TILLERING BEHAVIUR OF RICE (*Oryza sativa* L.) AND ITS CONTRIBUTION TO GRAIN YIELD AS INFLUENCED BY VARIETY AND SEEDLING AGE IN BORO SEASON

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CERTIFICATE

*This is to certify that the thesis entitled, **"TILLERING BEHAVIOR OF RICE RICE (Oryza sativa** **L.) AND ITS CONTRIBUTION TO GRAIN YIELD AS INFLUENCED BY SEEDLING AGE IN BORO SEASON''** 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 **MASTER OF SCIENCE (M.S.) IN AGRICULTURAL BOTANY,** embodies the result of a piece of bonafide research work carried out by **Afsana Ferdousi Mukta** bearing **Registration No. 12-05064** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any other institution elsewhere.*

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

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ABSTRACT

The present study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during November 2017 to March 2018, to determine the contribution of tillers on rice seed yield as affected by variety and seedling age in *Boro* season. The experiment was laid out in randomized complete block design (RCBD) with 3 replications. The experiment included two varieties of *Boro* rice (V_1= BRRI dhan28 & V_2= BRRI dhan29) and 5 treatments (T_1= 10 days old seedlings, T_2= 15 days old seedlings, T_3= 30 days old seedlings, T_4= 45 days old seedlings, T_5= 60 days old seedlings) along with each of 3 replications. The results revealed that higher values of all the yield attributes were maximum under T_2 (10 days old seedling) followed by T_1 (30 days old seedling) in both the varieties viz. BRRI dhan28- and BRRI dhan29 where a clear dominancy of BRRI dhan29 over BRRI dhan28 on every parameter. Transplantation of 15 days old seedlings (T_2) produced significantly higher grain yield. In variety and seedling age combination, most of the yield parameters exhibit the highest values V_2T_2 (BRRI dhan29 x 30 days old seedlings). The results revealed that transplantation of seedlings (above 15-30 and above 40 days old) and younger seedlings below 15 days old reduced the grain yield consistent

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LIST OF ABBREVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
BCR	=	Benefit Cost Ratio
cm	=	Centimeter
^0C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	and others
Kg	=	Kilogram
Kg ha^{-1}	=	Kilogram per hectare
g	=	gram (s)
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
P^H	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t ha^{-1}	–	ton per hectare
%	=	Percent

CHAPTER I

INTRODUCTION

All over the world, the importance of agriculture, especially rice production, is increasing. To cope with the rising population, rice production needs to increase following vertical, instead of horizontal, expansion. Varieties have a great effect on the growth performance and yield contributing characters. Rice (*Oryza sativa*) is the most important food for majority of people around the world. It is the staple food for more than two billion people in Asia (Hien *et al.*, 2006). The dominant food crop of Bangladesh is rice, accounting for about 75 percent of agricultural land use and 28 percent of GDP. Bangladesh is the fourth largest rice producer in the world, but its productivity was low compared with other Asian countries such as Malaysia and Indonesia (Wikipedia, 2010).

National average rice yield (4.2 tha ^{1}) in Bangladesh is very low compared to the other rice growing countries like 8.75 tha^{-1} in China, 8.22 tha^{-1} in Japan, and 8.04 tha^{-1} in Korea (FAO, 2009). Rice is grown in more than a hundred countries with total cultivated area of about 160 million hectares and occupies 11% of the world's cultivated area with the production of more than 700 million tons (IRRI, 2010; Alam, 2009). The world population is estimated to increase 9 - 11 billion by the year 2025 out of which 4.3 billion will be dependent on rice for their basic food (Bisne *et al.*, 2009). So, rice has a leading role in food security. Cultivation of hybrid rice is one of the strategies to

Increase production per unit area (Obulamma *et al.*, 2004) as hybrid rice gives 15% - 20% more yield than the commercial high yielding varieties (Metwally *et al.*, 2011). Among the improved agro-management practices, seedling age plays an important role in enhancing the yield of rice. Age of seedling is a key factor which influences the tiller production, grain formation and other yield contributing parameters (Faruk *et al*,. 2009). It is the main factor for uniform stand establishment of rice (Ginigaddara *et al.*, 2011) which controls its growth and yield (Faghani *et al.*, 2011). The use of appropriate aged seedlings for transplantation and its timely planting are important non-cash inputs for attaining the higher yield of rice (Patra and Haque, 2011). Seedling vigor contributes to successive tillering, yield and quality of transplanted rice. Growth and production of rice depend on timely cultivation and growth duration of cultivar which is affected by the age of seedlings at transplantation (Mishra *et al.*, 2008). All the above and below ground morphological characters of rice plants vary with the seeding rate, age of seedling and growing environment (Himeda, 1994; Sasaki, 2004).

Tillers are side shoot rose from the base of plant and play major role in the yield of a crop. Productive tillers are most important factor which determines the yield of crop, significant effect of seedling age and nitrogen levels on productive tillers was observed by many researchers. Dynamics of tillering greatly depends on the age of seedlings at transplanting and this is proved by the findings of many researchers (Ali *et al.*, 2013).

Seedling age is an important factor because it has tremendous influence on the plant height, tiller production, panicle length, grain formation, grains panicle-1 and other yield contributing characters. For optimum yield, age of seedlings at transplanting of a particular variety in particular season may not be suitable for other varieties in other seasons. So it is very important to find out the optimum age of seedling of a particular variety in a particular season (Himeda, 1994 and Sasaki, 2004)

Mia (1993) reported that plant height differed significantly among BR3, BR11, BR22, Nizershail, Pajam, and Badshabhog varieties in aman season (Jul-Dec). Tiller number varied widely among the varieties and the number of tillers plant^{-1} at the maximum tiller number stage ranged between 14.3 and 39.5 in 1995 and 12.2 and 34.6 in 1996. Among all the varieties, IR.26 followed by Suweon 258 produced the highest tiller number, while Dawn produced the lowest tiller number. Chowdhury *et al.* (1995) showed that grain and straw yields were higher in the improved (BR3, BR11, Pajam, and Mala) than the native (Maloti, Nizershail, and Chandrashail) varieties It was found that among rice varieties (BR14, Pajam, BR5, and Tulshimala), Tulshimala produced the highest number of spikelets and BR14 produced the lowest. Srivastva and Tripathi (1998) observed that increase in grain yield in local check compared with hybrid might be attributed to more effective tillers m^{-2}, fertile grains panicle^{-1}, panicle length, and 1000-grain weight. A study carried out by Kamal *et al.* (1998) among nine modern varieties (MVs) and six local improved varieties (LIVs) found that among the MVs, BR11 gave the highest grain yield.

Among the cultivation techniques, selection of variety and optimum seedling age are important components and manipulation of which could lead to optimized growth and yield. The main objectives of the research work were to find out optimum seedling age to obtain maximum production of rice.

OBJECTIVE:

- To find out the relationship between tillering ability and different morphological character of rice as influenced by seedling age.
- To find out the contribution of tillers on rice grain yield as affected by seedling age in *Boro* season.

CHAPTER II

REVIEW OF LITERATURE

2.1 Number of Tillers

Ali *et al.* (2013) reported more tillers hill^{-1} (31.5) when younger seedlings of 15 days age were transplanted while minimum (18.0) was observed in case of 30 days old seedlings.

Sarkar *et al.* (2011) tested Aman rice using three levels of row arrangement, two types of tiller seedlings and three levels of number of tiller seedling hill$^{-1.}$ They found that by transplanting older seedlings of 35 days gave more mean tillers hill^{-1} (13.36), while minimum (12.41) was recorded from 25 days old seedlings.

Prabha *et al.* (2011) counted 552 tillers m^{-2} at harvest by 14 days old seedlings in system of rice intensification.

Patra and Haque (2011) investigated tillering pattern of rice as influenced by the age of seedlings in the system of rice intensification. They tested seven levels of seedling age viz. 6, 8, 10, 12, 14 16 and 18 days. Results revealed that maximum tillers plant^{-1} 31.33 and 26.73 were obtained by transplanting 10 days old seedlings in the year 2008 and 2009, respectively.

Faghani *et al.* (2011) found the significant effect of seedling age on tillering pattern, maximum tillers hill^{-1} (16.3) were recorded by transplanting 25 days old seedlings while 35 days old seedlings gave minimum tillers hill^{-1} (15.3).

Sarkar *et al.* *(*2011) revealed that the response of *Boro* rice at differential ages of seedling and spacing under SRI method two ages of seedling aiz. 8 and 12-day old seedlings, and six spacing aiz. 25cm x 25cm, 30cm x30cm, 35cmx35cm, 40cmx40cm, 45cmx45cm and 50cm x 50cm were arranged in a randomized complete block design with three replications. l2-day old seedlings exhibited better performance than that of 8-day old seedlings in respect of all crop characters, yield components and yield of BRRI dhan29 in *Boro* season under SRI technique. Regarding spacing 50cmx50cm was the best in respect of total tillers hill^{-1}, effective tillers hill^{-1}, grains panicle1 but 25cm x 25cm spacing produced the highest grain and straw yields due to more number of effective tillers m^{-2} and total tillers m^{-2}, respectively. In case of interaction, l2-day old seedlings coupled with 25cm x 25cm spacing appeared as the best combination in order to obtain the highest grain and shaw yields in Boro season under SRI method.

Ali *et al.* (2013) reported more effective tillers hill^{-1} (24.9) when seedlings of 15 days age were transplanted while 30 days old seedlings gave minimum number of effective tillers (15.6).

Sarkar *et al.* (2011) did not find significant effect of seedlings age on effective tillers hill$^{-1.}$ They recorded 9.24 and 9.08 effective tillers hill^{-1} in case of 25 and 35 days old seedlings which were statistically same. It was observed that younger seedlings of 14 days age produced more productive tillers m^{-2} (501) as compared to older seedlings which gave minimum (401) productive tillers m^{-2}

Prabha *et al. (*2011) observed that 4 week old seedlings produced more effective tillers hill^{-1} (8.26) while minimum number of effective tillers was obtained from 2 week old seedlings.

Hybrid rice was tested using three levels of seedling age. Results revealed that younger seedlings of 10 days age produced significantly more effective tillers $hill^{-1}$ (17.07 and 18.90) during the year 2010 and 2011, while minimum (10.08 and 11.28) was observed from seedlings of 30 days. (Pramanik & Bera, 2011).

Patra & Hoque (2011) reported that the highest numbers of effective tillers $hill^{-1}$ were produced with seedling of 10 days age. Similarly, the plots transplanted with 10 days old seedling also recorded the highest number of grains $panicle^{-1}$, panicle length and test weight resulted in higher grain yield. Transplantation of 10 days old seedling gave 18.66% and 24.99% more grain yield than T_1 and T_7, respectively. It was also seen that for every days delay in transplanting beyond the age of 10 days, yield was reduced to the extent of 4.5% ha^{-1} $year^{-1.}$

2.2 Rice seed yield contributing attributes

Chakrabortty *et al.* (2015) conducted an experiment at Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from December 2011 to May 2012 to. Maximum number of filled grain (101.0 $panicle^{-1}$), 1000-grain weight (19.9 g), grain yield (5.1 tha^{-1}), straw yield (5.1 tha^{-1}), biological yield (10.2 tha^{-1}) were found and minimum weed population (43.7 m^{-2} at 30 DAT and 63.1m^{-2} at 60 DAT) was also found. 14 days old seedling was found as best for yield of BRRI dhan 50 under System of Rice Intensification.

Hossain and Haque (1988) revealed that the number of basal tillers $hill^{-1}$increased among 30-day old than 60-day old seedlings.

Kim *et al.* (1999) observed that 10-day old seedlings had more vigorous stem elongation and higher tillering ability compared with 15 and 40 day old seedlings. It was observed that the tiller production was higher among 30-day old seedlings transplanted in aman season than others (Khatun, 1995).

Prasad *et al.* (1992) reported that grain yield increased with the age of seedlings at transplanting up to 35 days.

Raju *et al.* (1989) reported that the number of panicles m^{-2}, number of grain per panicle, and 1000-grain weight was the highest among 30-day old seedlings.

Rashid *et al.* (1990) reported that the age of seedling had a significant effect on number of grains $panicle^{-1}$ (Hariom *et al.*, 1989). It was also observed that the 40-day old seedlings gave higher number of panicles than 20 or 60 day old seedlings.

2.2.1 Plant height

Plant height is an important morphological character of a plant. It can vary according to genetic makeup of plant, nutrient status of soil in which it grown, environmental conditions and different types of stresses faced during its life cycle. Various scientists have noticed significant effect of seedling age on plant height.

Ali *et al.* (2013) evaluated *Boro* Rice BRRI dhan 28 with two levels of seedling ages *viz*. 15 and 30 days old and two levels of water management. They found significant effect of seedling age on plant height. Maximum plant height (98.3 cm) was recorded when older seedlings of 30 days were transplanted, while minimum plant height (90.4 cm) was recorded by 15 days old seedlings.

El-Rewainy *et al. (*2007) tested rice cultivar Sakha 101 by using four seedling ages (25, 30, 35, 40 days) and four nitrogen levels (0, 48, 96, 144 kg ha^{-1}). Maximum plant height (79.80 cm) was obtained by seedlings of 30 days age while 25 days old seedlings gave minimum plant height (70.7). Regarding nitrogen levels maximum plant height (78.50 cm) was obtained when nitrogen was applied @ 144 kg ha^{-1} and minimum (71.60 cm) was observed with no nitrogen application.

Pramanik and Bera (2011) found the significant effect of seedling age and nitrogen fertilization on plant height of hybrid rice. The maximum plant height (103.81 cm and 112.84 cm) when 10 days old seedlings were transplanted and nitrogen was applied @ 200 $kgha^{-1}$, while minimum plant height (91.38 cm and 81.63 cm) was observed with the seedlings of 30 days age and with no nitrogen application.

Sarkar *et al.* (2011) recorded more plant height (130.60 cm) at harvest in case of 25 days old seedlings while minimum of 127.54 cm was observed when seedlings of 35 days were transplanted. It was investigated that seedlings of 14 days age produced taller plants (89.50 cm) at harvest compared to older seedlings of 21 days (Prabha *et al.*, 2011).

2.2.2 Panicle length

Ali *et al.* (2013) reported that panicle length was not significantly affected by seedling age. Thirty days old seedlings gave mean maximum (23.67 cm) and minimum (21.38 cm) panicle length, while 15 days old seedlings recorded a mean panicle length of 23.41 cm

Bagheri *et al. (*2011) conducted the experiment to determine the effect of seedling age and potassium rates on lodging and yield components of rice. Panicle length was significantly affected by seedling age and maximum panicle length (26.16 cm) was shown by transplanting 30 days old seedlings followed by 20 and 40 days age. Minimum panicle length (23.78 cm) was given by transplanting 40 days old seedlings.

Panicle length also favors the increase in the numbers of spikelets per panicle. Four rice cultivars were tested using three levels of seedling age (27, 30 and 35 days). Panicle length was significantly affected by seedling age. Seedlings of 27 days age gave maximum (22.95 cm) panicle length followed by 30 and 35 days old seedlings. Minimum Panicle length (21.04) was recorded from older seedlings of 35 days (Rahimpour *et al.*, 2013).

Patra *et al.* (2011) investigated seedling ages in order to determine their significance on yield and yield contributing parameters of rice under system of rice intensification. They found higher panicle length (22.55 cm) by transplanting 10 days old seedlings and minimum (18.09 cm) was recorded from 6 days old seedlings.

Prabha *et al.* (2011) reported more panicle length (24.1 cm) by transplanting younger seedlings of 14 days age compared with older seedlings of 21 days which received minimum panicle length of 18.8 cm in system of rice intensification.

Sarkar *et al.* (2011) found significant effect of seedling age of panicle length, they recorded more panicle length (27.98 cm) from seedlings of 25 days age while minimum (27.36 cm) from older seedlings of 35 days.

2.2.3 Number of grains panicle^{-1}

The individual unit of spike is termed as spikelet. Greater the number of spikelets greater will be grain yield and vice versa.

Brar *et al.* (2012) reported that seedling age had no significant effect on number of grains panicle^{-1}. Seedlings of 30 45 and 60 days produced similar number of grains panicle$^{-1.}$ It was observed in a study that 25 days old seedlings produced more number spikelets panicle^{-1} (170.79) as compared to seedlings of 35 days age. Sarkar *et al. (*2011) while in another study it was noted that seedling age had no significant effect on number of spikelets panicle^{-1} and researchers recorded similar number of spikelets (100.7 and 103.8) in case of 25 and 35 days old seedlings (Faghani *et al.*, 2011).

Manjunatha *et al.* (2010) tested the effect of seedling age under the system of rice intensification and it was observed that younger seedlings (9 and 12 days) produced significantly higher number of grains panicle^{-1} (159.33 and 158.13) as compared to older seedlings of 18 days which gave minimum (146.87) grains panicle$^{-1.}$

Rahimpour *et al.* (2013) checked the effect of seedling age on rice cultivars and found the significant effect of seedling age on number of spikelets panicle$^{-1.}$ Maximum number of spikelets (114.6) was recorded with the seedlings of 27 days age while minimum (106.4) was recorded in case of 30 days old seedling.

2.2.4 Filled grains panicle^{-1}

Several scientists researchs have made efforts in order to assess the number of filled grains panicle^{-1} as affected by seedling age. Rahimpour *et al.* (2013) found more filled grains panicle^{-1} (110.6) when younger seedlings of 27 days were transplanted while minimum number of grains panicle^{-1} (100.6) was given by seedlings of 30 days age.

Ali *et al.* (2013) reported the significant effect of seedling age on number of filled grains panicle^{-1}, maximum number of filled grains (188) was obtained by transplanting younger seedlings (15 days) while minimum number of filled grains (170) was recorded using older seedlings of 30 days age. More number of grains panicle^{-1} (140.99) was reported by transplanting younger seedlings (25 days) while minimum (135.44) was observed using older seedlings of 35 days age Sarkar *et al. (*2011).

Prabha *et al. (*2011) recorded maximum number of filled spikelets panicle^{-1} (211) in the treatment where 14 days old seedlings were transplanted while minimum number (141) was given by 21 days old seedlings. Similarly, Patra and Haque (Patra *et al.*, 2011) found more number of filled grains panicle^{-1} (123.30) when 10 days old seedlings were transplanted while minimum (86.20) was given by 6 days old seedlings under the system of rice intensification.

2.2.5 1000 grain weight

The 1000 grain weight is key factor in determining the final grain yield, and 1000 kernal weight or grain weight may vary among cultivars or may vary according to conditions. The 1000-kernel weight is the important indicator of paddy yield. Rahimpour Rahimpour *et al.*, (2013) investigated those 27 days old seedlings produced maximum

1000-kernel weight (22.08 g) as compared to 30 days old seedlings which gave minimum value of 20.33 g. Age of seedlings significantly influenced 1000-grain weight and the maximum 1000 grain weight (22.61 g) were obtained by transplanting younger seedlings of 15 days while and the minimum grains (21.00 g) were obtained from 30 days old seedlings (Ali *et al.*, 2013). Whereas Brar *et al. (*2012) reported that seedling age had no significant effect on 1000-kernel weight and seedlings of 30, 45 and 60 days conceived statistically similar thousand kernel weight. According to the findings of Sarkar *et al. (*2011) maximum 1000-kernel weight (26.40 g) was obtained by transplanting younger seedlings (25 days) while minimum (25.98 g) was given by older seedlings (35 days).

Pramanik & Bera (2011) evaluated hybrid rice to three levels of seedling age and five levels of nitrogen. They observed that 1000-kernel weight affected significantly by different levels of seedling age and nitrogen rates. Young seedlings of 10 days age produced maximum thousand grain weight (23.80 g) while minimum (22.86 g) was recorded from older seedlings of 30 days age. Thousand Kernel weight increased gradually with increase in nitrogen rate from 0 to 150 kg ha^{-1} maximum 1000-kernel weight (24.11 g) was obtained with the application of 150 kg·N·ha^{-1} and it decreased (to 23.87 g) with further increase in nitrogen up to 200 kg $ha^{-1.}$

2.2.6 Seed yield

Seed yield is the function of number of productive tillers, filled grains $panicle^{-1}$ and 1000-kernel weight. Seedling age influenced Seed yield which is proved by a number of scientists based on their field experiments.

Ali *et al.* (2013) tested *Boro* Rice BRRI dhan28 to different seedling ages. They found the maximum grain yield (8.77 tha^{-1}) when young seedlings of 15 days were transplanted while minimum (6.90 tha^{-1}) was observed in case of aged seedlings of 30 days.

Brar *et al.* (2012) also reported significant effect of seedling age on paddy yield. According to their findings younger seedlings of 30 days age produced more grain yield (6.82 tha^{-1}) as compared to older seedlings of 60 days which produced minimum grain yield (6.47 tha^{-1}).

Rahimpour *et al.* (2013) investigated the effect of seedling age on rice cultivars. Younger seedlings of 27 days age produced higher grain yield (5.82 tha^{-1}) as compared to older seedlings of 35 days which gave minimum Seed yield (5.38 tha^{-1}).

Sarkar *et al.* (2011) also recorded more grain yield (4.13 tha^{-1}) from younger seedlings of 25 days age while minimum (3.68 tha^{-1}) was obtained from older seedlings of 35 days. In system of rice intensification rice variety “Ranjit” was tested using seven levels of seedling age (6, 8, 10, 12, 14, 16 and 18 days). It was reported that seedling age significantly affected grain yield and maximum grain yield (7.11 tha^{-1}) was obtained by using 10 days old seedlings while minimum was given by 6 days old seedlings.

2.2.7 Straw Yield (tha^{-1})

Ali *et al.* (2013) reported that seedling age had no significant effect on straw yield. Whereas Sarkar *et al.* (2011) found significant effect of seedling age on straw yield. They recorded maximum straw yield (5.61 tha^{-1}) with older seedlings (35 days) while younger seedlings (25 days) produced minimum straw yield (4.81 tha^{-1}).

Bagheri *et al.* (2011) recorded more straw yield (846.90 g m^{-2}) when 30 days old seedlings were transplanted while minimum (635.80 g m^{-2}) was observed in case of 20 days old seedling. In another field study it was found that younger seedlings of 9 days age produced maximum straw yield (7019 kg ha^{-1}) while minimum (6716 kg ha^{-1}) was given by 21 days old seedlings (Manjunatha *et al.*, 2010). Faruk *et al. (*2009) reported that straw yield was significantly affected by age of seedlings. Maximum straw yield (5.54 tha^{-1}) was recorded by transplanting 4 weeks old seedlings while minimum straw yield (4.24 tha^{-1}) was obtained where 2 week old seedlings were transplanted.

2.2.8 Harvest index (HI)

Harvest index is the ration between grain yield and biological yield. Harvest index was significantly influenced by seedling age and maximum harvest index (47%) was recorded by transplanting younger seedlings of 15 days age while minimum (42%) was obtained from transplanting 30 days old seedlings (Ali *et al.*, 2013).

Similar findings were reported by Sarkar *et al. (*2011) with maximum harvest index of 46% when younger seedlings of 25 days age were transplanted while minimum (40%) was given by 35 days old seedlings.

Ginigaddara and Ranamukhaarachchi (2011) reported maximum harvest index (51%) by transplanting 9 days old seedlings.

CHAPTER III

MATERIALS AND METHODS

3.1 Site description

The experiment was conducted in the research field of Sher-e-Bangla Agricultural University, Dhaka, under the agro-ecological zone of Modhupur Tract, AEZ 28 during the *Boro* season of 2017. The experimental site is shown in the Map of AEZ of Bangladesh in Appendix I.

3.2 Climate

The experimental area under the subtropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the rabi season (October-March). The weather data during the study period at the experimental site are shown in Appendix II.

3.3 Soil

The farm belongs to the general soil type, shallow red brown terrace soils under Tejgaon series. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resources and Development Institute (SRDI), Dhaka. The physic-chemical properties of the soil are presented in Appendix III.

3.4 Crop / planting material

BRRI dhan 28 & BRRI dhan 29, were used as test crop /planting material.

3.5 Seed collection

Seeds of BRRI dhan 28 & BRRI dhan 29 were collected from BRRI, Joydebpur, Gazipur. Healthy seeds were selected following standard method. Seeds were immersed in water in two different buckets for 24 hrs. These were then taken out of water and kept in different gunny bags. The seeds started sprouting after 48 hrs which were suitable for sowing in 72 hrs.

3.6 Raising of seedlings

A common procedure was followed in raising of seedlings in the seedbed. The nursery beds were prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on 1 october,2017 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.7 Preparation of experimental land

The experimental field was first opened on 01 October, 2017 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. All kinds of weeds and residues of previous crop were removed from the field. The field layout was made on 10 October, 2017 according to design immediately after final land preparation. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.8 Fertilizer management

At the time of first ploughing cowdung at the rate of 10 tha^{-1} was applied. The experimental area was fertilized with 120, 80, 80, 20 and 5 kg ha^{-1} of N, P_2O_5, K_2O, S and Zn in the form of urea, triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively. The entire amounts of triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate were applied at final land preparation. The first one^{-1} hird urea was top dressed at 7 days after transplanting (DAT). The rest of urea was top dressed in three equal splits one at 23 days after transplanting (DAT), second at 38 days after transplanting (DAT), and the other at panicle initiation stage (52 DAT).

3.9 Treatments (Variety & seedling age)

The experiment consisted of two factors.

Factor a) Variety

1. V_1 – BRRI dhan28
2. V_2– BRRI dhan29

Factor b) Seedling age

1. T_1- 10 days old seedling
2. T_2- 15 days old seedling
3. T_3- 30 days old seedling
4. T_4- 45 days old seedling
5. T_5- 60 days old seedling

3.10 Experimental design

The experiment was laid out in randomized complete block design (RCBD) with three replications. There were 10 (5x2) treatment combinations. The total numbers of unit plots were 30. The size of unit plot is 5m x 3m (15 m^2). The distances between plot to plot and replication to replication were 1 and 1.5 m, respectively.

3.11 Uprooting and transplanting of seedlings

Treatment wise different day old seedlings were uprooted carefully and were kept in soft mud in shade. The seed beds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. Seedlings were then transplanted on 1 November as on the well puddled plots.

3.12 Intercultural operations

3.12.1 Gap filling: After one week of transplanting, a minor gap filling was done where it was necessary using the seedling from the same source.

3.12.2 Weeding: During plant growth period two hand weeding were done, first weeding was done at 23 DAT (Days after transplanting) followed by second weeding at 38 DAT.

3.12.3 Irrigation: Method of water application the experimental plots were irrigated through irrigation channels. For the purpose of irrigation to continuous saturated plot, deep tube well water was stored in the drain from which water was applied to the plots using plastic bucket.

3.12.4 Plant protection measures: Plants were infested with rice stem borer and leaf hopper to some extent which was successfully controlled by applying two times of Diazinone M45 and Ripcord 20EC. Crop was protected from birds during the grain filling period.

3.13 General observation of the experimental field

The field was observed time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable losses by pest should be minimized. The field looked nice with normal green color plants. The plants in continuous submergence appeared more vigorous and luxuriant growth than the other water level (saturated condition). Weed infestation in continuous saturated condition was more than other water level. Incidence of stem borer, green leaf hopper, leaf roller was observed during tillering stage. Attack of rice stem borer was more congenial in the water level of continuous submergence. But any bacterial and fungal disease was not observed. The flowering was not uniform. The plants in each plots of continuous standing water lodged during ripening stage due to heavy rainfall with gusty winds which was not appeared in plots of continuous saturated condition.

3.14 Harvesting and post-harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting was done on 10 march, 2018 from ten pre-selected hills from which data were collected and 6 mid lines from each plot was separately harvested, 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 tha^{-1}.

3.15 Recording of data

A. Crop growth characters

Plant height (cm) at 30, 60, 90 & 120 days after transplanting (DAT)

Number of tillers $hill^{-1}$ at 30, 60, 90 & 120 days after transplanting (DAT)

Leaf area index at 30, 60, 90 & 120 days after transplanting (DAT)

Dry weight $hill^{-1}$

Time of flowering

B. Yield and yield contributing characters

Penicle length (cm)

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

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

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

Weight of 1000-grain (g)

Straw yield (t ha^{-1})

Biological yield

Harvest index (%)

3.16 Experimental measurements:

Experimental data collection began at 15 days after transplanting, and continued till harvest. The necessary data on agronomic characters were collected from ten selected hills from each plot in field and at harvest.

Plant height:

Plant height was measured at 10 days interval and continued up to harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before heading, and to the tip of panicle after heading.

Number of tillers hill^{-1}:

Number of tillers hill^{-1} were counted at 10 days interval 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.

Leaf area index (LAI):

Leaf area index were estimated measuring the length and width of leaf and multiplying by a factor of 0.75 followed by Yoshida (1981).

Dry weight of plant:

The sub-samples of 5 hills plot^{-1} uprooting from 2nd line were oven dried until a constant level from which the weight of above ground dry matter were recorded at 30 days interval up to harvest.

Time of flowering:

Time of flowering was considered when emergence of 50% of the plants within a plot takes place. The number of days for flowers was recorded.

Panicle length:

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

Number of effective tillers hill^{-1}:

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

Number of ineffective tillers hill^{-1}:

The tiller having no panicle was regarded as ineffective tiller.

Number of filled grains panicle^{-1}:

Spikelet was considered to be fertile if any kernel was present their in. The number of total fertile spikelets present on each panicle was recorded.

Number of unfilled grains panicle^{-1}:

Sterile spikelet means the absence of any kernel inside in and such spikelets present on each panicle were counted.

Number of total spikelets panicle^{-1}:

The number of fertile spikelets panicle^{-1} plus the number of sterile spikelets panicle^{-1} gave the total number of spikelets panicle^{-1}.

Weight of 1000-grain (g):

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

Grain yield (tha^{-1}):

Grain yield was determined from the central 5 m length of all 6 inner rows of the plot and expressed as t ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

Straw yield

Straw yield was determined from the central 5m length of all 6 inner rows of each plot. After threshing, the sub-sample was oven to a constant wt. and finally converted to tha^{-1}

Harvest index (%)

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

Harvest index (%) = (Grain yield / Biological yield) x 100

3.17 Analysis of data:

Collected data will be statistically analyzed using Statistix 10 computer package program. The mean difference will be adjusted by least significant different test. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS & DISCUTION

4.1 Tillering behavior as influenced by seedling age:

4.1.1 Number of tillers hill^{-1}(TPH)

Number of tillers varied from treatments to treatments and with the advancement of crop growth. From the critical analysis of the data, it was found that the number of tillers was increased continuously among two varieties BRRI dhan28 & BRRI dhan29 where BRRI dhan29 clearly showed the greater number of tillers hill^{-1} at different growth stages. Highest number of tillers at 120 DAT was found in both BRRI dhan28 & BRRI dhan29 (28.46 & 36.96 respectively) where lowest number of tillers hill^{-1} found at 30 DAT in both BRRI dhan28 & BRRI dhan29 (13.13 & 16.00, respectively) (Fig. 1).

It was also found that the number of tillers was increased continuously and attained a maximum value at 30 to 45 days old seedlings, which was due to profuse tillering during vegetative growth and then decrease gradually and lowest number of panicle bearing tillers were found due to non-effective side tiller mortality in both varieties BRRI Dhan28 & BRRI Dhan29. However, maximum number of tillers at 120 DAT were found from T_3 (35.08 hill^{-1}) which was statistically identical with T_4 (34.17 hill^{-1}) while minimum tillers from T_1 (13.38 hill$^{-1)}$ at 30 DAT (Fig. 2).

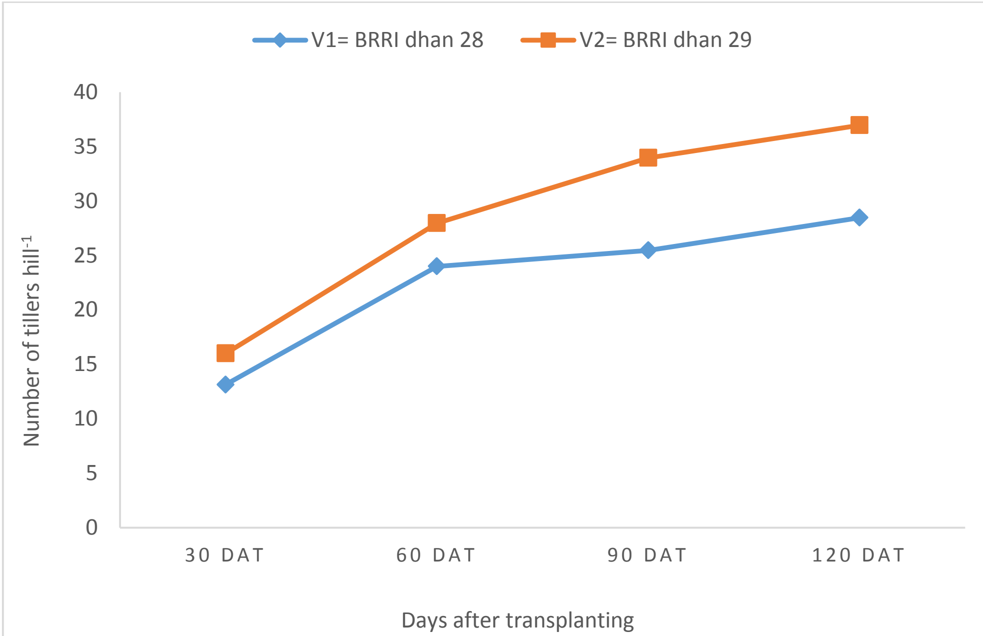

Fig. 01. Effect of variety on tillers hill^{-1} at different growth stages of rice

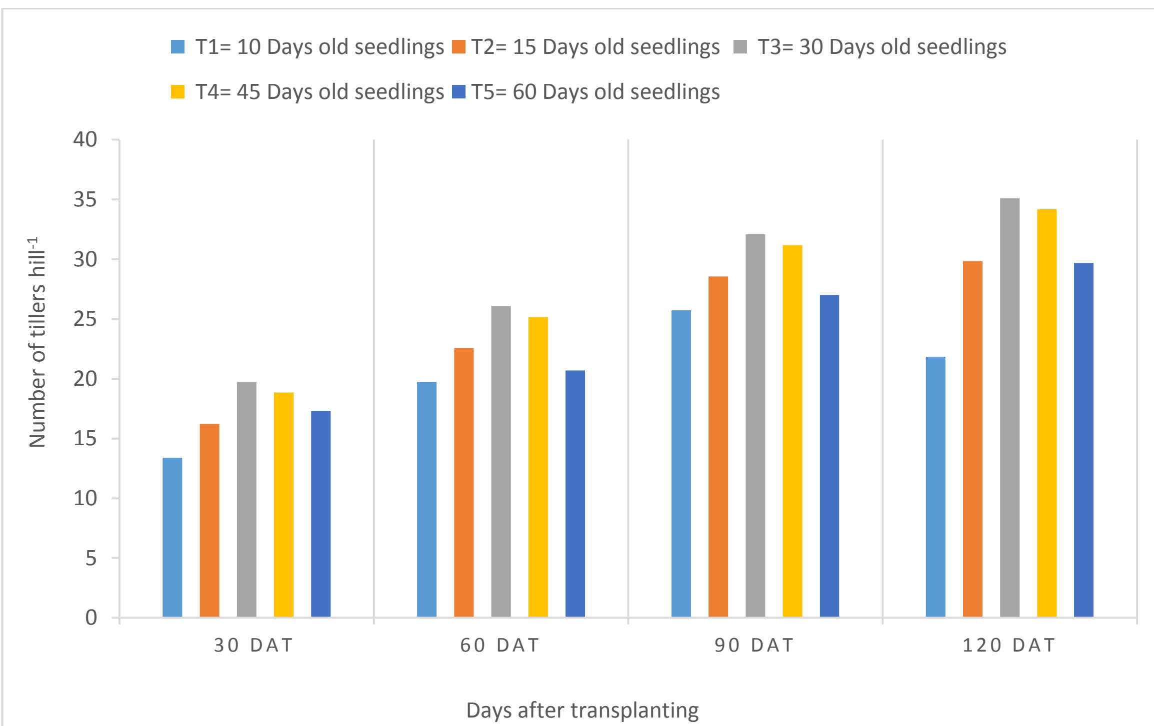

Fig. 02. Effect of seedling age on tillers hill^{-1} at different growth stages of rice

The combined effect of varieties and seedling age showed significant differences in respect of tillers hill^{-1} (Table 1). It was found that the highest number of tillers hill^{-1} in V_2T_3 (39.73) at 120 DAT which was statistically similar with V_2T_4 (38.67) and the lowest number of tillers hill^{-1} was found in V_1T_1 (9.33) at 30 DAT (Table 1). Sarkar *et al.* (2011) and Prabha *et al.* (2011) demonstrated the same result. Touhiduzzaman, (2011) also recorded similar increment of plant height having variety BRRI dhan 50. Optimum seedling age for growth under conventional method for transplanting *boro* rice was 35-45 days (DAE, 1992).

Table 1: Combined effect of varieties and different ages of seedlings on number of tillers hill^{-1} at different growth stages of rice

Variety x seedling age	30 DAT	60 DAT	90 DAT	120 DAT
V_1T_1	9.33 e	15.66 e	21.66 e	24.66 f
V_2T_1	17.43 bc	23.76 bc	29.76 c	32.76 bc
V_1T_2	12.03 de	18.37 d	24.36 d	27.37 d
V_2T_2	23.33 ab	29.67 ab	35.66 ab	38.67 ab
V_1T_3	15.10 cd	21.43 c	27.43 c	30.43 c
V_2T_3	24.40a	30.73a	36.73a	39.73a
V_1T_4	14.33cd	20.66 d	26.66 d	29.66 cd
V_2T_4	20.43 ab	26.76 ab	32.76 b	35.76 b
V_1T_5	14.83 cd	21.16 cd	27.17 c	30.17 c
V_2T_5	22.53 ab	28.86 ab	34.86 ab	36.87 b
CV%	3.18	2.33	1.86	1.69
LSD (0.05)	5.30	1.78	4.34	6.23

Mean having same letter(s) are not significantly different at 5% level of probability.

V_1T_1 = BRRI dhan28 x 10days old seedling
V_2T_1 = BRRI dhan29 x 10days old seedling
V_1T_2 = BRRI dhan28 x 15days old seedling
V_2T_2 = BRRI dhan29 x 15days old seedling
V_1T_3 = BRRI dhan28 x 30days old seedling
V_2T_3 = BRRI dhan29 x 30days old seedling
V_1T_4 = BRRI dhan28 x 45days old seedling
V_2T_4 = BRRI dhan29 x 45days old seedling
V_1T_5 = BRRI dhan28 x 60days old seedling
V_2T_5 = BRRI dhan29 x 60days old seedling

4.2 Growth parameters

4.2.1 Plant height (PH):

Significant variation was not found at different days after transplanting (DAT) in two varieties BRRI dhan28 & BRRI dhan29 in terms of plant height. The tallest plant was found at 120 DAT in BRRI dhan29 (93.43 cm) and minimum height was found in BRRI dhan29 (10.72 cm) at 30 DAT (Fig. 3).

It was also found that the plant height was increased continuously at different growth stages but there was no significant variation among different treatments. However, greater plant height was found from T_3 (93.00 cm) at 120 DAT which was statistically similar with T_1 and T_2 (91.67 cm & 91.00 cm respectively) while minimum height was found from T_5 (9.98 cm) at 30 DAT (Fig. 4).

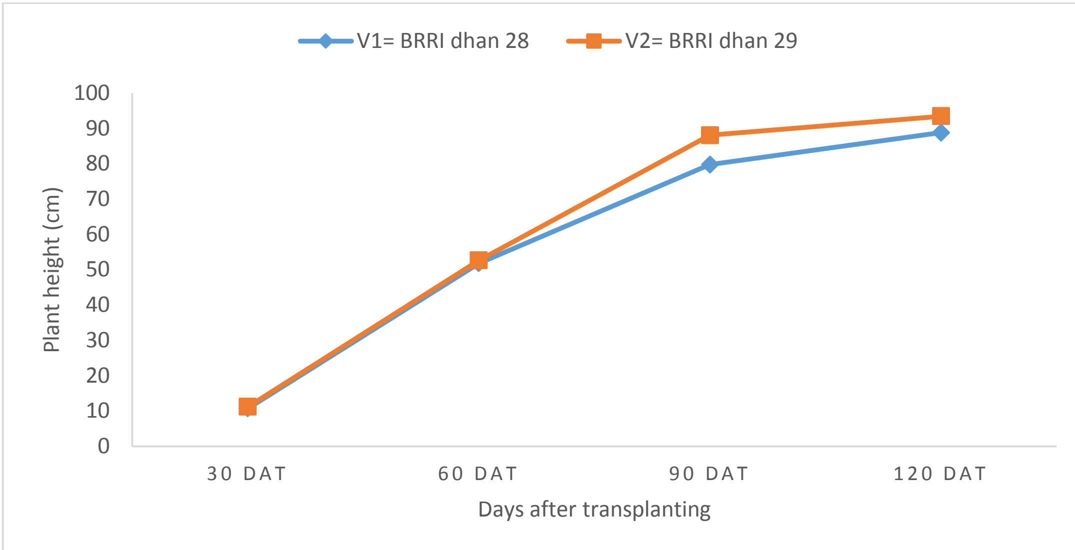

Fig. 03. Effect of variety on plant height at different growth stages of rice

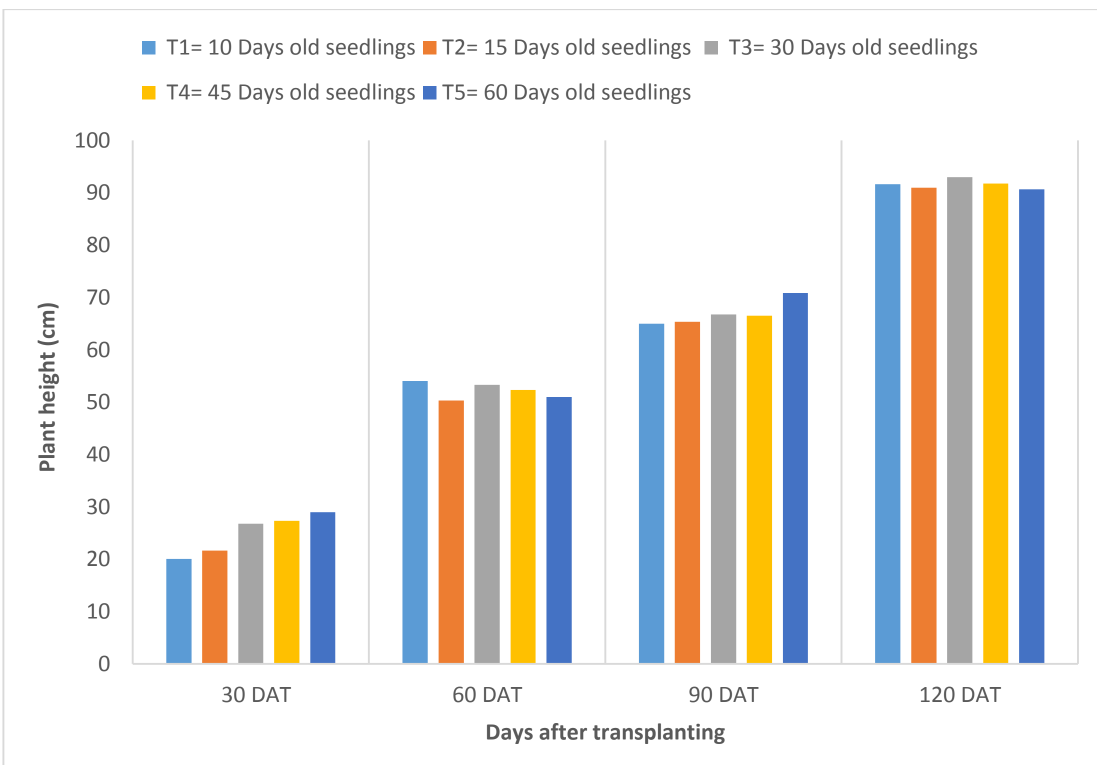

Fig. 04. Effect of seedling age on plant height at different growth stages of rice

The combined effect of varieties and seedling age on plant height showed non-significant differences in respect of plant height (Table 2) where highest plant height was found in V_2T_3 (94.67cm) at 120 DAT which was statistically similar with V_2T_2 (94.00 cm) and V2T4 (93.17 cm) and lowest plant height found in V_2T_5 and V_1T_5 (9.98 cm) at 30 DAT. Ali *et al.* (2013) evaluated *Boro* Rice BRRI dhan 28 and found maximum plant height (98.3 cm) was recorded when older seedlings of 30 days were transplanted. Sarkar *et al. (*2011) recorded more plant height (130.60 cm) at harvest in case of 25 days old seedlings while minimum of 127.54 cm was observed when seedlings of 35 days were transplanted. Kosta *et al.* (1982) also recorded similar increment of plant height.

Table 02: Combined effect of varieties and different ages of seedlings on plant height at different growth stages of rice

Variety x Seedling age	30 DAT	60 DAT	90 DAT	120 DAT
V_1T_1	10.84b	52.03b	63.00ab	89.66de
V_2T_1	13.23a	56.03a	67.00ab	93.67ab
V_1T_2	10.67b	50.33c	62.67b	88.00e
V_2T_2	10.67b	50.33c	73.37a	94.00ab
V_1T_3	10.77b	53.33b	65.17ab	91.33bcd
V_2T_3	10.77b	53.33b	68.33ab	94.66a
V_1T_4	11.33ab	52.33b	64.43ab	90.33cde
V_2T_4	11.33ab	52.33b	68.67ab	93.16cbc
V_1T_5	9.90b	51.00bc	63.00 ab	89.66de
V_2T_5	9.98b	51.00bc	68.33ab	91.66bcd
CV%	1.22	2.13	3.70	1.00
LSD (0.05)	0.43	0.90	8.00	2.96

Mean having same letter(s) are not significantly different at 5% level of probability.

V_1T_1 = BRRI dhan28 x 10days old seedling
V_2T_1 = BRRI dhan29 x 10days old seedling
V_1T_2 = BRRI dhan28 x 15days old seedling
V_2T_2 = BRRI dhan29 x 15days old seedling
V_1T_3 = BRRI dhan28 x 30days old seedling
V_2T_3 = BRRI dhan29 x 30days old seedling
V_1T_4 = BRRI dhan28 x 45days old seedling
V_2T_4 = BRRI dhan29 x 45days old seedling
V_1T_5 = BRRI dhan28 x 60days old seedling
V_2T_5 = BRRI dhan29 x 60days old seedling

4.2.2 Leaf area index:

Leaf area index (LAI) differ among two varieties BRRI dhan28 and BRRI dhan29. The Greater LAI was found at 90 DAT in BRRI dhan29 (5.01) and then slight reduction of LAI in both varieties BRRI dhan28 and BRRI dhan29 (3.66 & 4.6 respectively) and the lowest LAI was also found from BRRI dhan29 (0.88) at 30 DAT (Fig. 5).

It was found that the LAI was increased continuously at different growth stages but there was no significant variation among different seedling age. However, greater LAI was found from T_3 (1.02, 1.47, 4.92 & 4.01) at 30, 60, 90 and 120 DAT, respectively while minimum LAI was found from T_1 & T_5 (0.9 cm) at 30 DAT (Fig. 6).

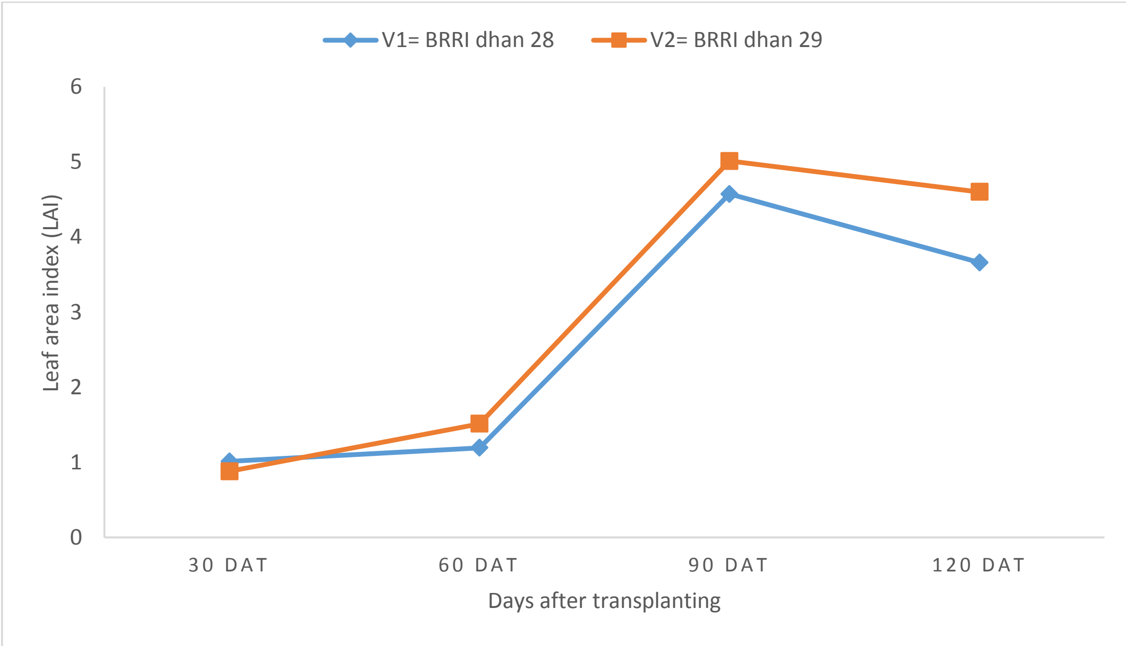

Fig. 05. Effect of variety on effective leaf area index (LAI) at different growth stages of rice

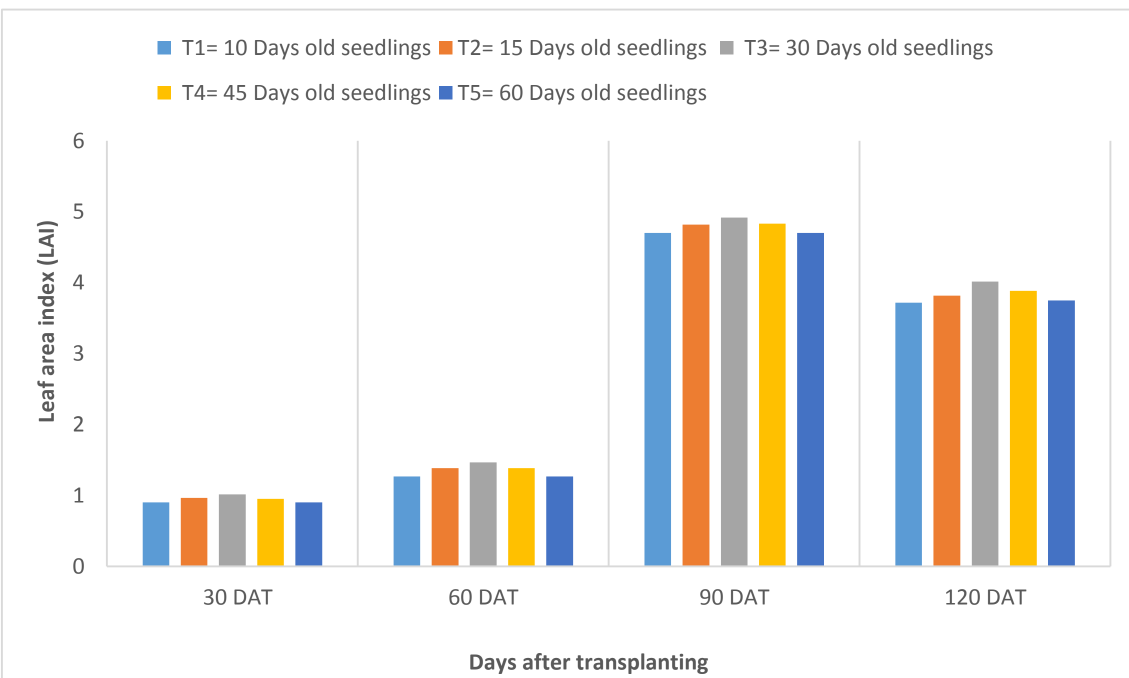

Fig. 06. Effect of seedling age on leaf area index (LAI) at different growth stages of rice

The combined effect of varieties and seedling age on leaf area index (LAI) showed non-significant differences mostly at 30 DAT. The highest LAI found from the combination of V_2T_3 (1.10, 1.60, 5.10 & 4.10) at 30, 60, 90 and 120 DAT, respectively where lowest LAI was found in V_1T_1 (0.83) at 30 DAT (Table 3). Chakrabarti *et al.* (2015) and Touhiduzzaman (2011) also recorded similar increment of leaf area index.

Table 03: Combined effect of varieties and different ages of seedlings on leaf area index (LAI) at different growth stages of rice

Variety x Seedling age	30 DAT	60 DAT	90 DAT	120 DAT
V_1T_1	0.83 b	1.07d	4.43e	3.46c
V_2T_1	0.96 b	1.47abc	4.97abc	3.97ab
V_1T_2	0.86 ab	1.20cd	4.56de	3.56bc
V_2T_2	1.06 a	1.57ab	5.06ab	4.06a
V_1T_3	0.93 a	1.33abcd	4.73bcde	3.93ab
V_2T_3	1.10 b	1.60a	5.10a	4.10a
V_1T_4	0.90 ab	1.27bcd	4.67cde	3.76abc
V_2T_4	1.00 b	1.50abc	5.00ab	4.00ab
V_1T_5	0.87 b	1.10d	4.46e	3.57bc
V_2T_5	0.93 abc	1.43abc	4.93 abcd	3.93ab
CV%	5.00	7.14	1.52	2.97
LSD (0.05)	0.16	0.31	0.24	0.37

Mean having same letter(s) are not significantly different at 5% level of probability.

V_1T_1 = BRRI dhan28 x 10days old seedling
V_2T_1 = BRRI dhan29 x 10days old seedling
V_1T_2 = BRRI dhan28 x 15days old seedling
V_2T_2 = BRRI dhan29 x 15days old seedling
V_1T_3 = BRRI dhan28 x 30days old seedling
V_2T_3 = BRRI dhan29 x 30days old seedling
V_1T_4 = BRRI dhan28 x 45days old seedling
V_2T_4 = BRRI dhan29 x 45days old seedling
V_1T_5 = BRRI dhan28 x 60days old seedling
V_2T_5 = BRRI dhan29 x 60days old seedling

4.3 Yield contributing parameters

4.3.1 Effective tillers hill^{-1}

It was found that the number of effective tillers was increased continuously among two varieties BRRI han28 and BRRI dhan29 where BRRI dhan29 has clearly showed the greater number of tillers hill^{-1} at different growth stages. Highest number of tillers at 120 DAT was found in both BRRI dhan28 and BRRI dhan29 (21.3 & 27.5 respectively) where lowest number of effective tillers hill^{-1} found at 30 DAT in both BRRI dhan28 BRRI dhan29 (6.5 & 12.00, respectively) (Fig. 7).

The result showed that effective tillers was increased and attained a maximum value at 15 to 30 days old seedlings and then decreased gradually. The maximum number of tillers hill^{-1} at 120 DAT was found from T_2 (27.82) which was statistically similar with T_3 (26.63) while minimum from T_1 (9.03) at 30 DAT (Fig. 8).

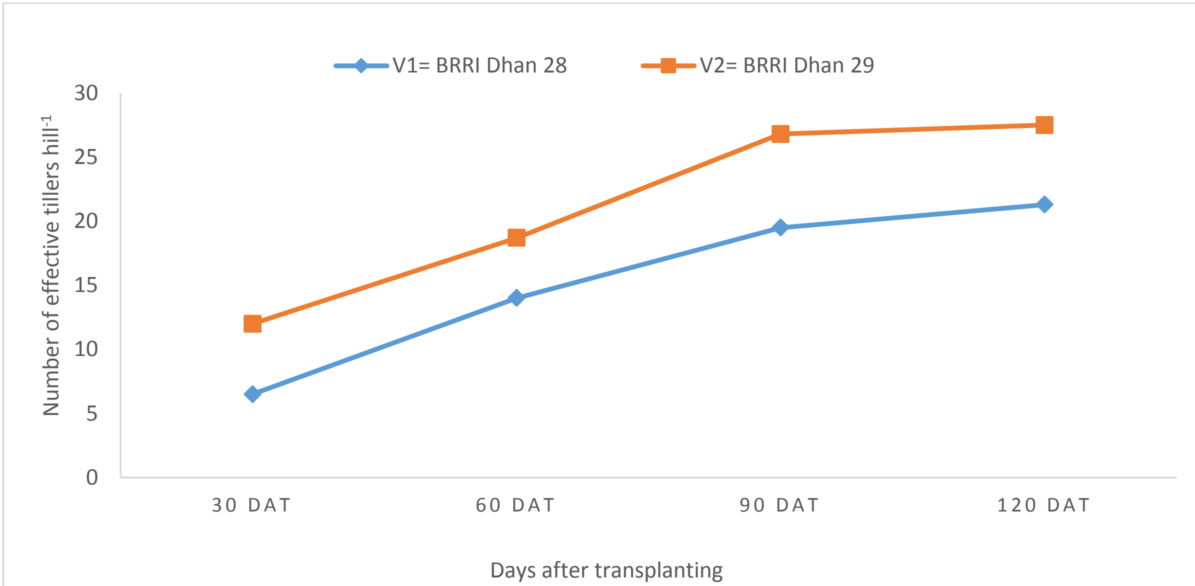

Fig. 07. Effect of variety on effective tillers hill^{-1} at different growth stages of rice

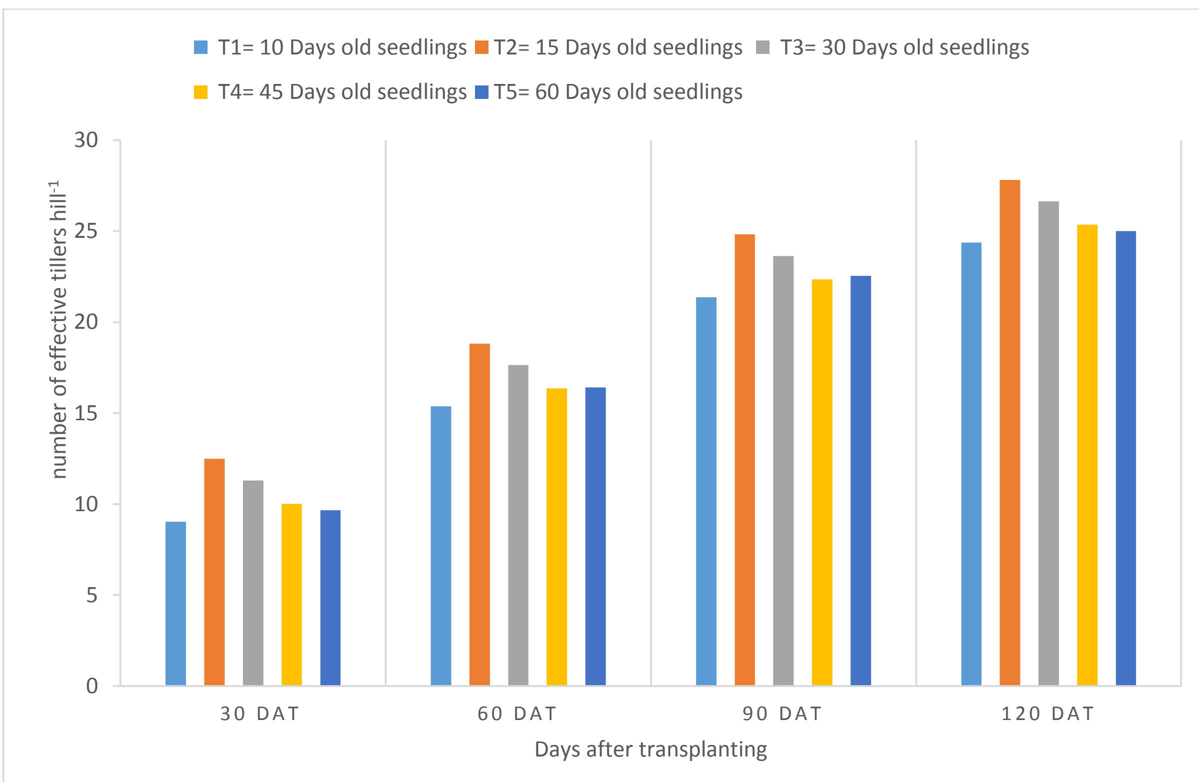

Fig. 08. Effect of seedling age on effective tillers hill^{-1} at different growth stages of rice

The highest number of effective tillers hill^{-1} was found from the combined effect of varieties and seedling age was(V_2T_2) (31.97) at 120 DAT which was statistically similar with V_2T_3 (30.93) where the lowest number of tillers hill^{-1} was found in V_1T_1 (5.33) at 30 DAT (Table 4). Sarkar *et al. (*2011) and Prabha *et al. (*2011) demonstrate the same result. Kosta *et al. (*1982), Sundersingh *et al. (*1983). and Touhiduzzaman, (2011) also recorded similar increment of plant height having variety BRRI dhan50.

Table 04: Combined effect of variety and different seedling age on effective tillers hill^{-1} at different growth stages of rice

Variety x Seedling age	30 DAT	60 DAT	90 DAT	120 DAT
V_1T_1	5.33 e	11.66 e	17.66 f	20.66 e
V_2T_1	12.73 c	19.07 c	25.06 bc	28.07 c
V_1T_2	6.16 de	12.50 d	18.50 e	21.50 de
V_2T_2	16.63 a	22.97 a	28.97 a	31.97 a
V_1T_3	7.00 de	13.33 de	19.33 de	22.33 de
V_2T_3	15.60 ab	21.93 ab	27.93 ab	30.93 ab
V_1T_4	8.33d	14.67 d	20.67 d	23.67 d
V_2T_4	13.86 bc	20.20 b	26.20 b	29.20 bc
V_1T_5	5.66 de	12.00 de	18.00 e	21.00 de
V_2T_5	12.87 c	19.20 c	24.20 c	26.20 cd
CV%	0.67	2.42	5.17	4.57
LSD(0.05)	2.85	0.06	2.34	0.23

Mean having same letter(s) are not significantly different at 5% level of probability.

V_1T_1 = BRRI dhan28 x 10days old seedling
V_2T_1 = BRRI dhan29 x 10days old seedling
V_1T_2 = BRRI dhan28 x 15days old seedling
V_2T_2 = BRRI dhan29 x 15days old seedling
V_1T_3 = BRRI dhan28 x 30days old seedling
V_2T_3 = BRRI dhan29 x 30days old seedling
V_1T_4 = BRRI dhan28 x 45days old seedling
V_2T_4 = BRRI dhan29 x 45days old seedling
V_1T_5 = BRRI dhan28 x 60days old seedling
V_2T_5 = BRRI dhan29 x 60days old seedling

4.3.2 Dry matter hill^{-1}

Significant variation was found in dry matter hill^{-1} among two varieties BRRI dhan28 and BRRI dhan29 where BRRI dhan29 clearly showed the maximum dry matter weight hill^{-1} (93.73 g) where the lowest minimum dry matter weight hill^{-1} (85.33 g) in BRRI dhan28 (Table 5).

The result showed that weight of dry matter was increased and attained a maximum value at 10 to 45 days old seedlings and then decreased. The maximum dry matter weight hill^{-1} was found in T_3 (91.13 g) which was statistically similar with T_2, T_1 and T_4 while minimum dry matter weight hill^{-1} was found in T_5 (87.2 g) (Table 6).

The highest weight of dry matter hill^{-1} was found from the combination of V_2T_3 (95.93 g) which was statistically similar with V_2T_4 (95.00 g) while minimum dry matter weight hill^{-1} was found in V_1T_5 (83.00 g) (Table 7). Chakrabarti *et al.* (2015) and Touhiduzzaman (2011) also found the similar increment of dry matter content hill^{-1}.

4.3.3 Panicle length:

Significant variation was not found in panicle length among two varieties BRRI dhan28 and BRRI dhan29 where BRRI dhan29 showed slightly better panicle length (26.61 cm) where minimum panicle length (25.61 cm) in BRRI dhan28 (Table 5).

The result showed that panicle length was increased and attained a maximum value at 15 to 30 days old seedlings and then decreased. The maximum panicle length was found in T_2 (26.97 cm) which was statistically similar with T_3 (26.95 cm) and T_4 (25.76cm) while minimum panicle length was found in T_5 (25.00 cm) (Table 6).

The combined effect of varieties and seedling age on panicle length showed significant differences (Table 7) where highest panicle length was found in V_2T_3 (27.65 cm) which was statistically similar with V_2T_2 (27.56 cm) while minimum panicle length was found in V_1T_3 (24.60 cm) (Table 7). Chakrabarti *et al.* (2015) and Touhiduzzaman (2011) also recorded similar increment of panicle length having variety BRRI dhan 50. *Thakuret a l.* (2010) observed measurable changes in longer panicles with transplanting younger seedling to older ones.

4.3.4 Filled grains panicle^{-1}:

Significant variation was found in filled grains panicle^{-1} among two varieties BRRI dhan28 and BRRI dhan29 where BRRI dhan29 showed clearly higher number of filled grains panicle^{-1} (106.9) while lower number of filled grains panicle^{-1} (106.9) in BRRI dhan28 (Table 5).

Number of filled grains panicle^{-1} was significantly affected by seedling age (Table 6). The result showed that filled grains panicle^{-1} was increased and attained a maximum value at 15 to 30 days old seedlings and then decreased. The maximum number of filled grains panicle^{-1} was found in T_2 (110.98) which was statistically identical with T_3 (110.77) while minimum number of filled grains panicle^{-1} was found in T_1 (95.42) (Table 6).

The combined effect of varieties and seedling age on filled grains panicle^{-1} showed non-significant difference (Table 7). The highest number of filled grains panicle^{-1} was found in V_2T_3 (27.65) which was statistically similar with V_2T_2 (27.56) while minimum number of filled grains panicle^{-1} was found in V_1T_3 (24.60) (Table 7). Chakrabarti *et al.,* (2015) and Touhiduzzaman (2011) also recorded similar increment of number of filled grain.

4.3.5 Unfilled grains panicle^{-1}

Significant variation was not found in unfilled grains panicle^{-1} among two varieties BRRI dhan28 and BRRI dhan29 where BRRI dhan28 showed the higher number of unfilled grains panicle^{-1} (27.43) while lower number of unfilled grains panicle^{-1} (22.73) in BRRI dhan29 (Table 5).

Number of unfilled grains panicle^{-1} was slightly affected by seedling age (Table 6). The maximum number of unfilled grains panicle^{-1} was found in T_5 (26.38) while minimum number of unfilled grains panicle^{-1} was found in T_2 (24.35) (Table 6).

The combined effect of varieties and seedling age on unfilled grains panicle^{-1} showed significant differences (Table 7). The highest number of unfilled grains panicle^{-1} was found in V_1T_5 (28.43) closely followed by V_1T_1(26.700, V_2T_3(27.33) and V_2T_4(27.73) while minimum number of unfilled grains panicle^{-1} was found in V_1T_2 (22.00 cm).

4.3.6 Weight of 1000-grains

The 1000-grains weight is key factor in determining the final grain yield, and 1000-grains weight varied significantly among two varieties BRRI dhan28 and BRRI dhan29 where BRRI dhan29 showed higher 1000-grains weight (21.57 g) and the lower 1000-grains weight was (19.07 g) found in BRRI dhan28 (Table 5). Maximum1000-grains weight as affected by seedling age, the maximum weight was found in T_2 (21.4 g) while minimum dry matter weight was found in T_1 (19.92 g) (Table 6).

The combined effect of varieties and seedling age on plant height showed significant differences (Table 7). The highest 1000-grains weight was recorded closly followed by V_2T_1, V_2T_3 and V_2T_4 (22.80 g) while minimum dry matter weight was found in V_1T_3 (18.66 g) which was statistically similar with V_1T_1 and V_1T_5 (18.67 g) (Table 7). Datta and Goutam (1988) reported that 1000-grain weight were significantly higher with 30 days old seedlings than with 50 days old ones during the wet season.

Table 5. Effect of variety on yield contributing parameters of rice

Variety	Dry Matter hill $^{-1}$ (g hill^{-1})	Panicle Length (cm)	Filled Grains panicle $^{-1}$ (no.)	Unfilled Grains (no.)	1000-Grain Weight (g)
V_1	85.33	25.31	101.6	27.43	19.07
V_2	93.73	26.63	106.9	22.73	21.57
CV%	3.16	1.04	5.32	2.21	4.06
LSD (0.05)	0.12	0.04	0.17	0.06	0.04

Here,
V_1= BRRI dhan 28
V_2= BRRI dhan 29

Table 6. Effect of different seedling age on yield contributing parameters of rice

Treatments	Dry Matter hill $^{-1}$ (g hill^{-1})	Panicle Length (cm)	Filled Grains panicle $^{-1}$ (no.)	Unfilled Grains (no.)	1000-Grain Weight (g)
T_1	87.93ab	25.33b	95.42bc	26.32	19.92
T_2	90.90a	26.97a	110.98a	24.35	21.40
T_3	91.13a	26.95a	110.77a	24.83	19.99
T_4	90.5ab	25.76ab	105.53a	25.53	20.51
T_5	87.2b	25.00b	99.55ab	26.38	19.77
CV%	2.89	2.7	4.5	6.83	6.34
LSD (0.05)	3.44	0.93	6.24	2.28	1.71

Similar letter does not show significant differences but dissimilar data show statistically significant differences at 5% level of probability.

T_1= 10 days old seedlings
T_2= 15 days old seedlings
T_3= 30 days old seedlings
T_4= 45 days old seedlings
T_5= 60 days old seedling

Table 7: Combined effect of variety and seedling ages on yield contributing characters

Treatments x Variety	Dry Matter hill $^{-1}$ (g hill^{-1})	Panicle Length (cm)	Filled Grains panicle $^{-1}$ (no.)	Unfilled Grains (no.)	1000-Grain Wt (TGW) (g)
V_1T_1	84.33cd	24.83c	93.67e	26.70ab	18.67d
V_2T_1	91.53b	25.83b	97.17cd	23.67c	21.16ab
V_1T_2	87.00c	24.66c	95.33d	22.00c	20.00bcd
V_2T_2	94.80ab	27.56a	113.63a	26.47b	22.80a
V_1T_3	86.33cd	24.60c	108.33ab	22.33c	18.66d
V_2T_3	95.93a	27.65a	113.87a	27.33ab	21.31ab
V_1T_4	86.00cd	26.20b	107.67b	23.33c	19.33cd
V_2T_4	95.00a	25.81b	110.73ab	27.73ab	21.68ab
V_1T_5	83.00d	26.26b	103.00c	28.43a	18.67d
V_2T_5	91.40b	26.20b	107.10b	22.33c	20.87bc
CV%	3.16	2.20	1.20	3.28	2.22
LSD (0.05)	0.27	0.08	0.39	0.03	0.8

Similar letter does not show significant differences but dissimilar letters show statistically significant differences at 5% level of probability.

V_1T_1 = BRRI dhan28 x 10days old seedling
V_2T_1 = BRRI dhan29 x 10days old seedling
V_1T_2 = BRRI dhan28 x 15days old seedling
V_2T_2 = BRRI dhan29 x 15days old seedling
V_1T_3 = BRRI dhan28 x 30days old seedling
V_2T_3 = BRRI dhan29 x 30days old seedling
V_1T_4 = BRRI dhan28 x 45days old seedling
V_2T_4 = BRRI dhan29 x 45days old seedling
V_1T_5 = BRRI dhan28 x 60days old seedling
V_2T_5 = BRRI dhan29 x 60days old seedling

4.4 Yield Parameters

4.4.1 Grain yield:

Grain yield is the function of number of effective tillers, filled grains panicle^{-1} and 1000-grain weight. Significant variation was found in grain yield among two varieties BRRI dhan28 and BRRI dhan29 where BRRI dhan29 showed clearly higher grain yield (6.61 t ha^{-1}) while lower grain yield (5.11 t ha^{-1}) found in BRRI dhan28 (Table 8).

Grain yield was significantly affected by seedling age. The maximum grain yield was found in T_2 (6.23 t ha^{-1}) while minimum grain yield was found in T_5 (5.70 t ha^{-1}) (Table 9).

The combined effect of varieties and seedling age on grain yield showed significant differences (Table 10). The highest grain yield was found from V_2T_2 (7.13 t ha^{-1}) while minimum grain yield was found in V_1T_4 (5.03 tha^{-1}). Chakrabarti *et al*. (2015) and Touhiduzzaman (2011) also recorded similar results.

4.4.2 Straw yield

Significant variation was found in straw yield among two varieties BRRI dhan28 & BRRI han29 where BRRI dhan29 has showed clearly higher straw yield (6.48 t ha^{-1}) while lower straw yield (4.58 t ha^{-1}) in BRRI dhan28 (Table 8).

Along with grain yield, Straw yield was significantly affected by seedling age. The maximum straw yield was found in T_2 (6.64 tha^{-1}) while minimum straw yield was found in T_4 (4.58 tha^{-1}) (Table 9).

The combined effect of varieties and seedling age on straw yield showed significant differences (Table 10). The highest grain yield was recorded from V_2T_2 (7.89 tha^{-1}) while minimum grain yield was found in V_1T_4 and V_1T_5 (3.93 tha^{-1}). Chakrabarti *et al.* (2015) and Touhiduzzaman (2011) also recorded similar results.

4.4.3 Biological yield

Biological yield among two varieties BRRI dhan28 and BRRI dhan29 where BRRI dhan29 has showed clearly higher biological yield (13.09 tha^{-1}) while lower biological yield (9.69 tha^{-1}) in BRRI dhan28 (Table 8).

Along with grain yield and straw yield, Biological yield was significantly affected by seedling age. The maximum biological yield was found in T_2 (12.87 tha^{-1}) while minimum biological yield was found in T_4 (10.29 tha^{-1}) (Table 9).

The combined effect of varieties & seedling age on biological yield showed significant differences (Table 10). The highest value was found in V_2T_2 (15.02 tha^{-1}) while minimum biological yield was found in V_1T_4 (8.97 tha^{-1}) (Table 10). Chakrabarti *et al.* (2015) and Touhiduzzaman (2011) also recorded similar increment of biological yield.

4.4.4 Harvest index

The harvest index varied between two variety BRRI dhan28 & BRRI dhan29 where BRRI dhan28 has showed higher harvest index (52.94%) while lower harvest index was recorded (50.78%) in BRRI dhan29 (Table 8).

Harvest index was significantly affected by seedling age. The maximum harvest index was found in T_4 (55.55%) closely followed by T_5 while minimum harvest index was found in T_2 (48.60%) (Table 9). Minimum harvest index was found in V_2T_2 (48.49%) (Table 10). Chakrabarti *et al.* (2015) and Touhiduzzaman (2011) also recorded similar increment of harvest index in variety BRRI dhan50. Also, Roy *et al.* (1992) reported lower harvest index with younger seedlings compared to the older seedlings.

Table 8. Effect of variety on yield parameters of rice

Variety	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (HI%)
V_1	5.11b	4.58b	9.69b	52.939a
V_2	6.61a	6.48a	13.09a	50.781b
CV%	4.51	7.20	1.22	1.67
LSD (0.05)	0.03	0.05	0.08	0.15

Here,
V_1= BRRI dhan 28
V_2= BRRI dhan 29

Table 9. Effect of different seedling age on yield parameters of rice

Treatments	Grain Yield (t ha^{-1})	Staw Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (HI%)
T_1	5.82b	5.63b	11.5b	50.71b
T_2	6.23a	6.64a	12.87a	48.60c
T_3	5.95b	6.00b	11.85b	49.58bc
T_4	5.74b	4.58c	10.29c	55.55a
T_5	5.70b	4.73c	10.43c	54.83a
CV%	4.76	4.35	4.02	2.26
LSD (0.05)	0.37	0.31	0.60	1.56

Similar letter does not show significant differences but dissimilar letters show statistically significant differences at 5% level of probability.

T_1= 10 Days old seedlings
T_2= 15 Days old seedlings
T_3= 30 Days old seedlings
T_4= 45 Days old seedlings
T_5= 60 Days old seedlings

Table 10: Combined effect of variety and seedling ages on yield parameters of rice

Variety x Seedling age	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (HI%)
V_1T_1	5.07 d	4.73e	9.80e	51.69bc
V_2T_1	6.56bc	6.63c	13.20b	49.74de
V_1T_2	5.33d	5.39d	10.73d	49.73de
V_2T_2	7.13a	7.89a	15.03a	47.42f
V_1T_3	5.07d	4.90e	9.93e	50.65cd
V_2T_3	6.68b	7.10b	13.73b	48.48ef
V_1T_4	5.03d	3.93f	8.97f	56.14a
V_2T_4	6.38bc	5.23d	11.62c	54.96a
V_1T_5	5.10d	3.93f	9.03f	56.44a
V_2T_5	6.30c	5.53d	11.83c	53.22b
CV%	3.76	1.28	6.96	4.35
LSD (0.05)	0.08	0.12	0.19	0.33

Similar letter does not show significant differences but dissimilar letters show statistically significant differences at 5% level of probability.

V_1T_1 = BRRI dhan28 x 10days old seedling
V_2T_1 = BRRI dhan29 x 10days old seedling
V_1T_2 = BRRI dhan28 x 15days old seedling
V_2T_2 = BRRI dhan29 x 15days old seedling
V_1T_3 = BRRI dhan28 x 30days old seedling
V_2T_3 = BRRI dhan29 x 30days old seedling
V_1T_4 = BRRI dhan28 x 45days old seedling
V_2T_4 = BRRI dhan29 x 45days old seedling
V_1T_5 = BRRI dhan28 x 60days old seedling
V_2T_5 = BRRI dhan29 x 60days old seedling

CHAPTER V

SUMMARY & CONCLUSION

Among two varieties BRRI dhan29 has clearly showed the greater number of tillers hill^{-1}, hence effective tillers hill^{-1} at 30, 60, 90 and 120 DAT. Highest number of tillers at 120 DAT in both BRRI dhan28 and BRRI dhan29 exhibits 28.46 and 36.96 respectively, hence effective tillers 21.3 and 27.5 respectively at same growth stage where, the lowest number of tillers hill^{-1} found at 30 DAT in both BRRI dhan28 and BRRI dhan29 exhibits 13.13 and 16.00 respectively and effective tillers exhibits 6.5 & 12.00, respectively. This result influenced the higher performance of BRRI dhan29 than BRRI dhan 28. It was also found that the number of tillers and effective tillers were increased continuously and attained a maximum value at 30 to 45 days old seedlings (T_2 and T_3). In seedling age & variety combination, the highest number of tillers was recorded in V_2T_3 and highest effective tiller in V_2T_2. The young seedlings produced more plant height and number of tillers hill^{-1} due to better roots growth, cell division and cell enlargement having increased photosynthetic rate. The younger seedling also produced more number of productive tillers due to less root damage, reduced transplanting shock, better stand establishment and more efficient use of nutrients, light, space etc. which increased plants hill^{-1} and consequently leading to increased effective tillers. Greater panicle length from younger seedlings is because of their good growth and development ability as compared to older ones, optimum supply of essential nutrients can also accelerate the panicle formation and panicle growth. Grain yield in rice depends mainly on number of spikelet per panicle, spikelet filling % and 1000-grain weight younger seedlings increased the 1000 grain weight due to the proper crop growth, development, assimilates synthesis and translocation to the grains. Among the yield attributes, productive tillers are very important because the final yield is mainly a function of the number of panicles bearing tillers per unit area.

Thousand grains weight, an important yield-determining component, is a genetic character and least influenced by environment.

7. It was recorded that higher values of all the yield attributes were maximum under T_2 (15 days old seedling) followed by T_3 (30 days old seedling) in both the varieties *viz*. BRRI dhan 28 & BRRI dhan 29. Transplantation of 10 days old seedling (T_1) recorded the lowest values closely followed by T_5 (60 days old seedlings) of all the yield attributes in both the varieties *viz*. BRRI dhan 28 and BRRI dhan 29. Highest number of unfilled grains was found under T_2 (15 days old seedling) in both the varieties *viz*.vi BRRI dhan 28 and BRRI dhan29. Transplantation of 15 days old seedlings (T_2) produced significantly higher grain yield followed by T_3, T_1 and T_4. Pooled data revealed that transplantation of aged (above 15-30 days old) and younger (below 15 days old) seedlings reduced the grain yield consistently. 15-30 days old seedlings recorded the highest value of all the yield attributes and yield due to profuse root growth which helps in tillering, more tillering provides more photosynthesis to support root growth; both contribute to greater grain filling and larger grains. 10-30 days old seedling also provides sufficient nutrient for vegetative growth and also for reproductive phase which

ultimately leads to increased tillering and yield attributes thereby increased grain yields. Below or at 10 days old seedlings take more time to recover and establishment after transplantation in the main field and hence resulting into shallow root system which discourages tillering, less tillering provides less photosynthesis to support root growth; both contribute to lower grain filling and shorter grains, all these were responsible for lower grain yield corresponding to T_1.

Conclusion:

- BARRI dhan 29 had the ability to produce maximum tiller hill-1 and gave the highest grain yield.
- 15-30 days old seedlings recorded the highest tillering and effective tillering that resulted in the highest grain yield.
- Above 40 days old seedling and below or at 10 days old seedlings discouraged tillering, that resulted in lower grain yield.

Recommendation:

- (15-30 days old seedling) should be used for transplanting to achieve higher yield of rice.

CHAPTER VI

REFFERENCE

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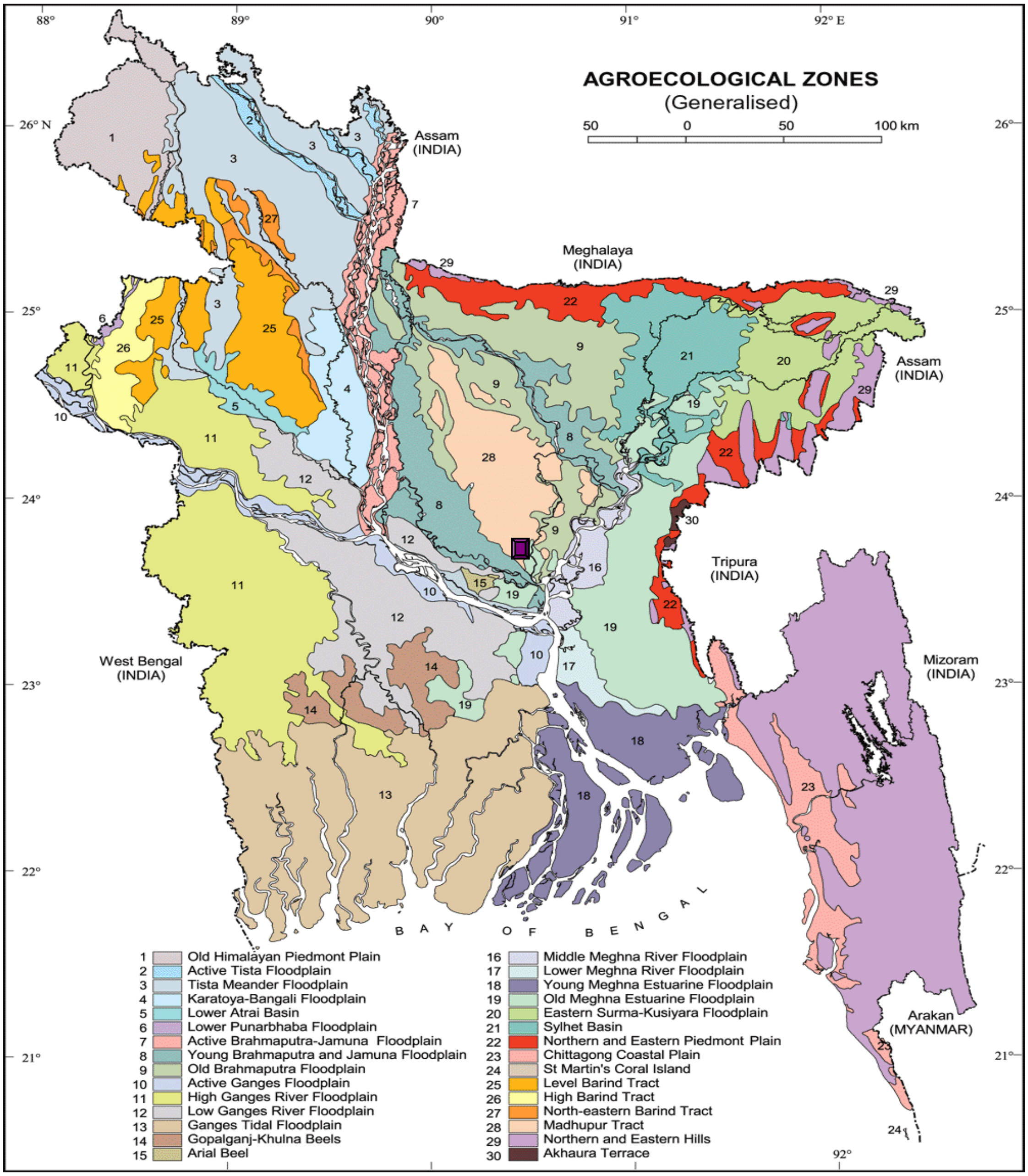
APPENDICES

Appendix I: Map showing the experimental sites under study



Experimental site

Appendix II: Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Field laboratory, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium hHigh land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Appendix III: Different ANOVA Tables:

Randomized Complete Block ANOVA table for tillers hill^{-1} at 30 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	87.449	43.724		
Treatments	4	160.295	40.074	8.81	0.0050
Error Replication*Treatments	8	36.395	4.549		
Variety	1	541.875	541.875	1776.64	0.0000
Treatments*Variety	4	2.550	0.637	2.09	0.1570
Error Replication*Treatments*Variety	10	3.050	0.305		

Randomized Complete Block ANOVA table for tillers hill^{-1} at 60 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F	p-value
Replication	2	50.582	25.291		
Treatments	4	160.295	40.074	8.81	0.0050
Error Replication*Treatments	8	36.395	4.549		
Variety	1	541.875	541.875	1776.64	0.0000
Treatments*Variety	4	2.550	0.637	2.09	0.1570
Error Replication*Treatments*Variety	10	3.050	0.305		

Randomized Complete Block ANOVA table for tillers hill^{-1} at 90 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F	p-value
Replication	2	19.982	9.991		
Treatments	4	160.295	40.074	8.81	0.0050
Error Replication*Treatments	8	36.395	4.549		
Variety	1	541.875	541.875	1776.64	0.0000
Treatments*Variety	4	2.550	0.638	2.09	0.1570
Error Replication*Treatments*Variety	10	3.050	0.305		

Randomized Complete Block ANOVA table for tillers hill^{-1} at 120 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F	p-value
Replication	2	7.182	3.591		
Treatments	4	160.295	40.074	8.81	0.0050
Error Replication*Treatments	8	36.395	4.549		
Variety	1	541.875	541.875	1776.64	0.0000
Treatments*Variety	4	2.550	0.637	2.09	0.1570
Error Replication*Treatments*Variety	10	3.050	0.305		

Randomized Complete Block ANOVA table for effective tillers hill^{-1} at 30 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	73.850	36.925		
Treatments	4	45.917	11.479	8.25	0.0061
Error Replication*Treatments	8	11.133	1.392		
Variety	1	480.000	480.000	96000.00	0.0000
Treatments*Variety	4	1.350	0.338	67.50	0.0000
Error Replication*Treatments*Variety	10	0.050	0.005		

Randomized Complete Block ANOVA table for effective tillers hill^{-1} at 60 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	37.517	18.758		
Treatments	4	45.917	11.479	8.25	0.0061
Error Replication*Treatments	8	11.133	1.392		
Variety	1	480.000	480.000	96000.00	0.0000
Treatments*Variety	4	1.350	0.338	67.50	0.0000
Error Replication*Treatments*Variety	10	0.050	0.005		

Randomized Complete Block ANOVA table for effective tillers $hill^{-1}$ at 90 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	8.517	4.258		
Treatments	4	45.917	11.479	8.25	0.0061
Error Replication*Treatments	8	11.133	1.392		
Variety	1	480.000	480.000	96000.00	0.0000
Treatments*Variety	4	1.350	0.338	67.50	0.0000
Error Replication*Treatments*Variety	10	0.050	0.005		

Randomized Complete Block ANOVA table for effective tillers $hill^{-1}$ at 120 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	3.517	1.758		
Treatments	4	45.917	11.479	8.25	0.0061
Error Replication*Treatments	8	11.133	1.392		
Variety	1	480.000	480.000	96000.00	0.0000
Treatments*Variety	4	1.350	0.337	67.50	0.0000
Error Replication*Treatments*Variety	10	0.050	0.005		

Randomized Complete Block ANOVA table for plant height at 30 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	8.9650	4.48252		
Treatments	4	14.3157	3.57894	4.85	0.0278
Error Replication*Treatments	8	5.8999	0.73749		
Variety	1	1.7136	1.71363	95.63	0.0000
Treatments*Variety	4	6.8545	1.71363	95.63	0.0000
Error Replication*Treatments*Variety	10	0.1792	0.01792		

Randomized Complete Block ANOVA table for plant height at 60 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	91.915	45.9573		
Treatments	4	57.525	14.3813	3.16	0.0781
Error Replication*Treatments	8	36.459	4.5573		
Variety	1	4.800	4.8000	3.88	0.0771
Treatments*Variety	4	19.200	4.8000	3.88	0.0372
Error Replication*Treatments*Variety	10	12.360	1.2360		

Randomized Complete Block ANOVA table for plant height at 90 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	21.131	10.5654		
Treatments	4	130.224	32.5559	2.50	0.1261
Error Replication*Treatments	8	104.322	13.0402		
Variety	1	41.489	41.4893	6.76	0.0265
Treatments*Variety	4	105.033	26.2583	4.28	0.0283
Error Replication*Treatments*Variety	10	61.333	6.1333		

Randomized Complete Block ANOVA table for plant height at 120 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	1.117	0.5583		
Treatments	4	19.300	4.8250	6.13	0.0147
Error Replication*Treatments	8	6.300	0.7875		
Variety	1	99.008	99.0083	117.63	0.0000
Treatments*Variety	4	13.700	3.4250	4.07	0.0327
Error Replication*Treatments*Variety	10	8.417	0.8417		

Randomized Complete Block ANOVA table for leaf area index at 30 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	0.03075	0.01537		
Treatments	4	0.05800	0.01450	0.79	0.5616
Error Replication*Treatments	8	0.14632	0.01829		
Variety	1	0.13333	0.13333	59.52	0.0000
Treatments*Variety	4	0.01667	0.00417	1.86	0.1942
Error Replication*Treatments*Variety	10	0.02240	0.00224		

Randomized Complete Block ANOVA table for leaf area index at 60 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	0.01267	0.00633		
Treatments	4	0.17800	0.04450	4.81	0.0284
Error Replication*Treatments	8	0.07400	0.00925		
Variety	1	0.76800	0.76800	82.29	0.0000
Treatments*Variety	4	0.02867	0.00717	0.77	0.5699
Error Replication*Treatments*Variety	10	0.09333	0.00933		

Randomized Complete Block ANOVA table for leaf area index at 90 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	0.01267	0.00633		
Treatments	4	0.20867	0.05217	2.83	0.0981
Error Replication*Treatments	8	0.14733	0.01842		
Variety	1	1.45200	1.45200	272.25	0.0000
Treatments*Variety	4	0.04467	0.01117	2.09	0.1565
Error Replication*Treatments*Variety	10	0.05333	0.00533		

Randomized Complete Block ANOVA table for leaf area index at 120 DAT

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	0.03467	0.01733		
Treatments	4	0.34133	0.08533	4.05	0.0440
Error Replication*Treatments	8	0.16867	0.02108		
Variety	1	0.93633	0.93633	72.03	0.0000
Treatments*Variety	4	0.13867	0.03467	2.67	0.0950
Error Replication*Treatments*Variety	10	0.13000	0.01300		

Randomized Complete Block ANOVA table for dry matter hill^{-1}

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	71.267	35.633		
Treatments	4	80.200	20.050	2.99	0.0875
Error Replication*Treatments	8	53.600	6.700		
Variety	1	529.200	529.200	26460.00	0.0000
Treatments*Variety	4	5.400	1.350	67.50	0.0000
Error Replication*Treatments*Variety	10	0.200	0.020		

Randomized Complete Block ANOVA table for panicle length

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F-ratio	p-value
Replication	2	0.7287	0.3643		
Treatments	4	18.4122	4.6030	9.37	0.0041
Error Replication*Treatments	8	3.9313	0.4914		
Variety	1	12.6750	12.6750	6337.50	0.0000
Treatments*Variety	4	0.3375	0.0844	42.19	0.0000
Error Replication*Treatments*Variety	10	0.0200	0.0020		

Randomized Complete Block ANOVA table for filled grain

Source	Degrees of Freedom (df)	Sum of squares (SS)	Mean squares (MS)	F-ratio	p-value
Replication	2	13.65	6.825		
Treatments	4	1297.42	324.354	14.77	0.0009
Error Replication*Treatments	8	175.73	21.967		
Variety	1	210.68	210.675	4681.67	0.0000
Treatments*Variety	4	12.15	3.037	67.50	0.0000
Error Replication*Treatments*Variety	10	0.45	0.045		

Randomized Complete Block ANOVA table for unfilled grain

Source	Degrees of Freedom (df)	Sum of squares (SS)	Mean squares (MS)	F-ratio	p-value
Replication	2	1.717	0.858		
Treatments	4	16.883	4.221	1.44	0.3059
Error Replication*Treatments	8	23.467	2.933		
Variety	1	165.675	165.675	33135.00	0.0000
Treatments*Variety	4	1.350	0.338	67.50	0.0000
Error Replication*Treatments*Variety	10	0.050	0.005		

Randomized Complete Block ANOVA table for 1000-grain weight

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	1.0207	0.5103		
Treatments	4	10.6708	2.6677	1.61	0.2630
Error Replication*Treatments	8	13.2827	1.6603		
Variety	1	46.8750	46.8750	23437.50	0.0000
Treatments*Variety	4	0.3375	0.0844	42.19	0.0000
Error Replication*Treatments*Variety	10	0.0200	0.0020		

Randomized Complete Block ANOVA table for grain weight

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	0.0007	0.0003		
Treatments	4	1.1388	0.2847	3.66	0.0560
Error Replication*Treatments	8	0.6227	0.0778		
Variety	1	16.8750	16.8750	8437.50	0.0000
Treatments*Variety	4	0.3375	0.0844	42.19	0.0000
Error Replication*Treatments*Variety	10	0.0200	0.0020		

Randomized Complete Block ANOVA table for straw yield

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	0.0374	0.0187		
Treatments	4	18.0441	4.5110	78.15	0.0000
Error Replication*Treatments	8	0.4618	0.0577		
Variety	1	27.0750	27.0750	5415.00	0.0000
Treatments*Variety	4	1.3500	0.3375	67.50	0.0000
Error Replication*Treatments*Variety	10	0.0500	0.0050		

Randomized Complete Block ANOVA table for biological yield

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	0.029	0.0143		
Treatments	4	27.320	6.8299	32.56	0.0001
Error Replication*Treatments	8	1.678	0.2098		
Variety	1	86.700	86.7000	7225.00	0.0000
Treatments*Variety	4	2.902	0.7256	60.47	0.0000
Error Replication*Treatments*Variety	10	0.120	0.0120		

Randomized Complete Block ANOVA table for harvest index

Source	Degrees of Freedom (df)	Sum of squares (ss)	Mean squares (MS)	F ratio	p-value
Replication	2	1.252	0.6261		
Treatments	4	237.506	59.3765	43.21	0.0000
Error Replication*Treatments	8	10.992	1.3740		
Variety	1	34.913	34.9128	1030.60	0.0000
Treatments*Variety	4	3.203	0.8009	23.64	0.0000
Error Replication*Treatments*Variety	10	0.339	0.0339		