INFLUENCE OF CLONAL TILLERS AGE ON GROWTH AND YIELD OF INBRED AND HYBRID RICE

BY

MD. OBAIDULLAH

REGISTRATION NO. 27609/00753

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Approved by:

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

(Prof. Dr. A. K. M. Ruhul Amin)
Co-supervisor

(Prof. Dr. Parimal Kanti Biswas)
Chairman
Examination Committee

CERTIFICATE

This is to certify that thesis entitled, **"INFLUENCE OF CLONAL TILLERS AGE ON GROWTH AND YIELD OF INBRED AND HYBRID RICE"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **MD. OBAIDULLAH**, Registration No. **27609/00753** 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: 27/6/07
Place: Dhaka, Bangladesh

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

Dedicated

To

MY BELOVED PARENTS

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INFLUENCE OF CLONAL TILLERS AGE ON GROWTH AND YIELD OF INBRED AND.HYBRID RICE

ABSTRACT

A field experiment was carried out at Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka during the period from August to November 2006 to study the growth and yield of inbred and hybrid rice with clonal tillers age. The trial was conducted with two levels of treatments viz. A. Variety: BRRI dhan 32 and Sonarbangla 1; and B. Clonal tillers age 20, 25, 30, 35 and 40 days. Variety had significant effect on all the parameters like plant height, number of tillers $hill^{-1}$, leaf area index (LAI), total dry weight, total grains $panicle^{-1}$, filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$, 1000-grain weight, grain yield and straw yield except effective tillers $hill^{-1}$, panicle length, rachis $panicle^{-1}$, and harvest index. The highest grain yield (5.58 t ha^{-1}) was obtained from the hybrid variety and the inbred variety gave the lowest grain yield (3.88 t ha^{-1}). The hybrid variety had the highest filled grains $panicle^{-1}$ (156.84) and 1000 grain weight (27.40 g) as compared to BRRI dhan 32 but the highest number of total grains flowering duration was found in inbred variety compared to hybrid variety. Clonal tiller age (days) did no significantly influence the growth and yield attributes except panicle length, where younger tillers gave longer panicles. Tillers age ranging from 20 to 30 days showed the best performance than other clonal tillers age. The highest grain yield (5.10 t ha^{-1}) was obtained from the clonal tiller separation at 25 days and the lowest grain yield (4.31 t ha^{-1}) was obtained from the clonal tillers of 40 days. Tillers $hill^{-1}$ was not affected by clonal tillers age except 60 DAT, where younger tillers produced higher number of tillers $hill^{-1}$ as compared to aged tillers. Aged clonal tiller extended the flowering duration. It was concluded that clonal tillers age should be within 20 to 30 days because aged clonal tillers affected the growth and yield of both hybrid and inbred rice.

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LIST OF ACRONYMS

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

Chapter 1
Introduction

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop of tropical world. There are 111 rice-growing countries in the world that occupy about 146.5 million hectares land more than 90% of which is in Asia (Anon., 1999). Rice is the staple food for more than two billion people in Asia and many millions in Africa and Latin America. To feed the fast increasing global population, the world's annual rice production must increase to 760 million tons by the year 2020 (Kundu and Ladha, 1995).

In Bangladesh there are three diverse growing seasons of rice namely Aus, Aman and Boro. About two-thirds of the cultivated land area of Bangladesh is occupied by rice. Increased rice production in this country is essential to meet the food demand of the teeming population. Unfortunately, the yield of rice is very low in Bangladesh (3.34 t ha^{-1}) compared to Australia (9.65 t ha^{-1}), Korean Republic (6.59 t ha^{-1}), Japan (6.70 t ha^{-1}) and Spain (6.59 t ha^{-1}) respectively (FAO, 2004).

Among the three distinct rice groups, transplanted Aman rice covers the largest area of about 5.678 million hectares with a production of 11.520 million tons of rice (BBS, 2004). The country is now producing about 42.3 million tons of clean rice @ 3.78 t ha^{-1} in 11.2 million ha of land.

As rice is the main crop of Bangladesh, so more emphasis should be given on its cultivation practices. Rice can be cultivated either by seeds, seedlings or clonal tillers.

Aman rice is more popular in Bangladesh and farmers cultivate this crop more than the other season's rice. The problem that because in Bangladesh flooding starts in the month of June-July and reaches its peak in the month of August-September. The vegetative stage of Aman rice occurs in this period. So, sometimes Aman rice may be badly affected by the flood.

Although rice is adapted to lowland, complete submergence for more than 2-3 days may kill most of the rice cultivars (Mishra *et al.*, 1996). This type of damage would be more serious for dwarf and semidawrf varieties because at may lead to total crop loss.

Roy *et al.* (1990) and Biswas and Salokhe (2001) recommended to transplant the field using clonal tillers of 30 days, but research is finding not available regarding other ages of clonal tillers.

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

Clonal 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 (from the undamaged fields) in the prepared main field after recession of flood water.

The utilization of clonal tillers collected from the already established field is now a well established system to patch up the damaged field (Sharma, 1995; Biswas *et al.*, 1989; Biswas and Salokhe, 2001; Biswas, 2001; and Roy *et al.* 1990). The age of clonal tillers may respond differently and hence it is necessary to conduct a detailed study with different age of clonal tillers using inbred and hybrid rice.

OBJECTIVES :

1. to find out the optimum age of clonal tillers to have maximum growth and yield of rice,
2. to compare the performance of inbred and hybrid clonal tillers and
3. to determine the interaction effect of variety and clonal tillers age on yield of rice.

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Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

The growth and development of rice may be vary due to the use of clonal tillers having different ages. Age of tiller seedlings using inbred and hybrid is important especially when tillers are used as planting material. Relevant reviews on the above aspects have been presented and discussed in this chapter.

2.1 Effect of clonal tillers age

Transplanting of clonal tillers at different ages separated from a previously transplanted rice crop might be regarded as an important technique of vegetative propagation of rice. Scientific studies in this regard are limited. Some of the work on clonal tiller age and related literature are discussed below.

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

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

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

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

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

Biswas and Salokhe (2001) observed that vegetative tillers gave higher yield than nursery seedlings transplanted on the same date. The yield components, i.e. weight of 1000 grains, grains panicle^{-1} and percent filled grain showed better responses with early transplanting of the photo periodically sensitive KDML 105 in the mother crop and vegetative tillers. The result suggested that in some flood prone lowland, where the transplant crop is damaged by natural hazards, vegetative propagation using tillers separated (maximum of 4 hill^{-1}) from the previously established transplanted crop at 30 DAT was beneficial for higher productivity.

Molla (2001) conducted an experiment 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 hybrid rice (Pro Agro 6201 and CNRH 3) and one HYV (IET4786), 2 seedling ages (21 and 28 days old), and 2 levels of seedling number per hill (1 and 2 seedlings per hill for hybrid rice and 3 and 6 seedlings per hill for 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 vigour (heterosis). Twenty eight days old seedlings produced more tiller, panicles m^{-2}, and grain yield than 21 days old seedlings. Seedlings per hill significantly influenced the number of tillers, mature panicles/m^2 and rice yield. Two seedlings per hill had significantly higher 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.

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

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

Mamin *et al.* (1999) observed that intact mother hills produced the highest yield (5.0 t ha^{-1}), when retaining 4 tillers with mother plant produced the lowest yield (4.46 t ha^{-1}). Intact mother hills 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 95-101 cm. 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}).

Paul (1999) reported that the maximum plant height and panicle length at harvest was found when tillers were separated at 25 DAT whereas, separated at 35 DAT was minimum in respect of above characters. He also obtained the highest number of effective tillers $hill^{-1}$, number of grains $panicle^{-1}$ and grain yield when 2 tillers were kept $hill^{-1}$.

ZhiRen *et al.* (1999) reported that the yield of rice (*Oryza sativa*) cv. II You 92 when sown in a dry seedbed and transplanted 25, 30, 35, 40 or 45 days after sowing was investigated in 1996 and 1997. Yield was significantly negatively correlated to age at transplanting. Mean yields were 6762, 6547, 5970, 4730 and 4557 kg ha^{-1} with transplanting at 25, 30, 35, 40 and 45 days, respectively. Yields at 25-35 days were significantly higher than at 40-45 days. The limit of transplanting age is therefore 35-40 days. Culm height, number of grains per panicle and grain filling rate decreased with increasing transplanting age. Logistic equations are presented which relate tillering of seedlings to their age at transplanting.

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 cv. Panidhan established by direct sowing and transplanting with either conventional nursery seedlings or 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) or 30 days (1995) of growth but further delayed in the uprooting of tillers up to 90 days (1994) and 75days (1995) decreased yield by 0.34-0.85 t ha^{-1} compared with the undisturbed crop. The decrease in yield was due to reduced panicle number/m^2 which was not compensated by increased panicle weight. The transplanted crop raised 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 (78.3-88.7 cm) and had more dry weight (0.86-2.05g $plant^{-1}$) 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 whereas 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.

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

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

WenXiong *et al.* (1996) reported that Shanyou 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 growth stages) and favourable partitioning of photosynthate 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.

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

Mallick (1994) carried out a pot experiment at the Institute of Postgraduate Studies in Agriculture (IPSA), Salna, Gazipur during the wet season, 1993 to evaluate the varietal differences in panicle characteristics, spikelet 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 (1994) compared the performance of intermediate rice under direct seeded and transplanted condition at Cuttack, India. The direct seeded crop with the higher seedling rate was thinned by uprooting some of the plants, including clonal tillers (100-120 m^{-2}), which were transplanted and reported that clonal tillers performed better than the others and could acclimatized more easily to flooded conditions. Clonal propagation was superior to nursery-grown seedlings and yield did not decrease with the removal of clonal tillers.

Tsukaguchi *et al.* (1994) reported that the maximum tiller number m^{-2} was obtained at 50 days after transplanting. Shieh (1979) reported that in rice plant, tillering begins about 20 days after transplanting. After reaching the maximum tiller number stage the number of tillers decreased much significantly.
Matsuo and Hoshikawa (1993) observed that tillers can absorbed nutrient substances through their own roots after complete emergence of 3rd leaf, since roots appeared at the prophyll nodes of tillers at this stage.

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

Mollah *et al.* (1992) observed that late tiller separation 40 DAT significantly reduced grain yield by 0.41 t ha^{-1} compared to an early tiller separation 30 DAT. The yield decrease in late tiller separation was accompanied by a reduction in effective tillers from both $plant^{-1}$ and $unit^{-1}$ area. As greater numbers of tillers were taken away from the mother hill, plant height, percent sterility of spikelet and straw yield were reduced significantly but growth duration was prolonged. These had, however, no influence on the grain yield and yield components as compared to the intact mother hill.

Sharma (1992) reported that there was no decrease in the yield of rice crop when clonal tillers were removed after 60 days to transplant either the equivalent or double the uproot plot area. The loss due to decrease in panicles m^{-2} with the removal of clonal tiller was compensated by the resulting increase in panicle weight. The crop planted from clonal tiller produced a significantly higher grain yield than planted from seedlings of equivalent age raised in a nursery seedbed with or without fertilizer application. Furthermore, the clonally propagated crop tolerated simulated flash flooding better at the early vegetative stage, measured by less tiller mortality and relatively higher dry matter production than in the crop raised from nursery seedlings. Therefore, planting with clonal tillers uprooted from a well-established direct-seeded crop was recommended under excess water condition.

Murthy *et al.* (1991) showed that shoot removal of rice plant reduced the grain yield. The tiller losses at any stage of crop growth would lead to a reduction. Shoot removal at flowering was most detrimental (25-100% reduction in yield), followed by shoot removal at panicle initiation (11.2-91.9%) and at active tillering (0.6-47.8%) time. Providing at least four tillers remained (including the main shoot), yield was unaffected by shoot removal at the active tillering stage. This indicated that not all the tillers produced were needed.

BRRI (1990a) stated that splitting of tillers ranging from 1 to 5 at 30 DAT or 40 DAT produced satisfactory grain yield without significant loss of the mother crop. This trend was observed in both Aus and transplant Aman crop. It was concluded that transplantation of splitted tillers from mother crop was a unique way to boost productivity during seedling scarcity.

BRRI (1990b) conducted an experiment with 35 and 27 days old seedlings of BR23. Two and three tillers were separated from mother plant at 32 days after transplanting and retransplanted in new plots. They found that 32 days after transplanting tiller seedlings performed well in respect of grain yield.

Rao (1990) conducted an experiment with plant derived from primary, secondary and tertiary tillers and transplanted at 20 x 10 cm spacing produced 48,800, 46,900 and 23,500 spikelets m^{-2} and grain yields of 551, 610 and 395 g m^{-2} respectively compared with 49,200 spikelets m^{-2}, and grain yields of 653 g

m^{-2} in control plants. High density grain index was 45.3, 45.3, 39.1 and 45.1% for plants derived from primary, secondary and tertiary tillers and control plants respectively.

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 as replanted 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 the control was 3.8 t ha^{-1}.

BRRI (1989a) reported that splitting tillers up to 3 $hill^{-1}$ did not affect yield of the main crop in Aus while in Aman, splitting tillers up to 5 did not reduce yield. It appeared that tillers could be separated from 30 days old mother plants and any delay reduced the yield when 3 or more tillers were separated.

BRRI (1989b) reported that splitted tillers at 40 days after transplanting gave higher grain yield than the tillers separated at 30 days after transplanting.

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.

Roy *et al.* (1989) conducted an experiment with variety BR11 at 4 to 5 seedlings hill^{-1}. After 35 days I, 3, 5 and 7 tillers were separated and replanted with 65 days old seedlings of the same variety as a control. They observed that number of panicles m^{-2} was higher with control and the lowest with tiller hill^{-1}. Number of grains panicle^{-1} was significantly lower with control but no significant differences were observed with 1000 grain weight. Grain yield was significantly reduced compared with the control and 1 tiller planted hill^{-1} but there was no significant difference in grain yield with 3 to 7 tillers planted hill^{-1}.

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

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

Reddy and Ghosh (1987) noted that uprooting of 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.

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

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

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

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

Luh (1980) reported that tillering and the production of leaves are the main visible activity during the vegetative phase of rice. In the tropics, maximum tiller number in rice occurred at 40 to 60 days after transplanting, depending upon the tillering capacity of the variety, the spacing used and the fertility level. The high yielding tropical varieties produced 25 to 30 tillers when grown as isolated plants.

Gomosta and Haque (1979) studied that the potential contribution to panicle formation of tillers produced in different weeks and reported that rice started to produce tillers after the second week of sowing. The tiller produced within 3rd week were 93 to 100% productive, 4th week 70 to 73% productive, 5th week were 15 to 34% productive and none of the 6th and 7th week tillers developed panicles.

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.

Fagade and Ojo (1977) reported that among the yield components, panicle number per unit area was largely influenced by the planting density and the amount of tillering. The number of tiller producing panicles was determined during the vegetative growth phase, a period from germination to panicle primordium initiation. A strong positive correlation was observed between nitrogen and the number of panicles produced $hill^{-1}$.

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

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 dwarf ones showed a large number. Tiller number and panicle number are positively correlated. Tall tropical and sub-tropical cultivars tend to have a low ratio of panicles 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.

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 *et al.* (1964) reported that vegetative propagation of rice reduced seedling mortality, increased number and weight of grains panicle^{-1}, increased panicle length and caused least sterility resulting in increased grain yield compared to that of plants from normal seedlings obtained from sexual propagation from seed.

Richharia *et al.* (1964) observed that twenty one, out of thirty varieties, exhibited differential response in increasing the grain yield by the simple process of separating the tillers three weeks after planting with a spacing of 15x15 cm^2 and replanting them with a closer spacing of 15.0x4.5 cm^2 with the same area. The plant height, number and weight of grains plant^1 and length of panicle were more in tiller plant than those in seed plants. They also showed some other advantages of tiller crop such as withstanding late planting by quicker establishment, uniform stand, least mortality, reducing sterility and flowering about 10 days earlier. Above all an increased yield by more than 10% was obtained by vegetative propagation as compared to that of normal seedlings.

Richharia and Patnaik (1963) stated that vegetatively propagated rice had less tillers, gave a higher grain yield and in general absorbed more nutrient than transplanted plant grown from seed.

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 through 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.

Richharia (1960) stated that formation of tillers by activation of dormant buds was more pronounced in photoperiodically sensitive, long duration varieties than in insensitive ones. Probably prolongation of the vegetative phase provided in photosensitive varieties until the advent of the favourable season for initiation of the reproductive phase gave an opportunity for more abundant development of dormant buds. This method of vegetative propagation might prove useful in breeding genetical stock and the multiplication of pure varieties.

2.2 Effect of variety

The successful production of any crop depends on manipulation of basic ingredients of crop culture. The variety of crop is one of the important basic ingredients. High yielding varieties of rice play an important role in achieving higher yield. Some of the works related to different rice varieties are cited below.

Akbar (2004) reported that variety, seedling age and their interaction exerted significant influence on almost all the crop characters. Among the varieties, BRRI dhan 41 performed the best in respect of number of bearing tillers hill^{-1}, panicle length, total spikelets panicle^{-1} and number of grains panicle^{-1}. BRRI 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 × 15 day-old seedlings. Therefore, BRRI dhan 41 may be cultivated using 15 day-old seedlings in Aman season following the SRI technique to have better grain and straw yields.

In a trial, varietal differences in harvest index and yield were examined using 60 Japanese varieties and 20 high yielding varieties bred in Asian countries. It was reported that harvest index varied form 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} to 40.0 g plant^{-1}. The mean value of yield in Japanese group was 22.8 g plant^{-1}, and that in the 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 high 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 I inbred variety HKR 126) during rainy season and observed that hybrid ORI 161 exhibited superiority to other varieties in grain yield and straw yield.

Tac *et al.* (1998) conducted an experiment with two rice varieties, Akitakomachi and Hitombore in Tohoku region of Japan. It was found that Hitombore yielded the highest (7.10 gm^{-2}) and Akitakomachi yielded the lowest (660 gm^{-2}).

BRRI (1995) conducted three experiments to find out the performance of different rice varieties. First experiment results indicated that BR4, BR10, BR11, Challish and Nizersail produced grain yield of 4.38, 3.12, 3.12, 3.12 and 2.70 t ha^{-1}, respectively. Challish cultivar flowered earlier than all other varieties. BR22 and BR23 showed poor performance. Second experiment was with rice cv. BR10, BR22, BR23 and Rajasail at three locations in Aman season. It was found that BR23 yielded the highest (5.17 t ha^{-1}), and Rajasail yielded the lowest (3.63 t ha^{-1}). Growth duration of BR22, BR23 and Rajasail were more or less similar (152-155 days). Third experiment was with BR22, BR23, BR25 and Nizersail during Aman season at three locations - Godagari, Noahata, and Putia where BR25 yielded the highest and farmer preferred it due to its fine grain and desirable straw qualities.

Ali and Murship (1993) conducted an experiment during July to December 1989 to determine suitable variety for late transplant Aman rice. They reported that local variety Kumargoir significantly out yielded the modern rice cultivars BR23 and BR11.

BINA (1993) evaluated the performance of four varieties- IRATOM 24, BR14, BINA-13 and BINA-9. It was found that the varieties differed significantly in respect of plant height, number of unproductive tillers $hill^{-1}$, panicle length and sterile spikelets $panicle^{-1}$.

Leenakumari *et al.* (1993) 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}).

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 trial 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, Pajam and BRl6, respectively (Hossain *et al.*, 1991).

Hossain and Alam (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 grain yield and Pajam yielded the lowest. The superiority of promising line over the high yielding varieties in respect of grain yield was recorded by Bhuiyan and Saleque (1989).

Islam and Ahmed (1981) reported that the varieties Naizersail, Latishail, IR5 and IR20 differed significantly in respect of their performance. The two exotic cultivars of rice IR5 and IR20 independently gave significantly higher yield of grain than either of the other two local cultivars; and of the two exotic cultivars, IR5 was higher yielder (5188 kg ha^{-1}) though it was statistically identical with IR20 (5022 kg ha^{-1}) in respect of yield.

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.

Chapter 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka during the period from June to November 2006. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and their analyses.

3.1 Site description

The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28 during the Aman season of 2006. The land area is situated at 23°41′N latitude and 90°22′E longitude at an altitude of 8.6 meter above sea level. The experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

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

3.3 Soil

The farm belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resources and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil is presented in Appendix IV.

3.4 Crop/Planting material

A high yielding variety of Aman rice BRRI dhan 32 and a hybrid rice variety Sonarbangla 1 were used as a test crop. The variety BRRI dhan 32 was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. The grains are medium-slender with light-golden husks. The milled rice is medium-thick and white. Sonarbangla 1 a hybrid rice variety which produces higher yield than modern variety. It is introduced in Bangladesh by Mollika Seed Company from China. The pedigree line (BR4363-3-8-1-2-4) of the BRRI dhan 32 variety was derived from a cross of BR4 and BR2662. The variety was released in 1994 for cultivation in Aman season. BRRI dhan 32 is resistant to Leaf Blight and moderately resistant to Tungro, Blast and Sheath Blight (BRRI, 2004).

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3.5 Seed collection and sprouting

Seeds of BRRI dhan 32 were collected from BRRI, Joydebpur, Gazipur, Bangladesh and the Sonarbangla 1 Hybrid rice seed was colleted from the Mollika seed company, Dhaka. Healthy seeds were selected following standard method. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of water and tightly kept in gunny bags. The seeds started to sprout after 48 hrs which became ready for sowing in 72 hrs.

3.6 Raising of seedlings

A common procedure was followed in raising seedlings in the seedbed. The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown as uniformly as possible on June 24, 2006. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.7 Collection and preparation of initial soil sample

The initial soil samples from the main field were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different locations covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves were picked up and removed. Then the sample was air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis. The physico-chemical properties of the soil are shown in Appendix IV.

3.8 Preparation of experimental land

The experimental field was first opened on August 21, 2006 with the help of a disc plough, later the land was irrigated and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of previous crop were removed from the field. The field layout was made on 18th August, 2006 according to design immediately after final land preparation. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.9 Fertilizer dose and methods of application

At the time of first ploughing cowdung at the rate of 10 t ha^{-1} was applied. The experimental area was fertilized with 120, 80, 120, 55 and 10 kg ha^{-1} N, P_2O_5, K_2O, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at final land preparation as a basal dose. Urea was applied in two equal installments. The first one-half of urea was applied after recovery at 7 days after transplantation, second one-half was applied at maximum tillering stage.

3.10 Experimental design

The experiment was laid in a split-plot design with three replications having variety in the main plots and tiller separation days in the sub-plots. There were 10 treatment combinations. The total numbers of unit plots were 30. The size of unit plot was 4m x 3m = $12m^2$. The distances between plot to plot and replication to replication were 1m. The layout of the experiment has been shown in Appendix II.

3.11 Experimental Treatments

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

A. Main plot (Variety): 2

1. BRRI dhan 32 (Inbred)-V_1
2. Sonarbangla 1 (Hybrid)-V_2

শেরেবাংলা কৃষি বিশ্ববিদ্যালয় গ্রন্থাগার শেরেবাংলা নগর, ঢাকা-১২০৭

B. Sub plot (Clonal tillers age): 5

1. 20 days (D_1)
2. 25 days (D_2)
3. 30 days (D_3)
4. 35 days (D_4)
5. 40 days (D_5)

3.12 Transplanting of seedlings and retransplanting of clonal tillers

A 25 days old seedlings were uprooted carefully for transplantation in adjacent field of mother crop at different days from which clonal tillers were collected. The seed beds were made wet by the application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. Clonal tillers of different ages as per treatment were uprooted and retransplanted on the well puddled plots on August 28, 2006 maintaining the standard spacing of 25cm x 15cm with two seedlings $hill^{-1}$.

3.13 Intercultural operations

3.13.1 Gap filling

After one week of each transplantation, a minor gap filling was done where it was necessary using the clonal tillers from the same source.

3.13.2 Weeding

During plant growth period two hand weedings were done. First weeding was done at 20 days after transplantation followed by second weeding at 15 days after first weeding.

3.13.3 Application of irrigation water

Irrigation water was added to each plot as per requirements. Before ripening, the field was allowed to become dry for all the treatments.

3.13.4 Plant protection measures

Plants were infested with rice stem borer and rice hispa to some extent which was successfully controlled by applying Diazinon two times @ 10 ml/ 10 liter of water for 5 decimal lands on 15 and 29 September and by Ripcord one time @ 10 ml/ 10 liter of water for 5 decimal lands on 18 September, 2006. Crop was protected from birds and rats during the grain filling period. Field trap and poisonous bait were used to control the rat. For controlling the birds watching was done properly, especially during morning and afternoon.

3.14 General observation of the experimental field

The field was observed time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable losses by pest was minimized. Incidence of stem borer, green leaf hopper, leaf roller and rice hispa was observed during tillering stage but controlled properly.

3.15 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains became golden yellow in color. The harvesting was done in two different dates for inbred as well as hybrid variety. For inbred variety harvesting was done on November 27 and for hybrid variety harvesting was done on November 08, 2006. Ten hills per plot were preselected randomly from which different growth and yield attributes 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 by using pedal thresher. The grains were cleaned and sun dried to a moisture content of 14 %. Straw was also sun dried properly.

3.16 Recording of data

Experimental data were recorded from 15 days of transplantation and continued up to harvest. The following data were recorded during the experimentation.

A. Crop growth characters

i. Plant height (cm) at 15 days interval
ii. Number of tillers $hill^{-1}$ at 15 days interval
iii. Leaf Area Index at 15 days interval
iv. Dry weight of plant at 25 days interval
v. Time of flowering

B. Yield and yield components

i. Number of effective tillers $hill^{-1}$
ii. Number of ineffective tillers $hill^{-1}$
iii. Length of panicle (cm)
iv. Number of filled grains $panicle^{-1}$
v. Number of unfilled grains $panicle^{-1}$
vi. Number of total grains $panicle^{-1}$

vii. Weight of 1000 grains (g)

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

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

x. Harvest index (%)

3.17 Detailed procedures of recording data

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

A. Crop growth characters

i. Plant height

Plant height was measured at 15 days interval starting from 15 days after transplantation (DAT) and continued up to harvest from randomly pre-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 before heading, and to the tip of panicle after heading. The collected data were finally averaged.

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

Number of tillers $hill^{-1}$ were counted at 15 days interval starting from 15 DAT and up to harvest from pre-selected ten hills $plot^{-1}$ and finally averaged as their number $hill^{-1}$. Only those tillers having three or more leaves were considered for counting as per Murata and Matsushima (1975).

iii. Leaf area index (LAI)

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

iv. Dry weight of plant

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

v. Time of flowering

Time of flowering was recorded when about 90% of the plants within a plot emerged flowering. The number of days for flowers was recorded.

B. Yield, yield components and other crop characters

i. Number of effective tillers hill^{-1}

The effective tillers from ten hills were counted and averaged to hill^{-1} basis. The panicles which had at least one grain was considered as effective tillers.

ii. Number of ineffective tillers hill^{-1}

The ineffective tillers from ten hills were counted and averaged to hill^{-1} basis. The panicles which had no grain was considered as ineffective tillers.

iii. Panicle length

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

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

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

v. Number of unfilled grains panicle^{-1}

Unfilled grains of spikelets present on each ten panicles were counted and averaged.

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

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

vii. Weight of 1000 grains

One thousand cleaned dried grains were counted randomly from each plot and weighed by using a digital electric balance when the grains retained 14% moisture and the mean weight was expressed in gram.

viii. Grain yield

Grain yield was determined from the central 6 m^2 area of each plot and expressed as t ha^{-1} on 14% moisture basis. Grain moisture content was measured by using a digital moisture tester.

ix. Straw yield

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

x. Harvest index (%)

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

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

3.18 Chemical analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in the laboratory of the Soil Resources and Development Institute (SRDI), Dhaka. The properties studied included texture, pH, organic matter, total N, available P, exchangeable K and available S. The physical and chemical properties of the initial soil have been presented in Appendix IV. The soil was analyzed following standard methods.

3.19 Statistical analysis of the data

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 significant 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 clonal tillers age of inbred and hybrid rice and their different interactions on the yield and yield components have been presented, discussed and compared in this chapter. The analytical results have been presented in Table 1 to Table 8, Figure 1 to Figure 16 and Appendix V to Appendix IX. A general view of the experimental plot have been shown in Plate 1.

4.1 Crop growth characters

4.1.1 Plant height at different days after transplantation

4.1.1.1 Effect of variety

The plant height of Aman rice was significantly influenced by different varieties at 45 and 60 days after transplantation (DAT) and at harvest but insignificant at 15 and 30 DAT (Appendix V and Table 1). The result revealed that at 45 DAT, the highest plant height (120.26 cm) was recorded in the hybrid variety (Sonarbangla 1) and the lowest height (85.44 cm) was in the inbred variety (BRRI dhan 32) and the same trend of plant height for hybrid variety over inbred variety was obtained at 60 days after transplanting and at harvest. At 60 DAT as well as at harvest the hybrid variety gave significantly highest plant height (119.27 cm and 118.54 cm) as compared to inbred variety (88.92 cm and 86.13 cm). The hybrid variety was about 38% taller at harvest as compared to the inbred variety. BINA (1993) and Ashrafuzzaman (2006) also observed that varieties differed significantly in respect of plant height.

4.1.1.2 Effect of clonal tillers age (days)

The plant height of Aman rice was significantly influenced by clonal tiller age at 15 DAT but no significant variations were observed at 30, 45 and 60 DAT and at harvest (Appendix V and Table 1). The result revealed that at 15 DAT, the highest plant height (71.80 cm) was observed from the clonal tillers of 40 days which was similar to 30 and 35 days of clonal tillers and the minimum plant height (59.40 cm) was observed from the clonal tillers of 20 days that was similar to 25 days old clonal tillers. At 30 DAT, numerically the tallest plant (80.66 cm) was obtained from the clonal tillers of 35 days. Numerically, the tallest plant (107.60cm) was recorded at 25 days old clonal tillers. At 60 DAT, the numerically tallest plant (106.60 cm) was obtained from the clonal tillers age of 25 days.

At harvest, there were no significant variations in plant height observed among the different ages of clonal tillers though 25 days old clonal tillers showed numerically tallest plant height (105.2 cm). Anwar and Begum (2004) reported that time of tiller separation of rice significantly influenced the plant height. These findings were similar with the findings of Kabir (2000) and Paul (1999) who observed maximum plant height with 25-30 days old rice tillers.

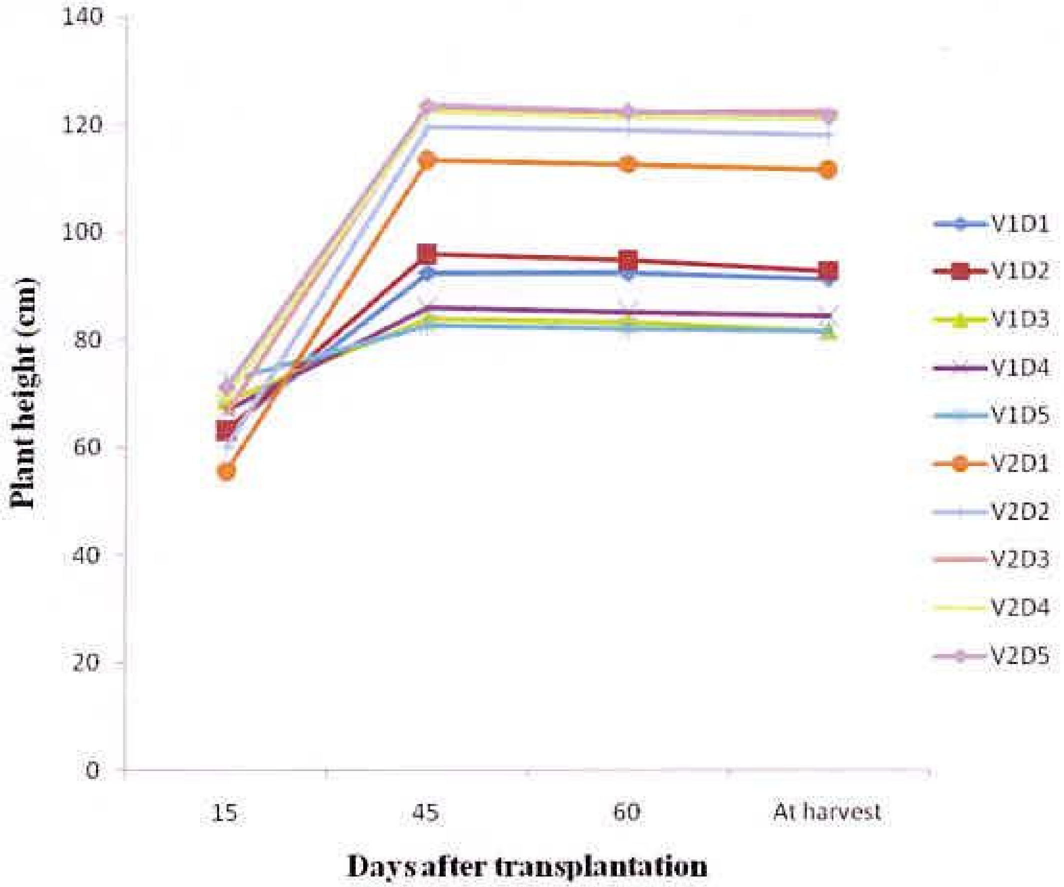
Table 1. Effect of variety and clonal tillers age on plant height of inbred and hybrid rice at different growth duration

Treatments	Plant height (cm) at different dates after transplantation				
	15	30	45	60	At harvest
Variety					
BRRI dhan 32	66.86	78.47	85.44	88.92	86.13
Sonarbangla 1	64.56	78.55	120.26	119.27	118.54
LSD (0.05)	NS	NS	3.833	3.869	3.789
CV (%)	5.92	4.12	2.75	1.14	1.62
Clonal tillers age: (days)					
20	59.40	74.70	102.80	102.30	101.30
25	61.54	77.47	107.60	106.60	105.20
30	67.54	80.10	103.30	103.40	103.30
35	68.25	80.66	104.00	103.00	102.50
40	71.80	79.63	96.47	102.10	101.30
LSD (0.05)	6.702	NS	NS	NS	NS
CV (%)	19.01	7.68	4.68	4.56	3.86

NS= Not significant

4.1.1.3. Interaction effect of variety and clonal tiller age (days)

The plant height of Aman rice was significantly influenced by the interaction effect of variety and clonal tiller ages at 15, 45 and 60 days after transplantation and at harvest but there was no significant variation observed at 30 days after transplantation (Appendix V and Figure 1). At 15 DAT, the inbred variety of 40 days old tillers showed the tallest plant height (72.39 cm) that was similar to the 40 days old clonal tillers of hybrid variety (71.20 cm). The lowest plant height (55.53 cm) was obtained from 20 days old tillers of the hybrid variety. At 45 DAT, hybrid variety irrespective of its clonal tillers age showed the highest plant height.



Here,

V1= BRRI dhan 32, V2= Sonarbangla 1, D1= 20 DAT, D2= 25 DAT, D3= 30 DAT, D4= 35 DAT, D5= 40 DAT

Figure 1. Interaction effect of variety and clonal tillers age on plant height of rice at different growth duration

In case of inbred variety younger tillers gave tallest plant height compared to aged tillers. At 60 DAT, the tallest plant (122.30 cm) was recorded from the clonal tillers age of 40 days of the hybrid variety followed by the clonal tillers age of 30 days of the same which was statistically similar with the tillers of 20, 25 and 35 days of the hybrid variety and 25 days of the inbred variety. The lowest plant height (81.86 cm) was recorded from the clonal tillers of 40 days inbred variety which was statistically similar with the ages of 30 days old of the inbred variety. The tallest plant (122.22 cm) was obtained at harvest from the clonal tillers of 30 days of the hybrid variety which was similar with 20, 35 and 40 days old of the same variety and lowest plant height (81.25 cm) was obtained from the clonal tillers of 40 days of inbred variety which was statistically similar with 30 and 35 days old of the same variety.

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

4.1.2.1 Effect of variety

The production of total number of tillers hill^{-1} of Aman rice was significantly influenced by different varieties at 30, 45 and 60 DAT but insignificant at 15 DAT and at harvest (Appendix VI and Table 2). At 15 DAT, the numerically maximum number of tillers hill^{-1} (4.25) was observed in hybrid variety (Sonarbangla 1) similar to the inbred variety (BRRI dhan 32). At 30 DAT, the higher number of tillers hill^{-1} (10.05) was counted in hybrid variety and the lower number of tillers hill^{-1} (7.63) in inbred variety. Similar trend was also found up to 60 DAT where hybrid variety (Sonarbangla 1) revealed higher tiller production compared to that of inbred variety (BRRI dhan 32). At 60 DAT, the higer tiller number hill^{-1} (13.65) was observed in the hybrid variety and the lower number of tillers hill^{-1} (9.23) was obtained from the inbred variety. BINA (1993) and Ashrafuzzaman (2006) also found that varieties differed significantly in respect of number of tillers hill^{-1}.

4.1.2.2 Effect of clonal tiller age (days)

The production of total tillers hill^{-1} was significantly influenced by different ages of clonal tillers at 60 DAT but not significant at 15, 30 and 45 DAT and at harvest (Appendix VI and Table 2). At 15 DAT, the numerically maximum number (4.37) of tillers hill^{-1} was recorded from the clonal tillers age of 40 days which was statistically similar with tiller ages of 20, 25, 30 and 35 days and the minimum number of tillers hill^{-1} (3.87) was recorded from the clonal tillers age of 35 days. At 30 DAT, maximum number (9.23) of tillers hill^{-1} was obtained from the clonal tillers age of 40 days which was statistically similar with the clonal tillers age of 20, 25, 30 and 35 days and the lowest number of tillers hill^{-1}

Table 2. Effect of variety and clonal tiller age on tiller production of Aman rice at different growth duration

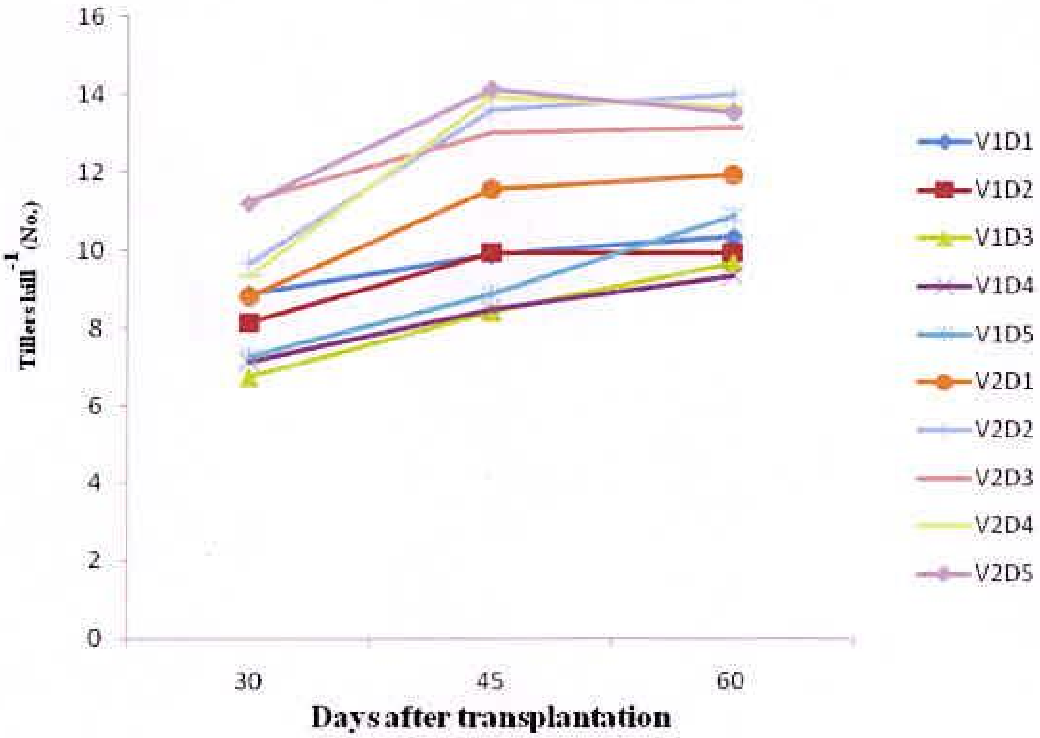
Treatments	Tiller number at different dates after transplantation				
	15	30	45	60	At harvest
Variety					
BRRI dhan 32	4.07	7.63	9.11	9.23	9.80
Sonarbangla -1	4.25	10.05	13.25	13.65	10.08
LSD (0.05)	NS	0.752	0.897	0.803	NS
CV (%)	22.15	9.42	10.54	11.19	13.33
clonal tiller age: (days)					
20	4.23	8.33	10.72	12.13	9.80
25	4.10	8.90	11.77	11.97	10.03
30	4.23	9.00	10.70	10.73	10.03
35	3.87	8.23	11.20	11.17	9.33
40	4.37	9.23	11.50	11.20	10.50
LSD (0.05)	NS	NS	NS	1.294	NS
CV (%)	11.13	10.29	10.34	12.62	10.44

NS= Not significant

(8.23) was obtained from the clonal tillers age of 35 DAT. At 45 DAT, maximum number of tillers hill^{-1} (11.77) was recorded from 25 days old tillers which was statistically similar with the clonal tillers ages of 20, 30, 35 and 40 days. At 60 DAT, the highest number of tillers hill^{-1} (12.13) was found in clonal tillers of 20 days that was similar to 25 days old tillers and the lowest number of tillers hill^{-1} (10.73) was recorded in 30 days old tillers. At harvest, numerically the maximum number of tillers hill^{-1} (10.50) was recorded from 40 days old tillers which was similar with other ages of clonal tillers. Kabir (2000) and Ashrafuzzaman (2006) observed that total number of tillers hill^{-1} was maximum when tillers were separated at 30-40 DAT. Luh (1980) reported that tillering and the production of leaves were the main visible activity during the vegetative phase of rice and the maximum tiller number occurred at 40 to 60 days. It was also found that tiller separation at 20 DAT gave the maximum number of tillers followed by 25 and 30 DAT and delayed tiller separation resulted the lower number of tillers hill^{-1}. Therefore, tiller age should be from 20 to 30 DAT than that of 35 and 40 DAT. Any delay in tiller age after the 30 DAT will, not only reduced the tiller number but also the grain and straw yield (BRRI, 1989a).

4.1.2.3 Interaction effect of variety and clonal tillers age (days)

Tiller numbers hill^{-1} were significantly influenced by the interaction effect between the variety and ages of clonal tillers at 30, 45, and 60 DAT (Appendix VI and Figure 2). At 15 DAT, numerically the maximum number of tillers hill^{-1} (4.80) was recorded in the hybrid variety of 30 days but it was similar with other ages of both the varieties. At 30 DAT, the magnitude of tiller production was to some extent changed where the highest number of tillers hill^{-1} (11.27) was recorded from the tillers age of 30 days of the hybrid variety which was similar to the 25 and 40 days old of the same variety. The lowest number of tillers hill^{-1} (6.73) was recorded from the clonal tillers age of 30 days of the inbred variety which was similar with the 25, 35 and 40 days of the inbred variety. At 45 DAT, the highest number of tillers hill^{-1} (14.13) was produced from the clonal tillers of 40 days of the hybrid variety which was statistically similar with the 25, 30 and 35 days old tillers of the same variety and the lowest number of tillers hill^{-1} (8.40) was produced from 30 days old of the inbred variety which was similar with the others tillers age (days) of the same variety. At 60 DAT, the highest number of tillers hill^{-1} (14.00) was counted from the 25 days old of the hybrid variety which was statistically similar with the 20, 30, 35 and 40 days old of the same variety. The lowest number of tillers hill^{-1} (9.33) was counted from the tillers age of 35 days of the inbred variety which was similar with the other ages clonal tiller of the same variety.



Here,

V1= BRRI dhan 32, V2= Sonarbangla 1, D1= 20 DAT, D2= 25 DAT, D3= 30 DAT, D4= 35 DAT, D5= 40 DAT

Figure 2. Interaction effect of variety and clonal tillers age on tiller production of Aman rice at different growth duration

At harvest, no significant variations in tillers hill^{-1} were observed for the interaction of variety and clonal tillers age though the higher numerical value of tillers number hill^{-1} (10.47) was recorded in 30 and 40 days old hybrid variety and the minimum number of tillers hill^{-1} (9.0) was found in 35 days old tillers of inbred variety.

4.1.3 Leaf area index (LAI)

4.1.3.1 Leaf area index (LAI) at different dates after transplantation

The leaf area of plant is one of the major determinants of its growth. The net dry matter production by a plant is more dependent on the size of its total assimilation system than on the photosynthetic rate of a single leaf which is just-one of the parameters determining the total photosynthetic production of the crop.

4.1.3.2 Effect of variety

Leaf area index (LAI) of Aman rice was significantly influenced by different age of clonal tillers at 15, 30, 45 and 60 DAT of growth duration (Appendix VII and table 3). At 15 DAT, the maximum LAI (2.36) was observed in hybrid variety (Sonarbangla 1) and the minimum LAI (1.66) was observed in inbred variety (BRRI dhan 32). Similar trend also continued upto harvest where hybrid variety (Sonarbangla 1) revealed maximum Leaf area index (LAI) compared to that of inbred variety (BRRI dhan 32). At 45 DAT, the highest leaf area index (7.45) was observed in hybrid variety (Sonarbangla 1) and the lowest leaf area index (5.39) was obtained from the inbred variety (BRRI dhan 32).

4.1.3.3 Effect of clonal tillers age (days)

Leaf area index (LAI) of Aman rice was significantly influenced by different dates of clonal tiller age at 15 DAT of growth duration but insignificant at 30, 45 and 60 days (Appendix VII and Table 3). At 15 DAT, significantly highest LAI (2.59) was recorded in older clonal tillers (40 days) which were statistically similar with tiller age of 35 days and the lowest LAI (1.59) was obtained in the clonal tillers age of 20 days. At 30 DAT, numerically the maximum LAI (4.82) was given by the clonal tillers age of 35 days that was similar with other ages of clonal tillers and the same trend of leaf area index was continued in case of 45 and 60 days after transplantation.

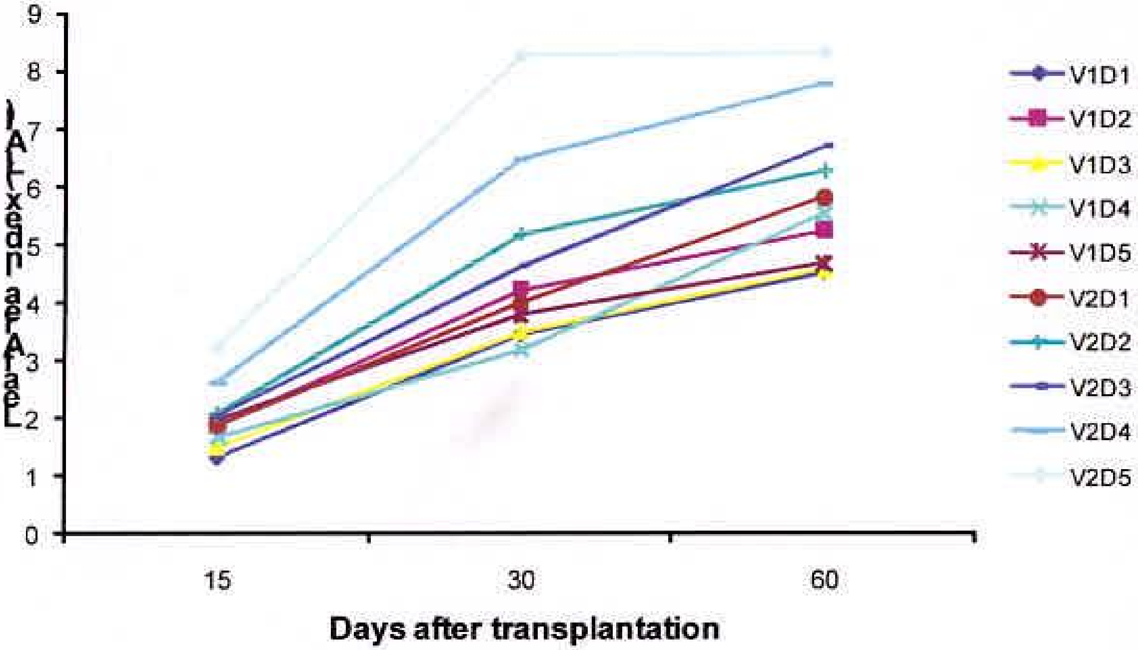
Table 3. Effect of variety and clonal tillers age on Leaf Area Index (LAI) of Aman rice at different growth duration

Treatments	Leaf Area Index (LAI) at different dates after transplantation			
	15	30	45	60
Variety				
BRRI dhan 32	1.66	3.63	5.39	4.92
Sonarbangla 1	2.36	5.19	7.45	6.82
LSD (0.05)	0.429	0.876	1.497	1.302
CV (%)	34.40	38.85	23.18	21.46
Clonal tillers age: (days)				
20	1.59	3.72	6.98	6.67
25	1.97	4.70	5.66	5.18
30	1.75	4.06	6.37	5.76
35	2.13	4.75	6.21	5.63
40	2.59	4.82	6.90	6.09
LSD (0.05)	0.694	NS	NS	NS
CV (%)	28.45	27.19	20.68	23.13

NS= Not significant

4.1.3.4 Interaction effect of variety and clonal tillers age (days)

The leaf area index (LAI) of Aman rice was significantly influenced by the interaction effect of variety and clonal tiller age at 15, 30 and 60 DAT but insignificant at 45 DAT (Appendix VII and Figure 3). At 15 DAT, the highest LAI (3.23) was recorded in older clonal tillers (40 days) of hybrid variety which was similar with 35 days old clonal tillers of the same variety. The lowest (1.32) LAI was found in 20 days clonal tillers of inbred variety.



Here,

V1= BRRI dhan 32, V2= Sonarbangla 1, D1= 20 DAT, D2= 25 DAT, D3= 30 DAT, D4= 35 DAT, D5= 40 DAT

Figure 3. Interaction effect of variety and clonal tillers age on leaf area index (LAI) of Aman rice at different growth duration

At 30 DAT, the highest LAI (6.47) was in case of 35 days older clonal tillers of hybrid variety which was similar with other ages of clonal tillers except 20 days and 25 days old clonal tillers of inbred variety. The lowest (3.17) LAI was noted from 35 days old clonal tillers of inbred variety. At 60 DAT, all the ages older clonal tillers showed similar LAI irrespective of variety except 20 days old clonal tillers of inbred variety.

4.1.4 Dry matter production

4.1.4.1 Effect of variety

Total dry weight $hill^{-1}$ was significantly influenced by variety at 25 DAT and at harvest. (Appendix VIII and Table 4). At 25 DAT, the hybrid variety had the highest weight (37.38 g) compared to the inbred variety (28.95 g). At harvest the trend was also similar to 25 DAT, where the hybrid variety gave about 98% higher dry weight $hill^{-1}$ than that of inbred variety.

Table 4. Effect of variety and clonal tillers age on total dry weight of Aman rice at different growth duration

Treatments	Weight of total dry matter (g $hill^{-1}$) at different dates after transplantation	
	25	At harvest
Variety		
BRRI dhan 32	28.95	61.87
Sonarbangla 1	37.38	121.98
LSD (0.05)	6.428	17.681
CV (%)	16.90	10.20
Clonal tillers age: (days)		
20	29.07	83.20
25	29.84	92.71
30	36.84	86.48
35	35.47	99.58
40	34.58	97.71
LSD (0.05)	NS	NS
CV (%)	25.75	18.77

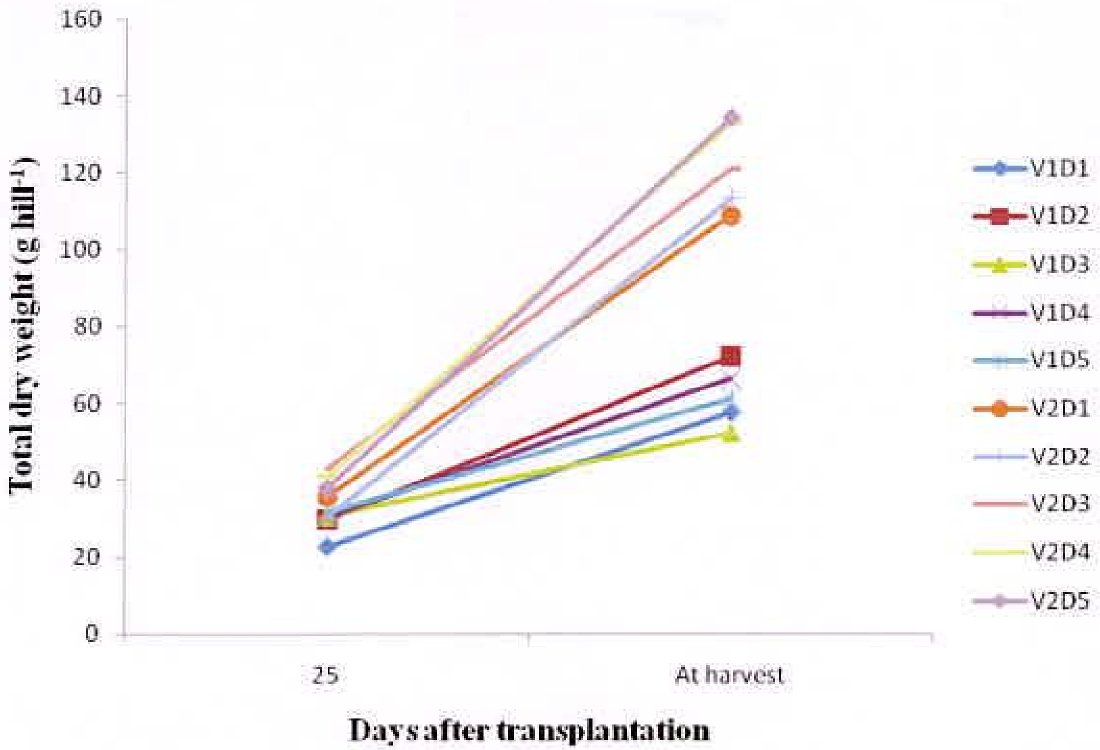
NS= Not significant

4.1.4.2 Effect of clonal tillers age (days)

Total dry weight of plant was significantly influenced by the clonal tiller age at 25 DAT at harvest (Appendix VIII and Table 4). At 25 DAT, numerically the maximum dry weight hill^{-1} (36.84 g) was recorded from the clonal tillers age of 30 days that was similar with the other ages of clonal tillers. The minimum dry weight hill^{-1} (29.07 g) was recorded from the age of 20 days. At harvest, the maximum dry weight hill^{-1} (99.58 g) was recorded from the age of 35 days and the minimum dry weight hill^{-1} (83.20 g) was recorded in the tillers age of 20 days.

4.1.4.3 Interaction effect of variety and clonal tillers age (days)

Interaction effect of variety and different ages of clonal tillers were significantly influenced in case of total dry matter production of rice at 25 DAT and at harvest (Appendix VIII and Figure 4). At 25 DAT, the highest dry matter hill^{-1} (42.78 g) was measured from the tillers age of 30 days of the hybrid variety followed by 35 days old of the same variety which was similar with different days of clonal tillers of the inbred variety except 25 days. The lowest dry matter hill^{-1} (22.70 g) was measured from the 20 days old of the inbred variety. At harvest, the highest dry matter hill^{-1} (134.12 g) was recorded from the clonal tillers age of 40 days of the hybrid variety which was similar to the other ages of clonal tillers of the same variety. The lowest dry matter hill^{-1} (52.14 g) was recorded from the 30 days old of the inbred variety.



Here,

V1= BRRI dhan 32, V2= Sonarbangla 1, D1= 20 DAT, D2= 25 DAT, D3= 30 DAT, D4= 35 DAT, D5= 40 DAT

Figure 4. Interaction effect of variety and clonal tillers age on total dry weight of Aman rice at different growth duration

4.1.5 Days to flowering

4.1.5.1 Effect of variety

The flowering days varied significantly between the varieties (Appendix IX and Table 5), where the inbred variety BRRI dhan 32 needed longer duration for flowering (101.27 days) compared to the hybrid variety Sonarbangla 1. The hybrid variety flowered 28 days earlier than the inbred variety. This might be due to the shortest life span of hybrid variety compared to that of inbred variety.

4.1.5.2 Effect of clonal tillers age (days)

The flowering duration significantly varied among the clonal tillers age (Appendix IX and Table 5). Tillers age of 40 days needed the longest duration for flowering (93 days). Tillers age of 35 days needed the second highest duration for flowering. The lowest duration for flowering (82.67 days) was observed from the tillers age of 25 days. Tillers age of 40 days flowered about 10 days earlier than that of 25 days.

Table 5. Effect of variety and clonal tillers age on flowering of Aman rice

Treatments	Flowering duration (days)
Variety	
BRRI dhan 32	101.27
Sonarbangla 1	72.93
LSD (0.05)	1.248
CV (%)	2.96
Clonal tillers age: (days)	
20	83.00
25	82.67
30	85.83
35	91.00
40	93.00
LSD (0.05)	1.973
CV (%)	13.192

4.1.5.3 Interaction effect of variety and clonal tillers age (days)

The flowering days significantly varied due to the interaction effect of variety and clonal tillers age (days) (Appendix IX and Figure 5). The highest duration (107 days) was needed for flowering in case of the tillers of 40 days old of the inbred variety and the lowest duration (68.67 days) from the tillers age of 20 days of the hybrid variety.

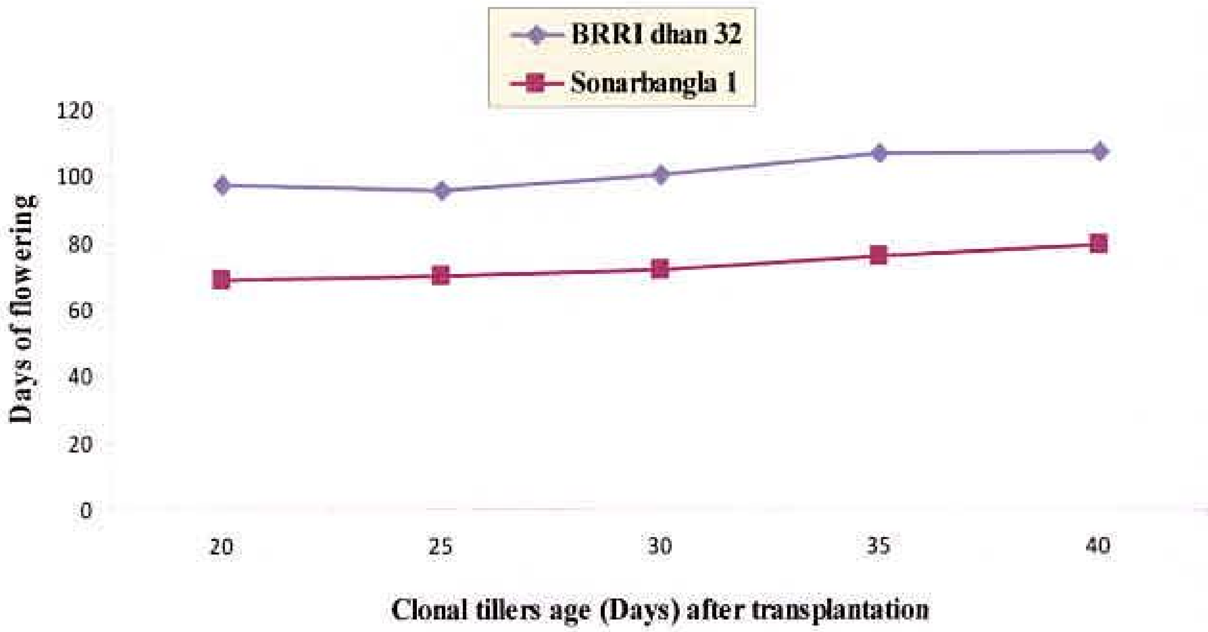


Figure 5. Interaction effect of variety and clonal tillers age (days) on flowering duration of Aman rice

4.2 Yield, yield attributes and other crop characters

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

4.2.1.1 Effect of variety

The number of effective tillers $hill^{-1}$ was not significantly influenced by variety (Appendix IX and Table 6). Numerically the maximum number of effective tillers $hill^{-1}$ (10.08) was obtained from hybrid variety and the minimum inbred variety (9.80).

4.2.1.2 Effect of clonal tillers age (days)

Number of effective tillers hill^{-1} was not significantly influenced by the different ages of clonal tillers (Appendix IX and Table 6). Numerically the maximum number of effective tillers hill^{-1} (10.50) was counted from 35 days old tillers which was statistically similar with the other ages of clonal tillers and minimum number of effective tillers hill^{-1} (9.33) was counted from 40 days old tillers.

Table 6. Effect of variety and clonal tillers age on effective and ineffective tillers hill^{-1} of Aman rice

Treatments	Effective tillers hill^{-1} (No.)	Ineffective tillers hill^{-1} (No.)
Variety		
BRRI dhan 32	9.80	1.39
Sonarbangla 1	10.08	1.29
LSD (0.05)	NS	NS
CV (%)	13.33	45.58
Clonal tillers age: (days)		
20	9.80	1.67
25	10.03	1.36
30	10.03	1.23
35	10.50	1.07
40	9.33	1.37
LSD (0.05)	NS	NS
CV (%)	10.44	40.45

NS= Not significant

4.2.1.3 Interaction effect of variety and clonal tillers age (days)

Number of effective tillers $hill^{-1}$ was not significantly influenced by the interaction effect of the variety and ages of clonal tillers (Appendix IX and Figure 6). The maximum number of effective tillers $hill^{-1}$ (10.53) was recorded from 35 days old tillers of the inbred variety which was similar with the different ages of clonal tillers irrespective of variety. The minimum number of effective tillers $hill^{-1}$ (9.00) was recorded from 40 days old tillers of the inbred variety.

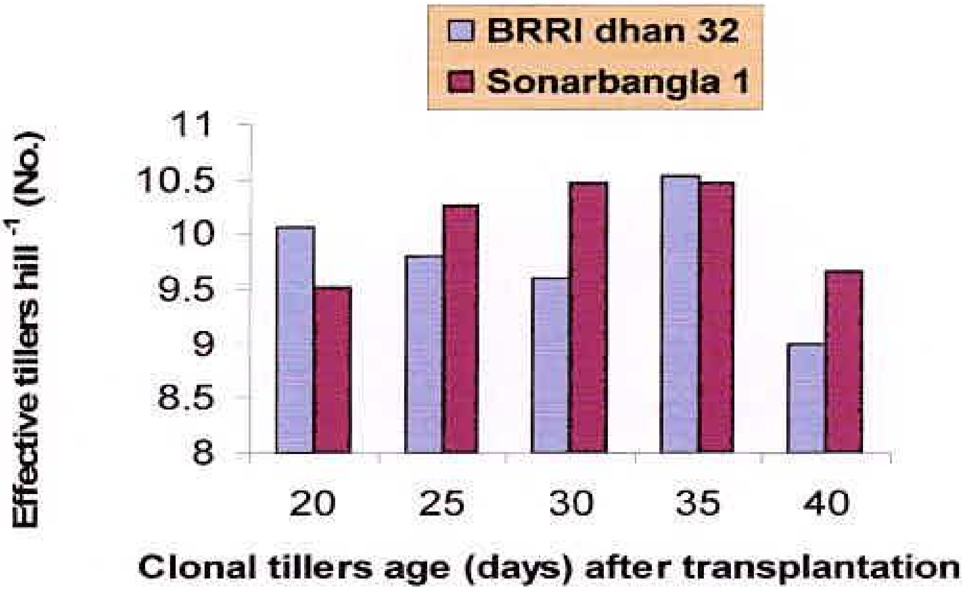


Figure 6. Interaction effect of variety and clonal tillers age (days) on the number of effective tillers $hill^{-1}$ of Aman rice

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

4.2.2.1 Effect of variety

The number of ineffective tillers $hill^{-1}$ was not significantly influenced by the variety (Appendix IX and Table 6) though the maximum number of ineffective tillers $hill^{-1}$ was obtained from inbred variety (1.39) and the minimum from hybrid variety (1.29).

4.2.2.2 Effect of clonal tillers age (days)

Number of ineffective tillers hill^{-1} was not significantly influenced by the different ages of tillers (Appendix IX and Table 6) though the higher number of ineffective tillers hill^{-1} (1.67) was counted from the 20 days old tillers and the lower number of ineffective tillers hill^{-1} (1.07) was counted from the clonal tillers age of 35 days.

4.2.2.3 Interaction effect of variety and clonal tillers age (days)

Number of ineffective tillers hill^{-1} was significantly influenced by the interaction effect of the variety and the clonal tillers age (Appendix IX and Figure 7).The highest number of ineffective tillers hill^{-1} (1.87) was recorded from the clonal tillers age of 20 days of the inbred variety which was statistically similar with all other treatments except 35 days old tillers of both varieties and these two treatments gave the lowest number of ineffective tillers hill^{-1} (1.07).

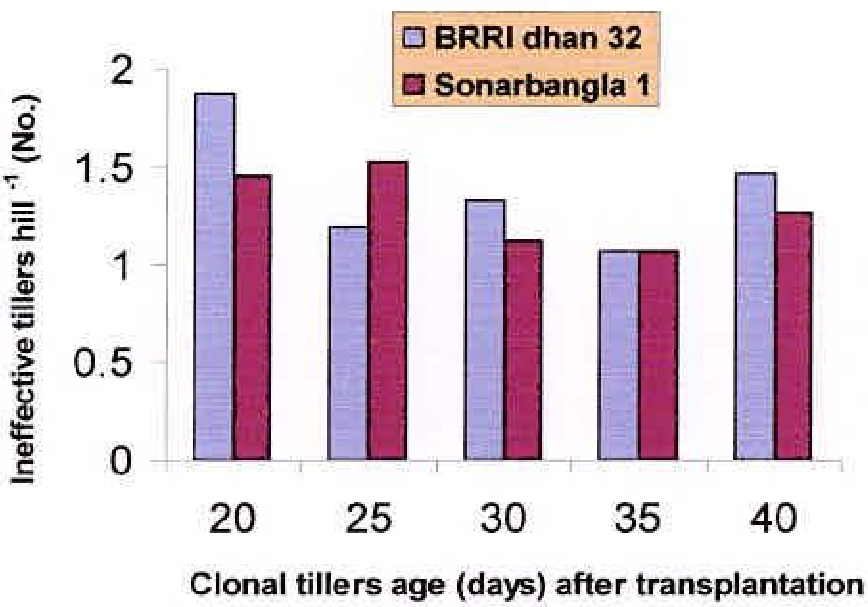


Figure 7. Interaction effect of variety and clonal tillers age on ineffective tiller of Aman rice

4.2.3 Panicle length

4.2.3.1 Effect of variety

The panicle length varied significantly due to variety (Appendix IX and Table 7) where the maximum (27.36 cm) and minimum (25.17 cm) panicle lengths were obtained from hybrid and inbred variety respectively. This finding agreed with BINA (1993) and Ashrafuzzaman (2006) who observed that varieties differed significantly in respect of panicle length.

Table 7. Effect of variety and clonal tillers age on different crop characters of Aman rice

Treatments	Panicle length (cm)	Rachis branch panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	1000 grains weight (g)
Variety						
BRRI dhan 32	25.17	9.63	112.83	86.77	34.12	20.09
Sonarbangla 1	27.36	11.02	196.75	156.84	39.00	27.40
LSD (0.05)	0.589	0.426	15.037	15.129	6.623	0.667
CV (%)	3.62	10.71	6.98	14.82	26.03	2.18
Clonal tillers age: (days)						
20	26.71	10.27	161.00	123.00	39.28	23.59
25	26.41	10.55	139.30	118.80	37.67	23.78
30	26.15	10.33	162.90	124.90	36.70	23.70
35	25.28	10.42	152.30	123.40	34.07	23.89
40	26.20	10.05	158.50	118.30	35.08	23.77
LSD (0.05)	0.932	NS	NS	NS	NS	NS
CV (%)	2.98	4.33	6.79	5.08	13.83	3.54

NS= Not significant

4.2.3.2 Effect of clonal tillers age (days)

Panicle length statistically differed due to the ages of clonal tillers (Appendix IX and Table 7). Significant variation in panicle length was observed among the different ages of clonal tillers where aged clonal tillers showed lower panicle length. Kabir (2000) and Biswas (2001) observed that panicle lengths at harvest were higher when tillers were separated at 30 DAT. Paul (1999) from the maximum panicle length at harvest when tillers were separated at 25 DAT whereas, those separated at 35 DAT were minimum.

4.2.3.3 Interaction effect of variety and clonal tillers age (days)

Panicle length was significantly influenced by the interaction effect of variety and the different ages of clonal tiller (Appendix IX and Figure 8). The longest panicle length (28.58 cm) was obtained from tillers age of 40 days of hybrid variety which was similar with 30 days old of the same variety. The shortest panicle length (23.82 cm) was obtained from the tillers age of 40 days of the inbred variety which was similar with the 35 days of the same variety. Kabir (2000), Paul (1999) and Ashrafuzzaman (2006) observed longest panicle with earlier tiller separation.

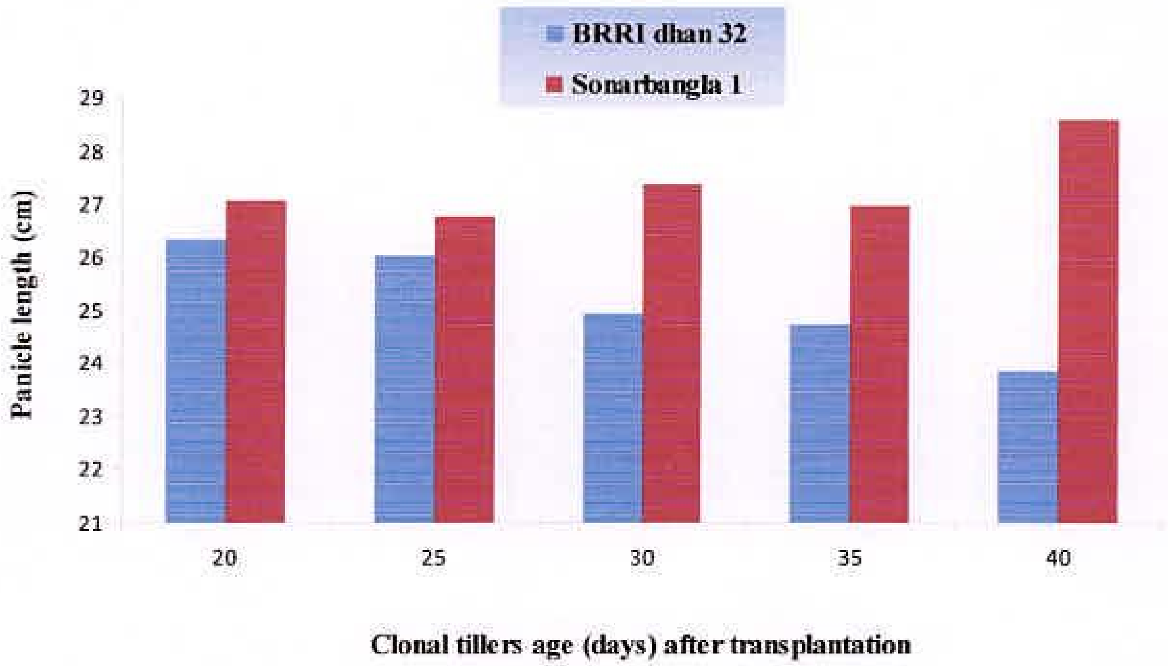


Figure 8. Interaction effect of variety and clonal tillers age on panicle length of Aman rice

4.2.4 Rachis branch panicle^{-1}

4.2.4.1 Effect of variety

The number of rachis branch panicle^{-1} was significantly influenced by the variety (Appendix IX and Table 7). The highest number of rachis branch panicle^{-1} (11.02) was observed in hybrid variety and the lowest number of branch (9.63) was observed in inbred variety.

4.2.4.2 Effect of clonal tillers age (days)

Number of rachis branch panicle^{-1} was not significantly influenced by the different ages of clonal tillers (Appendix IX and Table 7).Numerically the maximum number of rachis branch panicle^{-1} (10.55) was observed from the tillers age of 25 days and the trend was decreasing with increasing the ages of clonal tillers.

4.2.4.3 Interaction effect of variety and clonal tillers age (days)

Rachis branch panicle^{-1} was significantly influenced by the interaction effect of variety and the different ages of clonal tiller (Appendix IX and Figure 9).

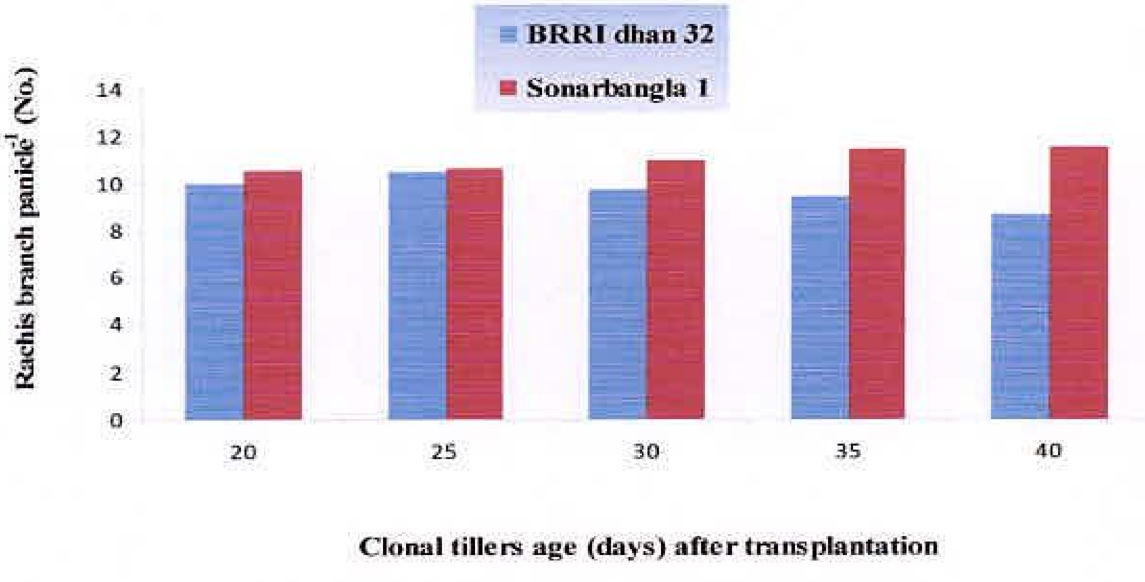


Figure 9. Interaction effect of variety and clonal tillers age on rachis branch panicle^{-1} of Aman rice

The highest number of rachis branch panicle^{-1} (11.50) was recorded from the tillers age of 40 days of the hybrid variety which was similar the 20, 25, 30 and

35 days old of the same variety and 25 days of the inbred variety. Younger tillers resulted with higher number of rachis branch panicle^{-1} in inbred variety.

4.2.5 Number of total grains panicle^{-1}

The number of total grains panicle^{-1} is an important factor which contributes towards grain yield. Variety had a significant effect on the number of total grains panicle^{-1}.

4.2.5.1 Effect of variety

The total grains panicle^{-1} was significantly influenced by the variety (Appendix IX and Table 7). The highest number of grains panicle^{-1} (196.75) was obtained from the hybrid variety Sonarbangla 1 and the lowest number panicle^{-1} (112.83) was obtained from inbred variety BRRI dhan 32. Hossain and Alam (1991) and Ashrafuzzaman (2006) also reported varietal variation in number of grains panicle^{-1}.

4.2.5.2 Effect of clonal tillers age (days)

Number of total grains panicle^{-1} did not significantly differ for clonal tillers age (Appendix IX and Table 7). Numerically the maximum (162.90) and minimum (139.30) number of grains panicle^{-1} was obtained with tillers age of 30 and 25 days respectively.

4.2.5.3 Interaction effect of variety and clonal tillers age (days)

The total grains panicle^{-1} was significantly influenced by the interaction effect between variety and clonal tillers age (Appendix IX and Figure 10). The highest (208.10) number of grains panicle^{-1} was obtained from the tillers age of 30 days of the hybrid variety which was similar with all other ages of clonal tillers of the same variety and the lowest (91.43) number of grains panicle^{-1} was obtained from the tillers age of 25 days of the inbred variety where no variation in grains panicle^{-1} was observed for different ages of clonal tillers of the inbred variety.

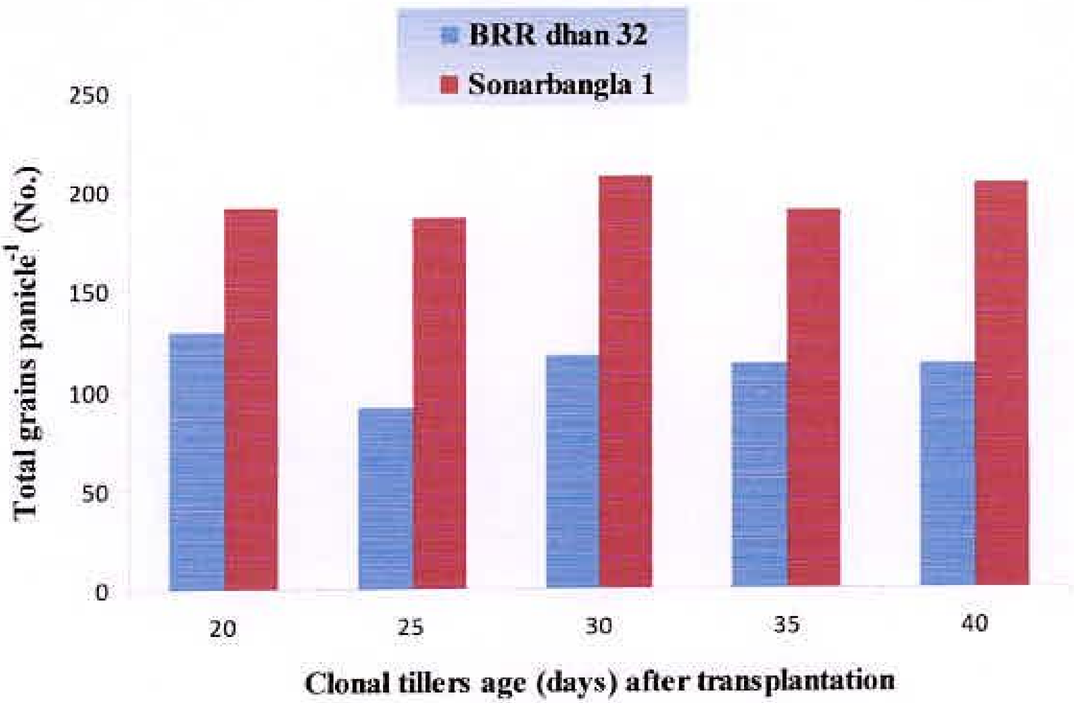


Figure 10. Interaction effect of variety and clonal tillers age on total grains panicle^{-1} of Aman rice

4.2.6 Filled grains panicle^{-1}

4.2.6.1 Effect of variety

The filled grains panicle^{-1} differed significantly for difference of the variety (Appendix IX and Table7). The higher number of filled grains panicle^{-1} (156.84) was found in the hybrid variety Sonarbangla 1 and the lower (86.77) number in the inbred variety BRRI dhan 32.

4.2.6.2 Effect of clonal tillers age (days)

The clonal tillers age showed significant effect on the filled grains panicle^{-1} (Appendix IX and Table 7). Numerically, the maximum number of filled grains panicle^{-1} (124.90) was obtained from the tillers age of 30 days and the minimum number of filled grains panicle^{-1} (118.30) was noted from the tiller age of 40 days.

4.2.6.3 Interaction effect of variety and clonal tillers age (days)

Interaction effect between variety and clonal tillers age was significant in respect of filled grains panicle^{-1} (Appendix IX and Figure 11). The highest number of filled grains panicle^{-1} (169.20) was obtained from the tillers age of 35 days of the hybrid variety which was similar to other ages of clonal tillers of the same variety. The lowest number of filled grains panicle^{-1} (77.67) was obtained from the 40 days old of the inbred variety.

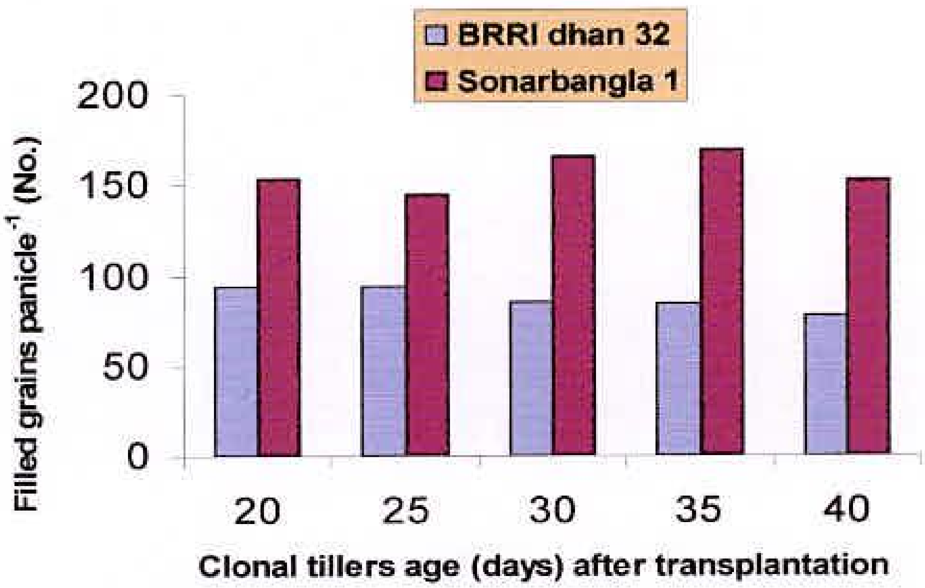


Figure 11. Interaction effect of variety and clonal tillers age on filled grains panicle^{-1} of Aman rice

4.2.7 Unfilled grains panicle^{-1}

4.2.7.1 Effect of variety

The unfilled grains panicle^{-1} showed significant difference due to the variety (Appendix IX and Table 7). The highest number of unfilled grains panicle^{-1} (39.00) was found in the hybrid variety and the lowest number of unfilled grains panicle^{-1} (34.12) in the inbred variety. This finding agreed with BINA

(1993) and Ashrafuzzaman (2006) who reported that varieties differed significantly in respect of unfilled grains panicle^{-1}.

4.2.7.2 Effect of clonal tillers age (days)

Number of unfilled grains panicle^{-1} was not significantly influenced by the different ages of clonal tillers (Appendix IX and Table 7). The maximum number of unfilled grains panicle^{-1} (39.28) was found from the tillers age of 20 days which was statistically similar to all other ages of clonal tillers and the minimum number of unfilled grains panicle^{-1} (34.07) was found from the clonal tillers of 35 days old which was statistically similar to all other ages of clonal tillers.

4.2.7.3 Interaction effect of variety and clonal tillers age (days)

Unfilled grains panicle^{-1} was not statistically influenced by the interaction effect of variety and the different ages of clonal tillers (Appendix IX and Figure 12) though younger tillers showed higher number of unfilled grains panicle^{-1} irrespective of variety. The maximum (40.70) number of unfilled grains panicle^{-1} was recorded under the tillers age of 25 days of the hybrid variety which was statistically similar to all other ages of clonal tillers of the same variety. The minimum (29.30) number of unfilled grains panicle^{-1} was recorded under the tillers age of 35 days of the inbred variety which was statistically similar with the other clonal tillers age of same variety.

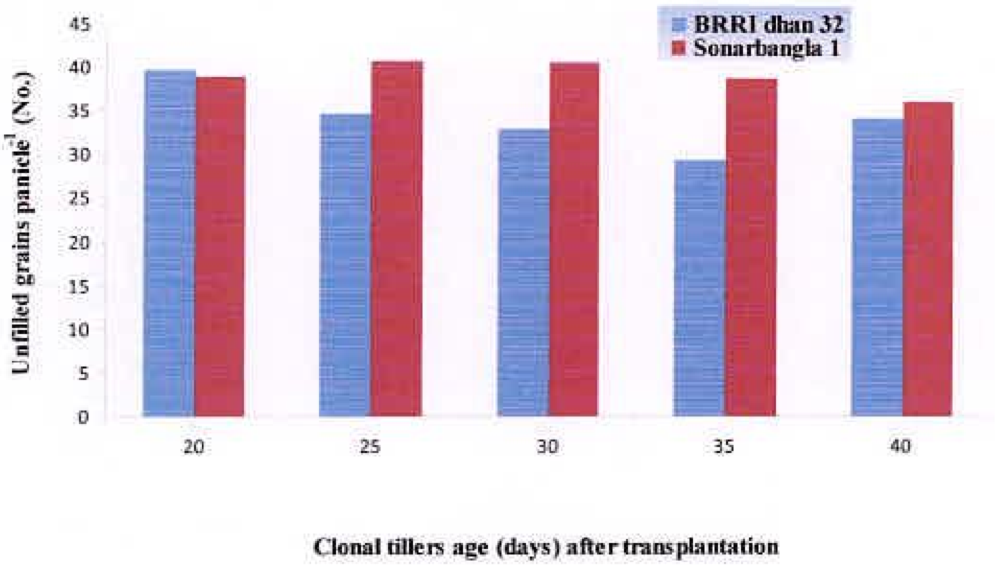


Figure 12. Interaction effect of variety and clonal tillers age on unfilled grains panicle^{-1} of Aman rice

4.2.8 Weight of 1000 grains

4.2.8.1 Effect of variety

The weight of 1000 grains was significantly influenced by the variety (Appendix IX and Table 7). The highest weight of 1000 grains (27.40 g) was obtained from the hybrid variety Sonarbangla 1 and the lowest weight (20.09 g) was obtained from the inbred variety BRRI dhan 32. The variation of 1000 grains weight between varieties might be due to the difference in their genetic make up. The result supports the findings of Akbar (2004) and Ashrafuzzaman (2006).

4.2.8.2 Effect of clonal tillers age (days)

There was no significant effect among the ages of clonal tillers in respect of weight of 1000 grains (Appendix IX and Table 7. Numerically, maximum 1000 grains weight (23.89 g) was found in 35 days old clonal tillers and the minimum (23.59 g) in 20 days old clonal tillers.

4.2.8.3 Interaction effect of variety and clonal tillers age (days)

Interaction effect between variety and the ages of clonal tillers was significant in respect of weight of 1000 grains (Appendix IX and Figure 13). Irrespective of clonal tillers age, the 1000 grains weight was significantly higher in hybrid variety compared to inbred variety. The highest weight of 1000 grains (27.93 g) was obtained from the tillers age of 35 days of the hybrid variety which was statistically similar with all other clonal tillers age of the same variety. The lowest weight of 1000 grains (19.84 g) was obtained from the tillers age of 35 days of the inbred variety.

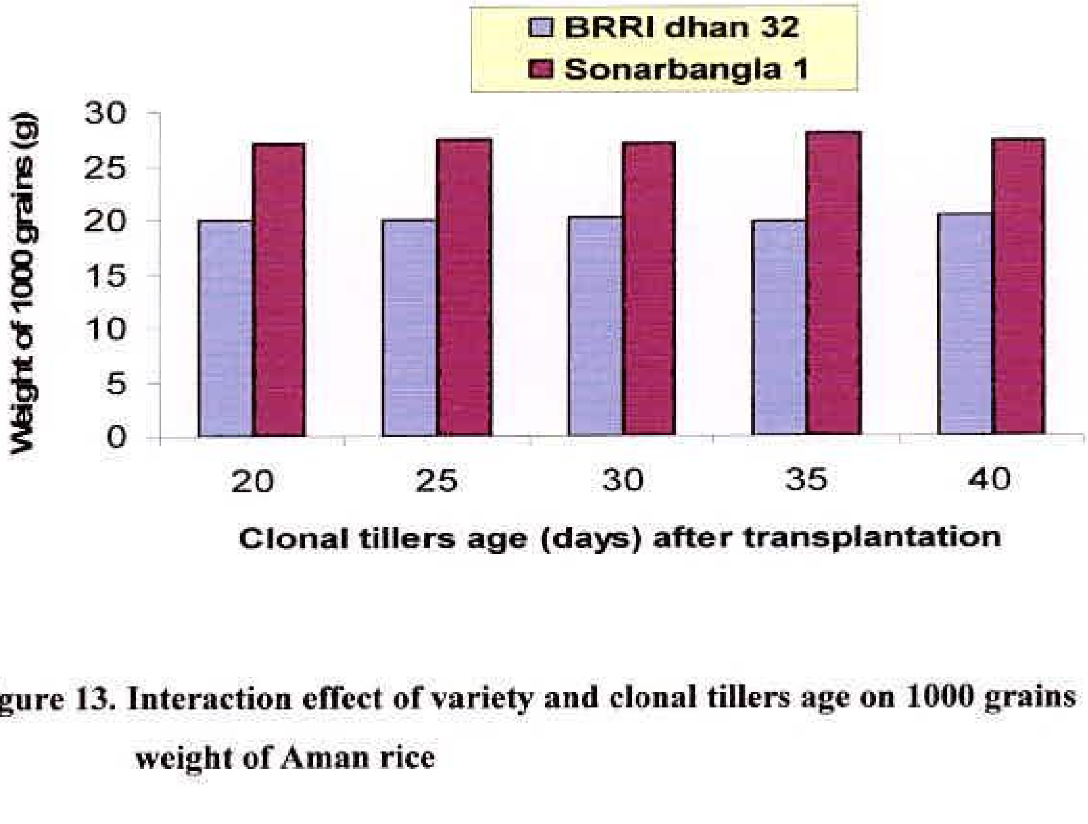


Figure 13. Interaction effect of variety and clonal tillers age on 1000 grains weight of Aman rice

4.2.9 Grain yield

4.2.9.1 Effect of variety

Grain yield was significantly influenced by the variety (Appendix IX and Table 8). The highest grain yield (5.58 t ha^{-1}) was obtained from the hybrid variety Sonarbangla 1 compared to the grain yield (3.88 t ha^{-1}) of inbred variety

BRRI dhan 32. Leenakumari *et al.* (1993) also found higher grain yield from the hybrid varieties over the modern varieties. However, Richharia and Rao (1962) and Ashrafuzzaman (2006) reported that both hybrid and modern varieties produced higher yield.

Table 8. Effect of variety and clonal tiller age on yield and harvest index of Aman rice

Treatments	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Harvest index (%)
Variety			
BRRI dhan 32	3.88	4.71	45.25
Sonarbangla 1	5.58	7.36	43.52
LSD (0.05)	0.378	0.309	NS
CV (%)	23.25	9.61	16.29
Clonal tillers age : (days)			
20	4.76	6.36	45.06
25	5.10	6.01	45.75
30	4.86	6.12	44.32
35	4.64	6.02	43.44
40	4.31	5.67	43.36
LSD (0.05)	0.597	0.489	NS
CV (%)	15.14	10.02	5.70

NS= Not significant

4.2.9.2 Effect of clonal tillers age (days)

The highest grain yield (5.10 $t\ ha^{-1}$) was obtained from the tillers age of 25 days which was statistically similar with 20, 30 and 35 days whereas the lowest grain yield (4.31 $t\ ha^{-1}$) was obtained from the tillers age of 40 days which was statistically similar with the 20, 30 and 35 days (Appendix IX and Table 8). The result was in conformity with the findings of Biswas and Salokhe (2001), BRRI (1989a), Mollah *et al.* (1992) who observed highest grain yield from the 30 days old clonal tillers. BRRI (1990a) stated that splitting of tillers at 30 or 40 DAT produced satisfactory grain yield without significant loss of the mother crop.

4.2.9.3 Interaction effect of variety and clonal tillers age (days)

Interaction between variety and ages of clonal tiller plays an important role for promoting the yield. Grain yield was significantly influenced by the interaction effect of the variety and ages of clonal tillers (Appendix XI and Figure 14).

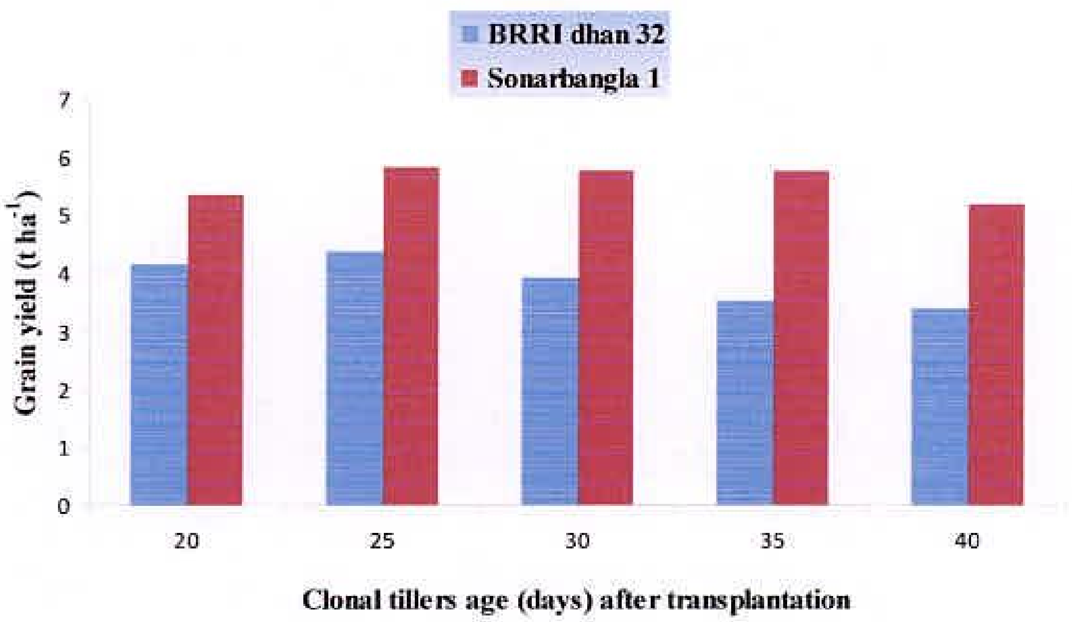


Figure 14. Interaction effect of variety and clonal tillers age on grain yield of Aman rice

The highest grain yield (5.83 t ha^{-1}) was observed from the 25 days old tillers of the hybrid variety which was statistically similar with all other ages of clonal tillers of the same variety except 40 days. The lowest grain yield (3.40 t ha^{-1}) was observed from the tillers age of 40 days of the inbred variety which was similar with 20 and 35 days old tillers of the same variety.

4.2.10 Straw yield

4.2.10.1 Effect of variety

The different ages of clonal tillers showed statistically similar effect on straw yield of Aman rice (Appendix IX and Table 8). The maximum (7.36 t ha^{-1}) straw yield was obtained from the hybrid variety Sonarbangla 1 compared to the straw yield (4.71) of inbred variety BRRI dhan 32. The result agreed with that of Om *et al.* (1999), who observed that hybrid variety exhibited superiority to other inbred varieties in grain and straw yield.

4.2.10.2 Effect of clonal tillers age (days)

Straw yield was significantly influenced by the ages of clonal tiller (Appendix IX and Table 8). The highest straw yield (6.36 t ha^{-1}) was found from the tillers age of 20 days which was statistically similar with all other ages of clonal tiller except 40 days and the lowest straw yield (5.67 t ha^{-1}) was found from the tillers age of 40 days which was statistically similar with the different ages of clonal tillers except 20 days old tillers. The result was in conformity with the findings of Biswas and Salokhe (2001), BRRI (1989a) and Mollah *et al.* (1992) who observed highest straw yield from 30 days old tillers.

4.2.10.3 Interaction effect of variety and clonal tillers age (days)

The interaction effect between variety and the ages of clonal tiller age had significant effect on the straw yield (Appendix IX and Figure 15). The highest straw yield (7.87 t ha^{-1}) was recorded from the tillers age of 30 days of the hybrid variety which was statistically similar with 20 and 35 days old clonal tillers of the same variety. The lowest straw yield (4.36 t ha^{-1}) was recorded from the tillers age of 30 days of the inbred variety which was statistically similar with 40 days old clonal tillers of the same variety.

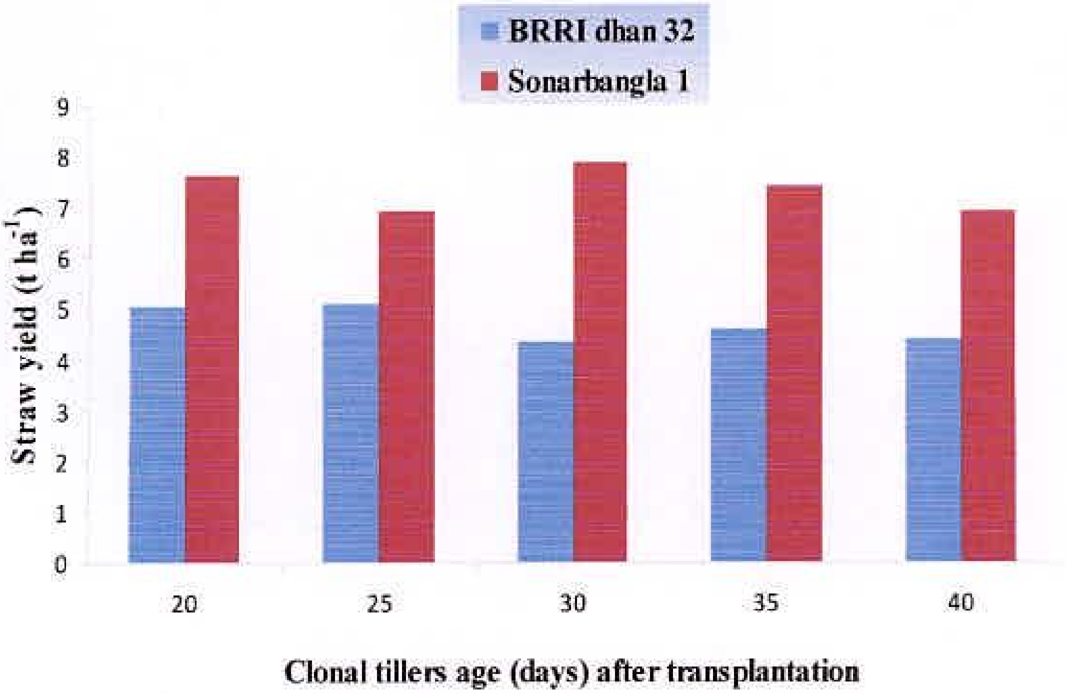


Figure 15. Interaction effect of variety and clonal tillers age (days) on straw yield of Aman rice

4.2.11 Harvest index

4.2.11.1 Effect of variety

Harvest index was not significantly influenced by the variety (Appendix IX and Table 8). The maximum harvest index (45.25) was found from from the inbred variety BRRI dhan 32 and the minimum (43.52) in Sonarbangla 1. Higher straw yield of hybrid variety was probably due to the minimum harvest index in hybrid variety Sonarbangla 1 compared to that of inbred variety BRRI dhan 32. Similar results were also reported by Cui *et al.* (2000).

4.2.11.2 Effect of clonal tillers age (days)

The ages of clonal tillers had no significant effect on harvest index (Appendix IX and Table 8) though tillers age of 25 days produced the maximum harvest index (45.75) and the minimum (43.36) in 40 days.

4.2.11.3 Interaction effect of variety and clonal tillers age (days)

Interaction effect between variety and the ages of clonal tillers was not significant in respect of harvest index (Appendix IX and Figure 16). Numerically the maximum harvest index (47.32) was recorded from the tillers age of 30 days of the inbred variety BRRI dhan 32. The minimum harvest index (41.33) was recorded from the tillers age of 30 days in Sonarbangla 1.

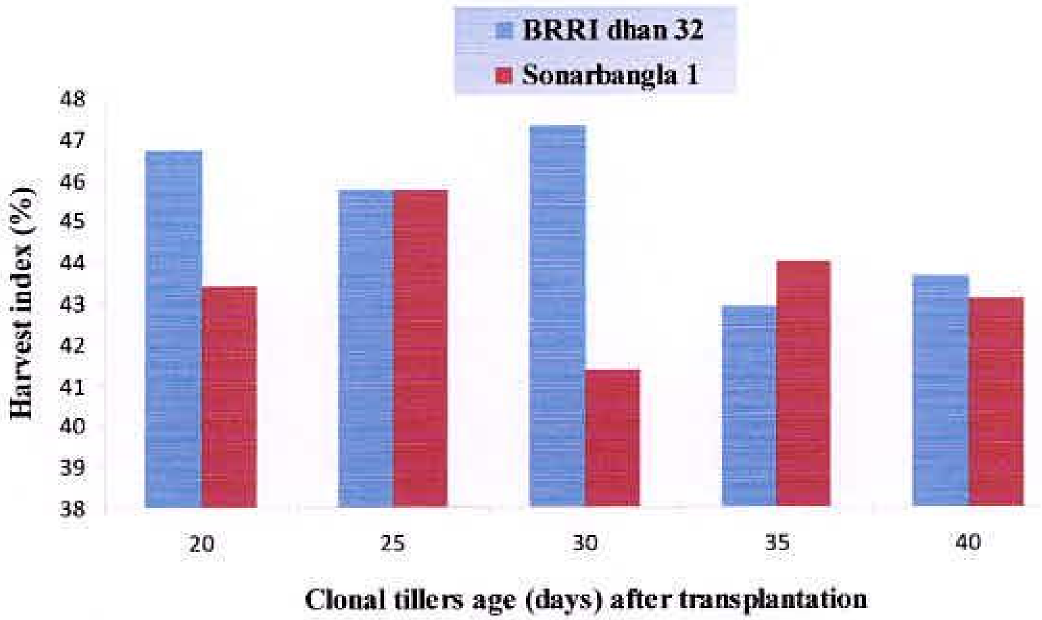


Figure 16. Interaction effect of variety and clonal tillers age on harvest index of Aman rice

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from August 2006 to November 2006 to study the performance of different tiller separation days in hybrid and inbred rice in Aman season under the Modhupur Tract (AEZ-28). The experiment consisted of two levels of treatments viz. A. Variety (2): BRRI dhan 32 and Sonarbangla 1; B. Clonal tillers age (days) (5): 20 days, 25 days, 30 days, 35 days and 40 days. The trial was laid out in split-plot design with three replications.

The data on crop growth characters like plant height, number of tillers hill^{-1}, dry mater yield were recorded in the field and yield as well as yield contributing characters like number of effective and ineffective tillers hill^{-1}, panicle length, rachis branch panicle^{-1}, number of total grains panicle^{-1}, number of filled and unfilled grains panicle^{-1}, 1000 grains weight, grain and straw yield and harvest index were recorded after harvest and analysed using the IRRISTAT package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

The variety had significant effect on all the agronomic parameters except effective tiller, ineffective tiller, panicle length, rachis branch panicle^{-1}, unfilled grains panicle^{-1} and straw yield. It revealed that hybrid variety showed significantly taller plant throughout the growing period. At 60 DAT and at harvest inbred variety showed significantly shorter plant (88.92 cm, 86.13 cm) compared to the hybrid variety (119.27 cm, 118.54 cm), respectively. The production of total number of tillers hill^{-1} was significantly influenced at 30, 45 and 60 DAT but insignificant at 15 DAT and at harvest. At 60 DAT, maximum tiller number hill^{-1} (13.65) was observed in the hybrid variety (Sonarbangla 1) and the minimum number (9.23) of tiller was obtained from the inbred variety

(BRRI dhan 32). Total dry weight hill^{-1} was significantly influenced by the variety at harvest but insignificant at 25 DAT. At harvest, maximum dry weight (121.98 g) hill^{-1} was recorded in hybrid variety and minimum dry weight (61.87 g) was recorded in inbred variety. The inbred variety needed longer duration for flowering compared to the hybrid variety Sonarbangla 1. The highest number of total grains and filled grains panicle^{-1} (196.75, 156.84) were obtained from the hybrid variety and the lowest number of total grains and filled grains panicle^{-1} (112.83, 86.77) were obtained from the inbred variety. The highest weight of 1000 grains (27.40 g) was obtained from the hybrid variety and the lowest weight of 1000 grains (20.09 g) was obtained from the inbred variety. The hybrid variety produced the highest grain yield (5.58 t ha^{-1}) whereas, the inbred variety produced the lowest grain yield (3.88 t ha^{-1}). The maximum harvest index (45.25) was found from the inbred variety and the lowest harvest index (43.25) was found from the hybrid variety.

Clonal tiller age also significantly influenced the growth and yield attributes except ineffective tillers hill^{-1}, panicle length, total grains panicle^{-1}, 1000 grains weight and harvest index. Clonal tiller age significantly influenced the plant height at 40 and 60 DAT and at harvest but there was no significant variation at 15 and 30 DAT. Shorter plant height observed with earlier clonal tillers age compared to delayed clonal tillers age. The production of total number of clonal tillers hill^{-1} of Aman rice was not significantly influenced by different clonal tillers age except 60 DAT. At 60 DAT, maximum number (12.13) of tillers hill^{-1} was observed from the clonal tillers age of 20 days and the minimum number (10.73) was observed from the 30 days. The clonal tillers age showed significant effect on the filled grains panicle^{-1}. The highest number of filled grains panicle^{-1} (124.90) was obtained from the clonal tillers of 30 days and the lowest number of filled grains panicle^{-1} (118.30) was obtained from the tillers of 35 days. The highest grain yield (5.10 t ha^{-1}) was obtained from the clonal tillers of 25 days that was similar with 20, 30 and 35 days whereas the lowest grain yield (4.31 t ha^{-1}) was obtained from the tillers of 40 days. The highest straw yield (6.36 t ha^{-1}) was found from the clonal tillers of 20 days and the lowest straw yield (5.67 t ha^{-1}) was found from the clonal tillers of 40 days.

Interaction effect of variety and clonal tillers' age also significantly effected all the growth, yield and yield contributing parameters. The tallest plant was initially found from the aged tillers irrespective of variety and in the middle stage tallest plant height was found from the hybrid variety irrespective of clonal tiller age. At later growth stages along with at harvest the tallest plant was observed from the hybrid variety irrespective of clonal tillers' age. The maximum number of tillers hill^{-1} was obtained from the hybrid variety irrespective of clonal tillers age. The dry matter production was higher with younger tillers of hybrid variety but the trend was reverse in case of inbred variety. Clonal tillers (40 days) of the inbred variety needed the longest duration for flowering, whereas the lowest duration for flowering was observed in the clonal tillers of 20 days of the hybrid variety. The longest panicle length (28.58 cm) was obtained from the clonal tillers of 40 days of the hybrid variety and the shortest panicle length (23.82 cm) was obtained from the aged clonal tillers of the inbred variety. The maximum number of grains panicle^{-1} was obtained from the hybrid variety irrespective of their clonal tillers age. Irrespective of their clonal tillers age, the hybrid variety showed higher number of filled grains panicle^{-1} compared to inbred variety. Irrespective of their clonal tillers age, the hybrid variety gave higher thousand grain weight compared to inbred variety. The highest grain yield (5.83 t ha^{-1}) was observed from the clonal tillers of 25 days of the hybrid variety which was statistically similar with the different clonal tillers age of the same variety except 40 days. The lowest yield (3.40 t ha^{-1}) was observed from the 40 days old tillers of the inbred variety. The highest straw yield (7.87 t ha^{-1}) was recorded from the tillers of 30 days old hybrid variety. The lowest straw yield (4.36 t ha^{-1}) was found from the 30 days tillers inbred variety.

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

- The hybrid variety showed higher yield than the inbred variety.
- Younger clonal tillers showed higher yield performance than all the aged tillers.
- The hybrid variety with 20-35 days old can be used for clonal propagation but for inbred variety it could be restricted within 20-30 days.

However, to reach a specific conclusion and recommendation, more research work on clonal tillers should be done in different Agro-ecological zones of Bangladesh.

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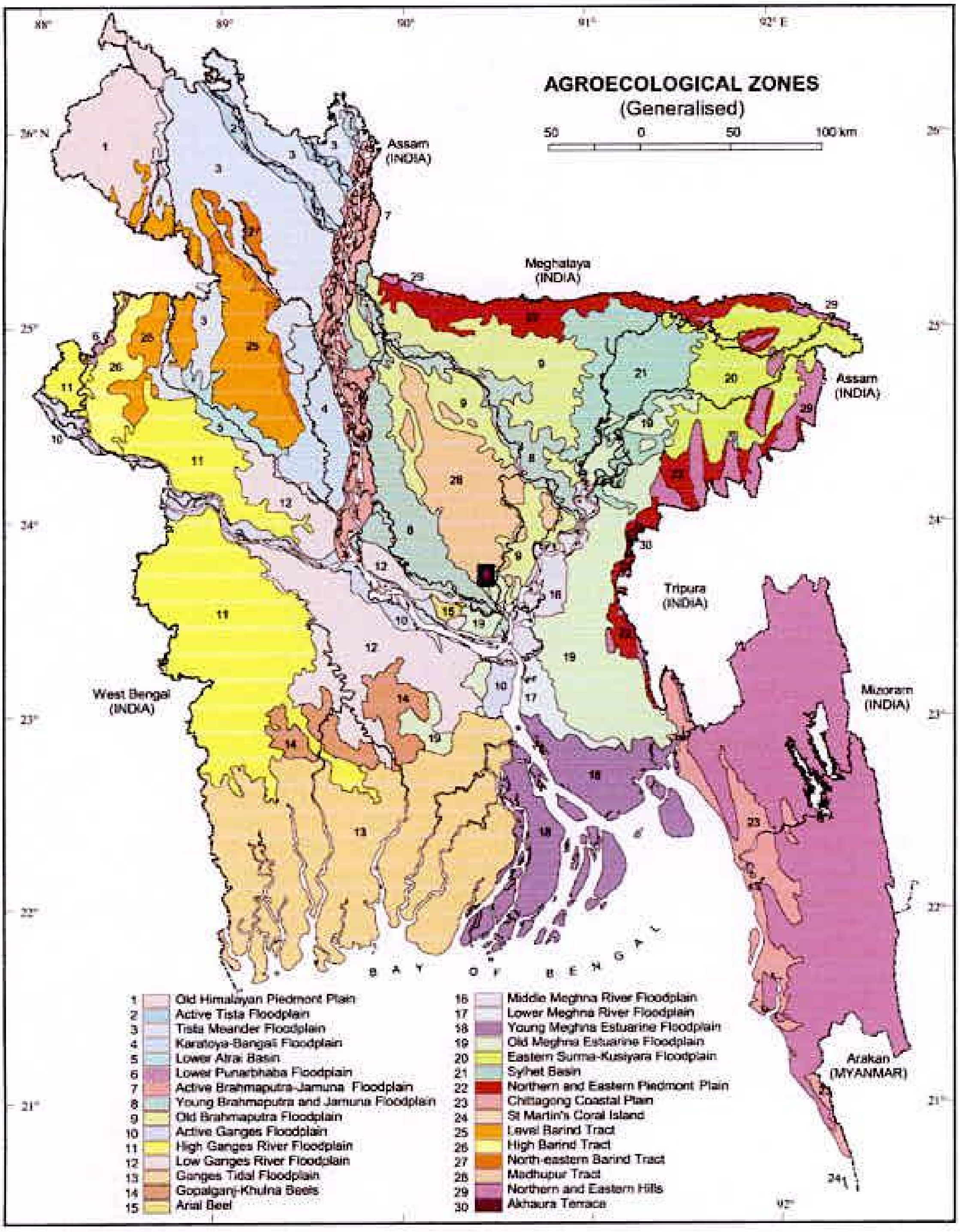
Appendices

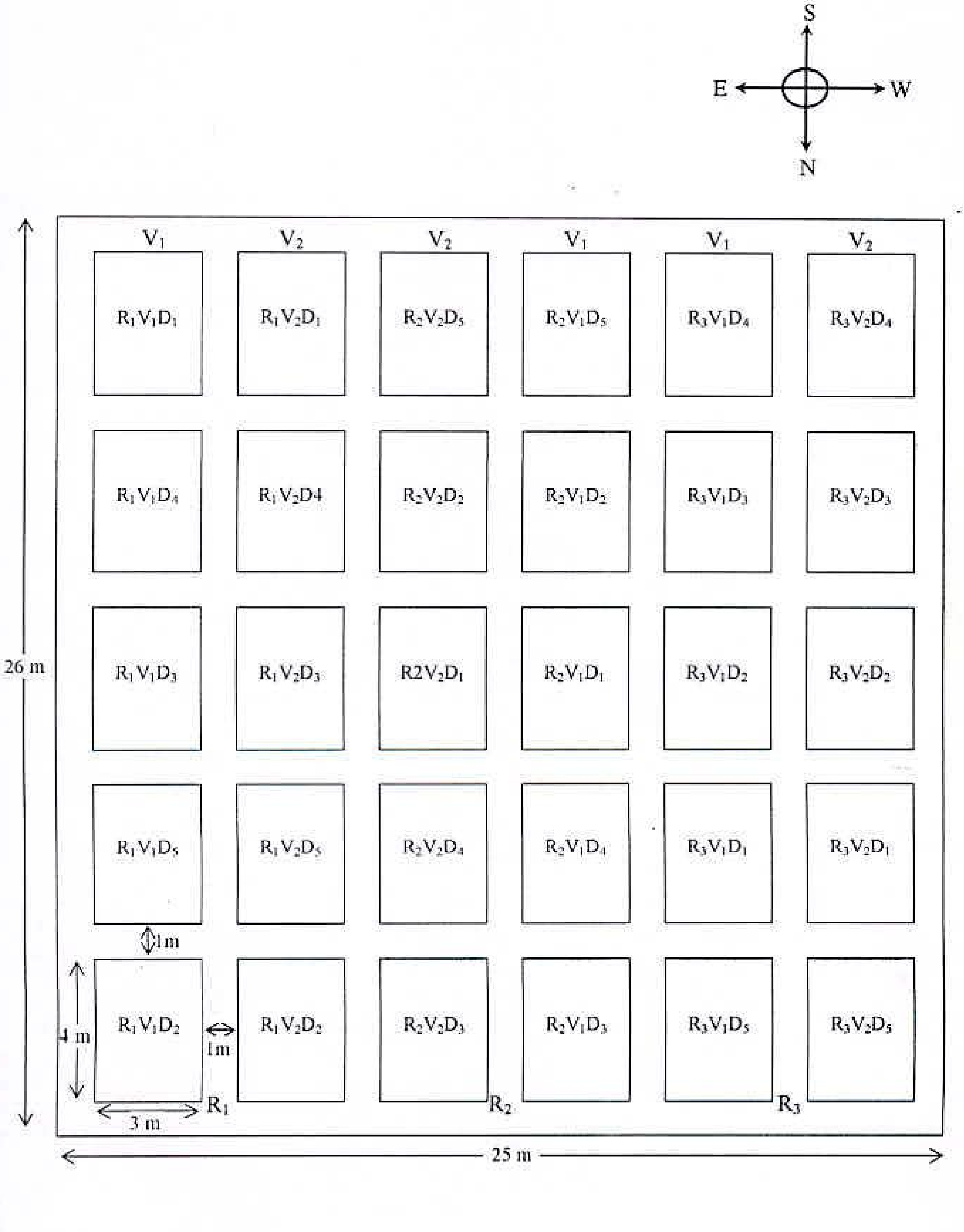
Appendices

Appendix I. Map showing the experimental sites under study

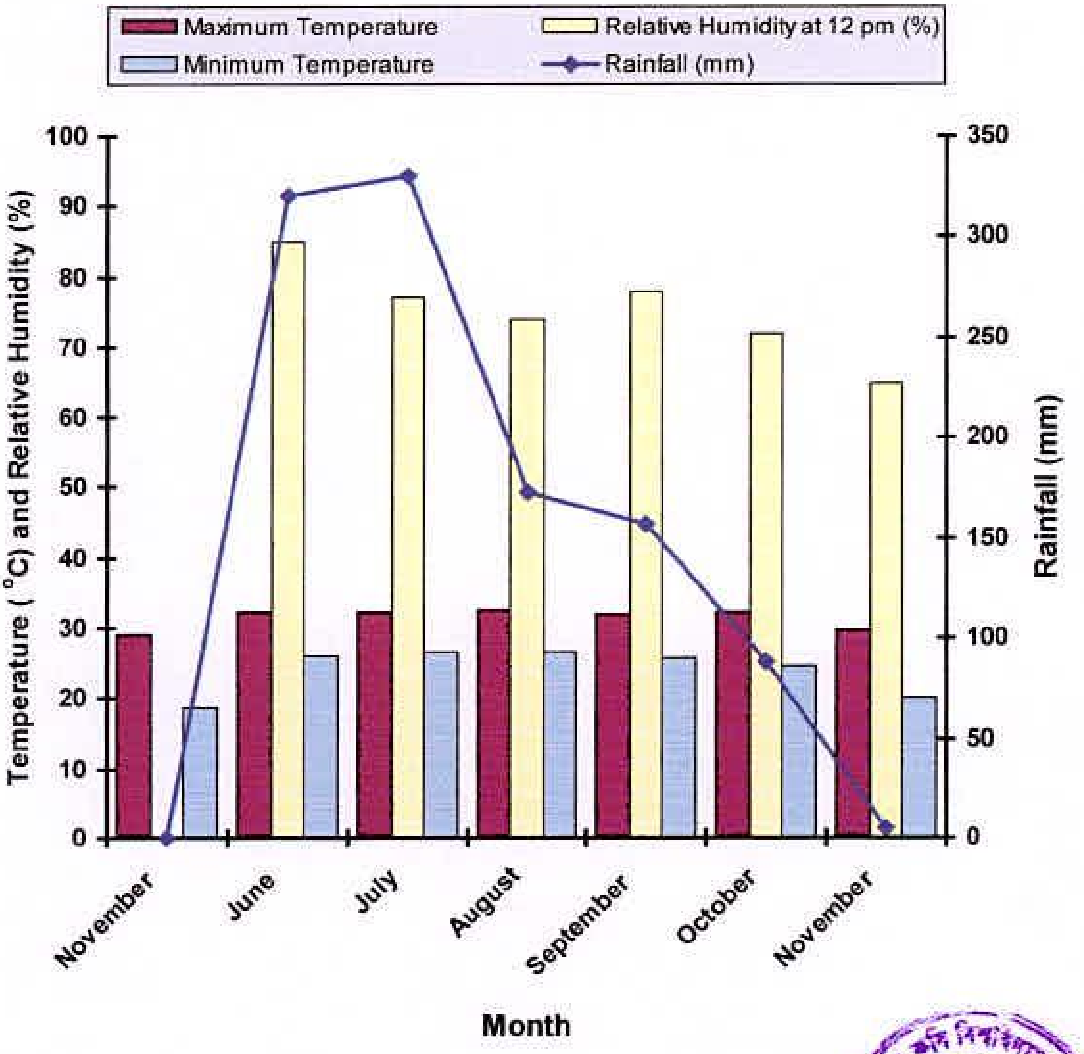


■ **The experimental site under study**

Appendix II. Layout of the experimental field



Appendix III. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from June 2006 to November 2006



Source: Bangladesh Meteorological Department, Agargoan, Dhaka-1212

Appendix IV. Physico-chemical properties of the initial soil

Soil sample	pH	Organic matter (%)	Exchangeable potassium (ml/100 g soil)	Total Nitrogen (%)	Available Phosphorus (ppm)
Initial	5.9	1.55	0.13	0.078	30.3
V_1D_1	6.1	1.34	0.12	0.067	22.9
V_1D_2	6.0	1.29	0.13	0.065	22.9
V_1D_3	6.1	1.46	0.24	0.073	27.9
V_1D_4	6.2	1.30	0.10	0.065	23.5
V_1D_5	6.1	1.27	0.09	0.064	26.6
V_2D_1	6.3	1.30	0.08	0.065	26.9
V_2D_2	6.1	1.21	0.10	0.061	26.1
V_2D_3	6.2	1.22	0.09	0.061	22.2
V_2D_4	6.3	1.25	0.11	0.063	28.2
V_2D_5	6.2	1.22	0.09	0.061	24.8

Appendix V. Mean square values for plant height of Aman rice at different days after transplantation

Sources of variation	Degree of freedom	Mean square values at different days after transplantation				
		15	30	45	60	At harvest
Replication	2	46.4809	46.9763	1.86010	2.82045	2.61782
Variety	1	39.7671	0.94081	7754.42	7689.92	7912.78
Error (a)	2	15.1313	10.4732	8.25009	1.38643	2.76758
Clonal tillers age (days)	4	165.053	36.4458	23.5679	22.1373	15.6525
Variety x Clonal tillers age (days)	4	21.0957	36.3244	124.504	128.208	122.810
Error (b)	16	29.9814	30.0581	24.5520	24.9851	23.9646

* Significant at 5% level

Appendix VI. Mean square values for tiller numbers hill^{-1} of Aman rice at different days after transplantation

Sources of variation	Degree of freedom	Mean square values at different days after transplantation				
		15	30	45	60	At harvest
Replication	2	0.840001	0.159999	0.800333	0.9160	0.587999
Variety	1	0.261333	44.1653	128.547	146.965	0.5880
Error (a)	2	0.849334	0.693332	1.6630	1.64133	1.7560
Clonal tillers age (days)	4	0.214667	0.828	1.3380	2.08467	1.0780
Variety x Clonal tillers age (days)	4	0.794667	5.165341	3.5320	0.5020	0.491337
Error (b)	16	0.546667	0.942667	1.3425	1.07533	1.11867

* Significant at 5% level

Appendix VII. Mean square values for leaf area index (LAI) of Aman rice at different days after transplantation

Sources of variation	Degree of freedom	Mean square values at different days after transplantation			
		15	30	45	60
Replication	2	1.20858	2.51946	2.18846	2.32766
Variety	1	3.69603	18.4867	31.6624	26.8853
Error (a)	2	0.478090	2.93707	2.21750	1.58470
Clonal tillers age (days)	4	0.892820	1.43869	1.76355	1.83923
Variety x Clonal tillers age (days)	4	0.268963	1.78454	1.02608	0.789358
Error (b)	16	0.307912	1.28235	3.74201	2.82910

* Significant at 5% level

Appendix VIII. Mean square values for total dry matter weight of Aman rice at different days after transplantation

Sources of variation	Degree of freedom	Mean square values at different days after transplantation	
		25	At harvest
Replication	2	46.5093	459.235
Variety	1	532.144	27086.5
Error (a)	2	31.4348	88.0102
Clonal tillers age (days)	4	72.9703	297.835
Variety x Clonal tillers age (days)	4	38.5284	266.637
Error (b)	16	68.9541	521.724

* Significant at 5% level

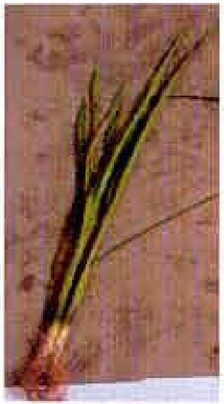
Appendix IX. Summary of analysis of variance for crop characters, yield and yield components of BRII dhan 32 and Sonarbangla 1 at harvest

Source of Variation	Degrees of freedom	Mean square values											
		Duration of flowering (Days)	Effective tillers hill^{-1} (no.)	Ineffective tillers hill^{-1} (no.)	Panicle length (cm)	Rachis branch panicle^{-1}	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grains weight (g)	Grain yield (t/ ha)	Straw yield (t/ha)	Harvest index (%)
Replication	2	1.901	0.588	0.144	0.296	0.124	121.454	185.336	8.208	0.569	0.912	0.353	68.673
Variety	1	6020.830	0.588	0.653	35.971	13.872	43183.454	38013.7	178.608	400.771	21.590	59.669	22.568
Error (a)	2	6.633	1.756	0.373	0.907	1.228	122.809	322.831	90.604	0.269	1.210	0.337	52.306
Clonal tillers age (days)	4	132.133	1.078	0.291	0.614	0.201	116.447	38.007	25.587	0.708	0.513	0.365	6.413
Variety × Clonal tillers age (days)	4	4.167	0.491	0.115	4.106	2.002	415.922	450.413	25.920	0.371	0.239	0.566	12.937
Error (b)	16	2.601	1.189	0.19	0.579	0.302	377.142	381.980	73.196	0.743	0.238	0.159	15.968

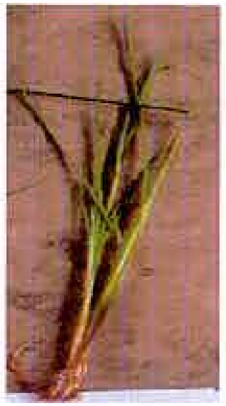
* Significant at 5% level

LIST OF PLATES

20 DAT
BRRI dhan 32



20 DAT
Sonarbangla 1



25 DAT
BRRI dhan 32

25
Sonarbangla 1

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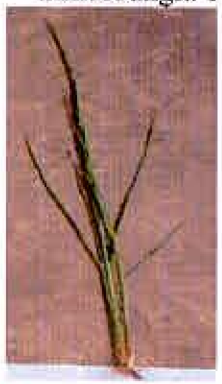
Sonarbangla 1



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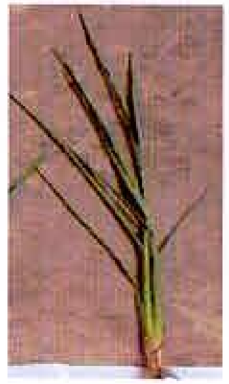
BRRI dhan 32



40 DAT
Sonarbangla 1

Plate 1. Clonal tillers of BRRI dhan 32 and Sonarbangla 1 at different ages (days)

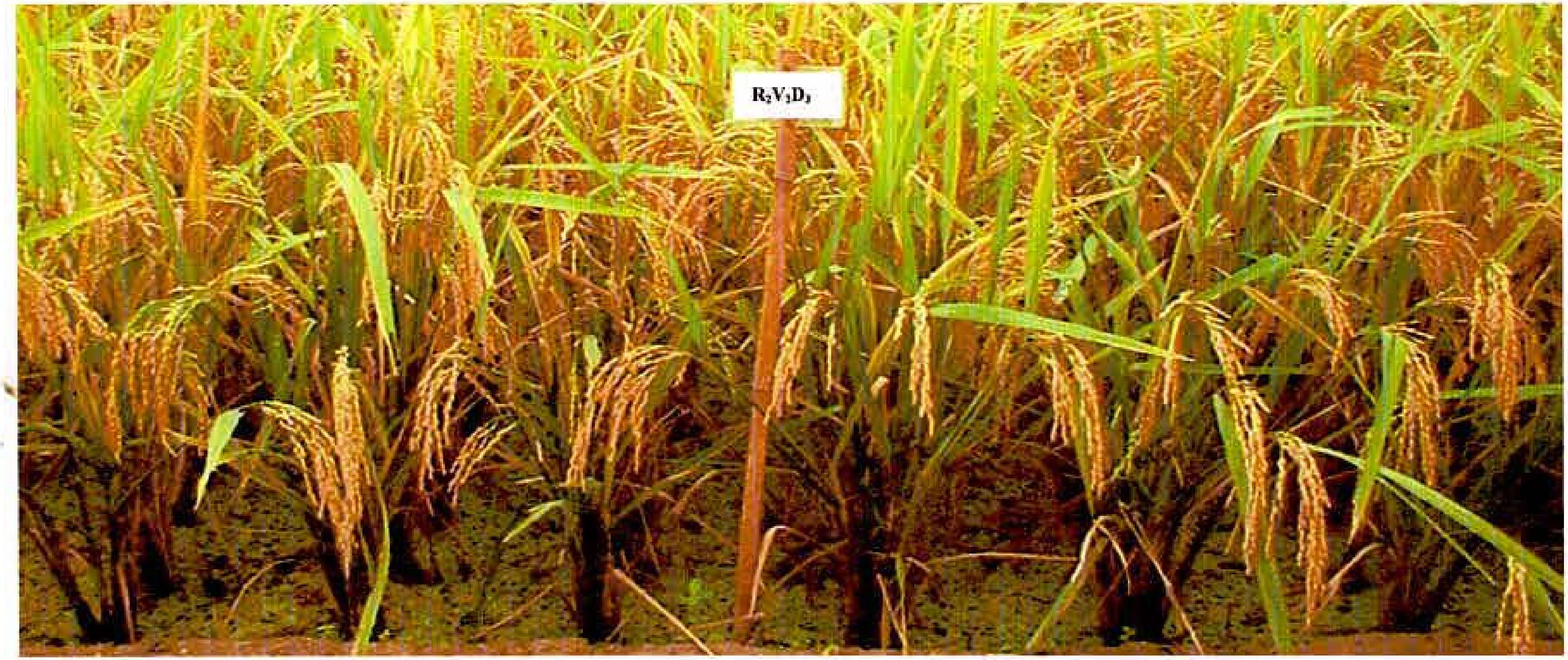


Plate 2. Sonarbangla 1 at harvesting stage (30 days old clonal tillers)

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সংযোজন নং 37
স্বাক্ষর 15/05/08