INFLUENCE OF PLANTING MATERIAL AND VARIETY ON YIELD OF *BORO* RICE

A Thesis
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CERTIFICATE

This is to certify that thesis entitled, **"INFLUENCE OF PLANTING MATERIAL AND VARIETY ON YIELD OF *BORO* RICE"** submitted to the ***DEPARTMENT OF AGRONOMY,*** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE in AGRONOMY*** embodies the result of a piece of bona fide research work carried out by ***ANURADHA DEBNATH***, Registration No. **08-03225** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Place: Dhaka, Bangladesh

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

Dedicated

To

Those Who:

Work for humanity

Struggle against poverty

Fight against superstitions

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INFLUENCE OF PLANTING MATERIAL AND VARIETY ON YIELD OF *BORO* RICE

ABSTRACT

A field experiment was carried out at Agronomy Field, 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 level of treatments viz. planting material and variety. The experiment was laid out in split-plot design with three replications. Experimental results showed that planting material significantly influenced all the studied characters such as panicle length, unfilled grains panicle^{-1}, total grains panicle^{-1}, 1000 grains weight, grain straw ratio and harvest index. The results revealed that 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 the mother plant and the lowest grain yield (4.47 t ha^{-1}) and straw yield (4.59 t ha^{-1}) was obtained from clonal tillers. Maximum biological yield (13.31t ha^{-1}) was calculated from the mother plant and minimum biological yield (9.06 t ha^{-1}) was found from the clonal tillers. 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 dhan 2 produced the highest dry grain yield (5.92 t ha^{-1}); the lowest straw yield (4.97 t ha^{-1}), whereas, BRRI dhan29 produced the lowest grain yield (4.16 t ha^{-1}); and highest dry straw yield (6.70 t ha^{-1}). The maximum harvest index (56.50 %) was found from BRAC aloron and the lower harvest index (37.67%) was found from BRRI dhan29. The harvest index was 33.32% higher in BRAC aloron compared to BRRI dhan29. The interaction effect of planting material and variety showed significant variation for tillers m^{-2}, panicle length, unfilled grains panicle^{-1}, total grains panicle^{-1}, 1000 grains weight, grain straw ratio and harvest index. Clonal tillers had the potentiality to produce similar effective tillers m^{-2} , grain wt. and harvest index as mother plant though the highest grain yield (7.80 t ha^{-1}) was given by mother plant of hybrid variety Sonarbangla-6 that similar to the mother plant of BRRI hybrid dhan2 (7.67 t ha^{-1}) and mother plant of BRAC aloron (7.28 t ha^{-1}).

LIST OF CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
Anon.	Anonymous
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
cm	Centi-meter
CV %	Percent Coefficient of Variance
et al.	And others
e.g.	*exempli gratia* (L), for example
etc.	Etcetera
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
i.e.	*id est* (L), that is
IRRI	International Rice Research Institute
kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter squares
M.S.	Master of Science
No.	Number
NS	Non significant
SAU	Sher-e-Bangla Agricultural University
var.	Variety
t ha^{-1}	Ton per hectare
%	Percentage

Chapter 1
Introduction

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food crop of more than half of the world's population (Anonymous, 2009). Ninety percent of this crop is grown and consumed in South and South East Asia, the major centers of the world's population (Nanda, 2002). Most of the consumers, who depend on rice as their primary food, live in less developed countries. Bangladesh is the fourth largest producer and consumer of rice in the world (Bhuiyan *et al*., 2002).

In Bangladesh, majority of food grains come from rice (*Oryza sativa* L.). About 80% of the cropped area of this country is used for rice cultivation with annual production of 25.18 million tons from 10.19 million ha of land (IRRI, 2006). The average yield of rice in Bangladesh is 2.45 t ha^{-1} (BRRI, 2004). The average yield is almost less than 50% of the world average rice grain yield. The increased rice production is needed if possible by the adoption of modern rice varieties on around 70.24% of the rice land which contributes to about 83.39% of the country's total rice production. So it is necessary to know the using of clonal tillers for maximum yield and reduce seed cost and labor cost of rice.

Bangladesh is still growing by adding two million peoples every year and may raise by another 30 millions over the next 20 years. Rice yield can be increased in many ways of which in developing new high yielding variety and adopting proper agronomic management practices to the existing varieties to achieve their potential yield is important.

The world's annual rice production must be increased to 760 million tons by the year 2020 (Kundu and Ladha, 1995). Rice plays a dominant role in the Bangladesh agriculture of which *Boro* season is the prominent producer. 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 prime issue. Ahmed (2006) reported that a single plant of rice has the ability to produce about 74 tillers in Bangladesh condition. The potentiality of inbred clonal tillers is reported by many researchers (Biswas, 2001; Biswas and Salokhe, 2001; Sharma, 1992). 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.

Rice is the most important crop in low and medium income countries where population pressure on limited land resources is high, and where a close balance between rice production and demand should be maintained (Maclean *et al.*, 2002). Estimates show that the demand for the cereal will increase by about 55% world wide and 80% in developing countries. Faced with increasing population growth pressure coupled with diminishing crop land area, the only way to food shortage is to significantly increase the yield level of food crops per unit land area through advanced technology. Using the success in China as a model (Longping, 2004), wide sacle use of hybrid varieties might be an effective way to close the gap between rice supply and demand.

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 have around 15 tillers /hill at 30 days of transplantation. Hence around 15 times more area can be transplanted by uprooting, splitting and replanting tiller that can save seed cost. As well as in natural calamities any damaging area of field can be recoped using this clonal tillers transplantation technique. Clonal tillers are those tillers that can be collected from mother plants and transplanted as a new crop. It is possible to transplant the collected tillers in the prepared main field those have the potentiality to produce yield as main crop.

The country is now producing about 42.3 million tons of clean rice @ 3.78 t ha^{-1} in 11.2 million ha^{-1} of land. A conservative statistics given by Bhuiyan *et al*. (2002) indicates that about 21% higher amount of rice than the production of 2000 have to be produced to feed the population by the year 2025. There is no opportunity to increase rice area consequently; much of the additional rice required will have to come from higher average yield on existing land. Clearly, it will require adoption of new technology such as high management package, high yielding cultivar, higher input use etc. (Wang *et al.*, 2002).

Rice, as well as other cereals, has the unique ability to tiller profusely as each leaf axil has the potential to produce tillers (Langer, 1979). Katayama (1931 and 1951) showed that tillers in rice develop synchronously with the development of the main stem, and if there are no nutritional or environmental stresses, tillers have the ability to retiller more in the form of compound interest law (Peterson *et al.*,1982).

In rice many of the late tillers do not produce panicles due to high population (Nishikawa and Hanada, 1951; Hanada, 1982) and nutritional stresses (Aspinall, 1961; Katayama, 1951; Langer, 1979). Removal of some tillers from the mother hill can help better development of the remaining tillers. The detached tillers can be used as seedling, especially during scarcity of seedlings after flood or other natural hazards (Biswas, 2001).

The results obtained from the main and the subsequent crops revealed that it is possible to detach tillers from the mother hills for multiplication and these tillers can be used as seedling in the post-flood agricultural rehabilitation. If 6-7 tillers are detached from the mother hill and replanted at 2-3 tillers per hill, 200 to 300% more area can be covered, yet giving the threshold yield. The findings can have important impact on the post-flood agricultural rehabilitation (Roy *et al*., 1990; Biswas & Salokhe, 2002; Obaidullah *et al*., 2009; Ashrafuzzaman *et al*., 2008).

The cultivation of hybrid rice varieties are gradually increasing in Bangladesh to cope with the additional demand of cereals grains. Possibility of splitting tillers from the mother plant by complete uprooting from the field at 30 DAT and their multiplication by retransplanting with 1-2 clonal tillers per hill may explore the expansion on hybrid rice cultivation in Bangladesh.

Because of this variable information about the effect of cultivation methods of inbred and hybrid rice varieties on yield, a detailed study was under taken with the following objectives:

i. To compare the performance of inbred & hybrid clonal tillers and mother plants
ii. To study the potentiality of using vegetative tillers of rice
iii. To suggest the possibility of cultivating hybrid rice using clonal tillers

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 mother plant. Mother plant and clonal tillers using inbred and hybrid 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 this regard is scanty. Some of the pertinent works on these technologies have been reviewed in this chapter.

2.1 Effect of 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 different of age. They found 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.

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.

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 (8.88t ha^{-1}) and sprouted seeds broadcast of the inbred variety gave the lowest grain yield (6.35 t ha^{-1}).

Main *et al.* (2007) stated that 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 seedlings (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 per panicle (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 showed significantly higher grain yield (4.24 t/ha) compared two other plant density along with nursery seedlings. The higher yield in clonal tillers compared to nursery seedlings might be due to the higher filled grains per panicle 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 per panicle 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 tiller $hill^{-1}$, number of bearing tillers and panicle length but grain and straw yields were unaffected. Therefore, 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 per hill 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 per hill. The treatments consisted of 2 hybrids rice (Pro Agro 6210 and CNRH 3) and one HYV (IET4786), 2 seedlings ages (21 and 28 days old) and 2 levels of seedlings number per hill (1 and 2 seedling per hill for hybrid rice and 3 and 6 seedlings per hill HYV). Pro Agro 6201 had significantly higher yield than IET4786, due to more mature panicles m^{-2}, higher number of filled grains per panicle 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 produce more tiller, panicles m^{-2}, grain yield than 21 days old seedlings. Seedlings per hill 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 *et al.* (2001) reported that vegetative propagation of rice using clonal tillers collected from the mother plant without hamparing its yield is 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 panical^{-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 cultivars. 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 reduce panicle number m^{-2} which was not compensated by increased panicle weight. The transplanted crop rice 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^{-1} 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 (1992, 1994 & 1995) conducted a series of experiments 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 BR 22 representing old and modern 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 BR 22 double transplanting increased the number of spikelets per panicle in both the varieties. Tiller removal also increased spikelets but not as much as was in the double transplanted rice.

Sharma (1992, 1994 & 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 droughts, floods 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 may 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). Therefore, this study was conducted to examine the effects of tillers as vegetative material for filling vacant areas that have been left behind by floods, droughts, pests and decreases and by other natural hazards.

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 at 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 and after 35 days 1, 3, 5 and 7 tillers were detached from the mother crop repanted 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 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. The 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. They found that tillers could be separated at 30-40 days after transplanting and grain yield increased with the number of tiller hill^{-1} from 2 to 3.

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

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

Ding *et al.* (1983) observed that the establishment of rice crop by tiller transplanting in place of seedling transplanting reduced the of 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 and 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.

Murata and Matstuhima (1975) observed that the tillers were capable of producing carbohydrates through photosynthesis. It appeared that after the 3rd leaf emerged completely, the nutrient supply to tillers shifts to autotrophy from heterotrophy.

Yoshida (1972) reported two aspects of tiller as, spatial arrangement of tillers and tillering capacity. Medium tillering capacity considered desirable for a high yielding variety. Lower yield of rice varieties believed to be caused by faster growth rate and excessively large LAI beyond an optimum, which in turn were closely related to high tillering capacity.

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 varieties

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 crop other yield contributing characters due to different varieties are cited below.

Obaidullah (2007) stated that variety significantly influenced panicle length, number of total grains panicle^{-1}, filled grains panicle^{-1}, 1000 grains weight, grain yield and straw yield but not for effective tillers hill^{-1} 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 panical^{-1} (196.75), filled grains panical^{-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 dhan 32 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) stated that there was no significant variation of effective tillers hill^{-1}, total grains panicle^{-1}, filled grains panicle^{-1}, 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 sonar bangle-1 gave the longer panicle (26.40 cm) compared to that of BR 11 (25.66 cm). The highest weight of 1000 grains (28.32 g) was obtained from the hybrid variety and the lowest (27.08 g) was obtained from the inbred variety. The highest grain yield (4.70 t ha^{-1}) was obtained from the hybrid variety Sonar bangla-1 and that was 4.43t ha^{-1} from inbred variety BR11 (Mukta). 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 b nursery seedlings of RD 23. The nursery seedlings RD 23 resulted the lowest number of filled grains panicle^{-1}. Planting density 1 to 4 clonal tillers hill^{-1}showed the same number of filled grains panicle^{-1} within the corresponding variety. For both varieties, clonal tillers produced significantly higher yield compared to nursery seedlings.

Akbar (2004) reported that variety, seedling age and their interaction exerted significant influence on almost all the crop characters. Among the varieties, BRRI dhan41 performed the best in respect of number of bearing tillers hill^{-1}, panicle length, total spikelets panicle^{-1}, and number of grain panicle^{-1}. BRRI dhan 41 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 highest number of non-bearing tillers hill^{-1} and sterile spikelets panicle^{-1}. Grain, straw and biological yields were found highest in the combination of BRRI dhan 41 x 15 day-old seedlings. Therefore, BRRI dhan41 may be cultivated using

15 day-old seedlings in *Aman* season following the SRI technique to better grain and straw yields.

In a trail, 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 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 highest (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 high number of productive tillers per plant had the largest direct effect on grain yield, resulting in increased sink capability. The higher tiller number and number of grains per panicle were attributable to higher leaf areas, higher net photosynthesis in individual leaves (particularly in the later stages) and favourable 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.

BINA (1993) evaluated the performance of four varieties- IRATOM 24, BR 14, BINA-13 and BINA-9. It was found that the varieties differed significantly in respect of plant height, number of unproductive tiller hill^{-1}, panicle length and sterile spikelets panbicle^{-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, IR20 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 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 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).

Hossain *et al.* (1991) reported that the growth characters like plant height, total tillers hill^{-1} and number of grains panicle^{-1} differed significantly among BR3, BR11, BR4, Pajam and Jaguli varieties in Boro season.

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 are 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 Laboratory, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December, 2008 to May, 2009.

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 the 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., 1988). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The area has 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.

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 ranged from 6.1-

6.3 and had organic matter 1.29%. 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. Planting material (2)

1. P_1 = Mother plant
2. P_2 = Clonal tillers

B. Variety (6):

1. V_1 = BRRI dhan29 (inbred)
2. V_2 = ACI 1 (hybrid)
3. V_3 = BRAC aloron (hybrid)
4. V_4 = Sonarbangla-6 (hybrid)
5. V_5 = Hira 5(hybrid)
6. V_6 = BRRI hybrid dhan2

3.2.2 Experimental design

The experiment was laid out in a split-plot design with three replications having planting material in the main plots and varieties in the sub-plot. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 3.5 m by 3.0 m. The distances between plot to plot and replication to replication were 1 m. The layout of the experiment has been shown in Appendix II.

3.3 Crop/Planting material

Mother plant and clonal tillers were used as plant material.

3.3.1 Mother plant

The plant that generated from the nursery seedlings remain intact are considered as mother plant. Mother plants provided clonal tillers.

3.3.2 Clonal tillers

Clonal tillers are those tillers that can be collected from mother plants and transplanted as a new crop. It is possible to transplant the collected tillers in the prepared main field those have the potentiality to produce yield as main crop.

3.4 Description of Variety

Six rice varieties (BRRI dhan 29, ACI 1, BRAC aloron, Sonarbangla-6, Hira 5, BRRI dhan2) were used as variety.

3.4.1 BRRI dhan29

BRRI dhan29, a high yielding variety of *boro* season 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 to 160 days to mature. It attains at a plant height of 95-100 cm and at maturity 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-grains weight of about 29 g, grain length of 5.9 mm, and grain width of 2.5 mm. The cultivar gives an average 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 (*Pyricularia oryzae*) and bacterial blight (*Xanthomonas oryzae*). In terms of yield, this is the best variety so far released by BRRI (Anon., 1991).

3.4.2 ACI 1

ACI 1 is a hybrid rice variety of *boro* season. The variety matures within 130 to 140 days in *boro* season. It attains at a height of 85 to 100 cm with 10 to 15 or more tillers $hill^{-1}$. Its panicle length is 25.20cm and each panicle contains about 150 grains. The weight of 1000-grains weight of this variety 30 to 38 g and gives an average yield of 5.8 to 8.00 t ha^{-1}.

3.4.3 BRAC aloron

BRAC aloron is a hybrid rice variety which produce higher yield than modern varieties. The lowest number of effective tillers was 12.95 per plant observed in Aloron. The panicle length of Aloron is 24.17cm. The number of filled grains /panicale was 105.40. The cultivar gives an average grain yield of 7.41 t ha^{-1}, straw yield gives 8.51 t ha^{-1} & harvest index is 46.54 (%).

3.4.4 Sonarbangla-6

Sonarbangla-6 (CNSGC-6), a hybrid rice variety which produce higher yield than modern varieties, was imported and marketed in Bangladesh by the Mallika Seed Company (MSC), 145, Siddique Bazar, Dhaka-1000, Bangladesh from Hefei Fengle Seed Co. Ltd., China. The variety is photoperiod insensitive and could be cultivated in *aus*, *aman* and *boro* seasons. This variety has a yield potential of 36 to 45% over the conventional HYV. The variety matures within 120 to 130 days in *boro* season. It attains at a height of 90 to 100 cm with 10 to 15 or more tillers hill-1. Its panicle length is larger than the HYV and local verities and each panicle contains about 120 to 150 grains. The weight of 1000-grains weight of this variety 27 to 29 g and gives an average yield of 8.30 to 9.68 t ha^{-1}.

3.4.5 Hira 5

Hira 5 is a hybrid rice variety of *boro* season. CR-404-48 x Cr-289-1208 was the parentage of Hira 5 rice variety. Hira 5 variety was released in 1989. The variety matures within 120 to 130 days in *boro* season. It attains at a height of 90 to 100 cm with 10 to 15 or more tillers $hill^{-1}$. Its panicle length is 25.50cm and each panicle contains about 106 grains. Grains were long bold, white. The weight of 1000-grains weight of this variety 23 to 24 g and gives an average yield of 7.50 t ha^{-1}, straw yield gives 8.60 t ha^{-1} & harvest index is 46.58 (%).

3.4.6 BRRI hybrid dhan2

BRRI hybrid rice scientists have developed the hybrid rice, namely BRRI hybrid dhan2 suitable for the *boro* season and the agro-climate conditions of the country. NSB released the variety for mass cultivation in Dhaka, Comilla, Jessore and Rajshahi. It takes about 140 to 145 days to mature. It has 8.5 tons yield per hectare.

3.5 Crop management

3.5.1 Seedling raising

3.5.1.1 Seed collection

Seeds of BRRI dhan29 and BRRI hybrid dhan2 were collected from Genetic Resource and Seed Division, BRRI, Joydebpur, Gazipur, Bangladesh and the hybrid rice seeds, ACI 1, BRAC aloron, Sonarbangla-6, Hira-5 were collected from the Mallika Seed Company, Lal Teer Seed Company, Supreme Seed Company Ltd. respectively.

3.5.1.2 Seed sprouting

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 seedlings in the seedbed. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when necessary. No fertilizer was used in the nursery bed.

3.5.1.4 Seed sowing

Seeds were sown in the seedbed on December 04, 2008 for raising nursery seedlings and clonal tillers treatments. The sprouted seeds were sown as uniformly as possible.

3.5.2 Preparation of experimental land

The experimental field was first ploughed on January 01, 2009 with the help of a tractor drawn disc plough, later on January 13, 2009 the land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on January 14, 2009 according to experimental specification. 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 was fertilized with 120, 80, 80, 20 and 5 kg ha^{-1} of 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 i.e., after seedling recovery, during the vegetation stage and at 7 days before panicle initiation.

3.5.4 Uprooting and transplanting of seedlings

For nursery seedlings and clonal tillers treatments, 40 days old seedlings were uprooted carefully on January 14, 2009 and were kept in soft mud in shade. The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. Seedlings were then transplanted on January 15, 2009 with 25 cm × 15 cm spacing on the well-puddled plots. In each plot, there were 14 rows, each row contains 20 hills of rice seedlings.

3.5.5 Clonal tiller collection and transplantion

Clonal tillers were separated at 30 DAT from the mother crop and retransplanted on the other plot. The entire hills of all the varieties having clonal tillers treatments were uprooted were uprooted and tillers were separated by splitting maintained properly. The separated tillers were then retransplanted as per treatment having 2 clonal tillers per hill on 14 February, 2009. Before retransplanting, the individual plots were spaded properly for will puddled and an extra dose of urea was spreaded after 7 days of retransplanting only on clonal tillers 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 which it was necessary using the seedling or separated clonal tillers from the previous source.

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 mother plant, first weeding was done at 20 days after transplanting and second weeding was done 15 days after retranslating.

3.5.6.3 Application of irrigation water

Irrigation water was added to each plot as per requirement so that all the plots were kept irrigated. Before ripening the field was kept dry for all the treatments.

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 Diazinone @ 10 ml/10 liter of water for 5 decimal lands on February 03 and by Ripcord @ 10 ml/10 liter of water for 5 decimal lands on February 20 and March 25, 2009. Crop was protected from birds and rats during the grain filling period. Field trap and foxtoxin poisonous bait was used to control the rat. 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 treatments 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.

3.5.6.6 Harvesting and post harvest operation

Maturity of crop was determined when 80-90% of the grains become golden yellow in colour. The harvesting was done in two different dates for mother plants as well as clonal tillers. For mother plants harvesting was done on May 05, 2009 and for clonal tillers harvesting was done on May 13, 2009. Ten pre-selected hills per plot from which different data were collected and 6 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 pedal thresher. The grains were cleaned and sun dried to a moisture content of 14%. Straw was also sun dried properly. Finally grain and straw yields were determined and converted to ton ha^{-1}.

3.5.7 Recording of data

Data on yield attributes and other crop characters were determined for the randomly selected ten hills per plot and grain and straw yields were record from the inner rows leaving border lines. The followings data were determined during the experimentation.

Yield and other plant characters

i. Plant height (cm) at harvest

ii. Number of effective tillers m^{-2}

iii. Number of ineffective tillers m^{-2}

iv. Number of total tillers m^{-2}

v. Length of panicle (cm)

vi. Number of filled grain $panicle^{-1}$

vii. Number of unfilled grains $panicle^{-1}$

viii. Number of total grains $panicle^{-1}$

ix. Weight of 1000-grains (g)

x. Grain yield (t ha^{-1})

xi. Straw yield (t ha^{-1})

xii. Biological yield (t ha^{-1})

xiii. Grain straw ratio

xiv. 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:

Yield and other plant characters

i. Plant height

Plant height was measured at harvest from randomly selected ten hills plot^{-1}. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf height at harvest and determined the average.

ii. Number of effective tillers

Number of tillers was counted at harvest from ten randomly selected hills leaving the harvest area and was converted to m^{-2}. The panicles which had at least one grain was considered as effective tillers.

iii. Number of ineffective tillers

The ineffective tillers from ten hills leaving the harvest area were counted and averaged to m^{-2} basis. The panicles which had no grains were considered as ineffective tillers.

iv. Number of total tillers

Number of effective tillers hill^{-1} plus number of uneffective tillers hill^{-1} gave the total number of tillers hill^{-1} that converted to m^{-2} basis.

v. Length of panicle

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

vi. Number of filled grains panicle^{-1}

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

vii. Number of unfilled grain panicle^{-1}

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

viii. Number of total grain panicle^{-1}

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

ix. Weight of 1000-grains

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 14% moisture and the mean weight were expressed in gram.

x. Grain yield

Grain yield was determined from the central 6.0 m^2 area of each plot and expressed as t ha^{-1} and adjusted with 14% moisture basis. Grain moisture content was measured by using a digital moisture tester.

xi. Straw yield

Straw yield was determined from the central 6 m^2 area of each plot. After separation of grains, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1}.

xii. Grain straw ratio

The ratio between weight of dry grain yield and weight of dry straw yield was considered as grain straw ratio.

xiii. Biological yield

Grain yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula and expressed as t ha^{-1}.

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

xiv. Harvest index

It denotes the ratio of economic yield (grain 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 Analysis

The data collected on different parameters were statistically analyzed to obtain the level of significance using the IRRISTAT computer package program. The mean differences among the treatments were compared by least significance difference test at 5% level of significance.

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

Results obtained from the present study regarding the effects of mother plant & 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 8, Figures 1 through 19 and Appendices III through VII.

4.1 Yield and other plant Characters

4.1.1 Plant height

4.1.1.1 Effect of planting material

The plant height of *boro* rice was significantly influenced by different planting material like mother plant and clonal tiller (Appendix v & Figure 1). The results revealed that plant height of mother plant (87.59 cm) was higher than the plant height of clonal tillers (77.23 cm). Similar higher plant height of mother plant compared to clonal tiller was also reported by Rahman (2001).

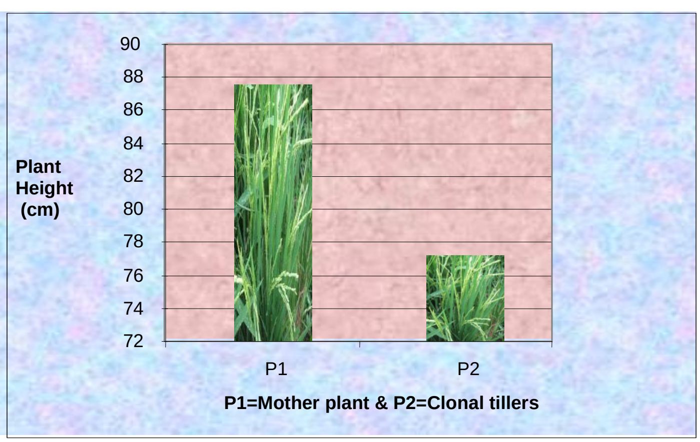


Figure 1. Effect of planting material on plant height (cm) of *boro* rice (LSD $_{0.05}$ = 4.63)

4.1.1.2 Effect of variety

Significant variation of plant height was found due to different varieties (Appendix V and Table 1). The results revealed that the tallest plant (86.33 cm) was obtained from the BRRI dhan 29 and statistically followed by the ACI 1 (83.14 cm), BRAC aloron (82.58 cm), Sonarbangla-6 (81.40 cm) and Hira 5 (81.20 cm). The shortest plant height (79.81 cm) was given by BRRI hybrid dhan2 that statistically similar with the ACI 1 (83.14 cm), BRAC aloron (82.58 cm), Sonarbangla-6 (81.40 cm) and Hira 5 (81.20 cm). The inbred variety was about 13.41% taller at harvest compared to the hybrid variety. Anon. (1998) and Rahman (2001) observed tallest plant in the inbred varieties and shortest plant height in Sonarbangla-6 and reported that the inbred variety was about 28.94% taller at harvest compared to the hybrid variety. BINA (1993) and Asrafuzzaman (2006) also observed that varieties differed significantly in respect of plant height.

Table 1. Influence of variety on plant height of *boro* rice

Treatment	**Plant height (cm)**
BRRI dhan 29 (V_1)	86.33a
ACI 1 (V_2)	83.14ab
BRAC Aloron (V_3)	82.58ab
Sonarbangla – 6 (V_4)	81.40ab
Hira 5 (V_5)	81.20ab
BRRI dhan 2 (V_6)	79.81b
LSD $_{(0.05)}$	5.67
CV (%)	5.29

4.1.1.3. Interaction effect of planting material and variety

Significant variation of plant height was found due to different planting material and interacted with variety (Appendix V and Table 2). The results revealed that the tallest plant (89.33 cm) was obtained from the mother plant of BRRI dhan29 which was statistically similar to all the hybrid varieties having mother plant and the BRRI dhan29 with clonal tillers and the shortest plant height (71.33 cm) was obtained from the clonal tillers of BRRI hybrid dhan2. Among the clonal tillers treatment the tallest plant height (82.93 cm) was recorded from the BRRI dhan29 that followed upto the BRRI hybrid dhan2 (71.33 cm) which was statistically similar.

Table 2. Interaction effect of planting material and variety on plant height of *boro* Rice

Interaction between planting material and variety	**Plant height (cm)**
Mother plant + BRRI dhan29 (P_1V_1)	89.33a
Mother plant + ACI 1(P_1V_2)	89.28ab
Mother plant + BRAC Aloron (P_1V_3)	88.36ab
Mother plant + Sonarbangla-6 (P_1V_4)	83.34ab
Mother plant + Hira5 (P_1V_5)	86.56ab
Mother plant + BRRI hybrid dhan2 (P_1V_6)	88.28ab
Clonal Tillers + BRRI dhan29 (P_2V_1)	82.93ab
Clonal Tillers + ACI 1 (P_2V_2)	77.00b
Clonal Tillers + BRAC Aloron (P_1V_3)	76.80b
Clonal Tillers + Sonarbangla-6 (P_2V_4)	79.47b
Clonal Tillers + Hira5 (P_2V_5)	75.83b
Clonal Tillers + BRRI hybrid dhan2 (P_2V_6)	71.33b
LSD $_{(0.05)}$	7.42
CV (%)	5.29

4.1.2 Number of effective tillers m^{-2}

4.1.2.1 Effect of planting material

The number of effective tillers m^{-2} was significantly influenced by planting material viz. mother plant (P_1) & clonal tillers (P_2) (Appendix VI and Figure 2). Results showed that, the mother plant (P_1) produced maximum number (141.50) of effective tillers m^{-2} and the minimum (106.33) was obtained from the clonal tillers (P_2). The variation in the production of effective tillers m^{-2} might be due to genetic constituents of the planting material. However, Anon. (1998) suggested that high yielding variety had more bearing tillers $hill^{-1}$ over the inbred variety. Tiller mortality from maximum tiller stage to harvesting was not significantly influenced by planting material. This might be due to the fact that the reduction of tiller number from maximum tiller stage to the final tiller number at maturity was a genetical behavior of the crop (Yoshida, 1981; Anon., 1970; Matsuo and Hoshikawa, 1993).

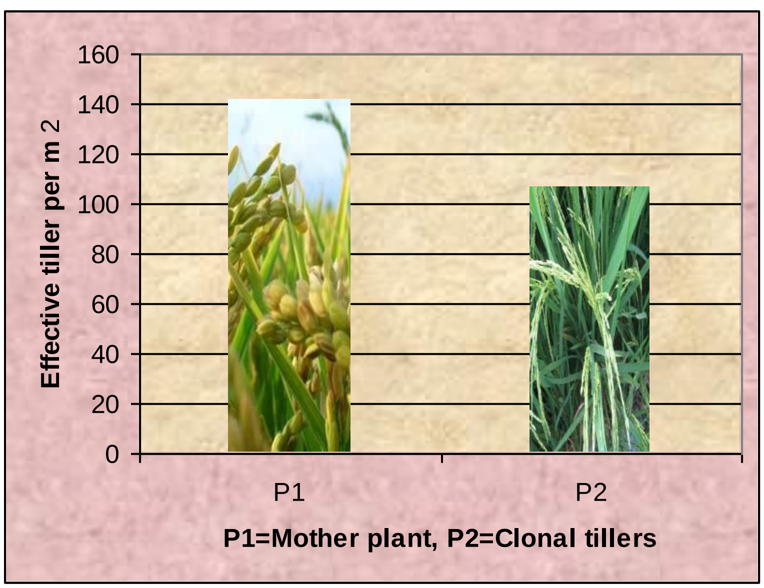


Figure 2. Effect of planting material on number of effective tillers of *boro* rice (LSD $_{0.05}$ = 18.26)

4.1.2.2 Effect of variety

The number of effective tillers m^{-2} of *boro* rice was statistically non significant and hence was not influenced by different varieties (Appendix VI & Table 3). The numerically maximum number of effective tillers m^{-2} (135.67) was observed in the inbred variety (BRRI dhan29) and the minimum number of effective tillers m^{-2} (117.33) was obtained from the hybrid variety BRRI hybrid dhan2. Such findings might be due to the genetic make-up of the varieties though Babiker (1986) observed that number of effective tillers m^{-2} differed due to the varietal variation. BINA (1993) and Asrafuzzaman (2006) observed that varieties differed significantly in respect of number of effective tillers m^{-2}. .

Table 3. Influence of variety on effective tillers, ineffective tillers and total tillers of *boro* rice

Variety	Number of effective tillers m^{-2}	Number of in effective tillers m^{-2}	Number of total tillers m^{-2}
V_1	135.67	19.00	154.67
V_2	119.17	24.50	142.00
V_3	128.00	24.17	151.17
V_4	118.33	20.50	138.83
V_5	125.00	22.50	147.50
V_6	117.33	24.33	141.67
LSD (0.05)	23.55 (NS)	7.29(NS)	26.62(NS)
CV (%)	15.76	26.87	15.11

V_1 = BRRI dhan29, V_2 = ACI 1, V_3 = BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan2.

4.1.2.3 Interaction effect of planting material and variety

The number of effective tillers m^{-2} was significantly influenced by the interaction effect of planting material and variety (Appendix VI and Table 4). The highest number of effective tillers m^{-2} (160.67) was obtained from the interaction of mother plant and BRAC aloron (P_1V_3) which was similar to P_1 V_5 (152.33), P_2 V_1 (140.33), P_1 V_2 (136.67), P_1 V_6 (135.00), P_1 V_4 (133.33) and P_1 V_1 (131.00). The lowest number of effective tillers m^{-2} (95.33) was obtained from the interaction of clonal tillers and BRAC aloron (P_2 V_3) that similar to all other clonal tillers treatment of hybrid variety. The higher effective tiller of BRRI dhan29 with mother plant and clonal tillers over hybrid variety was also reported by (Rahman, 2001).

4.1.3 Number of ineffective tillers m^{-2}

4.1.3.1 Effect of planting material

The number of ineffective tillers m^{-2} was significantly influenced by planting material (Appendix VI and Figure 3). Results showed that, the mother plant produced maximum number of ineffective tillers m^{-2} (27.78) and the minimum was obtained from the clonal tillers (17.22). The variation in the production of ineffective tillers m^{-2} might be due to genetical characters of mother plant & clonal tillers.

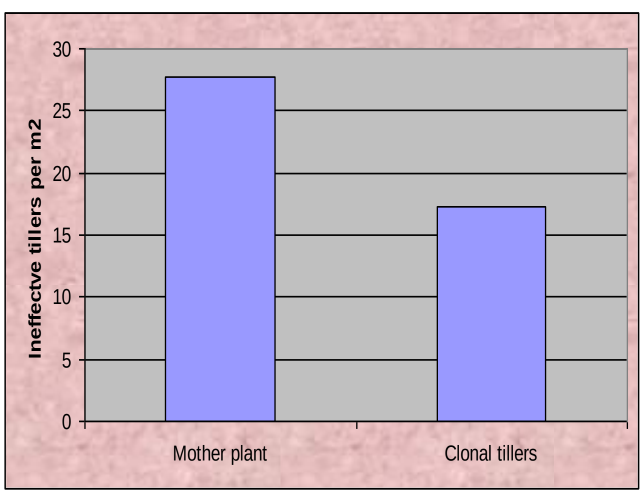


Figure 3. Effect of planting material on ineffective tillers of *boro* rice (LSD $_{0.05}$ = 3.51)

4.1.3.2 Effect of variety

The number of ineffective tillers m^{-2} was not significantly influenced by variety (Appendix VI and Table 3). Results showed that, the hybrid variety (ACI 1) produced maximum number of ineffective tillers m^{-2} (24.50) and the minimum (19.00) was obtained from the inbred variety (BRRI dhan 29). The variation in the production of ineffective tillers m^{-2} might be due to genetic constituents of the varieties. However, Anon. (1998) suggested that high yielding variety had more bearing ineffective tillers m^{-2} over the hybrid variety. Tiller mortality from maximum tillering stage to harvesting was not significantly influenced by variety. This might be due to the fact that the reduction of tiller number from maximum tillering stage to the final tiller number at maturity is a genetical behavior of the crop (Yoshida, 1981; Anon., 1970; Matsuo and Hoshikawa, 1993).

4.1.3.3 Interaction effect of planting material and variety

The number of ineffective tillers m^{-2} was significantly influenced by the interaction effect of planting material and variety (Appendix VI and Table 7). The highest number of ineffective tillers m^{-2} (33.00) was obtained from the (P_1 V_2) which was the interaction of mother plant & ACI 1 that followed by the interaction (P_1V_6) which was the combination of mother plant & BRRI hybrid dhan2. Irrespective of variety and the mother plant produced the highest number of ineffective tillers m^{-2} compared to that of clonal tillers. The lowest number of ineffective tillers m^{-2} (14.67) was obtained from the interaction of clonal tillers & inbred variety BRRI dhan29. Since, statistically similar lowest number was given by P_2 V_2 (16.00) & P_2V_5 (16.33) which was the interaction of clonal plant & ACI 1 clonal plant & hira 5 respectively.

4.1.4 Number of total tillers m^{-2}

4.1.4.1 Effect of planting material

The number of total tillers m^{-2} was significantly influenced by planting material (Appendix VI and Figure 4). Results showed that, the mother plant produced higher number (168.39) of tillers m^{-2} and the lower was obtained from the clonal tillers (123.56). The result disagree with the findings of Sharma (1992, 1994, 1995) who observed that clonal tillers performed better than mother plants and termed the tillers collected from the estabilished field at the maximum tillering stage as clonal tillers. Anon. (1992) reported that the proportion of total tillers was not statistically similar in mother plant and clonal tillers.

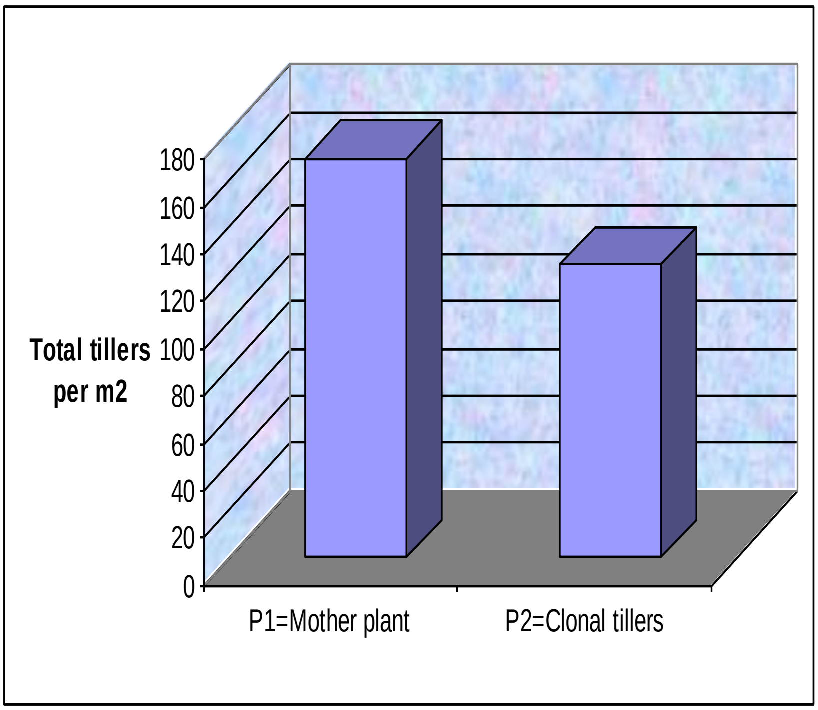


Figure 4. Effect of planting material on total tillers m^{-2} of *boro* rice (LSD $_{0.05}$ = 19.83)

4.1.4.2 Effect of variety

The production of total number of tillers m^{-2} of *boro* rice was not influenced by different varieties at harvest stage (Appendix VI & Table 3). Numerically the maximum total tiller numbers m^{-2} (154.67) was observed in the inbred variety (BRRI dhan29) and the minimum tiller numbers m^{-2} (138.83) was obtained from the hybrid variety (Sonarbangla-6). Davaraju *et al.* (1998) also found highest number of tillers m^{-2} in the inbred variety. Lafarge *et al.* (2004) reported that number of tillers was reduced in hybrid rice that was likely to senesce as productive tiller number $plant^{-1}$ at maturity. However, Yoshida (1972) and Anon. (1998) reported that hybrid variety had more tillering capacity than inbred variety.

4.1.4.3 Interaction effect of planting material and variety

The number of total tillers m^{-2} was significantly influenced by the interaction effect of planting material and variety (Appendix VI, and Table 4). The highest number of total tillers m^{-2} (185.67) was obtained from the interaction of mother plant & BRAC aloron (P_1 V_3). The statistically similar maximum number of total tillers (181.00), (166.33), (165.67) (157.33), (155.00), (154.33) was obtained from the interaction of mother plants & Hira 5 (P_1 V_5), mother plant & ACI 1 (P_1 V_2), and the interaction of mother plant and BRRI hybrid dhan2 (P_1 V_6) mother plant and sonarbangla-6 (P_1 V_4), clonal tiller and BRRI dhan29 (P_2 V_1) and mother plant and BRRI dhan29 (P_1 V_1), respectively. These results might be due to the combination of the higher tiller production ability of the interaction of mother plant & hybrid variety. The lowest number of total tillers m^{-2} (114.00) was obtained from the interaction of clonal tillers and Hira 5 (P_2 V_5) that was statistically similar to (116.67) the interaction of clonal tillers and BRAC aloron (P_2 V_3). .

Table 4: Interaction effect of planting material and variety on effective tillers, ineffective tillers & total tillers of *boro* rice

Interaction	No. of effective tillers m^{-2}	No. of ineffective tillers m^{-2}	No. of total tillers m^{-2}
P_1 V_1	131.00ab	23.33abcd	154.33abc
P_1 V_2	136.67a	33.00a	166.33a
P_1 V_3	160.67a	27.00abc	185.67a
P_1 V_4	133.33ab	24.00abcd	157.33ab
P_1 V_5	152.33a	28.67ab	181.00a
P_1 V_6	135.00a	30.67a	165.67a
P_2 V_1	140.33a	14.67d	155.00abc
P_2 V_2	101.67bc	16.00d	117.67cd
P_2 V_3	95.33c	21.33b	116.67d
P_2 V_4	103.33bc	17.00cd	120.33bcd
P_2 V_5	97.67c	16.33d	114.00d
P_2 V_6	99.67c	18.00cd	117.67cd
LSD (0.05)	33.26	10.30	37.57
CV (%)	15.76	26.87	15.11

P_1 = Mother plant, P_2 = Clonal tiller, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 =BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan2.

Tiller mortality from maximum tillering stage to harvesting was significantly influenced by the interaction effect of planting material and variety. The highest tiller mortality was observed from the clonal tillers combination.

4.1.5 Panicle length

4.1.5.1. Effect of planting material

There was no significant difference observed between mother plant and clonal tillers in panicle length due to planting material (Appendix IX and Figure 5). But the numerically maximum panicle length (24.25 cm) was observed from the clonal tillers (P_2). The minimum panicle length (24.23cm) was observed in mother plant (P_1).

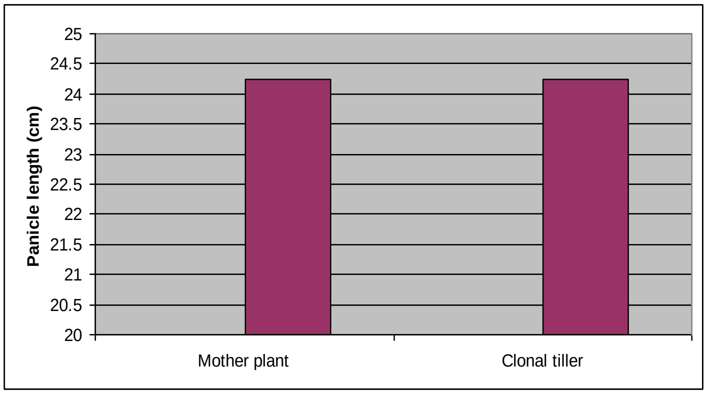


Figure 5. Effect of planting material on panicle length of *boro* rice

4.1.5.2. Effect of variety

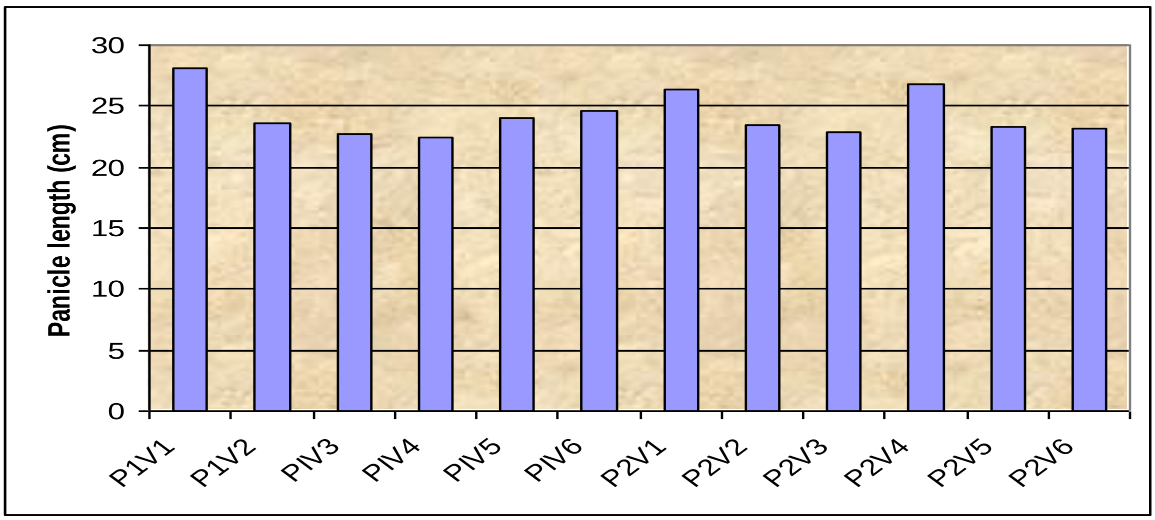
The panicle length was varied significantly due to different variety (Appendix IX and Table 5). The highest (27.23 cm) and the lowest (22.33 cm) panicle length was obtained from BRRI dhan29 (V_1) and BRAC Aloron (V_3) respectively. Such findings might be due to the genetic make-up of the varieties though Babiker (1986) observed that panicle length differed due to the varietal variation.

Table 5: Effect of variety on panicle length of *boro* rice

Variety	Panicle length (cm)
BRRI dhan 29 (V_1)	27.23a
ACI 1 (V_2)	23.51bc
BRAC Aloron (V_3)	22.33c
Sonarbangla – 6 (V_4)	24.46b
Hira 5 (V_5)	23.63bc
BRRI hybrid dhan 2 (V_6)	23.85b
LSD (0.05)	1.31
CV (%)	4.46

4.1.5.3. Interaction effect of planting material and variety

Panicle length was not significantly affected by the interaction effect of planting material and variety (Appendix IX and Figure 6). Numerically maximum panicle length (28.06 cm) was obtained from the interaction of mother plant and inbred variety BRRI dhan29 and the minimum panicle length (22.44 cm) was obtained from the interaction of mother plant and hybrid variety BRAC aloron and the same trend of panicle length was found in the interaction of clonal tillers and BRAC aloron (P_2 V_3). The interaction of P_1 V_1 showed almost 10% longer panicles compare to the other interactions.



P_1 = Mother plant, P_2 = Clonal tiller, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 =BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI dhan 2.

Figure 6. Interaction effect of planting material and variety on panicle length of *boro* rice

4.1.6 Number of filled grains panicle^{-1}

4.1.6.1 Effect of planting material

The different planting material showed significant variation on the number of filled grains panicle^{-1} (Appendix X and Table 3). The higher number of filled grains panicle^{-1} (154.66) was obtained from the mother plant and the lower number of filled grains panicle^{-1} (142.67) was obtained from the clonal tillers.

4.1.6.2 Effect of variety

The filled grains panicle^{-1} differed significantly for variation of the variety (Appendix VII & Table 3). The highest number of filled grains panicle^{-1} (162.57) was found in the hybrid variety BRRI hybrid dhan2 that similar to the all other varieties except ACI 1 which resulted the lowest number of filled grains panicle^{-1} (136.95). The filled grains panicle^{-1} of ACI 1 was similar to BRRI dhan29, BRAC aloron and Hira 5.

4.1.6.3 Interaction effect of planting material and variety

Interaction effect of planting material and variety was significant in respect of filled grains panicle^{-1} (Appendix VII and Figure 7). The highest number of filled grains panicle^{-1} (173.27) was obtained from the interaction effect of planting material, mother plant and variety of the hybrid variety BRRI hybrid dhan2 that followed by the mother plant and hybrid variety Sonarbangla – 6 (173.20) and the lowest number of filled grains panicle^{-1} (129.63) was obtained from the mother plant and ACI 1 interaction.

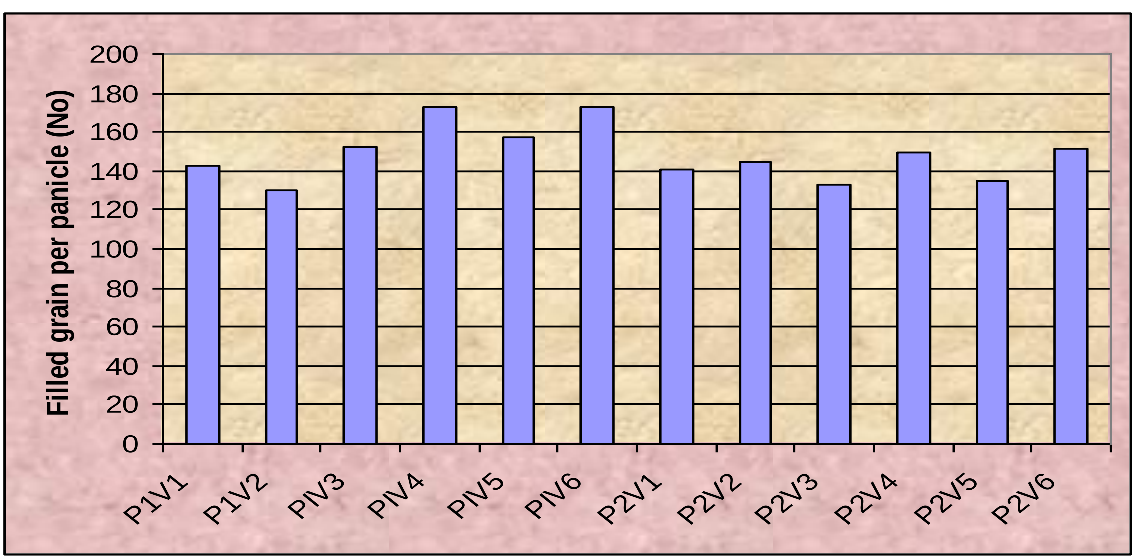


Figure 7: Interaction effect of planting material and variety on filled grains panicle^{-1} of *boro* rice (LSD $_{0.05}$ = 32.81)

4.1.7 Number of unfilled grains panicle^{-1}

4.1.7.1 Effect of planting material

Analysis of variance showed that number of unfilled grains panicle^{-1} was not statistically differed due to the different planting material (Appendix VII and Table 6) though the maximum number of unfilled grains panicle^{-1} (11.99) was counted from the clonal tillers and the minimum number of unfilled grains panicle^{-1} (11.43) was counted in the mother plant.

Table 6. Effect of planting material and variety on filled grains, unfilled grains and total grains panicle^{-1}

Treatments	Filled grains panicle^{-1} (No)	Unfilled grains panicle^{-1} (No)	Total grain panicle^{-1} (No)
Planting material			
Mother plant (P_1)	154.66a	11.43	166.90
Clonal tillers (P_2)	142.67b	11.99	157.94
$LSD_{(0.05)}$	7.37	5.89 (NS)	14.71 (NS)
CV (%)	3.69	37.33	6.74
Variety			
BRRI dhan 29 (V_1)	141.67abc	27.37a	179.33a
ACI 1 (V_2)	136.95c	11.72b	149.97d
BRAC Aloron (V_4)	142.70abc	6.60b	149.23d
Sonarbangla – 6 (V_5)	161.58ab	7.42b	168.85abc
Hira 5 (V_5)	146.42abc	8.32b	154.45cd
BRRI hybrid dhan 2 (V_6)	162.57a	8.83b	172.72ab
$LSD_{(0.05)}$	23.24	8.82	20.67

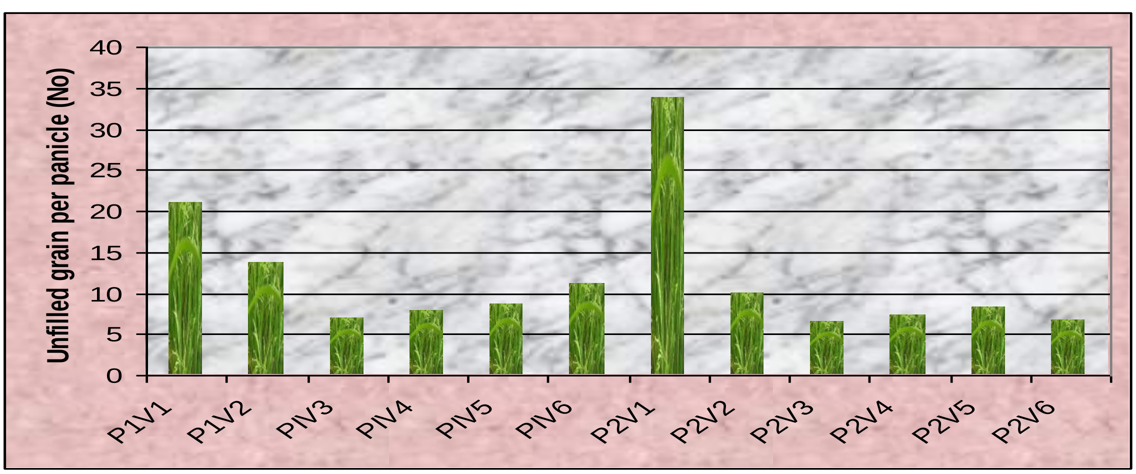
CV (%)	12.96	62.43	10.55

4.1.7.2 Effect of variety

The unfilled grains panicle^{-1} was significantly differed among the varieties (Appendix VII and Table 6). The highest number of unfilled grains panicle^{-1} (27.37) was counted in the inbred variety BRRI dhan29 and the lowest number of unfilled grains panicle^{-1} (6.60) was counted in the hybrid variety BRAC aloron. All the hybrid varieties showed similar number of unfilled grains panicle^{-1}. Akbar (2004) found the highest number of unfilled grains panicle^{-1} in Sonarbangla-6. BINA (1993) reported that varieties differed significantly in respect of unfilled grains panicle^{-1}.

4.1.7.3 Interaction effect of planting material and variety

The unfilled grains panicle^{-1} was statistically influenced by the interaction effect of planting material and variety (Appendix VII and Figure 8). The highest (33.77) number of unfilled grains panicle^{-1} was recorded from the interaction of clonal plant and the inbred variety of BRRI dhan 29 (P_2 V_1) whereas the lowest number (6.57) was counted from the interaction of clonal tiller and hybrid variety BRRI hybrid dhan2 (P_2V_6) which was statistically similar to the P_1V_3 (6.77), P_1V_4 (7.33), P_1V_5 (8.50), P_2V_4 (7.10), P_2V_5 (8.13) and P_2V_6 (6.57), respectively.



P_1 = Mother plant, P_2 = Clonal tiller, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 =BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI dhan2.

Figure 8. Interaction effect of planting material and variety on unfilled grains panicle^{-1} of *boro* rice (LSD $_{0.05}$ = 12.45)

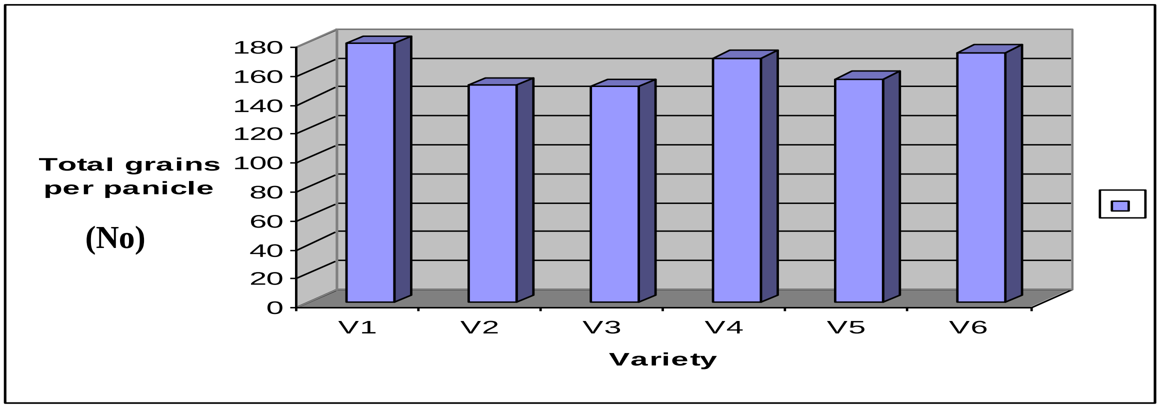
4.1.8 Number of total grains panicle^{-1}

4.1.8.1 Effect of planting material

The number of total grains panicle^{-1} was not significantly influenced by the planting material (Appendix VII and Table 6) though the maximum number of grains panicle^{-1} (166.90) was obtained from the mother plant and the minimum number of grains panicle^{-1} (157.94) was obtained from the clonal tillers.

4.1.8.2 Effect of variety

The total number of grains panicle^{-1} was not significantly influenced by the variety (Appendix VII and Figure 9) though the maximum number of grains panicle^{-1} (179.33) was obtained from the inbred variety BRRI dhan29 and the minimum number of grains panicle^{-1} (149.23) was obtained from the hybrid variety BRAC aloron. The inbred variety showed 14.50% higher number of total grains panicle^{-1} compared to hybrid variety BARC aloron. Hossain *et al.* (1991) reported varietal variation in number of grains panicle^{-1} and Anon. (1998) found higher number of grains panicle^{-1} in the hybrid varieties. Rahman (2001) found highest number of grains panicle^{-1} in the mother plants than the clonal tillers. However, Biswas (2001) reported higher grain in the clonal tillers than the mother plants.



V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 = BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan 2.

Figure 9. Effect of variety on total grains panicle^{-1} of *boro* rice

4.1.8.3 Interaction effect of planting material and variety

The total numbers of grains panicle^{-1} was significantly influenced by the interaction effect between planting material and variety (Appendix VII and Figure 10). The highest (195.57) number of grains panicle^{-1} was obtained from the interaction of clonal tillers and the inbred variety BRRI dhan29 and the lowest (139.67) number grains panicle^{-1} was obtained from the interaction of clonal tillers and the hybrid variety BRAC Aloron which was similar (143.23) to the interaction of clonal tillers and the hybrid variety Hira 5 and interaction of clonal tillers and the hybrid variety ACI 1 (146.03).

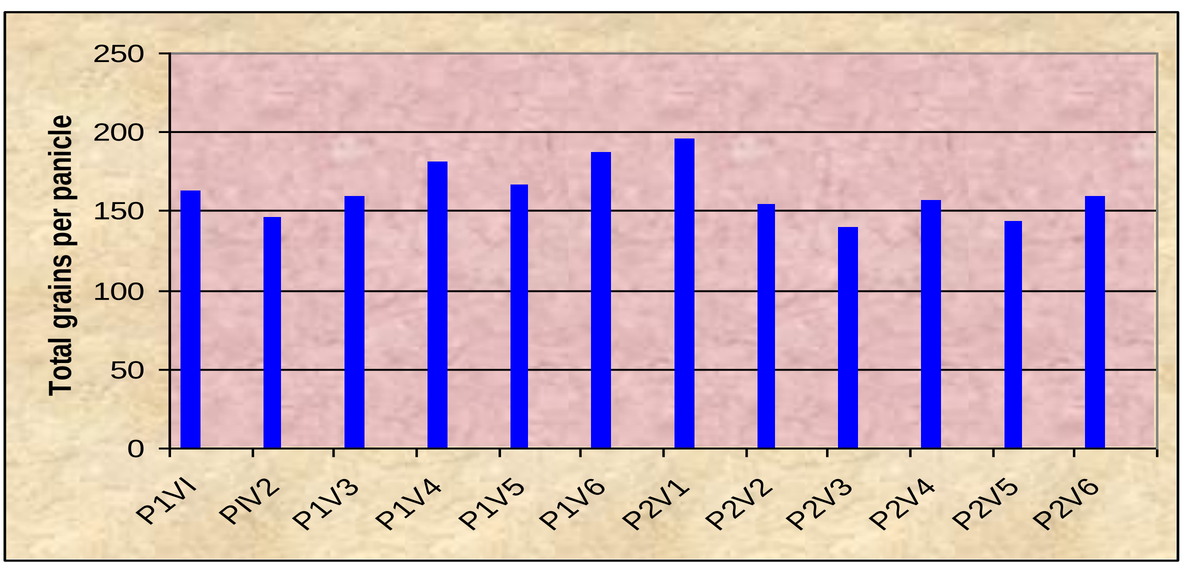


Figure 10. Interaction effect of planting material and variety on total grains panicle^{-1} of *boro* rice (LSD $_{0.05}$ = 12.45)

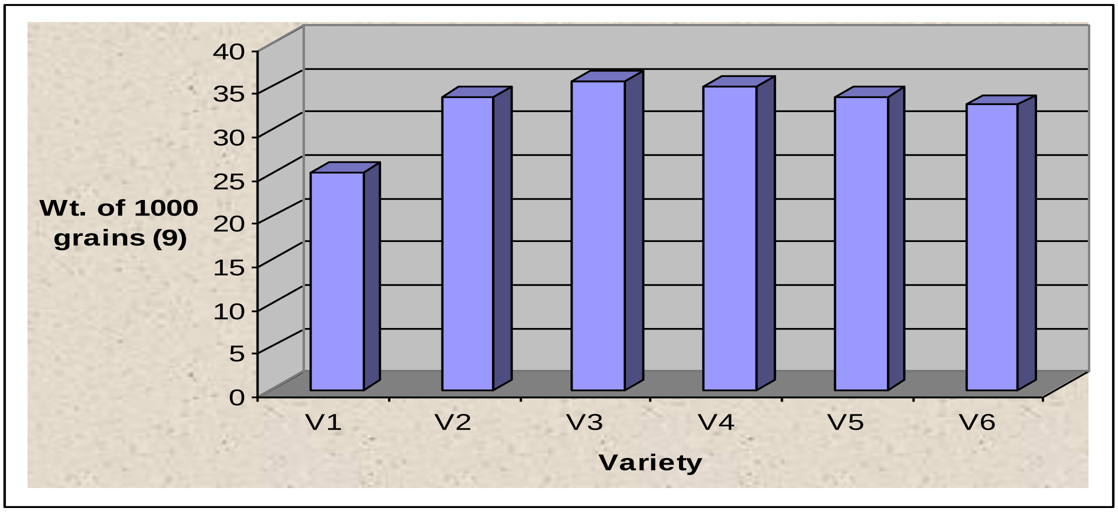
4.1.9 Weight of 1000-grains

4.1.9.1 Effect of planting material

There was no significant variation observed among the cultivation method in respect of weight of 1000-grains (Appendix VIII) though the maximum weight of 1000-grains (33.32 g) was obtained from the mother plant and minimum weight of 1000 grains (32.05 g) was obtained from the clonal tillers. This might be due to the encouraged proper crop growth and development and assimilate synthesis in the grains. The result supports the findings of Akbar (2004).

4.1.9.2 Effect of variety

The weight of 1000-grains was significantly influenced by the variety (Appendix VIII and Figure 11). The highest weight of 1000-grains (35.68 g) was obtained from the hybrid variety BRAC Aloron and the lowest weight of 1000-grains (24.98 g) was obtained from the inbred variety BRRI dhan29. The variation of 1000-grains weight among varieties might be due to genetic constituents. The result supports the findings of Ashrafuzzaman (2006) and Obaidullah (2007).

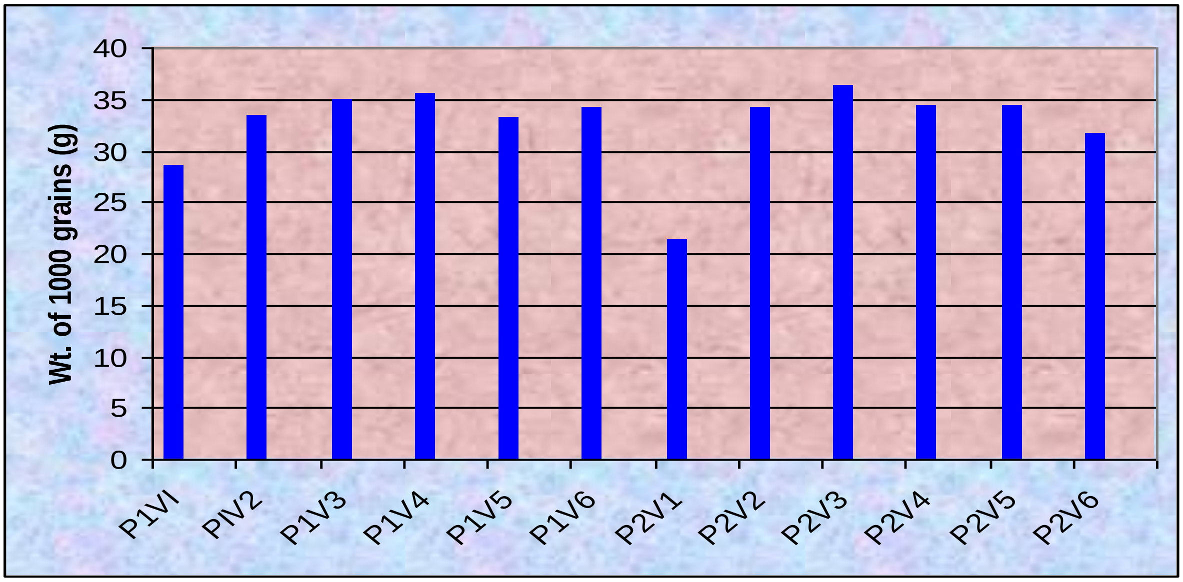


V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 = BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan 2.

Figure 11: Effect of variety on 1000 grain weight of *boro* rice (LSD $_{0.05}$ = 20.67)

4.1.9.3 Interaction effect of planting material and variety

Interaction effect between planting material and variety was found significant in respect of weight of 1000-grains (Appendix VIII and Figure 14). The highest weight of 1000-grains (36.32 g) was obtained from the interaction of clonal tillers and hybrid variety BRAC Aloron (P_2 V_3), which was similar to the and mother plant of the same variety. The lowest weight of 1000-grains (21.56 g) was obtained from the interaction of clonal tillers and inbred variety BRRI dhan29 (P_2 V_1) which was statistically similar to P_1 V_3 (35.04), P_1 V_4 (35.58), P_2 V_2 (34.24), P_2 V_1 (34.24), P_2 V_4 (34.31,), P_2 V_5 (34.40). Rahman (2001) found highest 1000-grains weight in the combination of Sonarbangla-6 and mother plant.



P_1 = Mother plant, P_2 = Clonal tiller, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 =BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI dhan 2.

Figure 12. Interaction effect of planting material and variety on 1000-grains weight of *boro* rice (LSD $_{0.05}$ = 5. 38)

4.1.10 Fresh grain yield (t ha^{-1})

4.1.10.1. Effect of planting material

Planting material has significant effect on fresh grain yield of rice (Appendix IX and Table 7). Mother plant produced significantly higher fresh grain yield (8.21 t ha^{-1}) and lower fresh grain yield (5.21 t ha^{-1}) produced by clonal tillers.

4.1.10.2. Effect of variety

Fresh grain yield was significantly influenced by the variety (Appendix IX and Table 7). The highest grain yield (7.36 t ha^{-1}) was obtained from the hybrid variety BRRI hybrid dhan2 and similar to the other hybrid varieties. The lowest fresh grain yield (5.58 t ha^{-1}) was found in inbred variety BRRI dhan29. Hossain *et al*. (2003) reported that hybrid rice had the potentiality to increase 15-20% yield. The yield improvement in the hybrid rice associated with an increase in total biomass as well as higher harvest index (Damodaran, 2001). Lafarge *et al.* (2004) reported that fresh grain yield was significantly higher for hybrid rice as hybrid increased assimilates allocation towards productive tillers. Davaraju *et al.* (1998); Ashrafuzzaman (2006) and Obaidullah (2007) also found higher grain yield from the hybrid varieties over the inbred varieties.

4.1.10.3. Interaction effect of planting material and variety

Interaction between planting material and variety played an important role for promoting the yield. Fresh grain yield was significantly influenced by the interaction effect of planting material and variety (Appendix IX and Figure 13). Among the interaction, the highest fresh grain yield was observed in mother plant of the hybrid variety BRRI hybrid dhan 2 (10.05 t ha^{-1}) and the lowest fresh grain yield was observed in clonal tillers of the inbred variety BRRI dhan 29 (4.55 t ha^{-1}) which was statistically similar to clonal tillers of the inbred variety BRRI hybrid dhan 2 (4.66 t ha^{-1}).

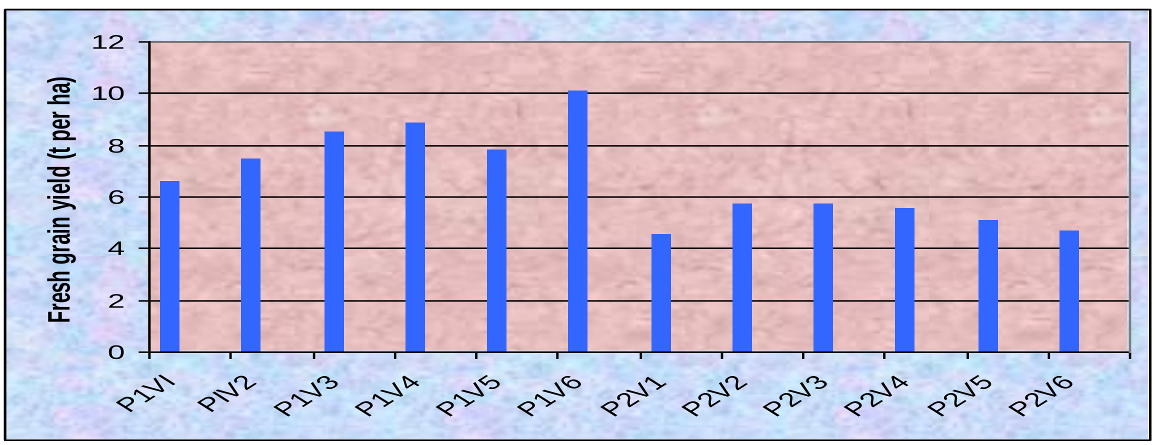


Figure 13: Interaction effect of planting material and variety on fresh grain yield of *boro* rice (LSD $_{0.05}$ = 1.72)

4.1.11 Dry grain yield (t ha^{-1})

4.1.11.1. Effect of planting material

Planting material has significant effect on grain yield (Appendix IX and Table7). Mother plant produced significantly the higher dry grain yield (6.85 t ha^{-1}) compared to clonal tillers (4.47 t ha^{-1}). Obaidullah (2007) reported the higher grain yield was found in mother plant than clonal tillers.

Table 7. Influence of planting material and variety on fresh and dry grain and straw yields of *boro* rice

Treatments	**Fresh grain yield (t ha^{-1})**	**Fresh straw yield (t ha^{-1})**	**Dry grain yield (t ha^{-1})**	**Dry straw yield (t ha^{-1})**
Planting material				
P_1	8.21a	14.10a	6.85a	6.45a
P_2	5.21b	10.45b	4.47b	4.59b
LSD (0.05)	1.17	1.05	0.40	0.85
CV (%)	13.32	6.38	16.78	11.39
Variety				
V_1	5.58d	14.39a	4.16b	6.70a
V_2	6.58abcd	12.06bc	5.69a	5.20b
V_3	7.09abc	11.64bcd	6.33a	4.86b
V_4	7.19ab	12.83b	6.31a	5.89ab
V_5	6.45abcd	11.45bcd	5.52a	5.52ab
V_6	7.36a	10.98d	5.92a	4.97b
LSD (0.05)	1.21	1.55	1.07	1.23
CV (%)	15.05	10.50	15.53	18.56

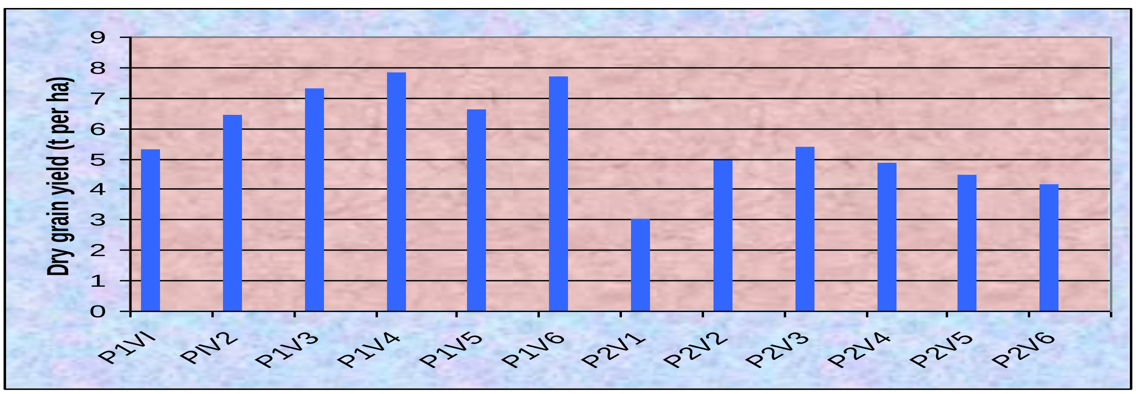
P_1 = Mother plant, P_2 = Clonal tillers, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 =BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan2.

4.1.11.2 Effect of variety

Grain yield was significantly influenced by the variety (Appendix IX, Table 7).The highest grain yield (6.33 t ha^{-1}) was obtained from the hybrid variety BRAC aloron that followed by hybrid variety, Sonarbangla – 6, BRRI hybrid dhan2, ACI 1 and Hira 5). The lowest grain yield (4.16 t ha^{-1}) was recored in inbred variety BRRI dhan29. Hossain *et al*. (2003) reported that hybrid rice has the potentiality to increase 15-20% more yield. The yield improvement in the hybrid has been associated with an increase in total biomass as well as higher harvest index (Damodaran, 2001). Lafarge *et al.* (2004) reported that grain yield was significantly higher for hybrid rice as hybrid increased assimilates allocation towards productive tillers. Davaraju *et al.* (1998); Anon. (1998); Julfiquar *et al.* (1998); Leenakumari *et al.* (1993), Ashrafuzzaman (2006) and Obaidullah (2007) found higher grain yields from the hybrid varieties over the inbred varieties.

4.1.11.3. Interaction effect of planting material and variety

Interaction between planting material and variety played an important role for promoting the yield. Grain yield was significantly influenced by the interaction effect of planting material and variety (Appendix IX and Figure 14). Among the interaction, the highest grain yield was observed in mother plant of the hybrid variety Sonarbangla-6 (7.80 t ha^{-1}), which was similar to mother plant of the hybrid variety BRRI hybrid dhan 2 (7.67 t ha^{-1}) and mother plant of the hybrid variety BRAC Aloron (7.28 t ha^{-1}). The lowest yield (4.16 t ha^{-1}) was found in the combination of clonal tillers and BRRI hybrid dhan2.



P_1 = Mother plant, P_2 = Clonal tillers, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 =BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan2.

Figure 14: Interaction effect of planting material and variety on grain yield of *boro* Rice (LSD $_{0.05}$ = 1.49)

4.1.12 Fresh straw yield

4.1.12.1. Effect of planting material

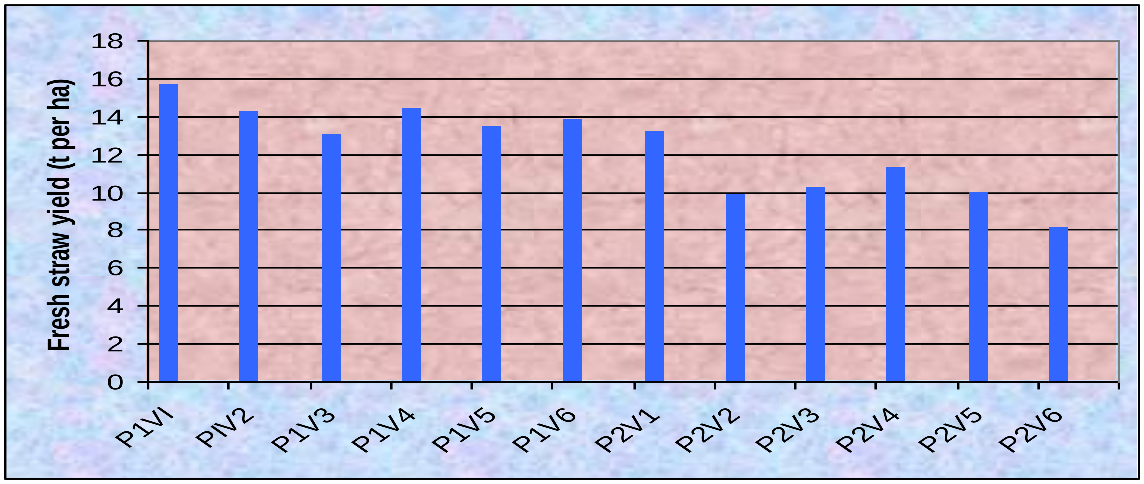
Planting material has significant effect on fresh straw yield (Appendix IX and Table 7). Mother plant produced significantly higher fresh straw yield (14.10 t ha^{-1}) and clonal tillers produced the fresh lower straw yield (10.45 t ha^{-1}). The probable reasons of increased straw yield in the mother plant might be due to higher total number of tillers m^{-2} and taller plants. Mamin *et al.* (1999) observed that straw yields were markedly higher in intact mother plant than clonal tillers.

4.1.12.2. Effect of variety

Straw yield was significantly influenced by the variety (Appendix IX and Table 7). The highest fresh straw yield (14.39 t ha^{-1}) was obtained from the inbred variety BRRI dhan29 and the lowest yield (10.98 t ha^{-1}) from the of hybrid variety BRRI hybrid dhan 2. The straw yield was 31% higher in the inbred variety compared to the hybrid variety. This might be due to the highest plant height and higher number of tillers $hill^{-1}$ of the inbred variety than the hybrid one. Akbar (2004) reported that inbred variety produced higher straw yield than the hybrid varieties. The result disagreed with that of Om *et al.* (1999), who observed that hybrid variety exhibited superiority to other inbred varieties in grain and straw yield.

4.1.12.3 Interaction effect of planting material and variety

Interaction effect of planting material and variety significantly affect the straw yield (Appendix IX and Figure 15). The highest straw yield (15.61 t ha^{-1}) was recorded from the mother plant of inbred variety BRRI dhan29 .The lowest straw yield (8.11 t ha^{-1}) was found from the hybrid variety BRRI hybrid dhan 2 which was statistically similar to other hybrid varieties.



P_1 = Mother plant, P_2 = Clonal tillers, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 =BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan2.

Figure 15: Interaction effect of planting material and variety on fresh straw yield of *boro* rice (LSD $_{0.05}$ = 2.20)

4.1.13 Dry straw yield

4.1.13.1. Effect of planting material

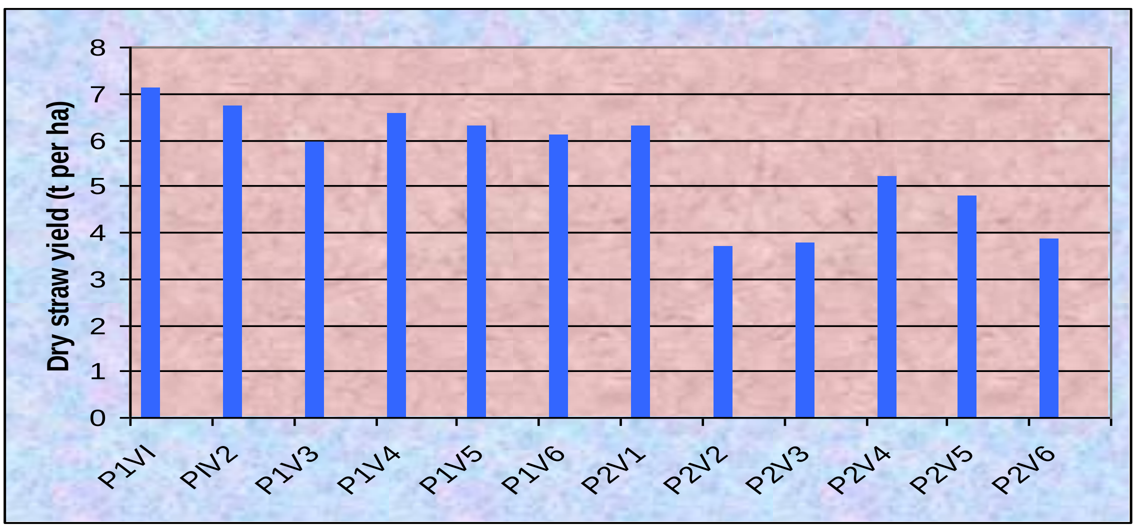
Planting material has significant effect on straw yield (Appendix IX, Table 10). Mother plant produced significantly higher straw yield (6.45 t ha^{-1}) and clonal tillers produced the lowest straw yield (4.59 t ha^{-1}). The probable reasons of increased straw yield in the mother plant might be due to higher total number of tillers m^{-2} and taller plants. Mamin *et al.* (1999) observed that straw yields were markedly higher in intact mother plant than clonal tillers. Mother plant was about 16% higher straw yields compared to the clonal tillers.

4.1.13.2. Effect of variety

The straw yield was significantly influenced by the variety (Appendix IX and Table 7). The highest straw yield (6.70 t ha^{-1}) was obtained from the inbred variety BRRI dhan29 and the lowest yield (4.86 t ha^{-1}) from the of hybrid variety BRAC Aloron. All the hybrid varieties showed the similar straw yield. The straw yield of BRRI dhan29 was 32.1% higher compared to the hybrid variety BARC aloron. This might be due to the highest plant height and higher number of tillers m^{-2} of the inbred variety than the hybrid one. Akbar (2004) reported that inbred variety produced higher straw yield than the hybrid varieties. The result disagreed with that of Om *et al.* (1999), who observed that hybrid variety exhibited superiority to other inbred varieties in grain and straw yield.

4.1.13.3 Interaction effect of planting material and variety

Interaction effect of planting material and variety significantly affect the straw yield (Appendix IX and Figure 16). The highest straw yield (7.11 t ha^{-1}) was recorded from the mother of inbred variety BRRI dhan29. The lowest straw yield (3.67 t ha^{-1}) was found from the hybrid variety ACI 1 which was statistically similar to straw yield (3.78 t ha^{-1}) and (3.83 t ha^{-1}) those resulted from clonal tillers of hybrid variety BRAC Aloron and BRRI hybrid dhan2, respectively.



P_1 = Mother plant, P_2 = Clonal tillers, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 =BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan2.

Figure 16: Interaction effect of planting material and variety on dry straw yield of *boro* rice (LSD $_{0.05}$ = 1.74)

4.1.14 Grain straw ratio

4.1.14.1. Effect of planting material

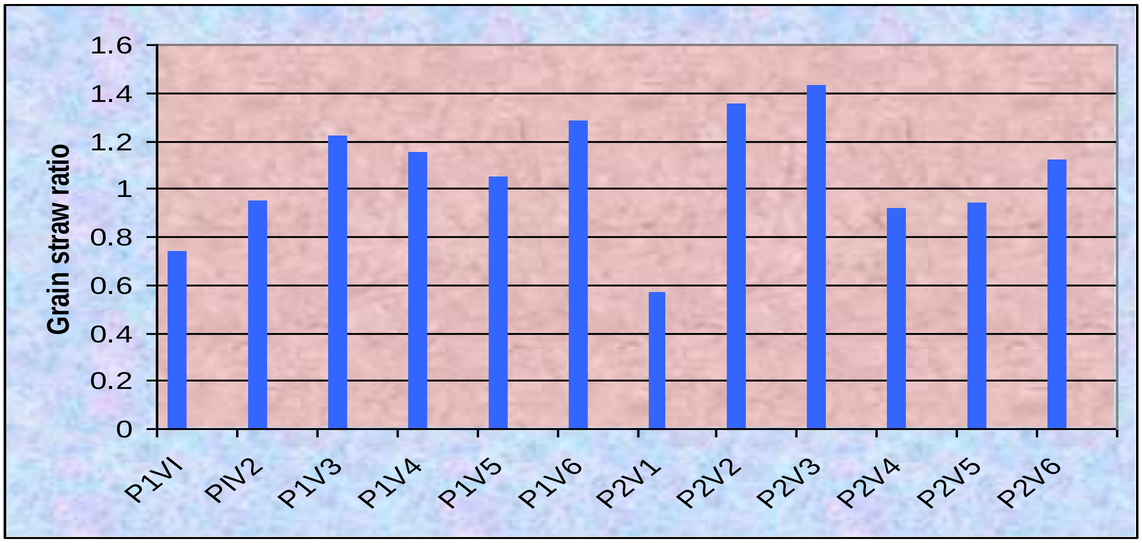
Grain straw ratio was not significantly affected by the planting material (Appendix IX and Table 8) though the maximum grain straw ratio (1.07) was obtained from the mother plant compared to the clonal tillers (1.05). The grain straw ratio was 1% higher in the mother plant compared to the clonal tillers. This might be due to the highest plant height and higher number of tillers m^{-2} of the mother plant than the clonal tillers.

4.1.14.2. Effect of variety

There was no significant difference observed among the variety in respect of grain straw ratio (Appendix IX and Table 8) though the increased grain straw ratio (1.32) was obtained from the hybrid variety BRAC Aloron. The probable reasons of increased grain straw yield in the variety might be due to higher total number of tillers m^{-2} and taller plants. The minimum grain straw ratio (0.66) was obtained from inbred variety BRRI dhan29.

4.1.14.3. Interaction effect of planting material and variety

Interaction effect between planting material and variety was significant in respect of grain straw ratio (Appendix IX and Figure 17). The highest grain straw ratio (1.43) was recorded in the clonal tillers of the hybrid variety BRAC aloron followed by the (1.35) of the hybrid variety ACI 1(1.35), 1.28 grain straw ratio was recorded in the mother plant of the hybrid variety BRRI hybrid dhan2 and (1.12) was recorded in the clonal tillers of the same variety. The lowest grain straw ratio (0.57) was found in the clonal tillers of the inbred variety BRRI dhan29.



P_1 = Mother plant, P_2 = Clonal tillers, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 = BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan 2.

Figure 17: Interaction effect of planting material and variety on grain straw ratio of *boro* rice (LSD $_{0.05}$ = 0.36)

4.1.15 Biological yield

4.1.15.1 Effect of planting material

There was significant difference between different planting material observed in respect of biological yield (Appendix IX, Table 8). The higher biological yield (13.31 t ha^{-1}) was found from the mother plant. Mother plant produced higher grain yield and straw yield which resulted in the higher biological yield. The lower biological yield (9.06 t ha^{-1}) was found from the clonal tillers. The mother plant produced 18% higher biological yield than the clonal tillers.

4.1.15.2 Effect of variety

Variety had no effect on biological yield (Appendix IX and Table 8) though the maximum biological yield (12.22 t ha^{-1}) was found from the hybrid variety Sonarbangla – 6 and the lowest biological yield (10.85 t ha^{-1}) was found from the inbred variety BRRI dhan29. Rahman (2001) reported that Sonarbangla-6 produced higher biological yield compared to the inbred varieties which was supported by Singh and Gangwer (1989).

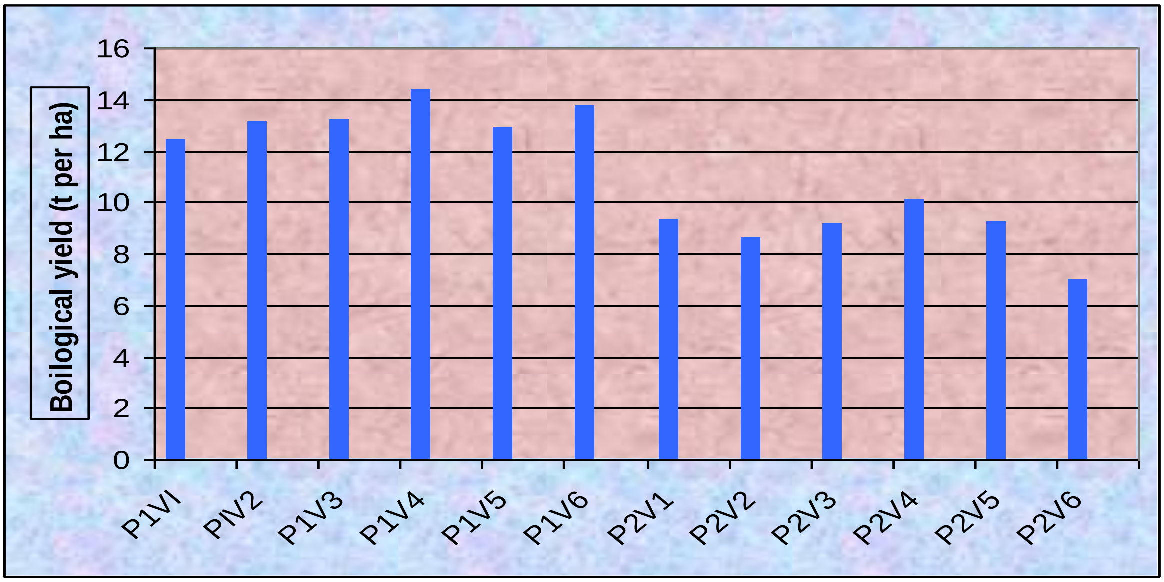
Table 8. Effect of planting material and variety on grain straw ratio, biological yield and harvest index of *boro* rice.

Treatments	**Grain straw ratio**	**Biological yield ($t\ ha^{-1}$)**	**Harvest index (%)**
Planting material			
P_1	1.07	13.31	50.67
P_2	1.05	9.06	49.06
LSD (0.05)	0.29 (NS)	0.89	7.78 (NS)
CV (%)	20.43	0.66	11.57
Variety			
V_1	0.66	10.85	37.67
V_2	1.15	10.89	52.33
V_3	1.32	11.20	56.50
V_4	1.04	12.22	50.67
V_5	0.96	11.06	49.17
V_6	1.20	10.98	52.83
LSD (0.05)	0.81 (NS)	1.69 (NS)	7.43
CV (%)	20.10	12.62	12.35

P_1 = Mother plant, P_2 = Clonal tillers, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 = BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan 2.

4.1.15.3 Interaction effect of planting material and variety

Interaction effect between planting material and variety was significant in respect of biological yield (Appendix X and Figure 18). The highest biological yield (4.39 t ha^{-1}) was recorded in the mother plant of the hybrid variety Sonarbangla – 6 and the lowest biological yield (7.00 t ha^{-1}) in the hybrid variety BRRI hybrid dhan2. The result disagreed with that of Akbar (2004), who found highest biological yield in combination of the inbred variety and 15 day-old seedlings.



P_1 = Mother plant, P_2 = Clonal tillers, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 = BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan 2.

Figure 18: Interaction effect of planting material and variety on biological yield of *boro* rice (LSD $_{0.05}$ = 2.40)

4.1.16 Harvest index

4.1.16.1 Effect of planting material

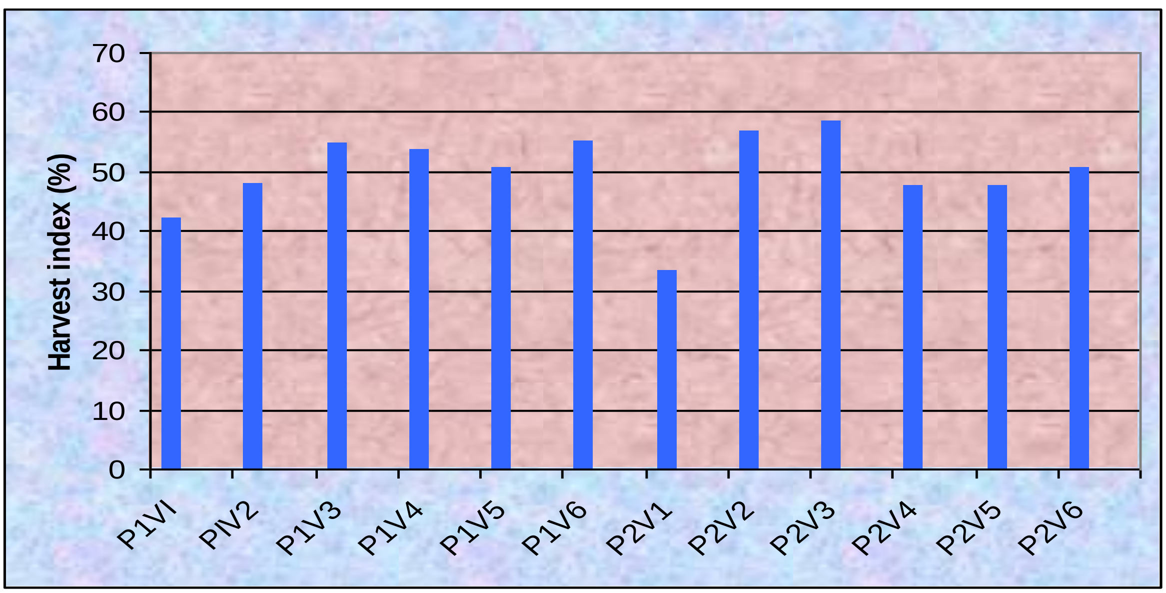
Planting material had no effect on harvest index (Appendix IX and Table 11) though the maximum harvest index (50.67 %) was found from the mother plant and the lowest harvest index (49.06 %) was found from the clonal tillers. The harvest index was 3 % higher in the mother plant than the clonal tillers. Similar results were also reported by Cui *et al.* (2000)

4.1.16.1 Effect of variety

Harvest index was significantly influenced by the variety (Appendix IX and Table 11). The highest harvest index (56.50%) was found from the hybrid variety BRAC Aloron and the lowest harvest index (37.67%) was found from the inbred variety BRRI dhan29 and it was 18.8 % different. Higher grain yield and lower biological yield was the probable reason for the maximum harvest index. Muir (1998) reported that hybrid varieties generally have a higher harvest index than do conventional varieties. Rahman (2001) observed highest harvest index in hybrid than the inbred varieties. Similar result was also reported by Cui *et al.* (2000).

4.1.16.3 Interaction effect of planting material and variety

Interaction effect of planting material and variety was significant in respect of harvest index (Appendix IX and Figure 19). The highest harvest index (58.33%) was recorded in the interaction of clonal tillers and hybrid variety BRAC aloron. The lowest harvest index (33.33%) was found in the interaction of the clonal tillers and inbred variety BRRI dhan29. This lower harvest index of BRRI dhan 29 might be due to its taller plant height and high straw yield which ultimately promoted higher total dry weight of the variety. Yoshida (1981) reported that harvest index of rice is inversely correlated with plant height and growth duration.



P_1 = Mother plant, P_2 = Clonal tillers, V_1 = BRRI dhan 29, V_2 = ACI 1, V_3 = BRAC aloron, V_4 = Sonarbangla-6, V_5 = Hira 5, V_6 = BRRI hybrid dhan 2.

Figure19: Interaction effect of planting material and variety on harvest index of boro rice (LSD $_{0.05}$ = 10.49)

Chapter 5
Summary and Conclusion

CHAPTER 5
SUMMARY AND CONCLUSION

The field experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from December 2008 to May 2009 to study the influence of mother plant and clonal tillers of *boro* rice varieties on yield of rice under the Modhupur Tract (AEZ-28). The experiment was comprised with two planting material viz. mother plant (P_1) and clonal tillers (P_2) and six varieties viz. inbred variety BRRI dhan29 (V_1) and hybrid variety ACI 1(V_2), BRAC aloron (V_3), Sonarbangla-6 (V_4), Hira5 (V_5) and BRRI hybrid dhan2 (V_6). The experiment was laid out in a split-plot design with three replications having mother plants in the main plots and clonal tillers in the sub-plots.

The data on yield and other plant characters like plant height (cm) at harvest, number of effective tillers m^{-2}, number of ineffective tillers m^{-2}, number of total tillers m^{-2}, length of panicle (cm), number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, number of total grains panicle^{-1}, weight of 1000-grains (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), grain straw ratio, biological yield (t ha^{-1}) and harvest index (%) were recorded. Data were analyzed using IRRISTAT package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

Results showed that mother plant had significant effect on growth parameters except panicle length, unfilled grains panicle^{-1}, total grains panicle^{-1}, weight of 1000 grains (g), grain straw ratio and harvest index (%). It revealed that mother plant showed significantly taller plant (87.59 cm) and clonal tillers showed shorter plant (77.23 cm) at harvest. The higher number of effective tillers at harvest stage was found in mother plant (141.50 m^{-2}) compared to the clonal tillers (106.33 m^{-2}). Again, mother plant produced higher number of in effective tillers (27.78 m^{-2}) and clonal tillers produced lower number of ineffective tillers (17.22 m^{-2}). Mother plant produced higher number total tillers (168.39) and clonal tillers produced lower number of total tillers (123.56). The production of filled grains panicle^{-1} was significantly influenced at harvest stage, higher number of filled grain panicle^{-1} (154.66) was observed in the mother plant and the lower number of filled grain panicle^{-1} (142.67) was obtained from the clonal tillers. Fresh grain yield was significantly influenced by the planting material. At harvest, higher fresh grain yield (8.21 t ha^{-1}) and lower fresh grain yield (5.21 t ha^{-1}) was recorded in mother plant and clonal tillers respectively. Mother plant gave higher dry grain yield (6.85 t ha^{-1}) compared to clonal tillers (4.47 t ha^{-1}). The mother plant produced higher fresh straw yield (14.10 t ha^{-1}) and lowest fresh straw yield (10.45 t ha^{-1}). Again higher dry straw yield (6.45 t ha^{-1}) was obtained from mother plant and lower dry straw yield (4.59 t ha^{-1}) was obtained from clonal tillers. The higher biological yield (13.31 t ha^{-1}) was found from mother plant and the lower biological yield (9.06 t ha^{-1}) was found from clonal tillers.

The variety had significant effect on all agronomic parameters except effective tillers ineffective tillers, total tillers, grain straw ratio, and biological yield. At harvest inbred variety BRRI dhan29 showed significantly highest plant height (86.33 cm) compared to hybrid variety ACI 1 (83.14 cm), BRAC aloron (82.58 cm), Sonarbangla-6 (81.40 cm), Hira5 (81.20 cm) and BRRI hybrid dhan2 (79.81 cm). BRRI dhan29 produced longer panicle (27.23 cm) compared to other varieties. The hybrid variety BRAC aloron produced shorter (22.33 cm) panicle^{-1} length. However, the highest number of filled grains panicle^{-1} (162.57) was counted in BRRI hybrid dhan2 and the lowest number (136.95) was obtained from ACI 1. The highest number of total grains and unfilled grains panicle^{-1}(179.33, 27.37) were obtained from inbred variety and the lowest number of total grains and unfilled grains panicle^{-1}(149,23, 6.60) were obtained from hybrid variety BRAC aloron. The highest weight of 1000-grains (35.68 g) was obtained from BRAC Aloron and the lowest weight of 1000-grains (24.98 g) was obtained from BRRI dhan29. BRRI hybrid dhan2 produced the highest fresh grain yield (7.36 t ha^{-1}) but the highest dry grain yield (6.33 t ha^{-1}) was given by BRAC aloron; the lowest fresh straw yield (10.98 t ha^{-1}) was recorded from the BRRI dhan2 and the lowest dry straw yield (4.86 t ha^{-1}) was found in BARC aloron. Whereas, BRRI dhan29 produced the lowest fresh grain yield (5.58 t ha^{-1}) and lowest dry grain yield (4.16 t ha^{-1}); the highest fresh straw yield (14.39 t ha^{-1}) and highest dry straw yield (6.70 t ha^{-1}). The highest harvest index (56.50 %) was found from BRAC aloron and the lowest harvest index (37.67 %) was found from BRRI dhan29. The harvest index was 33.32% higher in BRAC Aloron compared to BRRI dhan29.

Interaction effect of planting material and variety significantly affected yield as well as yield contributing characters. The tallest plant was found from the mother plants of the variety BRRI dhan29 (89.33) and the shortest plant was observed from the clonal tillers of variety of BRRI hybrid dhan2 (71.33 cm). The highest number of effective tillers m^{-2} (160.67) was obtained from the hybrid variety BRAC aloron mother plant and the highest ineffective tillers m^{-2} (33.00) was observed from the variety of ACI 1 of mother plant. The highest total tillers m^{-2} (185.67) was also found from the mother plant of BRAC aloron. However the lowest number of effective tillers and total tillers m^{-2} (95.33, 116.67) was obtained from the hybrid variety BRAC aloron of clonal tillers. The nursery seedlings of BRRI dhan29 produced maximum panicle length (28.06 cm). The highest number of filled grains $panicle^{-1}$ (173.27) was obtained from the mother plant of BRRI hybrid dhan2 and the lowest number of grains $panicle^{-1}$ (129.63) was obtained from the ACI 1of the mother plant. The highest number of unfilled grains $panicle^{-1}$ (33.77) was obtained from the clonal tillers of BRRI dhan29 and the lowest number (6.57) was obtained from the clonal tillers of BRRI hybrid dhan2. The highest number of total grains $panicle^{-1}$ (195.57) was counted for BRRI dhan29 of clonal tillers and the lowest number of total grains $panicle^{-1}$ (139.67) was counted from BRAC aloron of clonal tillers. The highest weight of 1000-grains (36.32 g) was obtained from the hybrid variety BRAC Aloron of the clonal tillers which was similar to the other hybrid varieties, whereas the lowest weight of 1000-grains (21.56 g) was obtained from the inbred variety BRRI dhan29 of the clonal tillers. Among the treatments, the highest fresh grain yield was observed in mother plant of BRRI hybrid dhan2 (10.05 t ha^{-1}) that was similar with other hybrid varieties of mother plant and the lowest yield (4.55 t ha^{-1}) was observed in mother plant of BRRI dhan29. Again, the highest dry grain yield was observed in mother plant of Sonarbangla6 (7.80 t ha^{-1}) that was statistically similar to hybrid variety BRRI hybrid dhan2 (7.67 t ha^{-1}) and BRAC aloron (7.28 t ha^{-1}) of mother plant and the lowest yield (3.03 t ha^{-1}) was observed in clonal tillers of BRRI dhan29. The highest fresh straw yield (14.39 t ha^{-1}) was recorded in the inbred variety BRRI dhan29 of mother plant and the lowest fresh straw yield (10.89 t ha^{-1}) was found in the hybrid variety BRRI hybrid dhan2 of clonal tillers. The highest dry straw yield (7.11 t ha^{-1}) was recorded in the inbred variety BRRI dhan29 of mother plant and the lowest dry straw yield (3.67 t ha^{-1}) was found in the hybrid variety ACI 1 of clonal tillers. The highest of grain straw ratio (1.43) was obtained from the clonal tiller BRAC aloron and the lowest grain straw ratio (0.57) was obtained from the BRRI dhan29 of the clonal tillers. The highest biological yield (14.39 t ha^{-1}) was recorded in the hybrid variety Sonarbangla-6 of mother plant and the lowest biological yield (7.00 t ha^{-1}) in the BRRI hybrid dhan2 of clonal tillers. The highest harvest index (58.33%) was recorded in the hybrid variety BRAC aloron of clonal tillers and the lowest harvest index (33.33%) in the inbred variety BRRI dhan29 of clonal tillers.

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

❖ The mother plant showed higher grain yield compared to the clonal tillers.

❖ The hybrid varieties showed higher yield than the inbred variety.

❖ Mother plant of Sonarbangla-6, BRRI hybrid dhan2 and BRAC aloron observed higher yield potentiality.

❖ Both of mother plant and clonal tiller of BRAC aloron showed higher grain production than hybrid varieties although clonal tillers produce lower yield compared to mother plant.

However, to reach a specific conclusion and recommendation, more research work on growing boro rice using clonal tillers practice compared with intact mother crop should be done over different Agroecological zones.

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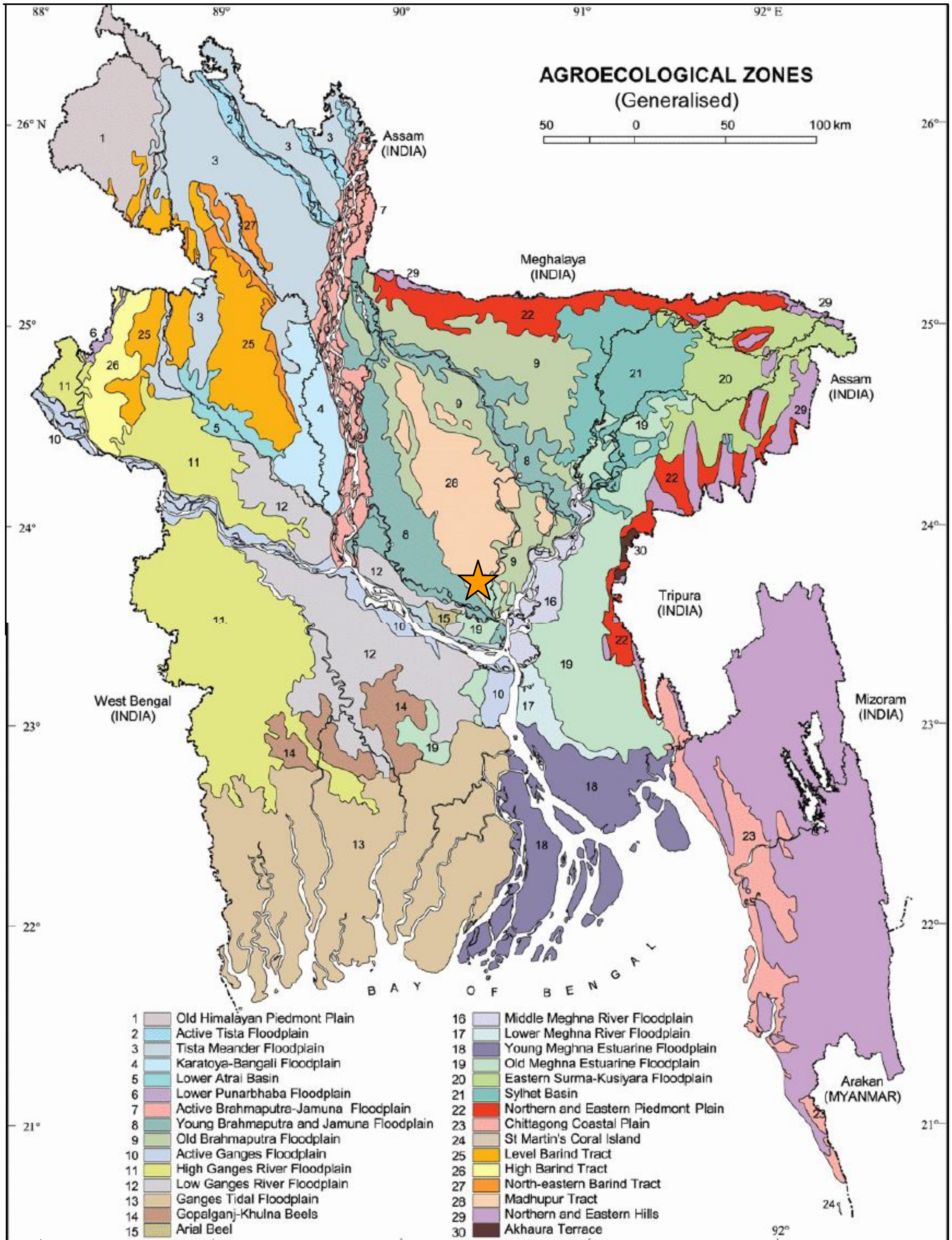
Appendices

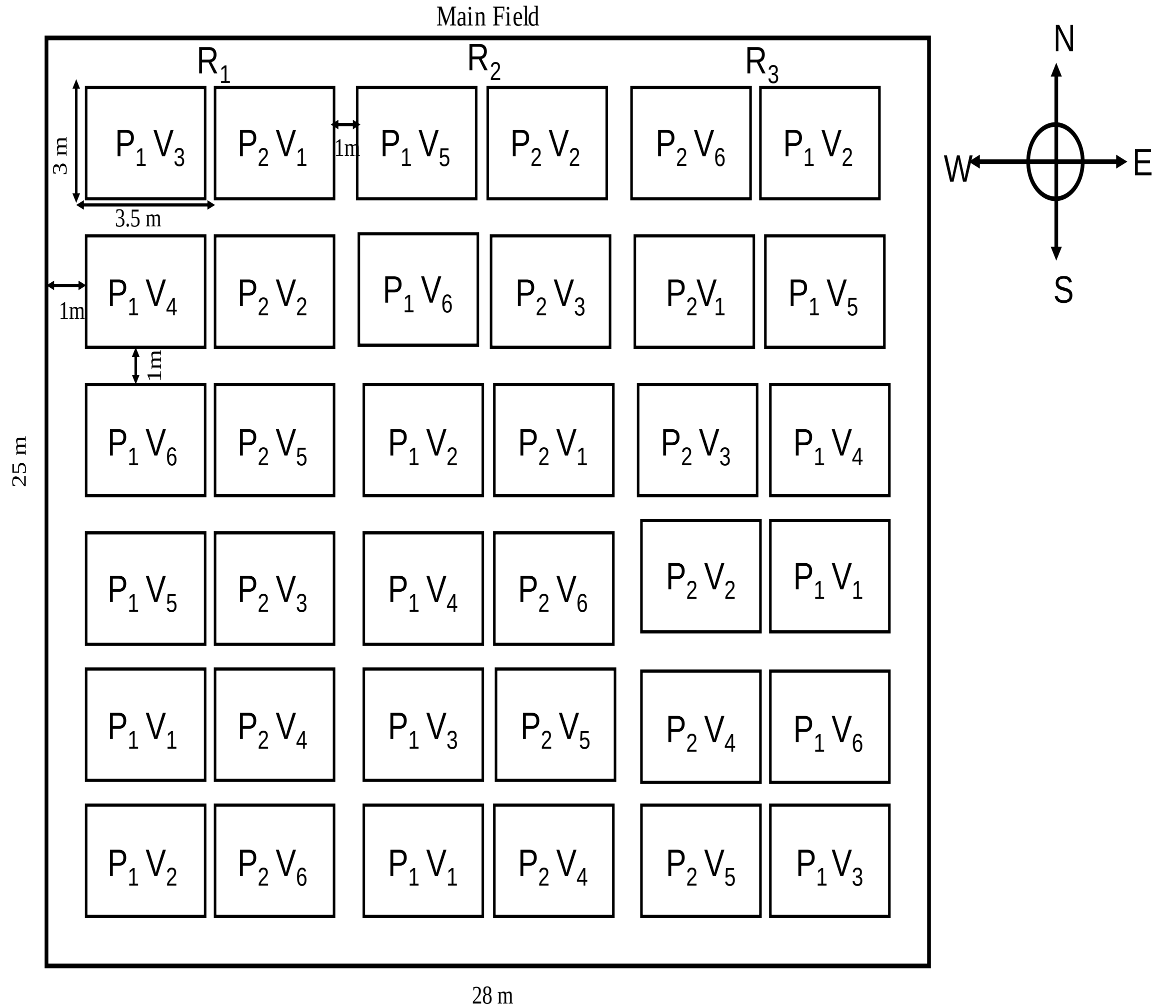
APPENDICES

Appendix I. Map showing the experimental sites under study



The experimental site under study

Appendix II. Layout of experimental field



Appendix III. Mean square values for plant height of *boro* rice at harvest

Sources of variation	Degrees of freedom	Mean square values
Replication	2	1.50405
Planting Material	1	967.003 *
Error (a)	2	11.8729
Variety	5	30.2396*
Variety x Planting Material	5	31.0073*
Error (b)	20	18.9968

* Significant at 5% level

Appendix IV. Mean square values for tiller numbers m^{-2} of *boro* rice

Sources of variation	Degrees of freedom	Mean square values for tiller numbers of *boro* rice at harvest		
		Effective tillers m^{-2}	Ineffective tillers m^{-2}	Total tillers m^{-2}
Replication	2	55.0333	20.5833	50.2694
Planting Material	1	1113.03 *	1002.78 *	1809.02 *
Error (a)	2	18.4333	6.86112	24.7750
Variety	5	30.3583	31.6667	22.8228
Variety x Planting Material	5	98.9183 *	26.7778 *	96.9517 *
Error (b)	20	38.1467	36.5556	48.6555

* Significant at 5% level

Appendix V. Mean square values for grains panicle^{-1} of *boro* rice

Sources of variation	Degrees of freedom	Mean square values		
		Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Total grains panicle^{-1}
Replication	2	783.501	93.6259	506.291
Planting Material	1	1299.60*	2.83362	722.714
Error (a)	2	30.0359	19.1053	120.009
Variety	5	704.390*	371.359*	991.106*
Variety x Planting Material	5	360.470*	58.7610*	868.005*
Error (b)	20	371.215	53.4366	293.647

* Significant at 5% level

Appendix VI. Mean square values for 1000 grain weight of *boro* rice

Sources of variation	Degrees of freedom	Mean square values
Replication	2	18.4619
Planting Material	1	14.5415
Error (a)	2	7.51591
Variety	5	91.1498*
Variety x Planting Material	5	15.6794*
Error (b)	20	10.0147

* Significant at 5% level

Appendix VII. Summary of analysis of variance for crop characters, yield and yield components of rice

Source of Variation	Degrees of freedom	Mean square values							
		Panicle length (cm)	Fresh grain yield (t ha^{-1})	Dry grain yield (t ha^{-1})	Fresh straw yield (t ha^{-1}))	Dry straw yield (t ha^{-1})	Grain straw ratio	Biological yield (t ha^{-1})	Harvest index
Replication	2	1.14123	1.38461	1.25923	0.519469	0.169233	0.04567	0.788575	46.3611
Planting Material	1	0.00233	80.9101*	51.0034 *	120.268*	31.1364*	0.01469	162.095*	23.3611
Error (a)	2	0.12187	.798526	0.898845	0.611503	0.395833	0.04697	0.542052	33.3611
Variety	5	14.6427*	2.59773*	3.87103*	8.64136*	2.83131*	0.32108*	1.65935	250.628*
Variety x Planting Material	5	6.50984*	2.52254*	0.814983*	2.16079*	0.950987*	0.09588*	1.24942*	63.5611*
Error (b)	20	1.16972	1.02158	0.770212	1.66161	1.04552	0.04543	1.99357	37.9278

* Significant at 5% level