INFLUENCE OF PLANTING TECHNIQUE ON GROWTH AND YIELD OF AMAN RICE

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CERTIFICATE

This is to certify that thesis entitled, "*INFLUENCE OF PLANTING TECHNIQUE ON GROWTH AND YIELD OF AMAN 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. ABDUL MAIN* Registration No. *00378* under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 27.6.06

Place: Dhaka, Bangladesh

Dr. Parimal Kanti Biswas

Supervisor

Dedicated to
My
Beloved Parents

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INFLUENCE OF PLANTING TECHNIQUE ON GROWTH AND YIELD OF AMAN RICE

ABSTRACT

A field experiment was carried out at Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka during June to November, 2005 to study the influence of planting technique on growth and yield of aman rice. The experiment consisted three levels of treatments viz, A. Planting material (3): Sprouted seed (M_1), Nursery seedling (M_2) and Clonal tiller (M_3); B. Variety (2): Inbreed variety (BR11, Mukta)-V_1 and Hybrid variety (Sonar Bangla-1)-V_2; C. Planting method (2): Broadcast (T_1) and Line sowing (T_2). The experiment was laid out in a split- split-plot design with four replications. Experimental results showed that planting material had significant effect on all the agronomic parameters like plant height, number of tillers hill^{-1}, Leaf area index (LAI), Total dry weight, flowering and maturity dates, filled grain panicle^{-1}, 1000-grain weight, grain yield, straw yield and harvest index except effective tillers hill^{-1}. The results revealed that clonal tiller (M_3) showed the best performance than other planting material. The highest grain yield (4.96 t ha^{-1}) and second highest straw yield (5.22 t ha^{-1}) were obtained from clonal tiller while nursery seedling gave the second highest grain yield (4.50 t ha^{-1}) and lowest straw yield (5.20 ton ha^{-1}). The lowest grain yield (4.24 t ha^{-1}) and highest straw yield (5.47 t ha^{-1}) obtained from the sprouted seeds. Variety also significantly influenced all the growth and yield attributes except effective tillers hill^{-1}, straw yield and harvest index .The highest grain yield (4.70 t ha^{-1}) and lowest straw yield were obtained from hybrid variety Sonar bangla-1, and the inbreed variety BR11 gave the lowest grain yield (4.43 t ha^{-1}) and highest straw yield. Methods of planting had significant effect only on grain yield and harvest index and other parameter were insignificant. The result also reveled that line sowing method showed better performance than broadcast method, where highest grain yield (4.81 t ha^{-1}) was obtained from line sowing method and the lowest grain yield (4.32 t ha^{-1}) was got from the broadcast method. Maximum harvest index 0.48 was counted in line sowing and 0.45 in haphazard method. The combined effect of planting material, variety and planting method had also significant effect on growth and yield, the highest grain yield was obtained from the clonal tiller of hybrid variety with line sowing method.

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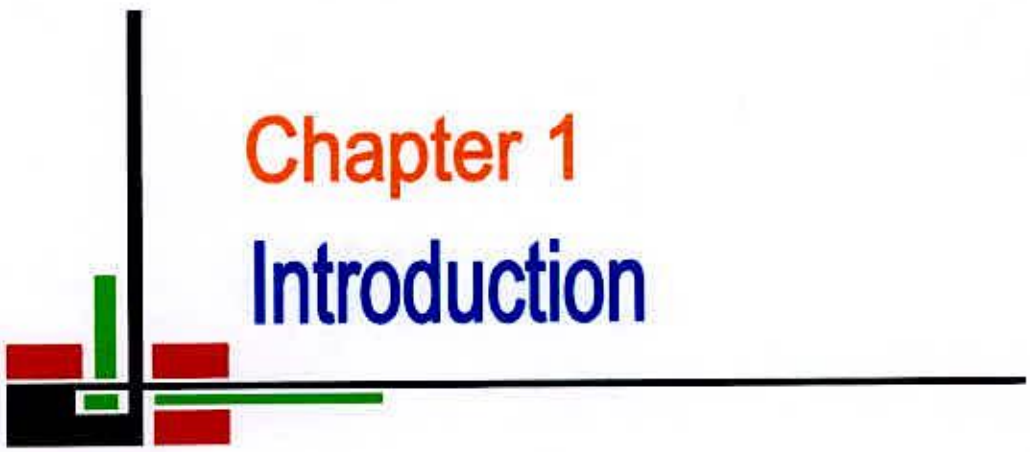
ACRONYMS

AEZ	=	Agro- Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
S	=	Sulphur
P_2O_5	=	Phosphorus Penta Oxide
K_2O	=	Potassium Oxide
SAU	=	Sher-e- Bangla Agricultural University
HI	=	Harvest Index
%	=	Percent
g	=	gram (s)
Kg	=	kilogram (s)
cv.	=	Cultivar (s)
t ha^{-1}	=	Tons per hectare
CV %	=	Percentage of Coefficient of Variance
hr	=	hour(s)
ppm	=	Parts per million
PK	=	Phosphorus, Potassium
mm	=	Millimeter
^{0} C	=	Degree Centigrade
m^2	=	meter squares
NS	=	Non significant
cm	=	Centi-meter
m	=	Meter
No.	=	Number
SA	=	Surface area
var.	=	Variety
et al.	=	And others
etc.	=	Etcetera



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 occupied about 146.5 million hectares more than 90% of which in Asia (Anon, 1999). Rice is the staple food for more than two billion people in Asia, Africa and Latin America. To feed the fast increasing global population, the world's annual rice production must be increase from the 520 million tons of 1994 to 760 million tons by the year 2020 (Kundu and Ladha, 1995).

Rice is grown in Bangladesh in three distinct seasons namely Aus, Aman and Boro. Rice is grown in 11.025 million hectares of land with a production of 26.796 million tons (BBS, 2004). Among the three seasons, Aman rice covers the large area of 5.678 million hectares with a production of 11.520 million tons (BBS, 2004).

Rice grows in a wide range of complex environments, such as dry and flooded conditions, low to high temperatures and in a wide range of soil type (Swaminathan, 1989). Approximately, 78% of the world's rice is grown under irrigated or rain fed lowland conditions (Anon, 1997). Rainfed lowland rice in South and Southeast Asia is about 25% of the world's rice production area, which accounts for about 37 million ha. These lands are typically flat to slightly sloping with periodic flooding to variable depths and durations (Garrity *et al.*, 1986). Flood-prone lowlands occupied more than 10 million ha in deltaic and costal areas (Anon, 1993). In these areas the crop is often subjected to excessive water logging and uncontrolled flooding (Sharma, 1995). In South and Southeast Asia, floodwater may remain for more than a month during the period of aman rice grown with maximum submergence reaching to about 50 to 400 cm in depth (Mazaredo *et al.*, 1996). Complete submergence by flash floods has been reported as a major production constraint in about 25 million ha of lowland in this

region. Although rice is adapted to lowland, complete submergence for more than 2-3 days killed most of the rice cultivars (Mishra *et al.*, 1996). This type of damage would be rather serious for dwarf and semidwarf varieties, which cause total crop losses.

Crop damage due to early or late flooded is very common in Bangladesh, in flood prone areas, farmers can not retransplant the affected land due to unavailability of seedlings. To overcome this problem, there is possibility to separate out tillers from comparatively high land of transplant aman rice which are not affected by flood water, which could be retransplanted to raise a new crop.

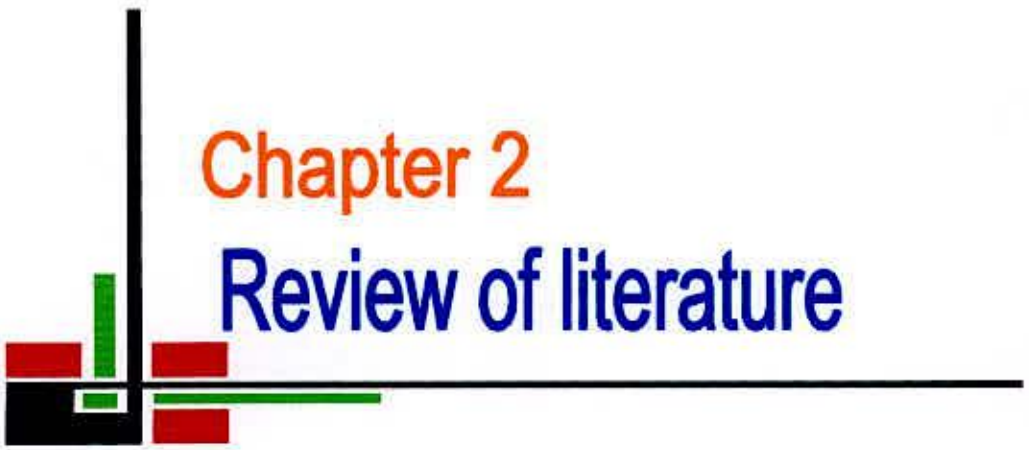
The population of Bangladesh is increasing day by day and that is why horizontal expansion of aman rice area is not possible due to high population pressure on land. Therefore, it is an urgent need of the time to increase rice production through increasing the yield. Proper planting and management practices are the most effective means for increasing yield of aman rice at farmers level using inbreed and hybrid varieties. (Alauddin, 2004).

Transplanting method is accomplished by raising the seedling in the seed bed and transplanted on the well puddled field with flooded water. For getting higher yield of modern varieties, transplanting method is recommended by Bangladesh Rice Research Institute (BRRI, 1974). According to Devasundrarajah (1971), the two advantages of transplanting are that the transplanted crop occupied the field for lesser time compared to the direct wet seeded crop and it is facilitated the control of weeds. Thus the transplanting methods are widely used in the areas with controlled water and no labour shortage. Many farmers of Bangladesh usually transplanted rice seedling at random (haphazard) in spite of recommendations for straight row transplanting having good spacing. But in haphazard transplanting method, farmers generally maintain low

spacing resulting very high inter-space competition between the plants which may create in mutual shading, lodging, less fertile grains panicle^{-1}, less grain weight etc. and thus favors more straw yield than grain.

There are different methods of planting such as direct seedings (haphazard and line sowing), transplanting of seedlings (haphazard and line sowing), transplanting of clonal tiller etc. The maximum benefits of aman rice production can be obtained from a field, if it is properly grown with suitable seeding methods. Haphazard planting produced the highest grain yield which was statistically similar to the row planting (Roknuzzaman, 1997). Varughese *et al.* (1993) observed slightly higher grain yield in seedling broadcast (haphazardly) method compared with transplanted seedlings. Reddy *et al.* (1987) found that grain yield, plant height and straw yield of aman rice did not differ significantly for different planting methods. The vegetative propagation using clonal tillers separated from the previously established transplanted crop was beneficial for restoration of a damaged crop of aman rice (Biswas, 2001). Because of these variable information's about the effect of planting techniques of inbreed and hybrid rice varieties on yield, a detailed study was under taken with the following objectives:

1. to find out the effect of planting technique for optimum growth and yield of aman rice.
2. to compare the performance of inbreed and hybrid rice varieties.
3. to predict the perfect planting method for optimum growth and yield of aman rice.



Chapter 2
Review of literature

REVIEW OF LITERATURE

The efficient growth and development of aman rice plants are greatly influenced by the environmental factors, variety used and agronomic practices.

Rajkhowa and Gogoi (2004) conducted a field experiment in Jorhat, Assam, India, during the 1999 and 2000 summer seasons to determine the effect of planting methods on transplanted summer rice cv. Luit. The treatments comprised 3 planting methods, namely closer (10x10 cm), normal (15x15 cm) and farmers' practice (haphazard planting). Normal planting showed significantly higher yield than the other planting methods in 1999, while closer planting recorded the highest grain yield in 2000. The highest panicle number was recorded with normal planting.

BRRI (2003) carried out tow experiment in T. Aman and Boro seasons at BRRI farm. In T. Aman season, planting methods were : line transplanting(T_1), seedling throughing / broadcasting (T_2), direct seedling (T_3) and seedling throwing with younger seedlings (12 day-old) raised in plastic tray (T_4) ,i.e. Japanese tray and seedling throwing with younger seedlings (12 day-old) raised in Chinese tray (T_5). During Boro season the treatments were same as T. Aman season except T5, Random transplanting with normal seedling was used as T_5 in Boro season. In T. Aman the establishment of crop by transplanting method showed the highest grain yield (4.56 t/ha) followed by T_2 treatment (4.33 t/ha) which was statistically significant. In case of labour requirement for only planting or seedling throwing indicated that about more than 65% labour can be saved by seedling throwing method compared to transplanting method of crop establishment. In Boro season the direct seeding method

gave the highest grain yield which was followed by line transplanting and seedling throwing with younger seedlings raised in trays.

Sarkar *et al.* (2003) conducted an experiment at Cuttack, Orissa, India where seeds of 6 rice cultivars (Tulasi, FR 13A, T 1471, Sabita, Kolasali and CH 19) were sown in moistened soil and maintained after 5 days under 5 cm of water were compared with 30-day-old seedlings transplanted in the normal way. Compared with transplanting, the crops from anaerobic direct sowing had greater plant height and above-ground dry matter, less chlorophyll and specific leaf weight, and more panicles per unit area and sterile spikelets. Panicle weight and harvest index had significantly positive associations with grain yield.

BRRI (2002a) observed the highest grain yield of T. aman rice obtained from transplanting method than the grain yield obtained from direct seeding method. While the grain yields of seedling throwing methods were not significantly different from transplanting method. However, no. of panicles, spikelets per panicle and sterility percentages were not differed significantly different among the four planting methods.

BRRI (2002b) conducted an experiment in Boro season , experiment conducted with the planting methods of transplanting , seedling throwing/ broadcasting with normal seedlings, direct seeding and seedling throwing with young seedling. The highest grain yield (5.4 t/ha) of BRRI dhan 29 was obtain from transplanting method and direct seeding method gave the lowest grain yield (4.73 t/ha). Seedling throwing method gave little bit lower yield than transplanting method but higher than direct seeding method. The highest sterility percentage (35%) was observed in direct seeding method and the lowest sterility was in transplanting method.

Ogura (2002) conducted an experiment using direct sowing in slots without ploughing and with fertilizer applied in the slots or by transplanting from long mats of seedlings grown hydroponically. Yields with transplanting were 470 g/m^2 compared with 451 g/ m^2 with direct sowing.

Venkatachalapathy and Veerabadran (2002) conducted a field experiment at the Agricultural College and Research Institute, Killikulam, Tamil Nadu, India during 1996 on wet-seeded rice cv. ADT-36. The highest yield was recorded in drum seeding with 2 cm intra row spacing. However, the net return per rupee invested was higher with drill seeding at 2 cm. Direct seeding an effective alternative technology to transplanting, since it gave more gain without extra expenditure.

Johnkutty *et al.* (2002) studied the effects of crop establishment (transplanting, broadcasting or line sowing) along with manual (plots were kept weed-free up to the maximum tillering stage) control treatments on the yield of aman rice cv. Jyothi in Pattambi, Kerala, India during the rabi season of 1996/97, 1997/98 and 1998/99. In 1998/99, direct sowing of sprouted seeds by DRR wet seeder was also evaluated. Line sowing was conducted at a spacing of 15x10 cm. A seed rate of 80 kg/ha was used for broadcasting. In 1996/97 and 1997/98, the grain yield did not significantly vary among the treatments. In 1998/99, the highest yields were obtained with random planting with hand weeding.

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 grains 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 was beneficial for higher productivity.

Rahman (2001) observed that the tallest plant, highest number of effective tillers $hill^{-1}$ longest panicle, maximum number of grains $panicle^{-1}$, total number of spikelets $panicle^{-1}$, highest grain yield and biological yield were found in intact crop.

Anbumani *et al.* (2000) reported that line planting of aman rice cv. ADT-38 revealed higher rice grain yield compared to direct sowing or random transplanting in Tamil Nadu, India, during August 1995-April 1996. The different planting methods did not influence the yield of aman rice.

Xiang *et al.* (1999) observed in a trials with rice cv. Jinzao 22 and Jiayu 293 where yields from direct sown crops were 8.69 and 8.30 t/ha, respectively, while yields of transplanted crops were 7.31 and 7.60 t/ha. Number of effective panicles, number of grains/panicle and 1000-grain weight were higher in cv. Jinzao 22 than in Jianyu 293 and in direct-sown crops than in transplanted crops.

Yang *et al.* (1998) evaluate dry matter production and photosynthetic rate of aman rice cv. Sangjubyeo, Hwayongbyeo, Jinmibyeo, Hwaseongbyeo, and Calrose 76 were evaluated in direct sown and transplanted rice at the National Yeongnam Agricultural Experiment Station in 1992-93. Cultivation methods did not affect heading date or the percentage of ripened grain, but culm length was shorter, and spikelet number per panicle and milled rice yield were lower in direct sown rice than in transplanted rice, while panicle length and panicle number per m^2 were higher in direct sown rice.

Photosynthetic rates of the flag leaf were generally higher in direct sown rice than in transplanted rice.

Valarmathi and Leenakumary (1998) carried out a field experiment in Kerala, India to evaluate the suitability of aman rice cultivars under direct sown conditions because of scarcity of labour for transplanting. Evaluation of 10 popular high yielding cultivars revealed that cultivars Jyothi, Jayathi and Aathira performed better under direct sown, upland conditions than the remaining cultivars. Jayathi and Aathira were recommended since Jyothi exhibited high grain shattering. Yield increases were dependent on an increase in the number of productive tillers per plant. Sorter duration in time to maturity was observed in all the cultivars under direct sowing, upland situation than under lowland transplanted conditions.

Sorour *et al.* (1998) observed in field experiments in 1993-94 at Kafr El-Sheikh, Egypt, the short duration rice cultivar Giza 177 and the traditional cultivar Giza 176 were planted using the following methods: traditional transplanting (TT, no fixed number of hills or seedlings/hill), hand transplanting (HT) in hills at a spacing of 20 x20 or 15 x 15 cm, mechanical transplanting (MT) in hills at a spacing of 30 x 14 or 30 X 12 cm, broadcasting (B), mechanical drilling (MD), or planted in puddled soil (D) in hills at a spacing of 20 x 20 or 15 x 15 cm. D 15 x 15 cm, HT 15 x15 cm and MT 30 x 12 cm gave significantly better results than TT as regards dry matter production, LAI, crop growth rate, plant height, number of panicles/m^2 and grain yield / feddan. The net assimilation rates for B, MD, TT and HT 20 x 20 cm exceeded those for other methods. The highest hulling and milling recovery percentages resulted from MT 30 x 12 cm in the first season. Giza 177 gave better results than Giza 176 for dry matter production, LAI, net assimilation rate, 1000-grain weight and

grain quality (hulling, milling and head rice percentages). The inverse was true for number of panicles/m^2, grain number/panicle and grain yield/feddan. HT 15 x 15 cm and MT 30 x12 cm spacing are recommended for optimum grain yield of Giza 177. [1 feddan = 0.42 ha.]

Sharma and Ghosh (1998) conducted a field experiment at Cuttack, India during the rainy season of 1994 and 1995 under semi-deep- water conditions (0-100 cm) to study the yield performance of aman 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 600seeds/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 75 days (1995) decreased yield by 0.34-0.85 t ha^{-1} compared with the undisturbed crop. The decreased 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) than that from nursery seedlings (0.46-1.29 t/ha). The clonal tillers were taller (78.3-88.7 cm) and had more dry weight (0.86-2.05 g/plant) which helped in their better establishment and greater survival under the similar flooded environment than the nursery seedlings (66.3-76.3 cm height and 0.56-0.85 g/seedling dry weight), which collapsed after transplanting and thus established poorly. Therefore, stand establishment of aman rice either by direct sowing or transplanting with clonal tillers gave best results under semi-deep water conditions.

Sharma *et al.* (1998) reported that the transplanted crop raised from clonal tillers performed better (1.07-2.28 t ha^{-1}) than that of nursery seedlings (0.461.29 t ha^{-1}).

They also stated that the clonals were taller (78.3-88.7cm) and had more dry weight (0.86-2.05g plant^{-1}) which helped in their better establishment and greater survival under the nursery seedling which collapsed after transplanting and established poorly. So, stand establishment of aman rice by direct seeding or transplanting with clonal tillers was beneficial for improving productivity under semi-deep water condition.

Mannan and Shamsuddin (1997) observed that the vegetative propagation did not produce higher yield compared to normal production method. Development of planting material in vegetative propagation was time consuming and costly.

Roknuzzaman (1997) conducted an experiment with rice cultivar BR11 where seedlings transplanted in haphazard and row arrangements. Haphazard planting produced the highest grain yield which was statistically similar to that produced by row method of planting. The harvest index was highest in haphazard planting but straw yield was highest in row planting.

Maqsood *et al.* (1997) grown rice cv. Basmati-385 grown at Faisalabad during 1994 and 1995 established by transplanting or direct sowing and given 0-100 kg N/ha. Yield was not significantly affected by establishment method in 1994, but in 1995 lower yield from direct sowing 3.58t/ha and higher yield (4.43 t/ha) from transplanting. Yield increased with increasing N rate in both years. Number of productive tillers per hill was significantly higher from transplanting than direct sowing for both the years. Net income was highest from transplanting and application of 100 kg N/ha.

Ye and Ye (1997) established rice cultivars with low, intermediate or strong tillering characteristics by direct sowing, by broadcasting seedlings or by hand transplanting.

With low and intermediate tillering cultivars, yields were highest with broadcasting seedlings but with the strongly tillering cultivar they were highest with direct sowing. In all cultivars yields were lowest with hand transplanting. With transplanting most tillers were from the 5th node or above but with broadcasting or direct sowing most tillers came from nodes 1-4. A similar proportion of tillers came from the main culm with all establishment methods.

Baroova *et al.* (1996) conducted a field experiment in Assam with rice cv. Luit and shared that yields in rows or broadcast planting were similar (2.13 and 2.15 t/ha, respectively).

Dwivedi *et al.* (1996) conducted a field experiment during the rainy seasons of 1991 and 1992 at RRS, Agwanpur, Saharsa (Bihar) to study the effect of different methods of planting on rice yield under mid upland situations. Transplanting rice (15 x 15 cm with 2 seedlings / hill) gave significant by the higher yield attributes, yield and net returns. Random transplanting, spreading of seedlings, random transplanting of single seedlings and row transplanting of single seedlings/hill also resulted higher yield attributes, yield and net returns than direct sowing of seeds.

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 decreased 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.

Matsuo and Hoshikawa (1993) observed in an 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, produce panicles at the tips of the stem and finally contributed to the yield as productive tillers. The number of panicles in a yield component depends largely on the number of tillers. The development of tillers during the tiller stage, therefore is important for the yield or rice

Nabheerong (1993) conducted an experiment with rice cv. IR72 grown at IRRI, Philippines in the 1989 wet season with no fertilizer N, 60 kg N/ha as prilled urea (40 kg basal + 20 kg 5-7 d before panicle initiation), the same N rate as *Sesbania rostrata* or *Aeschynomene afraspera* green manures, or 40 kg N as green manures and 20 kg N

as prilled urea top-dressed before panicle initiation. Rice was either broadcast sown or transplanted. Root growth was better after broadcasting, although on a per tiller basis root length in the 0-10 cm soil layer was better in transplanted rice. N treatment did not affect root growth, but the root:shoot ratio was higher in crops given no nitrogen. Total N uptake was higher in broadcast than in transplanted crops, while top-dressing urea in the mixed green manure-N fertilizer treatments increased N uptake compared with green manures alone.

Rajput and Yadav (1993) observed in a field trial at Bilaspur, Madhya Pradesh in the 1982-83 kharif [monsoon] seasons where the improved biasi (broadcasting + biasi + challai) method of establishing rice gave the highest rice yield and net profit. Transplanting gave yields not significantly different from the improved biasi method, while all establishment methods tested were superior to the local method.

Varughese *et al.* (1993) observed in a field experiment at Kerala, India that rice cv. Ptb 20 and Jaya seedlings broadcasted (haphazardly) gave slightly higher grain yield compared with transplanted seedlings.

Khan *et al.* (1992) conducted a study in Philippines and observed that direct- seeded rice gave more benefit in terms of reducing labour, increasing yield and income than transplanted rice in irrigated dry season cropping.

Sharma (1992) reported that there was no decrease in the yield of aman rice crop when clonal tillers were removed after 60 days to transplant either the equivalent of or double the uproot plot area. The loss due to decrease in panicles/m^2 with the removal of clonal tiller was compensated for 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.

Mollah *et al.* (1992) observed that late tiller separation at 40 DAT significantly reduced grain yield by 0.41 t ha^{-1} compared to an early tiller separation at 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 reduce 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.

Murthy *et al.* (1991) showed that shoot removal of aman rice plant reduced the grain yield. The tiller loses 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%). 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 (1990) 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

retransplantation of splitted tillers from mother crop was a unique way to boost productivity during seedling scarcity.

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, 9.1 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 could be separated without hampering the main crop yield but the removal of higher number of tiller/hill significantly reduced the mother crop yield. As compared with over aged nursery seedlings, the clonal tillers performed better to the grain yield.

BRRI (1989) 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 day old mother plants and any delay reduce yield when 3 or more tillers were separated.

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 is usually less than that of main crop; and iii) crop establishment savings were realized. Vegetative propagation method includes ratooning, stubble plating and planting of separated tillers.

Sharma *et al.* (1987) 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 (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.

Reddy *et al.* (1987) in India conducted an experiment in which rice cv. Tellahamsa seedling were transplanted in lines or at random. They found that grain yields (3.05-3.25 t ha $^{-1}$), plant height (78.1-78.01 cm) and straw yield (4.04-4.14 t ha $^{-1}$) did not differ significantly for the planting methods.

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 aman rice tillers could help in rapid multiplication of elite and newly developed cytogenetic male sterile lines for hybrid rice production.

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-day-old) seedlings from the nursery. Re-transplanting the tillers removed from 20- to 40-day-old crops was superior to seedling transplanting in increasing yields.

Ramaiah *et al.* (1986) observed in an experiment and found that at 30 days of growth, DM accumulation, N and P uptake in rice plants grown from pre-germinated seeds sown broadcast were higher than in plants grown by transplanting seedlings, but at later growth stages and at harvest they were higher in the transplanted plants. Increasing rates of N (0-90 kg/ha) and P_2O_5 (0-60 kg/ha) increased DM accumulation and N and P uptake.

Subramanian and Kolandaisamy (1983) conducted an experiment with rice variety IR8 in which seedlings were transplanted as local method without regular spacing and in rows. They observed the highest number of productive tillers m^{-2} and yields in row method. Lower straw yields in local method. In row method paddy yields were increased by 14.8% over local method.

Tsai (1982) 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.

Digh *et al.* (1982) observed that the establishments of aman rice crop by tiller transplanting in place of seedling transplanting reduce the amount of seeds. They also recorded 4-10% higher yield with tiller transplanting.

BRRI (1981) initiated a study in 1978 to confirm whether random (haphazard) and transplanting under similar managements made any differences in grain yield of aman rice. Rice seedlings of variety BR4 were transplanted in rows and at random. The number of hills were kept constant for both under random and row transplanting. The experimental findings indicated that random transplanting substantially showed lower grain yield (3.76 t ha^{-1}) and row transplanting at produced higher grain yield (4.57 t ha^{-1}).

Pedroso (1981) in Brazil conducted an experiment in which rice cv BR/IRGA-409 was sown in rows 10-30 cm apart or broadcast and observed that there was no significant differences in grain yields between treatments, although yield ranged from 3.17 to 4.36 t ha^{-1}.

Rao *et al.* (1981) reported that number of productive tillers m^{-2} were higher in local method of planting as compared to transplanting in 15cm X 10cm spacing but both grain yield and straw yield were higher in transplanting in row than local planting method. They further found no significant difference in panicle length, number of grains and1000-grains weight between local planting method and transplanting in rows.

Luh (1980) reported that tillering and the production of leaves are the main visible activity during the vegetative phase of aman rice. In the tropics, maximum tiller number in rice occurs 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 to30 tillers when grown as isolated plants.

Raju and Varma (1979) observed in a basic research on tillering pattern of aman 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 are mostly unproductive and their mortality was high. They are unsuccessful in the intraplant competition for photosynthate and other growth requirement and thus they contributed less to the grain yield.

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 weed were 15 to 34% productive and none of the 6th and 7th week tillers developed panicles.

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.

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

Auma and Gunasena (1972) in Srilanka reported from a field experiment in which rice cv. H4 and IR8 were (a) transplanted in rows or (b) transplanted at random. They found paddy yields of 4.8 and 5.3 t ha^{-1} for (a) and (b) respectively.

Chang and Vergara (1972) reported that the tillering pattern of aman rice varied with the varieties. In general, tall cultivars showed a tendency to have small number of tillers. 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 aman 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.

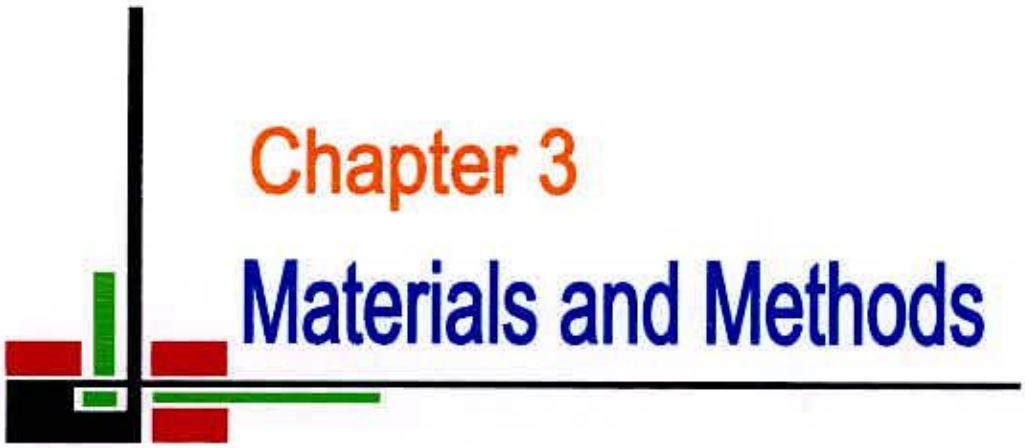
Richharia *et al.* (1964) observed that twenty one, out of thirty varieties, exhibited differential response in increasing the grain yield by the simple process of separating the tillers three weeks after planting with a spacing of 15 x15 cm^2 and replanting them with a closer spacing of 15.0 x 4.5 cm^2 with the same area. The plant height number and weight of grain $plant^1$ 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.



Chapter 3

Materials and Methods

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 2005. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout experimental design, intercultural operations, data recording and their analysis.

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 2005. For better understanding about the experimental site is shown in the AEZ Map of Bangladesh in Appendix i.

3.2 Climate

The experimental area was under the sub-tropical climate that 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 iv.

3.3 Soil

The farm belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resources and Development Institute (SRDI), Dhaka. The physiochemical properties of the soil are presented in Appendix iii.

3.4 Planting material

A high yielding variety of aman rice BR 11 (Mukta) and a hybrid rice variety Sonar Bangla-1 were used as test crop. The variety BR 11 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-fine and white. Sonar bangla-1 a hybrid rice variety which produce higher yield than modern variety. It is introduced in Bangladesh by Mollika Seed Company from China.

3.5 Seed collection and sprouting

Seeds of BR 11 were collected from BRRI, Joydebpur, Gazipur, Bangladesh and the Sonar Bangla-1 Hybrid rice seed was colleted from the Mollika seed company, Dhaka which they imported from China. Healthy seeds were selected following standard soaking method. Seeds were immersed in bucket of water for 24 hrs. These were then taken out of water and kept tightly in gunny bags. The seeds started sprouting after 48 hrs which were suitable for sowing in 72 hr.

3.6 Raising of seedlings

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

3.7 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite

sample. After collection of soil samples, the plant roots, leaves etc. 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.

3.8 Preparation of experimental land

The experimental field was first opened on June 12, 2005 with the help of a power tiller, later the land was irrigated and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of previous crop were removed from the field. The field layout was made on 17th June, 2005 according to design immediately after final land preparation. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.9 Fertilizer management

At the time of first ploughing cow dung at the rate of 10 t ha^{-1} was applied. The experimental area was fertilized with 120, 80, 80, 20 and 5 kg ha^{-1} N, P_2O5, 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 four equal installments. The first one-fourth urea was top dressed after seedling recovery. Second at 15 days after first top dressing, third at 15 days after second top dressing and fourth at 15 days after third top dressing .

3.10 Experimental treatments

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

A. Planting material (3)

i. Sprouted seed (M_1)

ii. Nursery seedling (M_2)

iii. Clonal tiller (M_3)

B. Variety (2)

i. BR11 (inbreed variety)-V_1

ii. Sonar bangla-1 (hybrid variety)-V_2

C. Planting method (2)

i. Broadcast (T_1)

ii. Line sowing (T_2)

3.11 Experimental design

The experiment was laid out in a split- split-plot design with four replications having seed source/planting material in the main plots and variety in the sub-plots and planting method in the sub-sub plots. There were 12 treatment combinations. The total numbers of unit plots were 48. The size of unit plot is 4 m x 3 m. The distances between plot to plot and replication to replication were 1m. The layout of the experiment has been shown in Appendix ii.

3.12 Direct seed sowing, Uprooting and transplanting of seedlings

Direct seeds were sown in the main field on June 22, 2005, same time as seed bed for raising of seedlings. A 25 days old seedling was uprooted carefully and was kept in soft mud in shade. The seed beds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots.

Seedlings were then transplanted as per experimental treatment in haphazard and line with the spacing of 20 x 15 cm on the well puddled plots on July 18, 2005. In each plot, there were 12 rows, each row containing 21 hills of aman rice seedlings having two seedlings $hill^{-1}$.

3.13 Clonal tiller separation and transplanting:

On 18th August, 2005 clonal tiller were separated (30 days after transplanting) from the mother crop and replanted on the main field. The clonal tillers were collected from the plot which was also prepared on the same day of seedling transplanting on the main field. During tiller separation it was observed that there were on average 11 tillers $hill^{-1}$ in BR11 and 13 tillers $hill^{-1}$ in case of Sonar bangla-1.

3.14 Intercultural operations

3.14.1 Thinning and Gap filling

After one week of direct seed sowing, thinning was done to maintain the population number. After transplanting the nursery seedlings and clonal tillers gap filling was done whenever it was necessary using the seedling or separated clonal tiller from the previous source.

3.14.2 Weeding

Two hand weedings were done for every planting technique, first weeding was done at 20 days after seedling planting followed by second weeding at 35 days after first weeding.

3.14.3 Application of irrigation water

Irrigation water was added to each plot according to the needs. All the plots were kept irrigated as per treatment. Before ripening the field was kept dry for all the treatments.

3.14.4 Plant protection measures

Plants were infested with rice stem borer and leaf hopper to some extent which was successfully controlled by applying Diazinon @ 10 ml/ 10 Liter of water for 5 decimal lands on 8 and 25 July and by Ripcord @ 10 ml/ 10 Liter of water for 5 decimal lands on 21 August and 18 September 2005. Crop was protected from birds and rats during the grain filling period. Field trap and fox toxin poisonous bait was used to control the rat. For controlling the birds watching was done properly, especially during morning and afternoon.

3.14.5 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting was done on October 25, 2005, October 30, 2005 and November 7, 2005 for sprouted seeded plot, nursery seeded and clonal tillers plot respectively. Ten pre selected hills per plot from which different agronomic data were collected and 6 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done using by pedal thresher. The grains were cleaned and sun dried to moisture content of 14 %. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were recorded and converted to ton ha^{-1}.

3.15 Recording of data

Experimental data were recorded from 45 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of hills at different dates from the inner rows leaving border rows and harvest area for grain.

The followings data were recorded during the experiment.

A. Crop growth characters

i. Plant height (cm) at 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 30 days interval

v. Time of flowering and maturity

B. Yield and yield components

i. Length of panicle (cm)

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

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

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

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

vi. Weight of 1000- grain (g)

vii. Grain yield ($t\ ha^{-1}$)

viii. Straw yield ($t\ ha^{-1}$)

ix. Harvest index

3.16 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 and continued up to harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before heading, and to the tip of panicle after heading.

ii. Number of tiller hill^{-1}

Number of tillers hiil^{-1} were counted at 15 days interval and up to harvest from pre selected hills and finally averaged as their number hill^{-1}. Only those tillers having three or more leaves were considered for counting.

iii. Leaf area index (LAI)

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

iv. Dry weight of plant

The sub-samples of 5 hills / plot were oven dried until a constant weight from which the weights of above ground dry matter were recorded at 30 days interval and at harvest.

v. Time of flowering

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

B. Yield and yield components

i. 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.

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

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

iii. 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 panicle was recorded.

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

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

v. 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 grain panicle^{-1}.

vi. Weight of 1000-grain

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

vii. 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.

viii. Straw yield

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

ix. Harvest index

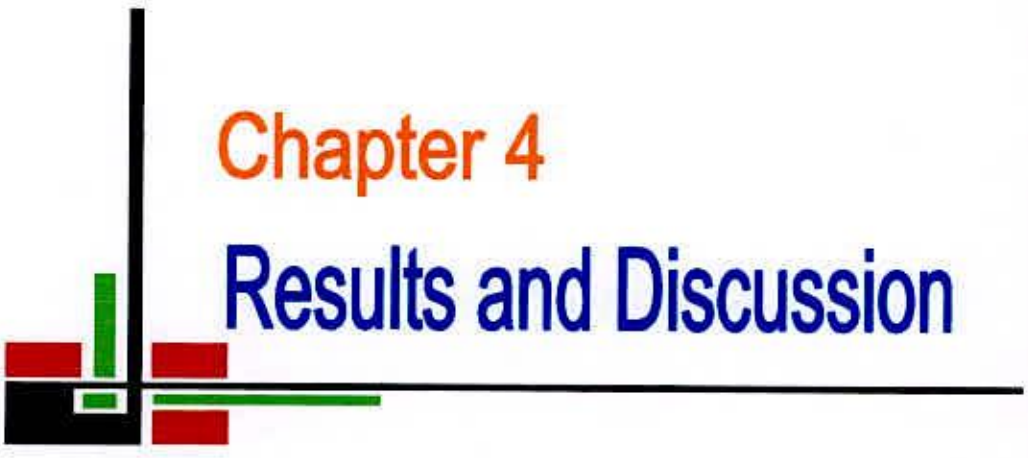
The harvest index was calculated as GY/ (GY+SY), where GY is the final grain yield and SY is the final straw yield.

3.17 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 iii. The soil was analyzed following standard methods.

3.18 Statistical analysis of the data

Analysis was done by using the IRRISTAT (Version 4.0, IRRI, Philippines) computer package program developed by IRRI. The mean differences among the treatments were compared by least significant difference test at 5 % level of significance.



Chapter 4

Results and Discussion

RESULTS AND DISCUSSION

Results obtained from the present study regarding the effect of planting techniques of inbreed and hybrid rice and their different interactions on the yield and yield components have been presented and discussed in this chapter. The mean square values for the different parameters have been presented in the appendix.

4.1 Crop growth characters

4.1.1 Plant height at different growth duration

4.1.1.1 Effect of planting material

The plant height of aman rice was significantly influenced by different planting material at 45, 60, 75 days at different growth duration and at harvest (Appendix v and Table1)

The results (Table 1) revealed that at 45 days, the tallest plant (57.54 cm) was obtained from clonal tiller that followed by sprouted seeds (53.54 cm) and nursery seedlings (36.30 cm). At 60 days, the tallest plant (88.71 cm) was observed in sprouted seeds followed by in clonal tiller (84.24 cm) and the lowest height (74.85 cm) was obtained from the sprouted seeds. At 75 days, the tallest height (100.34 cm) was from the sprouted seeds, the second highest height (94.03 cm) was found from the clonal tiller and the lowest height was (90.48 cm) obtained from the nursery seedlings. At harvest, the tallest plant height (105.48 cm) was observed in sprouted seeds followed by clonal tillers (97.55 cm) and nursery seedlings (95.11 cm). This finding was dissimilar with the findings of Sharma and Ghosh (1998), Richharia *et al.* (1964) who observed tallest height in clonal tiller. But this result was disagree with Sarkar *et al.* (2003) and who reported tallest plant in sprouted seeds transplanting than nursery seedling.

Table 1. Effect of planting material on plant height of aman rice

Treatment	*Plant height(cm) at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
M_1	53.54	88.71	100.34	105.48
M_2	36.30	74.85	90.48	95.11
M_3	57.54	84.24	94.03	97.55
LSD (0.05)	2.90	2.76	3.10	4.09
CV (%)	8.00	4.5	4.4	5.6

M_1= Sprouted seed, M_2= Nursery seedlings and M_3= Clonal tiller

4.1.1.2 Effect of variety

The plant height of aman rice was significantly influenced by variety at 45, 60, 75 days at different growth duration and at harvest (Appendix v and Table 2).

The result reveled that at 45 days, the significantly highest plant height (56.36 cm) was recorded in the hybrid variety (Sonar bangla-1) and the lowest height (41.89 cm) was recorded in the inbreed variety (BR 11) and the same increasing trend of plant height for hybrid variety over inbreed variety was obtained up to harvest. At harvest the highest height (105.75 cm) was obtained from the hybrid variety and the lowest height (91.68 cm) was recorded in inbreed variety. The hybrid variety was about 15% taller at harvest compare to the inbreed variety BR11.

Table 2. Effect of variety on plant height of aman rice

Treatment	*Plant height(cm) at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
V_1	41.89	71.92	86.35	91.68
V_2	56.36	93.28	103.55	105.75
LSD (0.05)	2.37	2.25	2.53	3.34
CV (%)	8.00	4.5	4.4	5.6

V_1= BR 11 and V_2= Sonar Bangla -1

4.1.1.3 Effect of planting method

The plant height of aman rice was not significantly influenced by planting method at 45, 60, 75 days at different growth duration and at harvest (Appendix v and Table 3).

The result showed that planting method had no significant influence on plant height throughout the life cycle of the crop. Sorour *et al.* (1998) reported taller plant height in transplanting method than broadcast method but it was differed with the result of Reddy *et al.* (1987) who found no significant variation of plant height for planting method

Table 3. Effect of planting method on plant height of aman rice

Treatment	*Plant height(cm) at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
T_1	48.98	81.68	94.78	98.27
T_2	49.27	83.52	95.11	99.16
LSD (0.05)	NS	NS	NS	NS
CV (%)	8.00	4.5	4.4	5.6

T_1=Broadcast and T_2=Line sowing

4.1.1.4 Interaction effect of planting material and variety

The plant height of aman rice was significantly influenced by the interaction effect of planting material and variety at 45, 60, 75 days at different growth duration and at harvest, (Appendix v and Table 4).

At 45 days the highest plant height was obtained from the clonal tiller of hybrid variety and sprouted seeds of hybrid variety and the lowest for nursery seedling of inbreed variety. At 60, 75 days and harvest, the highest plant height was recorded in sprouted seeds of hybrid variety and the lowest plant height was observed at 45 days

in nursery seedlings of inbreed variety but at 75 days and at harvest the lowest in nursery seedlings of inbreed variety.

Table 4. Effect of planting material and variety on plant height of aman rice

Treatment	*Plant height(cm) at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
M_1V_1	45.24	77.14	87.06	96.71
M_1V_2	61.84	100.28	113.63	114.25
M_2V_1	30.58	64.00	79.85	82.76
M_2V_2	42.02	85.70	101.10	103.46
M_3V_1	49.85	74.63	92.13	95.55
M_3V_2	65.23	93.85	95.93	99.53
LSD(0.05)	4.10	3.90	4.38	5.79
CV (%)	8.00	4.5	4.4	5.6

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11and V_2= Sonar Bangla -1

4.1.1.5 Interaction effect of planting material and planting method

The plant height of aman rice was significantly influenced by the interaction effect of planting material and planting method at 45, 60, 75 days at different growth duration and at harvest (Appendix v and Table 5).

At 45 days, the tallest plant (58.21 cm) was observed in the clonal tiller with haphazard planting and it was statistically similar with the clonal tillers planting in line. The lowest height (35.65 cm) was observed in nursery seedling with line sowing method that statistically similar with the nursery seedling with haphazard method. The plant height at 60, 75 days and at harvest, highest plant height was observed in sprouted seeds with line sowing method. And all the cases the lowest height was observed in nursery seedling with line sowing method.

Table 5. Effect of planting material and planting method on plant height of aman rice

Treatment	*Plant height(cm) at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
M_1T_1	51.78	86.14	99.65	104.68
M_1T_2	55.30	91.28	101.03	106.29
M_2T_1	36.94	75.95	91.95	94.23
M_2T_2	35.65	73.75	89.00	92.00
M_3T_1	58.21	82.95	92.75	95.90
M_3T_2	56.86	85.53	95.30	99.19
LSD (0.05)	4.10	3.90	4.38	5.79
CV (%)	8.00	4.50	4.40	5.60

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.1.1.6 Interaction effect of variety and planting method

The plant height of aman rice was significantly influenced by the interaction effect of variety and planting method at 45, 60, 75 days at different growth duration and at harvest (Appendix v and Table 6).

At 45, 60, 75 days and at harvest, the highest height was obtained in hybrid variety with irrespective of their planting method compared to that of BR 11 with both the planting methods.

Table 6. Effect of variety and planting method on plant height of aman rice

Treatment	*Plant height(cm) at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
V_1T_1	42.77	70.58	85.85	89.97
V_1T_2	41.00	73.27	86.84	93.39
V_2T_1	55.19	92.78	103.72	106.57
V_2T_2	57.53	93.78	103.38	104.93
LSD (0.05)	3.35	3.19	3.58	4.72
CV (%)	8.00	4.5	4.4	5.6

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.1.1.7 Interaction effect of planting material, variety and planting method

The plant height of aman rice was significantly influenced by the interaction effect of planting material, variety and planting method at 45, 60, 75 days growth duration and at harvest (Appendix v and Figure 1).

At 45 days, the highest height was recorded in clonal tiller of hybrid variety with irrespective of the planting method and it was statistically similar with sprouted seed of hybrid variety with line sowing method. At 60 days, the highest height was recorded in sprouted seeds of hybrid variety with irrespective of planting method and it was statistically similar with clonal tiller of hybrid variety with line sowing method. At 75 days, the highest height (113.65 cm) was recorded in nursery seedling of hybrid variety with line sowing method, at harvest the highest height (117.63 cm) was recorded in sprouted seeds of hybrid variety with broadcast sowing method and all the growth duration cases the lowest height was recorded in nursery seedling of inbreed variety with irrespective of their planting method..

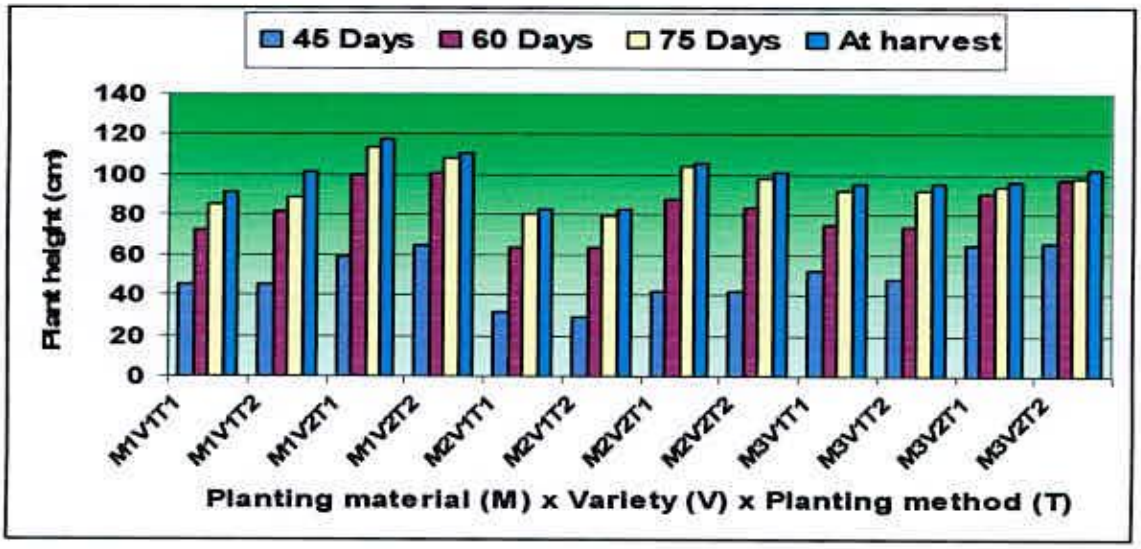


Figure 1. Influence of plant height (cm) of aman rice at different growth duration

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

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

4.1.2.1 Effect of planting material

The production of total tiller hill^{-1} was significantly influenced by planting material at 45 and 60 days growth duration but insignificant at 75 days and at harvest (Appendix vi and Figure 2).

At 45 days, significantly maximum number (8.14) of tillers hill^{-1} was recorded from sprouted seeds followed by clonal tiller (6.04) which was statistically similar with nursery seedlings (5.86) and it was the minimum number. At 60 days, maximum tillers hill^{-1} (11.65) found in clonal tiller followed by sprouted seeds which was statistically similar with nursery seedling and it was also minimum in number (10.14). At 75 days and at harvest no significant variation was observed.

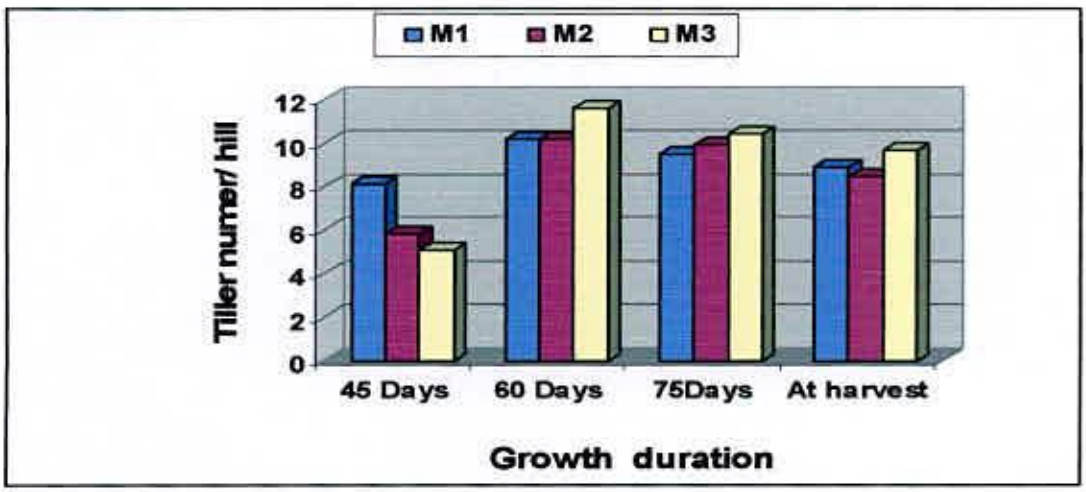


Figure 2. Number of tillers hill^{-1} of aman rice at different growth duration as influenced by planting material

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller

4.1.2.2 Effect of variety

The production of total tiller hill^{-1} was significantly influenced by the variety at 45, 60, 75 days growth duration but insignificant at harvest (Appendix vi and Table 7).

At 45, 60 and 75 days, all the cases maximum tiller number was observed in the

inbred variety (BR 11) and the minimum number of tiller was obtained from the hybrid variety (Sonar bangla-1). At harvest no significant variation at tiller number was observed in the studies varieties.

Table 7. Effect of variety on number of tillers hill^{-1} of aman rice

Treatment	*Number of tillers hill^{-1} at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
V_1	7.42	11.62	10.25	8.88
V_2	5.94	9.88	8.60	8.27
LSD (0.05)	0.64	0.97	1.09	NS
CV (%)	15.8	14.8	19.1	26.4

V_1= BR 11, V_2= Sonar Bangla -1

4.1.2.3 Effect of planting method

The production of total tillers hill^{-1} was not significantly influenced by planting method at 60 days growth duration only but insignificant at 45, 75 and at harvest (Appendix vi and Table 8).

At 60 days the maximum number of tillers hill^{-1} was observed in broadcast method (11.35) and the minimum (10.14) in line sowing method. And the other cases the number of tillers produced by the two planting methods was similar throughout the entire growing period though broadcast method revealed higher in number compared to that of line sowing

Table 8. Effect of planting method on number of tillers hill^{-1} of aman rice

Treatment	*Number of tillers hill^{-1} at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
T_1	6.93	11.35 a	9.80	8.93
T_2	6.43	10.14 b	9.03	8.83
LSD (0.05)	NS	0.97	NS	NS
CV (%)	15.8	1.09	19.1	26.4

T_1=Broadcast and T_2=Line sowing

4.1.2.4 Interaction effect of planting material and variety

Tiller number tillers hill^{-1} was significantly influenced by the interaction effect between planting material and variety at 45, 60, 75 days of growth duration but insignificant at harvest (Appendix vi and Figure 3).

At 45 days, the maximum number of tillers hill^{-1} (9.38) was obtained from sprouted seeds of inbreed variety and. The lowest number of tiller was produced by nursery seedling of hybrid variety.

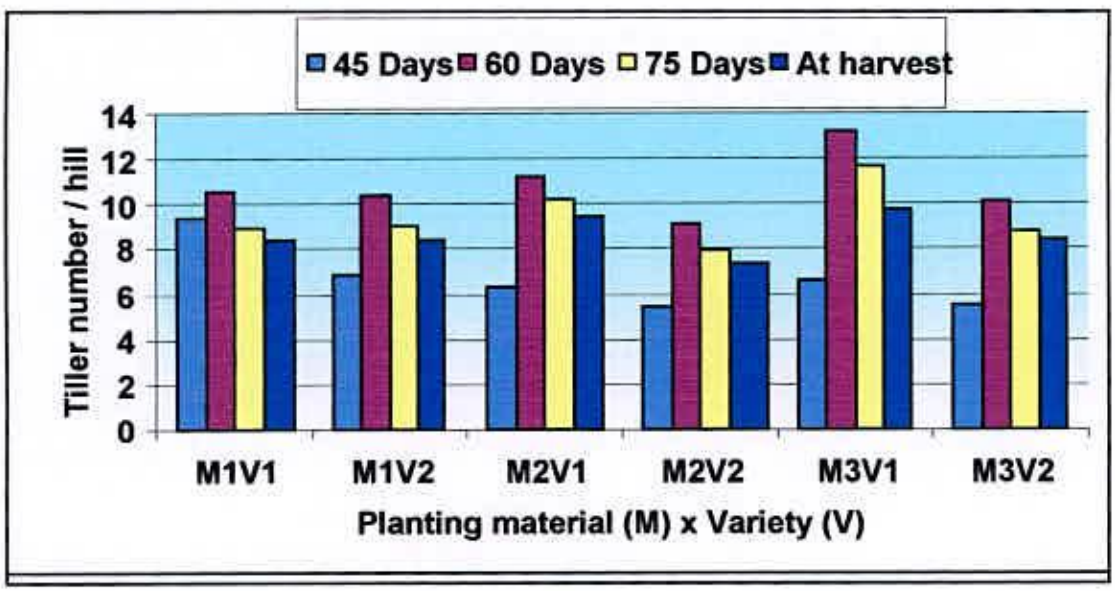


Figure 3. Number of tillers hill^{-1} of aman rice at different growth duration as influenced by the planting material and variety

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11and V_2= Sonar Bangla -1

At 60 and 75 days same trend observed and the magnitude of tiller production was to some extent changed where the highest number of tillers hill^{-1} was counted at clonal tiller of inbreed variety. The lowest number of tiller was produced in nursery of hybrid variety. But at harvest there was no significant variation observed.

4.1.2.5 Interaction effect of planting material and planting method

Tiller number hill^{-1} was significantly influenced by the interaction effect between planting material and planting method at 45, 60, 75 days of growth duration but insignificant at harvest (Appendix vi and Table 9).

At 45 days, the highest number of tillers hill^{-1} was counted in sprouted seeds with irrespective of their planting method. The lowest number of tiller (5.45) was produced in clonal tiller with line sowing method, there was statistical similarity of nursery seedling with both planting material. At 60 days, the magnitude of tiller production was to some extent changed where the highest number of tillers hill^{-1} (12.68) was counted at clonal tiller with haphazard method followed by sprouted seeds with haphazard method.

Table 9. Effect of planting material and planting method on number of tillers hill^{-1} of aman rice

Treatment	*Number of tillers hill^{-1} at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
M_1T_1	8.28	11.55	9.87	9.22
M_1T_2	8.00	9.35	8.08	8.08
M_2T_1	5.88	9.83	8.78	8.43
M_2T_2	5.85	10.45	9.35	8.55
M_3T_1	6.63	12.68	10.76	8.22
M_3T_2	5.45	10.63	9.69	9.27
LSD (0.05)	1.11	1.67	1.89	NS
CV (%)	15.8	14.8	19.1	26.4

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

The lowest number of tiller (9.35) was produced in sprouted seeds of line sowing method. At 75 days, the highest number of tillers hill^{-1} (10.76) was counted at clonal tillers transplanted of haphazard method. The lowest number of tillers hill^{-1} (8.08) was produced in sprouted seeds of line sowing method and that was statistically similar with the nursery seedlings with broadcast method.

4.1.2.6 Interaction effect of variety and planting method

Tiller number hill^{-1} was significantly influenced by the interaction effect between varieties and planting method at 45, 60, 75 days of growth duration but insignificant at harvest (Appendix vi and Table 10).

At 45 days, the highest number of tillers hill^{-1} (8.05) was counted at inbreed variety with broadcast method followed by inbreed variety with line sowing method. The lowest number of tiller (5.80) was produced in hybrid variety with broadcast method. At 60 days the highest number of tillers hill^{-1} (12.52) was counted at inbreed variety with broadcast method. The lowest number of tiller (10.18) was produced in hybrid variety with line sowing method and it was statistical similar with inbreed variety with line sowing method. At 75 days, the highest number of tillers hill^{-1} (10.62) was also counted at inbreed variety with broadcast method. The lowest number of tillers hill^{-1} (8.20) was produced in hybrid variety with line sowing method.

Table 10. Effect of variety and planting method on number of tillers hill^{-1} of aman rice

Treatment	*Number of tillers hill^{-1} at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
V_1T_1	8.05	12.52	10.62	8.72
V_1T_2	6.78	10.72	9.88	9.05
V_2T_1	5.80	10.18	8.99	8.13
V_2T_2	6.08	9.57	8.20	8.06
LSD (0.05)	0.90	1.37	1.55	NS
CV (%)	15.8	14.8	19.1	26.4

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.1.2.7 Interaction effect of planting material, variety and planting method

Tiller number hill^{-1} was significantly influenced by the interaction effect of planting material, variety and planting method at 45, 60 and 75 days of growth duration but insignificant at harvest (Appendix vi and Table 11).

At 45 days, the maximum number of tillers hill^{-1} (10.25) was obtained from sprouted seeds of inbred variety with broadcast method. The lowest number of tillers hill^{-1} (5.35) was produced by nursery seedling of hybrid variety with line sowing method and there was statistical similarity with clonal tiller of hybrid variety with irrespective planting method.

Table 11. Effect of planting material, variety and planting method on number of tillers hill^{-1} of aman rice

Treatment	*Number of tillers hill^{-1} at different growth duration*			
	45 days	*60 days*	*75 days*	*At harvest*
$M_1V_1T_1$	10.25	11.60	9.40	9.20
$M_1V_1T_2$	8.50	9.45	8.40	9.70
$M_1V_2T_1$	6.30	11.50	10.35	11.25
$M_1V_2T_2$	7.50	9.25	7.75	10.50
$M_2V_1T_1$	6.25	10.90	9.95	10.75
$M_2V_1T_2$	6.35	11.45	10.40	10.10
$M_2V_2T_1$	5.50	8.75	7.60	9.90
$M_2V_2T_2$	5.35	9.45	8.30	9.00
$M_3V_1T_1$	7.65	15.05	12.50	9.20
$M_3V_1T_2$	5.50	11.25	10.83	10.35
$M_3V_2T_1$	5.60	10.30	9.02	9.25
$M_3V_2T_2$	5.40	10.00	8.55	9.30
LSD (0.05)	1.57	2.36	2.68	NS
CV (%)	15.8	14.8	19.1	26.4

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

At 60 days, the highest number of tillers hill^{-1} (15.05) was counted at clonal tiller of inbred variety with haphazard planting method. The lowest number of tiller (8.75) was produced in nursery seedling of hybrid variety under haphazard method. At 75

days, where the highest number of tillers hill^{-1} (12.50) was counted at clonal tillers of inbreed variety with broadcast method. The lowest number of tiller (7.60) was produced in nursery seedling of hybrid variety under haphazard method.

4.1.3 Leaf area index (LAI)

The leaf area of plant is one of the major determinants of its growth. The net dry matter production by a plant in an interval time is more dependent on the size of its total assimilating 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.

4.1.3.1 Effect of planting material

Leaf area index (LAI) of aman rice was significantly influenced by the treatment of planting material at 45, 60 and 75 days of growth duration (Appendix vii and Figure 4).

At 45 days, significantly highest LAI (1.76) was recorded in sprouted seeds and it was statistically similar with clonal tiller and the lower LAI (1.31) was in nursery seedling. At 60 days, significantly higher LAI (4.66) was recorded from sprouted seeds, second highest LAI (4.21) in clonal tiller and lower (4.20) was at nursery seedling. But significantly maximum (3.41) from nursery seedling, second highest (3.18) from clonal tiller and minimum LAI (2.90) from sprouted seeds at 45 days was observed.

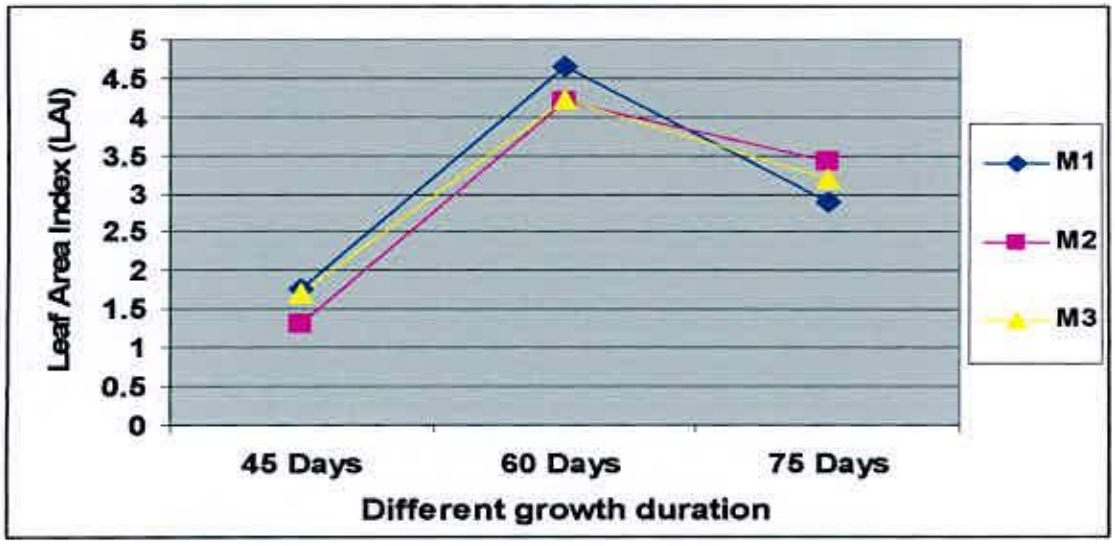


Fig 4. Changes in Leaf Area Index (LAI) of aman rice as influenced by planting material at different growth duration

4.1.3.2 Effect of variety

Leaf area index (LAI) of aman rice was significantly influenced by the treatment of variety at 45 days of growth duration but insignificant at 45, 60 days (Appendix vii and Table 12).

At 45 and 60 days higher LAI also found in inbreed variety though there was no significant variation between the tow varieties. At 75 days the maximum LAI (3.52) was observed in inbreed variety and the minimum LAI (2.82) was observed in hybrid variety.

Table 12. Effect of variety on LAI at different growth duration of aman rice

Treatment	*LAI at different growth duration*		
	45 days	*60 days*	*75 days*
V_1	1.56	4.48	3.52
V_2	1.61	4.24	2.82
LSD (0.05)	NS	NS	0.30
CV (%)	10.6	13.8	15.7

V_1= BR 11, V_2= Sonar Bangla -1

4.1.3.3 Effect of planting method

Leaf area index (LAI) of aman rice was significantly influenced by the treatment of planting method at 75 days of growth duration but insignificant at 45 and 60 and days (Appendix vii and Table13).

Both of two at 45 and 60 days the LAI also higher in the broadcast method than line sowing method. At 75 days the maximum LAI (3.24) was observed in broadcast method and the minimum LAI (3.09) in line sowing method. Sorour *et al.* (1998) disagree with this finding and they found greater LAI in transplanting than broadcast method.

Table 13. Effect of planting method on LAI at different growth duration of aman rice

Treatment	*LAI at different growth duration*		
	45 days	*60 days*	*75 days*
T_1	1.60	4.43	3.24
T_2	1.57	4.28	3.09
LSD (0.05)	NS	NS	0.10
CV (%)	10.6	13.8	15.7

T_1=Broadcast and T_2=Line sowing

4.1.3.4 Interaction effect of planting material and variety

Leaf area index of aman rice was significantly influenced by the interaction between planting material and variety at 45, 60 and 75 days (Appendix vi and Table 14).

At 45 days, the highest LAI (1.77) was observed in sprouted seeds of inbreed variety and it was statistically similar with the sprouted seeds of hybrid variety and also clonal tiller of irrespective variety. The lowest LAI (1.28) was observed in nursery seedling of inbreed variety and there was found statistical similarity with nursery seedling of hybrid variety. At 60 days the highest LAI (4.74) was observed in

sprouted seeds of inbreed variety and the lowest LAI (3.82) was observed in clonal tiller of hybrid variety. At 75 days the maximum LAI (3.90) was measured in clonal tiller of inbreed variety and minimum LAI (3.24) measured in sprouted seeds of inbreed variety which was statistically similar with clonal tiller of hybrid variety.

Table 14. Effect of planting material and variety on LAI at different growth duration of aman rice

Treatment	*LAI at different growth duration*		
	45 days	*60 days*	*75 days*
M_1V_1	1.77	4.74	3.24
M_1V_2	1.75	4.58	2.58
M_2V_1	1.28	4.08	3.42
M_2V_2	1.34	4.32	3.41
M_3V_1	1.64	4.61	3.90
M_3V_2	1.75	3.82	2.47
LSD(0.05)	0.17	0.63	0.52
CV (%)	10.6	13.8	15.7

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11and V_2= Sonar Bangla -1

4.1.3.5 Interaction effect of planting material and planting method

Leaf area index or aman rice was not significantly influenced by the interaction between planting material and planting method at 45, 60 and 75 days of growth duration (Appendix vii and Table 15).

At 45 days, the highest LAI (1.81) was observed in sprouted seeds with line sowing method and it was statistically similar with the sprouted seeds with broadcast method and also clonal tiller with irrespective of their planting method. Lowest LAI was observed in nursery seedling with line sowing method and here also found statistical similarity with nursery seedling with broadcast method. At 60 days the highest LAI (4.76) was observed in sprouted seeds with broadcast method and the lowest LAI (4.12) was observed in nursery seedling with broadcast method. At 75 days the

highest LAI (3.52) was observed in nursery seedling with line sowing method and sprouted seeds with line sowing method gave the lowest LAI (2.81).

Table 15. Effect of planting material and planting method on LAI at different growth duration of aman rice

Treatment	*LAI at different growth duration*		
	45 days	*60 days*	*75 days*
M_1T_1	1.71	4.76	3.01
M_1T_2	1.81	4.55	2.81
M_2T_1	1.34	4.12	3.31
M_2T_2	1.28	4.27	3.52
M_3T_1	1.77	4.41	3.40
M_3T_2	1.63	4.02	2.97
LSD (0.05)	0.18	0.63	0.52
CV (%)	10.6	13.8	15.7

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.1.3.6 Interaction effect of variety and planting method

There was found significant effect of interaction between variety and planting method on LAI at 45 and 75 days of growth duration but insignificant at 60 days (Appendix vii and Table 16).

At 45 days the highest LAI (1.68) was observed in hybrid variety with line sowing method and it was statistically similar with sprouted seeds with broadcast method and the lowest LAI (1.47) was found in sprouted seeds with line sowing method. At 75 days the maximum LAI was observed in inbreed variety with irrespective of their planting method and minimum LAI was observed in hybrid variety with irrespective of their planting method.

Table 16. Effect of variety and planting method on LAI at different growth duration of aman rice

Treatment	*LAI at different growth duration*		
	45 days	*60 days*	*75 days*
V_1T_1	1.66	4.68	3.68
V_1T_2	1.47	4.27	3.36
V_2T_1	1.55	4.18	2.80
V_2T_2	1.68	4.29	2.84
LSD (0.05)	0.15	NS	0.42
CV (%)	10.6	13.8	15.7

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.1.3.7 Interaction effect of planting material, variety and planting method

Leaf area index or aman rice was significantly influenced by the interaction between planting material, variety and planting method at 45,60 and 75 days of growth duration (Appendix vii and Table 17).

At 45 DAT the highest LAI (1.83) was observed in sprouted seeds of inbreed variety with broadcast method and it was statistically similar with sprouted seeds of inbreed variety or hybrid variety with line sowing method, here also found statistical similarity with clonal tiller of hybrid variety with line sowing method. The lowest LAI (1.21) was observed in nursery seedling of inbreed variety and with line sowing method. At 60 days the highest LAI (5.13) was observed in clonal tiller of inbreed variety with broadcast method and the lowest LAI (3.97) was observed in nursery seedling of inbreed variety with broadcast method. At 75 days the highest LAI (3.50) was observed also in clonal tiller of inbreed variety with broadcast method and the lowest LAI (2.44) was observed in clonal tiller of hybrid variety with line sowing method, it was statistically similar with both the interaction in clonal tiller of hybrid variety with broadcast method and sprouted seeds of hybrid variety with line sowing method.

Table 17. Effect of planting material variety and planting method on LAI at different growth duration of aman rice

Treatment	*LAI at different growth duration*		
	45 days	*60 days*	*75 days*
$M_1V_1T_1$	1.83	4.95	3.39
$M_1V_1T_2$	1.71	4.52	3.08
$M_1V_2T_1$	1.59	4.57	2.64
$M_1V_2T_2$	1.91	4.58	2.52
$M_2V_1T_1$	1.34	3.97	3.34
$M_2V_1T_2$	1.21	4.20	3.5
$M_2V_2T_1$	1.33	4.28	3.28
$M_2V_2T_2$	1.35	4.35	3.54
$M_3V_1T_1$	1.81	5.13	4.30
$M_3V_1T_2$	1.48	4.09	3.50
$M_3V_2T_1$	1.72	3.69	2.50
$M_3V_2T_2$	1.78	3.94	2.44
LSD (0.05)	0.25	0.9	0.74
CV (%)	10.6	13.8	15.7

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.1.4 Total dry weight

4.1.4.1 Effect of planting material

Total dry weight per hill was significantly influenced by planting material at 30, 60 days of growth duration and at harvest (Appendix viii and Figure 5).

At 30 days, maximum dry weight (16.00 g) was recorded in clonal tiller that followed nursery seedling (5.97 g) and the minimum dry weight (1.45 g) was recorded in sprouted seeds. This trend of dry matter production was also observed at 60 days. At harvest, maximum dry weight (54.20 g) was obtained from the clonal tiller and there

was statistically similarity of dry weight observed between nursery seedling and the sprouted seeds. Sharma and Ghosh (1998) observed highest dry weight in clonal tiller compared to nursery seedling, but Sarkar *et al*, (2003) got greater dry weight in sprouted seeds than transplanting.

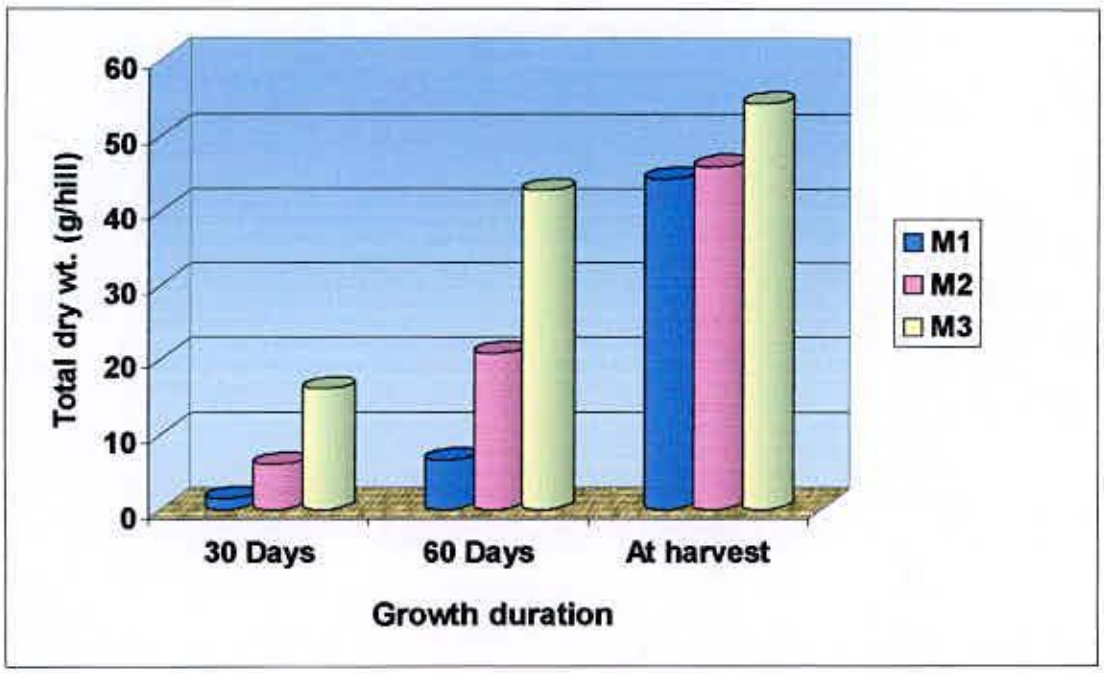


Figure 5. Total dry weight (g/hill) of aman rice at different growth duration as influenced by planting material

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller

4.1.4.2 Effect of variety

Total dry weight per hill was significantly influenced by variety at 60 days but insignificant at 30 days and at harvest (Appendix viii and Figure 6).

At 30 days, maximum dry weight (8.00 g) was recorded in hybrid variety and the minimum dry weight (7.65 g) was recorded in inbreed variety. At 60 days, the highest dry weight (24.16 g) was recorded in hybrid variety and the lowest dry weight (22.50 g) was recorded in inbreed variety. At harvest, maximum dry weight (48.38 g) was recorded in hybrid variety and the minimum dry weight (47.65 g) was recorded in

inbreed variety. The higher dry weight of hybrid variety might be due to higher vegetative growth.

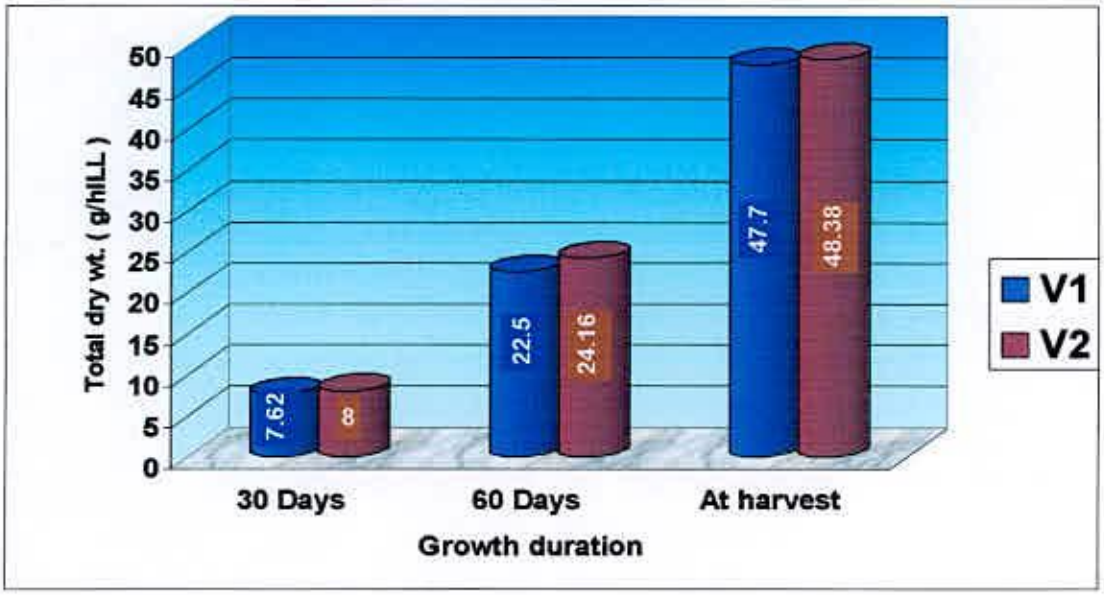


Figure 6. Total dry weight (g/hill) of aman rice at different growth duration as influenced by the variety

V_1= BR 11, V_2= Sonar Bangla -1

4.1.4.3 Effect of planting method

Total dry weight per hill was significantly influenced by planting method at harvest but insignificant at 30 and 60 days. (Appendix viii and Table 18).

At harvest, maximum dry weight (49.08 g) was recorded in line sowing and the minimum dry weight (47.00 g) was recorded in broadcast method. Sorour *et al.* (1998) who found greater dry weight in line sowing method than broadcast method. But Nabheerong (1993) and Ramaiah *et al.* (1986) disagree with this finding and they got higher dry weight in broadcast method than line sowing method

Table 18. Effect of planting method on total dry weight (g/hill) at different growth duration of aman rice

Treatment	*Total dry weight (g/hill) at different growth duration*		
	30 days	*60 days*	*At harvest*
T_1	7.73	23.20	47.00
T_2	7.9	23.47	49.08
LSD (0.05)	NS	NS	1.43
CV (%)	12.9	9.00	4.3

T_1=Broadcast and T_2=Line sowing

4.1.4.4 Interaction effect of planting material and variety

Interaction effect of planting material and variety was significantly influence on dry matter production of rice at 30, 60 days and at harvest. (Appendix viii and Table 19). At 30 days the highest dry matter (16.07 g) was measured in clonal tiller with inbreed variety and it was statistically similar with the clonal tiller and hybrid variety. Second highest dry matter (6.38 g) was measured in nursery seedling with hybrid variety and it was statistically similar with the nursery seedling of inbreed variety. The same trend of higher dry matter in clonal tillers irrespective of their variety was also observed at 60 days and at harvest there were no variation of dry matter production was observed fro nursery seedling & sprouted seeds for both the varieties.

Table19. Effect of planting material and variety on total dry weight (g/hill) at different growth duration of aman rice

treatment	*Total dry weight (g/hill) at different growth duration*		
	30 days	*60 days*	*At harvest*
M_1V_1	1.21	5.86	43.50
M_1V_2	1.70	7.36	44.75
M_2V_1	5.58	18.74	46.20
M_2V_2	6.38	22.78	45.39
M_3V_1	16.07	42.92	53.39
M_3V_2	15.94	42.34	55.01
LSD(0.05)	1.05	2.20	2.47
CV (%)	12.9	9.00	4.3

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11and V_2= Sonar Bangla -1

4.1.4.5 Interaction effect of planting material and planting method

Interaction effect of planting material and planting method was significantly influence on dry matter production of rice at 30, 60 days and at harvest. (Appendix viii and Table 20).

Irrespective of variety, the clonal tillers produced significantly higher dry matter that followed by nursery seedlings and sprouted seeds.

Table 20. Effect of planting material and planting method on total dry weight (g/hill) at different growth duration of aman rice

Treatment	*Total dry weight (g/hill) at different growth duration*		
	30 days	*60 days*	*At harvest*
M_1T_1	1.38	6.36	42.56
M_1T_2	1.53	6.86	45.70
M_2T_1	5.78	20.48	44.77
M_2T_2	6.17	21.03	46.83
M_3T_1	16.01	42.75	53.67
M_3T_2	15.99	42.50	54.74
LSD (0.05)	1.06	2.2	2.47
CV (%)	12.9	9.00	4.3

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.1.4.6 Interaction effect of variety and planting method

Interaction effect of variety and the planting method was significantly influenced at 60 days and harvest but insignificant at 30 days. (Appendix viii and Table 21)

At 60 days the highest dry weight (24.53 g) was recorded in hybrid variety with line sowing method that was statistically similar with the hybrid variety of broadcast method. Similar dry matter was observed in inbreed variety of both the planting method and hybrid variety under broadcast method. At harvest the highest dry weight (49.91 g) was recorded in hybrid variety with line sowing method that was statistically similar with inbreed variety of same planting method. The lowest dry matter was found in hybrid and inbreed variety of broadcast method.

Table 21. Effect of variety and planting method on total dry weight (g/hill) at different growth duration of aman rice

Treatment	*Total dry weight (g/hill) at different growth duration*		
	30 Days	*60 days*	*At harvest*
V_1T_1	7.41	22.64	47.14
V_1T_2	7.82	22.40	48.26
V_2T_1	8.03	23.79	46.85
V_2T_2	7.97	24.53	49.91
LSD (0.05)	NS	1.79	2.02
CV (%)	12.9	9.00	4.9

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.1.4.7 Interaction effect of planting material, variety and planting method

Interaction effect of planting material, variety and planting method was significantly influenced the total dry matter at 30, 60 days and at harvest (appendix viii and Table 22).

At 30 days the highest dry weight was recorded in clonal tillers irrespective of their variety and planting method that followed by nursery seedling and sprouted seeds. The similar trend of higher dry matter in clonal tillers that followed by nursery seedling and sprouted seeds irrespective of their variety & planting method was also recorded at 60 days. at harvest the highest dry weight (56.46 g) was recorded in clonal tiller of hybrid variety with line sowing method that similar with the same planting material irrespective of their variety and panting method. The lowest dry weight (42.02 g) was recorded in sprouted seeds of inbreed variety with broadcast method.

Table 22. Effect of planting material, variety and planting method on total dry weight (g/hill) at different growth duration of aman rice

Treatment	*Total dry weight (g/hill) at different growth duration*		
	30 days	*60 days*	*At harvest*
$M_1V_1T_1$	1.14	5.78	42.02
$M_1V_1T_2$	1.28	5.93	44.98
$M_1V_2T_1$	1.61	6.94	43.09
$M_1V_2T_2$	1.78	7.79	46.42
$M_2V_1T_1$	5.40	18.39	45.62
$M_2V_1T_2$	5.76	19.09	46.78
$M_2V_2T_1$	6.17	22.58	43.91
$M_2V_2T_2$	6.58	22.98	46.87
$M_3V_1T_1$	15.70	43.65	53.77
$M_3V_1T_2$	16.43	42.19	53.02
$M_3V_2T_1$	16.33	41.85	53.57
$M_3V_2T_2$	15.55	42.82	56.46
LSD (0.05)	1.49	3.11	3.5
CV (%)	12.9	9.00	4.9

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.1.5 Days to flowering and maturity

4.1.5.1 Effect of planting material

The flowering and maturity dates were significantly varied among the planting material (Appendix x and Figure 7).

Sprouted seeds needed the lowest duration (88.63 days) for flowering and for maturity (117.19 days) followed by nursery seedlings requred duration for flowering (90.00 days) and for maturity (123.69 days). For clonal tiller the highest duration (94.63 days) was needed to flowering and (131. 96days) for maturity. This might be due to

higher interplant competition that forces to shorten the life cycle of sprouted seeds Valarmathi and Leenakumary (1998) also found same finding where they observed sorter duration required for maturity in sprouted seeds than transplanted crop.

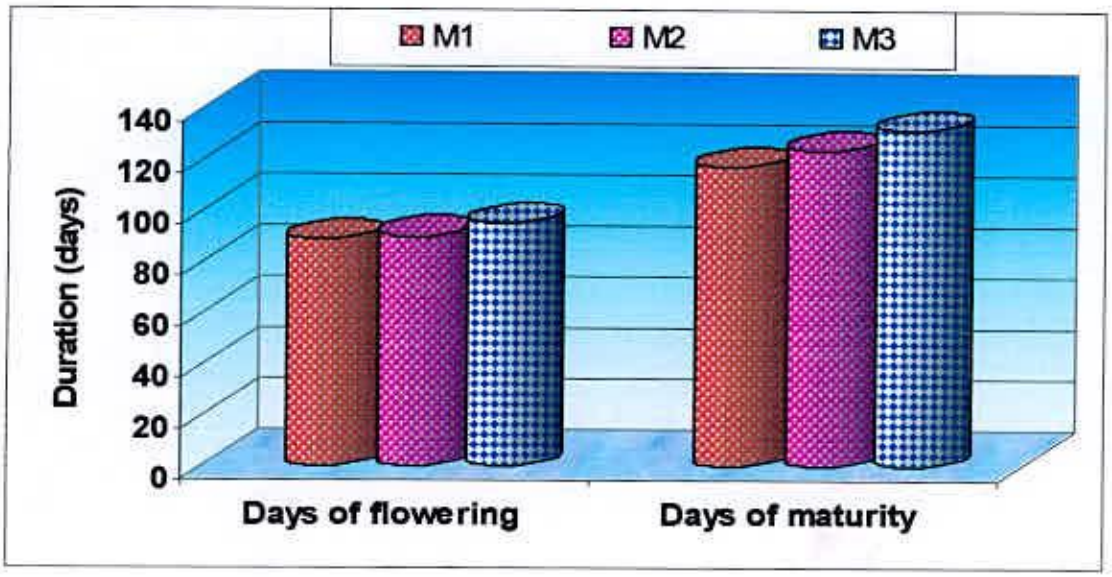


Figure 7. Days of flowering and maturity as influenced by planting material

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller

4.1.5.2 Effect of variety

The flowering and maturity dates were significantly varied among the variety where the inbreed variety needed longest duration for flowering (102.38 days) and maturity (133.69 days) compared to hybrid variety (Appendix x and Figure 8). This might be due to the shortest life span of hybrid variety compared to that of inbreed variety

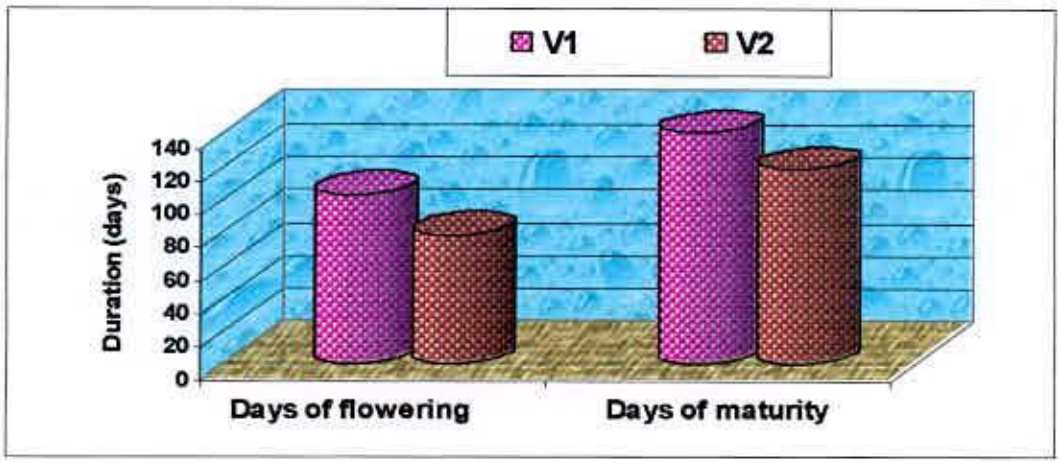


Figure 8. Effect of variety on days of flowering and maturity of rice

V_1= BR 11, V_2= Sonar Bangla -1

4.1.5.3 Effect of planting method

The flowering and maturity dates were significantly varied among the planting method (Appendix x and Table 23). Higher duration for flowering and maturity observed in line sowing method compared to broadcast or haphazard method.

Table 23. Effect of planting method on flowering and maturity date of aman rice

Treatment	*Days of flowering*	*Days of maturity*
T_1	88.63	123.38
T_2	91.50	125.00
LSD (0.05)	0.98	1.49
CV (%)	1.8	2.00

T_1=Broadcast and T_2=Line sowing

4.1.5.4 Interaction effect of planting material and variety

The flowering and maturity dates were significantly varied among the planting material and variety (Appendix x and Table 24). The highest duration (107.50 days) needed for flowering of nursery seedling with inbreed variety but lowest duration (75.50 days) in clonal tiller with hybrid variety that was statistically similar with the sprouted seeds of hybrid variety. In case of maturity the highest duration (141.25 days) needed for the nursery seedling of inbreed variety and the lowest duration (101.75 days) for the sprouted seeds of hybrid variety.

Table 24. Effect of planting material and variety on flowering and maturity date of aman rice

Treatment	*Days of flowering*	*Days of maturity*
M_1V_1	101.25	132.63
M_1V_2	76.00	101.75
M_2V_1	107.50	141.25
M_2V_2	81.75	122.13
M_3V_1	98.38	128.00
M_3V_2	75.50	119.38
LSD(0.05)	1.70	2.58
CV (%)	1.8	2.00

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11and V_2= Sonar Bangla -1

4.1.5.5 Interaction effect of planting material and planting method

The flowering and maturity dates were significantly varied among the planting material and planting method (Appendix x and Table 25). The highest duration (97.00 days) needed for flowering in nursery seedling with line sowing method and the lowest duration (86.13 days) for clonal tiller with broadcast method. That was statistically similar with the clonal tillers transplanted in line arrangement and sprouted seeds under haphazard method. In case of maturity the highest duration (131.75 days) needed for the nursery seedling with line sowing method and the lowest duration (116.25 days) for of sprouted seeds with haphazard method that was statistically similar with nursery seedling of sprouted seeds with line sowing method.

Table 25. Effect of planting material and planting method on days of flowering and maturity of aman rice

Treatment	*Days of flowering*	*Days of maturity*
M_1T_1	87.50	116.25
M_1T_2	89.75	118.13
M_2T_1	92.25	131.62
M_2T_2	97.00	131.75
M_3T_1	86.13	122.12
M_3T_2	87.75	125.25
LSD (0.05)	1.70	2.58
CV (%)	1.8	2.00

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.1.5.6 Interaction Effect of variety and planting method

The flowering and maturity dates were significantly varied among the treatment of variety and planting method (Appendix x and Table 26). The highest duration (103.75 days) needed for flowering in inbreed variety with line sowing method and the lowest duration (76.25 days) need for hybrid variety with broadcast method. In case of maturity the highest duration (134.67 days) needed for inbreed variety with line sowing method and the lowest duration (113.50 days) for hybrid variety with broadcast method that was statistically similar with the hybrid variety with line sowing method.

Table 26. Effect of variety and planting method on days of flowering and maturity date of aman rice

Treatment	*Days of flowering*	*Days of maturity*
V_1T_1	101.00	133.25
V_1T_2	103.75	134.67
V_2T_1	76.25	113.50
V_2T_2	79.25	115.33
LSD (0.05)	1.39	2.11
CV (%)	1.8	2.00

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.1.5.7 Interaction Effect of planting material, variety and planting method

The flowering and maturity dates were significantly varied among the planting material, variety and planting method (Appendix and Table 27). The highest duration (110.25 days) needed for flowering in nursery seedling of inbreed variety with line sowing method and the lowest duration (74.25 days) need for clonal tiller of hybrid variety with broadcast method. In case of maturity the highest duration (141.75 days)

need for the nursery seedling of inbreed variety with line sowing method that was statistically similar with nursery seedling of inbreed variety with broadcast method and the lowest duration (101.25 days) for sprouted seeds of hybrid variety with broadcast method.

Table 27. Effect of planting material, variety and planting method on days of flowering and maturity date of aman rice

Treatment	*Days of flowering*	*Days of maturity*
$M_1V_1T_1$	100.25	131.25
$M_1V_1T_2$	102.25	134.00
$M_1V_2T_1$	74.75	101.25
$M_1V_2T_2$	77.25	102.25
$M_2V_1T_1$	104.75	140.75
$M_2V_1T_2$	110.25	141.75
$M_2V_2T_1$	83.75	121.50
$M_2V_2T_2$	79.75	122.75
$M_3V_1T_1$	98.75	128.25
$M_3V_1T_2$	98.00	127.75
$M_3V_2T_1$	76.75	122.25
$M_3V_2T_2$	74.25	116.50
LSD (0.05)	2.40	3.65
CV (%)	1.8	2.00

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2 Yield contributing characters

4.2.1 Number of effective tiller hill^{-1}

There were no significant variation of effective tiller number hill^{-1} observed for individual effect of planting material, variety and planting method as well as their all interaction. (Appendix x and Table 28). Rahman (2001), Xiang *et al.* (1999), Yang *et*

al. (1998) and Ye and Ye (1997) found number of effective tiller hill^{-1}was high in sprouted seeds than nursery seedling. But Muhammad *et al.* (1997) and Dwivedi *et al.* (1996) disagree with this finding and they found more productive tiller in transplanting of seedling than sprouted seeded. Richharia and Patnaik (1963) stated that clonal tiller produce less tiller than sprouted seeds.Yoshida (1972) suggested that high yielding variety had more tillering capacity than modern variety. Rajkhowa and Gogoi (2004), Sorour *et al.* (1998) and Muhammad *et al.* (1997) also revealed same findings and found higher productive tiller in transplanting than haphazard planting.

4.2.2 Panicle length

4.2.2.1 Effect of planting material

Panicle length was significantly influenced by the planting material (Appendix ix and table 28). The highest panicle length (26.64 cm) was observed in the sprouted seeds material and nursery seedling and clonal tillers showed similar size. This result is agreement with Yang *et al.* (1998) found higher panicle length in sprouted seeds than transplanting. Rahman (2001) found highest panicle length in the intact crop than other seedling material, but Dwivedi *et al.* (1996) found higher panicle length in transplanting than sprouted seeds and Richharia *et al.* (1964) found higher panicle length in tiller than nursery seedling.

4.2.2.2 Effect of variety

Panicle length was not significantly influenced by the variety (Appendix ix and Table 26). The hybrid variety Sonar bangla-1 showed panicle length of 26.40 cm and the panicle length of inbreed variety BR 11 was 25.66 cm.

4.2.2.3 Effect of planting method

Panicle length was not significantly influenced by the planting method (Appendix ix and Table 26). The panicle length 26.05 cm was obtained from broadcast method and the panicle length of 26.01 cm was obtained from the line sowing method.

Table 28. Effect of planting material, variety and planting method on Number of effective tiller hill^{-1} and panicle length of aman rice

Treatment	*Number of effective tiller hill^{-1}*	*Panicle length(cm)*
Planting material		
M_1	8.50	26.64
M_2	8.81	25.69
M_3	8.50	25.76
LSD (0.05)	NS	0.72
CV (%)	21.7	3.7
Variety		
V_1	8.57	25.66
V_2	8.64	26.40
LSD (0.05)	NS	0.59
CV (%)	21.7	3.7
Planting method		
T_1	8.81	26.05
T_2	8.40	26.01
LSD (0.05)	NS	NS
CV (%)	21.7	3.7

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.2.4 Interaction effect of planting material and variety

Panicle length was significantly influenced by planting material and variety (Appendix ix and Figure 9). The highest panicle length (26.76 cm) was obtained from

the sprouted seeds of hybrid variety and the lowest panicle length (25.18 cm) was obtained from the nursery seedling of inbreed variety.

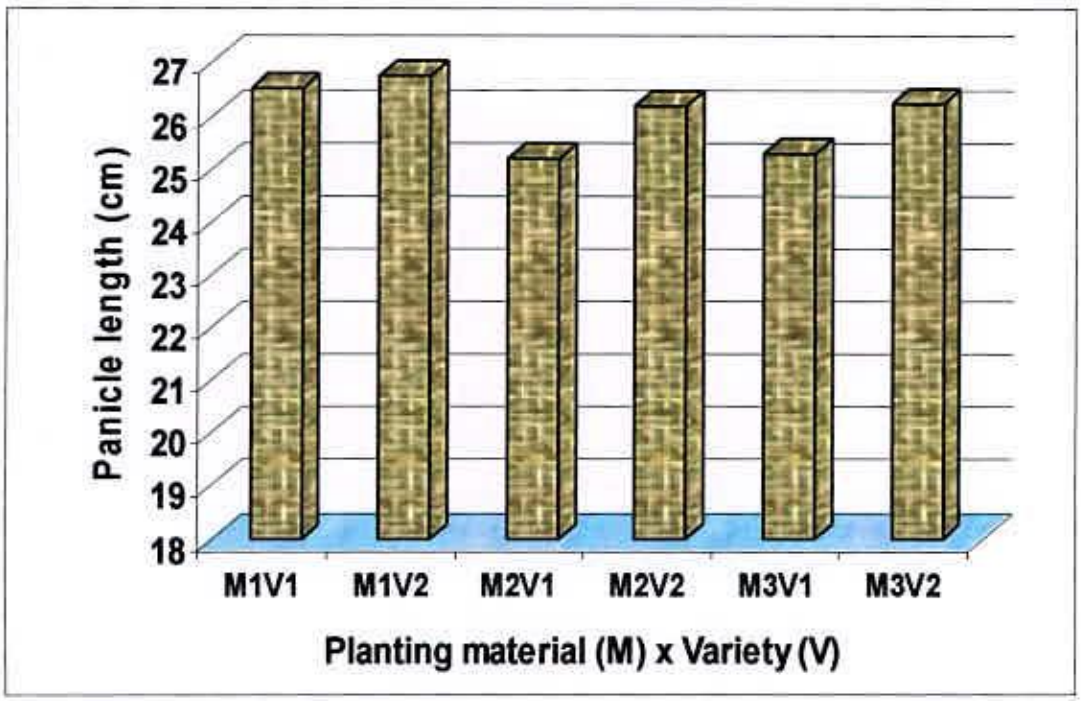


Figure 9. Influence of planting material and variety on panicle length of rice (LSD $_{0.05}$=1.02)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11and V_2= Sonar Bangla -1

4.2.2.5 Interaction effect of planting material and planting method

Panicle length was significantly influenced by planting material and planting method (Appendix ix and Figure 10). Highest panicle length (26.79 cm) was obtained from the sprouted seeds with the Broadcast method. The lowest panicle length (25.18 cm) was obtained from the Clonal tiller with sprouted seeds which was statistically similar with clonal tiller with line sowing method.

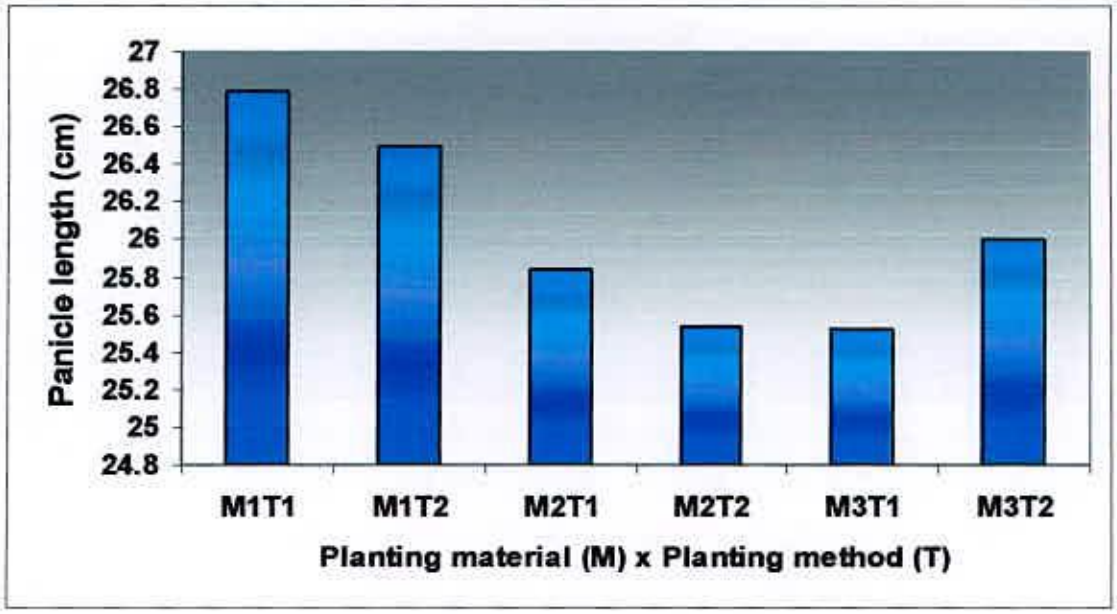


Figure 10. Influence of planting material and planting method on panicle length of rice ((LSD $_{0.05}$ =1.02)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.2.6 Interaction effect of variety and Planting method

Panicle length was not significantly influenced by the variety and Planting method (Appendix ix and Table 29). Highest panicle length (26.43 cm) was obtained from the hybrid variety and line sowing method. The lowest panicle length (25.60 cm) was obtained from the inbred variety and line sowing method

Table 29. Effect of variety and planting method on panicle length of aman rice

Treatment	*panicle length (cm)*
V_1T_1	25.73
V_1T_2	25.60
V_2T_1	26.38
V_2T_2	26.43
LSD (0.05)	NS
CV (%)	3.7

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.2.7 Interaction effect of planting material, variety and planting method

Panicle length was significantly influenced by planting material, variety and. Planting method (Appendix ix and Figure 11).Highest panicle length (27.05 cm) was obtained from the sprouted seeds of inbreed variety with Broadcast method. The lowest panicle length (25.20 cm) was obtained from the Clonal tiller of inbreed variety with Broadcast method.

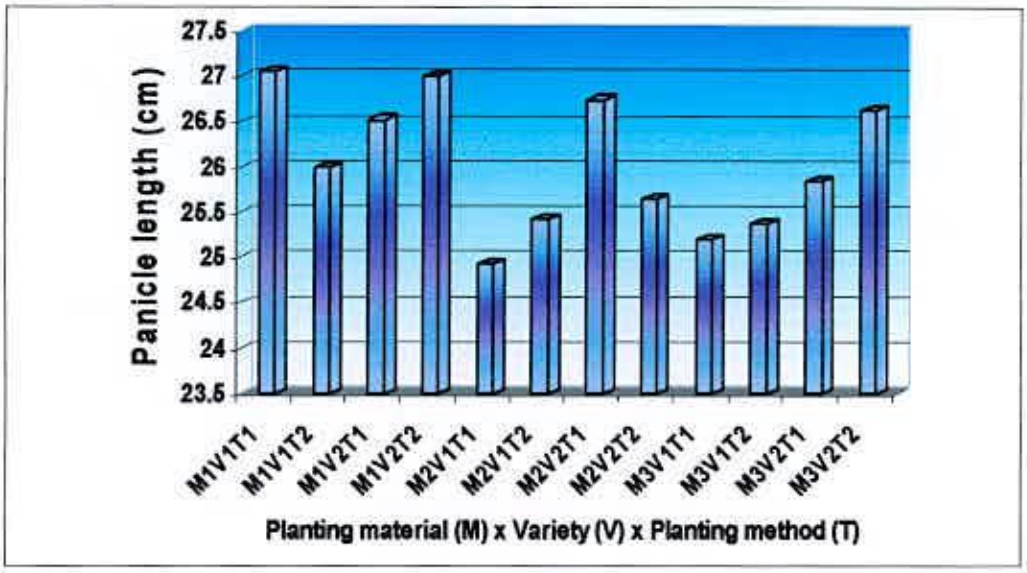


Figure 11. Influence of plating material, variety and planting method on Panicle length of rice (LSD $_{0.05}$=1.44)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.3 Total grains panicle^{-1}

4.2.3.1 Effect of planting material

Total grains panicle^{-1} was significantly influenced by the Planting material. (Appendix ix and Table 30). The highest number of total grains panicle^{-1} (202.72) was obtained from the clonal tillers followed by nursery seedling and lowest number of grain panicle^{-1} (168.09) was recorded from Clonal tiller. Biswas (2001) reported higher grain in clonl tiller than nursery seedling but Xiang *et al.* (1999), Yang *et al* (1998) reported the number of grain was high in sprouted seeds compare to that

transplanting seedling. Rahman (2001) found total grains panicle^{-1} was highest in intact crop than other seedling material and Dwivedi *et al.* (1996) found higher total grains panicle^{-1} in transplanting than sprouted seeds.

Table 30. Effect of planting material, variety and planting method on total grains panicle^{-1}, filled grains panicle^{-1} and wt. of 1000 grains of aman rice

Treatment	*Total grains panicle^{-1} (no)*	*Filled grains panicle^{-1} (no)*	*Wt. of 1000 grains (g)*
Planting material			
M_1	186.73	147.09	26.83
M_2	192.59	155.14	28.78
M_3	202.72	173.36	27.49
LSD (0.05)	13.13	12.81	1.30
CV (%)	9.1	10.9	6.3
Variety			
V_1	191.08	156.84	27.08
V_2	196.94	160.22	28.32
LSD (0.05)	NS	NS	1.06
CV (%)	9.1	10.9	6.3
Planting method			
T_1	193.21	157.41	27.29
T_2	194.81	159.65	28.11
LSD (0.05)	NS	NS	NS
CV (%)	9.1	10.9	6.3

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.3.2 Effect of variety

Total grains panicle^{-1} was not significantly influenced by the variety (Appendix and Table 30). The highest number of total grains panicle^{-1} (196.94) was obtained from the hybrid variety and the lowest (191.08) was obtained from the inbreed variety.

4.2.3.3 Effect of planting method

Total grains panicle^{-1} was not significantly influenced by the planting method (Appendix ix and Table 30). The maximum number of total grains panicle^{-1} (194.81)

was obtained from the line sowing method and the minimum number of total grains panicle^{-1}was obtained from the broadcast method.

4.2.3.4 Interaction effect of planting material and variety

Total grains panicle^{-1} was significantly influenced by the interaction effect between planting material and variety (Appendix ix and Figure 12). The highest number of total grains panicle-1 (217.39) was recorded in clonal tiller of variety and other planting material showed statistical similarity with irrespective of their variety.

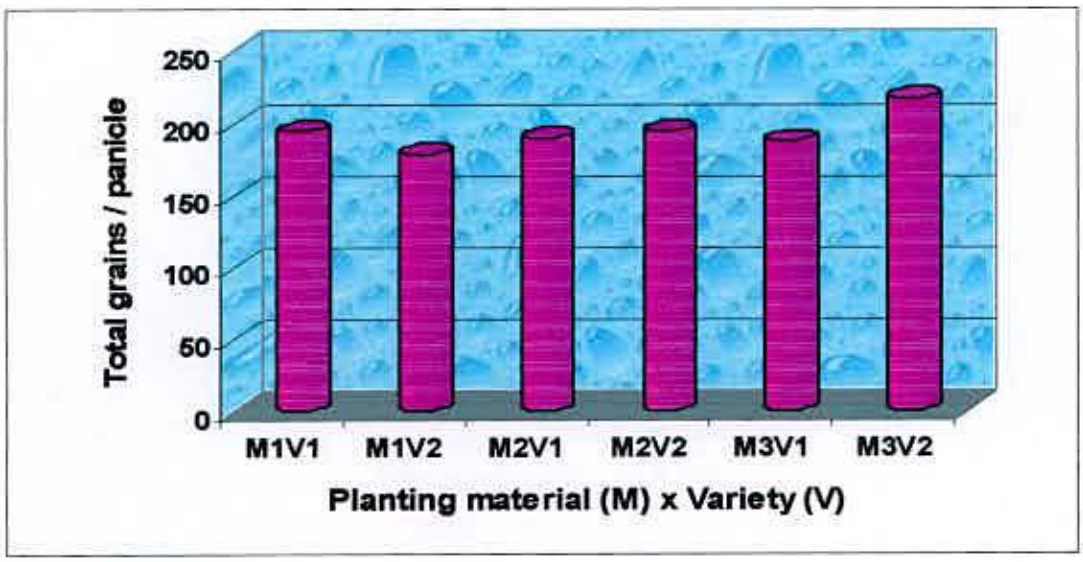


Figure 12. Influence of planting material and variety on total grains/ panicle of rice (LSD $_{0.05}$=24.51)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1,

4.2.3.5 Interaction effect of planting material and planting method

Total grains per panicle were significantly influenced by the interaction effect between planting material and planting method (Appendix ix and Figure 13). The highest number of total grains panicle^{-1} (208.21) was recorded in clonal tiller with line sowing method that was similar with nursery seedling with broadcast method. There was also found statistical similarity sprouted seeds with broadcast method and nursery seedling with line sowing method.

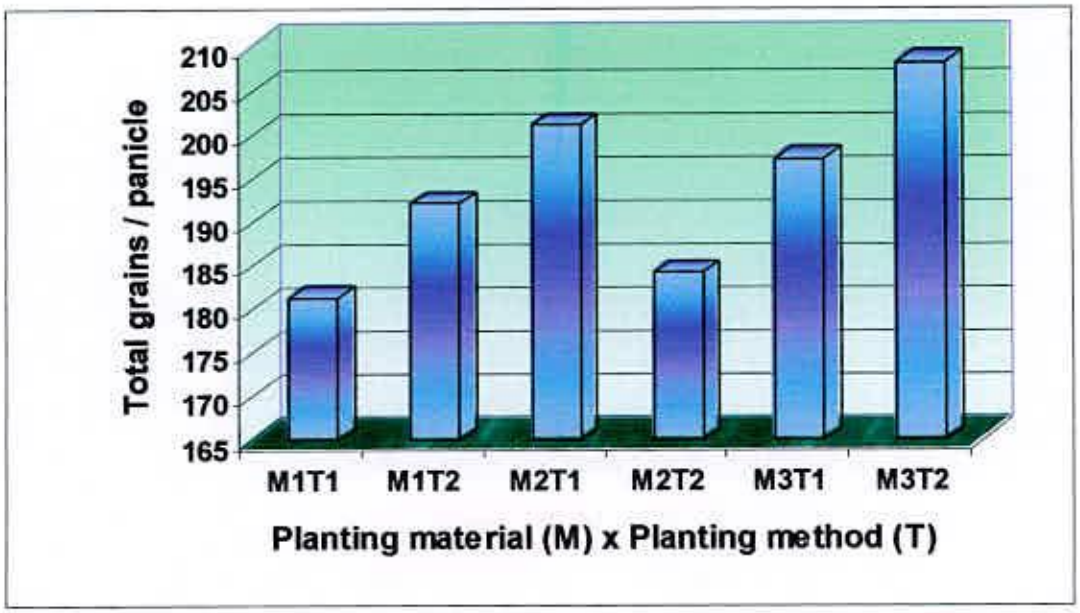


Figure 13. Influence of planting material and planting method on total grains / panicle of aman rice (LSD $_{0.05}$=24.51)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.2.3.6 Interaction effect of variety and planting method

A total grains per panicle was not significantly influenced by the interaction effect between variety and planting method. (Appendix ix and Table 31). The highest number of total grains panicle-1 (201.36) was recorded in hybrid variety with line sowing method method. The lowest grain number per panicle (188.28) was recorded in inbreed variety with line sowing method.

Table 31. Effect of variety and planting method on total grains per panicle of aman rice

Treatment	*Total grains panicle^{-1} (no.)*
V_1T_1	193.90
V_1T_2	188.28
V_2T_1	192.53
V_2T_2	201.36
LSD (0.05)	NS
CV (%)	9.1

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.3.7 Interaction effect of planting material, variety and planting method

Total number of grains per panicle was significantly influenced by the interaction effect between planting material, variety and planting method (Appendix ix and Figure 14). The highest number of total grains panicle^{-1} (229.63) was recorded in clonal tiller of hybrid variety with line sowing method followed by clonal tiller of hybrid variety with broadcast method. There was also found statistical similarity of nursery seedling of hybrid variety with irrespective of their planting method similarly found in clonal tiller of inbreed variety with irrespective of their planting method

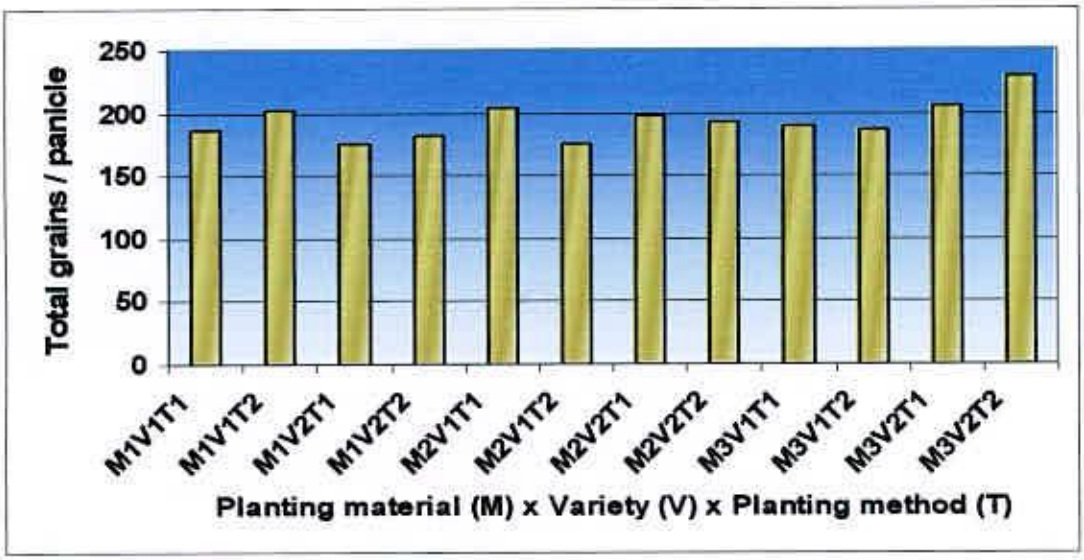


Figure 14. Influence of planting material, variety and planting method on total grain per panicle of aman rice (LSD $_{0.05}$=34.66)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Linc sowing

4.2.4 Filled grains panicle^{-1}

4.2.4.1 Effect of planting material

The filled grains panicle^{-1} differed significantly for variation of planting material (Appendix ix and Table 28). The maximum number of filled grains panicle^{-1} (173.76) was counted in contented in clonal tillers. The second highest grains panicle^{-1} (155.14) was counted in nursery seedling that was statistical similar with sprouted

seeds. Dwivedi et *al.* (1996) found higher filled grains panicle^{-1} in nursery seedling than sprouted seeds.

4.2.4.2 Effect of variety

The filled grains panicle^{-1}was not significantly differed between inbreed & hybrid Variety (Appendix ix and Table 28). The maximum number of filled grains panicle^{-1} (160.22) was counted in hybrid variety and the minimum number of filled grains panicle^{-1} (156.84) was counted in inbred variety.

4.2.4.3 Effect of planting method

The filled grains panicle^{-1} not significantly differed for planting method (Appendix ix and Table 28). The maximum number of filled grains panicle^{-1} (159.65) was counted in line sowing method and the minimum number of filled grains panicle^{-1} (157.41) was counted in broadcast method.

4.2.4.4 Interaction effect of planting material and variety

Interaction effect between planting material and variety was significant in respect of filled grains panicle^{-1} (Appendix ix and Figure 15). The highest number of filled grains panicle^{-1} (185.68) was obtained in clonal tiller of hybrid variety followed by clonal tillers of inbreed variety. There was found statistical similarity between sprouted seeds of inbreed variety and nursery seedling of their irrespective variety. The minimum number of filled grains panicle^{-1} (140.63) was obtained from the sprouted seeds of hybrid variety.

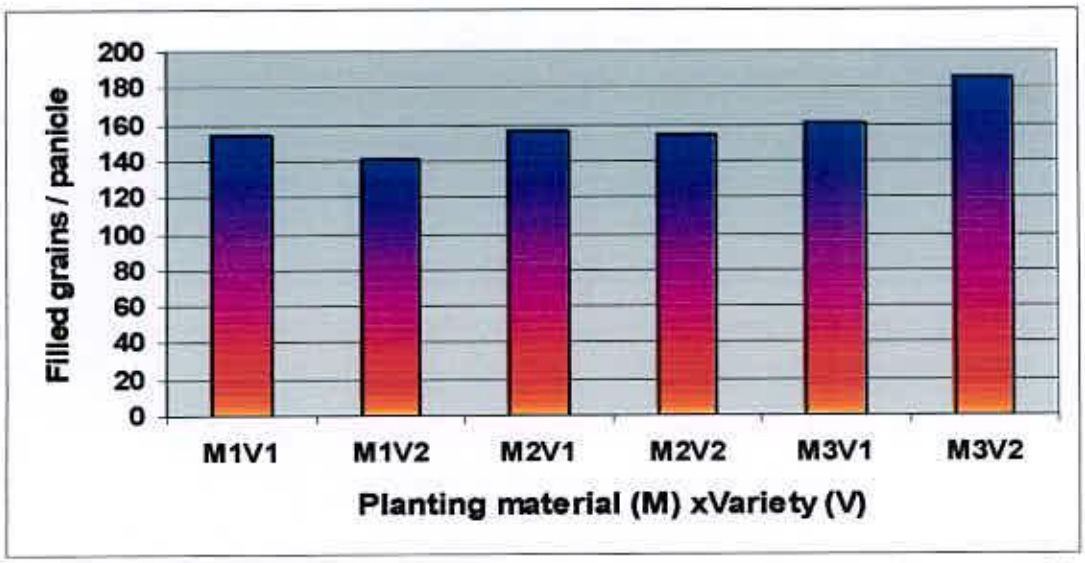


Figure 15. Influence of planting material and variety on filled grains per panicle on aman rice (LSD $_{0.05}$ =14.89)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1

4.2.4.5 Interaction effect of planting material and planting method

Interaction effect between planting material and planting method was significant in respect of filled grains panicle^{-1} (Appendix ix and Figure 16). The highest number of filled grains panicle^{-1} (178.59) was obtained in clonal tiller with line sowing method followed by clonal tillers with broadcast method.. The lowest filled grains panicle^{-1}(143.39) was found in clonal tiller with line sowing method.

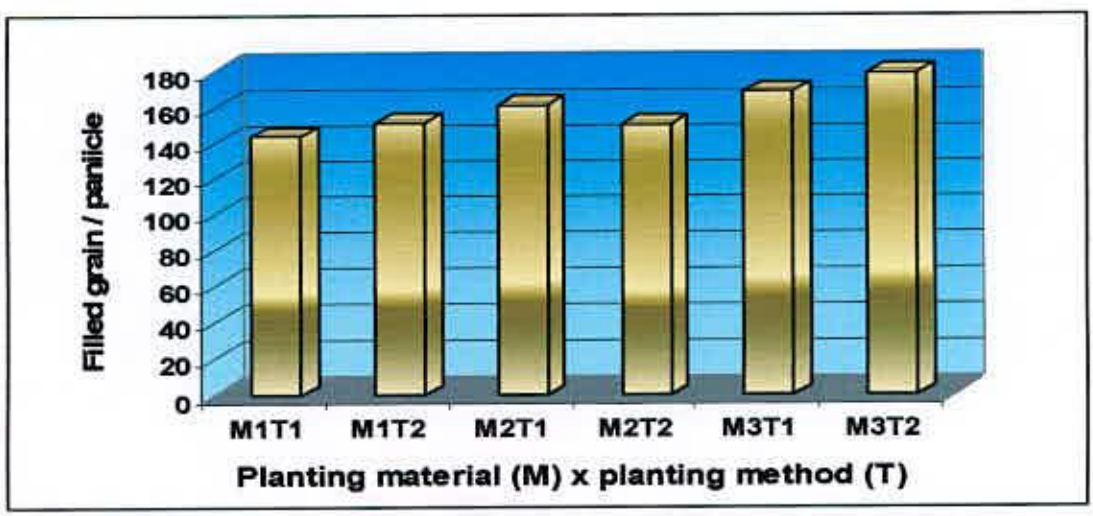


Figure 16. Influence of planting material and planting method on filled grains of aman rice (LSD $_{0.05}$ =21.35)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.2.4.6 Interaction effect of variety and planting method

Interaction effect between variety and planting method was not significant in respect of filled grains panicle^{-1} (Appendix ix and Table 32). The highest number of filled grains panicle-1 (172.54) was obtained in inbred variety with Broadcast method. Second highest filled grains panicle^{-1} was obtain from the inbreed variety with line sowing method. The lowest filled grains panicle^{-1} (135.29) was obtain in hybrid variety with line sowing method which was statistically similar with the nursery seedling with Broadcast method.

Table 32. Effect of variety and planting method on filled grains panicle^{-1} of rice

Treatment	*Filled grains panicle^{-1} (no.)*
V_1T_1	158.11
V_1T_2	155.58
V_2T_1	156.71
V_2T_2	163.73
LSD (0.05)	14.79
CV (%)	10.90

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.4.7 Interaction effect of planting material, variety and planting method

Interaction effect of planting material, variety and planting method was significant in respect of filled grains panicle^{-1} (Appendix ix and Figure 17). The highest number of filled grains panicle^{-1} (200.50) was obtained in clonal tiller of hybrid variety with line sowing method followed by clonal tiller of hybrid variety with broadcast method.

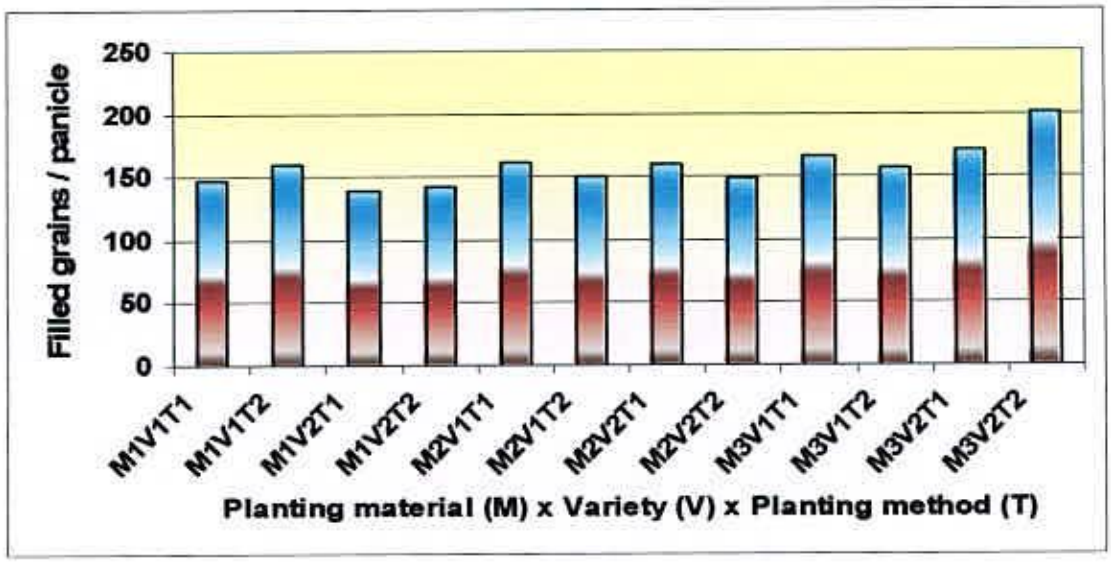


Figure 17. Influence of planting method, variety and planting material on filled grains per panicle of aman rice (LSD $_{0.05}$=30.19)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

There was statistical similarity in all nursery seedlings of the two varieties with irrespective of their planting method and also sprouted seeds of inbreed variety with irrespective of their planting method. The lowest filled grains panicle^{-1} (139.05) was obtained in sprouted seeds of hybrid variety with broadcast method.

4.2.5 Weight of 1000 grains

4.2.5.1 Effect of planting material

Weight of 1000 grains was significantly influenced by the planting material (Appendix ix and Table 28). The highest weight of 1000 grains (28.78g) was obtained from the nursery seedling followed by clonal tiller (27.43g) and the lowest weight (26.83g) was obtained from sprouted seeds. Dwivedi *et al.* (1996), found same result and the higher weight of 1000 grains in nursery seedling than sprouted seeds but Xiang *et al.* (1999) and Richharia *et al.* (1964) found higher 1000 grains weight in sprouted seeds than transplanting seedling and found weight of grain was high than nursery seedling

4.2.5.2 Effect of variety

Weight of 1000 grains was significantly influenced by the variety (Appendix ix and Table 28). The highest weight of 1000 grains (28.32g) was obtained from the hybrid variety and the lowest weight of 1000 grains (27.08g) was obtained from the inbreed variety.

4.2.5.3 Effect of planting method

Weight of 1000 grains was not significantly influenced by the planting method (Appendix ix and Table 28). Line transplanting method showed 1000 grain weight of 28.11g and it was 26.83g for broadcast sowing method.

4.2.5.4 Interaction effect of Planting material and variety

Interaction effect between planting material and variety was significant in respect of weight of 1000 grains (Appendix ix and Figure 18). The highest weight of 1000 grains (30.34 g) was obtained from the nursery seedling of hybrid variety and all other interactions showed similar grain weight.

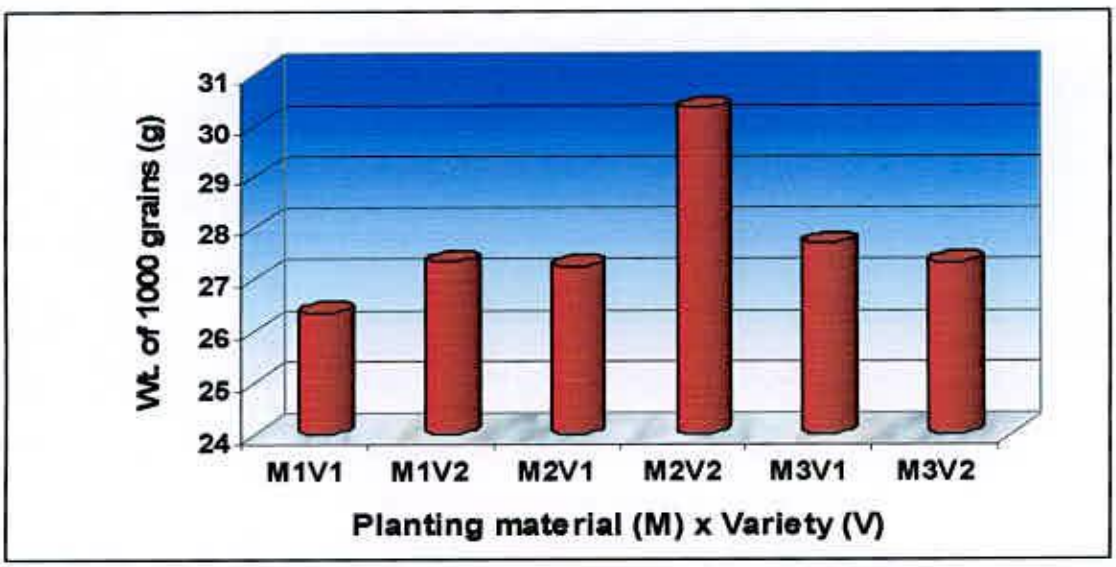


Figure 18. Influence of planting material and variety on wt. of 1000 grains (g) of aman rice ($LSD_{0.05}$ =1.84)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1

4.2.5.5 Interaction effect of planting material and planting method

Interaction effect between planting material and planting method was significant in respect of weight of 1000 grains (Appendix ix and Figure 19). The highest weight of 1000 grains (29.83 g) was obtained from the nursery seedlings with line sowing method but the other interaction effects was statistically similar.

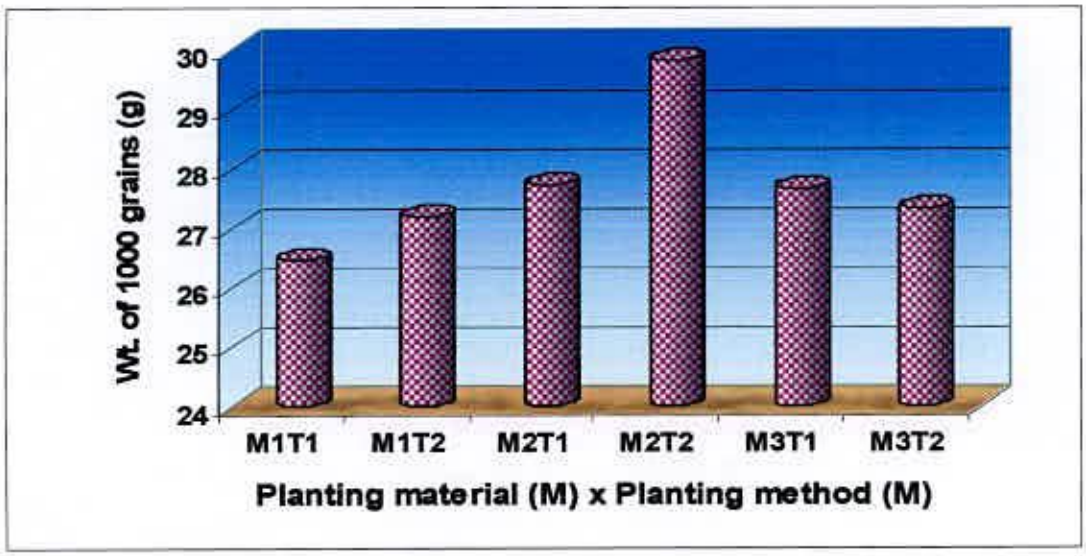


Figure 19. Influence of planting material and planting method on wt. of 1000 grains (g) of aman rice (LSD $_{0.05}$=1.84)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.2.5.6 Interaction effect of variety and planting method

Interaction effect between variety and planting method was significant in respect of weight of 1000 grains (Appendix ix and Figure 20). The highest weight of 1000 grains (28.38 g) was obtained from the hybrid variety with line sowing method and it was statistically similar with the other interaction except inbreed variety under broadcast method that showed the lowest weight of 1000 grains (26.32 g).

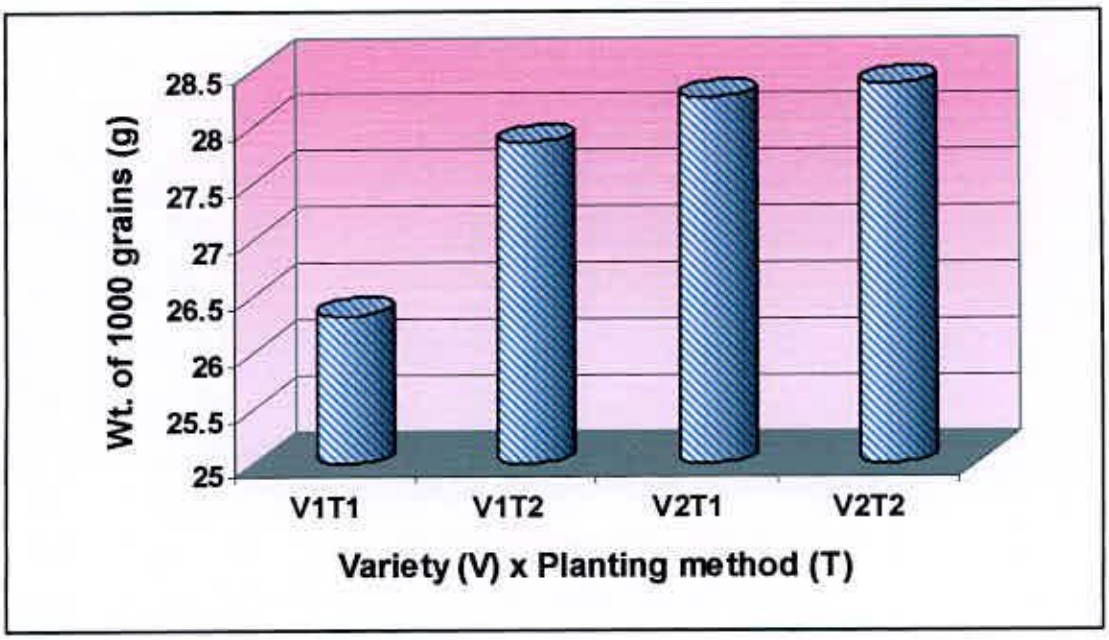


Figure 20. Influence of variety and planting method on wt. of 1000 grains (g) of aman rice (LSD $_{0.05}$ =1.50)

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.5.7 Interaction effect of planting material, variety and planting method

Interaction effect between planting material, variety and planting method was significant in respect of weight of 1000 grains (Appendix ix and Figure 21). The highest weight of 1000 grains (30.73 g) was obtain from the nursery seedling of hybrid variety with line sowing method and the similar weight of 1000 grains (29.95 g) was also obtained from the nursery seedling of hybrid variety with broadcast method and nursery seedlings of inbreed variety under transplanted condition. The lowest weight of 1000 grains (25.53 g) was obtained from the nursery seedling of inbreed variety with broadcast method.

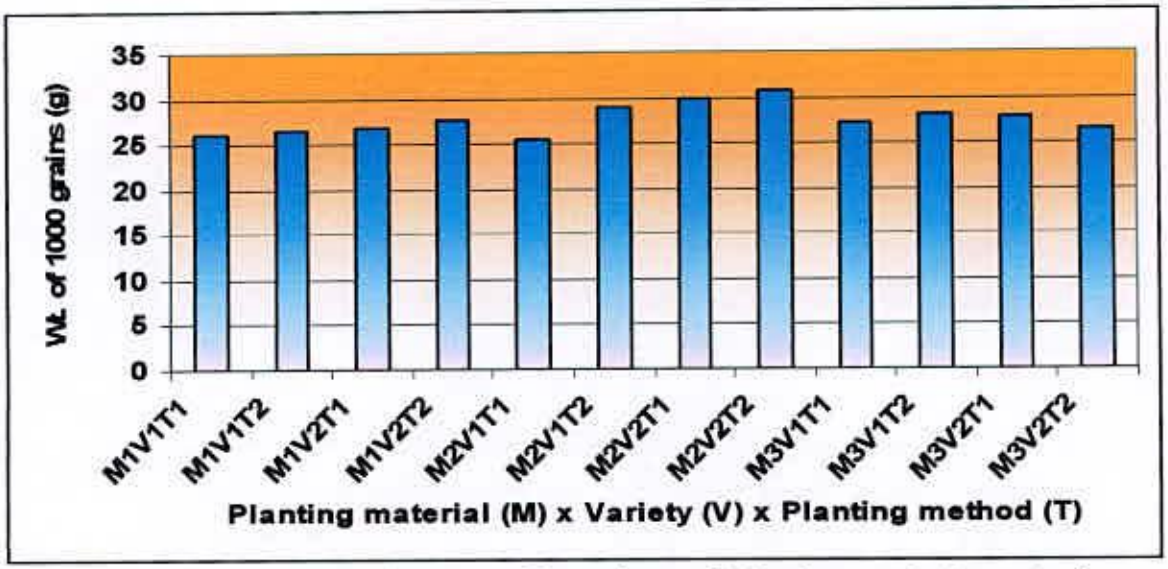


Figure 21. Influence of planting material, variety and planting method on wt. of 1000 grains (g) of aman rice (LSD $_{0.05}$ = 2.60)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.6 Grain yield

4.2.6.1 Effect of planting material

The grain yield of aman rice was significantly influenced by planting material. (Appendix x and Table 33). The highest grain yield (4.96 t ha^{-1}) was obtained with the planting material of clonal tiller. Second highest grain yield (4.50 t ha^{-1}) was obtained in nursery seedlings and the lowest grain yield (4.25 t ha^{-1}) was obtain with sprouted seeds., The vegetative tillers were healthier and vigorous than their nursery or sprouted seeds, low interplant competition for space and nutrients, clonal vigor etc. would have contributed to better growth of clonal tillers compared with rice crop growth with nursery seedling or sprouted seeds those experienced greater competition due to higher plant population. Biswas and Salokhe (2001), Sharma (1992), Sharma (1994), Reddy and Ghosh (1987), Sharma and Ghosh (1998) all were reported that the crop planted from clonal tiller produced a significantly higher grain yield than planted from nursery seedlings. Richharia and Rao (1961 and 1962) observed vegetatively

propagated crop produce 10-15% higher grain yield than normal seedling. Sharma and Ghosh (1998) and Roy *et al.* (1990) also reported that clonal tillers performed better than nursery seedling or sprouted seeds. Richharia and Patnaik (1963) stated that colnal tillers gave higher yield than sprouted seeds. Richharia *et al.* (1964) reported 10% yield increase of clonal tiller than normal seedling. Ding *et al.* (1982) found tiller transplanting gave 4-10% more yield than normal transplanted seedling. But Gogoi, (2004), BRRI (2003), Ogura (2002), BRRI (2002 a), BRRI (2002 b), Rajkhowa and Gogoi, Anbumani *et al.* (2000), Muhammad *et al.* (1997), Dwivedi *et al.* (1996), Ye and Ye (1997) found higher yield in transplanting than sprouted seeds but Sarkar *et al.* (2003) , Rahman (2001), Xiang *et al.* (1999) Varughese *et al.* (1993), Khan *et al.* (1992) Yang *et al.* (1998) observed that sprouted seeds gave higher yield than transplanting seedling. Johnkutty *et al.* (2002), Anbumani *et al.* (2000), Mannan and Shamsuddin (1997) and Bordoloi *et al.* (1996) disagree with this finding and observed vegetatively propagated crop did not produce more yield than other sexual propagation and there was no significant yield difference among the sprouted seeds or transplanting of seedling.

4.2.6.2 Effect of variety

Grain yield was significantly influenced by the variety (Appendix x and Table 33). Highest grain yield (4.70 t ha^{-1}) was obtained from the hybrid variety Sonar Bangla-1 than the yield (4.43 t ha^{-1}) of inbreed variety BR11 (Mukta). Richharia and Rao (1962) that both hybrid and inbreed variety produced higher yield but hybrid showed more vigority

Table 33. Effect of planting material, variety and planting method on grain yield, straw yield and harvest index of aman rice

Treatment	*Grain yield (t ha^{-1})*	*Straw yield (t ha^{-1})*	*Harvest index*
Planting material			
M_1	4.24	5.47	0.44
M_2	4.50	5.20	0.47
M_3	4.96	5.22	0.49
LSD (0.05)	0.15	NS	0.02
CV (%)	4.4	15.7	7.7
Variety			
V_1	4.43	5.19	0.46
V_2	4.70	5.40	0.47
LSD (0.05)	0.12	NS	NS
CV (%)	4.4	15.7	7.7
Planting method			
T_1	4.32	5.33	0.45
T_2	4.81	5.27	0.48
LSD (0.05)	0.12	NS	0.02
CV (%)	4.4	15.7	7.7

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.6.3 Effect of planting method

Grain yield was significantly influenced by the planting method (Appendix x and Table 33). In case of line sowing the grain yield was higher (4.81 t ha^{-1}) than broadcast method (4.32 t ha^{-1}). Rajkhowa and Gogoi (2004), Sorour *et al.* (1998), BRRI (1981) Rao *et al.* (1981), reported that row planting gave higher yield than haphazard transplanting. Venkatachalapathy and Veerabadran (2002) reported that row planting with drum seeder gave the higher yield but Rajkhowa. and Gogoi (2004), Anbumani *et al.* (2000) Roknuzzaman (1997), Ye and Ye (1997), Rajput and Yadav (1993), Varughese *et al.* (1993)) Auma and Gunasena (1972) found higher yield of rice haphazard or broadcast method . Bordoloi *et al.* (1996) Reddy *et al.*

(1987), Pedroso (1981) reported that there was no significant yield variation between the direct or line sowing method.

4.2.6.4 Interaction effect of planting material and variety

Grain yield was significantly affected by the interaction effect of the planting material and variety (Appendix x and Figure 22). Highest grain yield was observed in clonal tiller of hybrid variety (5.13 t ha^{-1}) followed by clonal tiller of inbreed variety and there was identical between nursery seedling with irrespective of their variety and sprouted seeds of hybrid variety. The lowest yield (4.04 t ha^{-1}) was observed in the nursery seedling of inbreed variety.

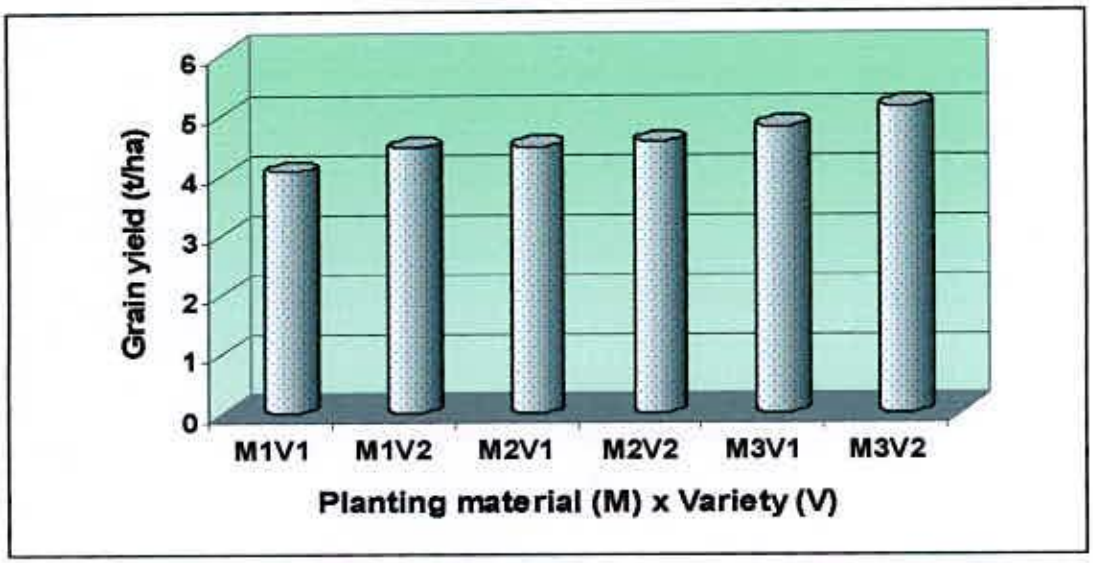


Figure 22. Influence of planting material and variety on grain yield of aman rice (LSD $_{0.05}$ =0.56)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1

4.2.6.5 Interaction effect of planting material and planting method

There was a significant effect of planting material and method of planting observed on grain yield (Appendix x and Figure 23). The highest grain yield (5.21 t ha^{-1}) was observed in clonal tiller with line sowing method followed by clonal tillers with broadcast method that was identical with nursery seedling with line sowing method. The lowest yield (3.96 t ha^{-1}) was found in nursery seedling with broadcast method

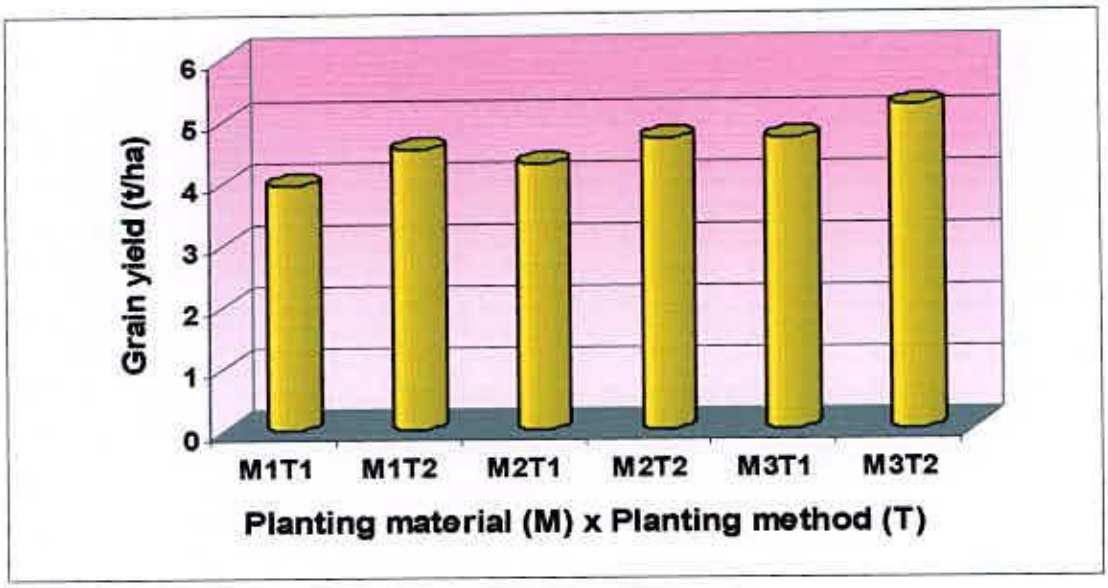


Figure 23. Influence of planting material and planting method on grain yield of aman rice (LSD $_{0.05}$=0. 56)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.2.6.6 Interaction effect of variety and planting method

Grain yield was influenced by the interaction effect of variety and planting method (Appendix x and Figure 24). The highest grain yield (5.03 t ha^{-1}) was observed in hybrid variety with line sowing method. The lowest grain yield (4.26 t ha^{-1}) was found in inbreed variety with broadcast method and which was identical with the hybrid variety with broadcast method.

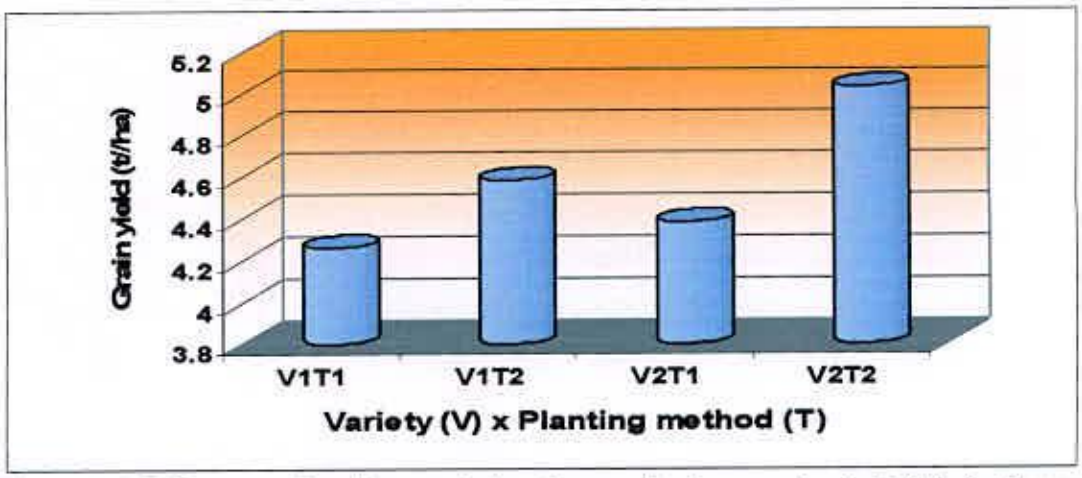


Figure 24. Influence of variety and planting method on grain yield (t/ha) of aman rice (LSD $_{0.05}$=0.45)

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.6.7 Interaction effect of planting material, variety and planting method

The grain yield of rice was significantly influenced by the planting material, variety and planting method (Appendix x and Figure 25). The clonal tiller of hybrid variety with line sowing method gave the highest grain yield of (5.42 t ha^{-1}) followed by clonal tiller of inbreed variety with line sowing method and it was statistically similar with sprouted seeds of hybrid variety with line sowing method. The lowest grain yield (4.13 t ha^{-1}) was observed in sprouted seeds of hybrid variety with broadcast method.

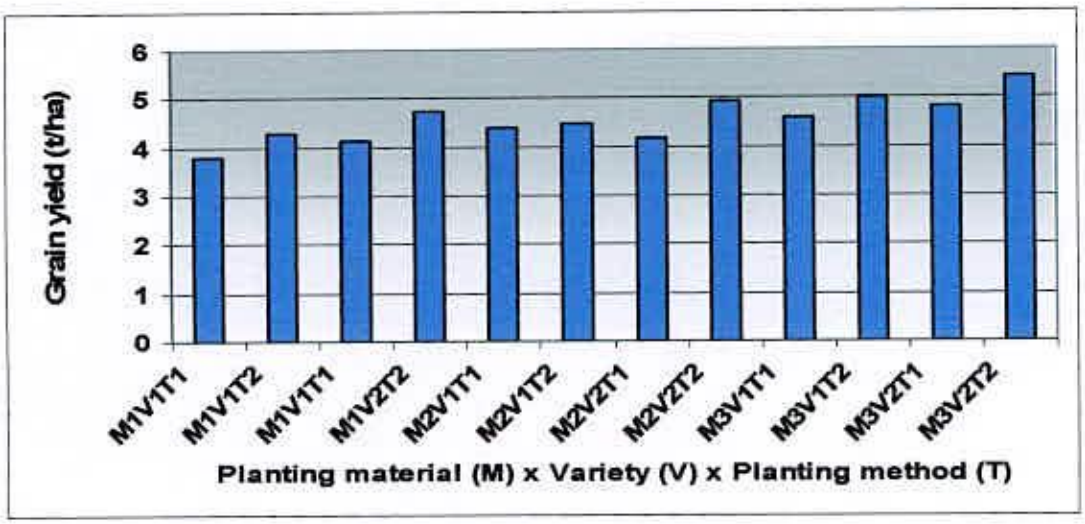


Figure 25. Influence of planting material, variety and planting method on grain yield of aman rice (LSD $_{0.05}$=0.79)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.7 Straw yield

4.2.7.1 Effect of planting material

Straw yield was not significantly affected by the planting material (Appendix x and Table 31). The highest straw yield (5.77 t ha^{-1}) was found from the sprouted seeds planting material followed by clonal tillers (5.22 t ha^{-1}). The lowest straw yield (5.20 t ha^{-1}) was found from the planting material of nursery seedling, which was statistically similar to the transplanted seedling material. Dwivedi *et al.* (1996) found higher straw yield in nursery seedling than sprouted seeds.

4.2.7.2 Effect of variety

Straw yield was not significantly affected by the variety (Appendix x and Table 31). The hybrid variety showed straw yield 5.4 t ha^{-1} and the inbreed variety resulted the straw yield 5.19 t ha^{-1}.

4.2.7.3 Effect of planting method

Straw yield was not significantly affected by the planting method (Appendix x and Table 31). The maximum straw yield (5.33 t ha^{-1}) was found from the broadcast method and the minimum straw yield (5.27 t ha^{-1}) was obtained from the line sowing method. Rao *et al.* (1981) and Roknuzzaman (1997) disagree with this findings and observed straw yield high in row transplanting.

4.2.7.4 Interaction effect of planting material and variety

It was found significant effect by the interaction between planting material and variety in respect of straw yield (Appendix x and Table 34). The highest straw yield (5.50 t ha^{-1}) was recorded in sprouted seeds of inbreed variety and the lowest (5.00 t ha^{-1}) in nursery seedling of inbreed variety.

Table 34. Effect of planting material and variety on straw yield (t ha^{-1}) of rice

Treatment	*Straw yield (t ha^{-1})*
M_1V_1	**5.50**
M_1V_2	**5.45**
M_2V_1	**5.00**
M_2V_2	**5.40**
M_3V_1	**5.08**
M_3V_2	**5.35**
LSD (0.05)	**NS**
CV (%)	**15.7**

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1

4.2.7.5 Interaction effect of planting material and planting method

The interaction effect between planting material and planting method significantly affect the straw yield (Appendix x and Figure 26). The highest straw yield was recorded in sprouted seeds with broadcast method (5.73 t ha^{-1}) and there was found statistical similarity with all other interaction except sprouted seed with line sowing method (4.21 t ha^{-1}).

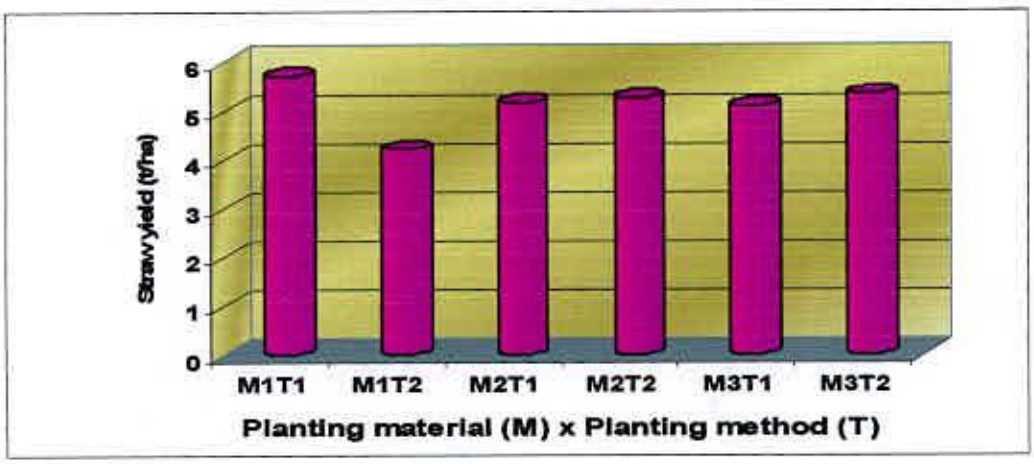


Figure 26. Influence of planting material and planting method on straw yield of aman rice (LSD $_{0.05}$=1. 30)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.2.7.6 Interaction effect of variety and planting method

There was no significant variation of straw yield for the interaction effect between the variety and planting method (Appendix x and Table 35). The maximum straw yield (5.52 t ha^{-1}) was recorded in hybrid variety with the line sowing method and the lowest (5.14 t ha^{-1}) in inbreed variety with broadcast method.

Table 35. Effect of variety and planting method on grain yield of aman rice

Treatment	*Straw yield (t ha^{-1})*
V_1T_1	5.14
V_1T_2	5.25
V_2T_1	5.52
V_2T_2	5.28
LSD (0.05)	NS
CV (%)	15.7

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.7.7 Interaction effect of planting material, variety and planting method

There was no significant variation of straw yield observed for interaction effect of planting material, variety and planting method in respect of straw yield (Appendix x and Table 36). The highest straw yield (5.84 t ha^{-1}) was recorded in sprouted seeds of hybrid variety with broadcast method and the lowest (4.66 t ha^{-1}) in nursery seedling of inbreed variety and broadcast method.

Table 36. Effect of planting material, variety and planting method on straw yield (t ha^{-1}) of aman rice

Treatment	*Straw yield (t ha^{-1})*
$M_1V_1T_1$	5.61
$M_1V_1T_2$	5.38
$M_1V_2T_1$	5.84
$M_1V_2T_2$	5.05
$M_2V_1T_1$	4.66
$M_2V_1T_2$	5.34
$M_2V_2T_1$	5.64
$M_2V_2T_2$	5.16
$M_3V_1T_1$	5.14
$M_3V_1T_2$	5.03
$M_3V_2T_1$	5.07
$M_3V_2T_2$	5.64
LSD (0.05)	NS
CV (%)	15.7

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.9 Harvest index (HI)

4.2.9.1 Effect of planting material

Harvest index was significantly influenced by the planting material (Appendix and Table 31). The maximum harvest index (0.49) was found from the clonal tillers that

was statistically similar with nursery seedling and the minimum harvest index (0.44) was at sprouted seeds. Such lower harvest index of nursery seedling and sprouted seeds compared to clonal tillers might be due to their lower grain yield. Biswas (2001) observed higher harvest index in clonal tiller than transplanted crop. Dwivedi *et al.* (1996) observed higher harvest index in transplanting than sprouted seeds crop but Sarkar *et al.* (2003) disagree with this finding and reported higher harvest index in sprouted than nursery seedling.

4.2.9.2 Effect of variety

Harvest index was not significantly influenced by the variety (Appendix x and Table 31). The highest harvest index (0.47) was found from the hybrid variety and the lowest harvest index (0.46) was at inbred variety.

4.2.9.3 Effect of planting method

Harvest index was significantly influenced by the planting method (Appendix x Table 31). The highest harvest index (0.48) was found from the line sowing and the lowest harvest index (0.45) was at broadcast method.

4.2.9.4 Interaction effect of Planting material and variety

Interaction effect of planting material and variety had significant effect of harvest index (Appendix x and Figure 27). Clonal tillers of their irrespective variety produced the highest harvest index (0.49) and that was statistically similar with nursery seedling of inbreed variety. Statistical similarity also observed in sprouted seeds of their irrespective of their variety. The lowest harvest index (0.46) was recorded in nursery seedling of hybrid variety.

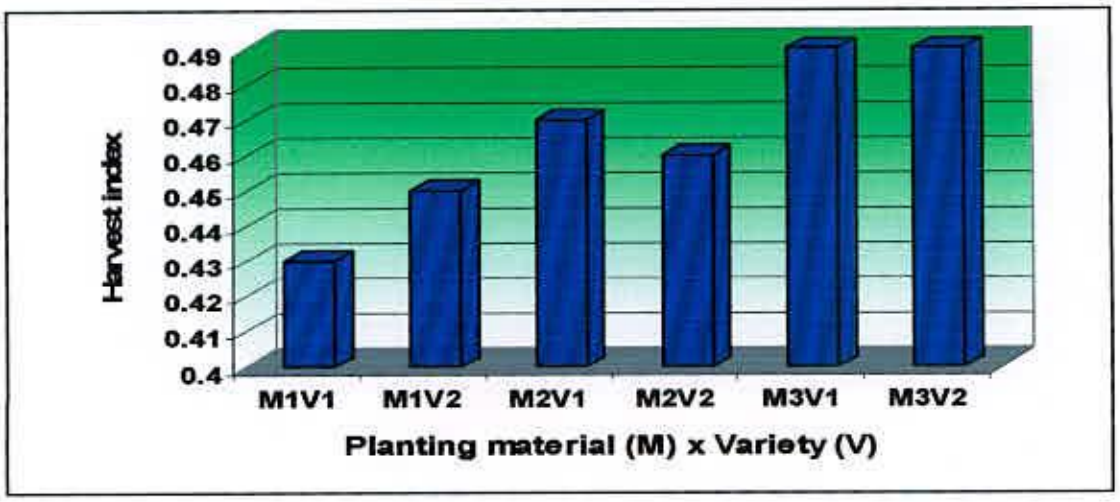


Figure 27. Interaction effect of planting material and variety on harvest index of aman rice (LSD $_{0.05}$=5.72)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1

4.2.9.5 Interaction effect planting material and planting method

Significant variation of harvest index was observed for interaction effect of planting material and planting method had effect on harvest index (Appendix and Figure 28). The highest harvest index (0.50) was observed in clonal tiller transplanted in line followed by clonal tiller transplanted in broadcast method that statistically similar with the nursery seedling and sprouted seeds transplanted in line. The lowest harvest index (0.41) from the sprouted seeds transplanted in broadcast method.

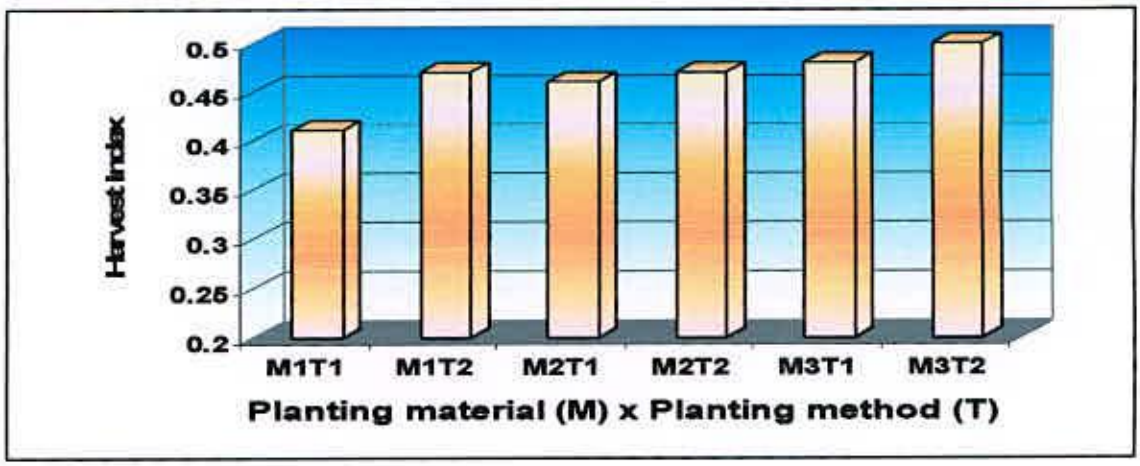


Figure 28. Interaction effect of planting material and planning method on harvest index of aman rice (LSD $_{0.05}$=5.71)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, T_1=Broadcast and T_2=Line sowing

4.2.9.6 Interaction effect of variety and Planting method

Interaction effect of variety and planting method had significant effect on harvest index (Appendix x and Figure 29). Hybrid variety with line sowing method produced the highest harvest index (0.49) followed by inbreed variety with line sowing method that was statistically similar with inbreed variety with broadcast method. The lowest harvest index (0.44) was observed in hybrid variety with broadcast method.

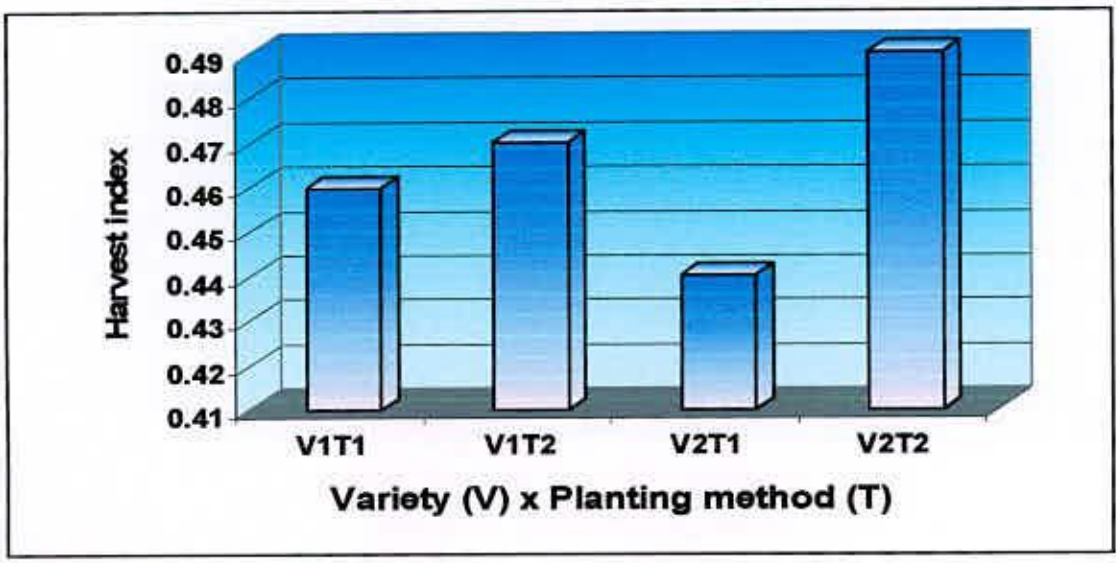


Figure 29. Interaction effect of variety and planting method on harvest index of aman rice (LSD $_{0.05}$=4.66)

V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing

4.2.9.7 Interaction effect of planting material, variety and planting method

Interaction effect of planting material, variety and planting method had significant effect on harvest index (Appendix x and Figure 30). Clonal tillers of inbreed variety with line sowing method produced the highest harvest index (50.00) that was statistically similar with clonal tiller of hybrid variety with irrespective of their planting method, nursery seedlings of hybrid variety with line sowing, nursery seedling of inbreed variety with their irrespective of planting method and also found

in sprouted seeds of hybrid variety with line sowing method. The lowest harvest index (0.41) was in sprouted seeds of their variety with broadcast method.

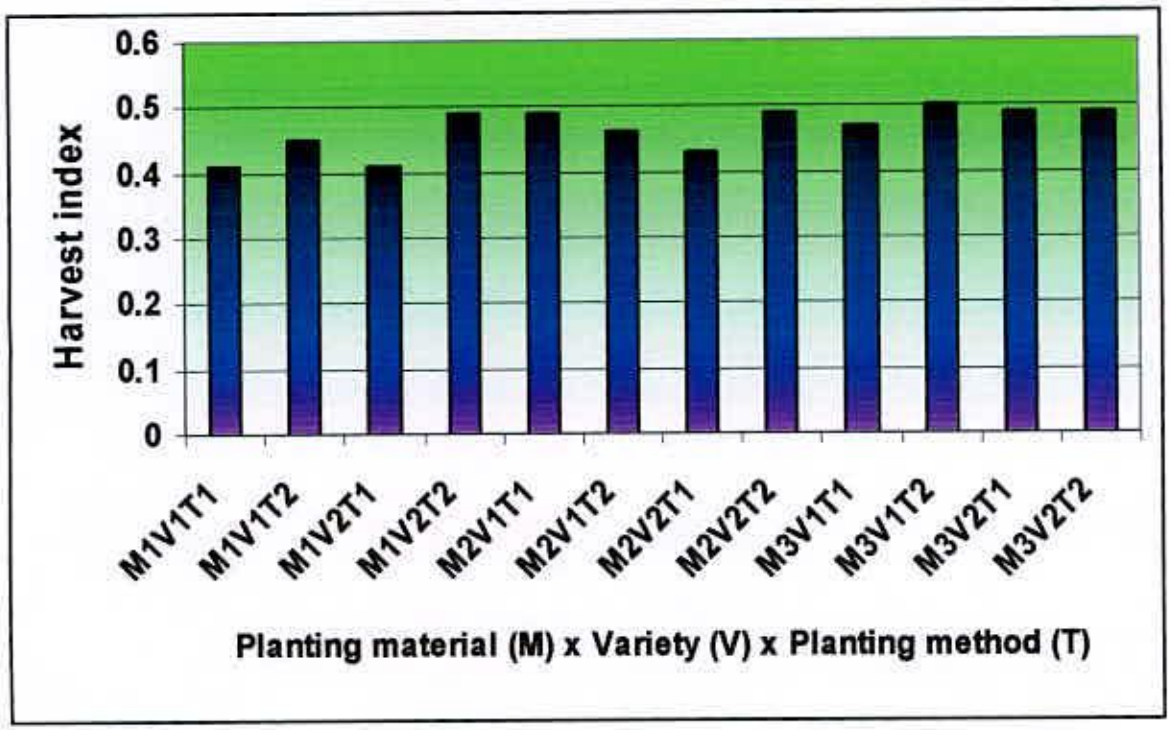
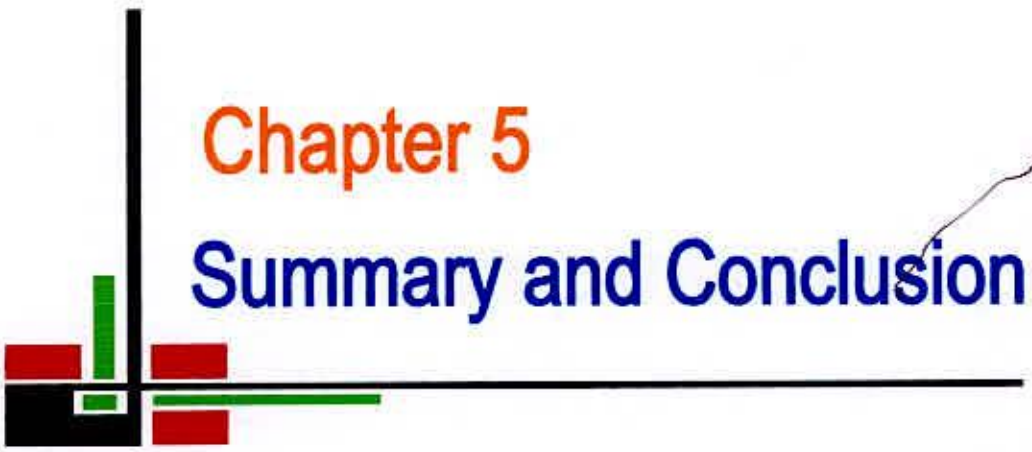


Figure 30. Interaction effect of planting material, variety and planting method on harvest index of aman rice (LSD $_{0.05}$=8.09)

M_1= Sprouted seed, M_2= Nursery seedlings, M_3= Clonal tiller, V_1= BR 11, V_2= Sonar Bangla -1, T_1=Broadcast and T_2=Line sowing



Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy Field Laboratory of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the aman season in 2005 to study the influence of planting technique on growth and yield of aman rice under Modhupur Tract (AEZ 28). The experiment consist three level of treatments viz A. planting material (3): Sprouted seed (M_1), Seedling (M_2) and Clonal tiller (M_3), B. Variety (2): Inbreed variety (BR11, Mukta)-V_1 and hybrid variety (Sonar bangla-1)-V_2. C. Planting method (2): Broadcast (T_1) and Line sowing (T_2). The experiment was laid out in split split-plot design with four replications of each treatment. The size of each plot was 4 m × 3 m. The distance between block to block and plot to plot was maintained 1 m. All the fertilizers except urea were applied fully during final land preparation; the urea was added in four equal splits. Twenty five days old seedlings were transplanted in the plots with row to row and plant to plant spacing of 25 cm × 15 cm. Intercultural operation viz. weeding, irrigation and insecticide application were done as and when required.

Five hills from each plot were randomly selected and tagged just after sowing or transplanting for recording data on growth parameters and yield and yield contributing characters. The data on crop growth characters like plant height, number of tillers hill^{-1}, leaf area index, dry mater and time of flowering and maturity were recorded at different stage after transplanting in the field and yield as well as yield contributing characters like number of effective tillers hill^{-1}, panicle length, number of grains panicle^{-1}, percent filled and unfilled grains, 1000-grain weight, grain and straw yield were recorded after harvest and analysis using the IRRISTAT (Version 4.0, IRRI, Philippines) computer package program developed by IRRI. The mean

differences among the treatments were compared by least significant difference (LSD) test at 5 % level of significance.

Results of the experiment showed that planting material had a significant influenced on growth characters, yield contributing characters and yield except effective tillers $hill^{-1}$. It reveals that clonal tiller gave the longest plant height at 45 days growth duration but thereafter sprouted seeds showed highest plant height. Planting material showed significant variation of tiller number at early stage but later there was no significant variation was observed. In case of LAI at 45 and 60 days maximum LAI found in sprouted seeds but later clonal tiller and nursery seedling showed highest performance in respect of dry matter production all time clonal tiller showed highest dry weight compare to nursery seedlings or sprouted seeds. Duration of flowering was earlier at clonal tiller compare to other material and duration of maturity was shortest at sprouted seed. Maximum grains $panicle^{-1}$ was found at clonal tiller (202.72) and minimum was at spouted seeds (186.73). Filled grains $panicle^{-1}$ was highest (173.36) at clonal tiller compare to other planting material. 1000 grains weight was maximum at nursery seedlings whereas other planting material showed minimum grain weight. Grain yield was highest in clonal tiller (4.96 t ha^{-1}) followed by nursery seedling and lowest yield (4.24 t ha^{-1}) was observed in sprouted seeds, but in case of straw yield no significant variation was found. Highest harvest index (0.49) was observed in clonal tillers that was statistically similar with nursery seedling and the lowest (0.44) in sprouted seeds.

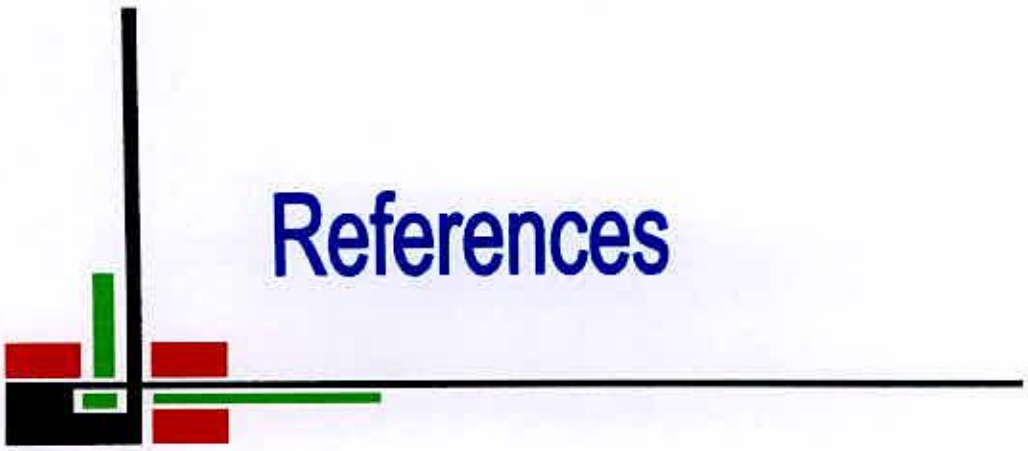
Interaction effect of planting material, variety and planting method on growth as well as yield and yield contributing characters. The tallest plant height initially found in clonal tiller of hybrid variety with line sowing but later tallest highest observed in

sprouted seeds of hybrid variety with broadcast method. Initially tiller number showed significant variation and higher tiller count in clonal tillers but finally there was no variation found. There was observed significant variation of LAI all over the life cycle and found highest LAI in clonal tillers of inbreed variety with broadcast method. Total dry weight significantly varied for planting material and always found highest dry weight in clonal tiller. At 45 days highest weight was count in inbreed variety transplanted in broadcast in 60 days highest weight observed in hybrid variety transplanted in line but at harvest sprouted seed with broadcast method gave highest dry weight. Duration of flowering varied significantly and the lowest days require for clonal tillers of hybrid variety with line sowing method but highest duration require for nursery seedling of hybrid variety with line sowing method. The maturity dates require for nursery seedling and for maturity minimum duration required in sprouted seeds of hybrid variety with line sowing method but maximum duration required for nursery seedlings of inbreed variety with broadcast method. Highest grain yield (5.42 t ha^{-1}) was observed in clonal tiller of hybrid variety with line sowing method, second highest yield was observed in clonal tiller of inbreed variety transplanted in line and the lowest yield (3.79 t ha^{-1}) was recorded in sprouted seeds of inbreed variety transplanted in haphazard. Straw yield was insignificant for the planting material, variety and planting method. Harvest index was highest (5.0) in clonal tillers of inbreed variety transplanted in line and the lowest harvest index (0.41) recorded in sprouted seeds of inbreed variety with broadcast method and similar harvest index was also observed in sprouted of hybrid variety sown in line.

Based on the result of the present study the conclusion may be drawn-

- Evaluation of clonal tillers as a proven technology to overcome the immediate damages of the rice fields due to natural hazard.
- Hybrid variety may be cultivate with this new technique to minimize the economic loss.

However, to reach a specific conclusion and recommendation, more research work on tiller separation or clonal tillers practice should be done over different Agro-ecological zones.



References

REFERENCES

Alauddin, M. H. (2004). Effect of methods of transplanting and seedlings per hill on the growth and yield of transplant aman rice cv. BRRI dhan 39. M. Sc. (Ag) Thisis. Dept. of Agronomy. BAU, Maymensingh.

Anbumani, S., Rajendran, K. and Kuppuswamy, G. (2000). Effect of planting methods and NPK levels on rice and rice fallow crops in single rice based cropping system. *J. Ecobiol.* **12**: 313-315

Anonymous. (1993) .*Rice Almanac*, 1993-1995. International Rice Research Institute, Los Banos, Laguna, Philippines.

Anonymous. (1997). *Rice Almanac* (Second Edition). International Rice Research Institute, Los Banos, Laguna, Philippines.

Anonymous. (1999). Feeding the world, Facts and Figures. http//www.riceweb.org.

Auma, E. O. and Gunasena, H. P. M. (1972). Effect of variety and method of stand establishment on the growth and yield of aman rice. *Tropi. Agriculturist*. **128** (3-4): 81-91.

BBS (Bangladesh Bureau of Statistics). (2004). Statistical Year Book of Bangladesh. Ministry of Planning, Govt. People's Repub. Bangladesh. pp.136-140.

Biswas, P. k. (2001). Tiller dynamics and yield of parent and clonal plant of transplanted rice cv.RD23 (photoperiod-insensitive) and KDML105 (photoperiod-sensitive). PhD Thesis. School of Environment, Resources and Development, AIT. Thailand. p.iv.

Biswas, P. K. and Salokhe, V. M. (2001). Effect of planting date, intensity of tiller separation and plant density on the yield of transplanted rice. *J. Agril. Sci.*,Cambridge, **137** (3): 279-287.

Bordoloi, S., Baroova, S. R. , Sharma. N., Choudhury, A. K. and Das, J. C. (1996). Effect of minimal irrigation and method of sowing on direct seeded sali rice. *J. Agric. Sci.*, Soc. North East India. **9** (1): 93-95.

BRRI (Bangladesh Rice Research Institute) . (2003). Effect of different crop stablishment methods on the performance of hybrid rice. Annual Internal review for 20001-2002.Crop Soil Water Management Program Agronomy Division, BRRI, Gazipur-1710. p. 5.

BRRI (Bangladesh Rice Research Institute). (2002 a). Effect of seedling throwing on the grain yield of wart land rice compared to other planting methods. Annual Internal review for 2000-2001. Crop Soil Water Management Program Agronomy Division, BRRI, Gazipur-1710. p. 2.

BRRI (Bangladesh Rice Research Institute). (2002 b). Effect of seedling throwing on the grain yield of wart land rice compared to other planting methods. Annual Internal review for 2000-2001.Crop Soil Water Management Program Agronomy Division, BRRI, Gazipur-1710. p. 2.

BRRI (Bangladesh Rice Research Institute). (1990). BRRI Annual Internal Review for 1989. Bangladesh Rice Res. Inst. Joydebpur, Gazipur. pp. 11-12.

BRRI (Bangladesh Rice Research Institute). (1989). Cultural practices. BRRI Annual Internal Review for 1988. Bangladesh Rice Res. Inst. Joydebpur, Gazipur. pp. 1-51.

BRRI (Bangladesh Rice Research Institute). (1981) Annual Report for 1978-79. BRRI Pub. No. 50. Joydebpur, Gazipur, Bangladesh. pp. 11-13.

BRRI (Bangladesh Rice Research Institute). (1974). BRRI Annual Internal Review for 1973. Bangladesh Rice Res. Inst. Joydebpur, Gazipur. pp. 10-11.

Chang, T. T. and Vergara, B. S. (1972). *Rice Breeding*, IRRI, Philippines: 727.

Devasundrarajah, N. (1971). Land preparation and water management requirement for broadcast seeded flooded rice. M. S. Thesis, Faculty of Graduate School of Cornell University, Ithaca, New York, pp. 26-40.

Digh, C. L., Liu, G. Y. and Pan, T. L. (1982). Study the separate tiller cultivation in hybrid rice. *Acta Agronomica Sinica*. **8** (1): 564.

Dwivedi, D. K., Ajay, Kumar., Singh, K. N. and Kumar, A. (1996). Efficacy of different rice planting methods under mid-upland ecosystem. *J. Appl. Biol*. **6** (1-2): 128-130.

Garrity, D. P., Oldeman, L. R. and Morris, R. A. (1986). Rainfed lowland rice ecosystems: characterization and distribution. In: Progress in rainfed lowland rice, 3-23. Los Banos, Laguna, Philippines: International Rice Research Institute.

Gomosta, A. R. and Haque, M. Z. (1979). Contribution of tillers produced at different weeks to panicle formation. *Int. Rice Res. Newsl.* **4** (4): 4.

Johnkutty, I., Mathew, G. and Mathew, J. (2002). Comparison between transplanting and direct seeding methods for crop establishment in rice. *J. Trop. Agric.* **40** (1/2): 65-66.

Khan, M. A. K., Bhuiyan,S. I. and Undan,R. C. (1992). Assessment of Direct-seeded rice in an irrigated system, in the Philippines. *Bangladesh Rice J.* **3** (1&2): 14-20.

Kundu, D. K. and Ladha, J. K. (1995). Enhancing soil nitrogen use and biological nitrogen fixation in wetland rice, *Exp. Agric*. **31**: 261-277.

Luh, B. S. (1980). Rice Production and Utilization. AVI Publishing Company, U. S. A.

Mahadevappa, M., Vishakanta, Sarma, D. P. K. and Gavindaraj, K.G. (1989). Stubble planting. Promising vegetative method of hybrid rice. *Intl. Rice. Res. Newsl.* **14** (4): 9-10.

Mallick, A. H. (1994). Tiller removal and double transplanting effects on yield and grain filling characteristics of aman rice. M. Sc. (Agronomy) Thesis. Department of Agronomy, The Institute of Postgraduate Studies in Agriculture, Salna, Gazipur.

Mannan, M. A. and Shamsuddin, A. M. (1997). Vegetative propagation versus seed production of transplant aman rice. *Bangladesh J. Agril. Sci.* **4** (1):59-64.

Matsuo, T. and Hoshikwa, K. (1993). Science of the rice plant. Vol.1 (morphology). Food and Agriculture policy Research Center, Tokyo, Japan: pp.686.

Mazaredo, A. M., Laureles, E. V. and Setter, T. L. (1996). Growth and Yield of modern deepwater rice: Comparisons with modern irrigated rice. *Field Crop Res.* **46**:105-116.

Mishra, S. B., Senadhira, D. and Manigbas, N. L. (1996). Genetics of submergence tolerance in rice (*Oryza sativa* L.) *Field Crop Res.* **46**:177-181.

Mollah, M. I. U., Hossain, S. M. A., Islam N. and Miah, M. N. I. (1992). Some aspect of tiller separation on transplant aman rice. *Bangladesh J. Agron.* **4** (1&2): 45-49

Maqsood, M., Hussain, A., Wajid, S. A. and Nadeem, A. (1997). Effect of planting methods and variable rates of nitrogen application on yield and components of yield of aman rice. *Pakistan J. Agric. Sci.* **34**(1-4): 89-93.

Murata, S and Matsushima, S. (1975). Rice In: Crop Physiology. Cambridge University Press, Cambridge (Ed L. T. Evan):73-99.

Murthy, P. S. S., Reddy, P. J. R., and Prasad, S. S. R. (1991). Effect of grain yield of shoot removal at different stage of aman rice crop growth. *Int. Rice Res. Newsl.* **16** (3): 10.

Nabheerong, N. (1993). Root growth and nutrient uptake of aman rice as affected by planting methods and green manures. *Kasetsart. J. (Nat. Sci.)* **27** (3), 358-368.

Ogura, A. (2002). A new farming system based on no-tillage direct sowing and transplanting technology using long mats of hydroponically grown rice seedlings. *J. Jpn. Soc. Agric. Mach.* **64**:4 (Special Edition), 14-16.

Pedroso, B. A. (1981). Sowing methods for irrigated rice (oryza sativa). In Aois, 11a reuniaoda culture do arroz irrigado pelotas, Brazil, UEAAE de pelotas, pp. 147-150. [Rice Abst. **6** (7): 170, 1988].

Rahman, M. S. (2001). Effect of tiller plantation on the performance of transplant aman rice. Thesis, Dept. Agron., Bangladesh Agril. Univ. Mymensingh. pp.60-65.

Rajkhowa, D. J., Gogoi, A. K. (2004). Effect of planting methods and weed management on transplanted summer rice. *Indian J. Weed Sci.* **36** (1/2): 119-121.

Rajput, R. L., Yadav, K. S. (1993). Effect of different planting methods on yield and yield attributes of aman rice in Chattisgarh Plains of Madhya Pradesh. Bhartiya Krishi Anusandhan Patrika. 8(1): 47-52.

Raju, A. and Varma, S. C. (1979). Tillering pattern of dwarf indica rice and its contribution to grain yield. *Int. Rice Res. Newsl.* 4(4): 4.

Ramaiah, N. V., Prasad, M., Reddy, T. M. M., Reddy, B. B. (1986). Effect of planting methods, nitrogen and phosphorus levels on accumulation of dry matter and uptake of N and P in 32541 rice culture. *PKV Res. J.* **10** (2): 154-156.

Rao, S. P. (1990). Influence of sequential planting of tillers on high density grain **in** rice. *Oryza.* **27** (3): 331-333.

Rao, Y. Y., Naidu, N. G., Reddy, M. G. and Mirza, W. A. (1981). Effect of different methods of planting on yield and yield components of aman rice. *Indian J. Agron.* **26** (2):142-146.

Reddy, M. D and Ghosh, B. C. (1986). Comparative efficiency of different planting methods in intermediate deepwater rice. *Int. Rice Res. Newsl.* **7** (1-4):1-2.

Reddy, M. D. and Ghosh, B. C. (1987). Comparative efficiency of different planting methods in intermediate deep water (15-20 cm) rice. *J. Agril. Sci.* Cambridge. **108**:573-577.

Reddy, T. M. M., Raghavolu, A. V., Ramaiah, N.V. and Reddy, G. V. (1987). Effect of methods of planting and nitrogen levels on growth, yield attributies and yield of aman rice under late conditions. *J. Res. APAU.* **15** (1):56-58

Richharia, R. H. and Rao, M. J. B. (1962). Vegetative propagation of aman rice and its potentiality. *Field Crop Abst.* **15** (4): 286.

Richharia, R. H. and Rao, M. J. B. (1962). Vegetaive propagation of aman rice and its potentiality-II. *Indian Agric.* **6**: 83-88.

Richharia, R. H. and Patnaik, S. (1963). Uptake of mineral nutrients by the vegetative propagated rice. *Indian J. PL. Physiol.* **6** (2):156-160.

Richharia, R. H., Mahapatra, I. C. and Manna, G. B. (1964). Vegetative propagation in rice and its potentiality-III. *Indian J. Agron.* **9** (3):164-174.

Roknuzzaman, M. (1997). Effect of row management and number of seedling per hill on the growth and yield of transplanted rice cv. BR 11. M. Sc. (Ag) Thesis. Dept. Agron., BAU. Mymensingh. p. 41.

Roy, B. C. and Satter, S. A. (1991). Tillering dynamics of transplanted rice as influenced seedling age. *Trop Agric.* (Trinidad). **69**: 351-356.

Roy, S. K., Biswas, P. K. and Quasem, A. 1990. Effect of tiller removal and replanted tillers on the yield of the main and the subsequent rice crops. *Bangladesh J. Agric.* **15** (1): 11-18.

Sarkar, R. K., Sanjukta, Das. and Das, S. (2003). Yield of rainfed lowland rice with medium water depth under anaerobic direct seeding and transplanting. *Trop. Sci.* **43** (4): 192-198.

Sharma, A. R. (1992). Effect of varying seed rates and transplanting clonal tillers on the performance of aman rice under intermediate deep water conditions. *J. Agric. Sci.* Cambridge. **119**: 171-177.

Sharma, A. R. (1994). Stand establishment practices affect performance of intermediate deepwater rice. *Int. Rice Res. Notes.* **19** (3): 26-27.

Sharma, A. R. (1995). Direct seedling and transplanting for rice transplanting for rice production under floodprone lowland conditions. *Field Crop Res.* **44**:129-137.

Sharma, A. R. and Ghosh, A. (1998). Performance of direct-sown and clonally-propagated transplanted rice (*Oryza sativa*) under conditions of intermediate deep-water and simulated flash flooding. *Indian J. Agric Sci.* **68** (7):347-351.

Sharma, H. L., Singh, H., Randhawa, H. S., Joshi, D. P., Gagneja, Sharma, A. R. and Ghosh, A. (1998). Performance of direct sown and clonally propagated transplant rice (*Oryza sativa*) under semi deep water condition. *Indian J. Agric . Sci.* **68** (8): 350-351.

Sharma, H. L., Singh, H., Randhawa H. S., Joshi, D. P. and Ganneja, M. R. (1987). Sequential tiller separation- a method for rapid rice seed multiplication. *Int. Rice Res. Newsl.* **12** (6): 9.

Shieh, Y. J. (1979). Comparative physiological studies on the growth of aman rice stand. In proceedings of the ROC- Japan symposium on Rice productivity. Institute of Botany, Academic Sinica, Taipei, Republic of China. Monograph Series No. **3**: 13.

Sorour, S. G. R., El, Keredy. M. S., Mosalem, M. E. and Hegazy, A. M. (1998). Evaluation of planting methods on two rice cultivars Proceedings, Seventh conference of agricultural development research, Cairo, Egypt, 15-17 December 1998. *Ann. Agric. Sci.* Special Issue. **3**: 645-661.

Subramanium, A. and Kolandaisamy, S. (1983). Studies on methods of planting under different levels of nitrogen and their influence on yield of IR8 rice. *Madas Agric.J.* **60** (8):741-745.

Swaminathan, M. S. (1989). In: Rice Farming Systems new Directions, IRRI, Philippines. No time of relax: 11-24.

Tsai, Y. Z. (1982). Studies on tiller bud formation and development of aman rice plants. *Mem. Coll. Agric.* **22** (1):119-123.

Tsukaguchi, T., Horie, T. and Ohnishi, M. (1994). Factors determining grain-filling rate in rice and their genetic variabilities. 1. Grain-filling rate of Nipponbare and Milyang 23 as influenced by availabilities of carbohydrates in initial grain-filling phase. *Jpn. J. Crop Sci.* **63** (1): 156-157.

Valarmathi, G. and Leenakumary, S. (1998). Performance analysis of high yielding rice varieties of Kerala under direct seeded and transplanted conditio *Crop. Res. Hisar.* **16** (2): 284-286.

Varughese, A., Nair, S. S. and Pillai, K. B. (1993). Transplanting rice by broadcasting seedlings. *Kerala J. Agri. Sci.* **31** (2):252-258.

Venkatachalapathy, V and Veerabadran, V. (2002). Technical package for lowland direct seeded rice. *J. Ecobiol.* **14** (1): 43-50.

Xiang, D.H., Ying, F. R., Fang, Li., Ding, X. H. , Fu, R. Y. and Fang, L. (1999). A study on tiller ear bearing of direct seeded rice for yield up to 8.25 t ha^{-1}. *China Rice*. No. **2**: 18-19.

Yang, S. U., Sang Y., Sung, T. P., Byong, T. C., Son, Y., Yeo, U. S., Park, S. T. and Chun, B. T. (1998). Physiological and yield responses of rice cultivars in direct seeded and transplanted rice cultivation. *RDA J. Crop Sci.* **40** (2): 109-111.

Ye, D. C. and Ye, D. C. (1997). Utilization of tillers in early hybrid rice with different planting methods. *China Rice*. No. 2, 13-15.

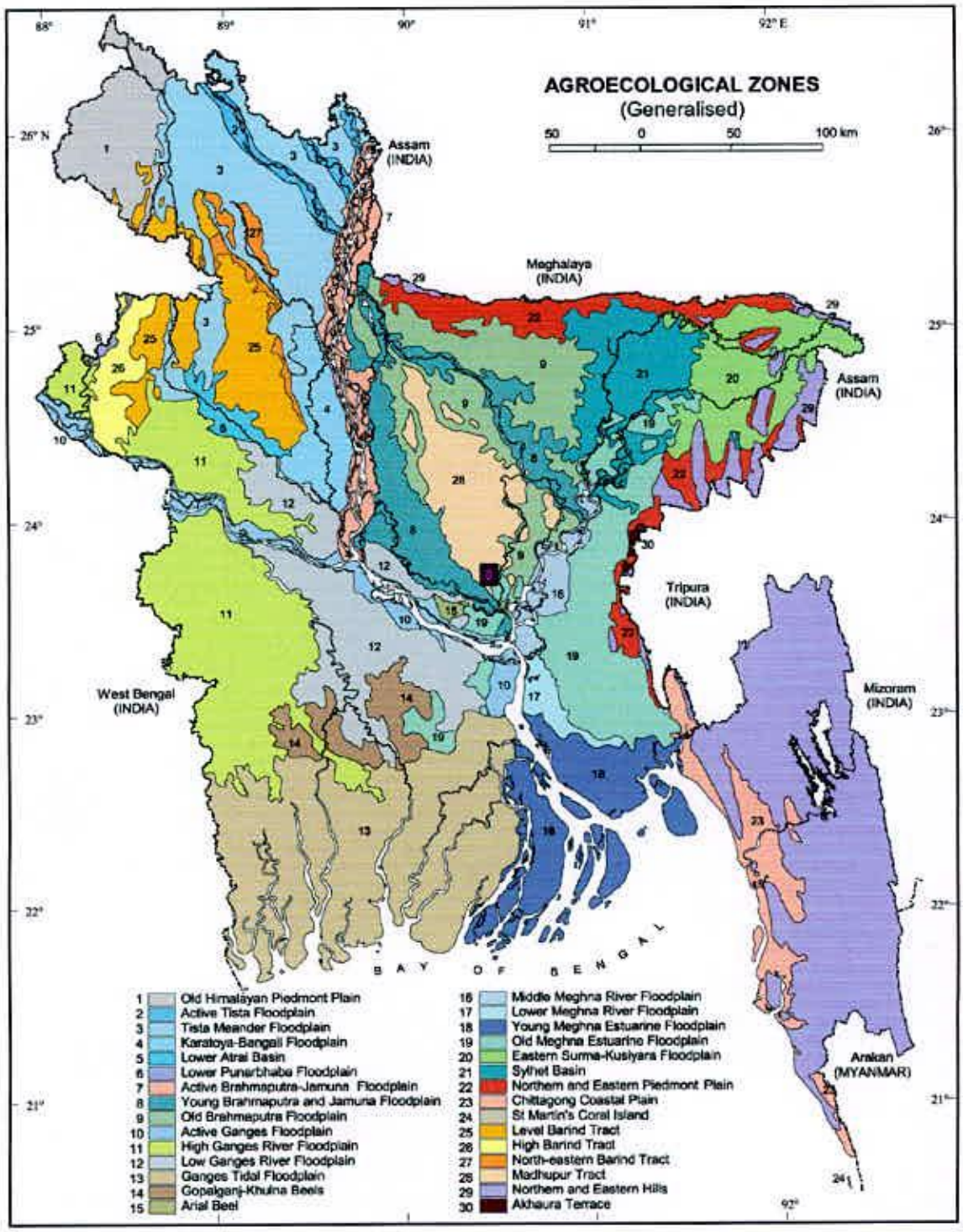
Yoshida, S. (1981). *Fundamentals of Rice Crop Sci.* IRRI, Philippines: 1-41.

Yoshida, S. (1972). Physiological aspects of grain yield. *Ann. Rev. Plant physiol.* **23**: 437-464.

Appendices

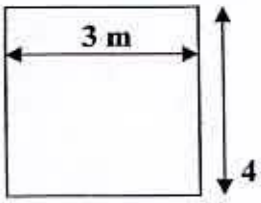
APPENDICES

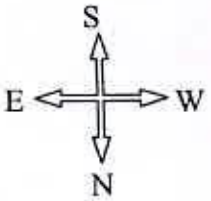
Appendix i. Map showing the experimental sites under study



■ **The experimental site under study**

Appendix ii. Layout of experimental field





R_4 $M_3V_2T_2$	R_4 $M_3V_2T_1$	R_4 $M_3V_1T_1$	R_4 $M_3V_1T_2$	R_3 $M_2V_1T_1$	R_3 $M_2V_1T_2$	R_3 $M_2V_2T_1$	R_3 $M_2V_2T_2$
R_4 $M_2V_2T_2$	R_4 $M_2V_2T_1$	R_4 $M_2V_1T_1$	R_4 $M_2V_1T_2$	R_3 $M_1V_1T_1$	R_3 $M_1V_1T_2$	R_3 $M_1V_2T_1$	R_3 $M_1V_2T_2$
R_4 $M_1V_2T_2$	R_4 $M_1V_2T_1$	R_4 $M_1V_1T_1$	R_4 $M_1V_1T_2$	R_3 $M_3V_1T_1$	R_3 $M_3V_1T_2$	R_3 $M_3V_2T_1$	R_3 $M_3V_2T_2$
R_1 $M_3V_1T_1$	R_1 $M_3V_1T_2$	R_1 $M_3V_2T_2$	R_1 $M_3V_2T_1$	R_2 $M_1V_2T_2$	R_2 $M_1V_2T_1$	R_2 $M_1V_1T_2$	R_2 $M_1V_1T_1$
R_1 $M_2V_1T_1$	R_1 $M_2V_1T_2$	R_1 $M_2V_2T_2$	R_1 $M_2V_2T_1$	R_2 $M_3V_2T_2$	R_2 $M_3V_2T_1$	R_2 $M_3V_1T_2$	R_2 $M_3V_1T_1$
R_1 $M_1V_1T_1$	R_1 $M_1V_1T_2$	R_1 $M_1V_2T_2$	R_1 $M_1V_2T_1$	R_2 $M_2V_2T_2$	R_2 $M_2V_2T_1$	R_2 $M_2V_1T_2$	R_2 $M_2V_1T_1$

Appendix iii. Physiochemical properties of the initial soil

Characteristics	*Value*
Partical size analysis.	
% Sand	26
% Silt	45
% Clay	29
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Dhaka-1207

Appendix iv. Weather data, 2005, Dhaka

Month	*RH (%)*	*Max. Temp. (°C)*	*Min. Temp. (°C)*	*Rain fall (mm)*
April	66.5	34.4	24.1	91
May	74.60	33.2	24.2	298
June	78.60	33.4	26.8	260
July	80.78	31.1	26.1	542
August	83.22	32.0	26.7	361
September	81.71	31.7	26.0	514
October	88.42	30.6	23.3	413
November	73.90	29.0	19.8	03
December	62.79	27.0	15.7	00

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix v. Means square values for plant height of aman rice at different growth duration of aman rice

Sources of variation	*Degrees of freedom*	*Means square*			
		45 days	*60 days*	*75 days*	*At harvest*
Replication	3	109.61	137.52	127.48	76.12
Planting material (M)	2	2038.41**	800.24**	399.79**	628.54**
Error (a)	6	27.98	66.41	47.96	23.42
Variety (v)	1	2513.87**	5472.01**	3551.80**	2376.42**
M x V	2	29.10*	15.67*	567.24**	315.24**
Error (b)	9	25.13	20.99	31.03	78.70
Planting method (T)	1	1.02*	40.52*	1.30*	9.52*
M x T	2	31.18*	55.47*	33.61*	32.03*
V x T	1	50.45*	8.76*	5.27*	76.56*
M x V x T	2	3.69*	76.86*	24.36*	130.13*
Error (c)	18	15.29	13.82	17.39	30.34
CV (%)		8.00	4.5	4.4	5.6

* Significant at 5% level
** Significant at 1% level

Appendix vi. Means square values for tiller number of aman rice at different growth duration of aman rice

Sources of variation	*Degrees of freedom*	*Means square*			
		45 days	*60* days	*75* days	*At harvest*
Replication	3	9.75	1.34	6.08	21.28
Planting material (M)	2	25.64**	10.20*	7.79	1.67*
Error (a)	6	3.81	1.65	2.38	6.29
Variety (v)	1	26.11**	36.40**	32.67*	0.003
M x V	2	3.04*	8.45*	10.14*	6.46
Error (b)	9	1.17	4.93	3.37	6.26
Planting method (T)	1	2.90	17.52*	7.05	0.12
M x T	2	1.46*	10.10*	5.93*	1.89
V x T	1	7.20*	4.20*	0.007*	2.25
M x V x T	2	2.68*	4.04*	2.02*	0.29
Error (c)	18	1.11	2.53	3.25	5.49
CV (%)		15.8	14.8	19.1	26.4

*Significant at 5% level
** Significant at 1% level

Appendix vi. Means square values for LAI of aman rice at different growth duration of aman rice

Sources of variation	*Degree of freedom*	*Means square*		
		45 days	*60 days*	*75 days*
Replication	3	0.06	0.06	0.44
Planting material (M)	2	0.96**	1.08*	1.02*
Error (a)	6	0.07	0.31	0.64
Variety (v)	1	0.03	0.69	5.89*
M x V	2	0.01*	1.08*	2.03*
Error (b)	9	0.03	0.36	1.29
Planting method (T)	1	0.01*	0.27*	0.24*
M x T	2	0.05*	0.30*	0.42*
V x T	1	0.31*	0.81	0.35*
M x V x T	2	0.02*	0.52*	0.11*
Error (c)	18	0.02	0.36	0.24
CV (%)		10.6	13.8	15.7

* Significant at 5% level
** Significant at 1% level

Appendix viii. Means square values for dry matter of aman rice at different growth duration of aman rice

Sources of variation	*Degree of freedom*	*Means square*		
		30 Days	*60 Days*	*At harvest*
Replication	3	1.34	13.08	11.85
Planting material (M)	2	887.22*	5267.56*	466.59*
Error (a)	6	3.74	12.74**	29.43
Variety (v)	1	1.77*	32.93	5.62
M x V	2	0.89*	21.44	6.86
Error (b)	9	2.27	5.80	12.12
Planting method (T)	1	0.36	0.86	52.46
M x T	2	0.17*	0.79*	4.29*
V x T	1	0.68*	2.66	11.29
M x V x T	2	0.79	1.90	2.67
Error (c)	18	1.01*	4.38*	5.55*
CV (%)		12.9	9.00	4.9

* Significant at 5% level
** Significant at 1% level

Appendix ix. Means Square values for effective tiller no / hill, panicle length (cm), total grains/ panicle, filled grains/ panicle and 1000 grain wt. (gm) of aman rice

Sources of variation	*Degrees of freedom*	*Means square*				
		Effective tiller no/ hill	*Panicle length (cm)*	*Total grains/ panicle*	*Filled grains/ panicle*	*1000 grain wt.(gm)*
Replication	3	20.13	1.50	254.31	100.31	2.40
Planting material (M)	2	0.52	4.52*	1046.63*	2896.58**	15.75*
Error (a)	6	5.67	1.34	121.38	52.95	2.16
Variety (v)	1	0.06	6.53	411.26	137.03	18.35
M x V	2	1.17	0.76*	2076.70*	1485.14*	12.34*
Error (b)	9	2.35	2.65	434.74	88.06	2.11
Planting method (T)	1	2.00	0.01	30.88	60.53	8.13
M x T	2	7.47	0.78*	1031.43*	546.64*	5.95*
V x T	1	0.007	0.09	627.13	274.09	6.06*
M x V x T	2	2.06	2.58*	371.11*	636.31*	2.69*
Error (c)	18	3.47	0.94	312.55	297.50	3.08
CV (%)		21.7	3.7	9.1	10.9	6.3

* Significant at 5% level
** Significant at 1% leve

Appendix x. Means square values for days of flowering, days of maturity, grain yield (t ha^{-1}) Straw yield (t ha^{-1}) harvest index of aman rice

Sources of variation	*Degrees of freedom*	*Means square*				
		Days of flowering	*Days of maturity*	*Grain yield (t ha^{-1})*	*Straw yield (t ha^{-1})*	*Harvest Index*
Replication	3	2.97	65.19	0.04	0.55	0.002
Planting material (M)	2	261.19**	844.00**	2.12**	0.36	0.01*
Error (a)	6	8.13	31.83	0.02	0.94	0.002
Variety (v)	1	72.76**	4582.52**	0.88**	0.51	0.00
M x V	2	9.44*	495.58*	0.12*	0.21	0.001*
Error (b)	9	29.97	34.84	0.01	0.13	0.00
Planting method (T)	1	99.19**	31.69*	2.92**	0.04	0.01*
M x T	2	10.94*	10.75*	0.02*	0.63*	0.002*
V x T	1	0.19*	0.52*	0.31*	0.37	0.003*
M x V x T	2	2.69*	17.58*	0.09*	0.88	0.003*
Error (c)	18	2.60	6.03	0.04	0.69	0.001
CV (%)		1.8	2.0	15.7	7.7	7.7

* Significant at 5% level
** Significant at 1% level

LIST OF PICTURE

Picture I. Field view of the experimental plots at a glance

Picture II. Field view of the experimental plots where showed plant height varied among the plnating material

Picture III. Separation / Spliting of tillers from stock plants

BR 11 (Mukta)

Sonar bangla-1

Picture IV. Showing the difference of nursery seedling and clonal tiller of inbreed variety BR 11(Mukta) and the hybrid variety Sonar bangle-1

Picture V. Showing the visual difference of transplanted clonal tillers and nursery seedling