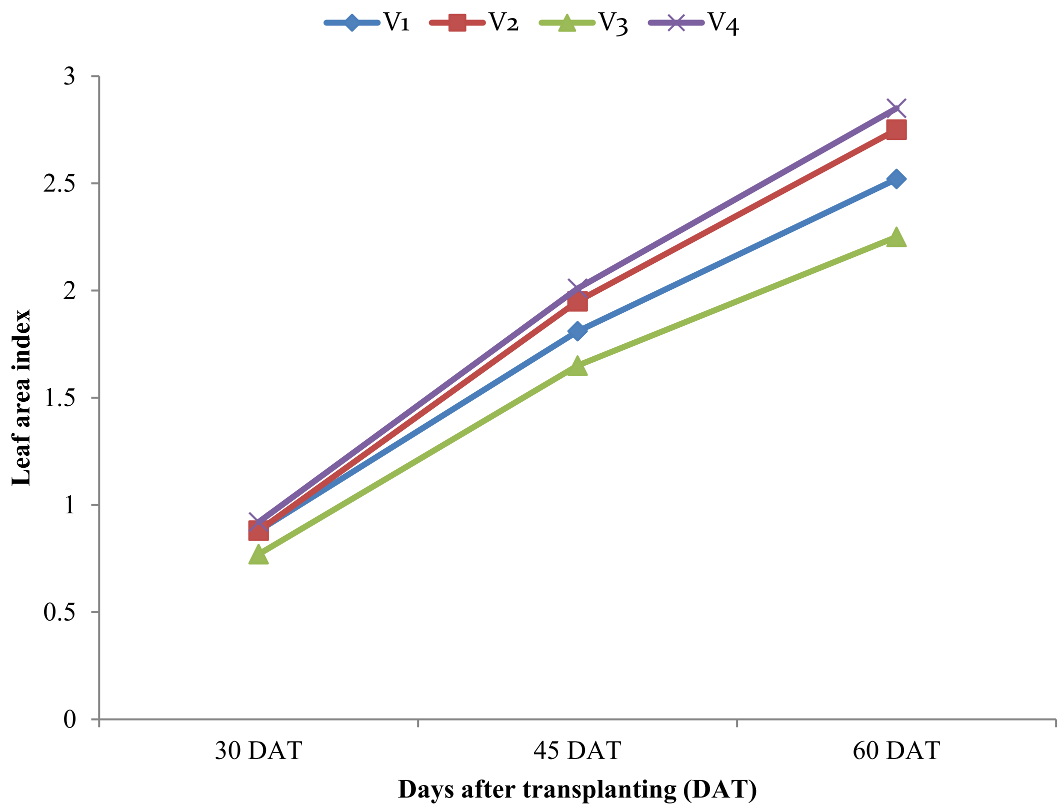


**Figure 5. Effect of variety on leaf area index of *Boro* rice at different DAT**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89]

**Effect of seedling age**

Significant variation was observed in leaf area index due to the effect of different seedling age (Figure 6).Experiment result showed that $S_1$ treatment recorded the maximum leaf area index (0.97, 2.14 and 3.08) at 30, 45, and 60 DAT. While the

BRRI dhan86 ($V_3$) variety recorded minimum leaf area index (0.76, 1.65 and 2.25) at 30, 45 and 60 DAT.

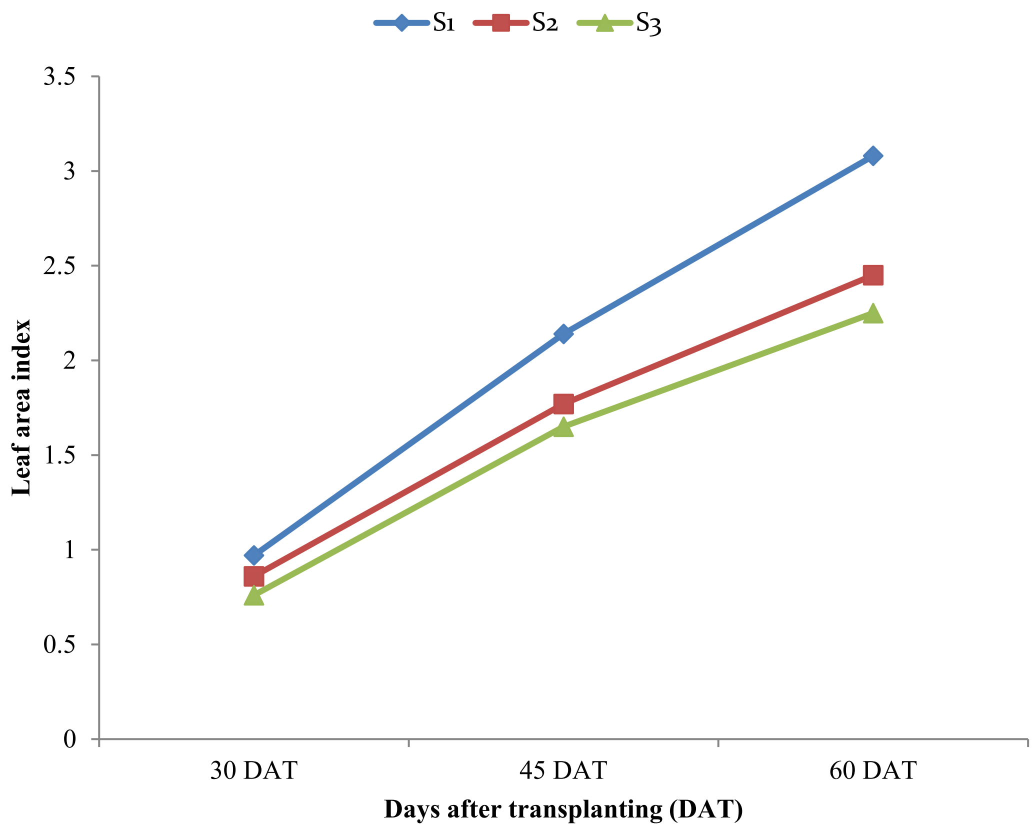


**Figure 6. Effect of seedling age on leaf area index of *Boro* rice at different DAT**

[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

### Combined effect of variety and seedling age

Combined effect of variety and seedling age showed significant effect on leaf area indexof *Boro* rice at different days after transplanting (Table 3). Experimental result revealed that the highest leaf area index(1.03, 2.37 and 3.45) at 30, 45 and 60 DAT was recorded in $V_4S_1$ treatment combination which was statistically similar with $V_2S_1$ (0.99) and $V_1S_1$ (0.99) treatment combination at 30 DAT; with $V_2S_1$ (2.26 and 3.28) at 45 and 60 DAT. Whereas the lowest leaf area index (0.63, 1.55 and 2.09) at 30, 45 and 60 DAT was recorded in $V_3S_3$ treatment combination which was statistically similar with $V_3S_2$ (1.55) and $V_1S_3$ (1.60) treatment combination at 45 DAT; with $V_3S_2$.

**Table 3. Combined effect of variety and seedling age on leaf area index of *Boro* rice at different DAT**

| Treatment combinations | Leaf area index at | | |
|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT |
| **$V_1S_1$** | 0.99 a | 2.09 b | 3.00 b |
| **$V_1S_2$** | 0.87 b | 1.72 de | 2.36 d |
| **$V_1S_3$** | 0.77 d | 1.60 ef | 2.18 de |
| **$V_2S_1$** | 0.99 a | 2.26 a | 3.28 a |
| **$V_2S_2$** | 0.87 b | 1.86 c | 2.61 c |
| **$V_2S_3$** | 0.80 cd | 1.71 e | 2.36 d |
| **$V_3S_1$** | 0.86 b | 1.84 cd | 2.57 c |
| **$V_3S_2$** | 0.84 bc | 1.55 f | 2.09 e |
| **$V_3S_3$** | 0.63 e | 1.55 f | 2.09 e |
| **$V_4S_1$** | 1.03 a | 2.37 a | 3.45 a |
| **$V_4S_2$** | 0.87 b | 1.94 c | 2.74 c |
| **$V_4S_3$** | 0.85 bc | 1.71 e | 2.35 d |
| **$LSD_{(0.05)}$** | 0.05 | 0.12 | 0.19 |
| **CV(%)** | 3.39 | 3.99 | 4.45 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 $V_4$: BRRI dhan89and $S_1$: 25 days,$S_2$: 35 days and $S_3$: 45 days old seedlings.

### 4.1.4Total dry matter weight hill$^{-1}$

**Effect of variety**

The dry matter weight hill$^{-1}$ (g)differ among different varieties due to reason that individual variety have individual leaf area, growth stage, and resources utilization its surrounded which influences the dry matter weight hill$^{-1}$ (g). In this experiment, result showed that different rice varieties showed significant effect on dry matter weight hill$^{-1}$ (g) of *Boro* rice at different DAT (Figure 7). Experimental result revealed that, among different treatments the highest dry matter weight hill$^{-1}$ (3.67, 10.04, 14.25, 18.25 and 36.39 g) at 30, 45, 60, 75 DAT and at harvest respectively was recorded in $V_4$ (BRRI dhan89) treatment which was statistically similar with $V_2$ (BRRI dhan88) treatment recorded dry matter weight hill$^{-1}$ (9.74, 13.76 and 34.99 g) at 45, 60 DAT and at harvest respectively. Whereas the lowest dry matter weight hill$^{-1}$ (3.09, 8.24, 11.28, 14.52 and 30.35 g) at 30, 45, 60, 75 DAT and at harvest respectively was recorded in $V_3$ (BRRI dhan86) treatment. The result obtained from the present study was similar with the findings of Chamely *et al*. (2015) and they reported that the highest total dry matter (g m$^{-2}$) differs among rice varieties. Alam *et al.* (2009) also found difference in total dry matter accumulation in different genotypes.

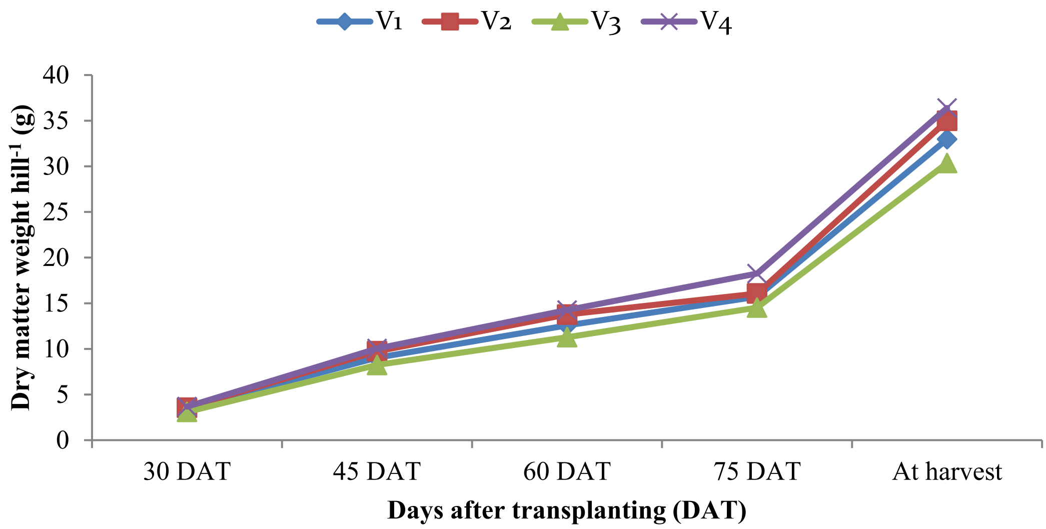


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**Figure 7. Effect of variety on dry matter weight hill$^{-1}$of *Boro* rice at different DAT**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89]

**Effect of seedling age**

The dry matter weight hill$^{-1}$ (g)consists of all its constituents excluding water. Significant variation was observed in dry matter weight hill$^{-1}$by seedling age of *Boro* rice at different days after transplanting (Figure 8). Experiment result showed that, the highest dry matter weight hill$^{-1}$(3.87, 10.71, 15.39, 17.86 and 38.58 g) at 30, 45, 60, 75 DAT and at harvest respectively was recorded in transplanting 25 days old seedling ($S_1$). Whereas transplanting 45 days old seedling ($S_3$) recorded the lowest dry matter weight hill$^{-1}$(3.05, 8.23, 11.24, 14.94 and 30.09 g) at 30, 45, 60, 75 DAT and at harvest respectively. Delay in transplanting results in concomitant reduction in dry matter production of seedling and longer stay of seedling in the seedbed affects seedling growth pattern in response to high seedling competition. Also the transplanting shock received during transplanting at advanced stage resulted in poor growth of old seedling, which might have hindered the dry weight accumulation. Mondal and Roy (1984) reported that seedling age affects dry matter accumulation. Crop raised with young seedling showed higher dry matter accumulation than older seedling.

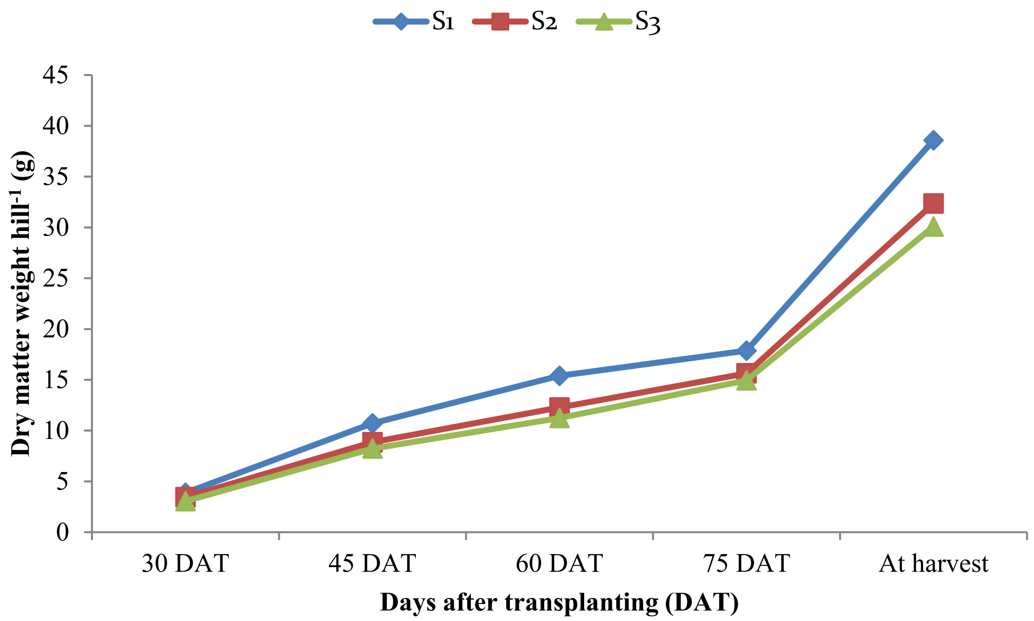


**Figure 8. Effect of seedling age on dry matter weight hill$^{-1}$of *Boro* rice at different DAT**

[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Dry matter weight hill$^{-1}$was significantly influenced by combined effect of variety and seedling ageof *Boro*rice at different days after transplanting (Table 4). Experimental result revealed that the highest dry matter weight hill$^{-1}$(4.13, 11.84 17.26, 21.44 and 42.32 cm) at 30, 45, 60, 75 DAT and at harvest respectively was recorded in $V_4S_1$ treatment combination which was statistically similar with $V_2S_1$ (3.97 g) and $V_1S_1$ (3.97 g) treatment combination at 30 DAT; with $V_2S_1$ (11.32, 16.41 and 40.61) at 45, 75 DAT and at harvest respectively. Whereas the lowest plant height (2.52, 7.77, 10.48, 13.42 and 28.76) at 30, 45, 60, 75 DAT and at harvest respectively was recorded in $V_3S_3$ treatment combination which was statistically similar with $V_3S_2$ (7.76 g) and $V_1S_3$ (8.02 g) treatment combination at 45 DAT; with $V_3S_2$ (10.47 cm) and $V_1S_3$ (10.90 g) treatment combination at 60 DAT; with $V_3S_2$ (14.42 g) and $V_1S_3$ (14.45 g) at 75 DAT and with $V_3S_2$ (28.73 g), $V_1S_3$ (29.60 g) and $V_2S_3$ (30.43 g) treatment combination at harvest respectively.

**Table 4. Combined effect of variety and seedling age on dry matter weight hill$^{-1}$ of *Boro* rice at different DAT**

| Treatment combinations | Dry matter weight hill$^{-1}$ (g) | | | | |
|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 75 DAT | At harvest |
| **$V_1S_1$** | 3.97 a | 10.48 b | 15.01 b | 17.15 b | 37.82 b |
| **$V_1S_2$** | 3.47 b | 8.59 de | 11.84 d | 15.56 cd | 31.49 de |
| **$V_1S_3$** | 3.09 d | 8.02 ef | 10.90 de | 14.45 de | 29.60 ef |
| **$V_2S_1$** | 3.97 a | 11.32 a | 16.41 a | 17.12 b | 40.61 a |
| **$V_2S_2$** | 3.47 b | 9.32 c | 13.06 c | 15.71 b-d | 33.92 cd |
| **$V_2S_3$** | 3.21 cd | 8.57 e | 11.82 d | 15.37 cd | 30.43 ef |
| **$V_3S_1$** | 3.42 b | 9.20 cd | 12.88 c | 15.71 b-d | 33.56 cd |
| **$V_3S_2$** | 3.34 bc | 7.76 f | 10.47 e | 14.42 de | 28.73 f |
| **$V_3S_3$** | 2.52 e | 7.77 f | 10.48 e | 13.42 e | 28.76 f |
| **$V_4S_1$** | 4.13 a | 11.84 a | 17.26 a | 21.44 a | 42.32 a |
| **$V_4S_2$** | 3.49 b | 9.71 c | 13.72 c | 16.82 bc | 35.24 c |
| **$V_4S_3$** | 3.39 bc | 8.57 e | 11.76 d | 16.50 bc | 31.60 de |
| **$LSD_{(0.05)}$** | 0.19 | 0.63 | 0.98 | 1.46 | 2.44 |
| **CV(%)** | 3.39 | 3.99 | 4.45 | 5.36 | 4.28 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 $V_4$: BRRI dhan89and $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.

### 4.2 Yield contributing characters

#### 4.2.1 Number of effective tillers hill$^{-1}$

**Effect of variety**

Number of effective tillers hill$^{-1}$significantly different by rice varieties of *Boro* rice at harvest (Figure 9). Experiment result revealed that the maximum, number of effective tillers hill$^{-1}$ (16.86) was recorded in $V_4$ (BRRI dhan89) treatment. Whereas the minimum, number of effective tillers hill$^{-1}$ (9.25) was recorded in $V_3$ (BRRI dhan86) treatment. The variation of effective tillers hill$^{-1}$ is probably due to the genetic make-up of the variety. The result obtained from the present study was similar with the findings of Latif *et al.* (2020) and they reported that the highest number of effective tillers hill$^{-1}$ (17.64) was produced by BRRI dhan29 whereas the lowest values of respective effective tillers were found in BR14. The reduction of number of effective tillers hill$^{-1}$ in BR14 was due to tiller mortality in the vegetative stages. The probable reason of these results might be due to different genetic makeup of these varieties which are influence by heredity. Chamely *et al*. (2015) also reported that the reasons for differences in producing bearing tillers hill$^{-1}$ might be due to the variation in genetic make-up of the variety that might be influenced by heredity.

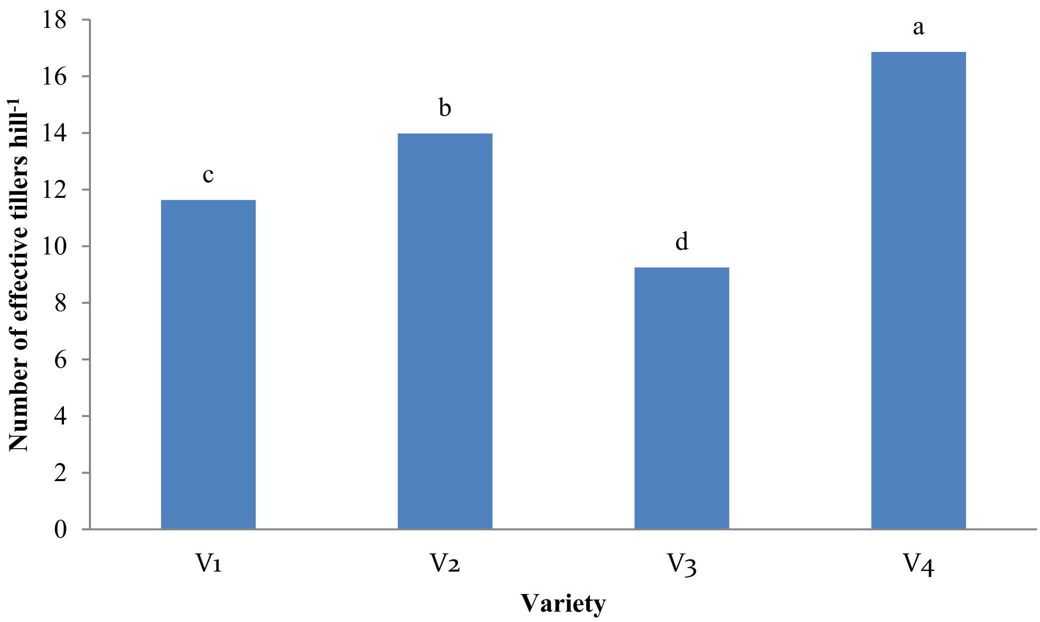


**Figure 9. Effect of variety on number of effective tillers hill$^{-1}$of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Seedling age had shown significant effect on effective tillers hill$^{-1}$ of *Boro* rice at harvest (Figure 10). Experiment result showed that, the highest number of effective tillers hill$^{-1}$ (14.87) was obtained in transplanting 25 days old seedling ($S_1$). Whereas the lowest number of effective tillers hill$^{-1}$ (10.53) was obtained in transplanting 45 days old seedling ($S_3$). The difference of effective tiller hill$^{-1}$might be due to longer growing period of the crop for better development of parts to allocate greater accumulation of photosynthesis in early planted crop. Sultana *et al.* (2020) reported that the effect of age of seedling, nitrogen levels and their interactions were significant on growth, yield and yield contributing characters of transplant rice. Ali *et al.* (2013) also reported that more effective tillers/hill (24.9) when seedlings of younger age were transplanted while 30 days old seedlings gave minimum number of effective tillers (15.6).

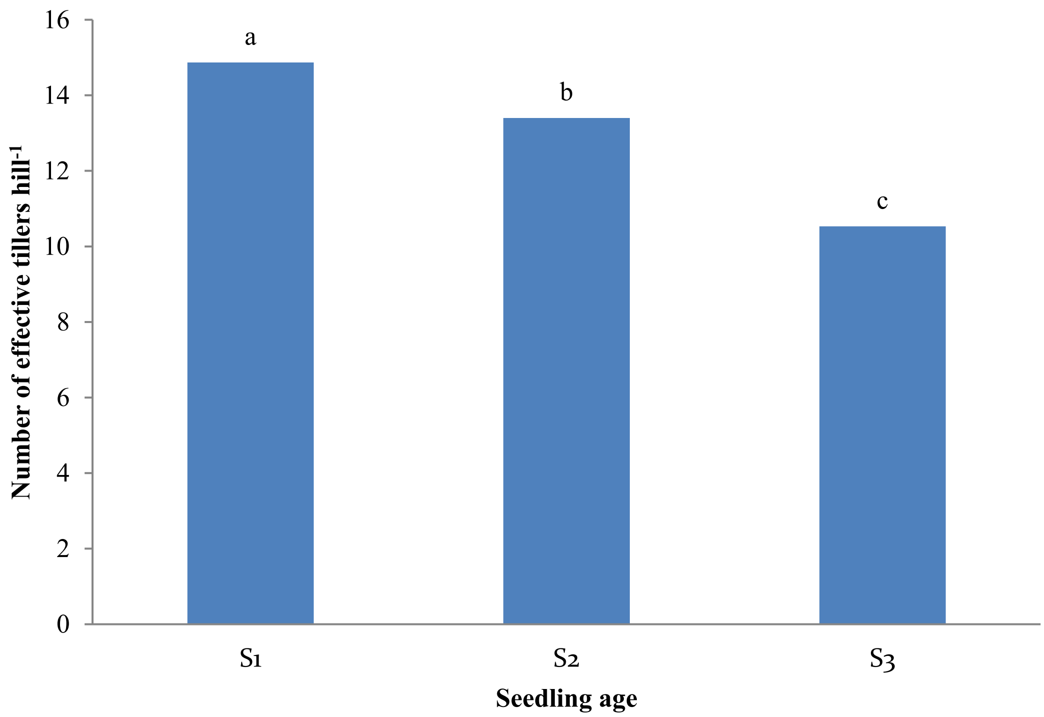


**Figure 10. Effect of seedling age on number of effective tillers hill$^{-1}$of *Boro* rice at harvest**[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

### Combined effect of variety and seedling age

Number ofeffective tillers hill$^{-1}$influenced by combined effect of variety and seedling age of *Boro* rice at harvest (Table 5). Experimental result revealed that the highest number of effective tillers hill$^{-1}$ (19.10) was recorded in $V_4S_1$ treatment combination, whereas the lowest number of effective tillers hill$^{-1}$ (11.63) was recorded in $V_3S_3$ treatment combination.

## 4.2.2 Number of non-effective tillers hill$^{-1}$

### Effect of variety

Rice variety significantly affected on number of non-effective tillers hill$^{-1}$ of *Boro* rice at harvest (Figure 11). Experiment result revealed that the maximum, number of non-effective tillers hill$^{-1}$ (4.51) was recorded in $V_3$ (BRRI dhan86) treatment. Whereas the lowest, number of non-effective tillers hill$^{-1}$ (1.73) was recorded in $V_4$ (BRRI dhan89) treatment. The variation of effective tillers hill$^{-1}$ is probably due to the genetic make-up of the variety. The result obtained from the present study was similar with the findings of Latif *et al.* (2020) and they reported that the highest number of effective tillers hill$^{-1}$ (17.64) was produced by BRRI dhan29 whereas the lowest values of respective effective tillers were found in BR14. The reduction of number of effective tillers hill$^{-1}$ in BR14 was due to tiller mortality in the vegetative stages. The probable reason of these results might be due to different genetic makeup of these varieties which are influence by heredity. Chamely *et al*. (2015) also reported that the reasons for differences in producing bearing tillers hill$^{-1}$ might be due to the variation in genetic make-up of the variety that might be influenced by heredity.

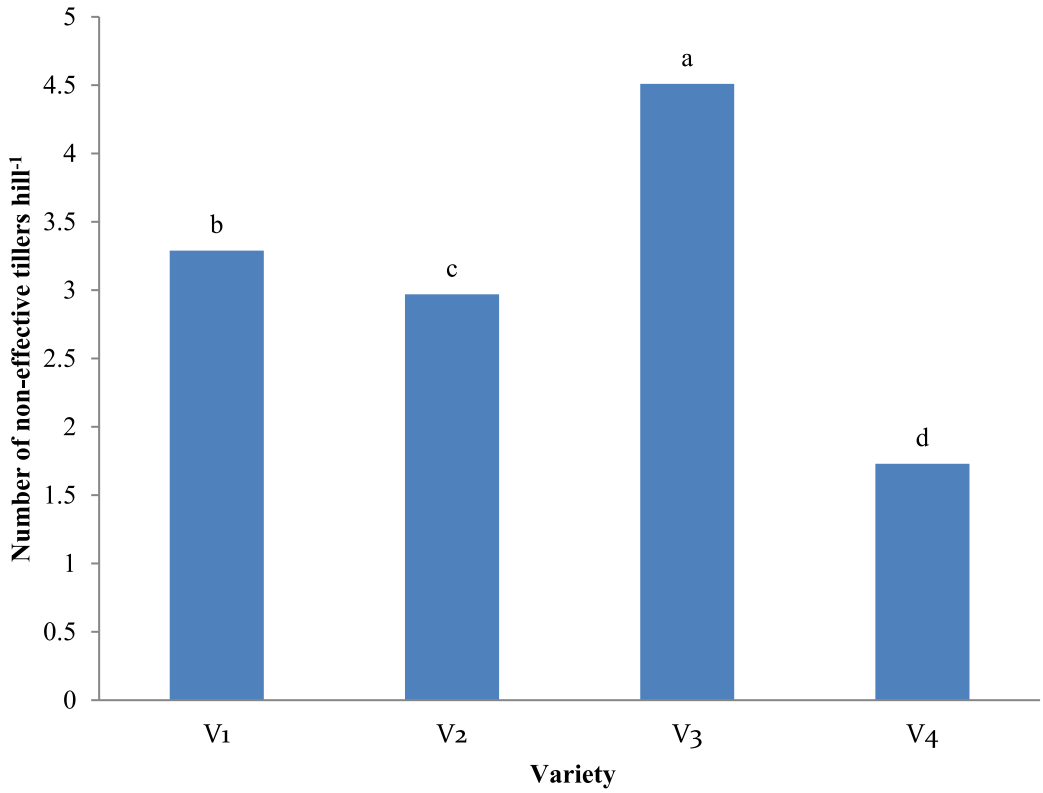


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**Figure 11. Effect of variety on number of non-effective tillers hill$^{-1}$of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89]

**Effect of seedling age**

At harvest, the non-effective tillers hill$^{-1}$ of *Boro* rice are greatly affected by seedling age(Figure 12). Experiment result showed that, the highest number of non-effective tillers hill$^{-1}$ (3.65) was obtained in transplanting 45 days old seedling ($S_3$). Whereas the lowest number of non-effective tillers hill$^{-1}$ (2.43) was obtained in transplanting 25 days old seedling ($S_3$). The highest number of non-effective tillers hill$^{-1}$ was increasing with seedling transplanting date due to reason that if the seedling age was higher, the damage of seedlings during transplantation would be severer, which not only affects vegetative growth, but also impairs reproductive growth.

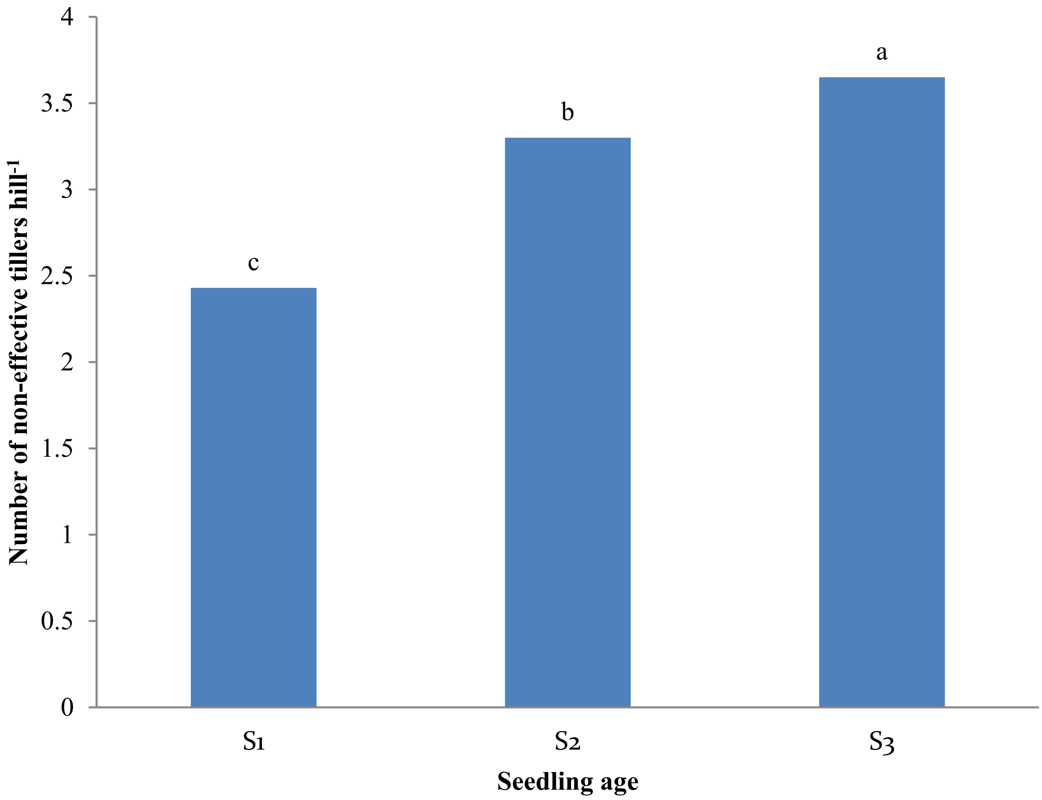


**Figure 12. Effect of seedling age on number of non-effective tillers hill$^{-1}$of *Boro* rice at harvest**

[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

At harvest, the combined influence of variety and seedling age considerably affected the hill$^{-1}$ of non-effective tillers of *Boro* rice(Table 5). Experimental result revealed that the highest number of non-effective tillers hill$^{-1}$ (5.54) was recorded in $V_3S_3$treatment combination, whereas the lowest number of effective tillers hill$^{-1}$ (1.00) was recorded in $V_4S_1$ treatment combination.

**Table 5. Combined effect of variety and seedling age on number of effective and non-effective tillers hill$^{-1}$of *Boro* rice at harvest**

| Treatment combinations | Effective tillers hill$^{-1}$ | Non effective tillers hill$^{-1}$ |
|---|---|---|
| **$V_1S_1$** | 13.37 d | 1.86 e |
| **$V_1S_2$** | 11.63 e | 3.80 c |
| **$V_1S_3$** | 9.90 f | 4.20 b |
| **$V_2S_1$** | 15.44 c | 2.66 d |
| **$V_2S_2$** | 13.63 d | 3.60 c |
| **$V_2S_3$** | 12.87 d | 2.66 d |
| **$V_3S_1$** | 11.57 e | 4.20 b |
| **$V_3S_2$** | 11.63 e | 3.80 c |
| **$V_3S_3$** | 4.56 g | 5.54 a |
| **$V_4S_1$** | 19.10 a | 1.00 f |
| **$V_4S_2$** | 16.70 b | 2.00 e |
| **$V_4S_3$** | 14.77 c | 2.20 e |
| **$LSD_{(0.05)}$** | 1.10 | 0.37 |
| **CV(%)** | 5.05 | 7.10 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 $V_4$: BRRI dhan89and $S_1$: 25 days ,$S_2$: 35 days and $S_3$: 45 days old seedlings.

### 4.2.3 Panicle length

#### Effect of variety

Panicle length is one aspect of panicle architecture and is usually measured as a yield-related trait. Panicle length, together with spikelet number and density, seed setting rate and grain plumpness, determines the grain number per panicle; hence, yield increases in rice. Experiment result revealed that different rice variety significantly influenced panicle length of *Boro* rice (Figure 13). From the experiment result it was clear that the highest panicle length (27.19 cm) was recorded in $V_4$ (BRRI dhan89) treatment, whereas the lowest panicle length (24.91 cm) was recorded in $V_3$ (BRRI dhan86) treatment.Different rice varieties have different panicle length due to the genetic makeup of the variety and higher panicle length is obtained from high yielding varieties comparable to low yielding rice varieties. Hossain *et al.* (2016); Chamely *et al.* (2015) and Diaz *et al.* (2000) found similar result which supported the present study and reported that panicle length varied among varieties.

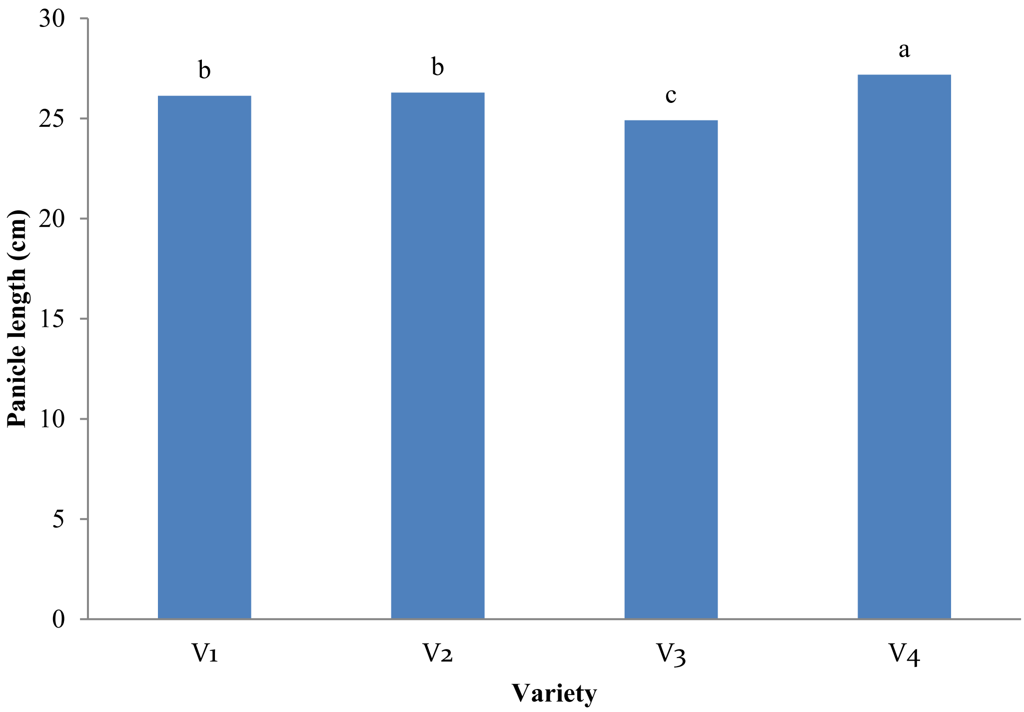


**Figure 13. Effect of variety on panicle length of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Panicle is an important yield contributing character as its bear grains and significantly influenced due to transplanting different age of seedling (Figure 14). Result revealed that among all the treatments the height panicle length(26.92 cm) was recorded in transplanting 25 days old seedling ($S_1$) whereas the lowest panicle length(25.33 cm) was recorded in transplanting 45 days old seedling ($S_3$). Pal and Mahunta (2010) from their study concluded that longest panicle was observed with transplanting of 25 days old seedlings as compared to 35 days old seedlings. Faruk *et al.* (2009) also reported that the panicle length was increased upto 4 weeks seedling age but beyond this, there was significant reduction in panicle length.

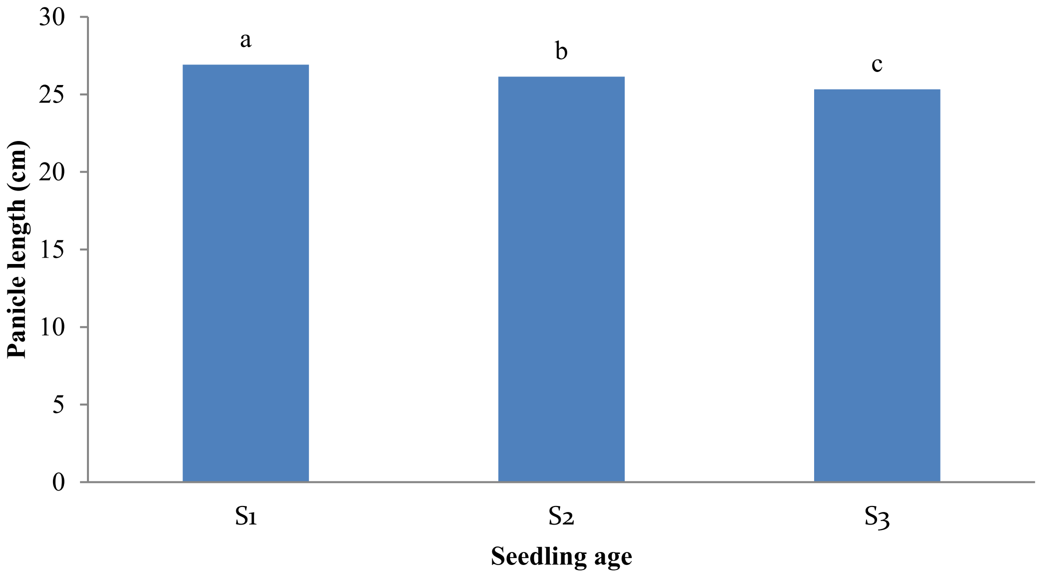


**Figure 14. Effect of seedling age on panicle length of *Boro* rice at harvest**

[Here, $S_1$: 25 days,$S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Panicle length was significantly affected due to combined effect of variety and seedling age of *Boro* rice at harvest.Experimental result revealed that the highest panicle length(28.87 cm) was recorded in $V_4S_1$ treatment combination, whereas the lowest panicle length(23.27 cm) was recorded in $V_3S_3$ treatment combination(Table 6).

### 4.2.4 Number of filled grains panicle$^{-1}$

**Effect of variety**

It is clear from the experiment data that different rice variety significantly influenced the number of filled grains panicle$^{-1}$ of *Boro* rice (Figure 15). Result showed that among different treatments the highest number of filled grains panicle$^{-1}$ (152.75) was recorded in $V_4$ (BRRI dhan89) treatment. While the lowest number of filled grains panicle$^{-1}$ (129.80) was recorded in $V_3$ (BRRI dhan86) treatment which was statistically similar with $V_1$ (BRRI dhan84) treatment recorded number of filled grains panicle$^{-1}$ (133.69).Variation in grain filling may have occurred due to genetic, environmental or cultural management practices adopted. Result obtained from the present study was similar with the findings of Ullah *et al.* (2016) and reported that among the varieties the maximum number of filled grain was for the Heera ($V_4$)(98.8 panicle$^{-1}$) whereas minimum for BRRI dhan58 ($V_2$) (82.1 panicle$^{-1}$) variety. The variation in filled grains panicle$^{-1}$ was recorded due to genotypic differences of varieties.

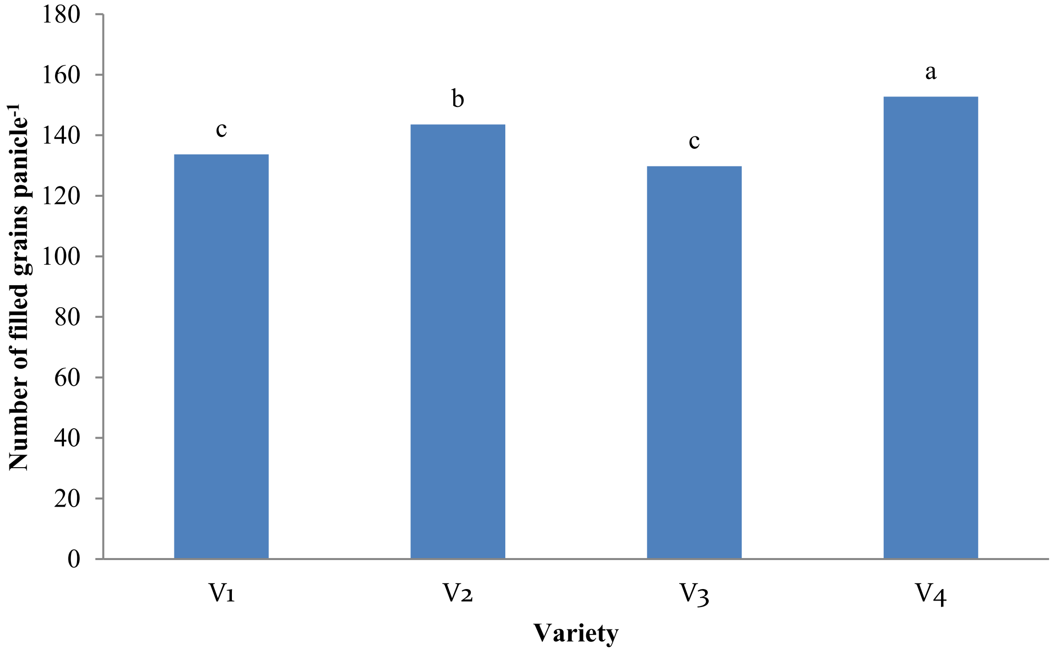


**Figure 15. Effect of variety on number of filled grains panicle$^{-1}$of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Filled grains panicle$^{-1}$of *Boro* rice was significantly differ due to different age of seedling (Figure 16). Experimental result revealed that the highest number of filled grains panicle$^{-1}$(150.45) was obtained in transplanting 25 days old seedling ($S_1$). Whereas the lowest highest number of filled grains panicle$^{-1}$ (131.85) was recorded in transplanting 45 days old seedling ($S_3$). The variation of filled grains panicle$^{-1}$at different seedling age might be due to the reason that, transplanting seedling at early age into the field easily handle the transplanting shock and comparative little or no root damage was occurred, whereas late transplanting result in poor growth, heavy transplanting shock, root damage, less solar radiation absorption and nutrient uptake occurred which ultimately impact on growth, yield and yield contributing characters of rice. Singh and Singh (1998) reported that transplanting of 25, 35, 45 days old seedlings responded significantly and found that number of filled spikelets per panicle decreased with increasing age of seedling.

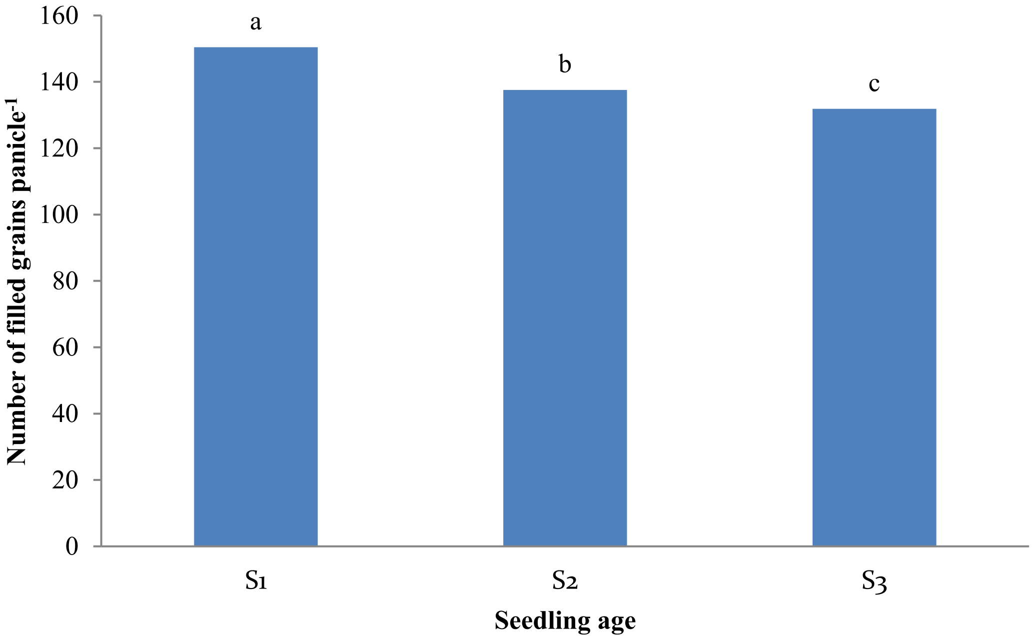


**Figure 16. Effect of seedling age on number of filled grains panicle$^{-1}$ of *Boro* rice at harvest**[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

At harvest, the variety and seedling age of the *Boro* rice had a combined effect that had a substantial impact on the number of filled grains panicle$^{-1}$.Experimental result revealed that the highest number of number of filled grains panicle$^{-1}$(161.63) was recorded in $V_4S_1$ treatment combination, which was statistically similar with $V_2S_1$ (156.43) treatment combination. Whereas the lowest number of filled grains panicle$^{-1}$(117.90) was recorded in $V_3S_3$ treatment combination(Table 6).

**4.2.5 Number of unfilled grains panicle$^{-1}$**

**Effect of variety**

Different rice variety showed significant effect on number of unfilled grains panicle$^{-1}$ of *Boro* rice at harvest (Figure 17). Experiment result revealed that the highest number of unfilled grains panicle$^{-1}$ (23.41) was recorded in $V_3$ (BRRI dhan86) treatment. While the lowest number of unfilled grains panicle$^{-1}$ (18.03) was recorded in $V_4$ (BRRI dhan89) treatment. Variation in number of unfilled grains panicle$^{-1}$ might be due to genetic characteristics of the varieties. Akter *et al.* (2018) reported thatnumerically BRRI dhan29 gave the higher (6.32) number of sterile spikelet panicle-$^{1}$ than BRRI dhan74 (6.01).

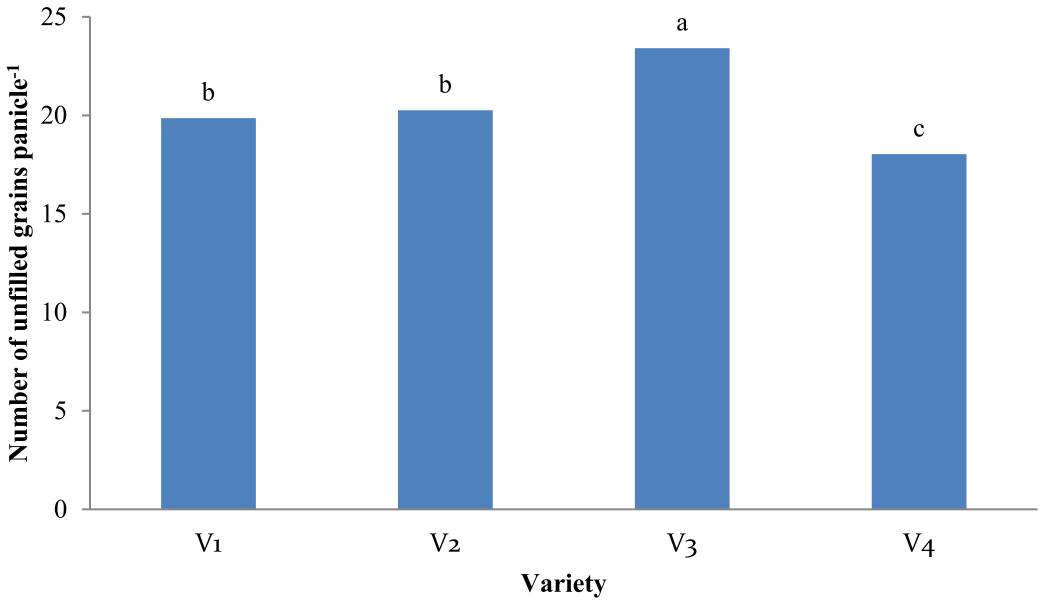


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**Figure 17. Effect of variety on number of unfilled grains panicle$^{-1}$ of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89]

**Effect of seedling age**

Number of unfilled grains panicle$^{-1}$of *Boro* rice was significantly differ due to different age of seedling at harvest (Figure 18). Experimental result revealed that the highest number of unfilled grains panicle$^{-1}$(21.97) was obtained in transplanting 45 days old seedling ($S_3$). Whereas the lowest highest number of unfilled grains panicle$^{-1}$ (18.74) was recorded in transplanting 25 days old seedling ($S_1$).

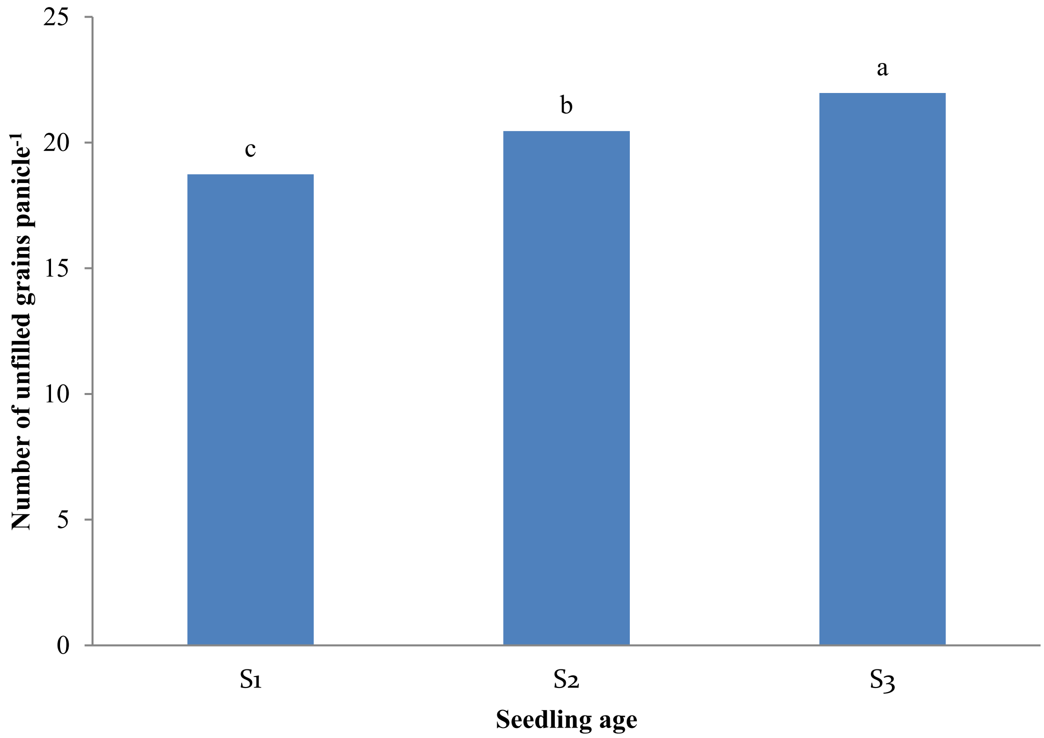


**Figure 18. Effect of seedling age on number of unfilled grains panicle$^{-1}$ of *Boro* rice at harvest**

[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Number of unfilled grains panicle$^{-1}$was significantly affected due to combined effect of variety and seedling age of *Boro* rice at harvest (Table 6). Experimental result revealed that the highest number of number of unfilled grains panicle$^{-1}$(26.50) was recorded in $V_3S_3$ treatment combination. Whereas the lowest number of filled grains panicle$^{-1}$(16.20) was recorded in $V_4S_1$ treatment combination.

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

**Effect of variety**

Different rice variety significantly influenced the number of total grains panicle$^{-1}$ of *Boro* rice at harvest (Figure 19). Result showed that among different treatments the height number of total grains panicle$^{-1}$ (170.78) was recorded in $V_4$ (BRRI dhan89) treatment. While the lowest number of total grains panicle$^{-1}$ (153.21) was recorded in $V_3$ (BRRI dhan86) treatment which was statistically similar with $V_1$ (BRRI dhan84) treatment recorded number of filled grains panicle$^{-1}$ (153.54).

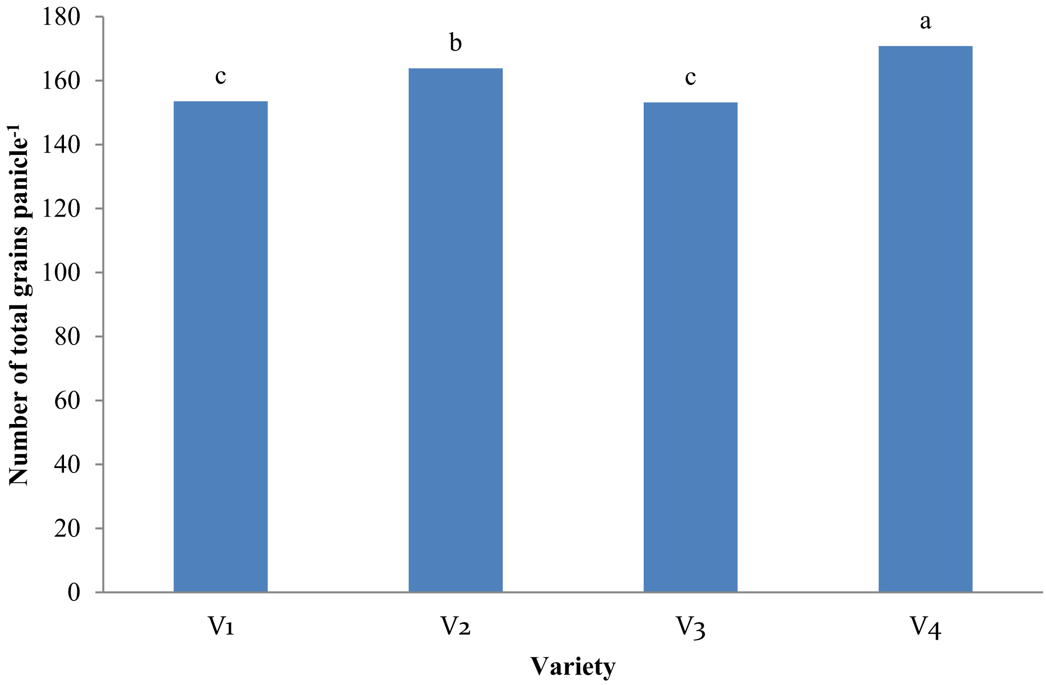


**Figure 19. Effect of variety on number of total grains panicle$^{-1}$ of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Number of total grains panicle$^{-1}$of *Boro* rice was significantly differ due to different age of seedling (Figure 20). Experimental result revealed that the highest number of total grains panicle$^{-1}$(169.19) was obtained in transplanting 25 days old seedling ($S_1$). Whereas the lowest highest number of total grains panicle$^{-1}$ (153.82) was recorded in transplanting 45 days old seedling ($S_3$).

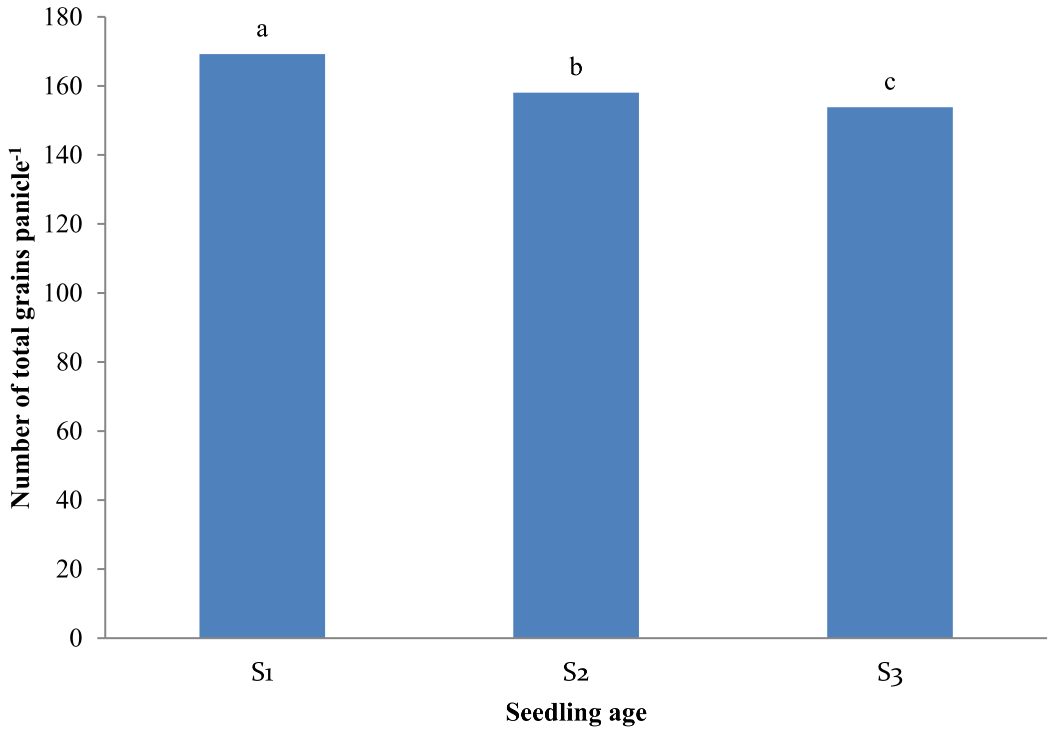


**Figure 20. Effect of seedling age on number of total grains panicle$^{-1}$of *Boro* rice at harvest**[Here, $S_1$: 25 days ,$S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Number of total grains panicle$^{-1}$was significantly affected due to combined effect of variety and seedling age of *Boro* rice at harvest (Table 6). Experimental result revealed that the highest number of number of total grains panicle$^{-1}$(177.83) was recorded in $V_4S_1$ treatment combination which was statistically similar with $V_2S_1$ (175.36) treatment combination. Whereas the lowest number of filled grains panicle$^{-1}$(144.40) was recorded in $V_3S_3$ treatment combination which was statistically similar with $V_1S_3$ (147.64) treatment combination.

**4.2.7 1000 grains weight**

**Effect of variety**

Different rice variety significantly effect on 1000 grains weight of *Boro* rice at harvest (Figure 21). Experiment result revealed that the height 1000 grains weight (28.39 g) was recorded in $V_4$ (BRRI dhan89) treatment, whereas the lowest 1000 grains weight (22.51 g) was recorded in $V_3$ (BRRI dhan86) treatment. The differences of the 1000 grains weight among different rice varieties may be attributes to the varietal performance and genetic makeup of the varieties. Latif *et al.* (2020) reported that 1000 grains weight was significantly differ due to the varietal performance. The highest 1000-grain weight (26.33 g) was obtained in BR14 than BRRI dhan28 (22.60 g) and BRRI dhan29 (22.43 g).Rahman *et al.* (2020) revealed that among the varieties the highest 1000-grain weight (26.65 g) was obtain in BRRI hybrid dhan3 while the lowest (21.43 g) was obtain in BRRI dhan28.

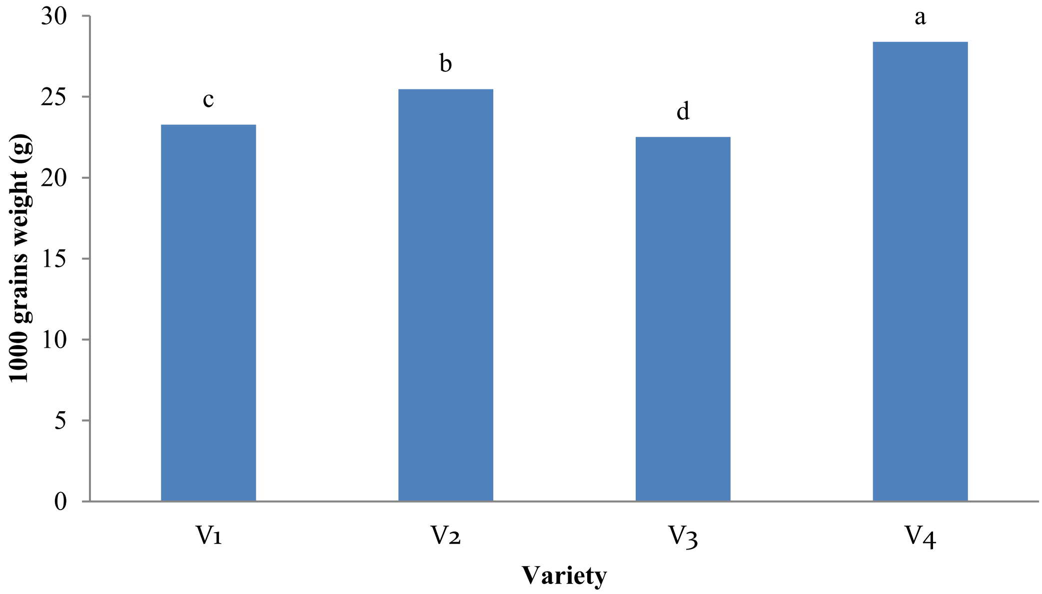


**Figure 21. Effect of variety on 1000 grains weight of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Seedling age significantly effect on 1000 seeds weight (g) of *Boro* rice at harvest (Figure 22). Experimental result revealed that the highest 1000 seeds weight (26.24 g) was obtained in transplanting 25 days old seedling ($S_1$). Whereas the lowest 1000 seeds weight (23.10 g) was obtained transplanting 45 days old seedling ($S_3$). Plants kept for longer time in seedbed either get too leggy or become too woody due to check of growth and such old age seedlings do not make a quick start when transplanted in the main field. As a result, its causes negative impact on yield contributing characters compares to early transplanting of the seedling. The result obtained from the present study was similar with the findings of Tari *et al.* (2007) and they stated that appropriate time of transplanting resulted in higher 1000 grain weight. Singh and Singh (1998) revealed that yield attributes viz 1000-grain weight significantly increased with transplanting of younger seedlings as compared to older seedlings.

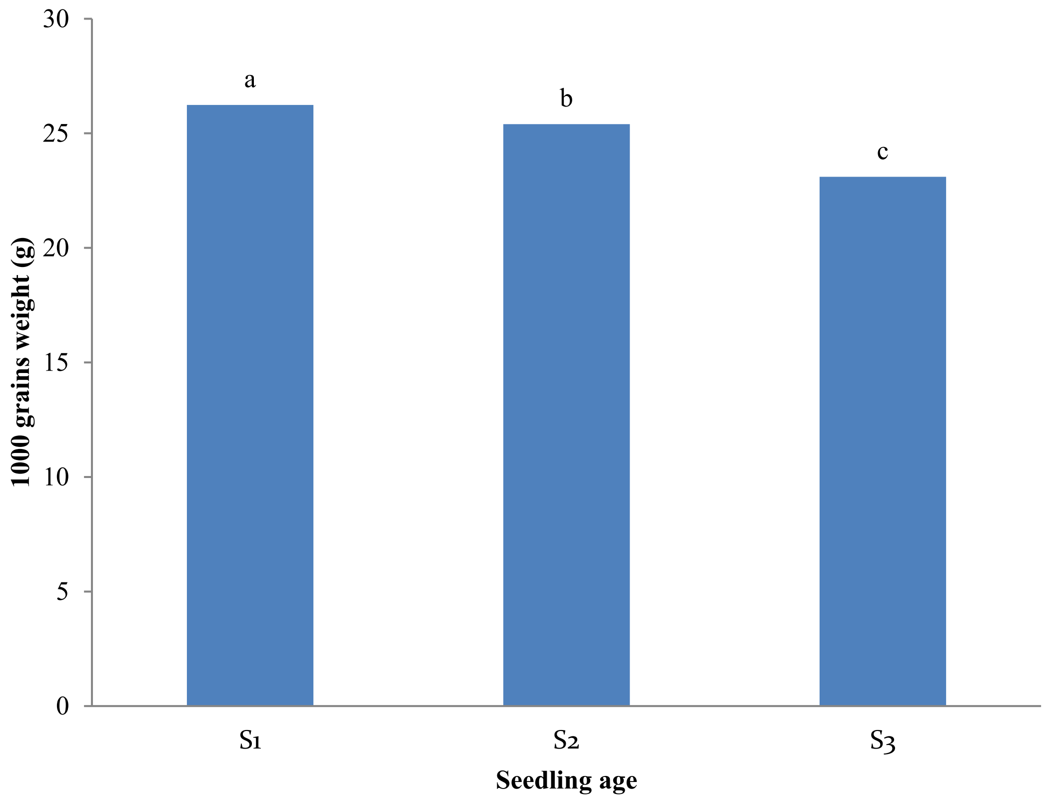


**Figure 22. Effect of seedling age on 1000 grains weight of *Boro* rice at harvest**[Here, $S_1$: 25 days ,$S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

1000 grains weight of *Boro* rice was significantly differed due to combined effect of variety and seedling age at harvest (Table 6). Experimental result revealed that the highest 1000 grains weight (30.20 g) was recorded in $V_4S_1$ treatment combination.

Whereas the lowest 1000 grains weight (20.33 g) was recorded in $V_3S_3$ treatment combination.

**Table 6. Combined effect of variety and seedling age on panicle length, number of filled grains, unfilled grains, total grains panicle$^{-1}$ and 1000 grains weight of *Boro* rice at harvest**

| Treatments combinations | Panicle length (cm) | No. of filled grains panicle$^{-1}$ | No. of unfilled grains panicle$^{-1}$ | No. of total grains panicle$^{-1}$ | 1000 grains weight (g) |
|---|---|---|---|---|---|
| $V_1S_1$ | 26.46 bc | 139.33 de | 19.40 d-f | 158.73 c | 24.30 e |
| $V_1S_2$ | 26.00 bc | 135.46 e | 18.80 ef | 154.26 cd | 23.53 e |
| $V_1S_3$ | 25.93 bc | 126.27 f | 21.37 c | 147.64 ef | 22.00 f |
| $V_2S_1$ | 26.80 b | 156.43 ab | 18.93 ef | 175.36 a | 26.77 c |
| $V_2S_2$ | 26.23 bc | 138.10 de | 21.17 cd | 159.27 c | 25.43 d |
| $V_2S_3$ | 25.83 bc | 136.21 e | 20.67 c-e | 156.88 c | 24.20 e |
| $V_3S_1$ | 25.53 c | 144.40 cd | 20.43 c-f | 164.83 b | 23.67 e |
| $V_3S_2$ | 25.93 bc | 127.10 f | 23.30 b | 150.40 de | 23.53 e |
| $V_3S_3$ | 23.27 d | 117.90 g | 26.50 a | 144.40 f | 20.33 g |
| $V_4S_1$ | 28.87 a | 161.63 a | 16.20 g | 177.83 a | 30.20 a |
| $V_4S_2$ | 26.40 bc | 149.57 bc | 18.57 f | 168.14 b | 29.10 b |
| $V_4S_3$ | 26.30 bc | 147.04 c | 19.33 d-f | 166.37 b | 25.87 cd |
| $LSD_{(0.05)}$ | 1.24 | 6.99 | 1.89 | 5.40 | 1.01 |
| CV(%) | 2.81 | 2.95 | 5.47 | 2.00 | 2.39 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 $V_4$: BRRI dhan89and $S_1$: 25 days , $S_2$: 35 days and $S_3$: 45 days old seedlings.

### 4.3 Yield characters

#### 4.3.1 Grain yield

**Effect of variety**

Different rice varieties significantly influenced grain yield (t ha$^{-1}$) of *Boro* rice (Figure 23). Experiment result showed the highest grain yield (6.69 t ha$^{-1}$) was recorded in $V_4$ (BRRI dhan89) treatment. Whereas the lowest grain yield (5.24 t ha$^{-1}$) was recorded in $V_3$ (BRRI dhan86) treatment. The probable reason of the different grain yields due to the different growth and yield attributes like tillers hill$^{-1}$, grains panicle$^{-1}$, 1000-grain weight etc which influenced by the genetic make-up of the variety.Counce and Keisling (1995) reported that grain yield and its components vary greatly with tiller type, and early initiated tillers produce more grains than late initiated ones.Miller *et al.* (1991) reported that, the tillering ability of the rice plant had a great impact on panicle production, which was highly correlated with grain yield.

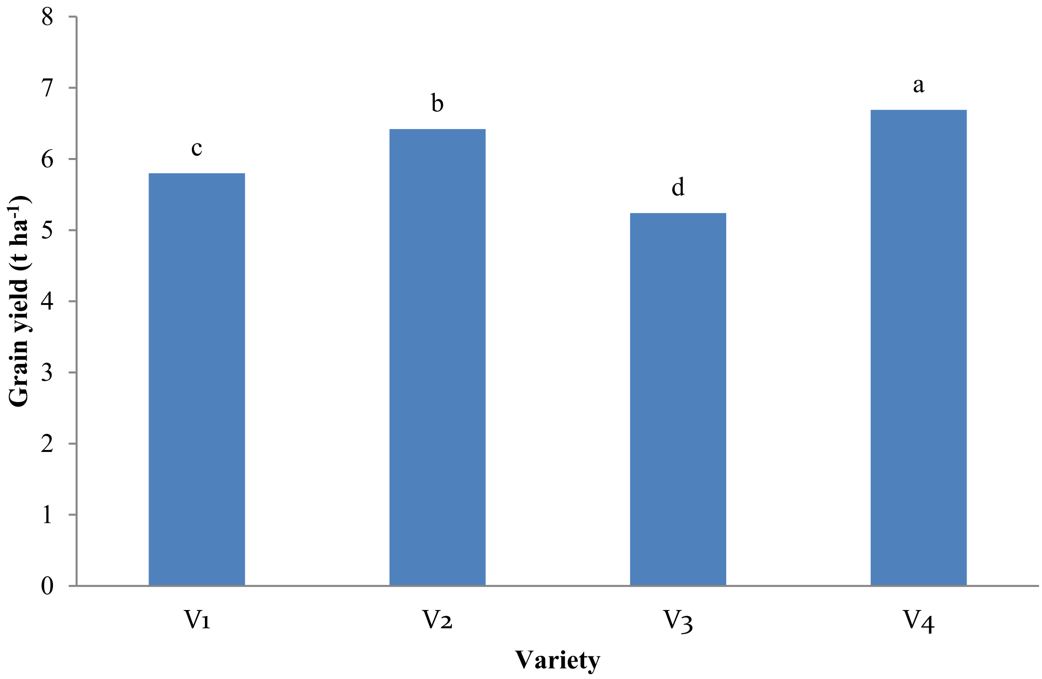


**Figure 23. Effect of variety on grain yield of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Seedling age significantly influenced thegrain yield (t ha$^{-1}$) of *Boro* rice (Figure 24). Experimental result revealed that, the highest grain yield (6.92 t ha$^{-1}$) was obtained in transplanting 25 days old seedling ($S_1$). Whereas the lowest grain yield (5.29 t ha$^{-1}$) was obtained in transplanting 45 days old seedling ($S_3$). Transplants of early age seedlings might have availed weather conditions and environment properly through improved upper ground plant and below ground root development. Better root development of early age seedlings might have utilized plant nutrients and soil moisture in sufficient amount throughout life period in the field, thus improved plant growth, yield attributes and finally produced higher yield per unit area. Virk*et al.* (2020) reported that younger seedling (20 days) produced 22% and 22.92% kg ha$^{-1}$ more yield in comparison to (35 days) older seedling in both years, respectively. Reuben *et al.* (2016) reported that grain yield of rice significantly differs due to age of different seedling. Menete *et al*. (2008) reported that higher older seedling resulted in lesser grain yield *i.e.*,9.3, 8.6 and 7.8 t ha$^{-1}$ as against 10-, 20- and 30-days old seedlings, respectively.

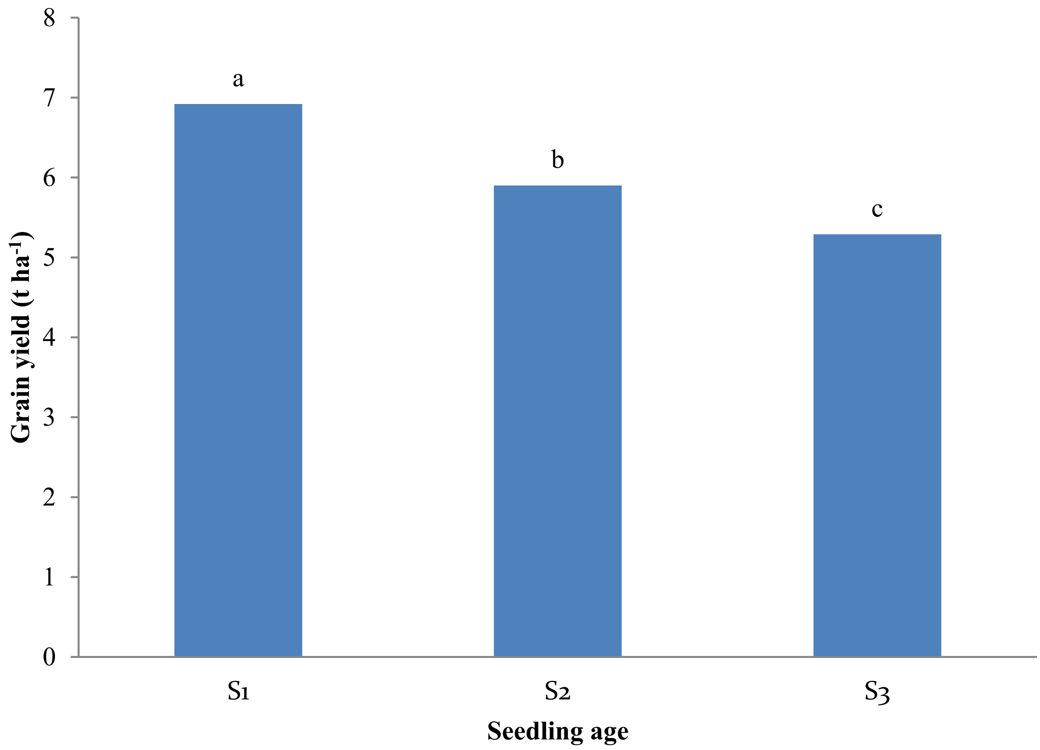


**Figure 24. Effect of seedling age on grain yield of *Boro* rice at harvest**

[Here, $S_1$: 25 days,$S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Different variety along with age of seedling significantly effect on grain yield *Boro* rice (Table 7). Experiment result showed that, the maximum grain yield (7.86 t ha$^{-1}$) was recorded in $V_4S_1$ treatment combination. Whereas, the minimum grain yield (4.80 t ha$^{-1}$) was recorded in $V_3S_3$ treatment combination which was statistically similar with $V_1S_3$ (5.02 t ha$^{-1}$) and $V_3S_2$ (5.17 t ha$^{-1}$) treatment combination.

### 4.3.2 Straw yield

**Effect of variety**

It was evident from the data that different rice variety caused significant variation in respect of straw yield of *Boro* rice at harvest (Figure 25). Experiment result showed that the highest straw yield (7.74 t $ha^{-1}$) was recorded in $V_4$ (BRRI dhan89) treatment which was statistically similar with $V_2$ (BRRI dhan88) treatment recorded straw yield (7.70 t $ha^{-1}$) at harvest. Whereas the lowest straw yield (7.10 t $ha^{-1}$) was recorded in $V_3$ (BRRI dhan86) treatment. The reduction in straw yield in varied with different rice varieties and with production of less tillers hill' which mainly responsible for this reduction in straw yield.

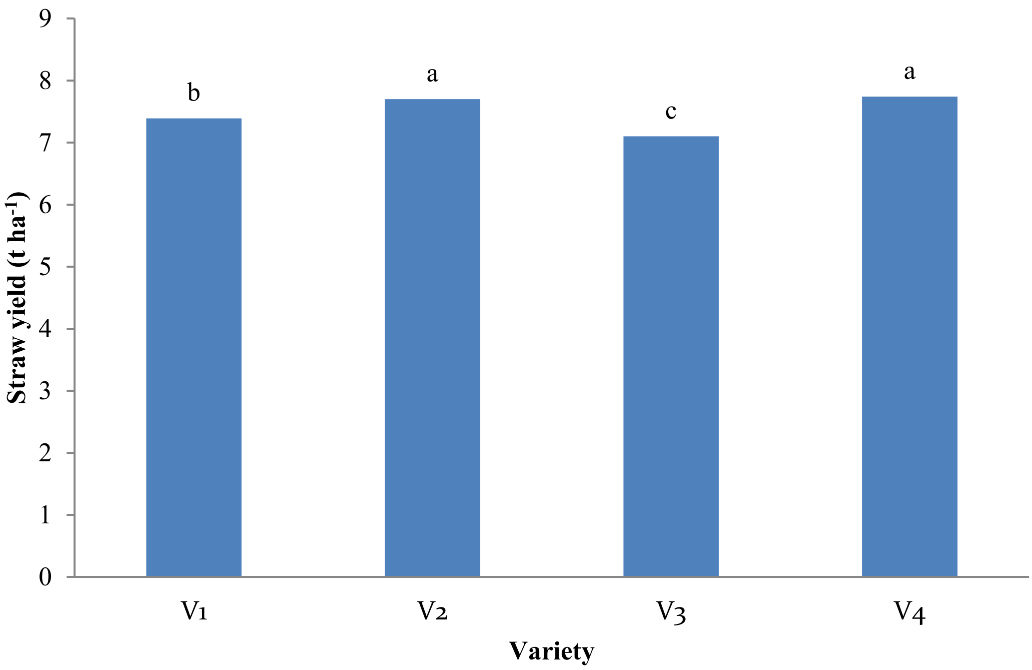


**Figure 25. Effect of variety on straw yield of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Seedling age significantly influenced the straw yield of *Boro* rice at harvest (Figure 26). Experimental result revealed that the highest straw yield (8.29 t $ha^{-1}$) was obtained in transplanting 25 days old seedling ($S_1$). Whereas the lowest straw yield (6.96 t $ha^{-1}$) was obtained in transplanting 45 days old seedling ($S_3$). Bagheri *et al.* (2011) noticed that the highest straw yield was obtained from 20 days old seedlings over 30 and 40 days. Rajesh and Thanunathan (2003) also reported that the seedling age had significant difference on straw yield. Sharma and Ghosh (1998) stated that younger seedlings produced significantly higher straw (7.53 t $ha^{-1}$) yields as compared to older seedlings from their studies on hybrids rice.

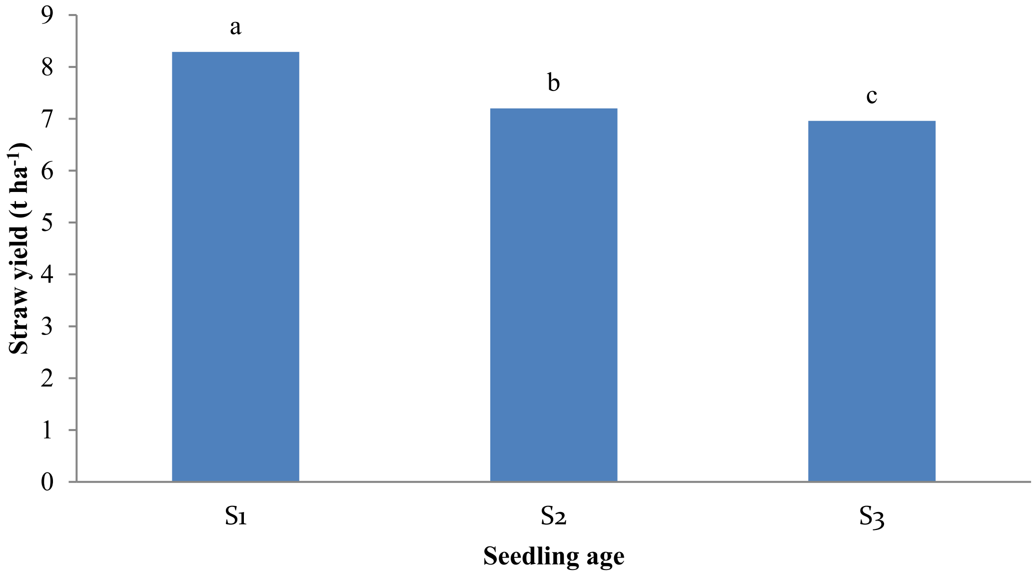


**Figure 26. Effect of seedling age on straw yield of *Boro* rice at harvest**

[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Combined effect of variety and seedling age significantly influenced the straw yield of *Boro* rice (Table 7). Experiment result showed that, the highest straw yield (8.76 t $ha^{-1}$) was recorded in $V_4S_1$ treatment combination which was statistically similar with $V_2S_1$ (8.59 t $ha^{-1}$) and $V_3S_2$ (5.17 t $ha^{-1}$) treatment combination. Whereas the lowest straw yield (6.82 t $ha^{-1}$) was recorded in $V_3S_3$ treatment combination which was statistically similar with $V_3S_2$ (6.92 t $ha^{-1}$), $V_1S_2$ (6.95 t $ha^{-1}$), $V_1S_3$ (6.98 t $ha^{-1}$), $V_2S_3$ (6.99 t $ha^{-1}$), and $V_4S_3$ (7.05 t $ha^{-1}$) treatment combination.

**4.3.3 Biological yield**

**Effect of variety**

Different rice varieties significantly influenced biological yield of *Boro* rice at harvest (Figure 27). Experiment result showed that among different treatment the highest biological yield (14.42 t $ha^{-1}$) was recorded in $V_4$ (BRRI dhan89) treatment which was statistically similar with $V_2$ (BRRI dhan88) recorded biological yield (14.12 t $ha^{-1}$). Whereas the lowest biological yield (12.34 t $ha^{-1}$) was recorded in $V_3$ (BRRI dhan86) treatment. The differences of straw yield may be attributed to the genetic makeup and variation of the different rice varieties. Chowhan *et al.* (2019) found similar results with the present study and reported that, varieties which had higher grain and straw yield ultimately obtained the highest biological yield.

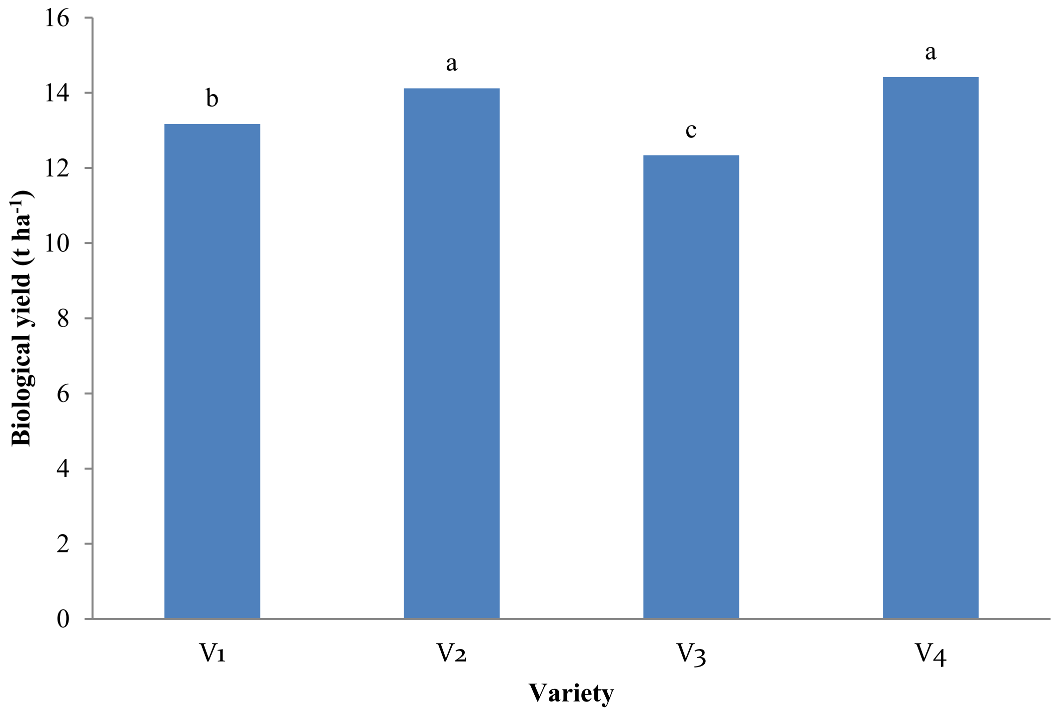


**Figure 27. Effect of variety on biological yield of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

### Effect of seedling age

Seedling age significantly effect on biological yield of *Boro* rice at harvest (Figure 31). Experimental result revealed that the height biological yield (15.19 t $ha^{-1}$) was obtained in transplanting 25 days old seedling ($S_1$). Whereas the lowest biological yield (12.25 t $ha^{-1}$) was obtained in transplanting 45 days old seedling ($S_3$). Chakrabortty (2013) also found similar result which supported the present finding and reported that seedling age significantly varied biological yield of *Boro* rice.

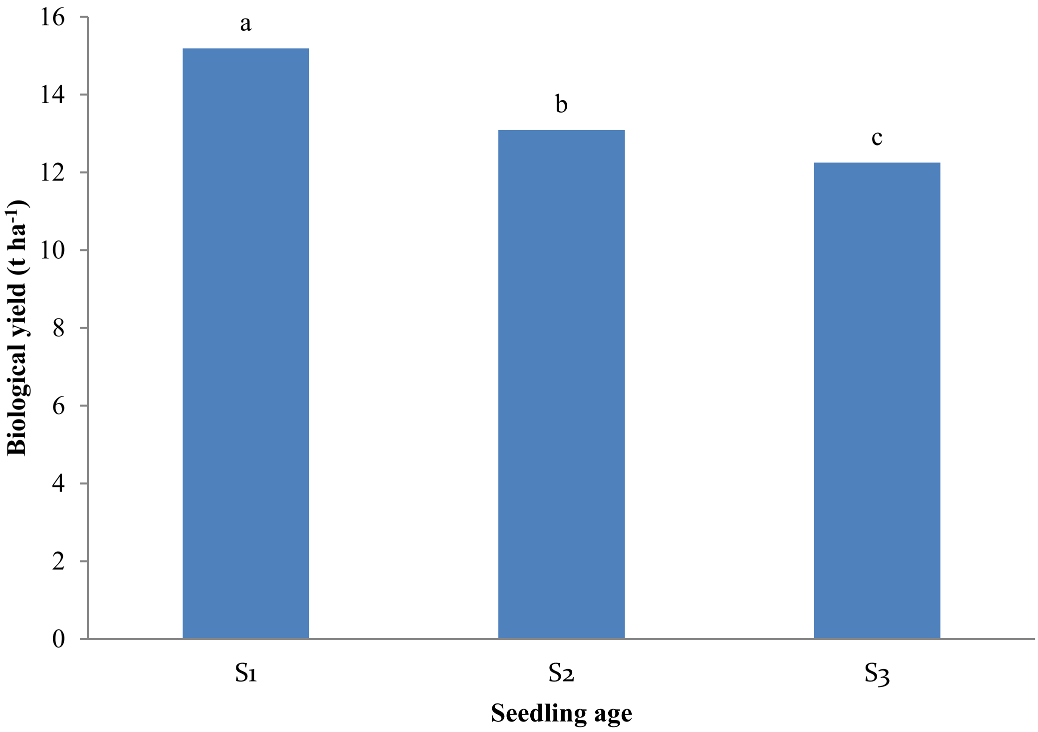


**Figure 28. Effect of seedling age on straw yield of *Boro* rice at harvest**

[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Combined effect of variety and seedling age significantly effect on biological yield of *Boro* rice (Table 7). Experiment result showed that, the highest biological yield (16.62 t $ha^{-1}$) was recorded in $V_4S_1$ treatment. Whereas the lowest biological yield (11.62 t $ha^{-1}$) was recorded in $V_3S_3$ treatment combination which was statistically similar with $V_1S_3$ (12.00 t $ha^{-1}$) and $V_3S_2$ (12.09 t $ha^{-1}$) treatment combination.

### 4.3.4 Harvest index

**Effect of variety**

It was evident from the data that different rice variety caused significant variation in respect of harvest index of *Boro* rice (Figure 29). Experiment result revealed that, the highest harvest index (46.26 %) was recorded in $V_4$ (BRRI dhan89) treatment which was statistically similar with $V_2$ (BRRI dhan88) treatment recorded harvest index (45.43 %) whereas the minimum harvest index (42.41 %) was recorded in $V_3$ (BRRI dhan86) treatment. Chowhan *et al.* (2019) also found significant differences of harvest index among different rice varieties and reported that hybrid rice maintained higher harvest index. Akter *et al.* (2018) reported that harvest index was higher in BRRI dhan29 (42.86%) than BRRI dhan74 (39.28%).

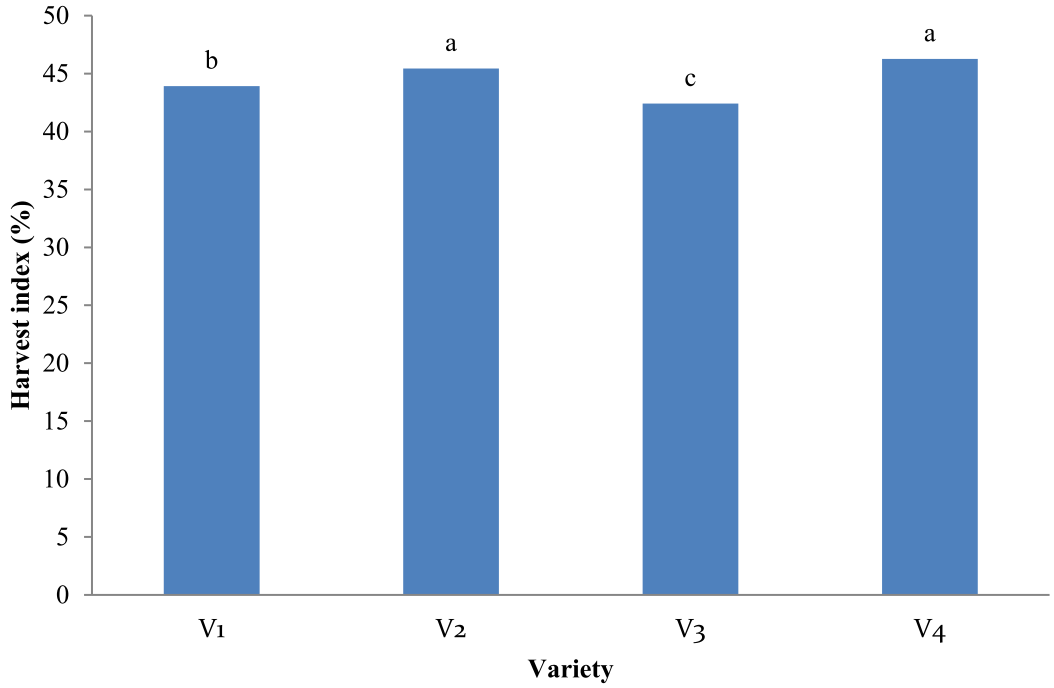


**Figure 29. Effect of variety on biological yield of *Boro* rice at harvest**

[Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89.]

**Effect of seedling age**

Transplanting different age of seedling showed significant effect on harvest index of *Boro* rice (Figure 30). Experiment result revealed that the highest harvest index (45.40 %) was obtained in transplanting 25 days old seedling ($S_1$) which was statistically similar with transplanting 35 days old seedling ($S_2$) recorded harvest index (44.98 %). Whereas the lowest harvest index (43.13 %) was obtained in transplanting 45 days old seedling ($S_3$). The result obtained from the present study was similar with the findings ofIslam*et al.* (2021) and reported that the highest highest harvest index (33.88%) was obtained from 22 days old seedlings. The lowest harvest index (30.467%) was obtained from 30 days old seedlings. Pramanik and Bera (2013) reported that maximum harvest index of 45.19 and 47.00 was noticed from early transplanting seedlings.

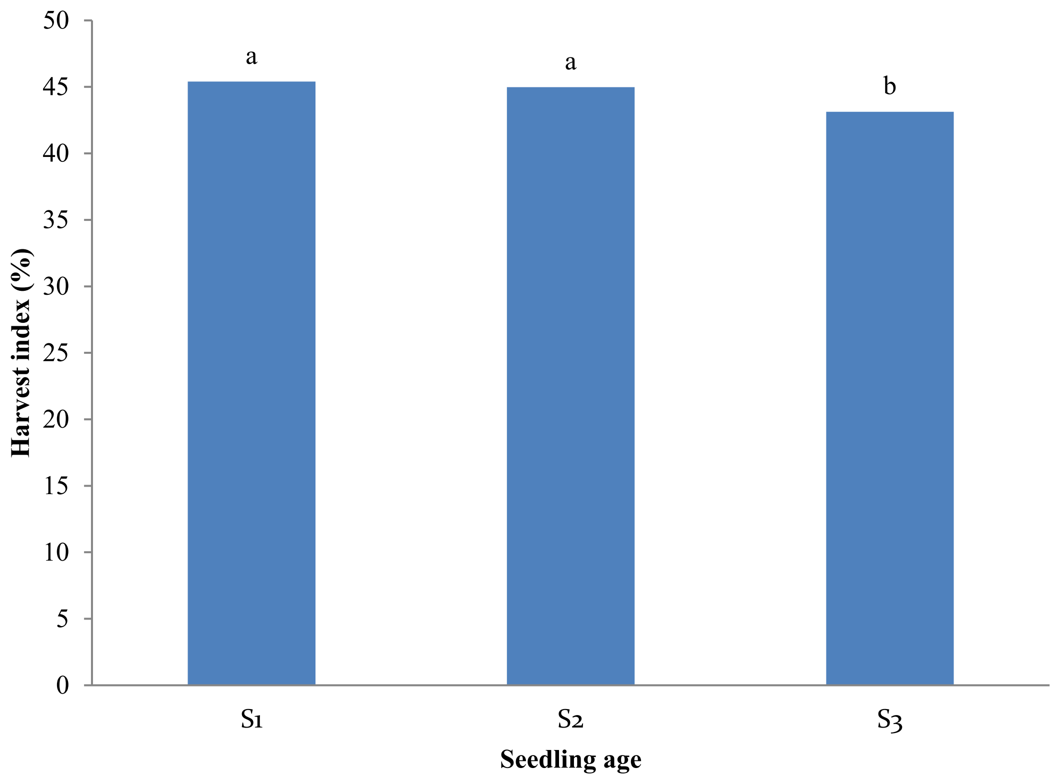


**Figure 30. Effect of seedling age on biological yield of *Boro* rice at harvest**

[Here, $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.]

**Combined effect of variety and seedling age**

Different rice variety along with seedling age significantly effect on harvest index of *Boro* rice at harvest (Table 6). Experiment result showed that, the highest harvest index (47.29 %) was recorded in $V_4S_1$ treatment which was statistically similar with $V_4S_2$ (46.69 %) and $V_2S_1$ (46.21 %) treatment combination. Whereas the lowest harvest index (41.31 %) was recorded in $V_3S_3$ treatment combination which was statistically similar with $V_1S_3$ (41.83 %) and $V_3S_2$ (42.76 %) treatment combination.

**Table 7. Combined effect of variety and seedling age on grains yield, straw yield, biological yield and harvest index of *Boro*rice at harvest**

| Treatment combinations | Grains yield (t $ha^{-1}$) | Straw yield (t $ha^{-1}$) | Biological yield (t $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| $V_1S_1$ | 6.69 c | 8.24 b | 14.87 b | 44.93 cd |
| $V_1S_2$ | 5.68 e | 6.95 e | 12.63 d-f | 44.97 cd |
| $V_1S_3$ | 5.02 f | 6.98 e | 12.00 fg | 41.83 fg |
| $V_2S_1$ | 7.38 b | 8.59 ab | 15.97 a | 46.21 a-c |
| $V_2S_2$ | 6.26 d | 7.51 c | 13.77 c | 45.50 b-d |
| $V_2S_3$ | 5.62 e | 6.99 e | 12.61 d-f | 44.57 de |
| $V_3S_1$ | 5.75 e | 7.57 c | 13.32 cd | 43.17 ef |
| $V_3S_2$ | 5.17 f | 6.92 e | 12.09 e-g | 42.76 fg |
| $V_3S_3$ | 4.80 f | 6.82 e | 11.62 g | 41.31 g |
| $V_4S_1$ | 7.86 a | 8.76 a | 16.62 a | 47.29 a |
| $V_4S_2$ | 6.48 cd | 7.40 cd | 13.88 c | 46.69 ab |
| $V_4S_3$ | 5.72 e | 7.05 de | 12.77 de | 44.79 cd |
| $LSD_{(0.05)}$ | 0.37 | 0.38 | 0.73 | 1.59 |
| CV(%) | 3.65 | 3.01 | 3.19 | 2.11 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 $V_4$: BRRI dhan89and $S_1$: 25 days,$S_2$: 35 days and $S_3$: 45 days old seedlings.

## 4. 4. Functional relationship between tillers number and grain yield of *Boro* rice at harvest

A positive linear relationship was observed between tillers number and grain yield of *Boro* rice. It was evident from the figure 31 that the regression equation y = 0.298x + 1.244 gave a good fit to the data, and the co-efficient of determination ($R^2$ = 0.657) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a strongly positive relationship between tillers number and grain yield of *Boro* rice. Tillering ability as well as the tiller type varies between varieties. Tiller produces panicle at generative phase.Tiller number per plant determines panicle number which is a key component of grain yield. Grain yield depends on panicle as its bear grains.In this present experiment the yield and yield contributing character were significantly varied due to combined effect of rice variety and seedling age and among different combination $V_4S_1$ treatment combination recorded the highest tillers number $hill^{-1}$ and grain yield comparable to others treatment combinations. Due to tillers number increased grain yield production increased in significant away.

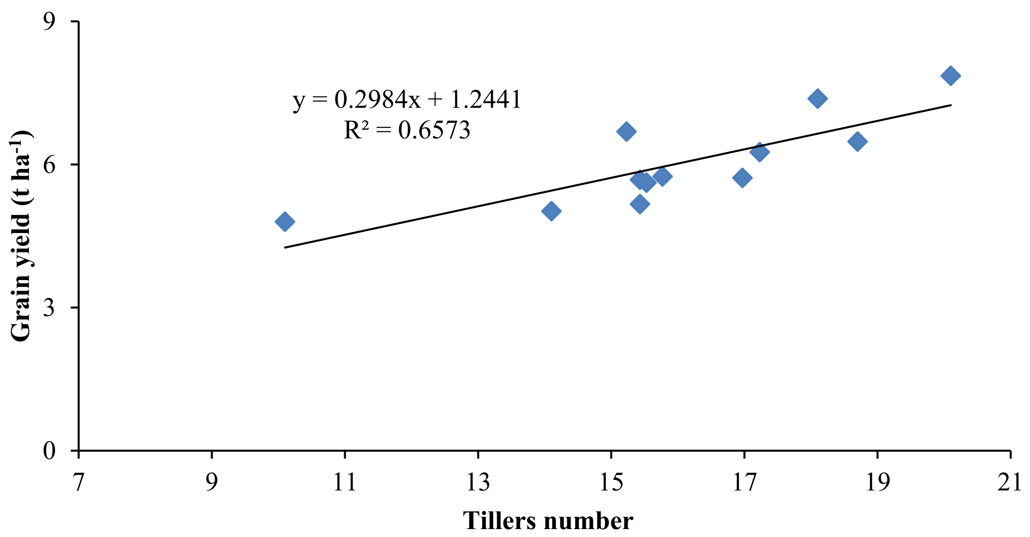


**Figure 31.Functional relationship between tillers number and grain yield of *Boro* rice at harvest**

## CHAPTER V

# SUMMARY AND CONCLUSION

### 5.1 Summary

A field experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka during, November-2019 to April 2020, to study the evaluation of growth and yield of four modern rice varieties as influenced by seedling age. The experiment consisted of two factors, and followed The Randomized Complete Block Design (RCBD) with three replications.Factor A: Different rice varieties (4) *viz;* $V_1$: BRRI dhan84, $V_2$: BRRI dhan88, $V_3$: BRRI dhan86 and $V_4$: BRRI dhan89and Factor B: Transplanting different age of seedling (3) *viz;* $S_1$: 25 days, $S_2$: 35 days and $S_3$: 45 days old seedlings.Data on different parameters were collected for assessing results for this experiment and showed significant variation in respect of growth, yield and yield contributing characteristics of *Boro* rice due to the effect of different rice variety, seedling age and their combinations.

In case of different rice varieties, the highest number of tillers hill$^{-1}$ (5.80, 7.93, 15.59, 21.66 and 18.59) at 30, 45, 60, 75 DAT and at harvest, respectively, was recorded in $V_4$ (BRRI dhan89) treatment.In similar way, the maximum plant height and dry matter weight hill$^{-1}$ were recorded in $V_4$ (BRRI dhan89) treatment.

Different rice variety significantly effect on yield contributing parameters and yield and of *Boro*rice. The highest, number of effective tillers hill$^{-1}$ (16.86), panicle length (27.19 cm), filled grains panicle$^{-1}$ (152.75), 1000 grains weight (28.39 g), grain yield (6.69 t ha$^{-1}$), straw yield (7.74 t ha$^{-1}$), biological yield (14.42 t ha$^{-1}$), harvest index (46.26 %) were recorded in BRRI dhan89 variety ($V_4$).

In case transplanting of different agedseedlings, plant growth deceasing with increasing of seedling age. The highest number of effective tillers hill$^{-1}$ (5.75, 8.12, 14.33, 22.28 and 17.30) at 30, 45, 60, 75 DAT and at harvest, respectively, were recorded in transplanting 25 days old seedlings ($S_1$). In similar way, the maximum plant height and dry matter weight hill$^{-1}$ were recorded in transplanting 25 days old seedlings ($S_1$).

Transplanting 25 days old seedlings ($S_1$) increased yield contributing parameters the yield of rice comparable to transplanting 35 days ($S_2$) and 45 days old seedlings ($S_3$). The highest number of effective tillers hill$^{-1}$ (14.87), panicle length(26.92 cm), filled grains panicle$^{-1}$(150.45), total grains panicle$^{-1}$(169.19), 1000 seeds weight (26.24 g), grain yield (6.92 t ha$^{-1}$), straw yield (8.29 t ha$^{-1}$), biological yield (15.19 t ha$^{-1}$) and harvest index (45.40 %) were recorded in transplanting 25 days old seedlings ($S_1$).

In case of combined effect, highest number of effective tillers hill$^{-1}$ was seen with the cultivation of BRRI dhan89 rice variety along with transplanting at 25 days old seedling ($V_4S_1$).In similar way, the maximum plant height and dry matter weight hill$^{-1}$ were recorded in $V_4S_1$ treatment combination.

Cultivation of BRRI dhan89 rice variety along with transplanting at 25 days old seedling ($V_4S_1$) treatment combination increased yield contributing parameters and yield of *Boro*rice comparable to other treatment combination. The highest number of effective tillers hill$^{-1}$ (19.10), panicle length(28.87 cm), filled grains panicle$^{-1}$(161.63), total grains panicle$^{-1}$ (170.78), 1000 grains weight (30.20 g), grain yield (7.86 t ha$^{-1}$), straw yield (8.76 t ha$^{-1}$), biological yield (16.62 t ha$^{-1}$ and highest harvest index (47.29 %)were recorded in $V_4S_3$ treatment combination.

**5.2 Conclusion**

i. BRRI dhan89gave the highest 1000 grains weight (28.39 g), grain yield (6.69 t ha$^{-1}$), straw yield (7.74 t ha$^{-1}$), biological yield (14.42 t ha$^{-1}$) and harvest index (46.26 %). Itproduced thehighest grain yield contributed by the higher tillers number and panicles hill$^{-1}$.
ii. Older seedling decreased plant growth and yield irrespective of varieties. In this experiment 25 days old seedling gave 30.81 % more yield than transplanting 45 days old seedling.
iii. In case of combined effect, cultivation of BRRI dhan89 along with transplanting at 25 days old seedling provided the highest grain yield (7.86 t ha$^{-1}$) compared to other treatment combinations.

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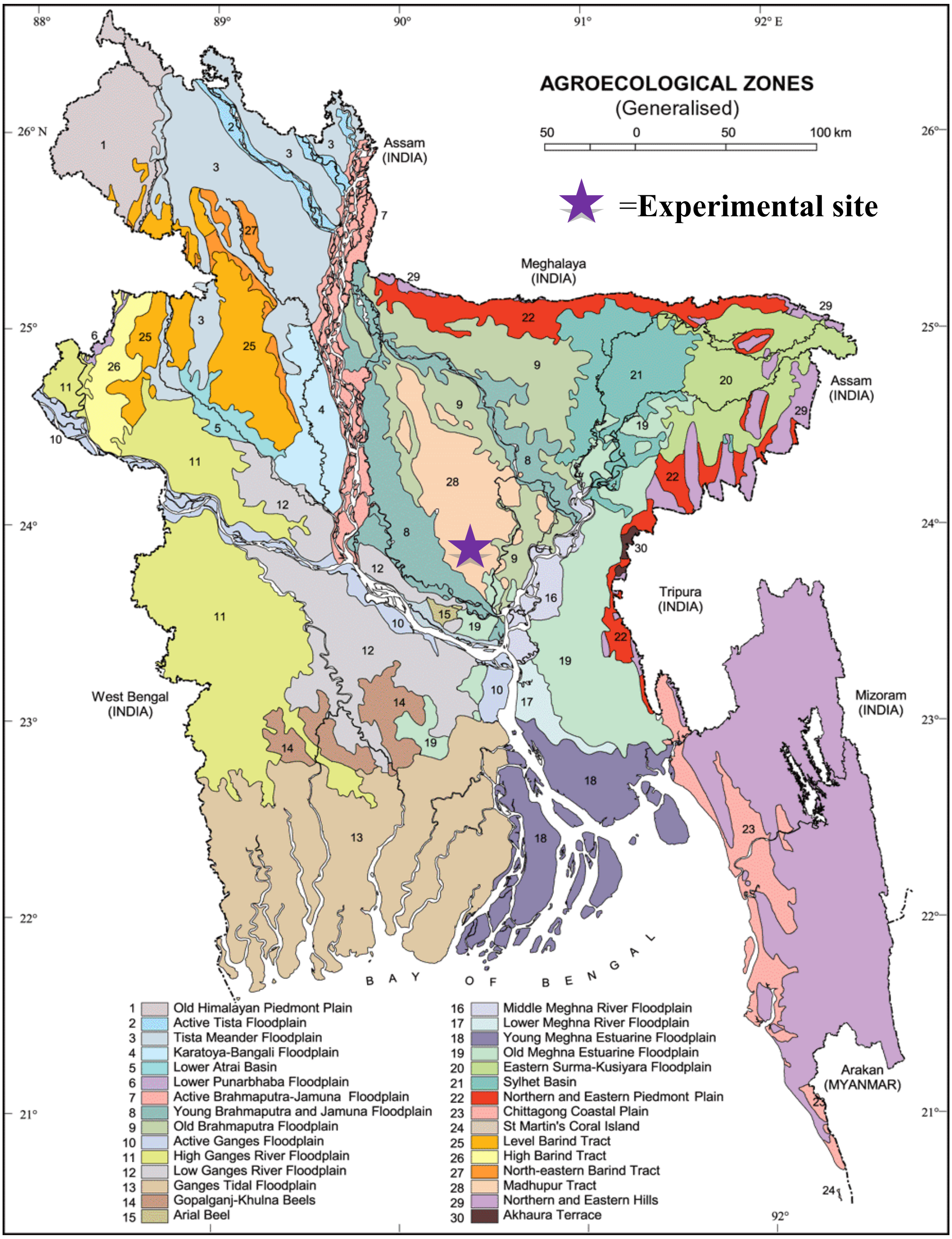
# APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of experimental plot

A. Morphological characteristics of the experimental field

| Morphological features | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University Agronomy research field, Dhaka |
| AEZ | AEZ-28, Modhupur Tract |
| General Soil Type | Shallow Red Brown Terrace Soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

**Physical characteristics**

| Constituents | Percent |
|---|---|
| Sand | 26 |
| Silt | 45 |
| Clay | 29 |
| Textural class | Silty clay |

**Chemical characteristics**

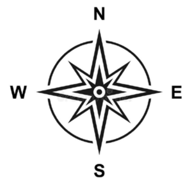
| Soil characteristics | Value |
|---|---|
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total nitrogen (%) | 0.03 |
| Available P (ppm) | 20.54 |
| Exchangeable K (mg/100 g soil) | 0.10 |

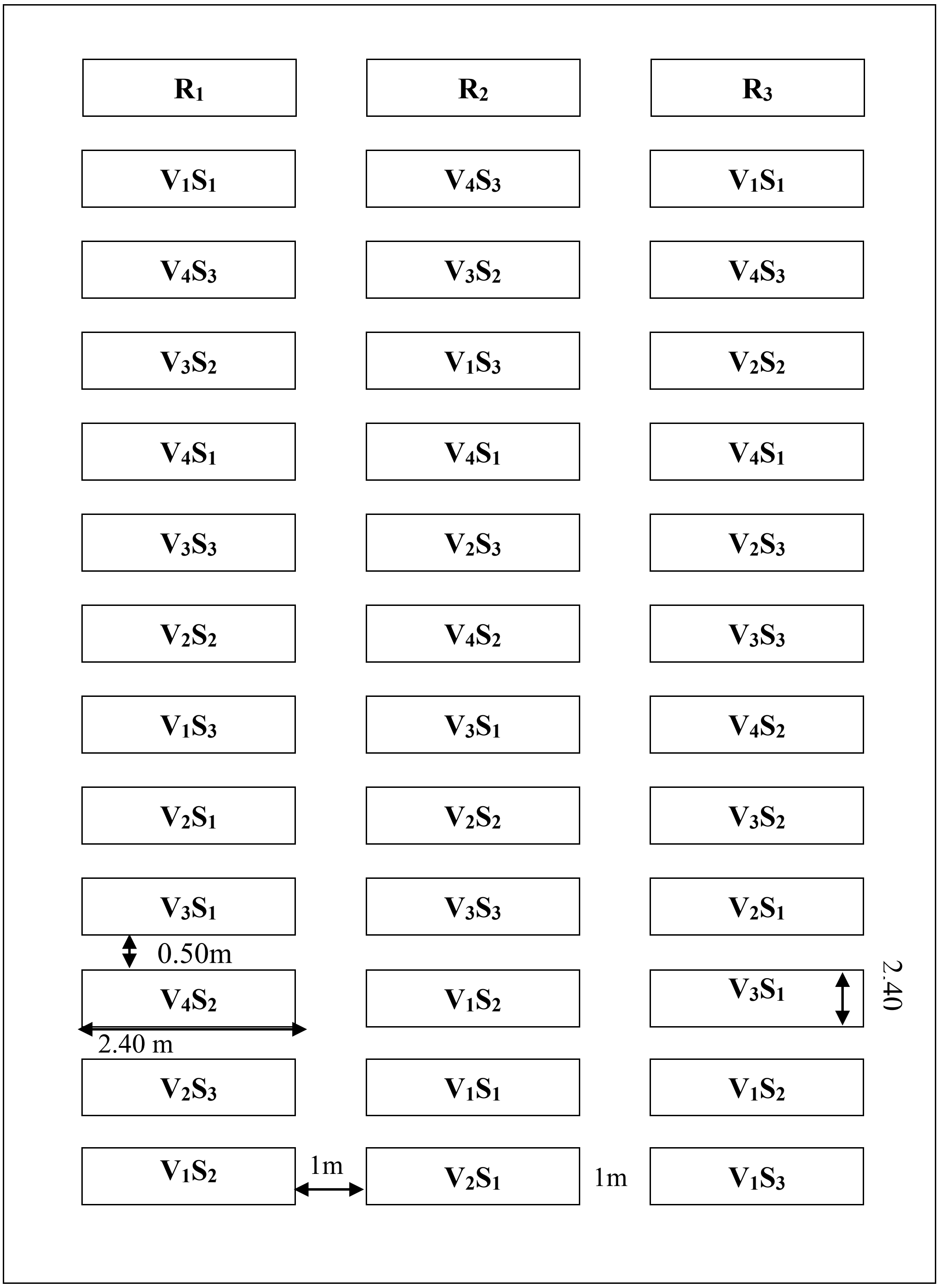
Appendix III.Monthly meteorological information during the period from November-2019 to February 2020.

| Year | Month | Air temperature ($^0C$) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|---|
| | | Maximum | Minimum | | |
| 2019 | November | 29.6 | 19.8 | 53 | 00 |
| | December | 28.8 | 19.1 | 47 | 00 |
| 2020 | January | 25.5 | 13.1 | 41 | 00 |
| | February | 25.9 | 14 | 34 | 7.7 |
| | March | 31.9 | 20.1 | 38 | 71 |
| | April | 33.7 | 23.9 | 74 | 168 |

(Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Layout of the experimental field




**Note:**

***Boro*rice varieties**

$V_1$: BRRI dhan84

$V_2$: BRRI dhan88

$V_3$: BRRI dhan86

$V_4$: BRRI dhan89

**Seedling age**

$S_1$: 25 days

$S_2$: 35 days and

$S_3$: 45 days old seedlings

Appendix V. Analysis of variance of the data of plant height of *Boro* rice different DAT

| Source | DF | Mean square of plant height at | | | | |
|---|---|---|---|---|---|---|
| | | 30 DAT | 45 DAT | 60 DAT | 75 DAT | At harvest |
| Replication | 2 | 2.083 | 6.333 | 4.083 | 7.000 | 7.000 |
| Variety (V) | 3 | 94.238* | 192.463* | 229.665* | 314.780* | 314.780* |
| Age (A) | 2 | 225.430* | 276.280* | 444.838* | 452.925* | 452.925* |
| V × A | 6 | 4.340* | 16.454* | 40.770* | 54.313* | 54.313* |
| Error | 22 | 4.356 | 11.788 | 8.538 | 14.273 | 14.273 |
| Total | 35 | | | | | |

*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data of number of tillers hill$^{-1}$ of *Boro*rice different DAT

| Source | DF | Mean square of number of tillers hill$^{-1}$ | | | | |
|---|---|---|---|---|---|---|
| | | 30 DAT | 45 DAT | 60 DAT | 75 DAT | At harvest |
| Replication | 2 | 0.03583 | 0.03694 | 0.0391 | 0.3611 | 0.6044 |
| Variety (V) | 3 | 2.83587* | 4.40785* | 45.7178* | 48.2661* | 41.2737* |
| Age (A) | 2 | 3.90407* | 8.07444* | 43.6784* | 92.2483* | 32.9833* |
| V × A | 6 | 0.10014* | 0.62979* | 3.2380* | 1.8094* | 3.7990* |
| Error | 22 | 0.03583 | 0.11876 | 0.2491 | 0.5732 | 0.3077 |
| Total | 35 | | | | | |

*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data of leaf area index of *Boro* rice different DAT

| Source | DF | Mean square of leaf area index | | |
|---|---|---|---|---|
| | | 30 DAT | 45 DAT | 60 DAT |
| Replication | 2 | 0.00106 | 0.00592 | 0.01403 |
| Variety (V) | 3 | 0.03545* | 0.23065* | 0.63313* |
| Age (A) | 2 | 0.12617* | 0.79931* | 2.24059* |
| V × A | 6 | 0.00503* | 0.01837* | 0.05210* |
| Error | 22 | 0.00086 | 0.00546 | 0.01331 |
| Total | 35 | | | |

*: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data of dry matter weight hill$^{-1}$ of *Boro* rice different DAT

| **Source** | **DF** | Mean square of plant height at | | | | |
|---|---|---|---|---|---|---|
| | | 30 DAT | 45 DAT | 60 DAT | 75 DAT | At harvest |
| Replication | 2 | 0.01701 | 0.1480 | 0.3508 | 0.8033 | 2.170 |
| Variety (V) | 3 | 0.56722* | 5.7663* | 15.8284* | 21.8495* | 61.879* |
| Age (A) | 2 | 2.01880* | 19.9828* | 56.0147* | 27.9354* | 231.611* |
| V × A | 6 | 0.08040* | 0.4593* | 1.3025* | 2.3507* | 5.537* |
| Error | 22 | 0.01374 | 0.1364 | 0.3327 | 0.7488 | 2.079 |
| Total | 35 | | | | | |

*: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data of number of effective tillers, non-effective tillers hill$^{-1}$ and panicle length of *Boro* at harvest

| **Source** | **DF** | Mean square of | | |
|---|---|---|---|---|
| | | No. of effective tillers hill$^{-1}$ | No. of non-effective tillers hill$^{-1}$ | Panicle length |
| Replication | 2 | 0.4897 | 0.0133 | 1.08333 |
| Variety (V) | 3 | 95.1613* | 11.7400* | 7.90962* |
| Age (A) | 2 | 58.5971* | 4.7356* | 7.51397* |
| V × A | 6 | 6.4480* | 1.5264* | 1.99238* |
| Error | 22 | 0.4272 | 0.0493 | 0.53788 |
| Total | 35 | | | |

*: Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data of number of filled grains, unfilled grains, total grains panicle$^{-1}$ and 1000 grains weight of *Boro* rice at harvest

| **Source** | **DF** | Mean square of | | | |
|---|---|---|---|---|---|
| | | No. of filled grains panicle$^{-1}$ | No. of unfilled grains panicle$^{-1}$ | No. of total grains panicle$^{-1}$ | 1000 grains weight (g) |
| Replication | 2 | 18.86 | 2.3333 | 8.361 | 0.5437 |
| Variety (V) | 3 | 957.51* | 44.9295* | 654.710* | 62.5442* |
| Age (A) | 2 | 1088.68* | 31.2954* | 756.877* | 31.6163* |
| V × A | 6 | 48.66* | 4.6439* | 28.189* | 1.1186* |
| Error | 22 | 17.04 | 1.2424 | 10.179 | 0.3552 |
| Total | 35 | | | | |

*: Significant at 0.05 level of probability

Appendix XI. Analysis of variance of the data of grains yield, straw yield, biological yield and harvest index of *Boro* rice at harvest

| **Source** | **DF** | Mean square of | | | |
|---|---|---|---|---|---|
| | | Grains yield | Straw yield | Biological yield | Harvest index (%) |
| Replication | 2 | 0.03601 | 0.07084 | 0.1879 | 2.3333 |
| Variety (V) | 3 | 3.78676* | 0.78919* | 8.0499* | 25.9450* |
| Age (A) | 2 | 8.13409* | 6.05152* | 27.5857* | 17.6139* |
| V × A | 6 | 0.19293* | 0.17515* | 0.6834* | 0.7142* |
| Error | 22 | 0.04845 | 0.05087 | 0.1855 | 0.8788 |
| Total | 35 | | | | |

*: Significant at 0.05 level of probability