# STUDY ON CULTIVATION OF TRANSPLANT AMAN RICE THROUGH SEPARATED TILLERS FROM INBRED AND HYBRID RICE VARIETIES

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# STUDY ON CULTIVATION OF TRANSPLANT AMAN RICE THROUGH SEPARATED TILLERS FROM INBRED AND HYBRID RICE VARIETIES

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# CERTIFICATE

This is to certify that the thesis entitled, "**STUDY ON CULTIVATION OF TRANSPLANT AMAN RICE THROUGH SEPARATED TILLERS FROM INBRED AND HYBRID RICE VARIETIES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M. S.) IN AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **MAHMUD MORSHED SHAON** bearing Registration No. 09-03688 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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**Place: Dhaka, Bangladesh**

DEDICATED TO

MY

BELOVED PARENTS

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# STUDY ON CULTIVATION OF TRANSPLANT AMAN RICE THROUGH SEPARATED TILLERS FROM INBRED AND HYBRID RICE VARIETIES


## ABSTRACT

The experiment was conducted at the experimental area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from June to November, 2014. The trial was conducted with two levels of treatments viz. A. Variety: BRRI dhan33, BRRI dhan62 and chamak 1; and B. Separated tillers age: 20, 25, 30 and 35 days. Variety had significant effect on all the parameters like plant height, number of tillers hill$^{-1}$, total dry weight, total grains panicle$^{-1}$, filled grains panicle$^{-1}$, unfilled grains panicle$^{-1}$, 1000-grain weight, grain yield and straw yield except effective tillers hill$^{-1}$, panicle length, and harvest index. The experiment was laid out in a split plot design with three replications. The tallest plant at harvest (95.22 cm) was recorded from $V_1$ (BRRI dhan33) treatment. In comparison, the shortest plant at harvest (81.57 cm) was observed in $V_3$ (Chamak 1) treatment. The longest panicle (27.25 cm) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the shortest panicle (23.72 cm) was observed in $V_2$ (BRRI dhan62) treatment. The highest number of grain panicle$^{-1}$ (141.40) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the lowest number of grain panicle$^{-1}$ (107.40) was observed in $V_2$ (BRRI dhan62) treatment. The maximum weight of 1000 grain (26.34 g) was recorded from $V_1$ (BRRI dhan33) treatment. In comparison, the minimum weight of 1000 grain (23.17 g) was observed in $V_3$ (Chamak 1) treatment. The maximum grain yield (4.74 t ha$^{-1}$) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the minimum grain yield (3.52 t ha$^{-1}$) was observed in $V_2$ (BRRI dhan62) treatment. Separated tillers of different age showed significant effect on plant height of T. aman rice. The tallest plant at harvest (93.30 cm) was recorded from $D_2$ (25 days old) treatment. On the other hand, the shortest plant at harvest (84.39 cm) was observed in $D_4$ (35 days old) treatment. The longest panicle (26.36 cm) was recorded from $D_2$ (25 days old) treatment. On the other hand, the shortest panicle (24.20 cm) was observed in $D_4$ (35 days old) treatment. The highest weight of 1000 grain (26.19 g) was recorded from $D_2$ (25 days old) treatment. On the other hand, the lowest weight of 1000 grain (23.86 g) was observed in $D_4$ (35 days old) treatment. The highest grain yield (4.68 t ha$^{-1}$) was recorded from $D_2$ (25 days old) treatment. On the other hand, the lowest grain yield (3.96 t ha$^{-1}$) was observed in $D_4$ (35 days old) treatment. It was concluded that separated tillers age should be within 20 to 30 days because aged separated tillers affected the growth and yield of both hybrid and inbred rice. However Chamak 1 showed higher yield over the varieties studied in the experiment.

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# LIST OF ACRONYMS

| | |
|---|---|
| AEZ | Agro- Ecological Zone |
| Anon. | Anonymous |
| BARI | Bangladesh Agricultural Research Institute |
| BAU | Bangladesh Agricultural University |
| BBS | Bangladesh Bureau of Statistics |
| BINA | Bangladesh Institute of Nuclear Agriculture |
| BRRI | Bangladesh Rice Research Institute |
| cm | Centimeter |
| CV | Coefficient of Variance |
| cv. | Cultivar (s) |
| DAT | Days After Transplanting |
| $^0$C | Degree Centigrade |
| *et al.* | And others |
| FAO | Food and Agriculture Organization |
| g | Gram (s) |
| HI | Harvest Index |
| IRRI | International Rice Research Institute |
| hr | Hour(s) |
| $K_2O$ | Potassium Oxide |
| Kg | Kilogram (s) |
| LSD | Least Significant Difference |
| m | Meter |
| $m^2$ | Meter squares |
| mm | Millimeter |
| MOP | Muriate of Potash |
| N | Nitrogen |
| No. | Number |
| NS | Non significant |
| % | Percentage |
| $P_2O_5$ | Phosphorus Penta Oxide |
| S | Sulphur |
| SAU | Sher-e- Bangla Agricultural University |
| SRDI | Soil Resources Development Institute |
| t $ha^{-1}$ | Ton per hectare |
| TSP | Triple Super Phosphate |
| var. | Variety |
| Wt. | Weight |
| Zn | Zinc |

# CHAPTER I

# INTRODUCTION

Rice (*Oryza sativa* L.) is the important food crop for more than two billion people in Asia and four hundred millions of people in Africa and Latin America (IRRI, 2006). There are 111 rice-growing countries in the world that occupy about 146 million hectares land more than 90% of which is in Asia (Anon., 1999). To feed the fast increasing global population, the world's annual rice production must increase to 760 million tons by the year 2020 (Kundu and Ladha, 1995). Rice alone constitute of 95% of the food grain production in Bangladesh (Julfiquare *et al*., 1998). In Bangladesh there are three diverse growing seasons of rice namely *Aus*, *Aman* and *Boro*. About two-thirds of the cultivated land area of Bangladesh is occupied by rice. Rice production needed to increase in this country to meet the food demand of the increasing population. Unfortunately, the yield of rice is very low in Bangladesh (3.34 t/ha) compared to Australia (9.65t/ha), Korean Republic (6.59 t/ha), Japan (6.70 t/ha) and Spain (6.59 t/ha) respectively (FAO, 2004).

Rice is grown on about 11.56 million hectares which has remained almost stable over the past three decades. Total rice production in Bangladesh was about 10.59 million tons in the year 1971 when the country's population was only about 70.88 millions. However, the country is now producing about 34.00 million tons to feed her 149.69 million people (Mondal and Choudhury, 2014). Thus it provides nearly 40% of national employment (48% of rural employment), about 70-76% of total calorie supply and 66% of protein intakes of an average person in the country (Ahmed, 2006). Moreover rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (Hossain, 2003).

However, there is no reason to be complacent as the population of Bangladesh is still growing by two million every year at the rate of 1.26% and the population of the country in the year 2030 will be 189.85 million. As such the country will require about 39.80 million tons of rice for the year 2030 (Mondal and Choudhury, 2014). During this time total rice area will also shrink to 10.28 million hectares. Rice yield therefore, needs to be increased from the present 2.74 to 3.74 t $ha^{-1}$ (BRRI, 2011).

However, there is a little scope to increase rice area. Moreover the arable land is decreasing at the rate of 1% per annum (BBS, 2011). In such situation, there is no other alternative rather than development and adoption of yield enhancing technologies. To get higher productivity, hybrid rice is an important portion and readily available way as it has 20-30% yield advantage over inbred varieties (Julfiquar *et al.*, 2009).

Aman rice is more popular in Bangladesh. Among different groups of rice transplant *aman* rice covers about 49.11% of total rice area and it contributes to 38.11% of the total rice production in the country (BBS, 2013). But rice production is affected by various biotic and abiotic constraints. Damage of seedling in the seedbed due to cold has been identified as a constraint in the expansion of modern rice varieties in those areas. In such situation farmers are in extreme need of seedling to transplant immediately after raising the temperature. In this situation it is difficult to raise seedling within a short period of time. In this perspective separation of tillers from rice plants could escape cold damage and replanting of the separated tillers to the new rice fields may be vital alternatives for growing rice (Mamun *et al.*, 2012). Use of rice separated tillers might be an option for maximum yield and reduce seed cost especially hybrid rice (Debnath, 2012).

In Bangladesh flooding starts in the month of June-July and reaches its peak in the month of August-September. The vegetative stage of *aman* rice occurs in this period. So, sometimes *aman* rice may be badly affected by the flood. Although rice is adapted to lowland, complete submergence for more than 2-3 days may kill most of the rice cultivars (Mishra *et al.*, 1996). This type of damage would be more serious for dwarf and semi-dwarf varieties because it may lead to total crop loss.

Roy *et al*. (1990) and Biswas and Salokhe (2001) recommended to transplant the field using clonal/separated tillers of 30 days. This crop is frequently subjected to severe onslaught of floods and ultimately causes total crop failure. Furthermore, hybrid rice cultivation is gradually in increasing trend in Bangladesh. One of the major constraints of hybrid rice is its higher seed cost and farmers have to purchase seeds every year from the traders. The above situation can be overcome by using separated tillers that is now a days a proven technology (Biswas, 2001; Biswas and Salokhe, 2001; Biswas and Salokhe, 2002; Roy *et al*. 1990 and Sharma, 1992).

Clonal/separated tillers are those tillers that can be collected from mother plants and transplanted as a new seedling. It is possible to transplant the collected tillers (from the undamaged fields) in the prepared main field after recession of flood water. The utilization of clonal/separated tillers collected from the already established field is now a well established system to patch up the damaged field (Sharma, 1995; Biswas *et al*., 1989; Biswas and Salokhe, 2001; Biswas, 2001; and Roy *et al*. 1990). The age of clonal/separated tillers may respond differently and hence it is necessary to conduct a detailed study with different age of separated tillers of inbred and hybrid rice. Thus a study with two inbred and a hybrid variety was undertaken with the following objectives:

1. To find out the optimum age of separated tillers to have maximum growth and yield of aman rice.
2. To compare the performance of tillers separated from rice varieties.

# CHAPTER II

# REVIEW OF LITERATURE

The growth and development of rice may be varying due to the use of separated tillers from nursery seedling. Nursery seedling and separated tillers using inbred and hybrid variety is important especially when tillers are used as planting material. New technologies are available now and received much attention to the researchers throughout Bangladesh to develop its suitable production technologies for rice areas. Although this idea is not a recent one but research findings in using separated tillers of successive generation is scanty. Some of the pertinent works available in home and abroad on these technologies have been reviewed in this chapter.

## 2.1 Effect of clonal tillers age

Alim and Sheuly (2012) reported that the highest grain growth parameters like number of panicles hill$^{-1}$, dry weight panicle$^{-1}$, and number of grains panicle$^{-1}$, dry weight grain$^{-1}$ and grain growth rate were observed when tillers were separated at 25 DAT but the lowest values were found at 45 DAT. The grain growth rate decreased with the advance of time. The highest grain yield (5.25 t ha$^{-1}$) was obtained from tillers separated at 25 days after transplanting (DAT) but the lowest values (4.13 t ha$^{-1}$) were recorded when tillers were separated at 45 DAT. The highest grain yield (5.88 t ha$^{-1}$) was found in intact hills, while the lowest values (2.64 t ha$^{-1}$) were obtained when kept 1 tiller hill$^{-1}$.

Mamun *et al.* (2012) conducted two experiments to determine optimum time and potentiality of separated tiller for new area coverage as well as yield of *boro* rice, in the research field of Bangladesh Rice research Institute, Gazipur during *boro* season in 2011 and 2012. Four planting times were selected at 15 days intervals starting from 15$^{th}$ December to 30$^{th}$ January and tillers were separated at forty days after transplanting (DAT). Split-plot design was followed putting planting time in the main plots and mode of tiller separation in the sub-plots. About 3-4 times more new area was covered with the tillers obtaining from 15$^{th}$ December and 30$^{th}$ January planting. Growth duration of newly transplanted plot was higher than undisturbed plots and that decreased with the advancement of transplanting dates. Grain yield was higher in undisturbed plot (6.5 t ha$^{-1}$). The grain yield obtained from disturbed plot and newly transplanted plots were comparable and were more than 5.0 t $ha^{-1}$. Maximum new area coverage as well as satisfactory grain yield from separated tillers transplantation was obtained from $30^{th}$ January transplanting. Tillers separation could be an alternative source of seedling during seedling scarcity.

Debnath *et al.* (2012) conducted a field experiment at Sher-e-Bangla Agricultural University, Dhaka during the period from December 2008 to May 2009 to study the growth and yield of inbred and hybrid rice in *boro* season using mother plant and separated tillers. The experiment consisted of two levels of treatments viz. planting material (Mother plant and separated tillers of first generation) and variety (BRRI dhan29, ACI 1, BRAC Aloron, Sonarbangla-6, Hira 5 and BRRI hybrid dhan2) and reported that the planting material significantly influenced all the studied characters such as panicle length, unfilled $grains^{-1}$, total grains $panicle^{-1}$, 1000-grain weight, grain: straw ratio and harvest index. Mother plant shows better performance compared to that separated tillers of first generation.

Sarkar *et al.* (2011) conducted an experiment to observe the effect of row arrangement, age of tiller seedlings and number of tiller seedlings $hill^{-1}$ on the vegetative characters, yield and yield contributing characters of transplant *aman* rice. The experiment consisted of three levels of row arrangement viz. single row (row spacing 25 cm), double row (row spacing 25-10-25 cm) and triple row (row spacing 25-10-10-25 cm), two types of tiller seedlings viz. 25 days and 35 days old; and three levels of number of tiller seedling $hill^{-1}$ viz. 2, 4 and 6 seedlings $hill^{-1}$. The experiment was laid out in a three factor Randomized Complete Block Design with three replications. The highest plant height, number of effective tillers $hill^{-1}$, number of grains $panicle^{-1}$ and harvest index were found in single row arrangement compared to double and triple row arrangements but number of total spikelets $panicle^{-1}$ and grain yield were highest in double row arrangement. The highest number of non-bearing tillers $hill^{-1}$, number of total tillers $hill^{-1}$ and number of sterile spikelets $panicle^{-1}$ were found in triple row arrangement compared to single and double row arrangements. The highest plant height, effectivity index of tillers, number of grains $panicle^{-1}$, grain yield, harvest index and sterility percentage were found by transplanting 25-day old tiller seedlings. Number of total tillers $hill^{-1}$, non-bearing tillers $hill^{-1}$, straw yield and sterility percentage were highest by transplanting 35-day old tiller seedlings. Plant height, harvest index, grain yield and panicle length were highest when 2 tiller seedlings were transplanted hill$^{-1}$. Number of total tillers hill$^{-1}$ and number of non-bearing tillers hill$^{-1}$ were highest when 6 tiller seedlings were transplanted hill$^{-1}$.Transplanting in single and double row arrangements emerged out as a promising practice. This practice improved yield of transplant *aman* rice. Twenty five day old tiller seedlings was found to be suitable in respect of grain yield and 2 tiller seedlings hill$^{-1}$ appeared to be enough for the cultivation of transplant *aman* rice.

Obaidullah *et al.* (2009) conducted a field experiment at Sher-e-Bangla Agricultural University, Dhaka during the period from November 2006 to April 2007 to study the growth and yield of inbred and hybrid rice with separated tillers of different ages. They found the highest grain yield (5.10 t ha$^{-1}$) from the separated tiller of 25 days old and the lowest grain yield (4.31 t ha$^{-1}$) from 40 days old clonal tillers. Irrespective of variety 25 to 35 days old separated tiller showed superior performance. Hybrid variety transplanted with 25 days old separated tiller gave significantly higher grain yield.

Ashrafuzzaman *et al.* (2008) conducted a field experiment at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during the period from June 2006 to November 2006 to study the growth and yield of inbred and hybrid rice with tiller separation at different growth periods. The experiment was conducted with two levels of treatments viz. A) Variety: BRRI dhan32 and Sonarbangla-1; and B) tiller separation days: 20, 25, 30, 35 and 40 days after mother plant transplantation. Maximum filled grains panicle$^{-1}$ (144.28) was observed from the tiller separation at 20 DAT. Total and effective tillers hill$^{-1}$ was affected by tiller separation beyond 30 DAT. Delayed tiller separation extended the flowering and maturity duration. Therefore, it was concluded that earlier tiller separation (20-30 DAT) resulted higher grain yield in hybrid variety but no such variations was observed in inbred variety.

Parveen *et al.* (2008) conducted a research work at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from July to December 2007 to investigate the effect of age and number of separated tiller seedlings hill$^{-1}$ on the performance of transplant *aman* rice cv. BRRI dhan41. The experimental treatments included (A) three ages of tiller seedlings viz., 20, 30 and 40 days; (B) four different number of tiller seedlings viz., 1, 2, 3 and 4 tiller seedlings hill$^{-1}$. The experiment was laid out in a two-factor randomized complete block design with three replications. Both the age and number of tiller seedlings hill$^{-1}$ had significant effect on different yield contributing characters including grain and straw yields. Grain yield was the highest due to highest number of effective tillers hill$^{-1}$ and grains panicle$^{-1}$ at 20-day old tiller seedlings. Straw yield also was found the highest at 20-day old tiller seedlings due to highest plant height and total tillers hill$^{-1}$. The lowest grain and straw yields were observed at 40-day old tiller seedlings. Grain and straw yields were highest when 2 tiller seedlings hill$^{-1}$ were transplanted. Effective tiller hill$^{-1}$, grains panicle$^{-1}$, 1000-grain weight, plant height and total tiller hill$^{-1}$ were lowest when 1 tiller seedling was transplanted hill$^{-1}$. The highest grain yield was obtained from the interaction between 20-day old tiller seedling and 3 tiller seedlings hill$^{-1}$. For achieving satisfactory yield 20-day old tiller seedling of BRRI dhan41 may be transplanted with 3 seedlings hill$^{-1}$ just after recession of flood water.

Ahmed *et al.* (2007) conducted a field experiment at Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during December 2005 to May 2006 to study the influence of cultivation methods on inbred and hybrid rice in *boro* season. The experiment consisted of two levels of treatment viz, variety and cultivation method and was laid out in a split plot design with four replications. Interaction of variety and cultivation method revealed that nursery seedlings of the inbred variety produced the highest grain yield (8.88 t ha$^{-1}$) and sprouted broadcasted seeds of the inbred variety gave the lowest grain yield (6.35 t ha$^{-1}$).

Ahmed (2006) conducted a field experiment at Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during the December 2005 to May 2006 to study the influence of cultivation methods on the growth pattern of inbred and hybrid rice in *boro* season. The experiment consisted of two levels of treatments viz, variety (BRRI dhan29 and Sonarbangla-1) and cultivation method ($P_1$, $P_2$, $P_3$, $P_4$ and $P_5$) and was laid out in a split-plot design with four replications. He reported that separated tillers needed the longest duration and sprouted seeds required the shortest duration to flower and mature.

Ingale *et at* (2005) conducted an experiment from 1999 to 2000 to determine the effects of seedling ages at transplanting (25, 40 and 55 days), number of seedlings per hill (one or two) and nitrogen rates (50, 100 and 150 kg ha"$^{1}$) on the yields of Sahyadri rice hybrid. A significant reduction in yield was observed with the delay in transplanting at 40 and 55 days old seedlings over 25 days old seedlings in 1999 and in the pooled mean of both years. Transplanting two 25 days old seedlings per hill at 20 x 15 cm spacing with 150 kg N ha"$^{1}$ was recommended for the commercial cultivation of Sahyadri rice hybrid.

Anwar and Begum (2004) reported that time of tiller separation of rice significantly influenced plant height, total number of tillers hill$^{-1}$, number of bearing tillers and panicle length but grain and straw yields were unaffected. Therefore, Sonarbangla 1 appealed to be tolerant to tiller separation and separation should be done between 20 and 40 DAT without hampering grain yield.

Biswas and Salokhe (2002) observed that the separation of more than 4 tillers hilt had an adverse effect on the mother plant. The application of higher doses of N produced a higher number of tillers. Never the less the enhancement of tiller separation beyond 4 tillers hill"$^{1}$ adversely affected grain weight and panicle number.

Sarkar *et al.* (2002) investigated the effect of row arrangement, time of tiller separation and number of tiller kept hill"$^{1}$ on transplant Aman rice (cv. BR23). The experiment comprised of three row arrangements viz. single, double and triple row; two times of tiller separation viz. 25 days after transplanting (DAT) and 35 DAT; and three levels of number kept hill"$^{1}$ viz. 2, 4, and intact hills. The tallest plant and the highest number of tiller hill$^{-1}$ were recorded in single row, intact hills and when tiller separation was done at 25 DAT. On the other hand, the highest leaf area index and total dry matter were recorded in triple row and intact hills. Growing of transplant Aman rice in triple rows with intact hills appeared as the promising practice in respect of highest leaf area index and total dry matter production. In single row tiller can be separated at 25 DAT without hampering plant height and tiller production hill"$^{1}$.

Kewat *et al.* (2002) conducted an investigation during the rainy seasons of 1998 and 1999 at Jabalpur, Madhya Pradesh, India to evaluate the effect of divergent plant spacing and seedling age on the yield and economics of' Pro-Agro 6201' hybrid rice *(Oryza saliva).* Transplanting seedlings at the closest spacing of 20 cm x 10 cm produced significantly highest grain (63 q ha"$^{1}$) and straw (162 q ha"$^{1}$) yields and benefitxost ratio (2:8) than the wider spacing of 20 cm x 20 cm and 20 cm x 15 cm, but was comparable to 15 cm x 15 cm spacing. Similarly, transplanting of 21 and 28 days old seedlings recorded significantly higher grain and straw yields, net monetary returns and benefitxost ratio than transplanting of thin and lanky 14 days old seedlings.

Pandey *et al.* (2002) reported that the effects of planting dates (20 July, 5 August and 20 August 1998) and N levels (50, 100 and 150 kg ha"$^{1}$) on rice (hybrid Proagro 6201) in Madhya Pradesh, India were studied during 1998. The number of tillers increased up to 60 days after transplanting (DAT) and declined thereafter, while the weight of tillers and dry matter accumulation continued to increase up to 90 DAT. Planting on 20 July and 5 August resulted in significantly higher number and weight of tillers hill"$^{1}$, dry matter accumulation, grain yield and heat units. The increasing level of N significantly increased the dry matter accumulation, grain yield, weight of tillers and tillers hill"'. The correlation coefficient indicated that the number of tillers and dry matter accumulation at 30 and 90 DAT were the most important parameters affecting grain yield.

Molla (2001) conducted experiments during 1998 and 1999 wet season in west Bengal, India to examine the performance of rice hybrids and high yielding cultivars (HYV) with different seedling ages and seedling number hill$^{-1}$. The treatments consisted of 2 hybrids rice (Pro Agro 6210 and CNRH 3) and one HYV (1ET4786), 2 seedlings ages (21 and 28 days old) and 2 levels of seedlings number hill$^{-1}$ (1 and 2 seedling per hill) for hybrid rice and 3 and 6 seedlings hill$^{-1}$ (HYV). Pro Agro 6201 had significantly higher yield than 1ET4786, due to more mature panicles m$^{-2}$, higher number of filled grains panicle$^{-1}$ and greater seed weight. Pro Agro 6201 had more profuse tillering habit at an early stage than the HYV, which could be due to hybrid vigor (heterosis). Twenty eight days old seedlings produced more tiller, panicles m$^{-2}$, grain yield than 21 days old seedlings. Seedlings hill$^{-1}$ significantly influenced the number of tillers, mature panicle m$^{-2}$ and rice yield than one seedling, including other parameters, in hybrids. For HYV, no significant response was obtained by increasing the number of seedlings from 3 to 6.

Biswas and Salokhe (2001) reported that vegetative propagation of rice using separated tillers collected from the mother plant without hampering its yield as a proven technology especially in adverse environmental situation as well as for expansion of hybrid rice cultivation area. The separation of 4, 6 and 8 tillers hill$^{-1}$ significantly reduced the grain yield. There was no yield reduction for separation of two tillers hill$^{-1}$. The highest straw yield (5.0 t ha$^{-1}$) was observed in the control (no tiller separation) followed by 2 tillers hill$^{-1}$ (4.8 t ha$^{-1}$). There were no differences between 2 and 4 tillers separated per hill.

Rahman (2001) observed that number of effective tillers was highest in intact crop compared to separated tillers. Similar trend was observed in grains panicle$^{-1}$. Almost similar trend was also observed by Dwivedi *et al.* (1996). However, Biswas (2001) reported higher grain in the separated tillers than the nursery seedling.

Kabir (2000) observed that the plant height and panicle length at harvest were higher when tillers were separated at 30 DAT but total tillers hill$^{-1}$ was maximum when tillers were separated at 40 DAT. The highest numbers of effective tillers hill$^{-1}$, number of grains panicle$^{-1}$ and grain yield were obtained when 2 tillers were kept hill$^{-1}$.The highest number of effective tillers hill" was obtained when tillers were separated at 40 DAT and in intact hills which was similar to tiller separation at 30 DAT keeping 2 or 4 tillers hill"$^{1}$. Tiller separation could be done at 30 DAT to 40 DAT without hampering grain yield.

Paul (1999) obtained the highest number of effective tillers hill$^{-1}$, number of grains panicle$^{-1}$ and grain yield when 2 tillers kept hill$^{-1}$.

Mamin *et al.* (1999) observed that intact mother hills produced the highest yield (5.00 t ha$^{-1}$), when retaining 4 tillers with mother plant produced the lowest yield (4.46 t ha$^{-1}$). Intact mother hill produced more panicles m$^{-2}$ (223-241), less spikelets panicle$^{-1}$ (106-115) and lower sterility percentage (9.6-11.5%), compared with split and replanted hills (167-195 panicles m$^{-2}$, 133-152 spikelets panicle$^{-1}$ and 21.3-25.3% sterility). Plant height was greatest in intact mother hills (105-106 cm), while the height of split and replanted tillers ranged from 95-101cm. Straw yields were markedly higher in intact mother hills (5.04- 5.87 t ha$^{-1}$) than those of split replanted tillers (3.98-4.67 t ha$^{-1}$).

Sharma and Ghosh (1998) conducted a field experiment at Cuttack, India during rainy season of 1994 and 1995 under semi deep water conditions (0-100 cm) to study the yield performance of rice cultivar. Pani dhan established by direct sowing and transplanting with either conventional nursery seedlings of tiller uprooted from the direct sown crop (clonal propagation). The yield of crop sown with 600 seeds m$^{-2}$

remained unaffected when clonal tillers at a density of 70-90 $m^{-2}$ were uprooted of tillers up to 90 days (1994) 30 days (1995) of growth but further delayed in the uprooting of tillers up to 90 days or more (1994) and 75 days (1995) decreased yield by 0.34 to 0.85 t $ha^{-1}$ compared with the undisturbed crop. The decrease in yield was due to reduced panicle number $m^{-2}$ which was not compensated by increased panicle weight. The transplanted rice crop from separated tillers performed better (1.07- 2.28 t $ha^{-1}$) than that from nursery seedlings (0.46-1.29 t $ha^{-1}$). The clonal tillers were taller (78.3- 88.7cm) and had more dry weight (0.86-2.05 g $plant^{-1}$) which helped their better establishment and greater survival under the similar flooded environment than the nursery seedlings (66.3-76.3 cm height and 0.56-0.85 g seedling dry weight), which collapsed after transplanting and thus established poorly. Therefore, stand establishment of rice either by direct sowing or transplanting with clonal tillers gave best results under semi-deep water conditions.

Mannan and Shamsuddin (1997) observed that the vegetative propagation of rice did not produce higher grain yield compared to normal sexual propagation method. Development of planting material in vegetative propagation was time consuming and costly where as in normal cultivation this method was not suitable, but in special cases, like breeding work and other cases where there was limitation of plant seed stock this method might advantageously be used.

Sharma conducted a series of experiments in 1992, 1994 and 1995 with direct seeded rice and experienced better performance of separated tillers over nursery seedlings. It was possible to uproot some plants from the main field without hampering the mother crop/ transplanted crop. Roy *et al.* (1990) also reported similar results.

Sharma (1995) found the initial establishment of the transplanted crop depended on seedling vigor and in general, the plants from the vegetatively propagated tillers established better as the initial advantage in their height and dry weight resulting in better growth, faster acclimatization to the soil. He also found that higher plant height of clonal tillers of two photoperiod sensitive rice varieties at maturity compared to nursery seedlings planted during the months of July and August.

Hari *et al.* (1997) conducted field experiments on rice hybrid PMS 2A/IR 31802 during kharif [monsoon] 1993 and 1994 to study the effect of seedling density in the nursery and nitrogen levels after transplanting on leaf area index (LAI) and dry matter production. LAI and dry matter accumulation increased with the increase in N application from 0 to 200 kg ha"[1]. The differences were significant up to 150 kg N ha"[1] at all the growth stages. There was a significant decrease in LAI and dry matter production with the increase in seedling density from the sowing rate of 20 to 60 g m in the nursery. Maximum LAI was obtained 80 days after transplanting in 1993 and 60 days after transplanting in 1994, whereas dry matter was highest at harvest.

Om *et al.* (1996) reported that in a field trial at Haryana in the 1993-1994 wet seasons, 4 rice genotypes were transplanted on the 15 June, 25 June, 5 July or 25 July. Grain yield averaged 7.0, 7.7, 7.4 and 4.9 t ha"[1] with the 4 transplanting dates, respectively, and was highest (7.6 t ha"[1]) in hybrid OR1 161.

Miah *et al.* (1996) carried out a field experiment at Kochi University, Japan during May-October. 1992, to investigate dry matter production characteristics (before and after heading), the partitioning of dry matter to panicles, and other related factors in 8 rice cultivars (the high-yielding semi dwarf indica (SDI) and japonica-indica hybrid (JI) cultivars compared with japonica panicle weight (JP) and japonica panicle number type (JN) cultivars as controls) transplanted either early or late in the season (ET and LT, respectively). JI and SDI leaf area indices (LAI) at both ET and LT were highest at full heading. However, decreasing percentages were more prevalent in these cultivars after heading, resulting in lower LAIs than those of japonica cultivars at maturity. Total top dry weights at full heading of SDI and Jl cultivars were higher than those of JP and JN cultivars at ET and LT, except for Akenohoshi at LT, although differences in dry matter increments during the period from full heading to maturity (HM) were non-significant between cultivars. Crop growth rates (CGR) during heading to maturity stages of SDI cultivars both in ET and LT, were the lowest among the varietal groups due to highest decreasing percentage of LAI and SPAD readings at the later grain filling stages. Panicle dry weights of SDI and JI cultivars were 125 to 190 g m"[2] (20-31%) and 105 to 115 g m"[2] (18-20%) higher than those of japonica cultivars in ET and LT, respectively. Mean ratios of panicle dry weight to total top dry weight at maturity of the SDI and Jl cultivars in both ET and LT were about 56%, being significantly greater than the corresponding mean ratios of JP and JN cultivars (-47%). Higher mean ratios resulted in panicle weight differences between the high yielding cultivars and japonica cultivars. Shoot dry matter partitioning percentages to the panicles of SD1 and JIcultivars were more than double at ET, and those of SD1 cultivars were about 4 times higher than those of the japonica cultivars at LT. Panicle dry weight at full heading (sink capacity) was closely related to the panicle dry weight at maturity. When the sink capacity was high, the increment in top dry weights during HM was lower. In addition, the partitioning ratios of the accumulated assimilates in shoots to panicles were closely related to the sink capacity.

Mallick (1994) carried out a pot experiment at the Institute of Postgraduate Studies in Agriculture (IPSA), Salna, Gazipur during the wet season, 1993 to evaluate the varietal differences in panicle characteristics, spikelets ripening, and special distribution of filled and unfilled spikelets within a panicle as influenced by tiller removal and double transplanting. The two varieties- Nizersail and BR22 representing old and modem rice were taken as variables. Removal of tillers from the mother shoot and double transplanting increased panicle formation by about 10% in both the varieties. Tiller removal increased grain yield per panicle by 27% in Nizersail and 21% in BR22 double transplanting increased the number of spikelets panicle$^{-1}$ in both the varieties. Tiller removal also increased spikelets but not as much as was in the double transplanted rice.

Matsuo and Hoshikaw (1993) observed in another experiment that the main stem of a rice plant produced a large number of tillers, reaching around 50 or more at the 'maximum tiller number stage'. The tillers that developed in an early growing stage of a plant usually grow vigorously, produced panicles at the tips of the stem and finally contributed to the yield as productive tillers. The number of panicles in a yield component depended largely on the number of tillers. The development of tillers during the tillering stage therefore was important for the yield of rice.

Sharma (1992, 1994 and 1995) and Roy *et al.* (1990) had shown better performance of separated tillers of direct seeded rice over nursery seedlings in terms of growth and yield, and hence shown the possibility to make use of separated tillers to restore plant stands when damaged by unexpected natural hazards, such as drought, flood etc. Therefore collection of tillers as planting material from mother plant at its maximum tillering stage may be an option to fill vacancies in a damaged field after recession of floodwater, which might be an alternate technology to overcome this problem. Furthermore increased yield of rice using vegetative propagation by tillers was also reported by Reddy and Ghosh (1987) and Biswas *et al.* (1989).

BRRI (1990) stated that splitting of tillers at 30 or 40 DAT produced satisfactory grain yield without significant loss of the mother crop.

Roy *et al.* (1990) conducted an experiment as a part of post-flood rehabilitation program, with transplanted rice at Hathazari, Bangladesh and showed that up to three separated tillers hill$^{-1}$ could be separated without hampering the main crop yield but the removal of higher number of tillers hill$^{-1}$ significantly reduced the mother crop yield. They also noted that it was possible to detach tiller from mother hills to use seedlings in the post flood agricultural rehabilitation. If 6-7 tillers were detached from the mother hill and replanted 2-3 tillers hill$^{-1}$, 200 to 300% more area could be covered. As compared with over aged nursery seedlings, the separated tillers performed better for the grain yield.

Biswas *et al.* (1989) carried out experiment where 45 day old seedlings were transplanted from where 35 days after transplantation 1, 3, 5 and 7 tillers were detached from the mother crop and replanted along with 65 days old seedlings of the same variety as the control. They found that the highest yield (5.3 t ha$^{-1}$) was produced by retransplanting of 3 to 5 tillers hill$^{-1}$ but yield of control was 3.8 t ha$^{-1}$.

Shahidullah *et al.* (1989) conducted an experiment on retransplantation with 5 different transplanting dates and 5 transplant Aman varieties. The fifty percent of each plot were disturbed by separating 50% of the total tillers hill"$^{1}$ and subsequently retransplanted on mid-September in the field with 40 cm lower elevation (considered as flood affected field) than that of main field. They suggested that the total production might be increased through tiller separation and replanting and thereby the flood damaged transplant aman field could be recovered successfully.

Roy *et al.* (1989) conducted an experiment with variety BR] I at 4 to 5 seedlings hill$^{-1}$. After 35 days 1, 3. 5 and 7 tillers were separated and replanted with 65 days old seedlings of the same variety as a control. I hey observed that number of panicles m$^{-2}$ was higher with control and the lowest with 1 tiller hill'$^{1}$. Number of filled grains panicle'$^{1}$ was significantly lower with control but no significant difference was obtained with 1000-grain weight. Grain yield was significantly reduced compared with the control and 1 tiller planted tiller'$^{1}$ but there was no significant difference in grain yield with 3 to 7 tiller planted hill$^{-1}$.

Siddique *et al.* (1988) worked with splitted tillers from mother plant and replanted in a new area. They indicated that the best time for splitting tillers from mother plant was 40 days after transplanting. They also added that splitting could be done 30 days after transplanting. They found similar results in Joydebpur in 1989. BRRI (1988) conducted an experiment with splitting of tillers. They found that tillers could be separated at 30-40 days after transplanting and grain yield increased with the number of tiller hill"[1] from 2 to 3.

Reddy and Ghosh (1987) noted that uprooting of separated tillers up to 40 days of growth from a transplanted crop and up to 82 days from direct sown crop (Sharma, 1995) caused no adverse effect on mother crop. They also obtained higher grain yield from a clonally propagated transplanted crop than that raised from conventional nursery seedling under intermediate low and flood prone condition.

Sharma *et al.* (1987) conducted an experiment at Ludhiana, India with 4 rice cultivars to increase seed production of elite cultivars in a single season and reported that sequential splitting and transplanting of rice tillers could help rapid multiplication of elite and newly developed cytogenetic male sterile lines for hybrid rice production. They separated 10 seedlings of 4 cultivars at 18 days after transplanting. They obtained maximum number of seedlings (963) from the original 10 in PR 109. Subsequent grain yield did not increase in proportion to the number of seedlings obtained, possibly due to the reduction in number and length of panicles and reduction in the number of fertile tillers and increased floret sterility. The authors concluded that the method could be used for rapid multiplication of elite and cytogenetically male sterile lines for hybrid seed production and also for multiplication of hybrid rice seed for testing at several sites in a single season.

Reddy and Ghosh (1986) observed that gaps sometimes appeared in stands of transplanted rice on intermediate deep water lands due either to heavy rains soon after planting or to water accumulation. Efficiency of removing separated tillers from closely planted and well established patches/fields and re-transplanting them for filling gaps was compared with that of using original (60 to 80 days old) seedlings from the nursery. Re-transplanting the tillers removed from 20 to 40 days old crops was superior to seedling transplanting in increasing yields.

Tsai (1984) examined the process of tiller formation and relationship with other organs and stressed that whole process could be divided into bud primordium formation, primordium differentiation, bud development and bud emergence. Of these four steps, only the last two were significantly affected by factors such as cultivars and environment.

Ding *et al.* (1983) observed that the establishment of rice crop by tiller transplanting in place of seedling transplanting reduced the amount of seeds. They also recorded 4-10% higher yield with tiller transplanting than that obtained with seedling.

Raju and Varma (1979) observed in a basic research on tillering pattern of rice in India and reported that the growth and development of tillers directly affected the economic and total biological yields. The contribution of mother culms, primary bearing, secondary bearing, and tertiary bearing to the grain was 10, 50, 35 and 5% respectively. The contribution of primary tillers was due to a large source of carbon assimilation and more sink capacity for accumulating photosynthates. Tertiary tillers were mostly unproductive aid their mortality was high. They were unsuccessful in the intraplant competition for photosynthate and other growth requirement and thus they contributed less to the grain yield.

Richharia and Rao (1961) reported that tiller separation acted as a trigger mechanism to activate the dormant buds thereby increasing the scope of vegetative multiplication of tillers. The multiplication proceeded at an increasing rate. They also showed that vegetatively propagated rice crop gave 10-15% increased grain yield.

## 2.2 Effect of variety

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

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

Obaidullah (2007) stated that variety significantly influenced panicle length, number of total grains panicle', filled grains panicle1, 1000 grains weight, grain yield and straw yield but not for effective tillers hill' and harvest index. The varietal effects on yield and other yield attributes where hybrid variety gave numerically maximum tillers hill$^{-1}$ (10.08), and significantly highest panicle length (27.36 cm), grains panicle$^{-1}$ (196.75), filled grains panicle$^{-1}$ (156.84), 1000 grain weight (27.40 g) which eventually elevated the grain yield (5.58 t ha$^{-1}$). These parameters were 9.8, 25.17 cm, 112.83, 86.77, 20.09 g and 3.88 t ha$^{-1}$, respectively as lowest measurements from inbred varieties.

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

Main *et al.* (2007) reported that there was no significant variation of effective tillers hill$^{-1}$, total grains panicle$^{-1}$, filled grains panicle, straw yield and harvest index observed between the two varieties but hybrid variety showed higher panicle length, grain weight and grain yield compared to inbred variety. The variety Sonarbangla-1 gave the longer panicle (26.40 cm) compared to that of BR11 (25.66 cm). The higher weight of 1000 grains (28.32 g) was obtained from the hybrid variety and the lower (27.08 g) was obtained from the inbred variety. The higher grain yield (4.70 t ha$^{-1}$) was obtained from the hybrid variety Sonar bangla-1 and from inbred variety BR11(4.43 t ha$^{-1}$). Irrespective of variety clonal tillers showed the highest range of harvest index (48.52 to 49.55%) that was statistically similar with nursery seedlings of inbred variety.

Biswas and Salokhe (2006) stated that irrespective of variety, clonal tillers were found significantly taller than nursery seedlings. The taller plant height (157.60 cm) was observed in KDML 105 with 3 clonal tillers hill$^{-1}$ and no variations were observed among 1 to 4 clonal tillers hill$^{-1}$ of the same variety. The lowest plant height (108 cm) was given by nursery seedlings of RD 23. The nursery seedlings of RD 23 resulted the lowest number of filled grains panicle$^{-1}$. Planting density of 1 to 4 clonal tillers hill$^{-1}$ showed the same number of filled grains panicle within the corresponding variety. For both varieties, clonal tillers produced significantly higher yield compared to nursery seedlings.

Akbar (2004) stated that variety, seedling age and their interaction exerted significant influence on almost all the studied crop characters of rice. Among the varieties, BRRI dhan4l performed the best in respect of number of bearing tillers hill$^{-1}$, panicle length, total spikelets panicle$^{-1}$, and number of grains panicle$^{-1}$. BRRI dhan41 also produced the maximum grain and straw yields, Sonarbangla-1 ranked first in respect of total tillers hill$^{-1}$ and 1000 grain weight but produced the highest number of non-bearing tillers hill and sterile spikelets panicle$^{-1}$. Grain, straw and biological yields were found highest in the combination of BRRI dhan41 x 15 day-old seedlings. Therefore, BRRI dhan4l may be cultivated using 15 day-old seedlings in *aman* season following the SRI technique to better grain and straw yields.

In a trial, varietal differences in harvest index and yield were examined using 60 Japanese varieties bred in Asian countries. It was reported that harvest index varied from 36.8% to 53.4%. Mean values of harvest index were 43.5% in the Japanese group and 48.8% in high yielding group. Yield ranged from 22.6 g plant$^{-1}$. The mean value of yield in Japanese group was 22.8 g plant$^{-1}$, and that in high yielding group was 34.1 g plant$^{-1}$. They also reported that a positive correlation was found between harvest index and yield in the yielding group (Cui *et al.* 2000).

Om *et al.* (1999) conducted a field experiment with four varieties (3 hybrids: ORI 161, PMS 2A, PMS 10A and one inbred variety HKR 126) during rainy season and observed that hybrid ORI 161 exhibited superiority to other varieties in grain yield and straw yield.

Tac *et al.* (1998) conducted an experiment with two varieties, Akitakomachi and Hitombore in tohoku region of Japan. It was found that Hitombore yielded the higher (710 g $m^{-2}$) and Akitakomachi the lowest (660 g $m^{-2}$)

WenXiong *et al.* (1996) reported that Shnyou 63 (Zhenshan 97A x Minhui 63) and Teyou 63 (Longtepu A x Minhui 63) showed significant grain yield increase over Minhui 63 of 35.2 and 48%, respectively, in China in 1993. The higher number of productive tillers $plant^{-1}$ had the largest direct effect on grain yield, resulting in increased sink capability. The higher tiller number and number of grains $panicle^{-1}$ were attributable to higher leaf areas, higher net photosynthesis in individual leaves (particularly in the later stages) and favorable partitioning of photosynthesis to plant organs. Compared with Minhui 63, hybrids showed slight heterosis in relative growth rate but significant heterosis in crop growth rate, especially at later growth stages, with increases of 160.52 and 97.62% in shanyou 63 and Teyou 63, respectively.

B1NA (1993) evaluated the performance of four varieties- IRATOM 24, BR 14, Binadhan-13 and Binadhan-9. It was found that the varieties differed significantly in respect of plant height, number of unproductive tillers $hill^{-1}$, panicle length and sterile spikelets $panicle^{-1}$.

Leenakumari *et al.* (1993) found higher grain yield from the hybrid varieties over the modern varieties. They evaluated eleven hybrids of varying duration against controls Jaya, Rasi, 1R20 and Margala, and concluded that hybrid OR 1002 gave the highest yield (7.9 t $ha^{-1}$) followed by IR 1000 (6.2 t $ha^{-1}$). Rahman (2001) also observed the highest harvest index in Sonarbangla-1 than the inbred varieties.

BRRI (1991) reported that the number of effective tillers produced by some transplant *aman* rice ranged from 7 to 14 tillers $hill^{-1}$ and it significantly differed from variety.

In a trail with six modern varieties in haor area during *Boro* season it was recorded that rice grain yield differed significantly where 4.59, 5.3, 5.73, 4.86, 3.75 and 4.64 t $ha^{-1}$ of grain yield were recorded with BR3, BR11, BR14, IR8, Panjam and BR16, respectively (Hossain *et al.*, 1991).

BRRI (1985) concluded that BR4 and BR10 were higher yielders than Rajasail and Kajalsail.

Kamal *et al.* (1988) observed that among three rice varieties BR3 produced the highest the grain yield and pajam yielded the lowest. The superiority of promising line over the high yielding varieties in respect of grain yield was recorded.

Miller (1978) from a study of 14 rice cultivars observed that grain yields ranged from 5.6 to 7.7 t $ha^{-1}$. He also reported that grain yield was significantly influenced by rice cultivars. Kumber and Sonar (1978) also reported variable effects of rice varieties on grain yield. Om *et al.* (1999) observed that hybrid variety exhibited superiority to other inbred varieties in grain and straw yield.

Chang and Vergara (1972) stated that the tillering pattern of rice varied with the varieties. In general tall cultivars showed a tendency to have small number of tillers and shorts on showed a large number. Tiller number and panicle number were positively correlated. Tall tropical and subtropical cultivars tend to have a low ratio of panicle to tillers. *Japonica* cultivars that produced few tillers under tropical conditions were vigorous and produced more tillers when grown under temperate conditions. *Indica* cultivars, which were vigorous under tropical conditions, showed few tillers under temperate conditions.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from June to November 2014. This chapter deals with a brief description on experimental site, climate, soil, and land preparation, layout of the experimental design, intercultural operations, data recording and their analyses.

## 3.1 Site Description

### 3.1.1 Geographical Location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above sea level.

### 3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of “The Modhupur Tract”, AEZ-28 (Anon., 1988a). 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., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

### 3.1.3 Climate

The experimental area is under the sub-tropical 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 of the experimental site is shown in Appendix III.

### 3.1.4 Soil

The farm belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranges from 5.4-5.6 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system. 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 physicochemical properties of the soil are presented in Appendix IV.

## 3.2 Experiment details

### 3.2.1 Crop/Planting material

Two high yielding varieties of Aman rice BRRI dhan33 and BRRI dhan62 and a hybrid rice variety Chamak 1 were used as the test crop. The inbred variety BRRI dhan33 was developed by Bangladesh Rice Research Institute (BRRI), Joydebpur, Gajipur, Bangladesh. Average height of the plant is 100 cm. The grains are short, thick with light brown husk. BRRI dhan62 was also developed by Bangladesh Rice Research Institute (BRRI), Joydebpur, Gajipur, Bangladesh. The pedigree line of BRRI dhan62 is BR 517-2R-27-3. Average height of the plant is 98 cm. The grains are long, slender and white in color .The grains are zinc enriched. Chamak 1 is a hybrid variety which produce higher yield than modern variety. It is introduced in Bangladesh from China. Plants are shorter than inbred variety. Grains are white in color.

### 3.2.2 Experimental Treatments

Two sets of treatments included in the experiment were as follows:

A. Main plot (Variety): 3

1. BRRI dhan33 (Inbred)-$V_1$
2. BRRI dhan62 (Inbred)-$V_2$
3. Chamak 1 (hybrid)-$V_3$

B. Sub Plot (Separation of tillers at)

1. 20 days (D1)
2. 25 days (D2)
3. 30 days (D3)
4. 35 days (D4)

### 3.2.3 Experimental design

The experiment was laid in a split-plot design with three replications having variety in the main plots and tiller separation days in the sub-plots. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 3m x 2m = 6 $m^2$. The distances between plot to plot and replication to replication were o.5 m and l m respectively. The layout of the experiment has been shown in Appendix II.

## 3.3 Growing of crops

### 3.3.1 Seed collection and sprouting

Seeds of BRRI dhan 33 and BRRI dhan 62 were collected from BRRI, Joydebpur, Gazipur, Bangladesh and the Chamak 1 Hybrid rice seed was collected from the Siddique Bazar, Dhaka. Healthy seeds were selected following standard method. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of water and tightly kept in gunny bags. The seeds started to sprout after 48 hrs which became ready for sowing in 72 hrs.

### 3.3.2 Raising of seedlings

A common procedure was followed in raising of seedlings in the nursery bed. The nursery bed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

### 3.3.3 Seed sowing

Seeds were sown on the nursery bed on July 8, 2014 for raising nursery seedlings.

### 3.3.4 Preparation of experimental land

The experimental field was first opened on July 25, 2014 with the help of a tractor drawn disc plough, later on August 5, 2014 the land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor plough and subsequently leveled by laddering. All kinds of weeds and residues of previous crop were removed from the field. After the final land preparation the field layout was made on August 6, 2014 according to experimental plan. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

### 3.3.5 Fertilizer dose and methods of application

Unit plots of the experiment were fertilized with 120, 80, 80, 20 and 10 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at the time of transplanting seedlings. Urea was top-dressed in three equal splits. The first one-third urea was top-dressed after seedling recovery, second during the vegetation stage and third at 7 days before panicle initiation. For separated tiller plots, the same dose as above was fertilized but basal application was done only before transplanting of separated tillers in respective plots and in respective time.

### 3.3.6 Transplanting of seedlings and re-transplanting of separated tillers

30 days old seedlings were uprooted carefully from the nursery beds on 07 August, 2014 for transplantation. For this purpose the nursery beds were made wet by the application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. Separated tillers of different ages as per treatment were collected and re-transplanted on the well puddled plots maintaining the standard spacing of 25cm x 15cm with two seedlings $hill^{-1}$.

### 3.3.7 Intercultural operations

#### 3.3.7.1 Gap filling

After one week of each transplantation, a minor gap filling was done as and where necessary using the seedling or separated tillers from the previous source as per treatment.

#### 3.3.7.2 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Two hand weeding were done for each treatment; first weeding was done at 20 days after transplanting followed by second weeding at 15 days after first weeding.

#### 3.3.7.3 Application of irrigation water

Irrigation water was added to each plot according to the need. All the plots were kept irrigated maintaining 3-5 cm stagnant water throughout the entire period up to 15 days before harvesting.

#### 3.3.7.4 Plant protection measures

Plants were infested with rice stem borer (*Scirphophaga incertolus*) and leaf hopper (*Nephotettix nigropictus*) to some extent which were successfully controlled by applying Diazinon @ 10 ml/10 liter of water for 5 decimal lands and by Ripcord @ 10 ml/10 liter of water for 5 decimal lands as and when needed. Crop was protected from birds during the grain filling period. For controlling the birds watch man was deep laid, especially during morning and afternoon.

## 3. 4 General observation of the experimental field

The field was investigated 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 could be minimized. The field looked nice with normal green color plants. Incidence of stem borer, green leaf hopper, leaf roller and rice hispa was observed during tillering stage that controlled properly. No bacterial and fungal disease was observed in the field.

## 3.5 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains became golden yellow in color. The harvesting was done in two different dates for inbred as well as hybrid variety. For inbred varieties harvesting was done on October 20, 2014 and for hybrid variety harvesting was done on October 25, 2014. Ten hills per plot were preselected randomly from which different growth and yield attributes data were collected and 3 $m^2$ areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done by using pedal thresher. The grains were cleaned and sun dried to a moisture content of 14 % approximately. Straw was also sun dried properly.

### 3.6 Recording of data

Experimental data were recorded from 30 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of hills at different dates from the inner rows leaving border rows and harvest area for grain. The followings data were recorded during the experiment.

**A. Crop growth characters**

i. Plant height (cm) at 30 days interval
ii. Number of tillers $hill^{-1}$ at 30 days interval
iii. Dry weight of plant at 30 days interval
iv. Time of flowering and maturity

**B. Yield and yield components**

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

### 3.7 Detailed procedures of recording data

**A. Crop growth characters**

**i. Plant height (cm)**

Plant height was measured at 30, 50, 70 DAT and at harvest. The height of the randomly pre-selected 5 hills $plot^{-1}$ was determined by measuring the distance from the soil surface to the tip of the leaf height before heading, and to the tip of panicle after heading. The collected data were finally averaged.

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

Number of tillers hiil$^{-1}$ were counted at 30, 50, 70 DAT and at harvest from five randomly pre-selected hills and averaged as their number hill$^{-1}$. Only those tillers having three or more leaves were considered for counting.

**iii. Dry weight of plant**

Five hills plot$^{-1}$ were uprooted from second line of each plot at 30 DAT and at harvest for measuring dry weight. The samples were partitioned by root, stem and leaf. The samples were oven dried until a constant weight from which the weights of above ground dry matter were recorded, converted and averaged.

**iv. Times of flowering**

Times of flowering was recorded when about 50% of the plants within a plot emerged flowering. The number of days for flowers was recorded.

**B. Yield and other crop characters**

**i. Effective tillers m$^{-2}$ (no.)**

The panicles which had at least one grain was considered as effective tillers. The number of effective tillers hill$^{-1}$ was recorded and finally averaged for counting effective tillers number m$^{-2}$.

**ii. Ineffective tiller hill$^{-1}$ (no.)**

The tiller having no panicle was regarded as ineffective tillers. The number of ineffective tillers hill$^{-1}$ was recorded and finally averaged for counting ineffective tillers number m$^{-2}$.

**iii. Panicle length (cm)**

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

**iv. Filled grains panicle$^{-1}$ (no.)**

Grain was considered to be filled if any kernel was present there in. The number of total filled grains present on ten panicles were recorded and finally averaged.

**vi. Unfilled grains panicle$^{-1}$ (no.)**

Unfilled grains means the absence of any kernel inside in and such grains present on each of ten panicles were counted and finally averaged.

**vii. Total grains panicle$^{-1}$ (no.)**

The number of filled grains panicle$^{-1}$ plus the number of unfilled grains panicle$^{-1}$ gave the total number of grains panicle$^{-1}$.

**viii. Weight of 1000 grains (g)**

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

**ix. Grain yield (t ha$^{-1}$)**

Grain yield was determined from the central 5 m$^2$ area of each plot and expressed as t ha$^{-1}$ on about 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

**x. Straw yield (t ha$^{-1}$)**

Straw yield was determined from the central 5 m$^2$ area of each plot. After separating of grains, the sub-samples were oven dried to a constant weight and finally converted to t ha$^{-1}$.

**xi. Biological yield (t ha$^{-1}$)**

Grain yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula:

$$\text{Biological yield (t ha}^{-1}\text{)} = \text{Grain yield (t ha}^{-1}\text{)} + \text{Straw yield (t ha}^{-1}\text{)}$$

**xii. Harvest Index (%)**

It denotes the ratio of economic yield to biological yield and was calculated with following formula (Donald, 1963; Gardner *et al*., 1985).

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

## 3.8 Statistical Analyses

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5 % level of significance. (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULT AND DISCUSSION

The experiment was conducted to find out the propagation efficacy through separated tillers in hybrid and inbred rice of Bangladesh. The results obtained from the study have been presented, discussed and compared in this chapter through tables, figures and appendices. The analyses of variance of data in respect of all the parameters have been shown in Appendix V-X. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings.

### 4.1 Plant height (cm)

Plant height of T. aman rice was significantly influenced by different variety (Figure 1). The tallest plant at 30 DAT (44.89 cm), 50 DAT (60.28 cm), 70 DAT (98.46 cm) and at harvest (95.22 cm) was recorded from $V_1$ (BRRI dhan33) treatment. In comparison, the shortest plant at 30 DAT (34.94 cm), 50 DAT (50.28 cm), 70 DAT (84.78 cm) and at harvest (81.57 cm) was observed in $V_3$ (Chamak 1) treatment. The results corroborated with the findings of Islam *et al*. (2009), Bisne *et al.* (2006), BINA (1993) and Hossain and Alam (1991) who observed various plant heights due to different varieties.

Separated tillers of different ages showed significant effect on plant height of T. aman rice (Figure 2). The tallest plant at 30 DAT (41.46 cm), 50 DAT (56.84 cm), 70 DAT (95.53 cm) and at harvest (92.30 cm) was recorded from $D_2$ (25 days old) treatment. On the other hand, the shortest plant at 30 DAT (36.51 cm), 50 DAT (51.89 cm), 70 DAT (87.61 cm) and at harvest (84.39 cm) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller’s age significantly influenced the plant height of T. aman rice (Table 1). The tallest plant at 30 DAT (48.34 cm), 50 DAT (63.72 cm), 70 DAT (103.80 cm) and at harvest (100.60 cm) was recorded from $V_1D_2$ (BRRI dhan33 with 25 days old) treatment combination. On the other hand, the shortest plant at 30 DAT (31.95 cm), 50 DAT (47.33 cm), 70 DAT (79.69 cm) and at harvest (76.49 cm) was observed in $V_3D_4$ (Chamak 1 with 35 days old) treatment combination.

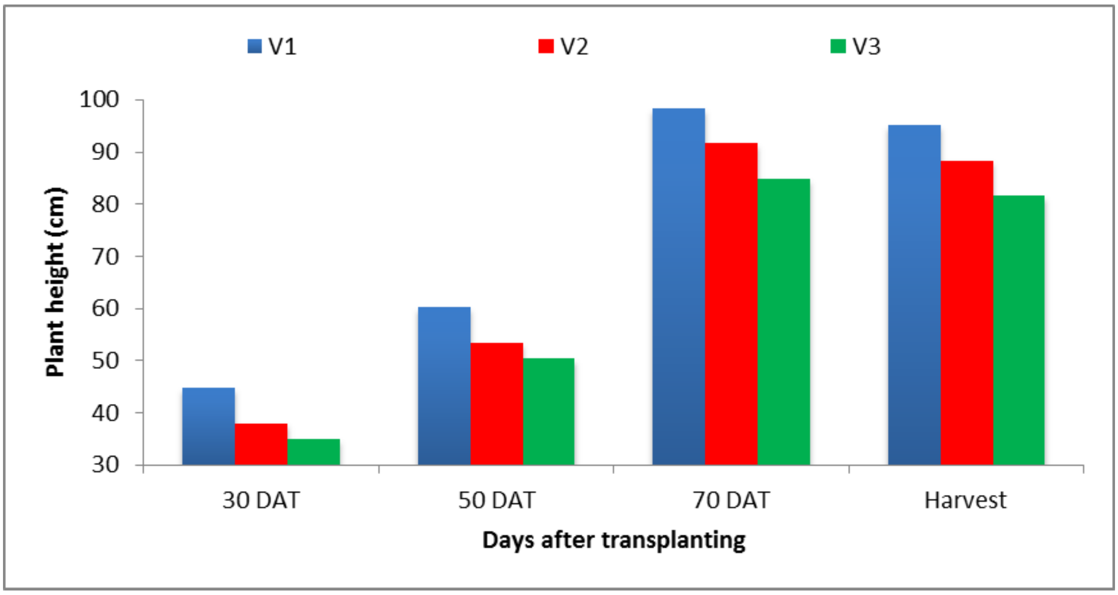


**Figure 1: Effect of variety on plant height (cm) of T. aman rice on different days after transplanting (DAT)** (LSD 0.05 = 0.29, 0.18, 0.38 and 0.26 at 30 DAT, 50 DAT, 70 DAT and harvest, respectively)

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62 and $V_3$- Chamak 1

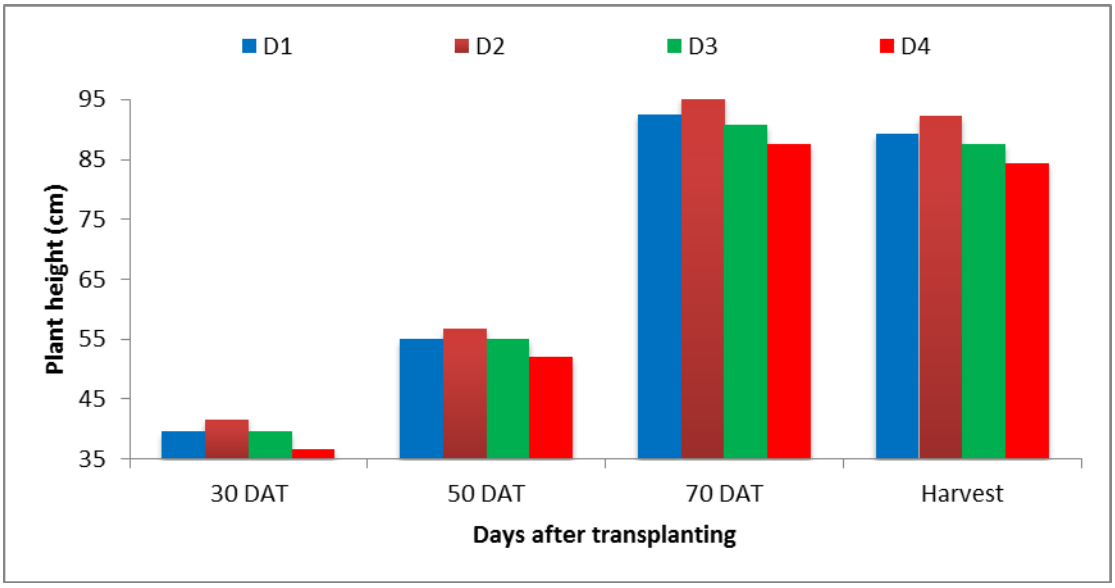


**Figure 2: Effect of separated tiller's age on plant height (cm) of T. aman rice on different days after transplanting (DAT)** (LSD 0.05 = 0.28, 0.23, 0.40 and 0.38 at 30 DAT, 50 DAT, 70 DAT and harvest, respectively)

Note: $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old and $D_4$- 35 days old.

**Table 1: Interaction effect of variety and separated tillers age on plant height (cm) of T. aman rice on different days after transplanting (DAT)**

| Treatment | Plant height (cm) | | | |
|---|---|---|---|---|
| | 30 DAT | 50 DAT | 70 DAT | Harvest |
| $V_1D_1$ | 44.51 c | 59.92 c | 96.79 c | 93.52 c |
| $V_1D_2$ | 48.34 a | 63.72 a | 103.80 a | 100.60 a |
| $V_1D_3$ | 45.79 b | 61.17 b | 98.22 b | 94.99 b |
| $V_1D_4$ | 40.92 d | 56.30 d | 95.00 d | 91.77 d |
| $V_2D_1$ | 38.22 f | 53.82 f | 93.11 f | 89.88 f |
| $V_2D_2$ | 39.18 e | 54.56 e | 94.35 e | 91.12 e |
| $V_2D_3$ | 37.79 g | 53.17 g | 90.60 g | 87.37 g |
| $V_2D_4$ | 36.65 h | 52.03 h | 88.13 h | 84.90 h |
| $V_3D_1$ | 35.76 i | 51.14 i | 87.51 i | 84.31 i |
| $V_3D_2$ | 36.87 h | 52.25 h | 88.39 h | 85.15 h |
| $V_3D_3$ | 35.17 j | 50.38 j | 83.53 j | 80.35 j |
| $V_3D_4$ | 31.95 k | 47.33 k | 79.69 k | 76.49 k |
| $LSD_{(0.05)}$ | 0.28 | 0.23 | 0.40 | 0.38 |
| CV (%) | 4.42 | 5.24 | 5.25 | 4.25 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62, $V_3$- Chamak 1 and $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, $D_4$- 35 days old.

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

Number of tiller per hill of T. aman rice was significantly influenced by different variety (Figure 3). The maximum number of tiller per hill at 30 DAT (8.53), 50 DAT (15.32), 70 DAT (12.17) and at harvest (10.68) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the minimum number of tiller per hill at 30 DAT (6.70), 50 DAT (11.69), 70 DAT (9.06) and at harvest (7.94) was observed in $V_1$ (BRRI dhan33) treatment. Islam *et al*. (2009), Bisne *et al.* (2006) and Bhowmick and Nayak (2000) reported similar trend of tillering habits with different varieties of rice.

Number of tiller per hill of T. aman rice was significantly affected by separated tillers of different age (Figure 4). The highest number of tiller per hill at 30 DAT (8.10), 50 DAT (14.32), 70 DAT (11.30) and at harvest (10.02) was recorded from $D_2$ (25 days old) treatment. In comparison, the lowest number of tiller per hill at 30 DAT (7.00), 50 DAT (12.54), 70 DAT (9.66) and at harvest (8.58) was observed in $D_4$ (35 days old) treatment.

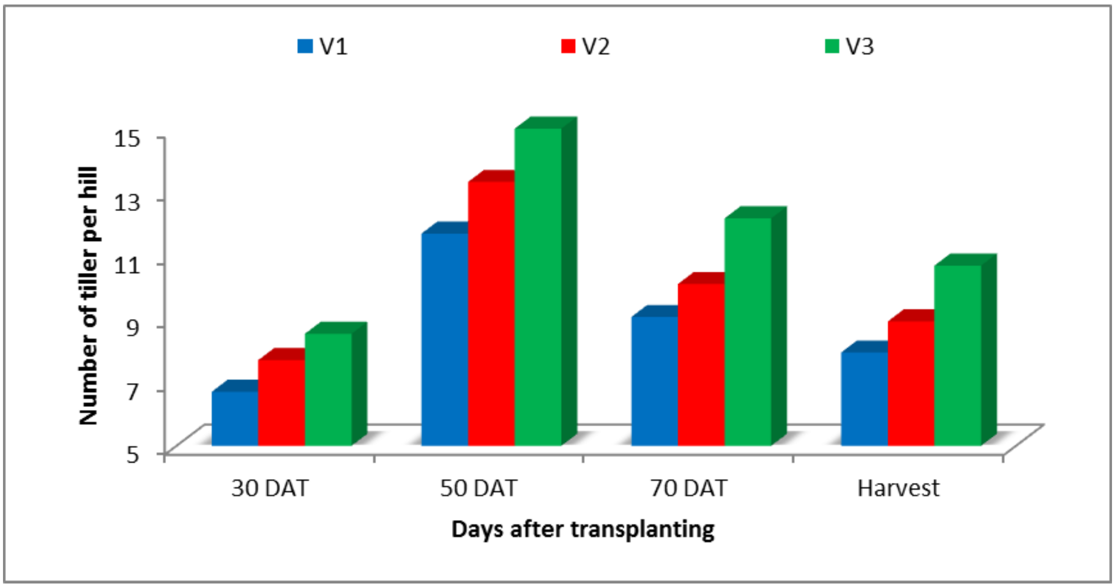


**Figure 3: Effect of variety on number of tillers per hill of T. aman rice on different days after transplanting (DAT)** (LSD 0.05 = 0.11, 0.06, 0.56 and 0.20 at 30 DAT, 50 DAT, 70 DAT and harvest, respectively)

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62 and $V_3$- Chamak 1

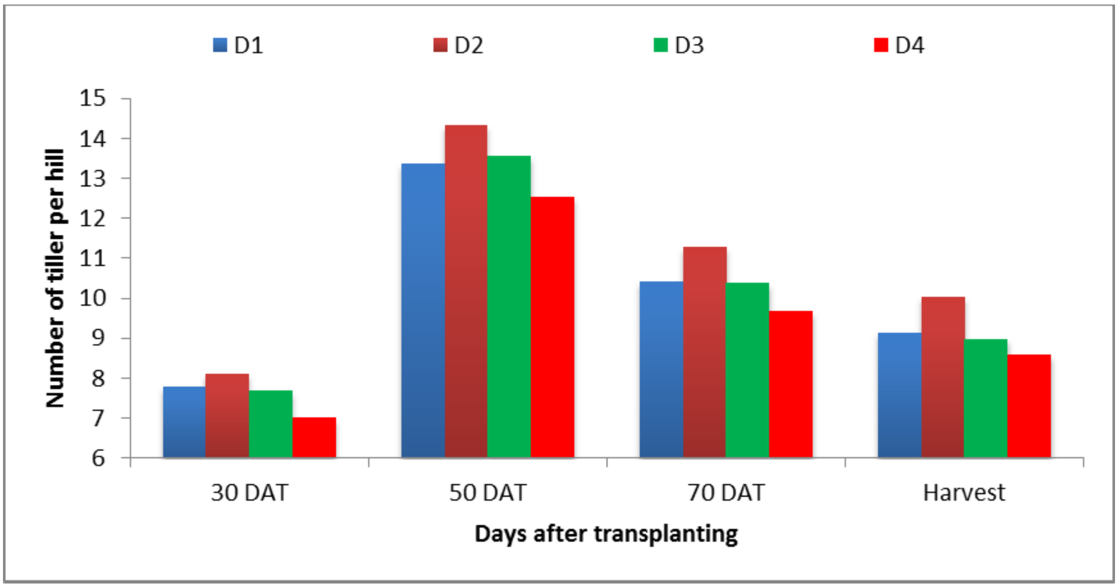


**Figure 4: Effect of separated tiller's age on number of tillers per hill of T. aman rice on different days after transplanting (DAT)** (LSD 0.05 = 0.09, 0.09, 0.05 and 0.11 at 30 DAT, 50 DAT, 70 DAT and harvest, respectively)

Note: $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old and $D_4$- 35 days old.

**Table 2: Interaction effect of variety and separated tillers age on number of tiller per hill of T. aman rice on different days after transplanting (DAT)**

| Treatment | Number of tiller per hill | | | |
|---|---|---|---|---|
| | 30 DAT | 50 DAT | 70 DAT | Harvest |
| $V_1D_1$ | 7.00 f | 12.13 i | 9.17 k | 7.90 j |
| $V_1D_2$ | 6.80 g | 12.47 h | 9.40 i | 8.50 h |
| $V_1D_3$ | 7.00 f | 12.10 i | 9.27 j | 8.15 i |
| $V_1D_4$ | 6.00 h | 10.07 j | 8.40 l | 7.20 k |
| $V_2D_1$ | 8.00 d | 13.00 f | 10.13 f | 9.00 f |
| $V_2D_2$ | 8.00 d | 14.00 d | 10.47 e | 9.17 e |
| $V_2D_3$ | 7.80 e | 13.53 e | 10.00 g | 8.80 g |
| $V_2D_4$ | 7.00 f | 12.75 g | 9.80 h | 8.70 g |
| $V_3D_1$ | 8.40 b | 15.00 b | 12.00 b | 10.51 b |
| $V_3D_2$ | 9.50 a | 16.50 a | 14.03 a | 12.40 a |
| $V_3D_3$ | 8.20 c | 15.00 b | 11.85 c | 10.00 c |
| $V_3D_4$ | 8.00 d | 14.80 c | 10.79 d | 9.83 d |
| $LSD_{(0.05)}$ | 0.09 | 0.09 | 0.05 | 0.11 |
| CV (%) | 3.78 | 4.38 | 4.37 | 5.67 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62, $V_3$- Chamak 1 and $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, $D_4$- 35 days old.

Interaction of variety and separated tiller's age significantly influenced the number of tiller per hill of T. aman rice (Table 2). The maximum number of tiller per hill at 30 DAT (9.50), 50 DAT (16.50), 70 DAT (14.03) and at harvest (12.40) was recorded from $V_3D_2$ (Chamak 1 with 25 days old) treatment combination. On the other hand, the minimum number of tiller per hill at 30 DAT (6.00), 50 DAT (10.07), 70 DAT (8.40) and at harvest (7.20) was observed in $V_1D_4$ (BRRI dhan33with 35 days old) treatment combination.

### 4.3 Dry matter weight per hill (g)

Dry matter weight per hill of T. aman rice was significantly influenced by different variety (Figure 5). The highest dry matter weight per hill at 30 DAT (7.15 g), 50 DAT (22.66 g), 70 DAT (41.28 g) and at harvest (43.83 g) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the lowest dry matter weight per hill at 30 DAT (5.47 g), 50 DAT (16.58 g), 70 DAT (32.29 g) and at harvest (34.74 g) was observed in $V_1$ (BRRI dhan33) treatment. Researcher Islam *et al*. ( 2009), Son *et al.* (1998) and

Patnaik *et al*, (1990) have suggested that dry matter accumulation capacity mainly depends on varietal performances.

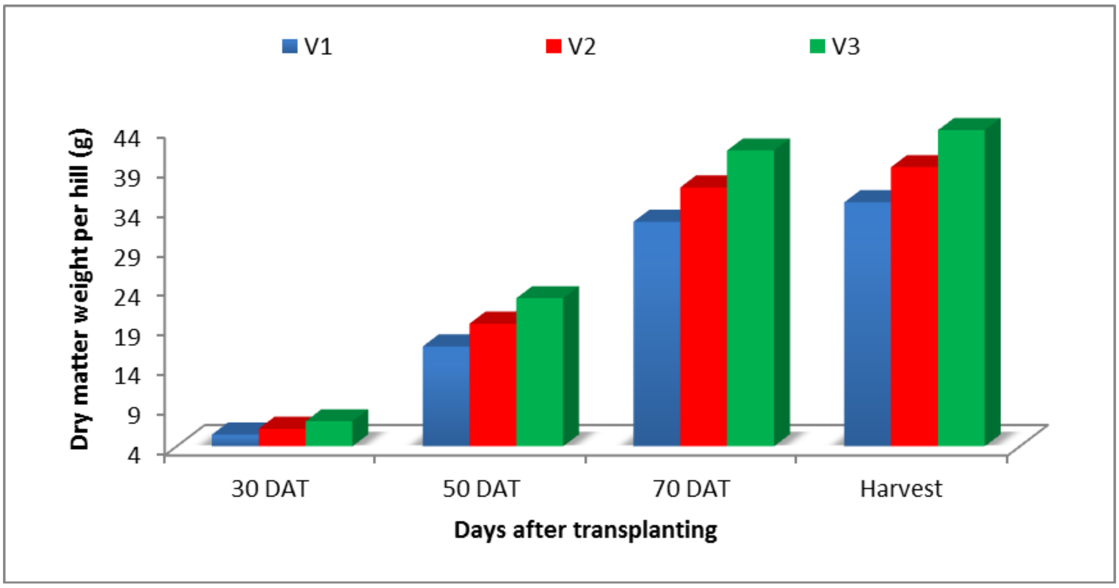


**Figure 5: Effect of variety on dry matter weight per hill (g) of T. aman rice on different days after transplanting (DAT)** (LSD 0.05 = 0.11, 0.27, 0.45 and 0.45 at 30 DAT, 50 DAT, 70 DAT and harvest, respectively)

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62 and $V_3$- Chamak 1

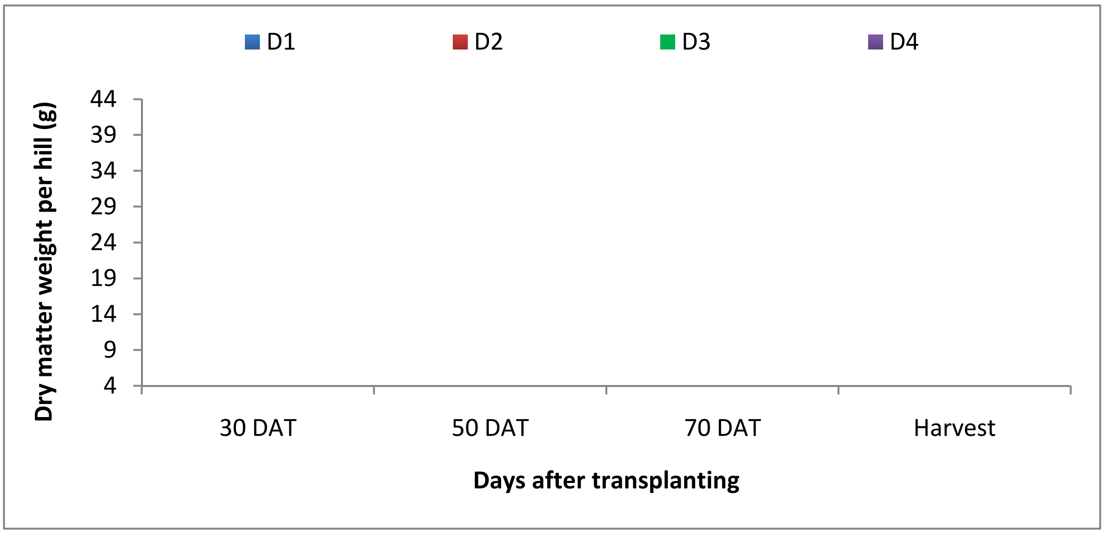


**Figure 6: Effect of separated tiller's age on dry matter weight per hill (g) of T. aman rice on different days after transplanting (DAT)** (LSD 0.05 = 0.09, 0.20, 0.35 and 0.41 at 30 DAT, 50 DAT, 70 DAT and harvest, respectively)

Note: $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old and $D_4$- 35 days old.

Dry matter weight per hill of T. aman rice was significantly affected by separated tillers of different age (Figure 6). The maximum dry matter weight per hill at 30 DAT (7.07 g), 50 DAT (21.14 g), 70 DAT (39.28 g) and at harvest (41.66 g) was recorded from $D_2$ (25 days old) treatment. In comparison, the minimum dry matter weight per hill at 30 DAT (5.47 g), 50 DAT (17.90 g), 70 DAT (34.72 g) and at harvest (37.28 g) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the dry matter weight per hill of T. aman rice (Table 3). The highest dry matter weight per hill at 30 DAT (8.20 g), 50 DAT (25.00 g), 70 DAT (44.33 g) and at harvest (46.90 g) was recorded from $V_3D_2$ (Chamak 1 with 25 days old) treatment combination. On the other hand, the lowest dry matter weight per hill at 30 DAT (4.20 g), 50 DAT (15.00 g), 70 DAT (29.67 g) and at harvest (32.25 g) was observed in $V_1D_4$ (BRRI dhan33 with 35 days old) treatment combination.

**Table 3: Interaction effect of variety and separated tiller's age on dry matter weight per hill (g) of T. aman rice on different days after transplanting (DAT)**

| **Treatment** | **Dry matter weight per hill (g)** | | | |
|---|---|---|---|---|
| | **30 DAT** | **50 DAT** | **70 DAT** | **Harvest** |
| $\mathbf{V_1D_1}$ | 6.00 h | 17.00 g | 32.00 h | 34.57 i |
| $\mathbf{V_1D_2}$ | 6.40 f | 17.33 f | 35.50 g | 37.57 h |
| $\mathbf{V_1D_3}$ | 5.30 j | 17.00 g | 32.00 h | 34.57 i |
| $\mathbf{V_1D_4}$ | 4.20 k | 15.00 h | 29.67 i | 32.25 j |
| $\mathbf{V_2D_1}$ | 6.40 f | 20.20 d | 36.67 f | 39.24 f |
| $\mathbf{V_2D_2}$ | 6.60 d | 21.10 c | 38.00 e | 40.52 e |
| $\mathbf{V_2D_3}$ | 6.20 g | 19.00 e | 36.33 f | 38.90 f |
| $\mathbf{V_2D_4}$ | 5.70 i | 17.50 f | 35.50 g | 38.07 g |
| $\mathbf{V_3D_1}$ | 7.20 b | 22.22 b | 41.10 b | 43.67 b |
| $\mathbf{V_3D_2}$ | 8.20 a | 25.00 a | 44.33 a | 46.90 a |
| $\mathbf{V_3D_3}$ | 6.70 c | 22.20 b | 40.67 c | 43.25 c |
| $\mathbf{V_3D_4}$ | 6.50 e | 21.20 c | 39.00 d | 41.52 d |
| $\mathbf{LSD_{(0.05)}}$ | 0.09 | 0.20 | 0.35 | 0.41 |
| **CV (%)** | 5.92 | 5.59 | 4.56 | 6.61 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62, $V_3$- Chamak 1 and $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, $D_4$- 35 days old.

### 4.4 Number of effective tiller hill$^{-1}$

Different variety showed significant effect on effective tiller hill$^{-1}$ of T. aman rice (Table 4). The highest number of effective tiller hill$^{-1}$ (9.90) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the lowest number of effective tiller hill$^{-1}$ (7.29) was observed in $V_1$ (BRRI dhan33) treatment. The results support the findings of Patnaik *et al.* (1990) and BRRI (1991) who observed that effective tillers producing capacity depends on the performance of different varieties.

Effective tiller hill$^{-1}$ of T. aman rice was significantly influenced by separated tillers of different age (Table 5). The maximum number of effective tiller hill$^{-1}$ (9.64) was recorded from $D_2$ (25 days old) treatment. On the other hand, the minimum number of effective tiller hill$^{-1}$ (7.59) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the effective tiller hill$^{-1}$ of T. aman rice (Table 6). The highest number of effective tiller hill$^{-1}$ (11.22) was recorded from $V_3D_2$ (Chamak 1 with 25 days old) treatment combination. On the other hand, the minimum number of effective tiller hill$^{-1}$ (6.27) was observed in $V_1D_4$ (BRRI dhan33 with 35 days old) treatment combination.

### 4.5 No of non-effective tiller hill$^{-1}$

Different variety showed significant effect on non-effective tiller hill$^{-1}$ of T. aman rice (Table 4). The highest number of non-effective tiller hill$^{-1}$ (2.35) was recorded from $V_1$ (BRRI dhan33) treatment. In comparison, the lowest number of non-effective tiller hill$^{-1}$ (1.20) was observed in $V_3$ (Chamak 1) treatment. . The results support the findings of Patnaik *et al.* (1990) and BRRI (1991) who observed that number of non-effective tillers depends on the performance of different varieties.

Non-effective tiller hill$^{-1}$ of T. aman rice was significantly influenced by separated tillers of different age (Table 5). The maximum number of non-effective tiller hill$^{-1}$ (2.64) was recorded from $D_4$ (35 days old) treatment. On the other hand, the minimum number of non-effective tiller hill$^{-1}$ (1.13) was observed in $D_2$ (25 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the non-effective tiller hill$^{-1}$ of T. aman rice (Table 6). The highest number of non-effective tiller hill$^{-1}$ (3.63) was recorded from $V_1D_4$ (BRRI dhan33 with 35 days old) treatment combination. On the other hand, the minimum number of non-effective tiller hill$^{-1}$ (0.56) was observed in $V_3D_2$ (Chamak 1 with 25 days old) treatment combination.

### 4.6 Panicle length (cm)

Different variety showed significant effect on panicle length of T. aman rice (Table 4). The longest panicle (27.25 cm) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the shortest panicle (23.72 cm) was observed in $V_2$ (BRRI dhan62) treatment. The results obtained under the present study were in conformity with the findings of Wang *et al.* (2006).

Panicle length of T. aman rice was significantly influenced by separated tillers of different age (Table 5). The longest panicle (26.36 cm) was recorded from $D_2$ (25 days old) treatment. On the other hand, the shortest panicle (24.20 cm) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the panicle length of T. aman rice (Table 6). The longest panicle (28.07 cm) was recorded from $V_3D_2$ (Chamak 1 with 25 days old) treatment combination. In comparison, the shortest panicle (21.25 cm) was observed in $V_2D_4$ (BRRI dhan62 with 35 days old) treatment combination.

### 4.7 Grain panicle$^{-1}$ (No.)

Different variety showed significant effect on grain panicle$^{-1}$ of T. aman rice (Table 4). The highest number of grain panicle$^{-1}$ (141.40) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the lowest number of grain panicle$^{-1}$ (107.40) was observed in $V_2$ (BRRI dhan62) treatment.

Grain panicle$^{-1}$of T. aman rice was significantly influenced by separated tillers of different age (Table 5). The maximum number of grain panicle$^{-1}$(136.50) was recorded from $D_2$ treatment. On the other hand, the minimum number of grain panicle$^{-1}$ (119.00) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the grain panicle$^{-1}$of T. aman rice (Table 6). The highest number of grain panicle$^{-1}$ (152.10) was recorded from $V_3D_2$ (Chamak 1 with 25 days old) treatment combination. On the other hand, lowest number of grain panicle$^{-1}$ (100.60) was observed in $V_2D_4$ (BRRI dhan62 with 35 days old) treatment combination.

### 4.8 Filled grain panicle$^{-1}$ (No.)

Different variety showed significant effect on filled grain panicle$^{-1}$ of T. aman rice (Table 4). The highest number of filled grain panicle$^{-1}$ (128.00) was recorded from $V_3$ (Chamak 1) treatment. In comparison, the lowest number of filled grain panicle$^{-1}$ (89.83) was observed in $V_2$ (BRRI dhan62) treatment. The results obtained by Murthy *et al.* (2004), Bhowmick and Nayak (2000) and Patel (2000) was in agreement with findings of present study.

Filled grain panicle$^{-1}$ of T. aman rice was significantly influenced by the application of different levels of nitrogen (Table 5). The maximum number of filled grain panicle$^{-1}$ (120.80) was recorded from $D_2$ (25 days old) treatment. On the other hand, the minimum number of filled grain panicle$^{-1}$ (97.22) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the filled grain panicle$^{-1}$ of T. aman rice (Table 6). The highest number of filled grain panicle$^{-1}$ (142.00) was recorded from $V_3D_2$ (Chamak 1 with 25 days old) treatment combination. On the other hand, lowest number of filled grain panicle$^{-1}$ (80.33) was observed in $V_2D_4$ (BRRI dhan62 with 35 days old) treatment combination.

### 4.9 Unfilled grain panicle$^{-1}$ (No.)

Different variety showed significant effect on unfilled grain panicle$^{-1}$ of T. aman rice (Table 4). The highest number of unfilled grain panicle$^{-1}$(23.41) was recorded from $V_1$ (BRRI dhan33) treatment. In comparison, the lowest number of unfilled grain panicle$^{-1}$(13.38) was observed in $V_3$ (Chamak 1) treatment.

Unfilled grain panicle$^{-1}$ of T. aman rice was significantly influenced by the application of different levels of nitrogen (Table 5). The maximum number of unfilled grain panicle$^{-1}$ (21.74) was recorded from $D_4$ (35 days old) treatment. On the other hand, the minimum number of unfilled grain panicle$^{-1}$ (15.73) was observed in $D_2$ (25 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the unfilled grain panicle$^{-1}$ of T. aman rice (Table 6). The highest number of unfilled grain panicle$^{-1}$ (28.00) was recorded from $V_1D_4$ (BRRI dhan33 with 35 days old) treatment combination. On the other hand, lowest number of unfilled grain panicle$^{-1}$ (10.10) was observed in $V_3D_2$ (Chamak 1 with 25 days old) treatment combination.

**Table 4: Effect of variety on yield contributing characters of T. aman rice**

| Treatment | Effective tiller hill$^{-1}$ (No.) | Non-effective tiller hill$^{-1}$ (No.) | Panicle length (cm) | Grain panicle$^{-1}$ (No.) | Filled grain panicle$^{-1}$ (No.) | Unfilled grain panicle$^{-1}$ (No.) |
|---|---|---|---|---|---|---|
| $V_1$ | 7.29 c | 2.35 a | 25.59 b | 136.00 b | 112.60 b | 23.41 a |
| $V_2$ | 8.67 b | 1.68 b | 23.72 c | 107.40 c | 89.83 c | 17.54 b |
| $V_3$ | 9.90 a | 1.20 c | 27.25 a | 141.40 a | 128.00 a | 13.38 c |
| $LSD_{(0.05)}$ | 0.19 | 0.11 | 0.06 | 1.13 | 1.13 | 0.12 |
| CV (%) | 3.06 | 3.94 | 5.49 | 2.58 | 4.75 | 3.83 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $V_1$ - BRRI dhan33, $V_2$ - BRRI dhan62, $V_3$ - Chamak 1

**Table 5: Effect of separated tiller's age on yield contributing characters of T. aman rice**

| Treatment | Effective tiller hill$^{-1}$ (No.) | Non-effective tiller hill$^{-1}$ (No.) | Panicle length (cm) | Grain panicle$^{-1}$ (No.) | Filled grain panicle$^{-1}$ (No.) | Unfilled grain panicle$^{-1}$ (No.) |
|---|---|---|---|---|---|---|
| $D_1$ | 8.75 b | 1.34 c | 25.97 b | 130.30 b | 113.10 b | 17.22 c |
| $D_2$ | 9.64 a | 1.13 d | 26.36 a | 136.50 a | 120.80 a | 15.73 d |
| $D_3$ | 8.50 c | 1.86 b | 25.54 c | 127.20 c | 109.40 c | 17.73 b |
| $D_4$ | 7.59 d | 2.64 a | 24.20 d | 119.00 d | 97.22 d | 21.74 a |
| $LSD_{(0.05)}$ | 0.15 | 0.09 | 0.05 | 1.04 | 1.02 | 0.13 |
| CV (%) | 3.56 | 4.56 | 6.57 | 3.27 | 5.49 | 4.39 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, and $D_4$- 35 days old.

**Table 6: Interaction effect of variety and separated tiller's age on yield contributing characters of T. Aman rice**

| Treatment | Effective tiller hill$^{-1}$ (No.) | Non-effective tiller hill$^{-1}$ (No.) | Panicle length (cm) | Grain panicle$^{-1}$ (No.) | Filled grain panicle$^{-1}$ (No.) | Unfilled grain panicle$^{-1}$ (No.) |
|---|---|---|---|---|---|---|
| $V_1D_1$ | 7.37 g | 1.70 f | 25.91 f | 139.20 c | 117.00 e | 22.22 b |
| $V_1D_2$ | 8.20 e | 1.63 f | 26.02 e | 143.40 b | 122.30 d | 21.10 c |
| $V_1D_3$ | 7.33 g | 2.47 b | 25.33 g | 137.00 d | 114.70 f | 22.30 b |
| $V_1D_4$ | 6.27 h | 3.63 a | 25.11 h | 124.30 f | 96.33 h | 28.00 a |
| $V_2D_1$ | 8.76 d | 1.34 g | 24.97 i | 108.80 h | 92.33 i | 16.45 g |
| $V_2D_2$ | 9.50 c | 1.20 h | 25.00 i | 114.00 g | 98.00 g | 16.00 h |
| $V_2D_3$ | 8.67 d | 1.89 e | 23.64 j | 106.20 i | 88.67 j | 17.50 e |
| $V_2D_4$ | 7.76 f | 2.30 c | 21.25 k | 100.60 j | 80.33 k | 20.22 d |
| $V_3D_1$ | 10.13 b | 1.00 i | 27.03 c | 143.00 b | 130.00 b | 13.00 j |
| $V_3D_2$ | 11.22 a | 0.56 j | 28.07 a | 152.10 a | 142.00 a | 10.10 k |
| $V_3D_3$ | 9.50 c | 1.24 h | 27.64 b | 138.40 c | 125.00 c | 13.40 i |
| $V_3D_4$ | 8.76 d | 2.00 d | 26.25 d | 132.00 e | 115.00 f | 17.00 f |
| $LSD_{(0.05)}$ | 0.15 | 0.09 | 0.05 | 1.04 | 1.02 | 0.13 |
| CV (%) | 3.56 | 4.56 | 6.57 | 3.27 | 5.49 | 4.39 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62, $V_3$- Chamak 1 and $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, $D_4$- 35 days old.

### 4.10 Days to flowering

Different variety had significant effect on days to flowering of T. aman rice (Table 7). Maximum days required to flowering (77.00) was recorded from $V_1$ (BRRI dhan33) treatment. In comparison, minimum days required to flowering (72.00) was observed in $V_2$ (BRRI dhan62) treatment. Endo *et al.* (2000) said that flowering occurred by 78 days after seedling emergence of hybrid.

Days to flowering of T. aman rice was significantly influenced by separated tillers of different age (Table 8). The latest flowering (78.33) was recorded from $D_4$ (35 days old) treatment. On the other hand, the earliest flowering (70.33) was observed in $D_1$ (20 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the days to flowering of T. aman rice (Table 9). The latest flowering (82.00) was recorded from $V_1D_4$ (BRRI dhan33 with 35 days old) treatment combination. On the other hand, the earliest flowering (68.00) was observed in $V_2D_1$ (BRRI dhan62with 20 days old) treatment combination.

### 4.11 Days to maturity

Different variety had significant effect on days to maturity of T. aman rice (Table 7). Maximum days required to maturity (102.50) was recorded from $V_3$ (Chamak 1) treatment. In comparison, minimum days required to maturity (99.00) was observed in V1 (BRRI dhan33) treatment.

Days to maturity of T. aman rice was significantly influenced by separated tillers of different age (Table 8). The latest maturity (104.00) was recorded from $D_4$ (35 days old) treatment. On the other hand, the earliest maturity (97.67) was observed in $D_1$ (20 days old) treatment.

Interaction of variety and separated tiller’s age significantly influenced the days to maturity of T. aman rice (Table 9). The latest maturity (106.00) was recorded from $V_3D_4$ (Chamak 1 with 35 days old) treatment combination. On the other hand, the earliest maturity (95.00) was observed in $V_1D_1$ (BRRI dhan33 with 20 days old) treatment combination.

**Table 7: Effect of variety on days to flowering, days to maturity and weight of 1000 grains (g) of T. Aman rice**

| Treatment | Days to flowering | Days to maturity | Weight of 1000 grain (g) |
|---|---|---|---|
| **$V_1$** | 77.00 a | 99.00 c | 26.34 a |
| **$V_2$** | 72.00 c | 100.50 b | 25.70 b |
| **$V_3$** | 73.50 b | 102.50 a | 23.17 c |
| **$LSD_{(0.05)}$** | 1.49 | 0.90 | 0.15 |
| **CV (%)** | 3.86 | 3.17 | 3.28 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62, $V_3$- Chamak 1

**Table 8: Effect of separated tiller's age on days to flowering, days to maturity and weight of 1000 grains (g) of T. Aman rice**

| Treatment | Days to flowering | Days to maturity | Weight of 1000 grain (g) |
|---|---|---|---|
| **$D_1$** | 70.33 d | 97.67 d | 25.33 b |
| **$D_2$** | 72.67 c | 99.67 c | 26.19 a |
| **$D_3$** | 75.33 b | 101.30 b | 24.91 c |
| **$D_4$** | 78.33 a | 104.00 a | 23.86 d |
| **$LSD_{(0.05)}$** | 1.56 | 0.86 | 0.11 |
| **CV (%)** | 4.58 | 3.48 | 3.92 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, $D_4$- 35 days old.

### 4.12 Weight of 1000 grain (g)

Different variety showed significant effect on weight of 1000 grains of T. aman rice (Table 7). The maximum weight of 1000 grains (26.34 g) was recorded from $V_1$ (BRRI dhan33) treatment. In comparison, the minimum weight of 1000 grains (23.17 g) was observed in $V_3$ (Chamak 1) treatment. The results are in agreement with the findings of Rahman *et al.* (2002) who observed the varied 1000 grains weight among different varieties of rice.

Weight of 1000 grain of T. aman rice was significantly influenced by separated tillers of different age (Table 8). The highest weight of 1000 grains (26.19 g) was recorded from $D_2$ (25 days old) treatment. On the other hand, the lowest weight of 1000 grains (23.86 g) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the weight of 1000 grain of T. aman rice (Table 9). The maximum weight of 1000 grains (28.20 g) was recorded from $V_1D_2$ (BRRI dhan33 with 25 days old) treatment combination. On the other hand, the minimum weight of 1000 grains (22.09 g) was observed in $V_3D_4$ (Chamak 1 with 35 days old) treatment combination.

**Table 9: Interaction effect of variety and separated tillers age on days to flowering, days to maturity and weight of 1000 grains (g) of T. Aman rice**

| Treatment | Days to flowering | Days to maturity | Weight of 1000 grains (g) |
|---|---|---|---|
| $V_1D_1$ | 73.00 e | 95.00 f | 26.75 b |
| $V_1D_2$ | 75.00 d | 98.00 e | 28.20 a |
| $V_1D_3$ | 78.00 b | 100.00 d | 25.97 d |
| $V_1D_4$ | 82.00 a | 103.00 b | 24.43 h |
| $V_2D_1$ | 68.00 h | 98.00 e | 25.67 e |
| $V_2D_2$ | 71.00 fg | 100.00 d | 26.60 c |
| $V_2D_3$ | 73.00 e | 101.00 c | 25.50 f |
| $V_2D_4$ | 76.00 cd | 103.00 b | 25.05 g |
| $V_3D_1$ | 70.00 g | 100.00 d | 23.56 j |
| $V_3D_2$ | 72.00 ef | 101.00 c | 23.78 i |
| $V_3D_3$ | 75.00 d | 103.00 b | 23.27 k |
| $V_3D_4$ | 77.00 bc | 106.00 a | 22.09 l |
| $LSD_{(0.05)}$ | 1.56 | 0.86 | 0.11 |
| CV (%) | 4.58 | 3.48 | 3.92 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62, $V_3$- Chamak 1 and $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, $D_4$- 35 days old.

### 4.13 Grain yield (t $ha^{-1}$)

Different variety showed significant effect on grain yield of T. aman rice (Table 10). The maximum grain yield (4.74 t $ha^{-1}$) was recorded from $V_3$ (Chamak 1) treatment whereas, the minimum grain yield (3.52 t $ha^{-1}$) was observed in $V_2$ (BRRI dhan62) treatment. The results are in agreement with the findings of Islam *et al*. (2009), Bisne *et al.* (2006) and Siddique *et al.* (2002) who stated that grain yield differed significantly among the varieties.

Grain yield of T. aman rice was significantly influenced by separated tillers of different age (Table 11). The highest grain yield (4.48 t $ha^{-1}$) was recorded from $D_2$ (25 days old) treatment. On the other hand, the lowest grain yield (3.96 t $ha^{-1}$) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the grain yield of T. aman rice (Table 12). The maximum grain yield (5.03 t $ha^{-1}$) was recorded from $V_3D_2$ (Chamak 1 with 25 days old) treatment combination while, the minimum grain yield (3.35 t $ha^{-1}$) was observed in $V_2D_1$ (BRRI dhan62 with 20 days old) treatment combination.

### 4.14 Straw yield (t ha$^{-1}$)

Different variety showed significant effect on straw yield of T. aman rice (Table 10). The maximum straw yield (5.09 t ha$^{-1}$) was recorded from $V_1$ (BRRI dhan33) treatment which was statistically identical with $V_2$ (BRRI dhan62) treatment (4.87 t ha$^{-1}$). In comparison, the minimum straw yield (4.47 t ha$^{-1}$) was observed in $V_3$ (Chamak 1) treatment. The results uphold with the findings of Patel (2000) and Om *et al.* (1999) where they concluded that straw yield differed significantly among the varieties.

Straw yield of T. aman rice was significantly influenced by separated tillers of different age (Table 11). The highest straw yield (5.17 t ha$^{-1}$) was recorded from $D_4$ (35 days old) treatment which was statistically similar with $D_3$ (30 days old) treatment (4.91 t ha$^{-1}$). On the other hand, the lowest straw yield (4.45 t ha$^{-1}$) was observed in $D_2$ (25 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the straw yield of T. aman rice (Table 12). The maximum straw yield (5.56 t ha$^{-1}$) was recorded from $V_1D_4$ (BRRI dhan33 with 35 days old)treatment combination. On the other hand, the minimum straw yield (4.14 t ha$^{-1}$) was observed in $V_3D_2$ (Chamak 1 with 25 days old) treatment combination.

**Table 10: Effect of variety on yield and harvest index of T. aman rice**

| Treatment | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| **$V_1$** | 4.44 b | 5.09 a | 9.53 a | 46.60 b |
| **$V_2$** | 3.52 c | 4.87 a | 8.39 c | 49.09 ab |
| **$V_3$** | 4.74 a | 4.47 b | 9.21 b | 51.45 a |
| **$LSD_{(0.05)}$** | 0.02 | 0.29 | 0.28 | 2.62 |
| **CV (%)** | 6.08 | 4.62 | 4.86 | 5.21 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62, $V_3$- Chamak 1

**Table 11: Effect of separated tillers age on yield and harvest index of T. aman rice**

| Treatment | Grain yield ($t\ ha^{-1}$) | Straw yield ($t\ ha^{-1}$) | Biological yield ($t\ ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| **$D_1$** | 4.25 b | 4.71 b | 8.97 | 50.60 b |
| **$D_2$** | 4.48 a | 4.45 c | 8.93 | 52.48 a |
| **$D_3$** | 4.24 b | 4.91 ab | 9.15 | 48.49 c |
| **$D_4$** | 3.96 c | 5.17 a | 9.11 | 44.62 d |
| **$LSD_{(0.05)}$** | 0.02 | 0.25 | NS | 1.84 |
| **CV (%)** | 6.84 | 5.42 | 5.38 | 5.83 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, $D_4$- 35 days old.

### 4.15 Biological yield ($t\ ha^{-1}$)

Different variety showed significant effect on biological yield of T. aman rice (Table 10). The highest biological yield (9.53 $t\ ha^{-1}$) was recorded from $V_1$ (BRRI dhan33) treatment. In comparison, the lowest biological yield (8.39 $t\ ha^{-1}$) was observed in $V_2$ (BRRI dhan62) treatment.

There were no significant differences among the treatments of different age of separated tillers.

Interaction of variety and separated tiller's age significantly influenced the biological yield of T. aman rice (Table 12). The maximum biological yield (9.73 $t\ ha^{-1}$) was recorded from $V_1D_4$ (BRRI dhan33 with 35 days old) treatment combination which was statistically similar with $V_1D_3$ (BRRI dhan33 with 30 days old) treatment combination (9.60 $t\ ha^{-1}$) whereas, the minimum (8.28 $t\ ha^{-1}$) was observed in $V_2D_2$ (BRRI dhan62 with 25 days old) treatment combination.

### 4.16 Harvest index (%)

Different variety showed significant effect on harvest index of T. Aman rice (Table 10). The highest harvest index (51.45 %) was recorded from $V_3$ (Chamak 1) treatment while, the lowest (46.60 %) was observed in $V_1$ (BRRI dhan33) treatment which was statistically similar (49.09 %) $V_2$ (BRRI shan62). Jiang *et al.* (1995) compared 10 varieties for yield components. The yield increase of dwarf over tall varieties mainly resulted from higher harvest index, while the yield increase of hybrid rice over the dwarf varieties was mainly from higher biomass production.

Harvest index of T. aman rice was significantly influenced by separated tillers of different age (Table 11). The maximum harvest index (52.48 %) was recorded from $D_2$ (25 days old) treatment. On the other hand, the minimum harvest index (44.62 %) was observed in $D_4$ (35 days old) treatment.

Interaction of variety and separated tiller's age significantly influenced the harvest index of T. aman rice (Table 12). The highest harvest index (54.85 %) was recorded from $V_3D_2$ (Chamak 1 with 25 days old) treatment combination. On the other hand, the lowest harvest index (42.86 %) was observed in $V_1D_4$ (BRRI dhan33 with 35 days old) treatment combination which was statistically similar with $V_2D_4$ (BRRI dhan62 with 35 days old) treatment combination (42.86 %).

**Table 12: Interaction effect of variety and separated tillers age on yield and harvest index of T. aman rice**

| Treatment | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| **$V_1D_1$** | 4.53 e | 4.89 c-e | 9.42 bc | 48.09 e |
| **$V_1D_2$** | 4.68 d | 4.67 e-g | 9.35 bc | 50.05 cd |
| **$V_1D_3$** | 4.36 f | 5.24 b | 9.60 ab | 45.42 fg |
| **$V_1D_4$** | 4.17 h | 5.56 a | 9.73 a | 42.86 h |
| **$V_2D_1$** | 3.35 l | 4.81 de | 8.16 g | 51.47 bc |
| **$V_2D_2$** | 3.72 i | 4.56 fg | 8.28 fg | 52.54 b |
| **$V_2D_3$** | 3.55 j | 4.97 cd | 8.52 ef | 48.36 de |
| **$V_2D_4$** | 3.46 k | 5.13 bc | 8.59 e | 44.00 gh |
| **$V_3D_1$** | 4.87 b | 4.45 g | 9.32 c | 52.25 b |
| **$V_3D_2$** | 5.03 a | 4.14 h | 9.17 cd | 54.85 a |
| **$V_3D_3$** | 4.82 c | 4.52 g | 9.34 c | 51.71 bc |
| **$V_3D_4$** | 4.24 g | 4.78 d-f | 9.02 d | 47.01 ef |
| **$LSD_{(0.05)}$** | 0.02 | 0.25 | 0.25 | 1.84 |
| **CV (%)** | 6.84 | 5.42 | 5.38 | 5.83 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: $V_1$- BRRI dhan33, $V_2$- BRRI dhan62, $V_3$- Chamak 1 and $D_1$- 20 days old, $D_2$- 25 days old, $D_3$- 30 days old, $D_4$- 35 days old.

# CHAPTER V

# SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Dhaka to study on the propagation efficacy through separated tillers in inbred and hybrid rice of Bangladesh in*aman*season underthe Modhupur Tract (AEZ-28).The experiment was comprised of two sets of treatments viz. A. Variety: (BRRI dhan33 and BRRI 3 dhan62 and Chamak 1) and B. Separation of tiller at: 20 days ($D_1$), 25 days (D2) ,30 days (D3) and 35 days (D4).The experiment was laid out in split-plot design with three replications having variety in the main plots and days of separation in the sub plots.

The data on crop growth characters (plant height, number of tillers hill$^{-1}$and dry weight of plant and time of flowering and maturity were recorded in the field and yield as well as yield contributing characters (number of effective and ineffective tillers hill$^{-1}$, panicle length, number of total grains panicle$^{-1}$, number of filled and unfilled grains panicle$^{-1}$, 1000 grains weight, grain and straw yield, biological yield and harvest index) were recorded after harvest and analyzedusing the MSTAT-C package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

The variety showed significant effect on all the agronomic parameters. It revealed that BRRI dhan33showed significantly taller plant throughout the growing period at 30, 50 and 70 DAT and at harvest and Chamak 1 showed the shorter plant throughout the growing period at 30, 50 and 70 DAT and at harvest. Highest dry matter per hill (43.830g) obtained from Chamak 1 and lowest dry matter weight per hill (34.74 g) obtained from BRRI dhan33.BRRI dhan33 needed longer time for flowering (77 days) as compared to BRRI dhan62 (72 days) which is identical to Chamak 1 (73.50 days).The longest (27.25cm) and shortest (23.72cm) panicle length was obtained from Chamak 1 and BRRI dhan62 respectively. The highest number of total grains, filled grains panicle$^{-1}$ (141.40, 128.00)respectively were obtained from the Chamak 1 and the lower number of total grains, filled grains panicle$^{-1}$ (107.40, 89.83) respectively were obtained from BRRI dhan62. The highest number of unfilled grain panicle$^{-1}$(23.41)obtained from BRRI dhan33 and lowest number of unfilled grain panicle$^{-}$

$^{1}$(13.38) obtained from Chamak 1.The highest weight of 1000-grain (26.34 g) was obtained from the BRRI dhan33 and the lowest weight of 1000-grain (23.17 g) was obtained from Chamak 1. Highest grain yield(4.74 tha$^{-1}$) obtained from Chamak 1 and lowest grain yield (3.52 t ha$^{-1}$) obtained from BRRI dhan62. Highest straw yield and biological yield (5.09 t ha$^{-1}$ and 9.53 t ha$^{-1}$) obtained from BRRI dhan33 and lowest straw yield and biological yield (4.87 t ha$^{-1}$ and 8.39 t ha$^{-1}$) obtained from BRRI dhan62. Highest harvest index (51.55%) obtained from Chamak 1 and lowest harvest index (46.60%) obtained from BRRI dhan33.

Separated tillers at different age showed significant effectthe growth and yield attributes. At harvest, the tallest plant (93.30 cm) was obtained from $D_2$ and the shortest plant height was obtained from $D_4$ (84.39 cm).The highest number of tillers hill$^{-1}$ at harvest was observed in $D_2$ (10.02) and the lowest number of tillers hill$^{-1}$ was observed in $D_4$(8.58).The total dry matter production of plant was significantly influenced by separated tiller age.The maximum dry matter weight per hill at harvest (41.66 g) was recorded from D2whereasminimum dry matter weight per hill at harvest (37.28 g) was observed in $D_{4.}$The highest duration (78.33and 104.00 days respectively) needed for flowering and for maturity from D4andthe lowest duration (70.33and 97.67 days respectively)for flowering and maturity was observed in $D_1$. The highest panicle length (26.36 cm) was observed in $D_2$ and the lowest panicle length (24.20 cm) observed in $D_4$. The highest number of total grains panicle$^{-1}$ (136.50) and highest number of filled grains panicle$^{-1}$ (120.80) was observed in $D_2$ and the lowest number of total grains panicle$^{-1}$ (119.00) and filled grains panicle$^{-1}$ (97.22) was obtained from $D_{4.}$ The weight of 1000-grains was significantly influenced by the separated tiller age. The highest weight of 1000-grain (26.19 g) was obtained from $D_2$ and the lowest weight of 1000-grain (23.86 g) was obtained from $D_4$. The highest grain yield(4.48t ha$^{-1}$) was obtained from the $D_2$ and the lowest grain yield (3.96 t ha$^{-1}$) was observed in $D_4$. Highest straw yield (5.17t ha$^{-1}$) was obtained from the $D_4$ and the lowest straw yield (4.45 t ha$^{-1}$) was observed in $D_{1.}$ Highest harvest index (52.48%) obtained from $D_2$and lowest harvest index obtained from (44.62 %) from $D_{4.}$

Interaction of variety and separated tiller's age significantly influenced the plant height of T.aman rice. The tallest plant at 30 DAT (48.34 cm), 50 DAT (63.72 cm), 70 DAT (103.80 cm) and at harvest (100.60 cm) was recorded from $V_1D_2$ treatment combination. On the other hand, the shortest plant at 30 DAT (31.95 cm), 50 DAT (47.33 cm), 70 DAT (79.69 cm) and at harvest (76.49 cm) was observed in $V_3D_4$treatment combination. The maximum number of tiller per hill at 30 DAT (9.50), 50 DAT (16.50), 70 DAT (14.03) and at harvest (12.40) was recorded from $V_3D_2$ treatment combination. On the other hand, the minimum number of tiller per hill at 30 DAT (6.00), 50 DAT (10.07), 70 DAT (8.40) and at harvest (7.20) was observed in $V_1D_4$treatment combination. Interaction of variety and separated tiller's age significantly influenced the dry matter weight per hill of T. aman rice. The highest dry matter weight per hill at 30 DAT (8.20 g), 50 DAT (25.00 g), 70 DAT (44.33 g) and at harvest (46.90 g) was recorded from $V_3D_2$ treatment combination. On the other hand, the lowest dry matter weight per hill at 30 DAT (4.20 g), 50 DAT (15.00 g), 70 DAT (29.67 g) and at harvest (32.25 g) was observed in $V_1D_4$ treatment combination.The highest number of effective tiller hill$^{-1}$ (11.22) was recorded from $V_3D_2$ treatment combination. On the other hand, the minimum number of effective tiller hill$^{-1}$ (6.27) was observed in treatment combination. The highest number of non-effective tiller hill$^{-1}$ (3.63) was recorded from $V_1D_4$treatment combination. On the other hand, the minimum number of non-effective tiller hill$^{-1}$ (0.56) was observed in $V_3D_2$ treatment combination. The longest panicle(28.07 cm) was recorded from $V_3D_2$ treatment combination.In comparison, the shortest panicle (21.25 cm) was observed in $V_2D_4$treatment combination.The latest flowering (77.00 days) was observed in $V_3D_4$ treatment combination and earliest flowering (68.00 days) was observed in $V_2D_1$ treatment combination. The latest maturity (106.00 days) was observed in $V_3D_4$ treatment combination whereas the earliest maturity (95.00 days) was observed in $V_1D_1$ treatment.The highest weight of 1000-grain (28.20 g) was obtained from $V_1D_2$ treatment combination and the lowest weight of 1000-grain (22.09 g) was obtained from $V_3D_4$treatment combination. The highest grain yield(4.87t ha$^{-1}$) was obtained from the $V_3D_2$treatment combination and the lowest grain yield (3.46 t ha$^{-1}$) was observed in $V_2D_4$treatment combination. Highest straw yield (5.56t ha$^{-1}$) was obtained from the $V_1D_4$treatment combination and the lowest straw yield (4.16 t ha$^{-1}$) was observed in $V_3D_2$treatment combination. Highest biological yield(9.73t ha$^{-1}$) was obtained from the $V_1D_4$treatment combination and the lowest biological yield (8.16 t ha$^{-1}$) was observed in $V_2D_1$treatment combination. Highest harvest index (54.85%) obtained from V3$D_2$treatment combinationand lowest harvest index (42.86%)

obtained from $V_1D_4$treatment combination. However Chamak 1 with 25 days old separated tillers showed higher yield over the other treatment combination.

**Recommendation**

Considering the above observations of the present study further investigation in the following areas may be suggested:

1. Further study may be needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.

2. More number of treatments with different separated tiller's age and other rice varieties may be selected to study such effect.

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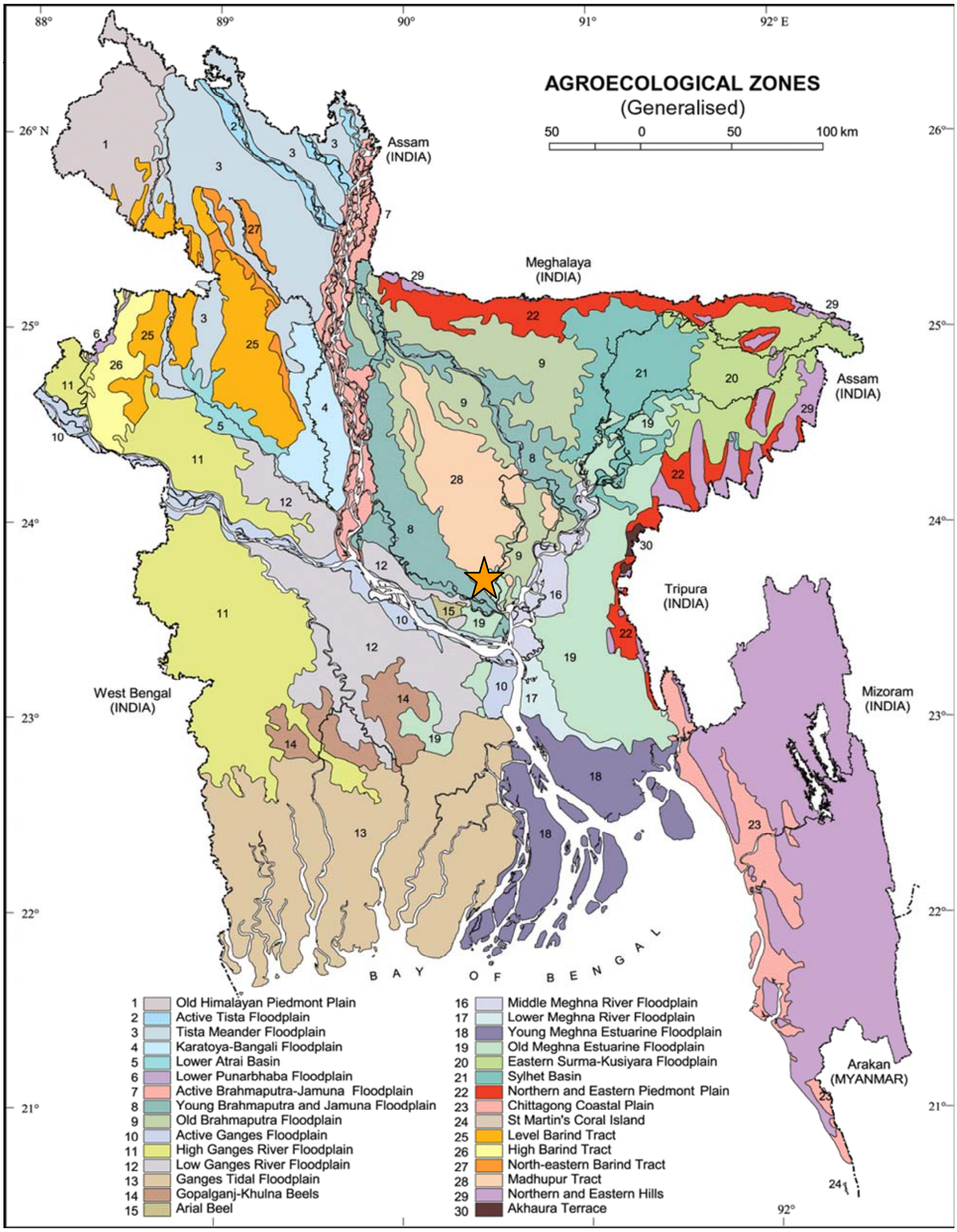
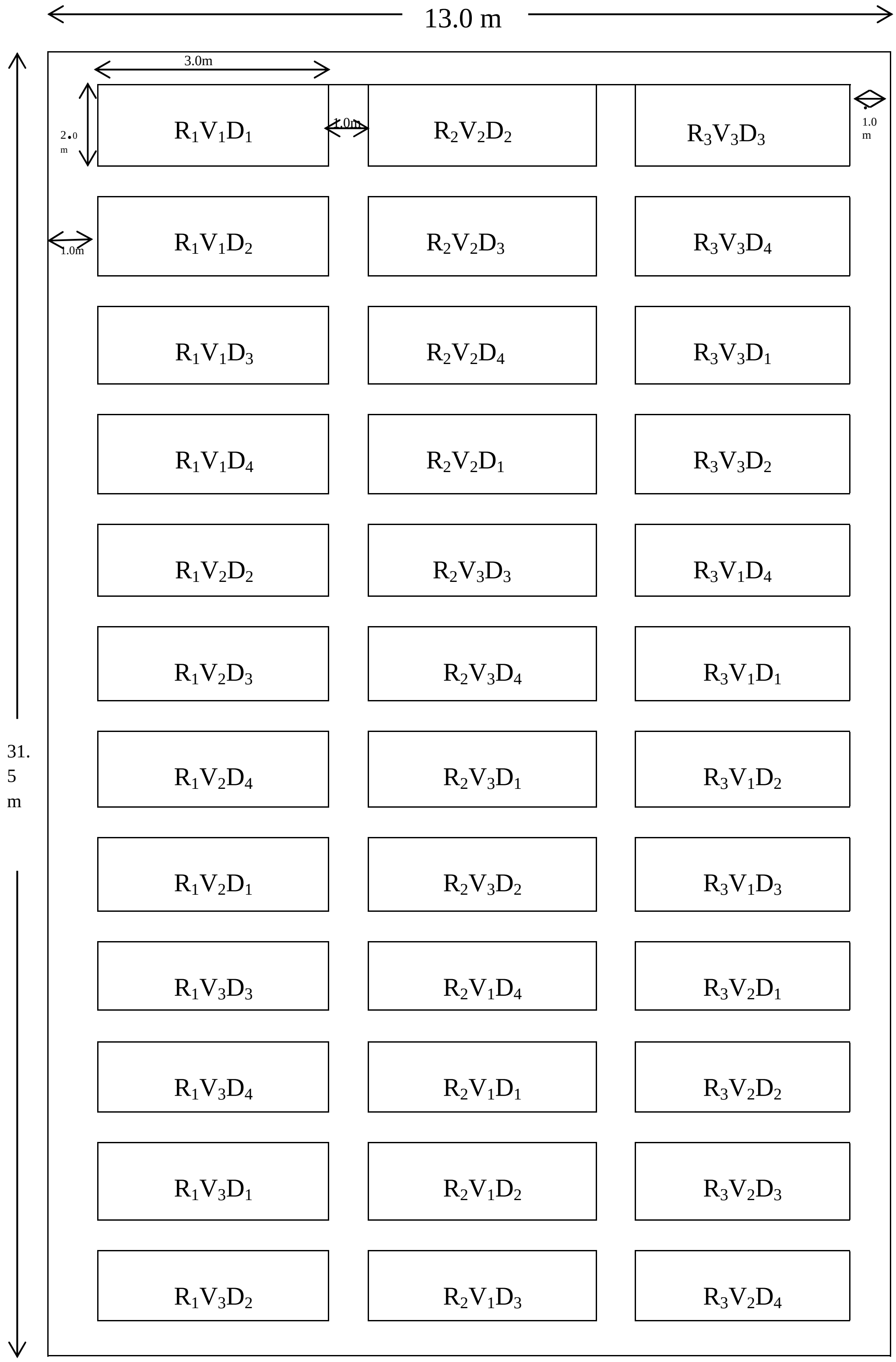
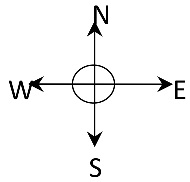
# APPENDICES

## Appendix I. Map showing the experimental sites under study




## The experimental site under study




Plot size: 3.0 m x 2.0 m

Plot spacing: .50 m

Between block: 1.00 m

**Treatments:**

A. **Main plot** (Variety):3 rice varieties

$V_{1:}$ BRRI dhan33

$V_{2}$ :BRRI dhan62

$V_{3:}$ Chamak 1 (Hybrid)

B. **Sub Plot** (Tillers separated at)

1.20 days ($D_{1}$)

2.25 days ($D_{2}$)

3.30 days ($D_{3}$)

4.35 Days ($D_{4}$)

**Appendix III. Monthly record of air temperature, relative humidity, rainfall and sunshine (average) of the experimental site during the period from June to November 2014**

| Month (2014) | Air temperature($^0$C) | | Relative humidity(%) | Rainfall (mm) | Sunshine (hr) |
|---|---|---|---|---|---|
| | Maximum | Minimum | | | |
| June | 35.5 | 23.2 | 78 | 312 | 5.4 |
| July | 36.0 | 24.5 | 83 | 563 | 5.1 |
| August | 36.0 | 23.5 | 81 | 319 | 5.0 |
| September | 34.5 | 24.4 | 81 | 279 | 4.4 |
| October | 26.5 | 19.4 | 81 | 22 | 6.9 |
| November | 25.8 | 16.0 | 78 | 00 | 6.8 |

Source: Bangladesh Meteorological Department (Climate and weather division) Agargoan,Dhaka-1212

**Appendix IV. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka**

**A. Morphological characteristics of the soil of experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Agronomy field ,SAU, Dhaka |
| AEZ | Madhupur field (28) |
| General soil type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |

**B. Physical and chemical properties of the initial soil**

| Characteristics | Value |
|---|---|
| % Sand | 27 |
| % Silt | 43 |
| % Clay | 30 |
| Textural class | Silty-clay |
| pH | 5.4-5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20.00 |
| Exchangeable K (me/100 g soil) | 0.10 |
| Available S (ppm) | 45 |

**Source: SRDI**

**Appendix V. Analysis of variance (mean square) of plant height at different days after transplanting Transplant aman rice**

| Source of variation | Degrees of freedom | Plant height | | | |
|---|---|---|---|---|---|
| | | 30 DAT | 50 DAT | 70 DAT | Harvest |
| Replication | 2 | 1.970 | 41.200 | 149.040 | 22.600 |
| Variety (A) | 2 | 50.408* | 119.856* | 205.300* | 238.898** |
| Error | 4 | 2.805 | 15.578 | 11.556 | 7.721 |
| Age (B) | 3 | 9.672* | 26.023* | 79.191* | 204.436** |
| A×B | 6 | 0.577* | 6.475* | 3.825* | 27.453* |
| Error | 18 | 2.327 | 13.856 | 25.211 | 11.441 |

* and ** indicate significant at 5% and 1% level of probability, respectively

**Appendix VI. Analysis of variance (mean square) of number of tillers hill$^{-1}$ at different days after transplanting of Transplant aman rice**

| Source of variation | Degrees of freedom | Number of tillers hill$^{-1}$ | | | |
|---|---|---|---|---|---|
| | | 30 DAT | 50 DAT | 70 DAT | Harvest |
| Replication | 2 | 0.030 | 0.043 | 0.007 | 0.030 |
| Variety (A) | 2 | 0.362* | 0.533* | 0.645* | 1.423* |
| Error | 4 | 0.033 | 0.029 | 0.029 | 0.064 |
| Age (B) | 3 | 0.040* | 0.213* | 0.971** | 1.924** |
| A×B | 6 | 0.007* | 0.070* | 0.051* | 0.328** |
| Error | 18 | 0.017 | 0.039 | 0.045 | 0.062 |

* and ** indicate significant at 5% and 1% level of probability, respectively

**Appendix VII. Analysis of variance (mean square) of dry matter weight per hill at different days after transplanting of Transplant aman rice**

| Source of variation | Degrees of freedom | Dry matter weight per hill | | | |
|---|---|---|---|---|---|
| | | 30 DAT | 50 DAT | 70 DAT | Harvest |
| Replication | 2 | 29.303 | 7.068 | 10.423 | 73.426 |
| Variety (A) | 2 | 295.013** | 334.201** | 339.464** | 411.886* |
| Error | 4 | 5.004 | 12.507 | 6.986 | 39.192 |
| Age (B) | 3 | 764.271** | 901.727** | 751.181** | 290.585** |
| A×B | 6 | 3.332** | 5.313** | 29.688* | 25.105* |
| Error | 18 | 5.092 | 10.383 | 18.235 | 26.726 |

* and ** indicate significant at 5% and 1% level of probability, respectively

**Appendix VIII. Analysis of variance (mean square) of yield components of Transplant aman rice**

| Source of variation | Degrees of freedom | Effective tiller hill$^{-1}$ | Non-effective tiller hill$^{-1}$ | Panicle length | Grain panicle$^{-1}$ | Filled grain panicle$^{-1}$ | Unfilled grain panicle$^{-1}$ |
|---|---|---|---|---|---|---|---|
| Replication | 2 | 156.208 | 0.239 | 80.330 | 7.238 | 7.313 | 1.646 |
| Variety (A) | 2 | 62.519* | 13.411* | 65.135* | 571.676* | 145.606* | 207.136* |
| Error | 4 | 103.905 | 1.677 | 102.527 | 2.702 | 9.943 | 8.452 |
| Age (B) | 3 | 3.558** | 16.141** | 11.910** | 546.668** | 12.964** | 167.304** |
| A×B | 6 | 3.345* | 0.396* | 2.393** | 8.145** | 3.995** | 0.001** |
| Error | 18 | 20.387 | 0.283 | 48.889 | 0.825 | 0.310 | 6.063 |

* and ** indicate significant at 5% and 1% level of probability, respectively

**Appendix IX. Analysis of variance (mean square) of days to flowering, days to maturity and 1000 grains weight of Transplant aman rice**

| Source of variation | Degrees of freedom | Days to flowering | Days to maturity | Weight of 1000 grain |
|---|---|---|---|---|
| Replication | 2 | 0.035 | 0.014 | 0.422 |
| Variety (A) | 2 | 4.297** | 23.808** | 30.884** |
| Error | 4 | 0.022 | 0.014 | 0.422 |
| Age (B) | 3 | 6.877** | 10.162** | 16.237** |
| A×B | 6 | 0.230* | 0.499** | 0.777* |
| Error | 18 | 0.040 | 0.015 | 0.422 |

* and ** indicate significant at 5% and 1% level of probability, respectively

**Appendix X. Analysis of variance (mean square) of yield and harvest index of Transplant aman rice**

| Source of variation | Degrees of freedom | Grain yield | Straw yield | Biological yield | Harvest index |
|---|---|---|---|---|---|
| Replication | 2 | 149.040 | 0.043 | 10.423 | 7.313 |
| Variety (A) | 2 | 205.300* | 0.533* | 339.464** | 145.606* |
| Error | 4 | 11.556 | 0.029 | 6.986 | 9.943 |
| Age (B) | 3 | 79.191* | 0.213* | 751.181$^{NS}$ | 12.964** |
| A×B | 6 | 3.825* | 0.070* | 29.688* | 3.995** |
| Error | 18 | 25.211 | 0.039 | 18.235 | 0.310 |

* and ** indicate significant at 5% and 1% level of probability, respective.