SUCCESSIVE CULTIVATION OF INBRED AND HYBRID RICE USING CLONAL TILLERS IN BORO SEASON

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Dedicated

To

The Farmers

Who

Feed the Nation and the World

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CERTIFICATE

This is to certify that the thesis entitled **"SUCCESSIVE CULTIVATION OF INBRED AND HYBRID RICE USING CLONAL TILLERS IN BORO SEASON"** submitted to the Faculty of Agriculture**,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGRONOMY,** embodies the results of a piece of *bona fide* research work carried out by **PRETOM KUMAR HORE,** Registration. No. **07-02392** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

Dated:

Dhaka, Bangladesh

(Dr. Parimal Kanti Biswas)
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The Author

SUCCESSIVE CULTIVATION OF INBRED AND HYBRID RICE USING CLONAL TILLERS IN BORO SEASON

ABSTRACT

A field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka from November 2012 to July 2013. Experiment consisted of two factors: Factor A: Variety viz. BRRI dhan29 (V_1) and BRRI hybrid dhan2 (V_2) and Factor B: Planting material viz. Nursery seedlings (N), First generation clonal tillers (C_1) collected from N, Second generation clonal tillers (C_2) collected from C_1, Third generation clonal tillers (C_3) collected from C_2 and Fourth generation clonal tillers (C_4) collected from C_3, following split-plot design with three replications. Hybrid variety BRRI hybrid dhan2 was the early variety (89 days and 123 days, respectively for flowering and maturity) whereas inbred variety BRRI dhan29 (100 days and 130 days, respectively for flowering and maturity) was the late one. The maximum number of total grains, filled grains and unfilled grains panicle^{-1} (212.82, 161.29 and 51.53, respectively) were obtained from BRRI dhan29 while the minimum from BRRI hybrid dhan2 (147.83, 139.31 and 8.52, respectively) but yield was not varied significantly. The maximum weight of 1000-grain (26.50 g) was obtained from hybrid variety and the minimum from the inbred one (19.70 g). The nursery seedlings gave highest grain yield (9.23 t ha^{-1}) that followed by first generation clonal tillers (7.44 t ha^{-1}) and second generation clonal tillers (6.57 t ha^{-1}). The next two successive generation of clonal tillers also produced around 3 t ha^{-1} grain yield. The maximum grain yield (9.6 t ha^{-1}) was observed in nursery seedlings of BRRI hybrid dhan2 that similar to the same planting material of BRRI dhan29 (8.86 t ha^{-1}). The first and second generation clonal tillers of both the varieties produced more than 6 t ha^{-1} grain yield.

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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	Centi-meter
CV	Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
^0C	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
LAI	Leaf area Index
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
t ha^{-1}	Ton per hectare
TSP	Triple Super Phosphate
var.	Variety
Wt.	Weight
Zn	Zinc

Chapter 1
Introduction

CHAPTER 1

INTRODUCTION

Rice is the most important human food, eaten by more than half of the world's population every day. In Asia, where 90% of rice is consumed, ensuring there is enough affordable rice for everyone, or rice security, is equivalent to food security (IRRI, 2013). It is the grain with the second-highest worldwide production, after corn. Bangladesh is the fourth highest rice (*Oryza sativa* L.) producing country in the world (FAO, 2013).

Rice is the staple food of about 150 million people of Bangladesh. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country. Almost all of the 13 million farm families of the country grow rice. Rice is grown on about 11.56 million hectares which has remained almost stable over the past three decades. About 76.71% of the total cropped area is planted to rice in the year 2012-13. 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, 2002).

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).

Rice is extensively grown in three seasons of Bangladesh viz., *Aus*, *Aman* and *Boro,* which covers 80% of the total cultivable area (AIS, 2011). *Aman* rice hold the major share of acreage but *boro* rice hold major share of production. In Bangladesh, rice yield level is far below than that of many other countries like China, Japan, Korea and Egypt where yield is 7.5, 5.9, 7.3 and 7.5 t ha^{-1}, respectively (FAO, 2009).

Among different groups of rice, *boro* season covers about 43.57% of total rice area which contributes 61.33% of the total rice production (BBS, 2008), 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 *boro* rice (Mamun *et al.*, 2012). Use of rice clonal tillers might be an option for maximum yield and reduce seed cost especially hybrid rice (Debnath, 2010).

Hossain *et al.* (2003) reported that hybrid rice has the potentiality to increase 15-20% yield but it costs about 19% higher compared to inbred rice of which seed cost is the prime issue. Ahmed (2006) reported that a single plant of rice has the ability to produce about 74 tillers in SRI system. The potentiality of inbred clonal tillers is reported by many researchers (Biswas, 2001; Biswas and Saloke, 2001; Parveen *et al.*, 2008; Hossain *et al.*, 2011; Sarkar *et al.*, 2011; Alim and Sheuly, 2012). As hybrid rice seeds are costly and scarce, successful use of their clonal tillers can help to reduce seed cost as well as expansion of hybrid rice cultivation area in Bangladesh to feed its ever increasing population.

The price of hybrid seed is much higher compared to inbred seed. Our poor farmers cannot purchase this seed. If we can provide clonal tillers, it can reduce the seed rate.

A rice plant has around 15 tillers hill^{-1} at 30 days after transplanting. Hence around 15 times more area can be transplanted by uprooting; splitting and replanting the tiller that can save seed cost. As well as in natural calamities any damaging area of field can be recoped using this clonal transplantation technique. It is possible to transplant the separated tillers in the prepared main field those have the potentiality to produce yield as main crop (Debnath, 2010). The detached tillers can be used as seedling, especially during scarcity of seedlings after flood or any other natural hazards (Biswas, 2001).

The cultivation of hybrid rice varieties are gradually increasing in Bangladesh to cope with the additional demand of cereal grains. Possibility of splitting tillers from the mother plant by complete uprooting from the field and their multiplication by retransplanting with 1-2 clonal tillers per hill is now a proven technology to explore the expansion on hybrid rice cultivation in Bangladesh.

The transplanting of rice by first generation clonal tillers has been practicing in some parts of Bangladesh during *aman* season. However, information exists on the potentiality of using clonal tillers of successive generations of hybrid and inbred *boro* rice varieties are scarce. Thus a detailed study with an inbred and a hybrid variety and their clonal tillers of successive generations was undertaken with the following objectives:

- ❖ To compare the yield performance of inbred and hybrid clonal tillers and nursery seedlings of *boro* rice.
- ❖ To find out the potentiality of clonal tillers of successive generations for optimum growth and yield of *boro* rice.
- ❖ To explore the possibility of cultivating rice using their clonal tillers of continuous generations.

Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

The growth and development of rice may be varying due to the use of clonal tillers from nursery seedling. Nursery seedling and clonal 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 clonal 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

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 clonal tillers. The experiment consisted of two levels of treatments viz. planting material (Mother plant and clonal 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 clonal tillers of first generation.

Alim and Sheuly (2012) reported that the highest grain growth parameters like number of panicles hill^{-1}, dry weight panicle^{-1}, 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 15th December to 30th 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 15th December and 30th 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 splitted tillers transplantation was obtained from 30th January transplanting. Tillers separation could be an alternative source of seedling during seedling scarcity.

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.

Debnath (2010) 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 clonal tillers. The experiment consisted of two levels of treatments viz. planting material (Mother plant and clonal tillers of first generation) and variety (BRRI dhan29, ACI 1, BRAC Aloron, Sonarbangla-6, Hira 5 and BRRI hybrid dhan2) and reported that the mother plant showed the better performance compared to clonal tillers. The higher grain yield (6.85 t ha^{-1}) and straw yield (6.45 t ha^{-1}) was obtained from mother plant and the lower grain yield (4.47 t ha^{-1}) and straw yield (4.59 t ha^{-1}) was obtained from clonal tillers.

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 clonal tillers of different ages. They found the highest grain yield (5.10 t ha^{-1}) from the clonal 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 clonal tiller showed superior performance. Hybrid variety transplanted with 25 days old clonal 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 clonal tillers needed the longest duration and sprouted seeds required the shortest duration to flower and mature.

In South and Southeast Asia, floodwater may remain for more than a month during the period of *Aman* rice grown with maximum submergence reaching to about 50-400 cm in depth (Mazaredo *et al.*, 1996). Comparative submergence by flash floods has been reported as a major production constraint in about 25 million ha of low land in this region. Although rice is adapted to lowland, complete submergence for more than 2-3 days killed most of the rice cultivars (Mishara *et al.*, 1996). This type of damage would be rather serious for dwarf and semi dwarf varieties, which cause total crop losses. Horizontal expansion of *aman* rice area is not possible due to high human population pressure on land. Therefore, it is an urgent need of the time to increase rice production through increasing the yield of *aman* rice at farmers level using inbreed and hybrid varieties (Alauddin, 2004). There are different methods of planting such as direct seelings (haphazard and line sowing), transplanting of seedlings (haphazard and line sowing), transplanting of clonal tillers. The vegetative propagation of using clonal tillers separated from previously established transplanted crop was beneficial for restoration of a damaged crop of *aman* rice (Biswas, 2001) where maximum number of filled grain panicle^{-1} (173.67), the highest grain yield (4.96 t ha^{-1}) was obtained with the clonal tillers followed by nursery seedlings the highest harvest index (49.04%) was found from the clonal tillers those were statistically similar with nursery seedlings.

AEF (2006) stated that planting 2 clonal tillers hill^{-1} showed significantly higher grain yield (4.24 t ha^{-1}) compared to two other plant densities along with nursery seedlings. The higher yield in clonal tillers compared to nursery seedlings might be due to the higher filled grains panicle^{-1} which was also reported by Sharma (1995), Reddy and Ghosh (1987) and Biswas *et al.* (1989). Clonal tillers gave significantly higher number of filled grains panicle^{-1} than nursery seedlings irrespective of variety.

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. Sonarbangla-1 appeared to be tolerant to tiller separation and separation should be done between 20 to 40 DAT without hampering grain yield.

Biswas and Salokhe (2002) conducted an experiment in a Bangkok clay soil to investigate the influence of N rate, light intensity, tiller separation, and plant density on the yield and yield attributes of parent and clone plants of transplanted rice. Application of 75 kg N and 120 kg N ha^{-1} resulted in similar yields. The 50% reduction of light intensity reduced grain yield to 43.5% compared with normal light intensity. Separation of more than 4 tillers hill^{-1} had an adverse effect on the mother crop. Nitrogen fertilizer had no influence on grain weight, per cent filled grains, and panicle size of the mother crop, but increased N produced a higher number of tillers. Reduction of light intensity and higher tiller separation adversely affected grain weight and panicle number. Variation of N rate and light intensity of the mother crop had no influence on grain yield, grain weight, and panicle number of clonal tillers transplanted with 75 kg N ha^{-1} and with normal light intensity. The clonal tillers produced higher yields than the nursery seedlings, and transplanting 2 clonal tillers hill^{-1} resulted in almost the same yield as 3 clonal tillers and 4 clonal tillers hill^{-1}. A single clonal tiller had the capacity to produce 4.5 t ha^{-1} grain yields. Yield components of clonal tillers, i. e., panicle number and grain weight, had no influence due to variations of N and light intensity of the mother crop, but higher densities of clonal tillers transplanted hill^{-1} gave lower panicle number and grain weight.

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 clonal 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 clonal 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 clonal tillers than the nursery seedling.

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. Panidhan 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 clonal 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 clonal 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.

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.

Sharma (1992, 1994 and 1995) and Roy *et al.* (1990) had shown better performance of clonal tillers of direct seeded rice over nursery seedlings in terms of growth and yield, and hence shown the possibility to make use of clonal 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 clonal 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 clonal 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}.

Mahadevappa *et al.* (1989) reported that the advantage of vegetative propagation were i) need for fresh hybrid seed was reduced; ii) duration of vegetatively propagated crop was usually less than that of main crop; and iii) crop establishment savings were realized. Vegetative propagation method included ratooning, stubble planting and tiller separation and planting.

Shahidullah *et al.* (1989) conducted an experiment on retransplantation with 5 different transplanting dates and 5 transplant aman varieties. Fifty percent of each plot were disturbed by separating 50% of the total tillers hill^{-1} and subsequently transplanted 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 damaged transplant *aman* field could be recovered successfully.

BRRI (1988) conducted an experiment with splitting of tillers and found that tillers could be separated at 30-40 days after transplanting and grain yield increased with the number of tillers hill^{-1} from 2 to 3.

Uprooting of clonal tillers up to 40 days of growth from a transplanted crop (Reddy and Ghosh, 1987) 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.

Tsai (1984) examined the process of tiller formation and relationship with other organs dressed that whole process could be divided into bud primordium formation, primordium differentiation bud development and bud emergence. Of these four steps, only 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 (1962) suggested that both hybrid and pure variety produced higher yield when propagated vegetatively and exploitation of hybrid vigor might be possible thought the technique of clonal propagation.

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 successful production of any crop depends on manipulation of basic ingredients of crop culture. The variety of crop is one of the basic ingredients. Varieation 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 varietial 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 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December 2012 to July 2013. This chapter deals with a brief description on experimental site, climate, soil, 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 (Anon., 2004).

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 area had sub tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix III.

3.1.4 Soil

The soil of the experimental site 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 0.82%. The experimental area was flat having available irrigation and drainage system and above flood level.

3.2 Details of the Experiment

3.2.1 Treatments

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

A. Variety (2):

1. BRRI dhan29 (inbred)-V_1 and
2. BRRI hybrid dhan2 (hybrid)-V_2

B. Planting material (5):

1. Nursery seedlings (N)
2. First generation clonal tillers (C_1) collected from N
3. Second generation clonal tillers (C_2) collected from C_1
4. Third generation clonal tillers (C_3) collected from C_2
5. Fourth generation clonal tillers (C_4) collected from C_3

3.2.2 Experimental design

The experiment was laid in a split-plot design with three replications having variety in the main plots and planting materials in the sub-plots. There were 10 treatment combinations. The total numbers of unit plots were 30. The size of unit plot was 5.0 m by 2.0 m. The distances between plot to plot and replication to replication were 1 m and 0.5 m respectively. The layout of the experiment has been shown in Appendix II.

3.3 Planting material

Mother plants and clonal tillers of different generations were used as planting material.

3.3.1 Nursery seedlings

The plant that generated directly from the seed remain intact are considered as nursery seedlings or mother plants. Nursery seedlings provided clonal tillers.

3.3.2 Clonal tillers

Clonal tillers are those tillers which was seperated from nursery seedlings or mother plants and was retransplanted as a new material. It is possible to transplant the collected tillers (from the undamaged field) in the prepared main field those have the potentiality to produce yield as a main crop.

3.4 Description of Variety

Two rice varieties (BRRI dhan29 and BRRI hybrid dhan2) were used as variety.

3.4.1 BRRI dhan29

BRRI dhan29, a high yielding variety of *boro* rice was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. The pedigree line (BR802-118-4-2) of the variety was derived from a cross (BG902/BR51-46-5) and was released in 1994. It takes about 155-160 days to mature. It attains a plant height or 95-100 cm at maturity and the flag leaf remains green and erect. The grains are medium slender with light golden husks and kernels are white in color. This genotype is known for its bold grains, with a 1000-grain weight of about 29 g, grain length of 5.9 mm, and grain width of 2.5 mm. The cultivar gives a grain yield of 7.5 t ha^{-1}. The milled rice is medium fine and white. It is resistant to damping off and moderately resistant to blast and bacterial blight in terms of yield, this is the best variety so far released by BRRI (Anon., 2003).

3.4.2 BRRI hybrid dhan2

BRRI hybrid dhan2, a hybrid variety suitable for the *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. The pedigree line of the variety is BR10H, and NSB released the variety for mass cultivation in Dhaka, Comilla, Jessore and Rajshahi in 2008. It takes about 140 to145 days to mature. It attains a plant height of 105 cm at maturity and the flag leaf remains green and erect. The grains are medium bold with light golden husks and kernels are white in color. This genotype is known for its medium bold grains and the cultivar gives an average grain yield of 8.5 t ha^{-1}.

3.5 Crop Management

3.5.1 Raising of Seedling

3.5.1.1 Seed collection

Seeds of BRRI dhan29 and the hybrid rice seed BRRI hybrid dhan2 were collected from Genetic Resource and Seed Division, BRRI, Joydebpur, Gazipur, Bangladesh.

3.5.1.2 Seed sprouting

Healthy seeds were selected by following specific gravity method. Seeds were immersed into water in a bucket for 24 hours. These were then taken out of water and kept tightly in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.5.1.3 Preparation of seedling nursery

A common procedure was followed in raising of seedlings in the seedbed. 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.

3.5.1.4 Seed sowing

Seeds were sown on the seedbed on November 12, 2013 for raising nursery seedlings.

3.5.2 Preparation of experimental land

The experimental field was first opened on December 01, 2012 with the help of a tractor drawn disc plough, later on December 13, 2012 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 December 14, 2012 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.

3.5.3 Fertilizer application

The experimental area specified for nursery seedlings and first generation clonal tillers were fertilized with 120, 80, 80, 20 and 5 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 final land preparation. Urea was top-dressed in three equal installments. 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 clonal tiller plots, the same dose and trend of fertilizers applicating as above was fertilized but basal application was done only before transplanting of clonal tillers in respective plots and in respective time.

3.5.4 Uprooting and transplanting of seedlings

The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. The 30 days old nursery seedlings were uprooted carefully on December 15, 2012 and were kept in soft mud in shade**.** The seedlings were then transplanted with 25 cm × 15 cm spacing on the well-puddled plots. Two sub-plots in each main plot was transplanted with nursery seedlings of which the entire hills of one plot was uprooted and splitted for using as first generation clonal tilletrs. In each plot, there were 8 rows, each row containing 33 hills of rice seedlings.

3.5.5 Clonal tiller separation and transplanting

The entire hills of one plot of each variety and in each replication those assigned for clonal tiller treatment (C_1) were uprooted at 45 DAT and tillers were separated having roots in each clonal tiller. The separated tillers were then retransplanted in two new plots variety^{-1} and replication^{-1} as per treatment having one clonal tiller per hill on 30 January, 2013. Second generation (C_2) clonal tillers were separated at 30 DAT from the C_1 plants and the separated tillers were then retransplanted following the earlier methods and as per treatment having one clonal tiller hill^{-1} on 2 March, 2013. Third generation (C_3) clonal tillers were separated as earlier at 25 DAT from the C_2 plants and the separated tillers were then retransplanted as per treatment having one clonal tiller per hill on 27 March, 2013. Lastly the fourth generation (C_4) clonal tillers were separated at 20 DAT from the C_3 plants and the separated tillers were then retransplanted as per treatment having one clonal tiller hill^{-1} on 17 April, 2013. Before retransplanting, the individual plots were spaded properly for well puddle and an extra dose of urea (one third of basal) was spreaded after seven days of retransplanting on uprooted plots and entire basal dose for newly transplanted plots.

3.5.6 Intercultural operations

3.5.6.1 Thinning and gap filling

After one week of each transplantation, a minor gap filling was done as and where necessary using the seedling or separated clonal tillers from the previous source as per treatment. No thinning was done for any treatment.

3.5.6.2 Weeding

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

3.5.6.3 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 upto 15 days before harvesting.

3.5.6.4 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 watching was done properly, especially during morning and afternoon.

3.5.6.5 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.

3.5.6.6 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting of BRRI dhan29 was done on May 12; Jun 3; Jun 14; Jul 1, 2013 for nursery seedlings (N) and first generation clonal tiller (C_1); second generation clonal tiller (C_2); third generation clonal tiller (C_3) and fourth generation clonal tiller (C_4), respectively. Ten pre-selected hills plot^{-1} from which different crop growth data were collected and 5 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 using by pedal thresher. The grains were cleaned and sun dried to moisture content of about 12%. Straw was also sun dried properly. Finally grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}.

3.5.7 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 25 days interval from 30 DAT and at harvest
ii. Number of tillers hill^{-1} at 25 days interval from 30 DAT and at harvest
iii. Number of leaves hill^{-1} at 25 days interval from 30 DAT and at harvest
iv. Leaf area index at 25 days interval from 30 DAT and at harvest
v. Length of root at 25 days interval from 30 DAT and at harvest
vi. Dry weight of plant at 25 days interval from 30 DAT and at harvest
vii. Time of flowering and maturity

B. Yield and other crop characters

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

3.5.8 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study is given below:

A. Crop growth characters

i. Plant height (cm)

Plant height was measured at 30, 55, 80 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, 55, 80 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. Number of leaves hill^{-1}

Number of leaves hiil^{-1} were counted at 30, 55, 80 DAT and at harvest from five randomly pre-selected hills and finally averaged as their number hill^{-1} basis.

iv. Leaf Area Index (LAI)

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

v. Length of root (cm)

Length of root was taken at 30, 55, 80 DAT and at harvest from two randomly selected hills were uprooted carefully and then washed with fresh water and averaged as their number hill^{-1} basis.

vi. Dry weight of plant (g)

The 2 hills plot^{-1} was uprooted from second line and oven dried (sub-sample) until a constant level from which the weights of above ground dry matter were recorded.

vii. Time of flowering

Time of flowering was measured when about 50% panicles of the plants within a plot emerged. 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 5 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 5 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. Rachis branches panicle^{-1} (no.)

Primary branches of panicle that contains a number of spikelet termed as rachis branches. The number of total rachis branches present on ten panicles were recorded and finally averaged.

v. 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).

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

3.5.9 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 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

Results obtained from the present study regarding the effects of nursery seedlings and clonal tillers of inbred and hybrid rice and their interactions on the yield and yield components have been presented, discussed and compared in this chapter. The analytical results have been presented in Tables 1 through 20, Figures 1 through 24 and Appendices IV through XI. A general view of the experimental plots and treatments has been shown in plates 1 through 6.

4.1 Crop growth characters

4.1.1 Plant height at different days after transplantation

4.1.1.1 Effect of variety

The plant height of *boro* rice was significantly influenced by different varieties at 30, 55 and 80 days after transplanting (DAT) and at harvest (Appendix IV and Table 1). The result revealed that at 30 DAT, the inbred variety BRRI dhan29 produced taller plant (57.64 cm) and the hybrid variety BRRI hybrid dhan2 gave the shorter plant (50.06 cm) and the same trend of plant height for inbred variety over hybrid variety was obtained at 55 and 80 DAT and at harvest. In the initial stage of growth, the increase of plant height was very slow and the crop remained in vegetative stage. The rapid increase of plant height was observed from 30 to 80 DAT. After reaching the maximum vegetative stage, the growth of plant became slow. The inbred variety was about 14% taller at harvest compared to the hybrid variety. Debnath (2010) observed taller plant in BRRI dhan29 and shorter plant in BRRI hybrid dhan2 and Ahmed (2006) also observed taller plant in BRRI dhan29 and shorter plant height in hybrid variety. This finding disagreed with Main (2006) who observed highest plant height in hybrid variety and the lowest in inbred variety.

Table 1. Effect of variety on plant height at different growth duration of inbred and hybrid *boro* rice

Treatments	Plant height (cm) at different DAT			
	30	**55**	**80**	**At harvest**
V_1 (BRRI dhan29)	57.64a	77.71a	87.53a	96.31a
V_2 (BRRI hybrid dhan2)	50.06b	66.52b	75.60b	84.75b
LSD $_{(0.05)}$	1.257	2.170	2.586	4.143
CV (%)	1.48	1.92	2.02	2.91

4.1.1.2 Effect of planting material

Significant variation of plant height was found due to different planting material in all the studied durations (Appendix IV and Table 2). The results revealed that at 30 DAT, the tallest plant (69.78cm) was obtained from the C_4 which was statistically similar with the C_2 (65.87 cm) and C_3 (67.24 cm) and the shortest plant (22.42 cm) was obtained from the nursery seedlings. The tallest plant (94.55 cm) was recorded at 55 DAT from C_2 followed by C_4 (81.73 cm) and C_3 (78.40 cm) and the shortest plant was obtained from the nursery seedlings (31.05 cm). At 80 DAT the tallest plant was observed from C_1 (98.00 cm) which was statistically similar with C_2 (93.20 cm) and the shortest plant was obtained from the nursery seedlings (53.58 cm). At harvest, the tallest plant (98.95 cm) was obtained from C_1, which was statistically similar with the nursery seedlings (98.11 cm) and the shortest plant was obtained from C_3 (77.20 cm). Ahmed (2006) also observed that the plant height at initial stage to before harvesting is higher in clonal tillers compared to nursery seedlings. The initial establishment of the transplanted crop depended on seedling vigor and in general, the plants from vegetatively propagated tillers established better as the initial advantage in their height and dry weight resulting in better growth and faster acclimatization to the soil (Sharma, 1995).

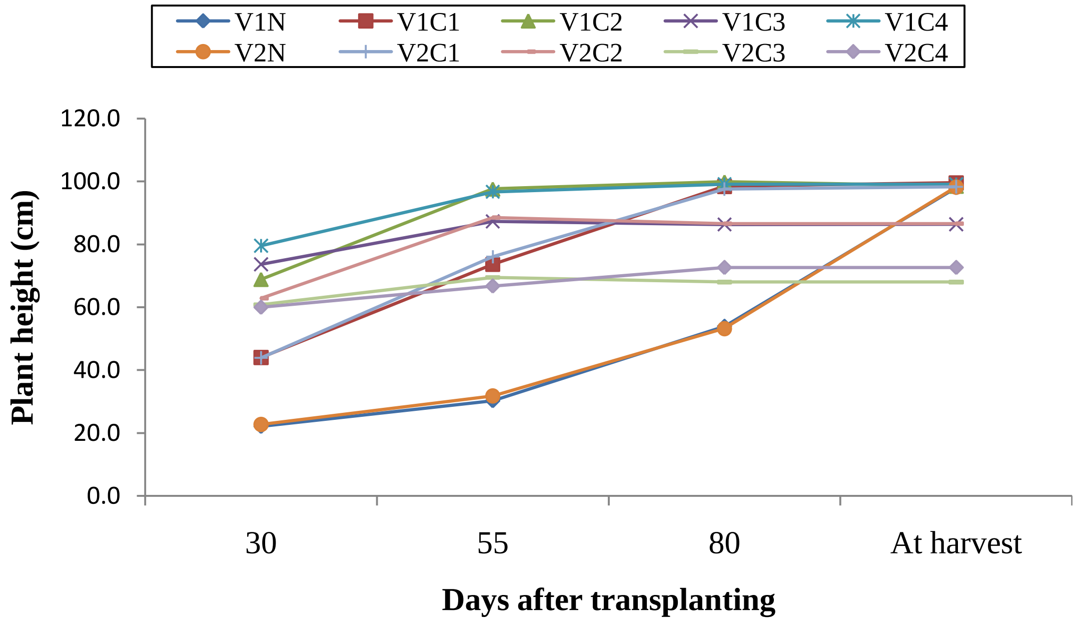
Table 2. Effect of planting material on plant height at different growth duration of inbred and hybrid *boro* rice

Treatments	Plant height (cm) at different DAT			
	30	55	80	At harvest
N	22.42c	31.05d	53.58d	98.11a
C_1	43.94b	74.84c	98.00a	98.95a
C_2	65.87a	94.55a	93.20a	92.52b
C_3	67.24a	78.40bc	77.18c	77.20d
C_4	69.78a	81.73b	85.88b	85.88c
LSD $_{(0.05)}$	4.786	4.301	5.766	4.432
CV (%)	7.28	4.88	5.78	4.01

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

4.1.1.3 Interaction effect of variety and planting material

Significant interaction effect between the variety and planting material on plant height was observed at 30, 55 and 80 DAT and at harvest (Appendix IV and Figure 1). The results revealed that at 30 DAT, the tallest plant (79.56cm) was obtained from the C_4 of the inbred variety (V_1) which was statistically similar with the C_3 of the inbred variety V_1 (73.67 cm) and the shortest plant (22.11 cm) was obtained from the nursery seedlings of the inbred variety (V_1) which was statistically similar with the nursery seedlings (22.74) of the hybrid variety (V_2). The tallest plant (100.6 cm) was recorded at 55 DAT from C_2 of the inbred variety (V_1) which was statistically similar with the C_4 (96.76) of the inbred variety (V_1) and the shortest plant (30.27 cm) was obtained from the nursery seedlings of the inbred variety (V_1) which was statistically similar with the nursery seedlings (31.83) of the hybrid variety (V_2). At 80 DAT the tallest plant was observed from C_2 (99.87 cm) of the inbred variety (V_1) which was statistically similar with C_4 (99.13) and C_1 (98.40 cm) of the inbred variety (V_1) and the shortest plant (53.93 cm) was obtained from the nursery seedlings of the inbred variety (V_1) which was statistically similar with the nursery seedlings (53.23) of the hybrid variety (V_2). At harvest, the tallest plant (99.57 cm) was obtained from C_1 of the inbred variety (V_1), which was statistically similar with C_4 (99.13 cm), C_2 (98.50), and nursery seedlings (97.98 cm) of the inbred variety (V_1), and the shortest plant was obtained from C_3 (68.03 cm) of the hybrid variety (V_2) which was statistically similar with C_4 (72.63 cm) of the hybrid variety (V_2). The higher plant height of clonal tillers at early growth stage might be due to the combination of the initial higher weight and the force to quick completion of the life cycle of the clonally propagated crop (Ahmed 2006).



V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2, N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 1. Interaction effect of variety and planting material on plant height at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 6.783, 6.094, 8.160 and 6.278 at 30, 55 and 80 DAT and at harvest, respectively)

4.1.2 Number of tillers hill^{-1} at different days after transplantation

4.1.2.1 Effect of variety

The production of total number of tillers hill^{-1} of *boro* rice was statistically insignificant and was not influenced by different varieties (Appendix V and Table 3). Numerically higher number of tillers hill^{-1} at 30, 55, 80 DAT and at harvest was observed in the inbred variety V_1 (BRRI dhan29) and the lower number of tillers hill^{-1} was obtained from the hybrid variety V_2 (BRRI hybrid dhan2). Ashrafuzzaman (2006) observed that varieties differed significantly in respect of varietal variation. On thr other hand it was observed by Debnath (2010) that BRRI dhan29 produced higher number of tillers hill^{-1} compared to BRRI hybrid dhan2 insignificantly.

Table 3. Effect of variety on number of tillers hill^{-1} at different growth duration of inbred and hybrid *boro* rice

Treatments	Tiller number hill^{-1} at different DAT			
	30	55	80	At harvest
V_1 (BRRI dhan29)	5.76	8.23	9.92	9.02
V_2 (BRRI hybrid dhan2)	4.79	7.11	8.79	8.37
LSD $_{(0.05)}$	NS	NS	NS	NS
CV (%)	41.14	17.17	26.97	13.37

NS = Not significant

4.1.2.2 Effect of planting material

The total number of tillers hill^{-1} was significantly influenced by different planting material at 30, 55 and 80 DAT but insignificant at harvest (Appendix V and Table 4). At 30 DAT the highest numbers of tillers hill^{-1} was observed in C_1 (6.37) which was statistically similar with C_4 (6.23), C_2 (5.92) and C_3 (5.70) followed by nursery seedlings (2.17). The highest number of tillers hill^{-1} (9.87) at 55 DAT was observed in C_1 which was statistically similar with C_2 (8.70) and C_4 (8.30) and the lowest numbers of tillers hill^{-1} was obtained from nursery seedlings (4.43). At 80 DAT highest numbers of tillers hill^{-1} was observed in nursery seedlings (12.57) and the lowest numbers of tillers hill^{-1} was obtained from C_3 (8.20) which was statistically similar with all other clonal tiller treatments. Main (2006) observed significant difference of tillers number hill^{-1} at 45 and 60 DAT and insignificant difference of tillers number hill^{-1} at harvest. Ahmed (2006) also observed insignificant difference of tillers number hill^{-1} at harvest among different planting material of rice.

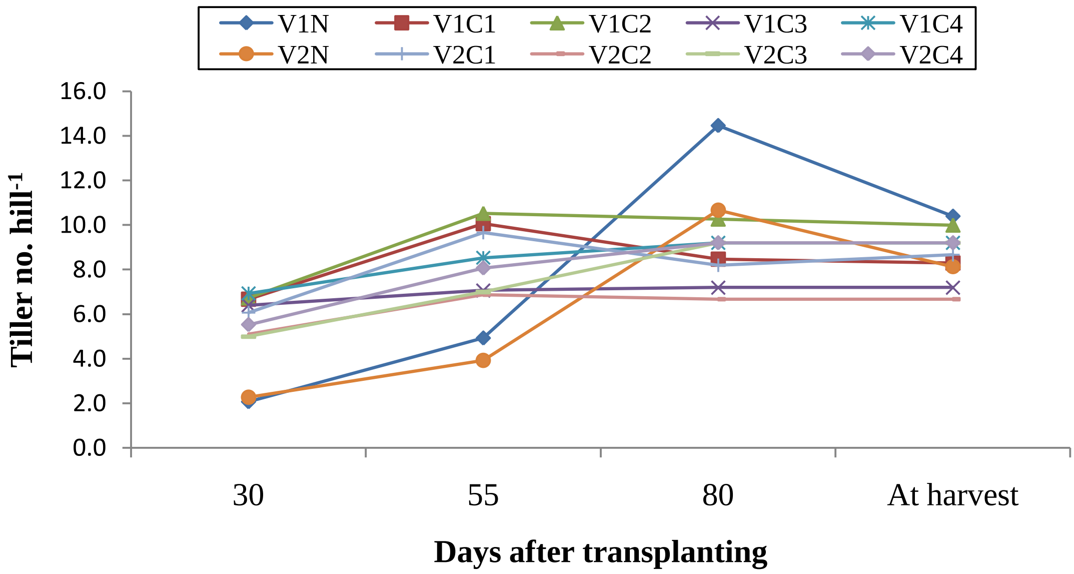
Table 4. Effect of planting material on number of tillers hill^{-1} at different growth duration of inbred and hybrid *boro* rice

Treatments	Tiller number hill^{-1} at different DAT			
	30	55	80	At harvest
N	2.17b	4.43c	12.57a	9.27
C_1	6.37a	9.87a	8.33b	8.48
C_2	5.92a	8.70ab	8.47b	8.33
C_3	5.70a	7.03b	8.20b	8.20
C_4	6.23a	8.30ab	9.20b	9.20
LSD $_{(0.05)}$	1.543	2.001	1.686	NS
CV (%)	23.90	21.35	14.78	13.43

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3, NS = Not significant

4.1.2.3 Interaction effect of variety and planting material

Significant interaction effect between the variety and planting material on number of tillers hill^{-1} was observed at 30, 55 and 80 DAT and at harvest (Appendix V and Figure 2). The results revealed that at 30 DAT, the highest numbers of tillers hill^{-1} was observed in C_4 (6.93) of the inbred variety (V_1) which was statistically similar with C_2 (6.73), C_1 (6.66) and C_3 (6.40) of the inbred variety (V_1) and C_1 (6.06), C_4 (5.53), C_2 (5.10) and C_3 (5.00) of the hybrid variety (V_2) followed by nursery seedlings (2.26) of the hybrid variety (V_2) which was statistically similar with the nursery seedlings (2.06) of the inbred variety (V_1). At 55 DAT highest number of tillers hill^{-1} were obtained from C_2 (10.53) of the inbred variety (V_1) which was statistically similar with C_1 (10.07), C_4 (8.53), of the inbred variety (V_1) and C_1 (9.66), C_4 (8.06) of the hybrid variety (V_2) followed by nursery seedlings (4.93) of the inbred variety (V_1) which was statistically similar with the nursery seedlings (3.93) of the hybrid variety (V_2). Highest numbers of tiller hill^{-1} at 80 DAT was observed in nursery seedlings (14.47) of the inbred variety (V_1) and the lowest numbers of tiller hill^{-1} was obtained from C_2 (6.66) of the hybrid variety ($V_{2)}$ which was statistically similar with C_1 (8.46), C_3 (7.20) of the inbred variety (V_1) and C_1 (8.20) of the hybrid variety (V_2). At harvest highest number of tillers hill^{-1} were obtained from nursery seedlings (14.47) of the inbred variety (V_1) which was statistically similar with C_2 (10.0), C_4 (9.20) of the inbred variety (V_1) and C_3 (9.20), C_4 (9.20), C_1 (8.66) of the hybrid variety (V_2) and the lowest number of tillers hill^{-1} was obtained from C_2 (6.66) of the hybrid variety (V_2) which was statistically similar with C_1 (8.30), C_3 (7.20) of the inbred variety (V_1) and nursery seedlings (8.13), C_1 (8.66) of the hybrid variety (V_2).



V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2, N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 2. Interaction effect of variety and planting material on tiller numbers hill^{-1} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 2.183, 2.834, 2.393 and 2.022 at 30, 55 and 80 DAT and at harvest, respectively)

4.1.3 Number of leaves hill^{-1} at different days after transplantation

4.1.3.1 Effect of variety

The production of total number of leaves hill^{-1} of *boro* rice was statistically non significant and hence was not influenced by different varieties (Appendix VI and Table 5). Numerically maximum number of leaves hill^{-1} at 30, 55, 80 DAT and at harvest was observed in the inbred variety V_1 (BRRI dhan29) and the minimum number of leaves hill^{-1} was obtained from the hybrid variety V_2 (BRRI hybrid dhan2). This might be due to higher plant height in inbred variety BRRI dhan29.

Table 5. Effect of variety on leaf numbers hill^{-1} at different growth duration of inbred and hybrid *boro* rice

Treatments	Leaf numbers hill^{-1} at different DAT			
	30	55	80	At harvest
V_1 (BRRI dhan29)	21.23	36.82	45.89	45.83
V_2 (BRRI hybrid dhan2)	16.09	26.61	41.47	38.28
LSD $_{(0.05)}$	NS	NS	NS	NS
CV (%)	40.06	20.52	22.02	23.11

NS = Not significant

4.1.3.2 Effect of planting material

The total number of leaves hill^{-1} was significantly influenced by different planting material at 30, 55 and 80 DAT but insignificant at harvest (Appendix VI and Table 6). At 30 DAT highest number of leaves hill^{-1} was observed in C_4 (22.07) which was statistically similar with C_1 (21.92), C_3 (21.03) and C_2 (20.95) followed by nursery seedlings (7.33). The highest number of leaves hill^{-1} (43.50) at 55 DAT was observed in C_2 which was statistically similar with C_1 (8.70) and the lowest number of leaves hill^{-1} was obtained from nursery seedlings (15.13). At 80 DAT highest numbers of tiller hill^{-1} was observed in nursery seedlings (51.80) which was statistically similar with C_4 (46.00) and the lowest numbers of leaves hill^{-1} was obtained from C_1 (36.70) which was statistically similar with C_4 (46.00), C_2 (42.67) and C_3 (40.50).

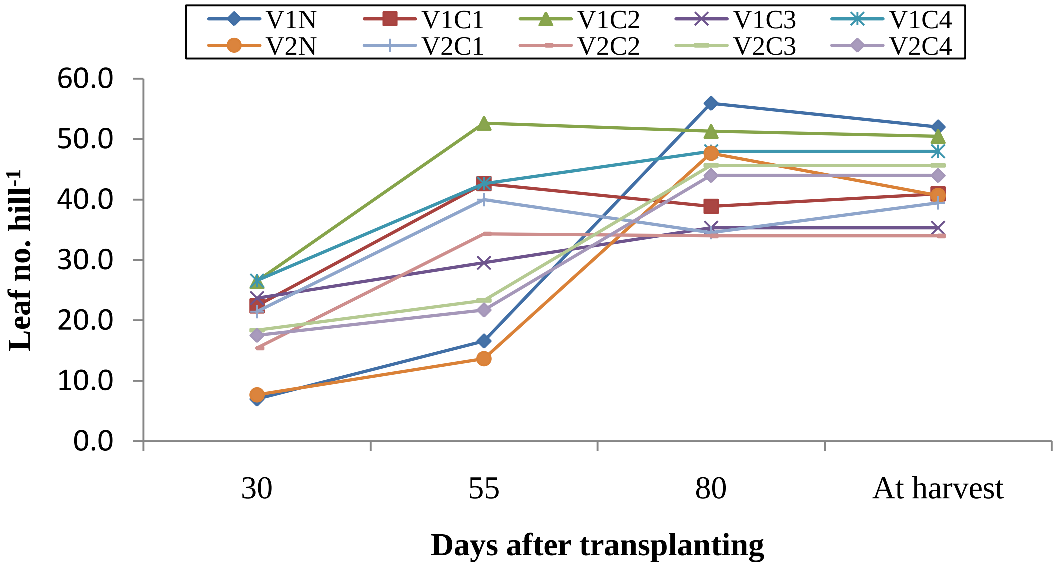
Table 6. Effect of planting material on leaf number hill^{-1} at different growth duration of inbred and hybrid *boro* rice

Treatments	Leaf number hill^{-1} at different DAT			
	30	55	80	At harvest
N	7.33b	15.13c	51.80a	46.33
C_1	21.92a	41.31a	36.70c	40.20
C_2	20.95a	43.50a	42.67bc	42.25
C_3	21.03a	26.43b	40.50bc	40.50
C_4	22.07a	32.20b	46.00ab	46.00
LSD $_{(0.05)}$	5.501	7.753	8.050	NS
CV (%)	24.08	19.97	15.10	14.88

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from $C_{3,}$ NS = Not significant

4.1.3.3 Interaction effect of variety and planting material

Significant interaction effect between the variety and planting material on number of leaves hill^{-1} was observed at 30, 55 and 80 DAT and at harvest (Appendix VI and Figure 2). The results revealed that at 30 DAT, the highest number of leaves hill^{-1} was observed in C_4 (26.60) of the inbred variety (V_1) which was statistically similar with C_2 (26.47), C_3 (23.67), C_1 (22.40) of the inbred variety (V_1) and C_1 (21.43) of the hybrid variety (V_2) followed by nursery seedlings (7.66) of the hybrid variety (V_2) which was statistically similar with the nursery seedlings (7.00) of the inbred variety (V_1). At 55 DAT highest number of leaves hill^{-1} were obtained from C_2 (52.67) of the inbred variety (V_1) which was statistically similar with C_4 (42.67), C_1 (42.63), of the inbred variety (V_1) followed by nursery seedlings (13.67) of the hybrid variety (V_2) which was statistically similar with the nursery seedlings (16.60) of the inbred variety (V_1) and C_4 (21.73), C_3 (23.33) of the hybrid variety (V_2). Highest number of leaves hill^{-1} at 80 DAT was observed in nursery seedlings (55.93) of the inbred variety (V_1) which was statistically similar with C_1 (51.33), C_4 (48.00) of the inbred variety (V_1) and nursery seedlings (47.67), C_1 (45.67) of the hybrid variety (V_2) and the lowest number of leaves hill^{-1} was obtained from C_2 (34.00) of the hybrid variety (V_2) which was statistically similar with C_3 (35.33), C_1 (38.87) of the inbred variety (V_1) and C_1 (34.53), C_4 (44.00) of the hybrid variety (V_2). At harvest the highest number of leaves hill^{-1} were obtained from nursery seedlings (52.00) of the inbred variety (V_1) which was statistically similar with C_4 (48.00), C_2 (50.50) and C_1 (40.93) of the inbred variety (V_1) and C_3 (45.67), C_4 (44.00) of the hybrid variety (V_2) and the lowest number of leaves hill^{-1} was obtained from C_2 (34.00) of the hybrid variety (V_2) which was statistically similar with C_4 (35.33), C_1 (40.93) of the inbred variety (V_1) and nursery seedlings (40.67), C_1 (39.47) and C_4 (44.00) of the hybrid variety (V_2).



V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2, N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 3. Interaction effect of variety and planting material on leaf numbers hill^{-1} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 7.779, 10.960, 11.380 and 11.090 at 30, 55 and 80 DAT and at harvest, respectively)

4.1.4 Length of root (cm) at different days after transplantation

4.1.4.1 Effect of variety

The root length of boro rice was not significantly influenced by different varieties (Appendix VII and Table 7). Numerically higher root length at 30, 55, 80 DAT and at harvest was observed in the inbred variety V_1 (BRRI dhan29) and the lower root length was obtained from the hybrid variety V_1 (BRRI hybrid dhan2).

Table 7. Effect of variety on root length at different growth duration of inbred and hybrid *boro* rice

Treatments	Root length (cm) at different DAT			
	30	**55**	**80**	**At harvest**
V_1 (BRRI dhan29)	16.02	21.67	20.27	19.73
V_2 (BRRI hybrid dhan2)	14.99	20.67	19.20	18.30
LSD $_{(0.05)}$	NS	NS	NS	NS
CV (%)	30.38	13.21	10.88	6.23

NS = Not significant

4.1.4.2 Effect of planting material

The length of root was significantly influenced by different planting material at 30, 55, 80 DAT and at harvest (Appendix VII and Table 8). At 30 DAT highest root length was observed in C_3 (19.50 cm) followed by nursery seedlings (13.01 cm) which was statistically similar with C_2 (14.58 cm), C_4 (15.17 cm) and C_1 (15.28 cm). The highest root length (24.75 cm) at 55 DAT was observed in C_2 which was statistically similar with nursery seedlings (23.75 cm) and C_1 (22.67 cm) and the lowest root length was obtained from C_4 (16.42 cm) which was statistically similar with C_3 (18.25 cm). At 80 DAT highest root length was observed in C_1 (24.75 cm) which was statistically similar with nursery seedlings (22.83 cm) and the lowest root length was obtained from C_4 (16.25 cm) which was statistically similar with, C_3 (17.17 cm) and C_2 (17.67 cm). The highest root length (20.92 cm) at harvest, was obtained from C_2, which was statistically similar with C_1 (20.50 cm) and the nursery seedlings (20.25 cm) and the lowest root length was obtained from C_4 (16.25 cm) which was statistically similar with C_3 (17.17 cm).

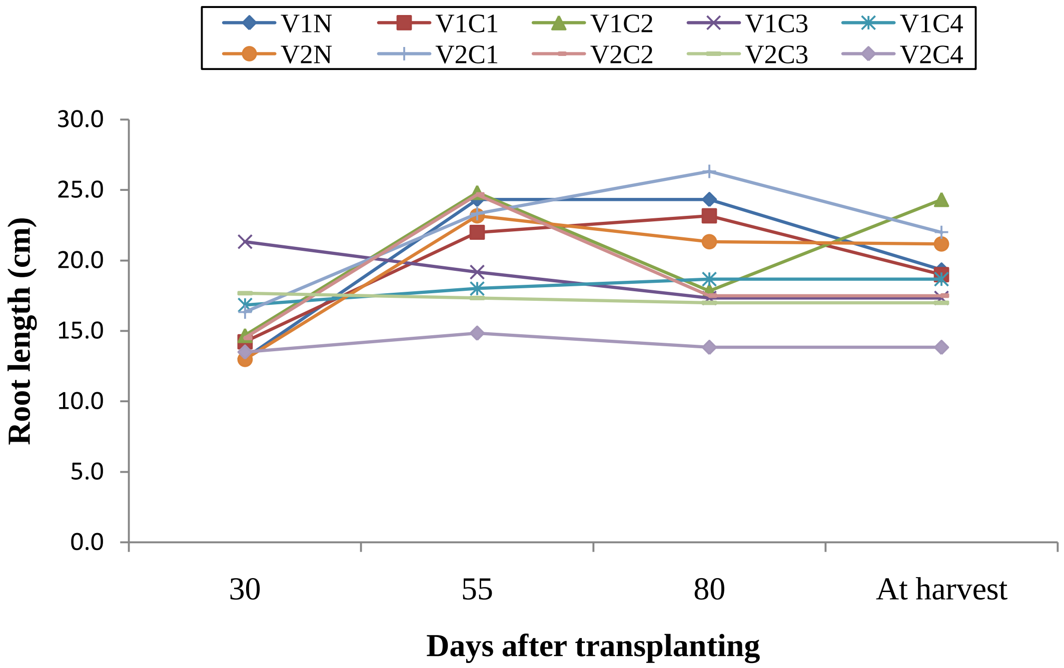
Table 8. Effect of planting material on root length at different growth duration of inbred and hybrid *boro* rice

Treatments	Root length (cm) at different DAT			
	30	55	80	At harvest
N	13.01b	23.75a	22.83a	20.25ab
C_1	15.28b	22.67a	24.75a	20.50a
C_2	14.58b	24.75a	17.67b	20.92a
C_3	19.50a	18.25b	17.17b	17.17bc
C_4	15.17b	16.42b	16.25b	16.25c
LSD $_{(0.05)}$	2.410	3.201	2.519	3.270
CV (%)	12.69	12.36	10.44	14.06

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

4.1.4.3 Interaction effect of variety and planting material

Significant interaction effect between the variety and planting material on root length (cm) was observed at 30, 55 and 80 DAT and at harvest (Appendix VII and Figure 4). The results revealed that at 30 DAT, the highest root length was observed in C_3 (21.33 cm) of the inbred variety (V_1) followed by nursery seedlings (12.97 cm) of the hybrid variety (V_2) which was statistically similar with the nursery seedlings (13.05 cm), C_1 (14.23 cm), C_2 (14.67 cm) of the inbred variety (V_1) and C_4 (13.50 cm), C_2 (14.50 cm), C_1 (16.33 cm) of the hybrid variety (V_2). At 55 DAT highest root length were obtained from C_2 (24.83 cm) of the inbred variety (V_1) which was statistically similar with the nursery seedlings (24.33 cm) and C_1 (22.00 cm) of the inbred variety (V_1) and C_2 (24.67 cm), C_1 (23.33 cm) and the nursery seedlings (23.17 cm) of the hybrid variety (V_2) and the lowest root length observed in C_4 (14.83 cm) of the hybrid variety (V_2) which was statistically similar with C_4 (18.00 cm), C_3 (19.17 cm) of the inbred variety (V_1) and C_4 (17.33 cm) of the hybrid variety (V_2). Highest root length at 80 DAT was observed in C_1 (26.33 cm) of the hybrid variety (V_2) which was statistically similar with the nursery seedlings (24.33 cm) and C_1 (23.17 cm) of the inbred variety (V_1) and the lowest root length was obtained from C_4 (13.83 cm) of the hybrid variety (V_2) which was statistically similar with C_3 (17.00) of the hybrid variety (V_2) and C_3 (17.33 cm) of the inbred variety (V_1). At harvest the highest root length were obtained from C_2 (24.33 cm) of the inbred variety (V_1) which was statistically similar with C_1 (22.00 cm) and the nursery seedlings (21.17 cm) of the hybrid variety (V_2) and the lowest root length was obtained from C_4 (13.83 cm) of the hybrid variety (V_2) which was statistically similar with C_3 (17.17 cm) of the hybrid variety (V_2) and C_3 (17.33 cm) of the inbred variety (V_1).



V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2, N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 4. Interaction effect of variety and planting material on root length at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 3.407, 4.528, 3.566 and 4.628 at 30, 55 and 80 DAT and at harvest, respectively)

4.1.5 Leaf Area Index (LAI) at different days after transplantation

4.1.5.1 Effect of variety

Varietal effect significantly influenced leaf area index (LAI) of *boro* rice at 55 DAT, 80 DAT and at harvest however, it was not significantly influenced at 30 DAT (Appendix VIII and Table 9). At 55 DAT, 80 DAT and at harvest, the higher leaf area index (2.60, 3.77 and 3.25, respectively) was found in the inbred variety V_1 (BRRI dhan29) and the lower leaf area index (1.79, 2.81 and 2.56, respectively) was found in the hybrid variety V_2 (BRRI hybrid dhan2). This might be due to the production of comparatively lower tillers of the hybrid variety than the inbred variety which consequently decreased the number of leaves plant^{-1} and leaf area index. Ahmed (2006) also observed highest leaf area index in BRRI dhan29 than hybrid variety.

Table 9. Effect of variety on leaf area index at different growth duration of inbred and hybrid *boro* rice

Treatments	Leaf area index at different DAT			
	30	55	80	At harvest
V_1 (BRRI dhan29)	1.41	2.60a	3.77a	3.25a
V_2 (BRRI hybrid dhan2)	1.01	1.79b	2.81b	2.56 b
LSD $_{(0.05)}$	NS	0.239	0.310	0.418
CV (%)	53.71	14.44	12.57	18.88

NS = Not significant

4.1.5.2 Effect of planting material

Planting material significantly influenced Leaf area index (LAI) of *boro* rice was at 30, 55 and 80 DAT and at harvest (Appendix VIII and Table 10). At 30 DAT, clonal tillers C_2 produced the highest leaf area index (1.92) which was statistically similar with C_4 (1.77) and nursery seedlings produced the lowest leaf area index (0.13). At 50 DAT highest leaf area index (3.12) was observed in C_2 which was statistically similar with C_4 (2.61) and C_1 (2.55) and the lowest was observed in nursery seedlings (0.88). This might be due to higher leaf number in clonal tiller at early growth stage of rice plant. Highest leaf area index (3.68) at 80 DAT was obtained from C_2 which was statistically similar with C_4 (3.41), N (3.40) and C_1 (3.18) and the lowest leaf area index (2.76) was observed in C_3 which was statistically similar with C_1 (3.18), N (3.40) and C_4 (3.41). At harvest C_4 produced highest leaf area index (3.34) which was statistically similar with C_2 (3.30), C_3 (2.76) and N (2.75) and the lowest leaf area index (2.34) was observed in C_1 which was statistically similar with N (2.75) and C_3 (2.76).This finding disagree with Ahmed (2006) who found lowest leaf area index in clonal tillers and highest in nursery seedling at harvest.

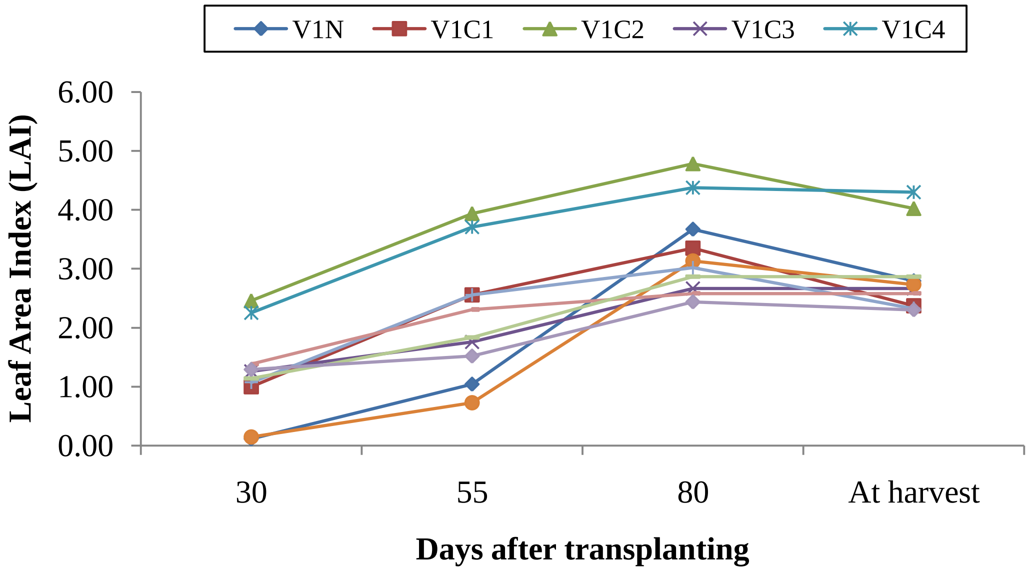
Table 10. Effect of planting material on leaf area index at different growth duration of inbred and hybrid *boro* rice

Treatments	Leaf area index at different DAT			
	30	55	80	At harvest
N	0.13d	0.88c	3.40ab	2.75ab
C_1	1.03c	2.55a	3.18ab	2.34b
C_2	1.92a	3.12a	3.68a	3.30a
C_3	1.19bc	1.79b	2.76b	2.76ab
C_4	1.77ab	2.61a	3.41ab	3.34a
LSD $_{(0.05)}$	0.702	0.581	0.750	0.723
CV (%)	47.14	21.65	18.71	20.41

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

4.1.5.3 Inteaction effect of variety and planting material

Interaction effect of variety and planting material significantly influenced leaf area index (LAI) of *boro* rice at 30, 55 and 80 DAT and at harvest (Appendix VIII and Figure 5). At 30 DAT, V_1C_2 produced the highest leaf area index (2.46) which is statistically similar with V_1C_4 (2.25) and the lowest LAI was observed in V_1N (0.11) which is statistically similar with V_2N (0.14), V_1C_1 (0.99) and V_2C_1 (1.07). At 55 DAT the highest LAI was obtained from V_1C_2 (3.94) which was statistically similar with V_1C_4 (3.71) and the lowest LAI was observed in V_2N (0.72) which was statistically similar with V_1N (1.04) and V_2C_4 (1.52). Highest LAI at 80 DAT was observed in V_1C_2 (4.78) which was statistically similar with V_1C_4 (4.38) and the lowest LAI was observed in V_2C_4 (2.43) which was statistically similar with V_2C_2 (2.58), V_1C_3 (2.67), V_2C_3 (2.86), V_2C_1 (3.02), V_2N (3.13) and V_1C_1 (3.35). At harvest highest LAI (4.38) was obtained from V_1C_4 which was statistically similar with V_1C_2 (4.02) and the lowest LAI (2.30) was obtained from V_2C_4 which was statistically similar with V_2C_1 (2.33), V_1C_1 (2.37), V_2C_2 (2.58), V_1C_3 (2.67), V_2N (2.73), V_1N (2.79), and V_2C_3 (2.86).



V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2, N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 5. Interaction effect of variety and planting material on leaf area index (LAI) at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.986, 1.073, 1.202 and 1.708 at 30, 55 and 80 DAT and at harvest, respectively)

4.1.6 Dry matter production (g m^{-2}) at different days after transplantation

4.1.6.1 Effect of variety

The total dry weight of plant was not significantly influenced by different varieties (Appendix IX and Table 11). Numerically higher dry weight (g m^{-2}) at 30, 55, 80 DAT and at harvest was observed in the inbred variety V_1 (BRRI dhan29) than the hybrid variety V_2 (BRRI hybrid dhan2). Ahmed (2006) also observed higher dry weight in BRRI dhan29 compared to hybrid variety.

Table 11. Effect of variety on dry matter production at different growth duration of inbred and hybrid *boro* rice

Treatments	Total dry weight (g m^{-2}) at different DAT			
	30	55	80	At harvest
V_1 (BRRI dhan29)	171.32	556.80	966.52	1346.07
V_2 (BRRI hybrid dhan2)	102.50	507.46	746.98	1114.22
LSD $_{(0.05)}$	NS	NS	NS	NS
CV (%)	51.76	40.22	39.95	52.32

NS = Not significant

The dry matter production of different plant parts at harvesting time was recorded in which all partitioned components were statistically influenced by variety (Appendix X). The dry matter production of different plant parts was always higher in the inbred variety compared to the hybrid variety (Figure 6).

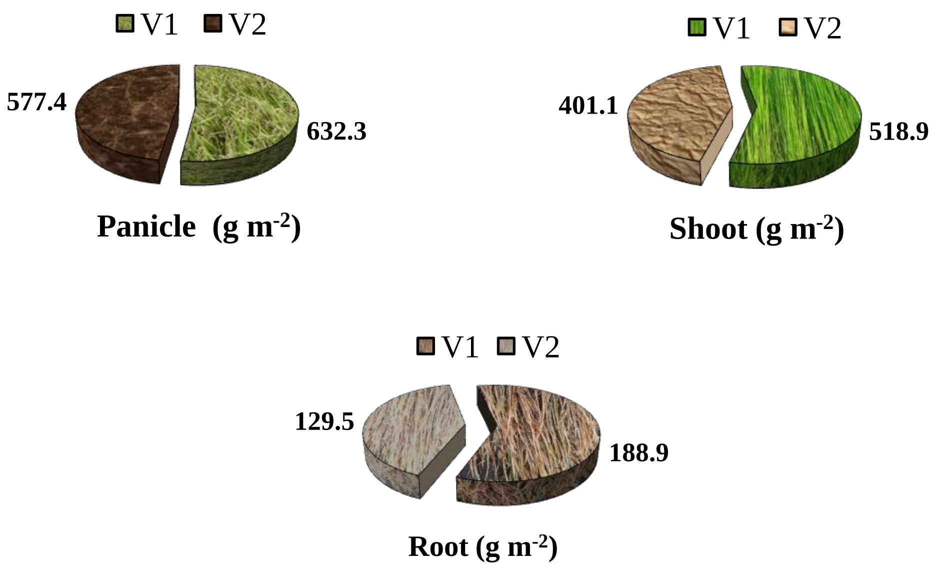


Figure 6. Influence of variety on dry matter production of different plant parts at harvest

4.1.6.2 Effect of planting material

The total dry matter production of plant was significantly influenced by planting material at 30, 55, 80 DAT and at harvest (Appendix IX and Table 12). At 30 DAT, the highest dry weight (268.00 g m^{-2}) was recorded in the clonal tillers C_4 and the lowest dry weight (12.79 g m^{-2}) was recorded in the nursery seedlings (6.33 g m^{-2}) which was statistically similar with C_1 (81.75 g m^{-2}). Sharma and Ghosh (1998) and

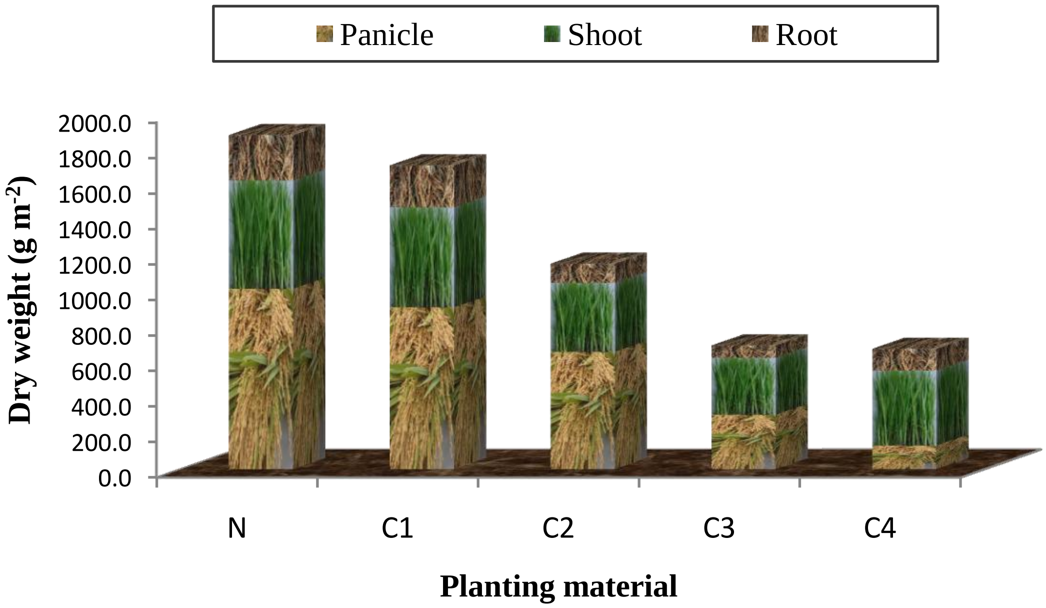
Sharma (1992) also observed highest dry weight in clonally propagated crop compared to nursery seedlings. The highest dry weight (719.20 g m^{-2}) at 55 DAT was observed in C_2 which was statistically similar with C_3 (691.50 g m^{-2}), C_1 (631.00 g m^{-2}) and C_4 (554.40 g m^{-2}) and the lowest dry weight was obtained from the nursery seedlings (64.13 g m^{-2}). At 80 DAT highest dry weight (1351.00 g m^{-2}) was recorded in C_1 which was statistically similar with C_2 (1066.00 g m^{-2}) and the lowest dry weight was obtained from the nursery seedlings (472.90 g m^{-2}) which was statistically similar with C_3 (696.30 g m^{-2}) and C_4 (697.20 g m^{-2}). The highest dry weight (1891 g m^{-2}) at harvest was obtained from the nursery seedlings (1891.00 g m^{-2}) which is statistically similar with C_1 (1710.00 g m^{-2}) and the lowest dry weight was observed in C_3 (696.30 g m^{-2}) which was statistically similar with C_4 (697.20 g m^{-2}). Ahmed (2006) also observed highest dry weight in clonally propagated crops at early growth stage and at harvest nursery seedlings provided highest dry weight.

Table 12. Effect of planting material on dry matter production at different growth duration of inbred and hybrid *boro* rice

Treatments	Total dry weight (g m^{-2}) at different DAT			
	30	55	80	At harvest
N	6.33d	64.13b	472.90b	1891.00a
C_1	81.75cd	631.00a	1351.00a	1710.00a
C_2	154.30bc	719.20a	1066.00a	1157.00b
C_3	173.30b	691.50a	696.30b	696.30c
C_4	268.00a	554.80a	697.20b	697.20c
LSD $_{(0.05)}$	83.820	209.798	343.597	367.670
CV (%)	50.09	32.22	32.77	24.42

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

The dry matter production of different plant parts at harvesting time was recorded in which dry weight of all parts were influenced by cultivation method (Appendix X and Figure 7). Statistically highest dry weight of panicle, shoot and root was produced by the nursery seedlings.

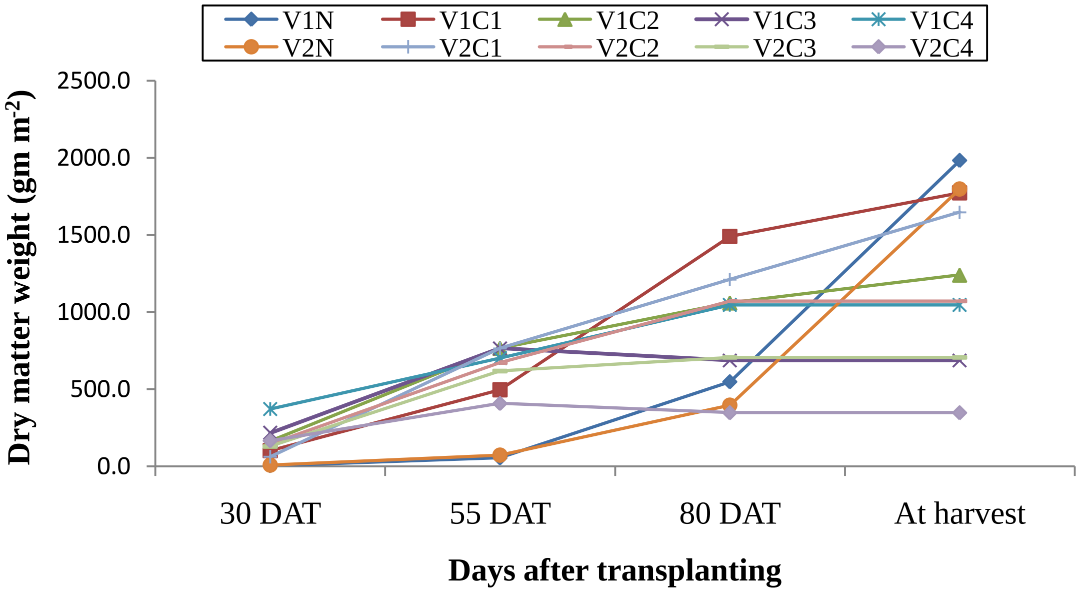


N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 7. Influence of planting material on dry matter production in different plant parts at harvest ($LSD_{0.05}$ = 195.50, 158.90 and 89.99 for panicle, shoot and root, respectively)

4.1.6.3 Interaction effect of variety and planting material

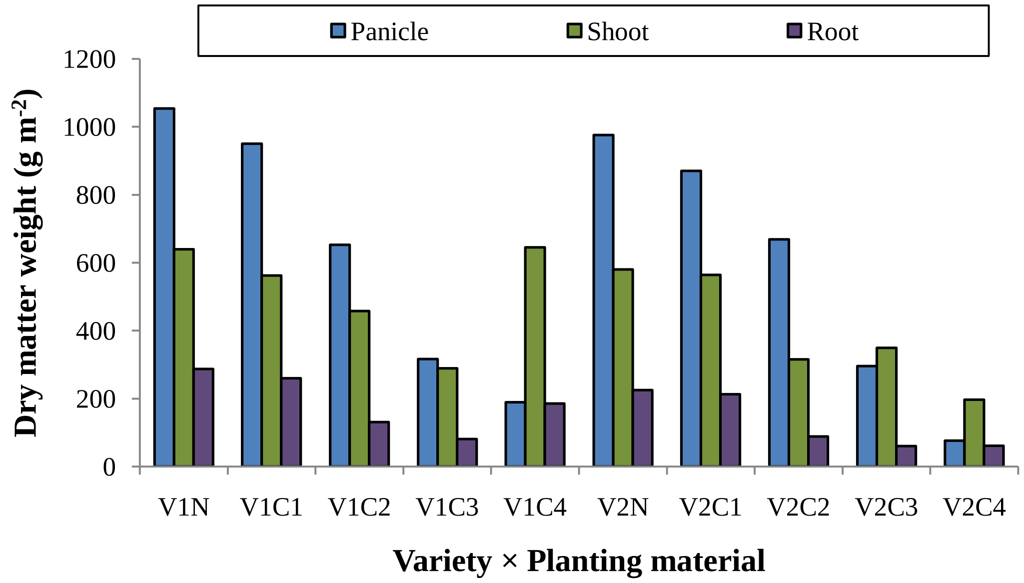
Significant interaction effect between the variety and planting material on dry matter production (g m^{-2}) was observed at 30, 55 and 80 DAT and at harvest (Appendix IX and Figure 8). The results revealed that at 30 DAT, the highest dry weight was observed in C_4 (370.9 g m^{-2}) of the inbred variety (V_1) and the lowest in nursery seedlings (4.05 g m^{-2}) of the inbred variety (V_1) which was statistically similar with the nursery seedlings (8.62 g m^{-2}), C_1 (61.95 g m^{-2}) of the hybrid variety (V_2) and C_1 (101.6 g m^{-2}) of the inbred variety (V_1). At 55 DAT the highest dry weight were obtained from C_2 (765.9 g m^{-2}) of the inbred variety (V_1) which was statistically similar with C_3 (765.2 g m^{-2}), C_4 (701.5 g m^{-2}) and C_1 (496.4 g m^{-2}) of the inbred variety (V_1) and C_1 (765.5 g m^{-2}), C_2 (672.6 g m^{-2}) and C_3 (617.9 g m^{-2}) of the hybrid variety and the lowest from nursery seedlings (55.04 g m^{-2}) of the inbred variety (V_1) which was statistically similar with the nursery seedlings (73.22 g m^{-2}). At 80 DAT the highest dry weight was observed in C_1 (1491 g m^{-2}) of the inbred variety (V_1) which was statistically similar with C_2 (1060 g m^{-2}) and C_4 (1047 g m^{-2}) of the inbred variety (V_1) and C_1 (1212 g m^{-2}) and C_2 (1072 g m^{-2}) of the hybrid variety and the lowest in C_4 (347.5 g m^{-2}) of the hybrid variety (V_2) which was statistically similar with nursery seedlings (548.2 g m^{-2}) and C_3 (687.1 g m^{-2}) of the inbred variety (V_1) and nursery seedlings (397.7 g m^{-2}) and C_3 (705.5 g m^{-2}) of the of the hybrid variety (V_2). At harvest the highest dry weight was obtained from nursery seedlings (1983 g m^{-2}) of the inbred variety (V_1) which was statistically similar with C_1 (1060 g m^{-2}) of the inbred variety (V_1) and nursery seedling (1799 g m^{-2}) and C_1 (1648 g m^{-2}) of the of the hybrid variety (V_2) and the lowest from C_4 (347.5 g m^{-2}) of the hybrid variety (V_2) which was statistically similar with C_3 (687.1 g m^{-2}) of the inbred variety (V_1) and C_3 (705.5 g m^{-2}) of the of the hybrid variety (V_2).



V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2, N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 8. Interaction effect of variety and planting material on dry matter production at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 118.50, 296.70, 486.00 and 520.00 at 30, 55 and 80 DAT and at harvest, respectively)

In case of the dry matter production of different plant parts at harvesting, dry weight of panicle, shoot and root was statistically influenced by the interaction effect of variety and clonal tiller (Appendix X and Figure 9).



V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2, N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 9. Interaction effect of variety and planting material on dry matter production of different plant parts of inbred and hybrid *boro* rice at harvest ($LSD_{0.05}$ = 276.40, 224.80 and 127.30 for panicle, shoot and root, respectively)

4.1.7 Days to flowering and maturity

4.1.7.1 Effect of variety

The flowering and maturity duration significantly varied among the variety (Appendix XI and Table 13), where the inbred variety BRRI dhan29 needed longer time for flowering (100 days) and maturity (130 days) as compared to the hybrid variety BRRI hybrid dhan2 (89 days and 123 days respectively). The hybrid variety matured 7 days earlier than the inbred variety. Ashrafuzzaman (2006); Main (2006) and Ahmed (2006) also observed that inbred variety needed longest time for flowering and maturity as compared to the hybrid variety. This might be due to the shortest life span of hybrid variety compared to that of inbred variety.

Table 13. Effect of variety on flowering and maturity duration of inbred and hybrid *boro* rice

Treatments	Days to flowering	Days to maturity
V_1 (BRRI dhan29)	100a	130a
V_2 (BRRI hybrid dhan2)	89b	123b
LSD $_{(0.05)}$	0.991	1.829
CV (%)	0.67	1.01

4.1.7.2 Effect of planting material

The flowering and maturity duration were significantly varied among the planting material (Appendix XI and Table 14). The highest duration (143.80 days) needed for flowering of nursery seedling (N) and the lowest duration for flowering (64.17 days) was observed in the third generation clonal tillers (C_3). The highest duration (172.20 days) needed for the maturity of nursery seedlings (N) and the lowest duration for maturity was observed in the fourth generation clonal tillers (C_4). Dissimilar result was observed whereas the clonal tillers needed the longest duration for flowering (116 days) and for maturity (150 days). Mamun *et al.*, (2012) also reported that tiller separation increased growth duration. This might be due to removal of tillers from the mother hill and replanting again (Mollah *et al.*, 1992).

Table 14. Effect of planting material on flowering and maturity duration of inbred and hybrid *boro* rice

Treatment	Days to flowering	Days to maturity
N	143.80a	172.20a
C_1	115.30b	141.20b
C_2	81.17c	117.80c
C_3	64.17e	105.20d
C_4	65.83d	95.67e
LSD $_{(0.05)}$	1.059	0.968
CV (%)	0.92	0.63

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

4.1.7.3 Interaction effect of variety and planting material

Interaction effect of variety and planting material significantly influenced the flowering and maturity duration (Appendix XI and Figure 11 & Figure 12). Nursery seedlings of the inbred variety needed the highest duration for flowering (145.3 days) and C_4 of the hybrid variety needed the lowest duration for flowering (54.33 days) which was statistically similar with C_3 (55.67 days) of the hybrid variety. Nursery seedlings of the inbred variety BRRI dhan29 required the highest duration also for maturity (175.3 days). The longer duration required than recommended one might be due to low temperature at early growth stage of nursery seedlings during studied period (Figure 10), that needed more time for flowering and maturity. Kabir *et al.* (2008) also reported 170 days duration of BRRI dhan29 transplanted at 15 December. Temperature drop by 1°C causes a 13-day delay in heading and critical low temperature is 13°C for seedling establishment (Yoshida, 1981). C_4 of the hybrid variety needed the lowest duration for maturity (97.00 days) which is statistically similar with C_3 (108.7 days) of the inbred variety.

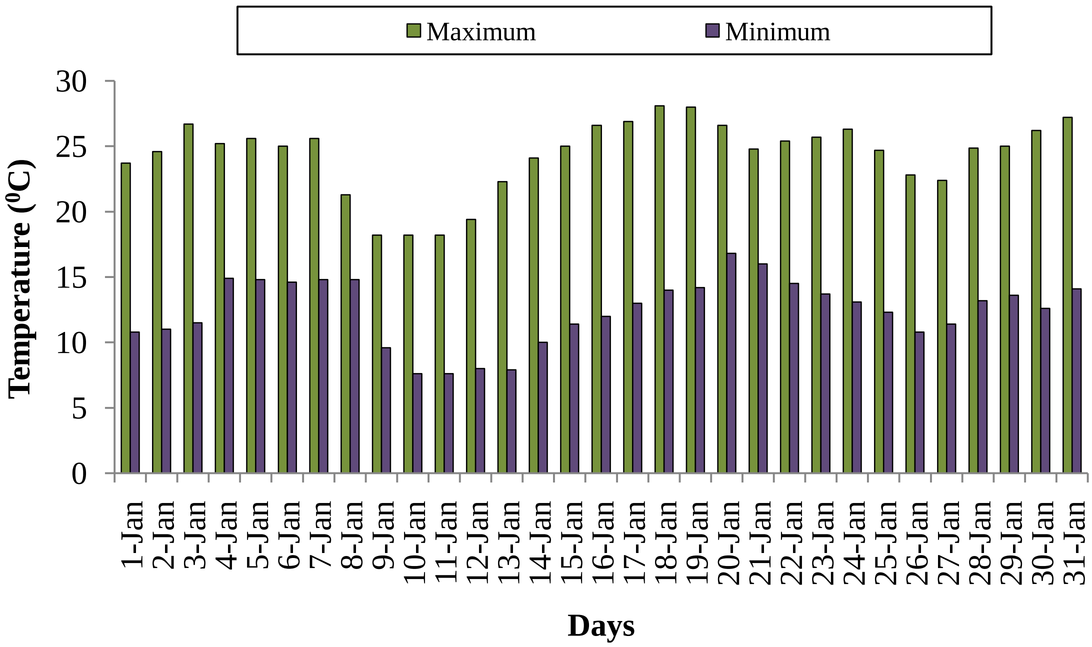
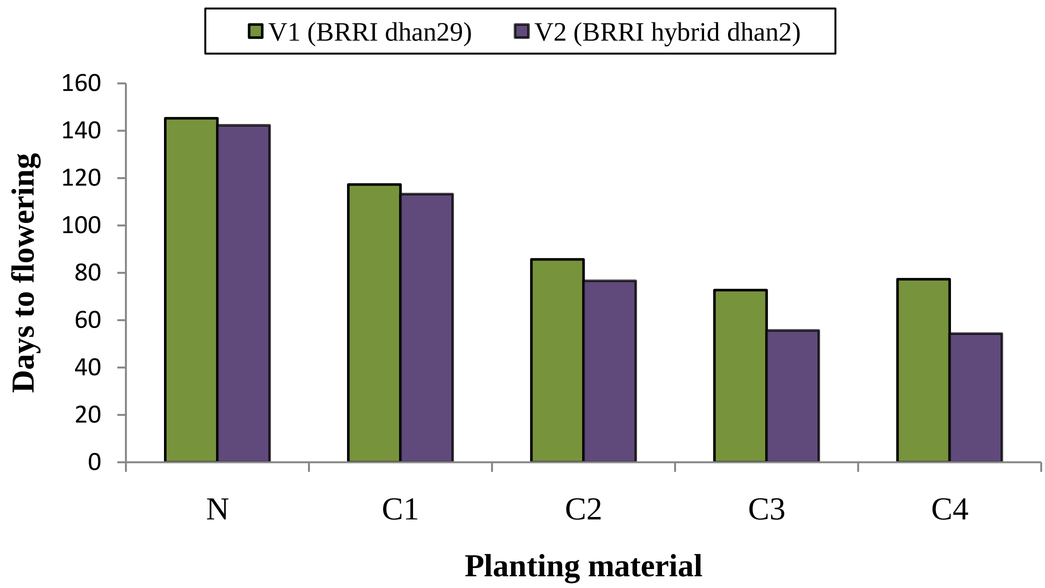
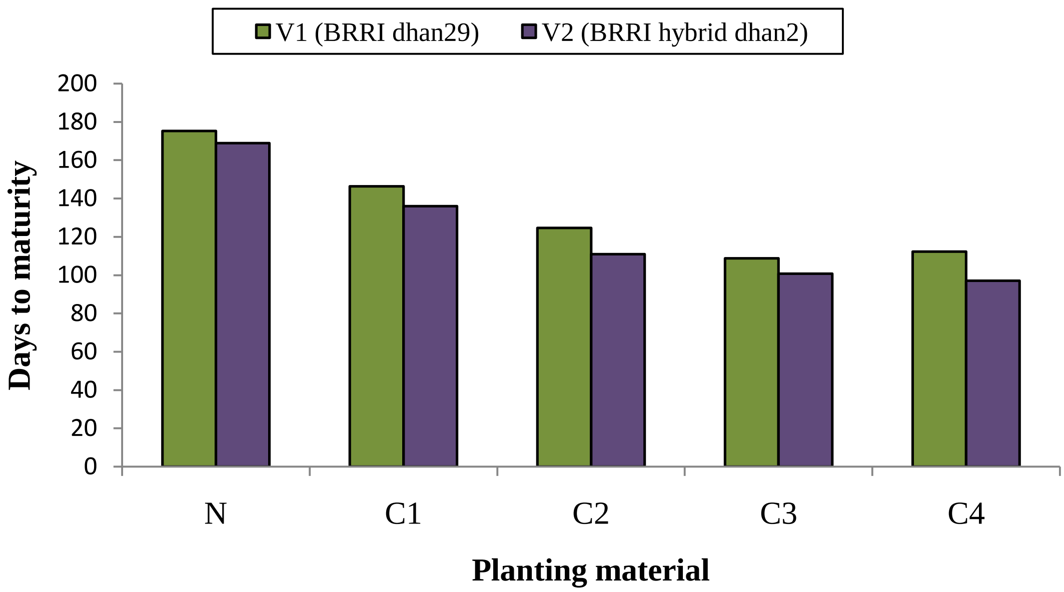


Figure 10. Extreme low temperature at early growth stage of nursery seedlings



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 11. Interaction effect of variety and planting material on flowering duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.50)



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 12. Interaction effect of variety and planting material on maturity duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.38)

4.2 Yield and other crop characters

4.2.1 Number of effective tillers m^{-2}

4.2.1.1 Effect of variety

The number of effective tillers m^{-2} was not significantly influenced by variety (Appendix XI and Table 15). The higher number of effective tillers m^{-2} (234.27) was obtained from inbred variety V_1 (BRRI dhan29) and the lower number of effective tillers m^{-2} (218.59) observed in hybrid variety V_2 (BRRI hybrid dhan2). Debnath (2010) and Ashrafuzzman (2006) also observed that varieties differed insignificantly in respect of number of effective tillers m^{-2} though Ahmed (2006) found significant effect between inbred and hybrid varieties in respect of number of effective tillers m^{-2}.

Table 15. Effect of variety on effective and ineffective tillers m^{-2} of inbred and hybrid *boro* rice

Treatments	Effective tillers (no. m^{-2})	Ineffective tillers (no. m^{-2})
V_1 (BRRI dhan29)	234.27	24.99
V_2 (BRRI hybrid dhan2)	218.59	18.66
LSD $_{(0.05)}$	NS	NS
CV (%)	23.87	52.98

NS = Not significant

4.2.1.2 Effect of planting material

The number of effective tillers m^{-2} was not significantly influenced by different planting material with nursery seedlings (Appendix XI and Table 16). Numerically the highest number of effective tillers m^{-2} (246.9) was obtained from C_4 and the lowest number of effective tillers m^{-2} (208.6) observed in C_3. Debnath (2010) and Ahmed (2006) found significant effect between nursery seedlings and clonal tillers.

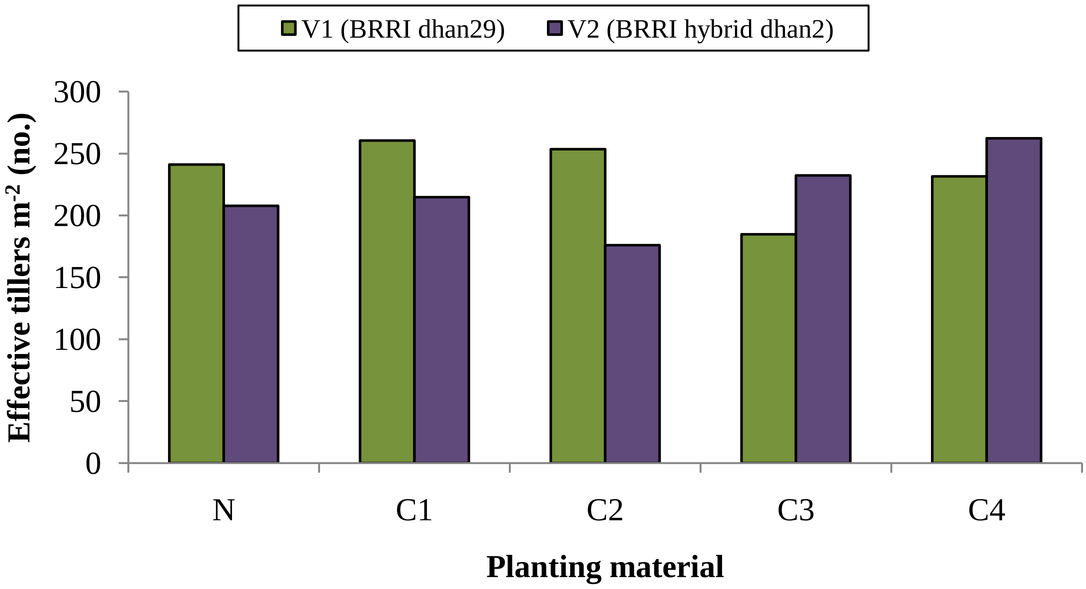
Table 16. Effect of planting material on effective and ineffective tillers m^{-2} of inbred and hybrid *boro* rice

Treatments	Effective tillers (no. m^{-2})	Ineffective tillers (no. m^{-2})
N	224.4	30.80a
C_1	237.6	33.44a
C_2	214.7	16.72b
C_3	208.6	15.84b
C_4	246.9	12.32b
LSD $_{(0.05)}$	NS	12.370
CV (%)	20.28	46.33

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from $C_{3,}$ NS = Not significant

4.2.1.3 Interaction effect of variety and planting material

Interaction effect of variety and planting material significantly influenced the number of effective tillers m^{-2} (Appendix XI and Figure 13). The highest number of effective tillers m^{-2} (260.5) was observed in C_1 of the inbred variety (V_1) which was statistically similar with C_2 (253.4), N (241.1) C_4 (231.5), and C_3 (184.8) of the inbred variety (V_1) and C_3 (232.3), C_1 (214.7) and N (207.7) of the hybrid variety (V_2). The lowest number of effective tillers m^{-2} (176.0) was obtained from C_2 of the hybrid variety (V_2) which was statistically similar with C_3 (184.8), C_4 (231.5), N (241.1), C_2 (253.4) and of the inbred variety (V_1) and C_3 (232.3), C_1 (214.7) and N (207.7) of the hybrid variety (V_2). Debnath (2012) also observed combination of clonal tiller with BRRI dhan29 produce more effective tillers m^{-2} than combination with nursery seedlings of the same variety.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 13. Interaction effect of variety and planting material on number of effective tillers m^{-2} of inbred and hybrid *boro* rice (LSD$_{0.05}$ = 79.5)

4.2.2 Number of ineffective tillers m^{-2}

4.2.2.1 Effect of variety

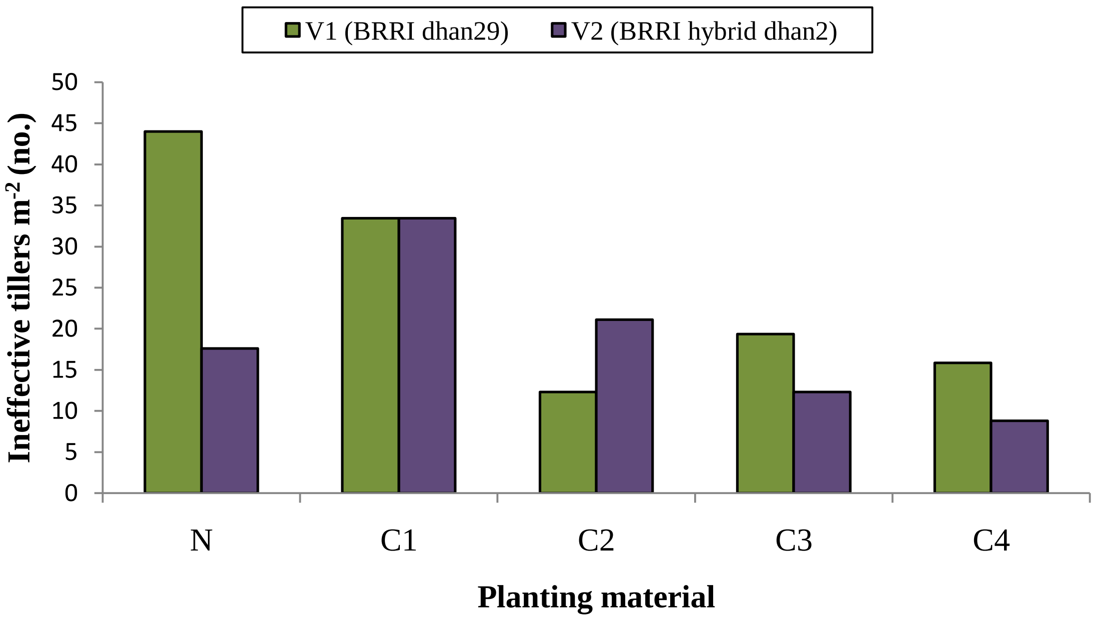
The number of ineffective tillers m^{-2} was not significantly influenced by variety (Appendix XI and Table 15). Numerically the higher number of ineffective tillers m^{-2} (24.99) was obtained from inbred variety V_1 (BRRI dhan29) and the lower number of ineffective tillers m^{-2} (18.66) observed in hybrid variety V_2 (BRRI hybrid dhan2). Debnath (2010) and Ashrafuzzman (2006) also observed that varieties differed insignificantly in respect of number of ineffective tillers m^{-2} though Ahmed (2006) found significant effect between inbred and hybrid varieties in respect of number of ineffective tillers m^{-2}.

4.2.2.2 Effect of planting material

The number of ineffective tillers m^{-2} was significantly influenced by different planting material (Appendix XI and Table 16). The highest number of ineffective tillers m^{-2} (33.44) was obtained from C_1 which was statistically similar with nursery seedlings N (30.80) and the lowest number of ineffective tillers m^{-2} (12.32) observed in C_4 which was statistically similar with C_3 (15.84) and C_2 (16.72). Debnath (2012) also observed highest ineffective tillers m^{-2} in nursery seedlings compared to clonal tillers though Ahmed (2006) found higher ineffective tillers m^{-2} in clonal tillers compared to nursery seedlings.

4.2.2.3 Interaction effect of variety and planting material

Interaction effect of variety and planting material significantly influenced the number of ineffective tillers m^{-2} (Appendix XI and Figure 14). The highest number of ineffective tillers m^{-2} (44.00) was observed in nursery seedlings of the inbred variety (V_1) which was statistically similar with C_1 (33.44) of the same variety and C_1 (33.40) of the hybrid variety (V_2). The lowest number of ineffective tillers m^{-2} (8.80) was obtained from C_4 of the hybrid variety (V_2) which was statistically similar with C_2 (12.30), C_4 (15.84), and C_3 (19.36) of the inbred variety (V_1) and C_3 (12.32), N (17.6) and C_2 (21.12) of the hybrid variety (V_2). Debnath (2010) found the highest ineffective tillers m^{-2} in combination of nursery seedlings with BRRI hybrid dhan2.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 14. Interaction effect of variety and planting material on number of ineffective tillers m^{-2} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 17.5)

4.2.3 Panicle length (cm)

4.2.3.1 Effect of variety

The panicle length was varied significantly due to the variation of variety (Appendix XI and Table 17). The higher (26.79 cm) and lorwer (22.77 cm) panicle length was obtained from BRRI dhan29 and BRRI hybrid dhan2 respectively. Such findings might be due to the genetic make-up of the varieties though Babiker (1986) observed that panicle length differed due to the varietal variation. Ahmed (2006) also observed maximum panicle length in BRRI dhan29 than hybrid variety and Debnath (2012) found the highest panicle length in BRRI dhan29 and lowest in BRRI hybrid dhan2 among other varieties. This finding disagreed with Ashrsfuzzaman (2006) and Main (2006) who observed that varieties differed insignificantly in respect of panicle length.

Table 17. Effect of variety on different crop characters of inbred and hybrid *boro* rice

Treatments	Panicle length (cm)	Rachis branches panicle^{-1} (no.)	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grains weight (g)
V_1 (BRRI dhan29)	26.79a	9.85a	212.82a	161.29a	51.53a	19.70b
V_2 (BRRI hybrid dhan2)	22.77b	8.27b	147.83b	139.31b	8.52b	26.50a
LSD $_{(0.05)}$	0.591	0.350	21.173	7.978	15.150	0.486
CV (%)	1.54	2.37	7.47	3.38	32.11	1.34

4.2.3.2 Effect of planting material

There was significant difference in panicle length observed between different planting material (Appendix XI and Table 18). The highest panicle length (25.72 cm) was observed in C_1 which was statistically similar with C_2 (25.67 cm) and nursery seedlings (24.88 cm) and the lowest panicle length (23.72 cm) was obtained from C_4 which was statistically similar with C_3 (23.92 cm) and nursery seedlings (24.88 cm) though Debnath (2010) and Ahmed (2006) observed insignificant difference in panicle length between nursery seedlings and clonal tillers. Paul (1999) and Rahman (2001) found that nursery seedlings gave the longest panicles compared to the clonally propagated tillers.

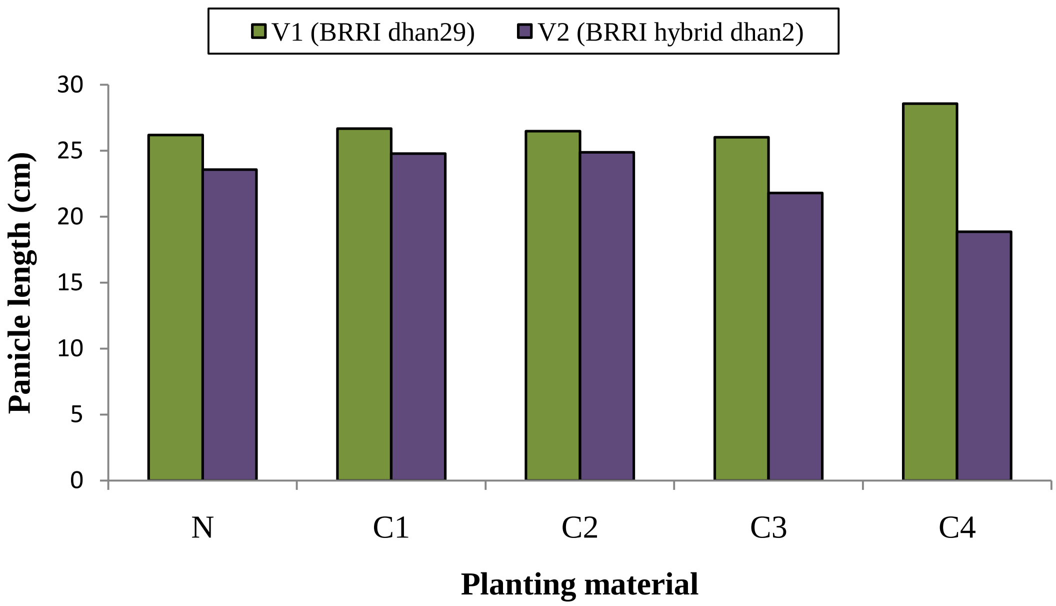
Table 18. Effect of planting material on different crop characters of inbred and hybrid *boro* rice

Treatments	Panicle length (cm)	Rachis branches panicle^{-1} (no.)	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grains weight (g)
N	24.88b	10.05a	171.60c	143.30b	28.30bc	24.40a
C_1	25.72a	9.97ab	214.30a	171.60a	42.65a	24.62a
C_2	25.67a	9.28b	190.20b	168.60a	21.60c	22.53b
C_3	23.92b	7.85c	159.60c	139.80bc	19.75c	22.37bc
C_4	23.72b	8.15c	166.10c	128.20c	37.83ab	21.60c
LSD $_{(0.05)}$	1.216	0.716	16.708	14.258	12.617	0.780
CV (%)	4.01	6.46	7.57	7.75	34.33	2.75

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

4.2.3.3 Interaction effect of variety and planting material

Panicle length was significantly influenced by the interaction effect of variety and planting material (Appendix XI and Figure 15). The highest panicle length (25.72 cm) was observed in C_4 (28.57 cm) of the inbred variety (V_1) and the lowest panicle length was observed in C_4 (18.87 cm) of the hybrid variety (V_2). This finding disagreed with Debnath (2010) who observed maximum panicle length in nursery seedlings with combination of BRRI dhan29 compared to other combination of BRRI dhan29 and BRRI hybrid dhan2.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 15. Interaction effect of variety and planting material on panicle length of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.72)

4.2.4 Rachis branches panicle^{-1}

4.2.4.1 Effect of variety

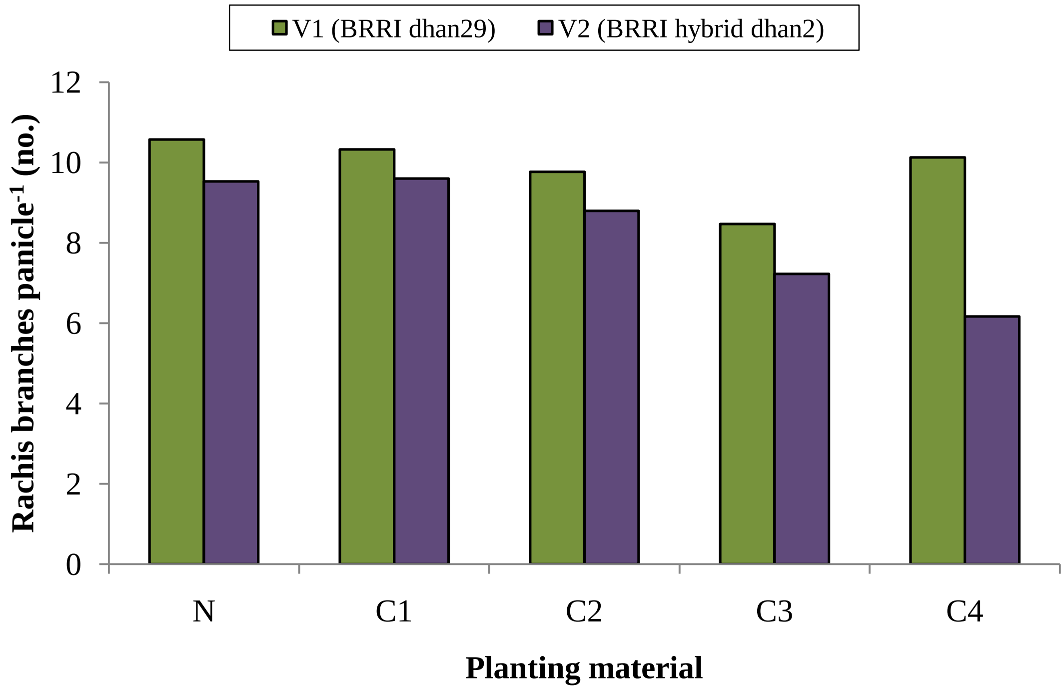
The number of rachis branches panicle^{-1} was significantly influenced by the variety (Appendix XI and Table 17). The maximum number of rachis branches panicle^{-1} (9.85) was observed in BRRI dhan29 and the minimum number of branches panicle^{-1} (8.27) was observed in BRRI hybrid dhan2. This result disagreed with Main (2006) and Obaidullah (2007) who observed the maximum number of rachis branches panicle^{-1} in hybrid variety and the minimum number of branches panicle^{-1} in inbred variety.

4.2.4.2 Effect of planting material

The number of rachis branches panicle^{-1} was significantly influenced by the planting material (Appendix IX and Table 18). The highest number of rachis branches panicle^{-1} (10.05) was obtained from nursery seedlings (N) and the lowest number of rachis branches panicle^{-1} (7.85) was obtained from C_3 which was statistically similar with C_4 (8.15).

4.2.4.3 Interaction effect of variety and planting material

The number of rachis branches panicle^{-1} was significantly influenced by the interaction of variety and planting material (Appendix XI and Figure 16). The highest number of rachis branches panicle^{-1} (10.57) was obtained from nursery seedlings (N) of the inbred variety (V_1) which was statistically similar with C_1 (10.33), C_4 (10.13) and C_2 (9.77) of the inbred variety (V_1) and C_1 (9.6) of the hybrid variety (V_2). The lowest number of rachis branches panicle^{-1} was observed in C_4 (6.17) of the hybrid variety (V_2).



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 16. Interaction effect of variety and planting material on number of rachis branches panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.01)

4.2.5 Total number of grains panicle^{-1}

The total number of grains panicle^{-1} is an important factor which contributes towards grain yield. Variety and clonal tiller treatment along with nursery seedlings show significant effect on the total number of grains panicle^{-1}.

4.2.5.1 Effect of variety

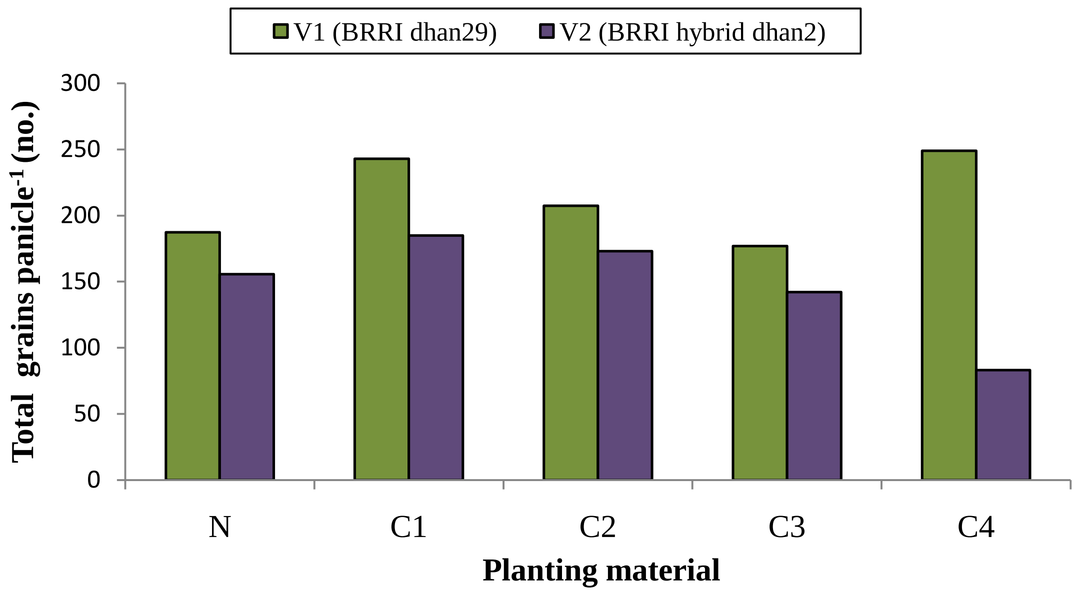
The number of total grains panicle^{-1} was significantly influenced by the variety (Appendix XI and Table 17). The higher number of total grains panicle^{-1} (212.82) was observed in BRRI dhan29 and the lower number of total grains panicle^{-1} (147.83) was obtained from BRRI hybrid dhan2. This finding agreed with Ashrafuzzaman (2006) who observed maximum number of total grains panicle^{-1} in inbred variety than that of hybrid variety though Obaidullah (2007) and Main (2006) were observed dissimilar findings where the number of total grains panicle^{-1} in hybrid variety was higher than that of inbred variety.

4.2.5.2 Effect of planting material

The number of total grains panicle^{-1} was significantly influenced by the planting material (Appendix XI and Table 18). The highest number of total grains panicle^{-1} (214.30) was observed in C_1 and the lowest number of total grains panicle^{-1} (159.60) was obtained from C_3 which was statistically similar with C_4 (166.10) and nursery seedlings (171.60). Ahmed (2006) observed dissimilar result where the total grains panicle^{-1} was not significantly influenced by the nursery seedlings and clonal tiller.

4.2.5.3 Interaction effect of variety and planting material

The total number of grains panicle^{-1} was significantly influenced by the interaction of variety and planting material (Appendix XI and Figure 17). The highest number of total grains panicle^{-1} (248.9) was observed in C_4 of the inbred variety (V_1) which was statistically similar with C_1 (243.6) of the inbred variety (V_1). The lowest number of total grains panicle^{-1} (83.23) was obtained from C_4 of the hybrid variety (V_2). Debnath (2010) also observed the highest number of total grains panicle^{-1} in clonal tiller combination with BRRI dhan29.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 17. Interaction effect of variety and planting material on total number of grains panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 26.63)

4.2.6 Filled grains panicle^{-1}

4.2.6.1 Effect of variety

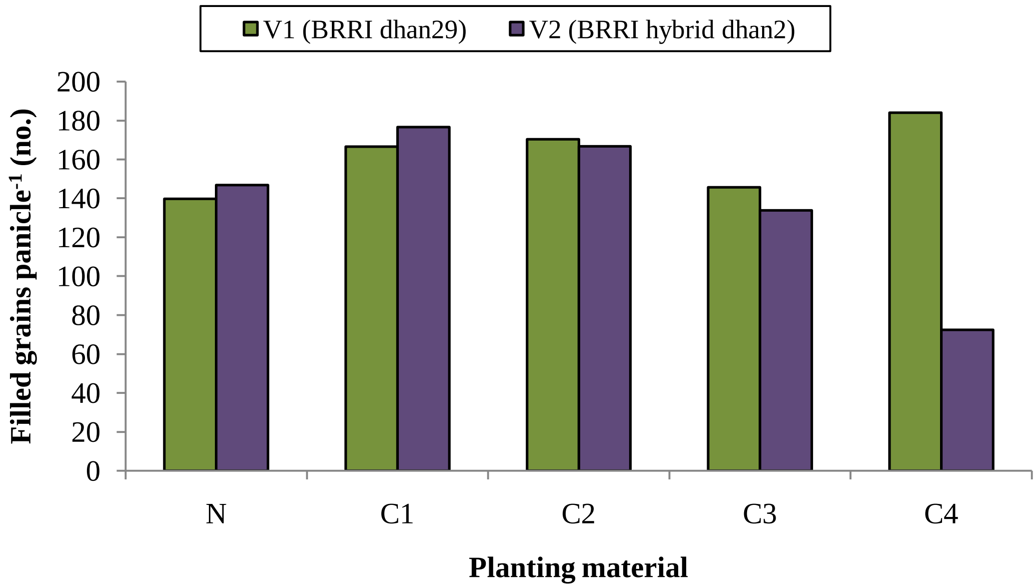
The number of filled grains panicle^{-1} differed significantly for variation of the variety (Appendix XI and Table 17). The higher number of filled grains panicle^{-1} (161.29) was found in the inbred variety BRRI dhan 29 and the lower number of filled grains panicle^{-1} (139.31) was obtained from the hybrid variety BRRI hybrid dhan2. This finding disagreed with Debnath (2010) who obtained the highest number of filled grains panicle^{-1} from the hybrid variety BRRI hybrid dhan2 and the lowest number of filled grains panicle^{-1} from the inbred variety BRRI dhan29.

4.2.6.2 Effect of planting material

The number of filled grains panicle^{-1} was significantly influenced by the planting material (Appendix XI and Table 18). The highest number of filled grains panicle^{-1} (171.60) was observed in C_1 which was statistically similar with C_2 (168.60) and the lowest number of filled grains panicle^{-1} (128.20) was obtained from C_4 which was statistically similar with C_3 (139.80). Ahmed (2006) observed dissimilar result where the number of filled grains panicle^{-1} was higher in nursery seedlings followed by clonal tillers.

4.2.6.3 Interaction effect of variety and planting material

The number of filled grains panicle^{-1} was significantly influenced by the interaction of variety and planting material (Appendix XI and Figure 18). The highest number of filled grains panicle^{-1} (184.90) was observed in C_4 of the inbred variety (V_1) which was statistically similar with C_2 (170.40), C_1 (166.60) of the inbred variety (V_1). The lowest number of filled grains panicle^{-1} (72.43) was obtained from C_4 of the hybrid variety (V_2).



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 18. Interaction effect of variety and planting material on number of filled grains panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 20.17)

4.2.7 Unfilled grains panicle^{-1}

4.2.7.1 Effect of variety

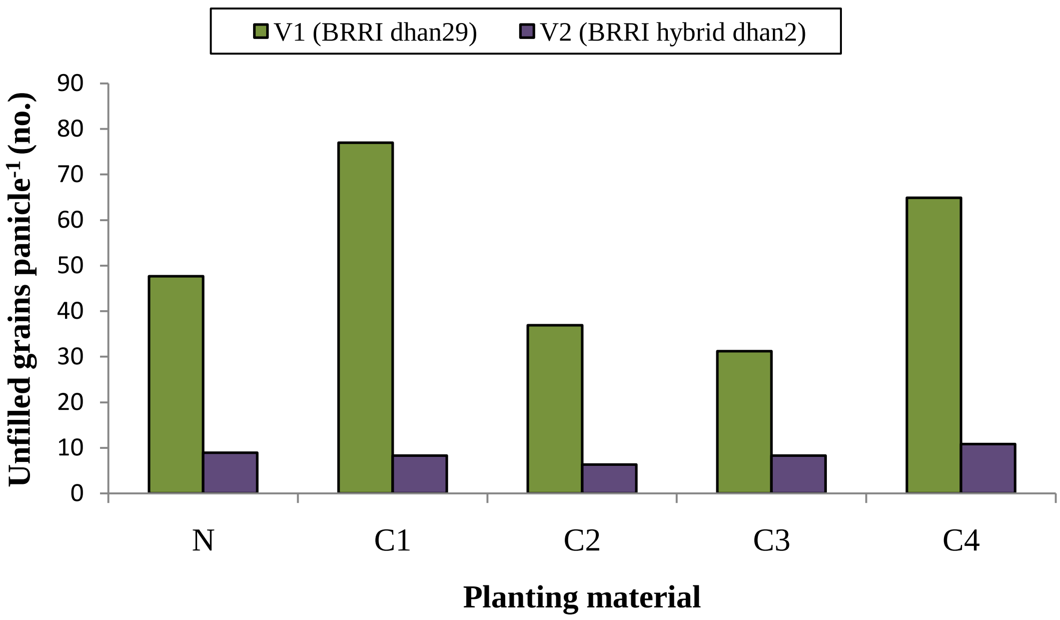
The number of unfilled grains panicle^{-1} differed significantly for variation of the variety (Appendix XI and Table 17). The higher number of unfilled grains panicle^{-1} (51.53) was found in the inbred variety BRRI dhan29 and the lower number of unfilled grains panicle^{-1} (8.52) was obtained from the hybrid variety BRRI hybrid dhan2. This finding agreed with Debnath (2010) who obtained the highest number of unfilled grains panicle^{-1} from the inbred variety BRRI dhan29 than hybrid variety BRRI hybrid dhan2 though Obaidullah (2007) observed the highest number of unfilled grains panicle^{-1} in the hybrid variety and the lowest number of unfilled grains panicle^{-1} in the inbred variety.

4.2.7.2 Effect of planting material

The number of unfilled grains panicle^{-1} was significantly influenced by the planting material (Appendix XI and Table 18). The highest number of unfilled grains panicle^{-1} (42.65) was observed in C_1 which was statistically similar with C_4 (37.83) and the lowest number of unfilled grains panicle^{-1} (19.75) was obtained from C_3 which was statistically similar with C_2 (21.60) and nursery seedlings (28.30). Ahmed (2006) observed dissimilar result where the unfilled grains panicle^{-1} was not significantly influenced by the nursery seedlings and clonal tillers.

4.2.7.3 Interaction effect of variety and planting material

The number of unfilled grains panicle^{-1} was significantly influenced by the interaction of variety and planting material (Appendix XI and figure 19). The highest number of unfilled grains panicle^{-1} (77.00) was observed in C_1 of the inbred variety (V_1) which was statistically similar with C_4 (64.87) of the inbred variety (V_1). The lowest number of unfilled grains panicle^{-1} (6.30) was obtained from C_2 of the hybrid variety (V_2) which was statistically similar with C_3 (8.26), C_1 (8.30), N (8.93) and C_4 (10.80) of the hybrid variety (V_2). Debnath (2010) also observed similar result where the combination of BRRI dhan29 with clonal tiller produced the highest number of unfilled grains panicle^{-1} and the combination of BRRI hybrid dhan2 with clonal tiller produced the lowest number of unfilled grains panicle^{-1}.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 19. Interaction effect of variety and planting material on number of unfilled grains panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 17.84)

4.2.8 Weight of 1000-grain

4.2.8.1 Effect of variety

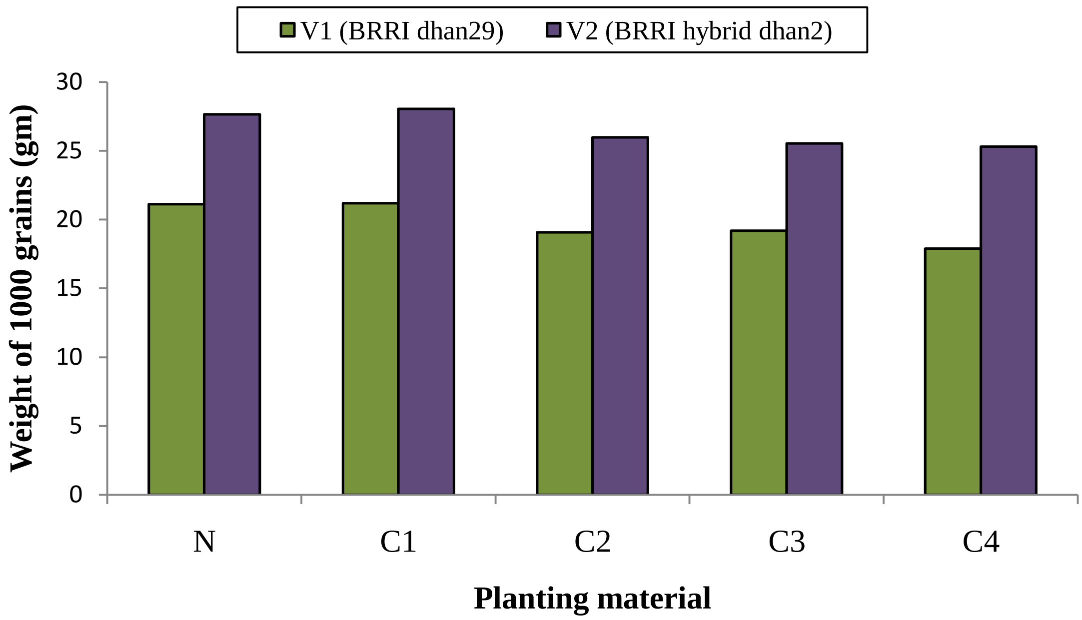
The weight of 1000-grain was significantly influenced by the variety (Appendix XI and Table 17). The maximum weight of 1000-grain (26.50 g) was obtained from the hybrid variety BRRI hybrid dhan2 and the minimum weight (19.70 g) was obtained from the inbred variety BRRI dhan29. The variation of 1000-grain weight between varieties might be due to the difference in their genetic makeup. The result supports the findings of Obaidullah (2007), Ashrafuzzaman (2006) and Debnath (2010) who found the highest weight of 1000-grains in hybrid variety than the inbred variety BRRI dhan29.

4.2.8.2 Effect of planting material

The weight of 1000-grain was significantly influenced by the planting material (Appendix XI and Table 18). The highest weight of 1000-grain (24.62 g) was obtained from C_1 which was statistically similar with nursery seedlings (24.40 g) and the lowest weight of 1000-grain (21.60 g) was obtained from C_4 which was statistically similar with C_3 (22.37 g). This finding disagreed with Debnath (2010), Ahmed (2006) and Bari (2004) who insignificant effect of nursery seedlings and clonal tiller in respect of weight of 1000-grains.

4.2.8.3 Interaction effect of variety and planting material

Interaction effect of variety and planting material was found significant in respect of weight of 1000-grain (Appendix XI and Figure 20). The highest weight of 1000-grain (28.05 g) was obtained from C_1 of the hybrid variety (V_2) which was statistically similar with nursery seedlings (27.66 g) of the hybrid variety (V_2) and the lowest weight of 1000-grain (17.89 g) was obtained from C_4 of the inbred variety (V_1). Debnath (2010) also observed higher weight of 1000-grain in the combination of BRRI hybrid dhan2 with nursery seedlings and clonal tillers than the combination of BRRI dhan29 with clonal tiller.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 20. Interaction effect of variety and planting material on weight of 1000 grains of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.1)

4.2.9 Grain yield

4.2.9.1 Effect of variety

Grain yield was not significantly influenced by the variety (Appendix XI and Table 19). Numerically the higher grain yield (6.05 t ha^{-1}) was obtained from the inbred variety BRRI dhan29 and lower (6.01 t ha^{-1}) from the hybrid variety BRRI hybrid dhan2. Debnath (2010) also observed dissimilar result where BRRI hybrid dhan2 produced significantly higher yield (5.92 t ha^{-1}) than BRRI dhan29 (4.97 t ha^{-1}) and Ahmed (2006) found higher grain yield in hybrid variety than BRRI dhan29.

Table 19. Effect of variety on yield and other crop characters of inbred and hybrid *boro* rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1 (BRRI dhan29)	6.05	5.59	11.63	52.26
V_2 (BRRI hybrid dhan2)	6.01	5.5	11.51	51.48
LSD $_{(0.05)}$	NS	NS	NS	NS
CV (%)	5.08	7.80	4.87	4.27

NS = Not significant

4.2.9.2 Effect of planting material

Grain yield was significantly influenced by the planting material (Appendix XI and Table 20). The highest grain yield (9.23 t ha^{-1}) was obtained from the nursery seedlings (N) and the lowest grain yield (2.97 t ha^{-1}) was observed in C_3. The yield reduction of clonal tillers than nursery seedlings was 24.06%, 40.48%, 210.77% and 136.06% for C_1, C_2, C_3 and C_4, respectively. Debnath (2012), Obaidullah (2007) and Ahmed (2006) also found higher grain yield in nursery seedlings than clonal tillers of first generation. The reduction of yield in clonal tillers compared to nursery seedlings might be due to the removal of tillers from the mother plant (Murthy *et al*., 1991).

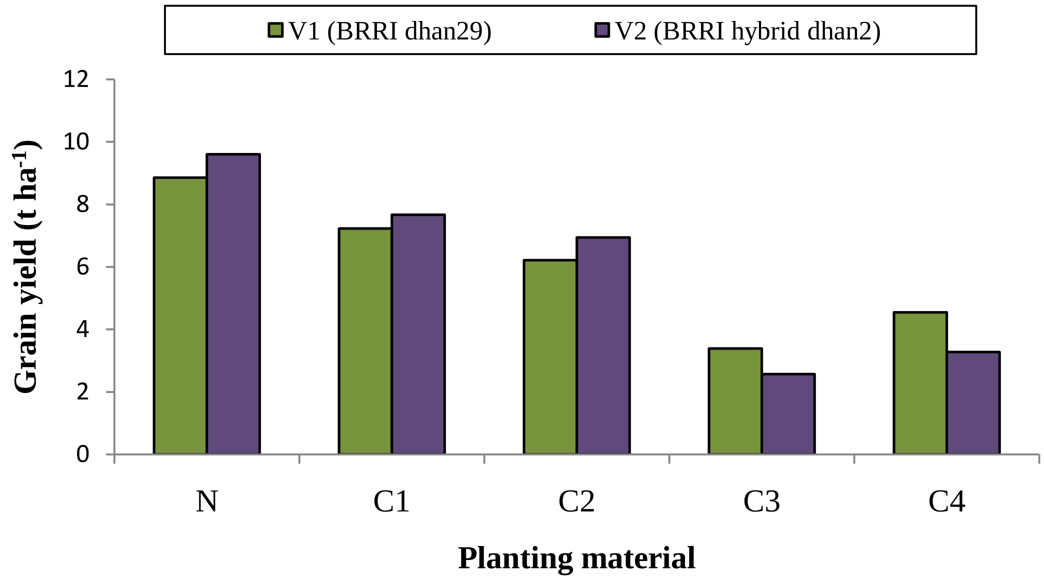
Table 20. Effect of planting material on yield contributing characters of inbred and hybrid *boro* rice

Treatments	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
N	9.23a	8.26a	17.50a	52.73
C_1	7.44b	6.87b	14.32b	52.06
C_2	6.57c	6.07c	12.66c	52.03
C_3	2.97e	2.82e	5.79e	51.34
C_4	3.91d	3.69d	7.60d	51.20
LSD $_{(0.05)}$	0.59	0.63	1.08	NS
CV (%)	8.09	9.27	7.66	5.44

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from $C_{3,}$ NS = Not significant

4.2.9.3 Interaction effect of variety and planting material

Interaction between variety and planting material played an important role for promoting the yield. Grain yield was significantly influenced by the interaction effect of variety and planting material (Appendix XI and Figure 21). Among the treatments, the highest grain yield (9.60 t ha^{-1}) was observed in nursery seedlings of the hybrid variety (V_2), which was statistically similar with nursery seedlings (8.86 t ha^{-1}) of the inbred variety (V_1). This result disagreed with Ahmed (2006) who found the highest yield in the combination of the inbred variety and nursery seedlings. The lowest grain yield was observed in C_3 (2.57 t ha^{-1}) of the hybrid variety (V_2) which was statistically similar with C_4 (3.28 t ha^{-1}) of the hybrid variety (V_2) and C_3 (3.39 t ha^{-1}) of the inbred variety (V_1). Debnath (2012) also observed similar result where the highest grain yield produced in the combination of nursery seedlings with BRRI hybrid dhan2 and the lowest in the combination of clonal tillers with BRRI hybrid dhan2.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 21. Interaction effect of variety and planting material on grain yield of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.84)

4.2.10 Straw yield

4.2.10.1 Effect of variety

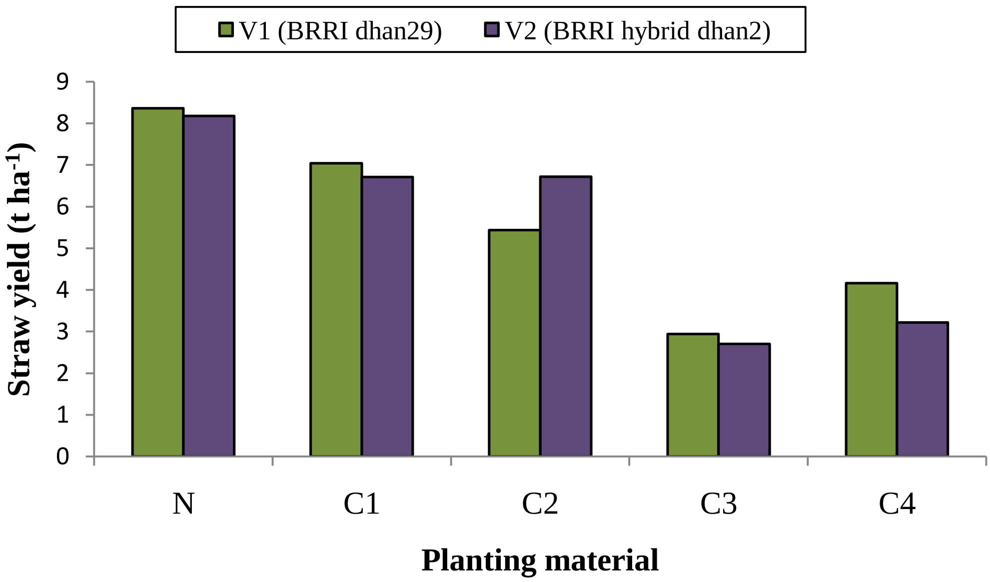
Straw yield was not significantly influenced by the variety (Appendix XI and Table 19). Numerically higher straw yield (5.59 t ha^{-1}) was obtained from the inbred variety BRRI dhan29 and lower (5.50 t ha^{-1}) from the hybrid variety BRRI hybrid dhan2. This might be due to the higher plant height and higher number of tillers $hill^{-1}$ of the inbred variety than the hybrid one. Debnath (2012) and Ahmed (2006) also observed similar result where BRRI dhan29 produced higher straw yield than BRRI hybrid dhan2. Akbar (2004) reported that inbred variety produced higher straw yield than the hybrid varieties.

4.2.10.2 Effect of planting material

Straw yield was significantly influenced by the planting material (Appendix XI and Table 20). The highest straw yield (8.27 t ha^{-1}) was obtained from the nursery seedlings (N) and the lowest straw yield (2.82 t ha^{-1}) was observed in C_3. The probable reasons of increased straw yield in the nursery seedlings might be due to higher total number of tillers m^{-2} and taller plants. Debnath (2012) and Ahmed (2006) also found higher straw yield in nursery seedlings than clonal tillers.

4.2.10.3 Interaction effect of variety and planting material

Straw yield was significantly influenced by the interaction effect of variety and planting material (Appendix XI and Figure 22). Among the treatments, the highest straw yield (8.36 t ha^{-1}) was observed in nursery seedlings (N) of the inbred variety (V_1), which was statistically similar with nursery seedlings (8.18 t ha^{-1}) of the hybrid variety (V_2). The lowest straw yield was observed in C_3 (2.70 t ha^{-1}) of the hybrid variety (V_2) which was statistically similar with C_3 (2.94 t ha^{-1}) of the inbred variety (V_1) and C_4 (3.22 t ha^{-1}) of the hybrid variety (V_2). Debnath (2010) also observed similar result where the highest straw yield produced in the combination of nursery seedlings with BRRI hybrid dhan2 and the lowest in the combination of clonal tillers with BRRI hybrid dhan2.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 22. Interaction effect of variety and planting material on straw yield of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.89)

4.2.11 Biological yield

4.2.11.1 Effect of variety

Biological yield was not significantly influenced by the variety (Appendix XI and Table 19). Numerically higher biological yield (11.63 t ha^{-1}) was obtained from the inbred variety BRRI dhan29 and lower (11.51 t ha^{-1}) from the hybrid variety BRRI hybrid dhan2. Debnath (2010) and Ahmed (2006) also observed similar result where BRRI dhan29 produced higher biological yield than BRRI hybrid dhan2 however Rahman (2001) reported that hybrid variety produced higher biological yield compared to BRRI dhan29.

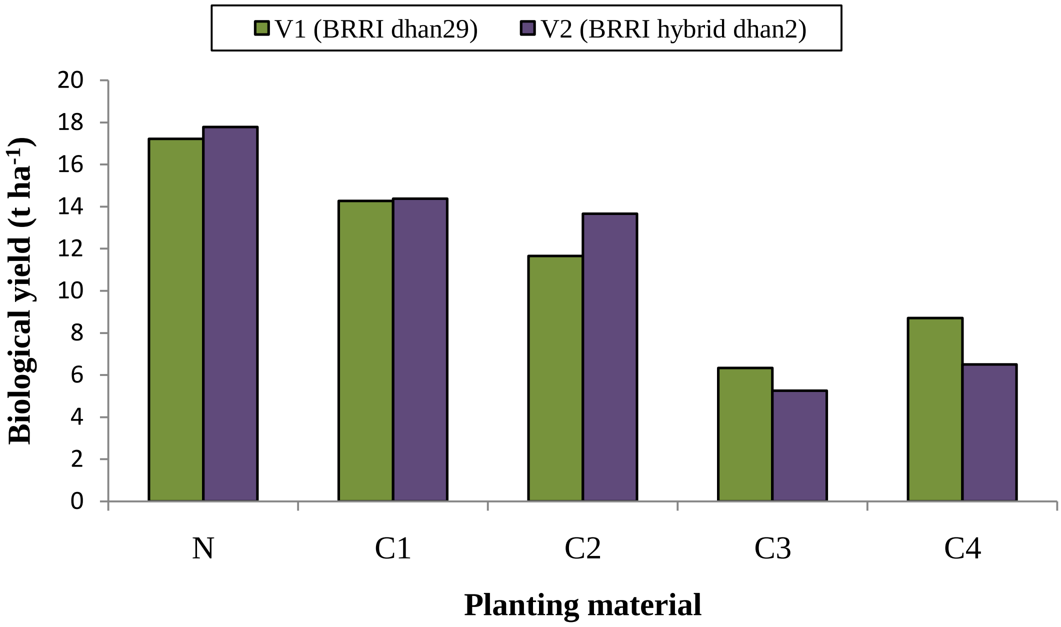
4.2.11.2 Effect of planting material

Biological yield was significantly influenced by the planting material (Appendix XI and Table 20). The highest biological yield (17.50 t ha^{-1}) was obtained from the nursery seedlings. Nursery seedlings produced the highest grain yield and straw yield which resulted in the highest biological yield. Rahman (2001) observed the highest biological yield in the intact crop comparing to the clonally propagated crops. The lowest biological yield (5.80 t ha^{-1}) was found from C_3. This was due to the lowest amount of grain and straw yield in C_3. Debnath (2012) and Ahmed (2006) also found higher biological yield in nursery seedlings than clonal tillers.

4.2.11.3 Interaction effect of variety and planting material

Interaction effect between variety and planting material was significant in respect of biological yield (Appendix XI and Figure 23). The highest biological yield (17.78 t ha^{-1}) was observed in nursery seedlings (N) of the hybrid variety (V_2), which was statistically similar with nursery seedlings (17.22 t ha^{-1}) of the inbred variety (V_1). This result disagreed with Ahmed (2006) who found the highest yield in the combination of the inbred variety and nursery seedlings. The lowest yield was observed in C_3 (5.26 t ha^{-1}) of the hybrid variety (V_2) which was statistically similar with C_3 (6.33 t ha^{-1}) of the inbred variety (V_1) and C_4 (6.50 t ha^{-1}) of the hybrid variety (V_2). Akbar (2004) found the highest biological yield in combination of the inbred variety and 15 day-old seedlings. Debnath (2012) also observed similar result where the highest biological yield produced in the combination of nursery seedlings with

BRRI hybrid dhan2 and the lowest in the combination of clonal tillers with BRRI hybrid dhan2.



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 23. Interaction effect of variety and planting material on biological yield of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.53)

4.2.12 Harvest index (%)

4.2.12.1 Effect of variety

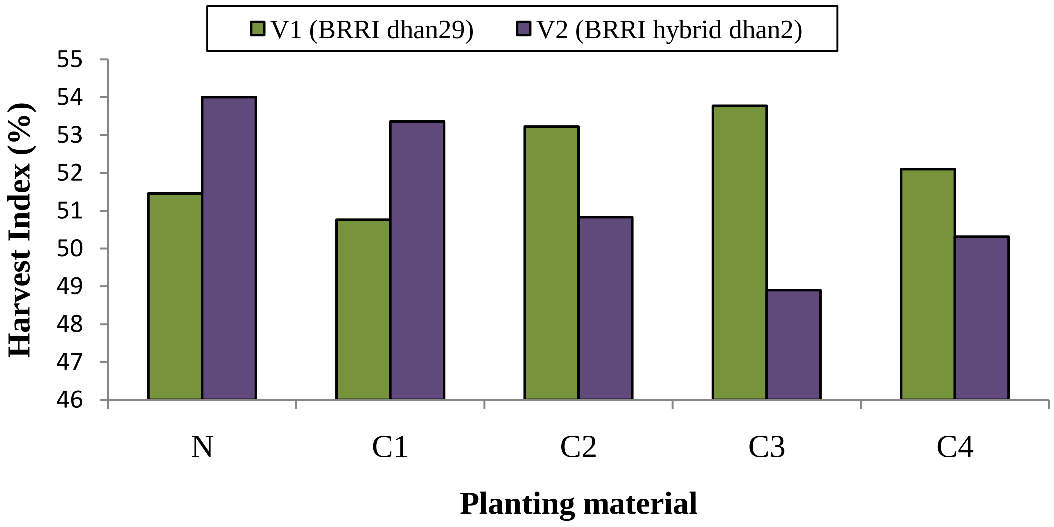
Harvest index was not significantly influenced by the variety (Appendix XI and Table 19). Numerically higher harvest index (52.26%) was obtained from the inbred variety BRRI dhan29 and lower (51.48%) from the hybrid variety BRRI hybrid dhan2. However this finding disagreed with Debnath (2010) and Ahmed (2006) who observed significant difference between inbred and hybrid variety in respect of harvest index where the higher harvest index was obtained from the hybrid variety than that of inbred variety. Rahman (2001) also observed highest harvest index in hybrid variety than the inbred varieties.

4.2.12.2 Effect of planting material

Harvest index was not significantly influenced by the planting material (Appendix XI and Table 20). Numerically the highest harvest index (52.73%) was obtained from the nursery seedlings (N). The lowest harvest index (51.20%) was found from C_4. This was due to the lowest amount of grain and straw yield in C_3. Debnath *et al.* (2012) also found higher harvest index in nursery seedlings than clonal tillers though Biswas (2001) observed higher harvest index in clonal tillers than nursery seedlings.

4.2.11.3 Interaction effect of variety and planting material

Interaction effect between variety and planting material was significant in respect of harvest index (Appendix XI and Figure 24). The highest harvest index (54.00%) was observed in nursery seedlings of the hybrid variety (V_2), which was statistically similar with C_3 (53.77%), C_2 (53.22%), C_4 (52.10%), N (51.46%) and C_1 (50.76%) of the inbred variety (V_1) and C_1 (53.36%), C_2 (50.83%) and C_4 (50.31%) of the hybrid variety (V_2). The lowest harvest index (48.90%) was observed in C_3 of the hybrid variety (V_2), which was statistically similar with C_4 (50.31), C_2 (50.83%) and C_1 (53.36%) of the hybrid variety (V_2) and C_1 (50.76%), N (51.46%), C_4 (52.10%), C_2 (53.22%) and C_3 (53.77%) of the inbred variety (V_1).



N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

Figure 24. Interaction effect of variety and planting material on harvest index (%) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 4.88)

Chapter 5

Summary and conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from November 2012 to July 2013 to study on the cultivation of different clonal tillers separated from the successive generation of nursery seedlings of hybrid and inbred rice in *boro* season under the Modhupur Tract (AEZ-28). The experiment was comprised of two sets of treatments viz. A. Variety: (BRRI dhan29 and BRRI hybrid dhan2) and B. Planting material: (Nursery seedlings (N), First generation clonal tillers (C_1) collected from N, Second generation clonal tillers (C_2) collected from C_1 , Third generation clonal tillers (C_3) collected from C_2 and Fourth generation clonal tillers (C_4) collected from C_3). The experiment was laid out in split-plot design with three replications having variety in the main plots and planting materials in the sub plots.

The data on crop growth characters (plant height, number of tillers hill^{-1}, number of leaves hill^{-1}, length of root, leaf area index (LAI) and dry mater production) were recorded in the field and yield as well as yield contributing characters (number of effective and ineffective tillers hill^{-1}, panicle length, rachis branches panicle^{-1}, 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 analysed using 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 except total number of tillers hill^{-1}, number of leaves hill^{-1}, length of root, dry mater production, effective and ineffective tillers m^{-2}, grain and straw yield, biological yield and harvest index. It revealed that BRRI dhan29 showed significantly taller plant throughout the growing period at 30, 55 and 80 DAT and at harvest. The leaf area index (LAI) was not significantly influenced at early growth stage but later it showed significant effect throughout the growing period till harvest whereas BRRI dhan29 gave higher leaf area index than that of BRRI hybrid dhan2. BRRI dhan29 needed longer time for flowering (100 days) and maturity (130 days) as compared to BRRI hybrid dhan2 (89 days and 123 days respectively). The higher (26.79 cm) and lower (22.77 cm) panicle length was obtained from BRRI dhan29 and BRRI hybrid dhan2 respectively. The higher number of rachis branches panicle^{-1} (9.85) was observed in BRRI dhan29 and the lower number of branches panicle^{-1} (8.27) was observed in BRRI hybrid dhan2. The higher number of total grains, filled grains and unfilled grains panicle^{-1} (212.82, 161.29 and 51.53) respectively were obtained from the inbred variety and the lower number of total grains, filled grains and unfilled grains panicle^{-1} (147.83, 139.31 and 8.52) respectively were obtained from the hybrid variety. The higher weight of 1000-grain (26.50 g) was obtained from the hybrid variety and the lower weight of 1000-grain (19.70 g) was obtained from the inbred variety.

Planting material also significantly had influenced the growth and yield attributes except number of effective tillers m^{-2} and harvest index. At harvest, the tallest plant (98.95 cm) was obtained from C_1 and the shortest plant height was obtained from C_3 (77.20 cm). The highest number of tillers hill^{-1} at early growth stage was observed in C_1 (6.37) and the lowest number of tillers hill^{-1} was obtained from nursery seedlings (2.17) though there was no significant difference in respect of number of tillers hill^{-1} among the planting materials at harvest.

The highest leaf area index (LAI) at early growth period to 50 DAT produced by C_2 and the lowest leaf area index produced by the nursery seedlings. Highest LAI (3.68) at 80 DAT was obtained from C_2 and the lowest LAI (2.76) was observed in C_3. However C_4 produced highest LAI (3.34) and the lowest LAI (2.34) was observed in C_1 at harvest. The total dry matter production of plant was significantly influenced by planting material whereas nursery seedlings produced lowest dry weight from early growth stage to 80DAT though at harvest the highest dry weight (1891 g m^{-2}) was obtained from the nursery seedlings (1891 g m^{-2}) and the lowest dry weight was observed in C_3 (696.3 g m^{-2}). The highest duration (143.80 and 172.20 days respectively) needed for flowering and for maturity of nursery seedling (N) and the lowest duration (64.17, 95.67 days respectively) for flowering and maturity was observed in C_3 and C_4 respectively.

The highest panicle length (25.72 cm) was observed in C_1 and the lowest panicle length (23.72 cm). The highest number of rachis branches panicle^{-1} (10.05) was obtained from nursery seedlings (N) and the lowest number of rachis branches panicle^{-1} (7.85) was obtained from C_3. The highest number of total grains panicle^{-1} (214.30) and highest number of filled grains panicle^{-1} (171.60) was observed in C_1 and the lowest number of total grains panicle^{-1} (159.60) and filled grains panicle^{-1} (128.20) was obtained from C_3 and C_4 respectively. The weight of 1000-grains was significantly influenced by the planting material. The highest weight of 1000-grain (24.62 g) was obtained from C_1 and the lowest weight of 1000-grain (21.60 g) was obtained from C_4. The highest grain yield and straw yield (9.23 t ha^{-1} and 8.27 t ha^{-1}) were obtained from the nursery seedlings and the lowest grain yield and straw yield (2.97 t ha^{-1} and 2.82 t ha^{-1}) were observed in C_3.

Interaction effect of variety and planting material also significantly influenced all the growth as well as yield and other crop characters. The results revealed that at 30 DAT, the tallest plant (79.56cm) was obtained from the V_1C_4 and the shortest plant (22.11 cm) was obtained from the V_1N. The tallest plant (100.6 cm) was recorded at 55 DAT from V_1C_2 and the shortest plant (30.27 cm) was obtained from V_1N. At 80 DAT the tallest plant was observed from V_1C_2 (99.87) and the shortest plant (53.93 cm) was obtained from V_1N. At harvest, the tallest plant (99.57 cm) was obtained from V_1C_1 and the shortest plant was obtained from V_2C_3 (68.03 cm). The highest numbers of tillers hill^{-1} was observed at 30 DAT in V_1C_4 (6.93) followed by V_2N (2.26). At 55 DAT highest number of tillers hill^{-1} were obtained from V_1C_2 (10.53) followed by V_1N (4.93). Highest numbers of tiller hill^{-1} at 80 DAT was observed in V_1N (14.47) and the lowest numbers of tiller hill^{-1} was obtained from V_2C_2 (6.66). At harvest highest number of tillers hill^{-1} were obtained from V_1N (14.47) and the lowest number of tillers hill^{-1} was obtained from V_2C_2 (6.66).The highest leaf area index (LAI) at 30 DAT, was observed in V_1C_2 (2.46) and the lowest LAI was observed in V_1N (0.11). At 55 DAT the highest LAI was obtained from V_1C_2 (3.94) and the lowest LAI was observed in V_2N (0.72). Highest LAI at 80 DAT was observed in V_1C_2 (4.78) and the lowest LAI was observed in V_2C_4 (2.43). At harvest highest LAI (4.38) was obtained from V_1C_4 and the lowest LAI (2.30) was obtained from V_2C_4. The highest dry weight was observed in V_1C_4 (370.9 g m^{-2}) and the lowest in V_1N (4.05 g m^{-2}). At 55 DAT the highest dry weight were obtained from V_1C_2 (765.9 g m^{-2}) and the lowest from V_1N (55.04 g m^{-2}). At 80 DAT the highest dry weight was observed in V_1C_1 (1491 g m^{-2}) and the lowest in V_2C_4 (347.5 g m^{-2}). At harvest the highest dry weight was obtained from V_1N (1983 g m^{-2}) and the lowest from V_2C_4

(347.5 g m^{-2}). Nursery seedlings of the inbred variety needed the highest duration for flowering (145.3 days) and also for maturity (175.3 days) and C_4 of the hybrid variety needed the lowest duration for flowering (54.33 days) and for maturity (95.00 days). The highest number of effective tillers m^{-2} (260.5) was observed in V_1C_1 and the lowest number of effective tillers m^{-2} (176.0) was obtained from V_2C_2. The highest panicle length and the highest number of rachis branches panicle^{-1} was observed in V_1C_4 (25.72 cm) and V_1N (10.57) respectively and the lowest panicle length and lowest number of rachis branches panicle^{-1} was observed in V_2C_4 (18.87 cm and 6.17 respectively). The highest number of total grains panicle^{-1} and filled grains panicle^{-1} (248.90 and 184.90 respectively) was observed in V_1C_4 and the lowest number of total grains panicle^{-1} and filled grains panicle^{-1} (83.23 and 72.43 respectively) was obtained from V_2C_4. The highest weight of 1000-grain (28.05 g) was obtained from V_2C_1 the lowest weight of 1000-grain (17.89 g) was obtained from V_1C_4. The highest grain yield and harvest index (9.60 t ha^{-1} and 54.00%) were observed in V_2N and the lowest grain yield and harvest index were observed in V_2C_3 (2.57 t ha^{-1} and 48.90%).

Based on the results of the present study, the following conclusions may be drawn-

- ❖ Both inbred and hybrid varieties gave similar yield irrespective to nursery seedling and upto third generation clonal tillers treatment.
- ❖ The clonal tillers can be utilized upto second generation with little sacrifice of yield irrespective of inbred and hybrid rice.
- ❖ Rice may be cultivated using their clonal tillers of continuous generations.

However, to reach a specific conclusion and recommendation the experiments with clonal tillers of successive generation need to be repeated with more varieties and in different agro-ecological zones.

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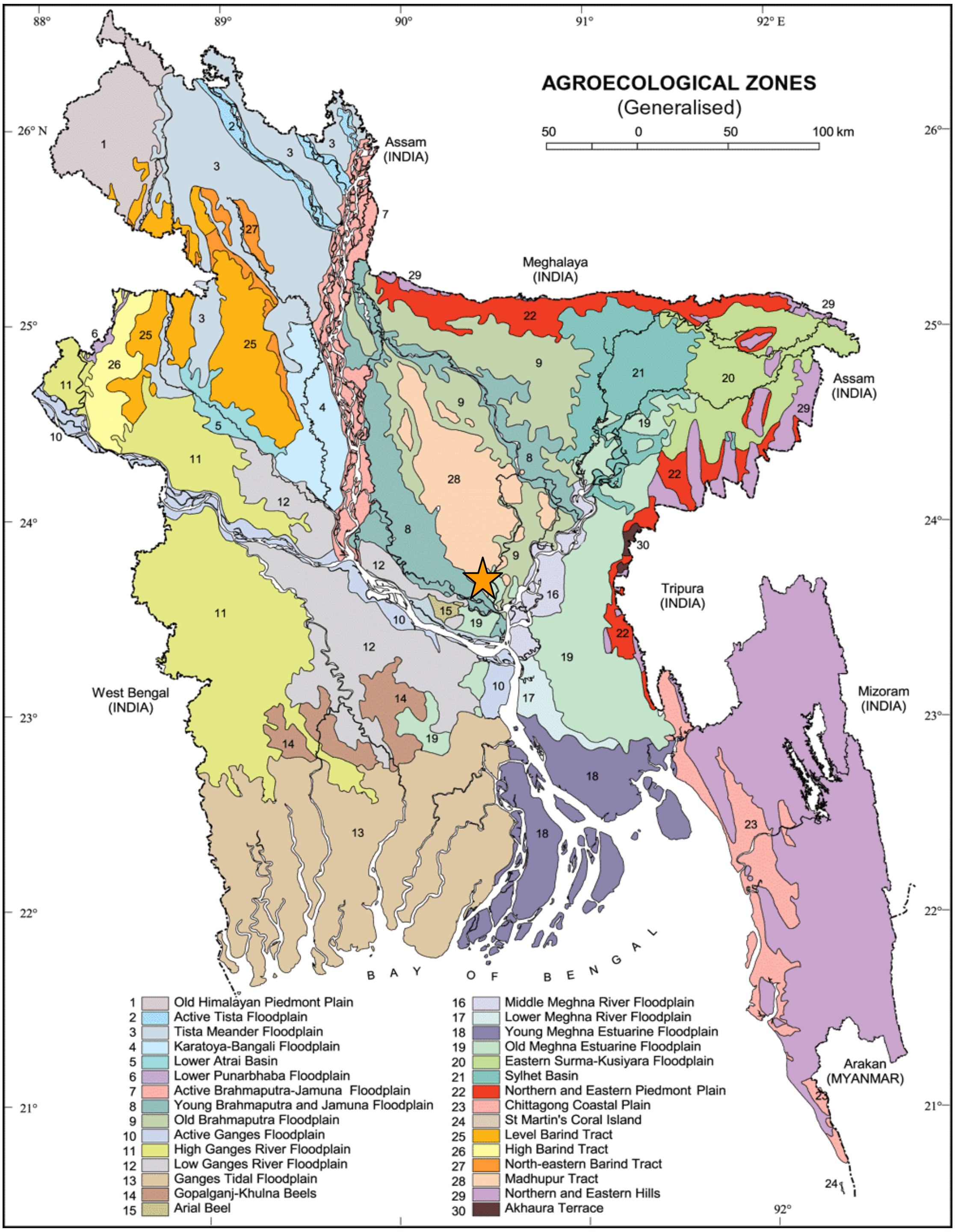
Appendices

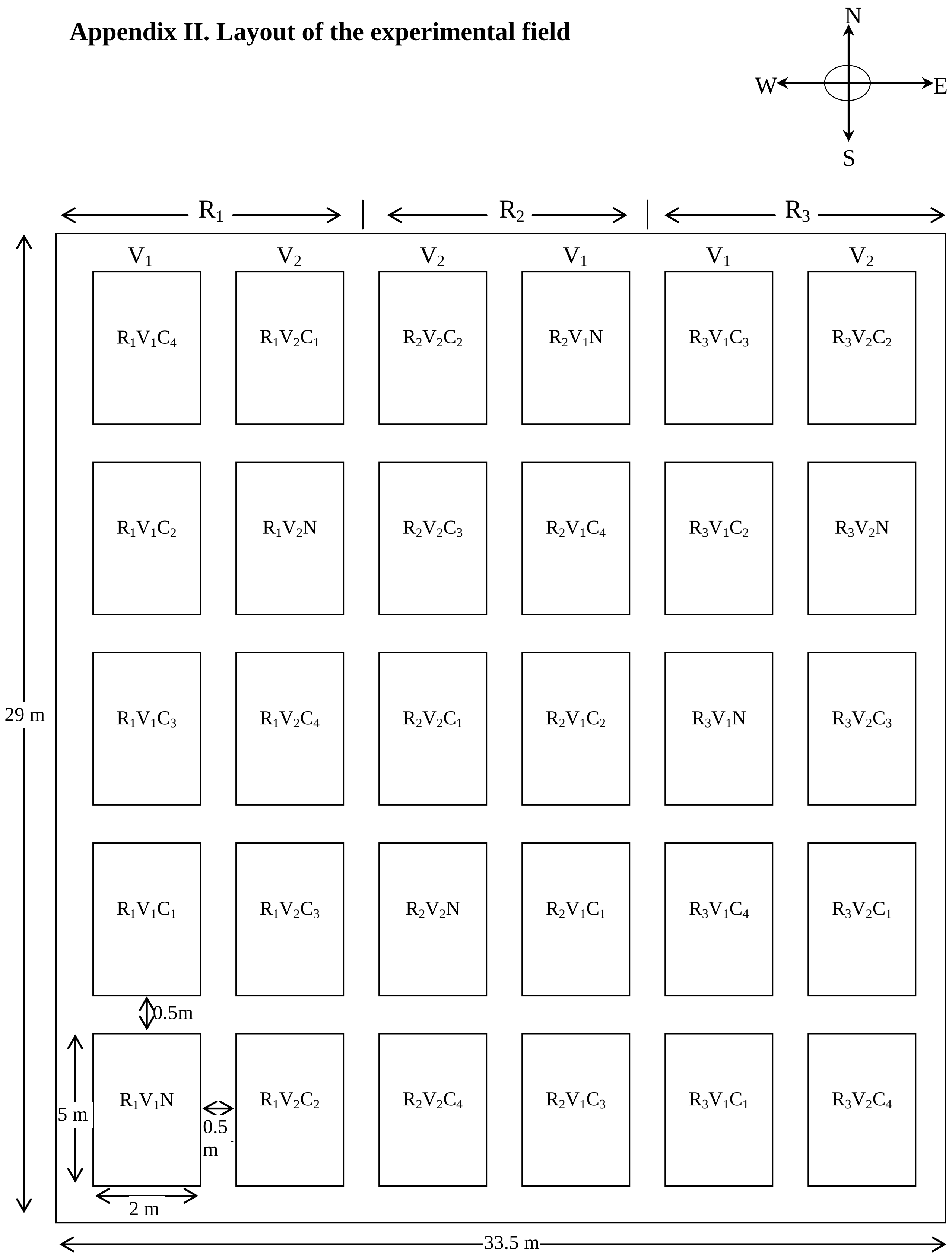
APPENDICES

Appendix I. Map showing the experimental sites under study

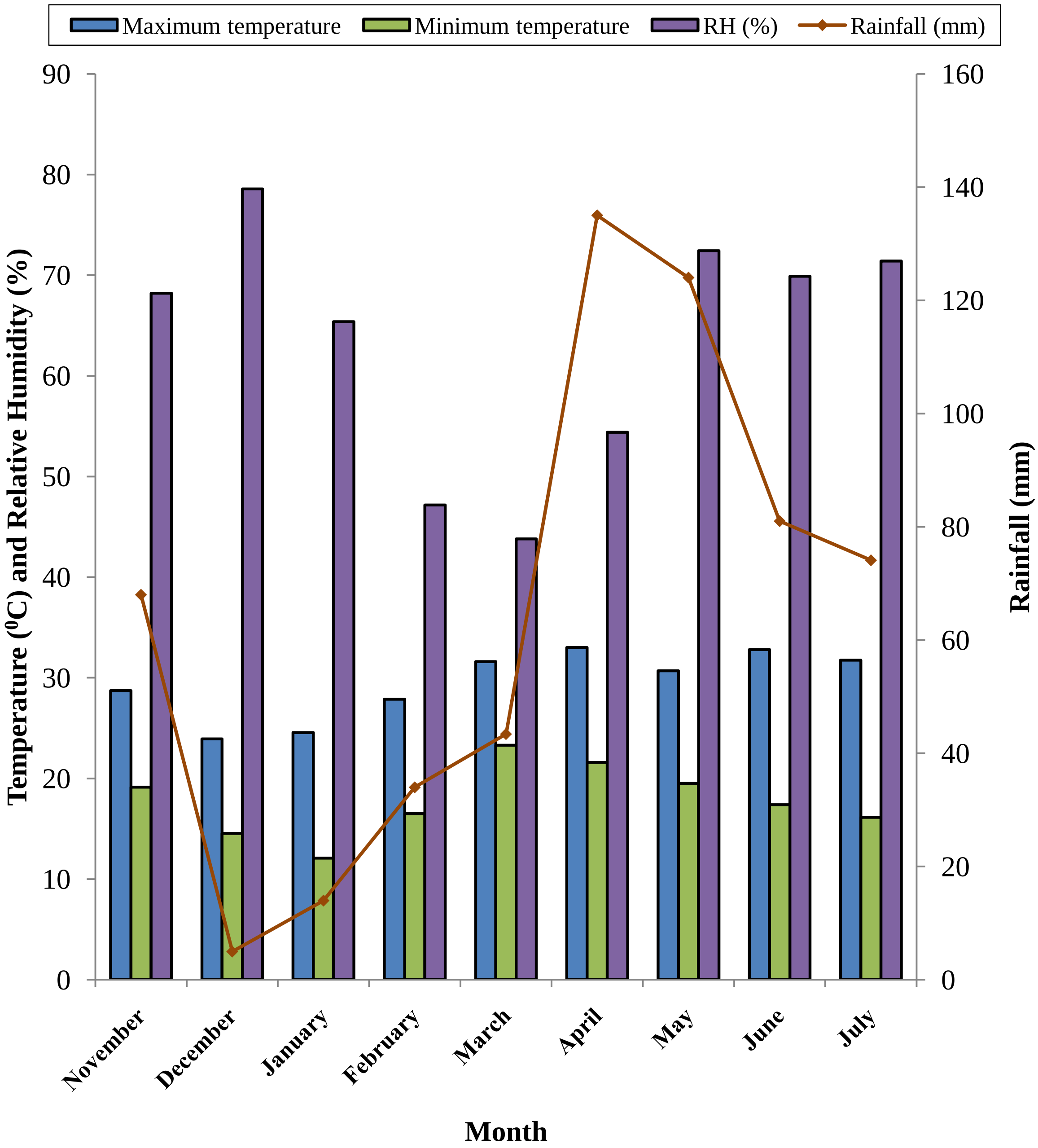


☆ The experimental site under study

Appendix II. Layout of the experimental field



Appendix III. Monthly record of average air temperature, relative humidity and total rainfall of the experimental site during the period from November 2012 to July 2013



Source: Weather station, Sher-e-Bangla Agricultural University, Dhaka-1207.

Appendix IV. Mean square values for plant height at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for plant height at different days after transplanting			
		30	55	80	At harvest
Replication	2	5.05	19.98	1.65	8.68
Variety	1	431.07*	938.78*	1067.80*	144.22*
Error (a)	2	0.64	1.91	2.72	6.94
Planting material	4	2495.04*	3493.43*	1839.41*	497.49*
Variety × planting material	4	111.36*	280.10*	189.38*	193.48*
Error (b)	16	15.36	12.40	22.22	13.16

* Significant at 5% level

Appendix V. Mean square values for tiller numbers hill^{-1} at different days after transplanting of *boro* rice

Sources of variation	Degrees of freedom	Mean square values for tiller numbers hill^{-1} at different days after transplanting			
		30	55	80	At harvest
Replication	2	2.60	5.82	6.38	8.08
Variety	1	7.00	9.41	9.63	3.14
Error (a)	2	4.71	1.73	6.36	2.84
Planting material	4	18.55*	25.74*	20.26*	1.50
Variety × planting material	4	0.87*	3.21*	9.39*	6.86*
Error (b)	16	1.59	2.68	1.91	1.36

* Significant at 5% level

Appendix VI. Mean square values for leaf numbers hill^{-1} at different days after transplanting of *boro* rice

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting			
		30	55	80	At harvest
Replication	2	79.07	101.40	112.06	174.91
Variety	1	197.63	781.12	167.09	158.24
Error (a)	2	55.95	42.40	91.92	99.01
Planting material	4	242.07*	801.17*	196.60*	52.12
Variety × planting material	4	37.99*	115.39*	149.60*	157.55*
Error (b)	16	20.19	40.11	43.22	41.05

* Significant at 5% level

Appendix VII. Mean square values for length of root at different days after transplanting of *boro* rice

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting			
		30	55	80	At harvest
Replication	2	4.34	5.36	8.11	1.63
Variety	1	7.95	7.50	8.53	15.41
Error (a)	2	22.21	7.82	4.61	1.43
Planting material	4	34.81*	79.25*	86.65*	27.61*
Variety × planting material	4	8.89*	4.33*	13.85*	27.10*
Error (b)	16	3.87	6.84	4.24	7.19

* Significant at 5% level

Appendix VIII. Mean square values for leaf area index at different days after transplanting of *boro* rice

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting			
		30	55	80	At harvest
Replication	2	0.756	0.869	1.292	0.943
Variety	1	1.261	4.945*	6.950*	3.516*
Error (a)	2	0.432	0.103	0.168	0.303
Planting material	4	3.037*	4.572*	0.699*	1.043*
Variety × planting material	4	0.473*	1.598*	1.658*	1.526*
Error (b)	16	0.325	0.225	0.378	0.351

* Significant at 5% level

Appendix IX. Mean square values for total dry matter weight at different days after transplanting of *boro* rice

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting			
		30	55	80	At harvest
Replication	2	14657.50	14345.90	217679.25	354528.17
Variety	1	35881.59	18259.50	361491.47	403140.06
Error (a)	2	7364.27	45818.93	117199.10	414325.50
Planting material	4	58353.51*	434585.07*	730443.83*	1861358.66*
Variety × planting material	4	10478.95*	66405.29*	130821.03*	112075.25*
Error (b)	16	4690.09	29387.90	78831.49	90241.58

* Significant at 5% level

Appendix X. Mean square values for dry matter weight of different plant parts of *boro* rice at harvest

Sources of variation	Degrees of freedom	Mean square values at harvest		
		Panicle	Shoot	Root
Replication	2	118654.49	32614.42	4647.34
Variety	1	22636.71	104070.65	26478.38
Error (a)	2	48327.23	78722.24	21179.95
Planting material	4	865019.65*	89524.80*	40394.34*
Variety × planting material	4	3992.67*	59739.75*	2350.08*
Error (b)	16	25501.91	16861.86	5405.65

* Significant at 5% level

Appendix XI. Summary of analysis of variance for crop growth characters, yield and other crop charaters of BRRI dhan29 and BRRI hybrid dhan2 at harvest

Sources of Variation	Degrees of freedom	Mean square values													
		Duration of flowering (Days)	Duration of maturity (Days)	Effective tillers m^{-2} (no.)	Ineffective tillers m^{-2} (no.)	Panicle length (cm)	Rachis branches $panicle^{-1}$	Total grains $panicle^{-1}$ (no.)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	1000-grains weight (g)	Grain yield (t/ ha)	Straw yield (t/ha)	Biolo-gical yield (t/ha)	Harvest index (%)
Replication	2	0.933	0.300	1368.74	6.505	1.443	0.181	108.02	44.33	82.92	0.063	0.484	0.304	0.961	24.12
Variety	1	940.80*	320.13*	1844.34	301.08	120.80*	18.88*	31674.50*	3621.20*	13876.10*	347.48*	0.010	0.052	0.108	4.579
Error (a)	2	0.400	1.633	2921.01	253.69	0.146	0.446	181.55	25.82	92.97	0.096	0.094	0.187	0.318	4.915
Planting material	4	7179.80*	5672.13*	1505.57	551.59 *	5.325*	6.22*	2940.32*	2153.41*	599.84*	10.68*	39.55*	30.48*	139.45*	2.289
Variety × planting material	4	111.30*	46.13*	4192.86*	252.30*	16.79*	0.533*	4927.93*	3876.18*	508.59*	0.253*	1.335*	1.014*	3.877*	16.05*
Error (b)	16	0.750	0.633	2109.33	102.22	0.987	0.512	186.33	135.72	106.28	0.403	0.238	0.265	0.787	7.962

* Significant at 5% level

Nursery seedlings

Uprooted hills for clonal tiller separation

Separation of clonal tillers

Separated clonal tillers

Plate 1. Information of the planting materials

Preparation of main field

Transplantation of seedlings

A field view at a glance

Plate 2. Information of the experiment

Vegetative stage (Nursery seedlings)

Vegetative stage (Clonal tillers)

Nursery seedlings of BRRI dhan29

First generation clonal tillers of BRRI dhan29

Plate 3. Field view of different planting materials of BRRI dhan29

Second generation clonal tillers of BRRI dhan29

Third generation clonal tillers of BRRI dhan29

Fourth generation clonal tillers of BRRI dhan29

Nursery seedlings of BRRI hybrid dhan2

Plate 4. Field view of different planting materials of BRRI dhan29 and BRRI hybrid dhan2

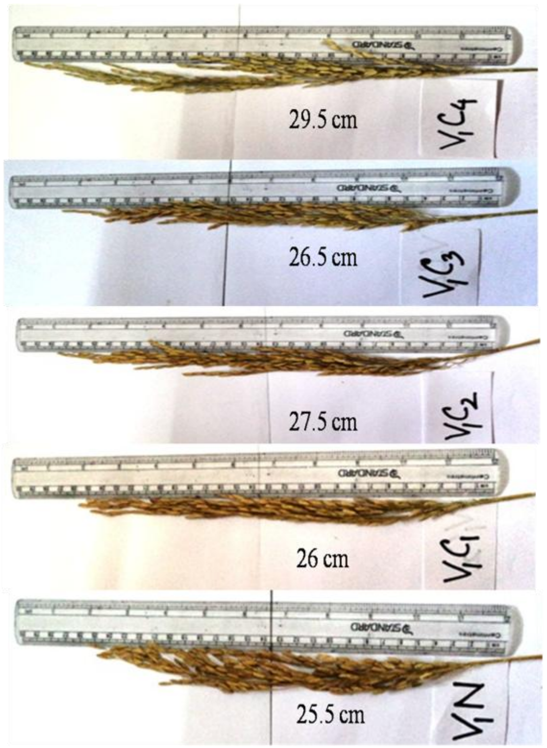
First generation clonal tillers of BRRI hybrid dhan2

Second generation clonal tillers of BRRI hybrid dhan2

Third generation clonal tillers of BRRI hybrid dhan2

Fourth generation clonal tillers of BRRI hybrid dhan2

Plate 5. Field view of different planting materials of BRRI hybrid dhan2



Panicle length of different planting materials (BRRI dhan29)

Panicle length of different planting materials (BRRI hybrid dhan2)

Plate 6. Panicle length of two varieties with different planting materials