EFFECT OF SEEDLING AGE ON YIELD AND SEED QUALITY OF T. AMAN RICE VARIETIES

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*This is to certify that thesis entitled "**EFFECT OF SEEDLING AGE ON YIELD AND SEED QUALITY OF T. AMAN RICE VARIETIES** " submitted to the **INSTITUTE OF SEED TECHNOLOGY,** Sher-e- Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN SEED TECHNOLOGY,** embodies the result of a piece of bona fide research work carried out by MD. SHARIEUTULLAH, Registration no. 14-06085 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2021
Place: Dhaka, Bangladesh

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DEDICATED
TO
MY BELOVED
PARENTS

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ABSTRACT

A field experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University to find out the effect of different age of seedling on the yield and seed quality of T. aman rice, cultivated during the Aman season (July 2019 to December 2019). The experiment comprised two factors viz, factor A: Variety – 3, i) V_1= BRRI dhan32, ii) V_2 = BRRI dhan62 and iii) V_3 = BRRI dhan80; factor B: Age of seedling – A_1= 20 days, A_2= 25 days, A_3= 30 days and A_4= 35 days. The experiment was laid out in two factors RCBD with three replications. Data were collected on different aspects of growth, yield attributes, yield and seed quality of T. aman rice. Result revealed that BRRI dhan32 gave the highest seed yield (4.68 t ha^{-1}) and maximum seed germination percentage (88.33%). This may be attributed to maximum number of effective tillers $hill^{-1}$ (17.30), longest panicle (28.53 cm), highest number of filled seeds $panicle^{-1}$ (117.1), highest 1000-seed weight (26.36 g) and highest vigor index (1991.72) in this variety. Out of 4 different age of seedlings treatment A_3 (30 days old seedling) produced the highest seed yield (4.83 t ha^{-1}) and maximum seed germination percentage (92.01%). This treatment also showed maximum number of effective tillers $hill^{-1}$ (16.69), longest panicle (28.15 cm), maximum number of filled seeds $plant^{-1}$ (124.9), highest weight of 1000 seed (27.69 g) and highest vigor index (2001.54). Regarding the interaction of variety and different age of seedling, the interaction of V_1A_3 (BRRI dhan32 with 30 days old seedling) was highest yielder (5.12 t ha^{-1}) among the other interactions which was attributed to higher 1000 seed weight. Besides, these interaction V_1A_3 also gave maximum seed germination percentage (92.86%) and highest vigor index (2152.49). Considering the above result, it may be concluded that variety BRRI dhan32 (V_1) and 30 days old seedling (A_3) and their interaction V_1A_3 was found superior in producing highest yield of best quality seed.

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Abbreviation	Full meaning
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BINA	Bangladesh Institute of Nuclear Agriculture
BBS	Bangladesh Bureau of Statistics
BCPC	British Crop Production Council
cm	Centi-meter
CV	Coefficient of variation
°C	Degree Celsius
d.f.	Degrees of freedom
DAT	Days After Transplanting
et al.	And others
FAO	Food and Agriculture Organization
G	Gram
ha	Hectare
CRSP	Collaborative Research Support Program
J.	Journal
Kg	Kilogram
LSD	Least Significant Difference
mg	Milligram
m^2	Meter Squares
MoP	Muriate of Potash
%	Per cent
SPD	Split Plot Design
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of Bangladesh. Almost all the people depend on rice and has tremendous influence on agrarian economy of Bangladesh. In Bangladesh, rice covers an area of 28.21 thousand acres with a production of 36.60 million metric tons while the average yield of rice is around 1.3 thousand tons per acres whereas the transplant aman rice covers the largest area of 13165 acres with a production of 13940 thousand M. ton rice seed during 2019-20 (BBS, 2019). BRRI has developed 106 rice varieties among which 46 is of aman varieties (BRRI, 2021). Unfortunately, the national average rice yield in Bangladesh (4.2 t ha^{-1}) is very low considering the other rice growing countries like South Korea and Japan where the average yield is 7.50 and 6.22 t ha^{-1}, respectively (FAO. 2013). On the other hand, Bangladesh lacks arable land to extend rice production. Besides, rice production is decreasing day by day due to high population pressure, continuing drought and flood in farming areas, and conversion of farmlands to grow cash crops instead of rice. Therefore, it is an urgent need of the time to increase rice yield in Bangladesh. The reasons for low yield of rice are manifold; some are varietals, others are technological and rests are climatic. Undoubtedly, with the introduction of high yielding varieties the yield of rice has been increased, but the trend of increase is not linear. The yield can be increased by using improved cultural practices like use of quality seed, high yielding varieties, adopting plant protection measures, optimum seedling age, using optimum number of seedling $hill^{-1}$, seedling raising technique, judicious application of fertilizers, etc. Among the improved cultural practices, seedling age can play an important role in boosting yield of rice. Age of seedling is an important factor as it has a tremendous influence on the tiller production, seed formation and other yield contributing characteristics (Faruk *et al.,* 2009). Generally, farmers of Bangladesh do not give due attention to the age of seedlings at transplanting and use aged seedling. The use of over-aged seedling retards the general performance of crop and the yield of the crop reduces drastically (Shrestha *et al.,* 2019), as the farmers are not aware of this factor for rice production. For optimum yield, age of seedlings at transplanting of a particular variety at a particular season may not be suitable for other varieties at another season. So, it is very important to find out the optimum age of seedling of a particular variety for a particular season.

Seedling age is an important factor because it has tremendous influence on the plant height, tiller production, panicle length, seed formation, seeds panicle^{-1} and other yield contributing characters. For optimum yield, age of seedlings at transplanting of a particular variety in particular season may not be suitable for other varieties in other seasons. So, it is very important to find out the optimum age of seedling of a particular variety for particular season (Sasaki, 2004 & Aslam *et al.,* 2015). Tillers are side shoot rose from the base of plant and play major role in the yield of a crop. Productive tillers are most important factor which determines the yield of crop, significant effect of seedling age and nitrogen levels on productive tillers was observed by many researchers. Dynamics of tillering greatly depends on the age of seedlings at transplanting and this is proved by the findings of many researchers (Ali *et al.,* 2013). The age of rice seedling plays a vital role in the growth and development of rice and as well as the production of seed. Rice seedlings lose much of their growth potential if they are transplanted more than 15 days after they emerge in their nursery. Early aged seedlings utilize maximum time for vegetative growth, whereas older seedling recover slowly particularly when injured during up rooting and produce fewer tillers, delay maturity and may reduce yield (Chakrabortty, 2013).

Younger the seedling means less transplanting shock which helps to rejuvenate quickly. In addition, early transplanting date gives plant longer time to uptake nutrients like nitrogen, phosphorus and potash (Kumar, 2001 and Islam *et al.,* 2021) for better growth and development. It means better root growth, better establishment, more stem elongation, more leaves and more tillers compared to late transplanting. Liu *et al.* (2017) explained dry matter stored in vegetative organs before their heading stage are the source of carbohydrate for seed filling stage. Therefore, longer vegetative growth period means more carbohydrate in storage. All these effects lead to higher seed yield when early age seedling transplanted (Naresh, 2012). Moreover, early transplanting has shown to increase irrigation water productivity as well (Brar *et al.,* 2012). Whereas, late transplanting causes more non-effective tillers and higher straw yield (Sarker *et al.,* 2011). Late transplanting also resulted into higher pest infestation causing seed yield loss (Shrestha *et al.,* 2019).

Due to intensive cropping systems, the farmers of Bangladesh cannot transplant T. aman rice with proper ages seedlings because of late harvest of *aus* rice, over flooding condition of cultivable land and lack of proper knowledge regarding the effect of seedling age. Therefore, there is a vast scope to conduct research activities to evaluate

the performance of different aman rice varieties to prescribe the suitable variety/varieties and optimum seedling age for cultivation. Keeping all the points in mind mentioned above, the present piece of research work was under taken with the following objectives:

- To find out the varietal effect on yield and quality of T. aman rice seed,
- To select appropriate seedling age for higher yield and quality of T. aman, rice seed and
- To find out the interaction effect of variety and seedling age on seed yield and seed quality of T. aman rice.

CHAPTER II

REVIEW OF LITERATURE

Agronomic management is unavoidably necessary for crop production. Among the management practices, the use of good varieties and proper age of seedlings have considerable role on the growth and yield of rice. A number of experiments have been conducted in Bangladesh and also elsewhere in the world with these aspects to evaluate the performance of transplant aman rice. In this chapter, an attempt has been made to review some of the remarkable findings of various researches at home and abroad related to the variety and age of seedlings on the performance of some transplant aman rice varieties.

2.1 Effect of varieties on the growth, yield and seed quality of rice

Sharma *et al.* (2017) showed in a study in India that, rice variety 'Pusa Basmati 1' showed higher panicle length, filled seeds/panicle, spikelet fertility, seed yield, seed yield, harvest indices and germination percentage as compared to 'Pusa Basmati 1121'. However, 'Pusa Basmati 1121' gave higher effective tillers, 1000 seed weight, straw yield, shoot length, root length, seedling dry weight and vigour index than 'Pusa Basmati 1'**.**

Hossain (2014) reported that in case of seed germination, local and modern aromatic rice varieties respond differently. Local small aromatic rice cv. Badshabhog showed higher germination percentage (85.00%) that was statistically similar to Kataribhog. Lowest germination percentage (75.27%) was observed in modern aromatic rice variety BRRI dhan37. The varietal differences in germination of the seeds also reported by Sa *et al.* (1988). The germination rate of small seed was the highest among other seed sizes. Large seed needs more water than small seed and resulted in decrement of germination rate (Sadeghi *et al.*, 2011).

Koirala *et al.* (2010) reported from their experiment that, among the tested varieties Pusa 834 and CNTRL 85033 produced the highest seed yield in different location in Nepal.

Kumar *et al.* (2017) evaluated that, among the varieties viz, PR-115, DRRH-3, PAC-837 and PR-121, PAC-837 recorded highest plant height and number of tillers m^{-2} at all the growth stages. All yield attributes viz. number of effective tillers m^{-2}, number

of seeds per panicle, 1000-seed weight, spikelet sterility, seed yield, straw yield, harvest index, seed moisture, vigority and protein content in seed were significantly differed from other varieties.

2.2 Effect on seedling age on the growth, yield and seed quality of rice

Islam *et. al.,* (2021) conducted a field experiment to evaluate the effects of age of seedlings on the yield and growth performance of transplanted Aus (T. Aus) rice variety. The experiment was carried out assigning four age of seedlings and two rice varieties. In case of variety, the highest plant height (102.108 cm), the highest seed yield (2.643 t ha^{-1}), and the highest harvest index (32.317%) were obtained in BRRI dhan83. The age of seedlings had significantly affected total tillers/hill, effective tillers/hill, panicle length in T. Aus rice variety. The highest plant height (98.16 cm), straw yield (6.122 t ha^{-1}), the maximum number of effective tillers/hill (15.347) were obtained in 24 days old seedlings. In case of interaction, the highest plant height (104.667 cm) and the harvest index (34.86%) were observed in BRRI dhan83 at 27 days old seedlings. The highest seed yield (2.94 t ha^{-1}) was observed in BRRI dhan83 at 22 days old seedlings.

Seedlings of 25, 35 and 45 days old were manually transplanted and cultivated in rainfed condition at the regional agricultural research station in Nepal. Three years findings revealed that days to maturity were significant earlier (at least 2 days) in 25 days seedling compared to old aged seedlings. Rice seed yield was highest in the plots in 25 days old seedling (4,467 kg ha^{-1}) was 500 kg higher when compared with 10 days later transplanted (Shrestha *et al.,* 2019).

Mukta (2019) conducted an experiment to determine the contribution of tillers on rice seed yield as affected by variety and seedling age in *boro* season. The results revealed that higher values of all the yield attributes were maximum under 10 days old seedling followed by 30 days old seedling in both the varieties viz. BRRI dhan28 and BRRI dhan29 where a clear dominancy of BRRI dhan29 over BRRI dhan28 on every parameter. Transplantation of 15 days old seedlings produced significantly higher seed yield. In variety and seedling age combination, most of the yield parameters exhibit the highest values.

Chakrabortty *et al.* (2015) conducted an experiment at Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from December 2011 to May

2012. Maximum number of filled seed (101.0 panicle^{-1}), 1000-seed weight (19.9 g), seed yield (5.1 tha^{-1}), straw yield (5.1 tha^{-1}), biological yield (10.2 tha^{-1}) was found and minimum weed population (43.7 m^{-2} at 30 DAT and 63.1m^{-2} at 60 DAT) was also found. 14 days old seedling was found as best for yield of BRRI dhan 50 under System of Rice Intensification.

Ali *et al.* (2013) evaluated Boro Rice BRRI dhan 28 with two levels of seedling ages viz. 15 and 30 days old and two levels of water management. They found significant effect of seedling age on plant height. Maximum plant height (98.3 cm) was recorded when older seedlings of 30 days were transplanted, while minimum plant height (90.4 cm) was recorded by 15 days old seedlings. They also reported more tillers hill^{-1} (31.5), maximum number of filled seeds (188), more number of filled seeds panicle^{-1} (123.30) when 10 days old seedlings were transplanted while minimum (86.20) was given by 6 days old seedlings under the system of rice intensification. when younger seedlings of 15 days age were transplanted while minimum tillers hill^{-1} (18.0), minimum number of filled seeds (170), minimum seed yield (6.90 tha^{-1}) was observed in case of 30 days old seedlings.

Panicle length also favors the increase in the numbers of spikelets per panicle. Four rice cultivars were tested using three levels of seedling age (27, 30 and 35 days). Panicle length was significantly affected by seedling age. Seedlings of 27 days age gave maximum (22.95 cm) panicle length followed by 30 and 35 days old seedlings. Minimum Panicle length (21.04) was recorded from older seedlings of 35 days (Rahimpour *et al.*, 2013).

Brar *et al.* (2012) also reported significant effect of seedling age on paddy yield. According to their findings younger seedlings of 30 days age produced more seed yield (6.82 tha^{-1}) as compared to older seedlings of 60 days which produced minimum seed yield (6.47 tha^{-1}).

Pramanik and Bera (2011) found the significant effect of seedling age and nitrogen fertilization on plant height of hybrid rice. The maximum plant height (103.81 cm and 112.84 cm) when 10 days old seedlings were transplanted and nitrogen was applied @ 200 kg/ha, while minimum plant height (91.38 cm and 81.63 cm) was observed with the seedlings of 30 days age.

Sarkar *et al.* (2011) tested aman rice using three levels of row arrangement, two types

of tiller seedlings and three levels of number of tiller seedling hill^{-1}. They found that by transplanting older seedlings of 35 days gave more mean tillers hill^{-1} (13.36), while minimum (12.41) was recorded from 25 days old seedlings. They also recorded more panicle length (27.98 cm) from seedlings of 25 days age while minimum (27.36 cm) from older seedlings of 35 days.

Patra and Hoque (2011) reported that the highest numbers of effective tillers hill^{-1} were produced with seedling of 10 days age. Similarly, the plots transplanted with 10 days old seedling also recorded the highest number of seeds panicle^{-1}, panicle length and test weight resulted in higher seed yield. Transplantation of 10 days old seedling gave 18.66% and 24.99% more seed yield than T_1 and T_7, respectively. It was also seen that for every days delay in transplanting beyond the age of 10 days, yield was reduced to the extent of 4.5% ha^{-1} year^{-1}. They also found more number of filled seeds panicle^{-1} (123.30) when 10 days old seedlings were transplanted while minimum (86.20) was given by 6 days old seedlings under the system of rice intensification.

Bagheri *et al.* (2011) conducted the experiment to determine the effect of seedling age and potassium rates on lodging and yield components of rice. Panicle length was significantly affected by seedling age and maximum panicle length (26.16 cm) was shown by transplanting 30 days old seedlings followed by 20 and 40 days age. Minimum panicle length (23.78 cm) was given by transplanting 40 days old seedlings.

Patra *et al.* (2011) investigated seedling ages in order to determine their significance on yield and yield contributing parameters of rice under system of rice intensification. They found higher panicle length (22.55 cm) by transplanting 10 days old seedlings and minimum (18.09 cm) was recorded from 6 days old seedlings.

Krishna and Biradarpatil (2009) conducted an experiment to study the Influence of age of seedlings and spacings on seed yield and quality under SRI (system of Rice Intensification) method of cultivation in ES-18 short duration variety during rabi season at Agricultural Research Station Gangavati, Karnataka during 2004-05 and reported that the younger seedlings (8 days-old) flowered early. Time of 50% flowering increased as the age of the seedling increased from 8 days old to 12 days old, 16 days old, 25 days old.

Krishna *et al.* (2009) studied influence of age of seedlings and spacing on seed yield and quality of short duration variety during T. aman season at Agricultural Research

Station Gangavati, Karnataka during 2004-05. The 25 days seedlings produced more number of tillers and productive tillers per plant at harvest compared to 10, 15 and 35 days old seedlings

Islam (2008) conducted and experiment during the period from June to November 2007 to study the influence of the seedling age and number of seedlings $hill^{-1}$ on the performance of BRRJ dhan44. The highest tiller (17.96 $hill^{-1}$), filled seeds (92.25 $panicle^{-1}$), seed yield (5.52 th^{-1}), straw yield (5.94 th^{-1}) was shown by 30 days old seedling.

El-Rewainy *et al.* (2007) tested rice cultivar Sakha 101 by using four seedling ages (25, 30, 35, 40 days) and four nitrogen levels (0, 48, 96, 144 kg ha^{-1}). Maximum plant height (79.80 cm) was obtained by seedlings of 30 days age while 25 days old seedlings gave minimum plant height (70.7 cm).

Hossain (2006) carried out an experiment to study the effect of seedling age on the yield of aromatic varieties. The result revealed that 30 days old seedlings showed the best performance than other seedling ages treatment. The highest seed yield (3.3 t ha^{-1}), number of effective tillers/hill, number of total spikelets/panicle, seed/$panicle^{-1}$, 1000-seed weight and the longest panicle were obtained from 30 days old seedlings whereas the highest plant height, number of total and non-effective tiller were found in 15 days old seedlings.

Akber (2004) conducted an experiment with 10 and 15 days old seedlings. He observed that plant height differed significantly due to different ages of seedlings. Filleen days old seedlings appeared to be taller at the early stage of the crop growlh which lasted tip to 45 l)AT (Days after transplanting). But after 45 DAT, both 10 and 15 days old seedlings grew faster. At the final harvest, the plant height of both the seedling ages was found to be statistically similar (139.34 cm and 141.09 cm for 10 and 15 days old seedlings respectively).

From the review discussed above, it is clear that there is a wide scope to work on variety and seedling age for higher yield and quality seed production in rice.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July 2019 to December 2019 to study the effect of seedling age on yield and quality of T. aman variety. This chapter will deal with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and data analysis. The details are presented below under the following headings:

3.1 Experimental site

The study was conducted at central research field of Sher-e-Bangla Agricultural University, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The location of the site is 23º74/N latitude and 90º35/E longitude with an elevation of 8.2 meter from sea level. The location of the experimental field was presented in Appendix I.

3.2 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details of the meteorological data of air temperature, relative humidity and rainfall during the period of the experiment were collected from the Bangladesh Meteorological Department, Agargaon, Dhaka presented in Appendix II.

3.3 Soil

The soil belongs to “The Modhupur Tract”, AEZ – 28. Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish- brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix III.

3.4 Planting material

In this research work, three inbreed varieties i.e. BRRI dhan32, BRRI dhan62 and BRRI dhan80 were used as planting materials. BRRI varieties were collected from the Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.

3.5 Experimental details

3.5.1 Treatments

The experiment consists of 2 factors, they were

Factor A: Variety-3

V_1 = BRRI dhan32

V_2 = BRRI dhan62

V_3 = BRRI dhan80

Factor B: Age of seedling-4

A_1 = 20 days old seedling

A_2 = 25 days old seedling

A_3 = 30 days old seedling

A_4 = 35 days old seedling

Treatment Combination

V_1A_1 = BRRI dhan32 × 20 days old seedling

V_1A_2 = BRRI dhan32 × 25 days old seedling

V_1A_3 = BRRI dhan32 × 30 days old seedling

V_1A_4 = BRRI dhan32 × 35 days old seedling

V_2A_1 = BRRI dhan62 × 20 days old seedling

V_2A_2 = BRRI dhan62 × 25 days old seedling

V_2A_3 = BRRI dhan62 × 30 days old seedling

V_2A_4 = BRRI dhan62 × 35 days old seedling

V_3A_1 = BRRI dhan80 × 20 days old seedling

V_3A_2 = BRRI dhan80 × 25 days old seedling

V_3A_3 = BRRI dhan80 × 30 days old seedling

V_3A_4 = BRRI dhan80 × 35 days old seedling

3.5.2 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each block was divided into twelve-unit plots. The total numbers of plots were 36. The plot size was 4 m × 2.0 m. The distance between plots were 0.5 m and replication to replication were 1.0 m.

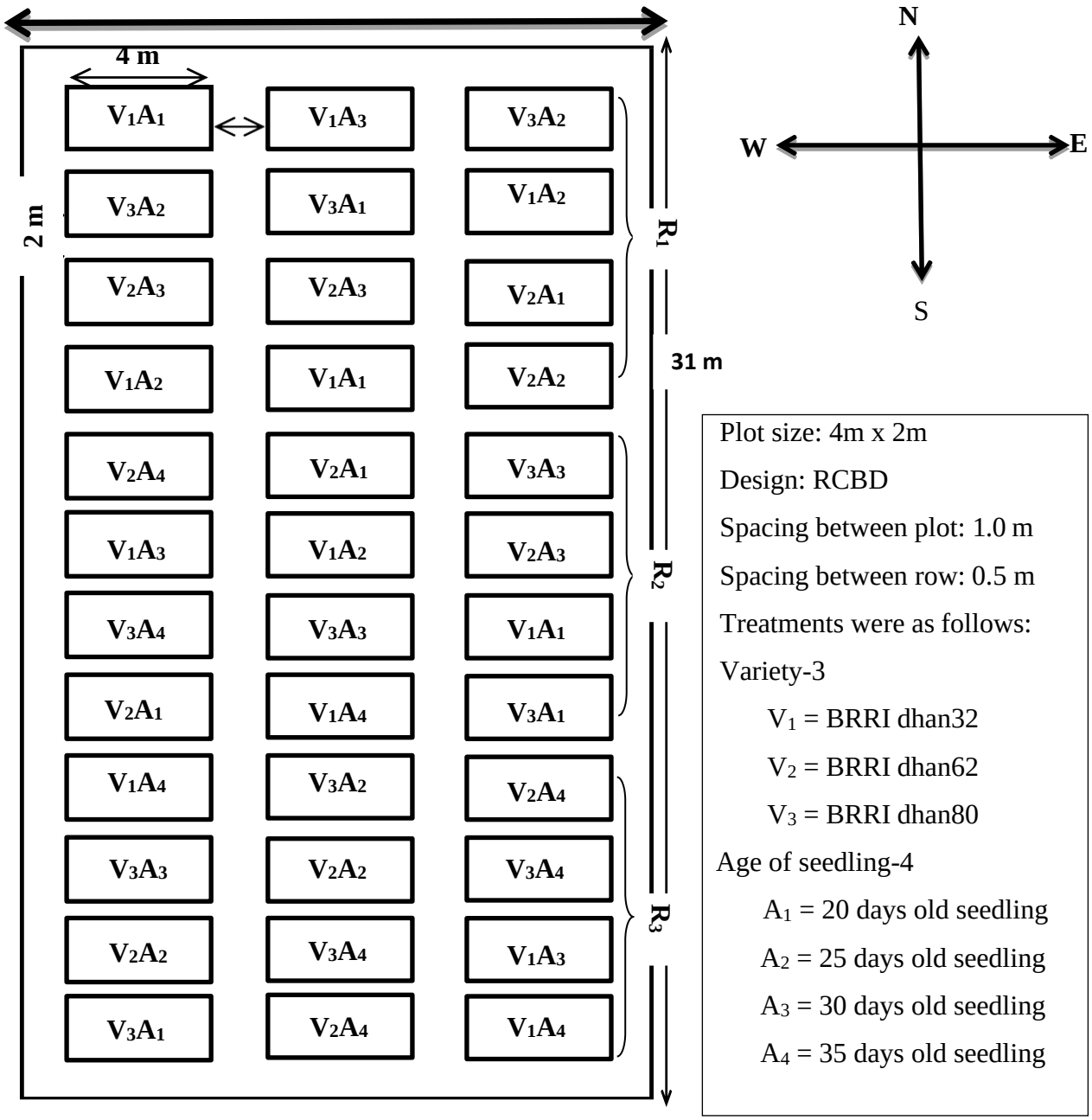


Figure 1: Layout of the experimental plot

3.6 Growing of crops

3.6.1 Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1m wide adding nutrients as per the requirement of soil. Seeds were sown in the seed bed on 20 June 2019, 25 June 2019, 30 June 2019 and 05 July 2019 in order to transplanting the seedlings in the main field.

3.6.2 Preparation of the main field

The plot selected for the experiment was opened in the second week of July 2019 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.6.3 Fertilizer application

The fertilizers N, P, K, S and B fertilizers were applied in the form of urea, TSP, MP, Gypsum and borax, at the rate of 160, 100, 100, 60 and 10 kg ha^{-1}, respectively. Full amounts of TSP, MP, Gypsum and borax were applied as basal dose before transplanting of rice. Urea were applied in 3 equal splits: one third was applied at basal before transplanting, one third at active tillering stage (30 DAT) and the remaining one third was applied at panicle initiation stage (60 DAT). The dose and method of application of fertilizers are shown in Table 1.

Table 1. Dose and method of application of fertilizers in rice field

Fertilizers	Dose (Kg/ha)	Application (%)		
		Basal	1st installment	2nd installment
Urea	160	33.33	33.33	33.33
TSP	100	100	-	-
MP	100	100	-	-
Gypsum	60	100	-	-
Borax	10	100	-	-

Source: Adunik Dhaner Chase, 23rd edition,2019, BRRI, Joydebpur, Gazipur.

3.6.4 Uprooting seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on July, 25, 2019 for transplant on the date of July 26, 2019 without causing much mechanical injury to the roots.

3.6.5 Transplanting of seedlings

Seedlings of 20, 25, 30 and 35 days old were transplanted on the well puddled experimental plot on 26 July 2019, respectively in main field at the rate of 3 seedlings $hill^{-1}$ with 25 cm spacing between the lines and 15 cm spacing between the hills.

3.6.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.6.6.1 Gap filling

Gap filling was done for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings.

3.6.6.2 Irrigation

Necessary irrigations were provided to the plots as and when required during the growing period of rice crop. Fifteen days before harvest, the plots were dried to ensure maturation of the crop.

3.6.6.3 Weeding

The plots were infested with some common weeds, which were removed by uprooting them from the field three times at 15, 30 and 45 DAT during the period of the cropping season.

3.6.6.4 Insect and pest control

There was no infestation of diseases in the field but leaf roller (*Chaphalocrosis medinalis*, Pyralidae, Lepidoptera) was observed in the field and used Malathion @ 1.12 L per ha to control them.

3.7 Crop harvest

The rice plant was harvested depending upon the maturity of seeds and harvesting was done with the help of sickle from each plot. Maturity of crop was determined when 80-90% of the seeds become golden yellow in color. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Crops of central 1 m^2 area was harvested in each plot for taking seed and straw yield. For taking yield attributes data, 10 hills were collected from each plot outside the harvested area. Fresh weight of seed and straw were recorded plot wise. Finally, the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of seed and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.8 Seed quality test

Seed quality test was taken under in the agronomy laboratory of SAU. Dried and clean seeds was collected from each plot and used for quality tests. For quality test, 50 seeds of each plot set in Petridis using sand media.

3.9 Date recording

The following data was recorded-

A. Plant characters data

i. Plant height (cm)
ii. Tillers hill^{-1} (no.)

B. **Yield attributes and yield**

i. Effective tillers hill^{-1} (no.)
ii. Non-effective tillers hill^{-1} (no.)
iii. Total tillers hill^{-1} (no.)
iv. Panicle length (cm)
v. Filled seed panicle^{-1} (no.)
vi. Unfilled seed panicle^{-1} (no.)
vii. Total seed panicle^{-1} (no.)
viii. Weight of 1000 seed (g)
ix. Seed yield (t ha^{-1})
x. Straw yield (t ha^{-1})
xi. Biological yield (t ha^{-1})
xii. Harvest index (%)

C. Seed quality parameters data

Dried and clean seeds of each plot were taken separately from which the following seed quality parameters data were taken-

i. Germination percentage
ii. Seedling root and shoot length (cm)
iii. Seedling root and shoot dry weight (g)
iv. Vigor index

3.9.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 60, 90 DAT and at harvesting stage. Data were recorded as the average of 5 plants selected at

random from the inner rows of each plot. The height was measured from the ground level to the tip of the leaf.

3.9.2 Tillers hill^{-1}

The number of tillers hill^{-1} was recorded at the time of 30. 60 and 90 DAT by counting total tillers. Data were recorded as the average of 5 hills selected at random from the inner rows of each plot.

3.9.3 Effective tillers hill^{-1}

The number of effective tillers hill^{-1} was counted as the number of panicle bearing hill. Data on effective tillers hill^{-1} were counted from 5 selected hills and average value was recorded.

3.9.4 Non-effective tillers hill^{-1}

The number of non-effective tillers hill^{-1} was counted as the number of non-panicle bearing tillers of the hill. Data on non-effective tillers hill^{-1} were counted from 5 selected hills and average value was recorded.

3.9.4 Total tiller hill^{-1}

The total number of tiller/hill was counted as the number of effective tiller/hill and non- effective tiller/hill. Data on total tiller hill were counted from 5 selected hills and average value was recorded.

3.9.5 Panicle length

The length of panicle was measured with a meter scale from 10 selected panicle and the average value was recorded to have length of panicle in cm.

3.9.6 Filled seeds panicle^{-1}

Filled seed panicle^{-1} was taken from 20 randomly selected panicles of each plot. The seeds which have something inside was considered as filled seed. The average number of seeds of 20 panicles was recorded to have seeds panicle^{-1}.

3.9.7 Unfilled seeds perpanicle^{-1}

The numbers of unfilled seeds were counted randomly from selected 20 panicles of each plot and averaged them to have unfilled seed panicle^{-1}. The seed which have nothing inside was considered as unfilled seed panicle^{-1}.

3.9.8 Total seeds panicle^{-1}

The total numbers of filled and unfilled seeds were counted from randomly selected 20 panicles of each plots and average them to have total seeds panicle^{-1}. The number of filled and unfilled seeds were termed as total seeds panicle^{-1}.

3.9.9 Weight of 1000 seed

One thousand seeds were counted randomly from the harvested seeds of each individual plot and then weighed with an electric balance in grams and recorded.

3.9.10 Seed yield

The seeds of central 1 m^2 harvested area was cleaned and dried properly. Then weighted in an electric balance and converted the weight to t ha^{-1}. The seed weight was adjusted at 14% moisture content of seeds.

3.9.11 Straw yield

The straw of the harvested 1 m^2 area was sundried properly and then weighted. The weight was then converted into t ha^{-1}.

3.9.12 Biological yield

Seed yield and straw yield together were regarded as biological yield, the biological yield was calculated with the following formula:

Biological yield = Seed yield + Straw yield.

3.9.13 Harvest index

Harvest index was calculated from the seed and straw yield of rice for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.9.14 Germination percentage

After harvesting germination test was done in the laboratory of the Department of Agronomy, SAU on 8 January 2020. Fifty seeds were placed in a petridis and replicated thrice. Germinated seedling was counted after 3 days of placement in petridis. Finally, total number was converted as percentage. Germination percentage was calculated by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds set for test}} \times 100$$

3.9.15 Shoot length and root length

From the germinated seedling, shoot length and root length was measured using measuring scale and recorded as centimeter (cm). Average values of 10 shoot and root were used for determining shoot and root length. Shoot and root length was taken at 14 days of seedling age.

3.9.16 Shoot weight and root weight

From the germinated seedling, after taking shoot length and root length the dry weight of shoot and root measured separately. Fourteen days old seedlings were used for this estimation. As the weight was very low, the recorded data was measured as miligram (mg).

3.9.17 Vigor index

Vigor index was computed by using the following formula as suggested by Baki and Anderson (1973) and expressed in number.

Vigor index = Germination (%) x (Shoot length + Root length) in cm

3.10 Data analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program. The mean values for all the parameters were calculated and analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Least Significant Different (LSD) at 5% levels of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the effect of different age of seedling on the yield and seed quality of T. aman rice varieties. Data on different growth parameter, yield attributes, yield and seed quality parameters were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix IV-XXX. The results have been presented and possible interpretations given under the following headings:

4.1 Plant height

4.1.1 Effect of variety

The plant height of T. aman rice was significantly influenced by varieties at different days after transplanting (DAT) (Figure 2). The figure shows that plant height increased gradually with advances of growth stages irrespective of varieties. The highest increase was found at harvest stage. However, numerically at 30 DAT, the variety BRRI dhan32 produced the tallest plant (36.10 cm) and the variety BRRI dhan62 gave the shortest plant (29.29 cm). At 60 DAT, 90 DAT and at harvest, BRRI dhan32 gave highest plant height (96.25, 122.10 and 123.40 cm, respectively) and BRRI dhan62 produce the shortest plant (79.94, 97.08 and 98.33 cm, respectively). It indicates that different varieties had different age of seedlings requirement for plant height. Variation in plant height of the cultivars also indicates different genetic make-up of the varieties. The results of the experiment are in agreement with Hossain (2001), who observed the tallest plant at harvest (91.33 cm) in case of BINA dhan5 and the lowest plant highest at harvest (72.43 cm) in case of BINA dhan6.

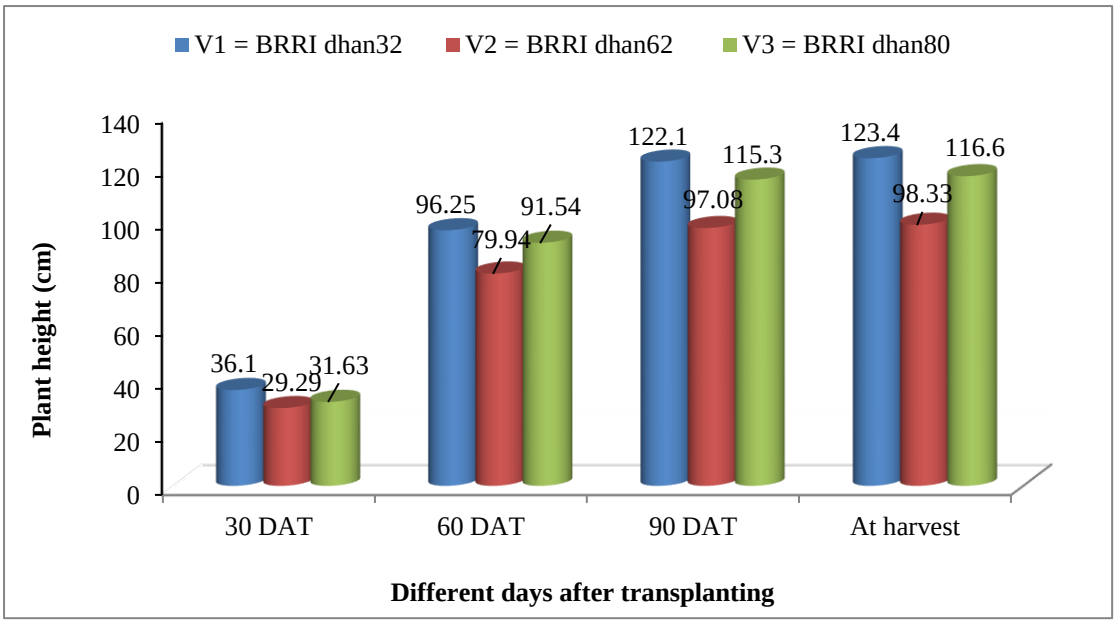


Figure 2. Effect of variety on plant height at different days after transplanting ($LSD_{0.05}$ = 1.40, 2.57, 3.92 and 3.96 at 30, 60, 90 and at harvest, respectively)

4.1.2 Effect of seedling age

Statistically significant variation was recorded for plant height of T. aman rice due to the different age of seedlings at 30, 60, 90 DAT and at harvest (Figure 3). The figure indicates that irrespective of different age of seedlings, plant height increased progressively with the advance of growth stages and the highest increase was found at harvest stage. At the different days after transplanting (DAT) the tallest plant (33.98 cm, 93.50 cm, 113.90 cm and 115.20 cm) was recorded from A_3 (30 days old seedling) at 30, 60, 90 DAT and at harvest, respectively. On the other hand, at the same DAT the shortest plant (31.07 cm, 86.11 cm, 108.60 cm and 109.90 cm) was observed from A_1 as 20 days old seedling. From the data it was revealed that all the ages of seedlings produced significantly taller plants compared to the 20 days old seedling.

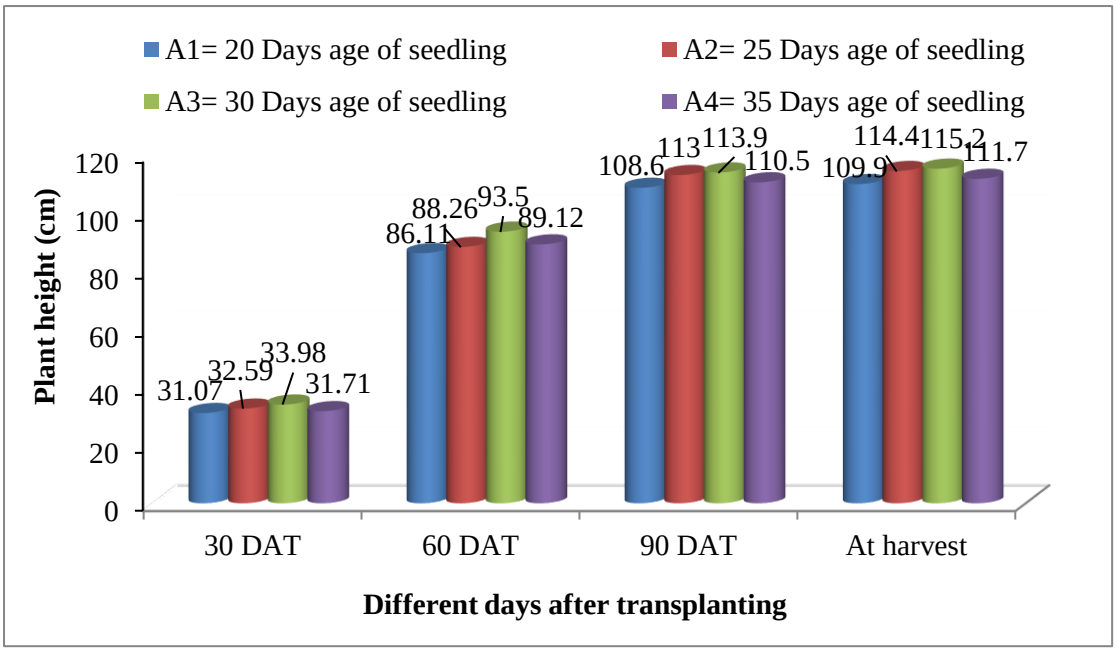


Figure 3. Effect of seedling age on plant height on T. aman rice at different days after transplanting ($LSD_{0.05}$ = 1.62, 2.97, 4.52 and 4.57 at 30, 60, 90 and at harvest, respectively)

4.1.3 Interaction effect of variety and seedling age

Interaction of variety and age of seedling showed significant variation on plant height of rice at 30 DAT, 60 DAT, 90 DAT and at harvest (Table 1). At 30 DAT, the longest plant (38.65 cm) was observed from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment and the shortest plant (27.64 cm) was observed from V_2A_1 treatment. Similarly at 60 DAT, 90 DAT and at harvest, the highest plant height (104.00 cm, 127.00 cm and 128.20 cm, respectively) was observed from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment and the lowest plant height (76.90 cm, 92.33 cm and 93.58 cm, respectively) was observed from V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment.

Table 1. Interaction effect of variety and seedling age on plant height of rice at different days after transplanting

Treatment	Plant height (cm) at different days after transplanting			
	30 DAT	**60 DAT**	**90 DAT**	**At harvest**
V_1A_1	34.36 bc	92.45 bc	122.8 a-c	124.1 a-c
V_1A_2	36.01 ab	93.81 bc	125.6 ab	127.2 ab
V_1A_3	38.65 a	104.0 a	127.0 a	128.2 a
V_1A_4	35.37 bc	94.75 b	113.0 de	114.3 de
V_2A_1	27.64 g	76.90 d	92.33 f	93.58 f
V_2A_2	29.20 fg	80.62 d	95.35 f	96.60 f
V_2A_3	30.52 ef	81.01 d	94.90 f	96.15 f
V_2A_4	29.79 e-g	80.25 d	105.7 e	107.0 e
V_3A_1	31.20 d-f	88.98 c	116.2 cd	117.5 cd
V_3A_2	32.57 c-e	90.36 bc	118.0 b-d	119.3 b-d
V_3A_3	33.50 b-d	95.48 b	119.9 a-d	121.1 a-d
V_3A_4	29.24 fg	91.35 bc	107.1 e	108.4 e
LSD $_{(0.05)}$	**2.80**	**5.14**	**7.83**	**7.92**
CV (%)	**5.12**	**3.40**	**4.15**	**4.15**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
[V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80; A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling]

4.2 Tillers hill^{-1}

4.2.1 Effect of variety

The number of tillers hill^{-1} of T. aman rice was significantly influenced by varieties at different days after transplanting (DAT) (Table 2). The table shows that the number of tillers hill^{-1} increased gradually with advances of growth stages irrespective of varieties. The highest increase was found at harvest stage. However, numerically at 30 DAT, the variety BRRI dhan32 produced the highest number of tillers hill^{-1} (3.80 tillers) and the variety BRRI dhan62 gave the lowest number of tillers hill^{-1} (2.95 tillers). At 60 DAT, 90 DAT and at harvest, BRRI dhan32 gave the highest number of tillers hill^{-1} (13.42, 15.31 and 20.22 tillers, respectively) and BRRI dhan62 produce the lowest number of tillers hill^{-1} (11.07, 13.39 and 17.92 tillers, respectively). It

indicates that different varieties required different age of seedlings for the number of tillers hill^{-1}. Variation in the number of tillers hill^{-1} among the cultivars also indicates different genetic make-up of the varieties.

4.2.2 Effect of seedling age

Statistically significant variation was recorded for number of tillers hill^{-1} of T. aman rice due to the different age of seedlings at 30, 60, 90 DAT and at harvest (Table 2). The table indicates that irrespective of different age of seedlings, number of tillers hill^{-1} increased progressively with the advance of growth stages and the highest increase was found at harvest stage. At the different days after transplanting (DAT) the highest number of tiller hill^{-1} (3.69, 12.94, 16.26 and 20.68 tillers) was recorded from A_3 (30 days old seedling) at 30, 60, 90 DAT and at harvest, respectively. On the other hand, at the same DAT the lowest number of tillers hill^{-1} (2.76, 11.46, 13.42 and 18.38 tillers) was observed from A_1 (20 days old seedling). The number of tillers hill^{-1} was significantly influenced by the age of seedling was also reported by Babu *et al.* (2001)..

4.2.3 Interaction effect of variety and seedling age

Interaction of variety and age of seedling showed significant variation on the number of tillers hill^{-1} of rice at 30 DAT, 60 DAT, 90 DAT and at harvest (Table 2). At 30 DAT, the highest number of tillers hill^{-1} (4.78 tillers) was observed from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment and the lowest number of tillers hill^{-1} (2.51 tillers) was observed from V_2A_1 treatment. Similarly at 60 DAT, 90 DAT and at harvest, the highest number of tillers hill^{-1} (14.71, 18.39 and 21.70 tillers, respectively) was observed from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment and the lowest number of tillers hill^{-1} (10.66, 12.55 and 17.57 tillers, respectively) was observed from V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment.

Table 2. Effect of variety, age of seedling and their interaction on tiller number per hill of T. aman rice at different days after transplanting (DAT)

Treatment	Number of total tiller per hill at different days after transplanting			
	30 DAT	**60 DAT**	**90 DAT**	**At harvest**
Variety				
V_1	3.80 a	13.42 a	15.31 a	20.22 a
V_2	2.95 c	11.07 c	13.39 b	17.92 b
V_3	3.30 b	11.94 b	15.06 a	19.57 a
LSD $_{(0.05)}$	**0.16**	**0.53**	**0.64**	**0.82**
CV (%)	**5.50**	**5.12**	**5.18**	**4.94**
Seedling age				
A_1	2.76 c	11.46 c	13.42 c	18.38 c
A_2	3.43 b	12.38 ab	14.84 b	19.86 ab
A_3	3.69 a	12.94 a	16.26 a	20.68 a
A_4	3.60 a	11.79 bc	13.82 c	19.16 bc
LSD $_{(0.05)}$	**0.18**	**0.61**	**0.74**	**0.94**
CV (%)	**5.50**	**5.12**	**5.18**	**4.94**
Interaction of different variety and seedling age				
V_1A_1	3.15 e	12.61 b-d	13.66 e-g	19.62 b-d
V_1A_2	3.53 bc	13.08 bc	15.57 bc	20.51 a-c
V_1A_3	4.78 a	14.71 a	18.39 a	21.70 a
V_1A_4	3.74 b	13.26 b	13.60 e-g	19.04 c-e
V_2A_1	2.51 f	10.66 hi	12.55 g	17.57 e
V_2A_2	3.20 e	11.84 d-g	13.77 e-g	17.93 e
V_2A_3	2.59 f	11.32 f-i	14.23 d-f	18.44 de
V_2A_4	3.49 b-d	10.46 i	13.00 fg	17.75 e
V_3A_1	2.62 f	11.10 g-i	14.04 d-f	17.96 e
V_3A_2	3.30 c-e	12.21 c-f	15.18 b-d	21.12 ab
V_3A_3	3.71 b	12.80 b-d	16.16 b	21.89 a
V_3A_4	3.56 bc	11.64 e-h	14.87 c-e	20.70 ab
LSD $_{(0.05)}$	**0.31**	**1.05**	**1.28**	**1.63**
CV%	**5.50**	**5.12**	**5.18**	**4.94**

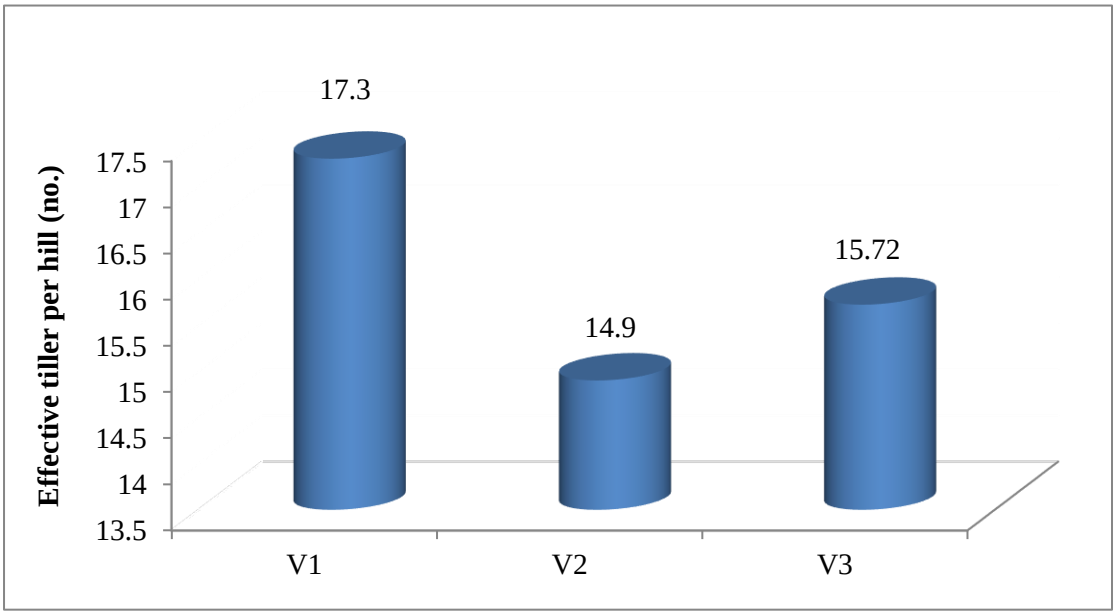
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
[V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80; A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling]

4.3 Effective tillers hill^{-1}

4.3.1 Effect of variety

The number of effective tillers hill^{-1} of T. aman rice was significantly influenced by varieties (Figure 4). The figure shows that the number of effective tillers hill^{-1} increased gradually with advances of growth stages irrespective of varieties.

However, the variety BRRI dhan32 produced the highest number of effective tillers hill^{-1} (17.30 tillers) and the variety BRRI dhan62 gave the lowest number of effective tillers hill^{-1} (14.90 tillers). It indicates that different varieties had different age of seedlings requirement for producing the number of effective tillers hill^{-1}. Variation in the number of tillers hill^{-1} of the cultivars also indicates different genetic make-up of the varieties. The results of the experiment are in agreement with Hossain (2001).

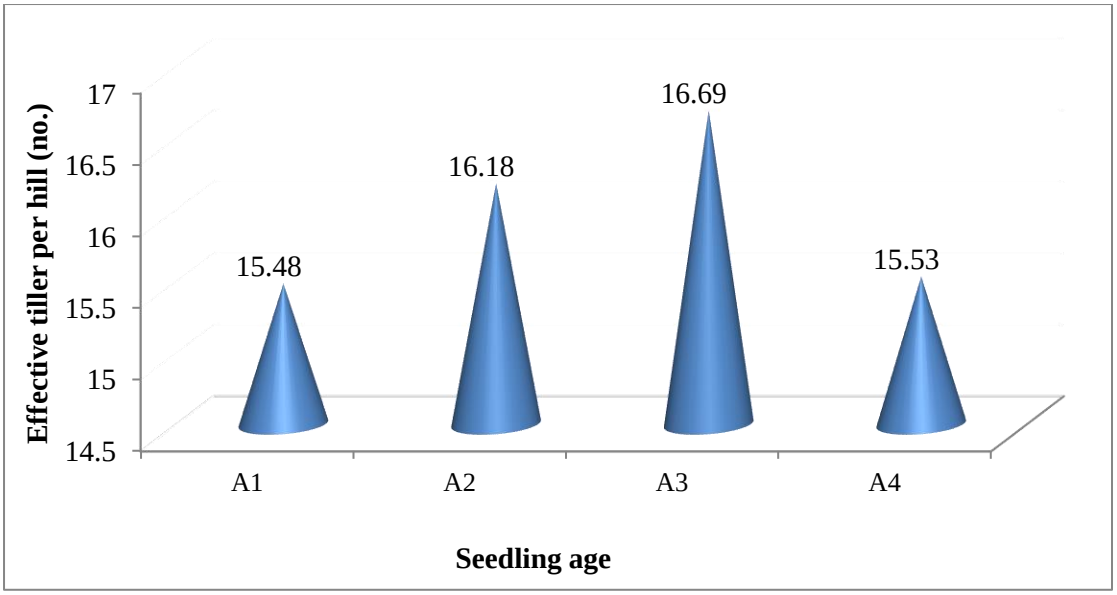


V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 4. Effect of variety on number of effective tillers per hill of T. aman rice ($LSD_{0.05}$ = 0.68)

4.3.2 Effect of seedling age

Statistically significant variation was recorded for number of effective tillers hill^{-1} of T. aman rice due to the different age of seedlings (Figure 5). The figure indicates that irrespective of different age of seedlings, number of effective tillers hill^{-1} increased progressively with the advance of growth stages. The highest number of effective tiller hill^{-1} (16.69 tillers) was recorded from A_3 (30 days old seedling). On the other hand, the lowest number of effective tillers hill^{-1} (15.48 tillers) was observed from A_1 as 20 days old seedling, which was statistically similar with A_4 (35 days old seedlings). The number of effective tillers hill^{-1} was significantly influenced by the age of seedling was also reported by Babu *et al.* (2001).



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 5. Effect of seedling age on number of effective tillers per hill of T. aman rice ($LSD_{0.05}$ = 0.79)

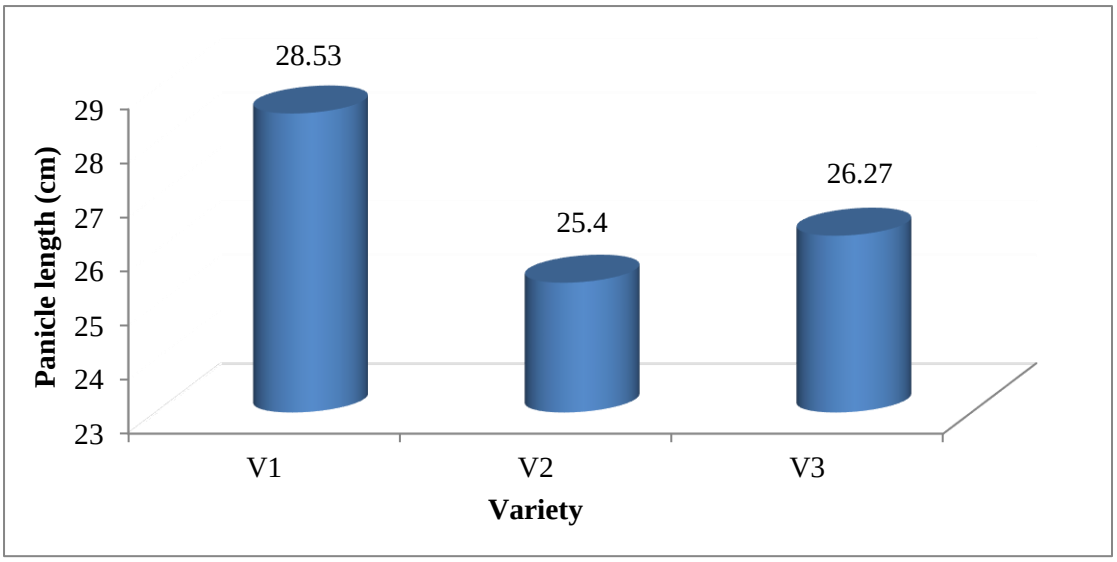
4.3.3 Interaction effect of variety and seedling age

Interaction of variety and age of seedling showed significant variation on the number of effective tillers hill^{-1} of rice (Table 3). The highest number of effective tillers hill^{-1} (18.39 tillers) was observed from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment which was statistically similar with V_1A_2 interaction (17.33) and the lowest number of effective tillers hill^{-1} (14.43 tillers) was observed from V_2A_1 interaction treatment.

4.4. Panicle length (cm)

4.4.1 Effect of variety

Panicle length of T. aman rice was statistically significant among the three varieties (Figure 6). The maximum panicle length (28.53 cm) was observed in the V_1 (BRRI dhan32) and the minimum panicle length (25.40 cm) was obtained from the variety V_2 (BRRI dhan62). Debnath (2010) and Ashrafuzzman (2006) observed that varieties differed insignificantly in respect of number of ineffective tillers m^{-2} though Ahmed (2006) found significant effect between inbred and hybrid varieties in respect of number of ineffective tillers m^{-2}.

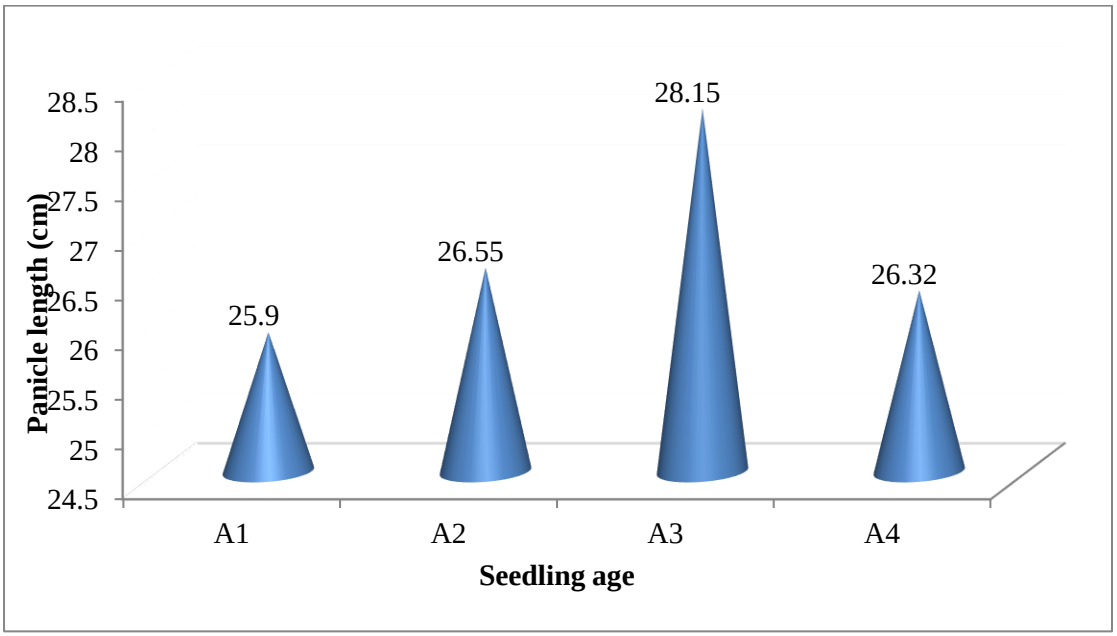


V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 6. Effect of variety on panicle length of T. aman rice ($LSD_{0.05}$ = 1.14)

4.4.2 Effect of seedling age

The panicle length of T. aman rice was statistically significant due to different ages of seedling (Figure 7). The maximum panicle length (28.15 cm) was observed in the A_3 (30 days old seedling) and the minimum panicle length (25.90 cm) was obtained from A_1 (20 days old seedling) treatment.



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 7. Effect of seedling age on number of panicle length of T. aman rice ($LSD_{0.05}$ =1.32)

4.4.3 Interaction effect of variety and seedling age

Significant influence was observed on panicle length due to the different interaction of varieties and different age of seedling of T. aman rice (Table 3). The highest panicle length (30.48 cm) was observed from V_1A_3 treatment combination which was statistically similar with V_1A_2 interaction (28.30) and lowest panicle length (24.03) was observed from V_2A_1 treatment combination.

Table 3. Interaction effect of variety and seedling age on effective tiller hill^{-1} and panicle length of T. aman rice

Treatment	Effective tiller hill^{-1} (no.)	Panicle length (cm)
V_1A_1	16.81 bc	27.67 bc
V_1A_2	17.33 ab	28.30 ab
V_1A_3	18.39 a	30.48 a
V_1A_4	16.66 b-d	27.68 bc
V_2A_1	14.43 f	24.03 f
V_2A_2	1505 ef	24.82 ef
V_2A_3	15.52 c-f	26.81 b-e
V_2A_4	14.58 f	25.93 c-f
V_3A_1	15.36 c-d	26.60 c-f
V_3A_2	16.17 b-e	26.53 b-e
V_3A_3	16.16 b-e	27.17 b-d
V_3A_4	15.20 d-f	25.36 d-f
LSD $_{(0.05)}$	**1.37**	**2.28**
CV%	**5.05**	**5.03**

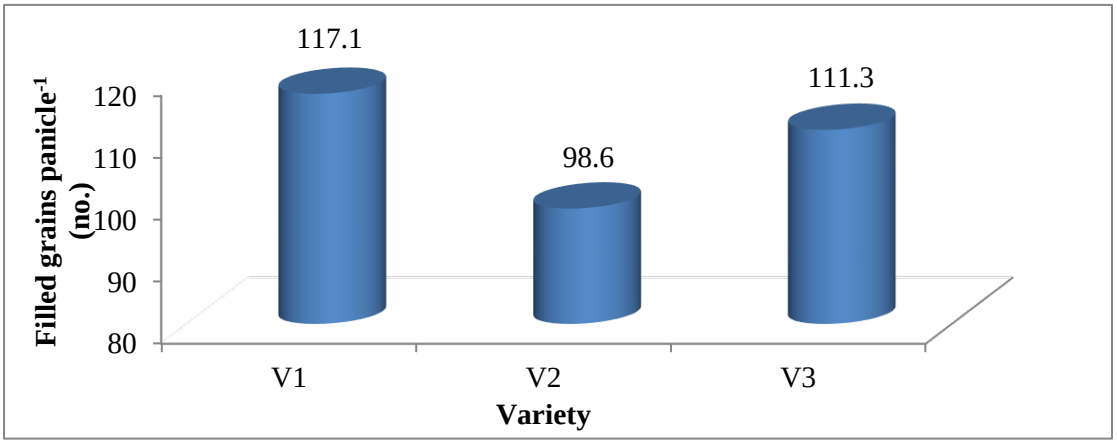
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
[V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80; A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling]

4.5 Filled seeds panicle^{-1}

4.5.1 Effect of variety

The number of filled seeds panicle^{-1} of T. aman rice was significantly influenced by different varieties (Figure 8). The result revealed that the variety BRRI dhan32 produced the highest number of filled seeds panicle^{-1} (117.1) and the variety BRRI dhan62 gave lowest number of filled seeds panicle^{-1} (98.6). This may be due to

varietal difference. Singh *et al.* (1990) found that number of filled seeds panicle^{-1} significantly differed among the varieties. BRRI (2006) studied the performance of BR14, Pajam, BR5 and Tulsimala and reported that Tulsimala produced the highest number of filled seeds panicle^{-1} and BR14 produced the lowest number of filled seeds panicle^{-1}.

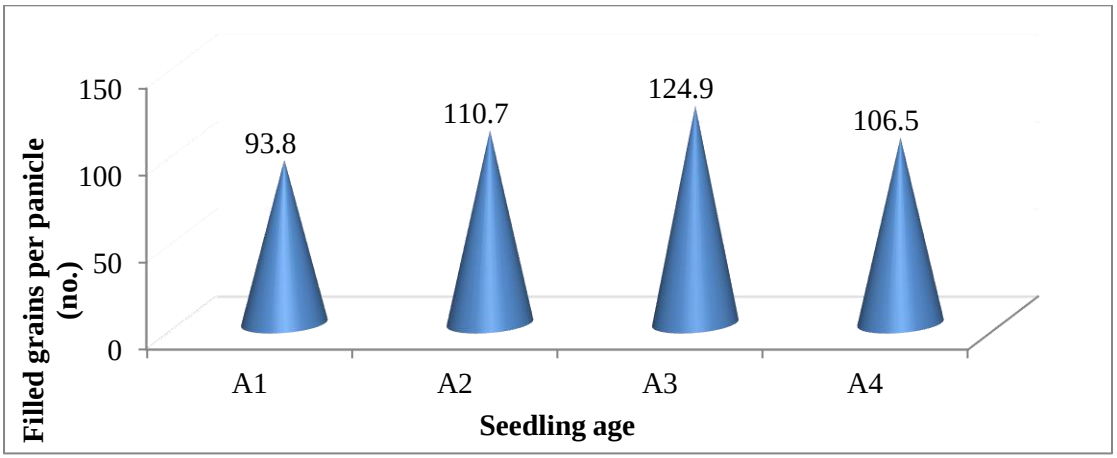


V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 8. Effect of different T. aman rice varieties on number of filled seeds panicle^{-1} ($LSD_{0.05}$ = 5.55)

4.5.2 Effect of seedling age

Due to different age of seedling, statistically a significant variation was recorded for number of filled seeds panicle^{-1} of T. aman rice (Figure 9). The maximum number of filled seed per panicle (124.9) was found from A_3 (30 days old seedling) which was statistically different from other treatments. On the other hand, the minimum (93.8) was recorded from A_1 (20 days old seedling) treatment.



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 9. Effect of different age of seedling on number of filled seeds panicle^{-1} of T. aman rice ($LSD_{0.05}$ =6.41)

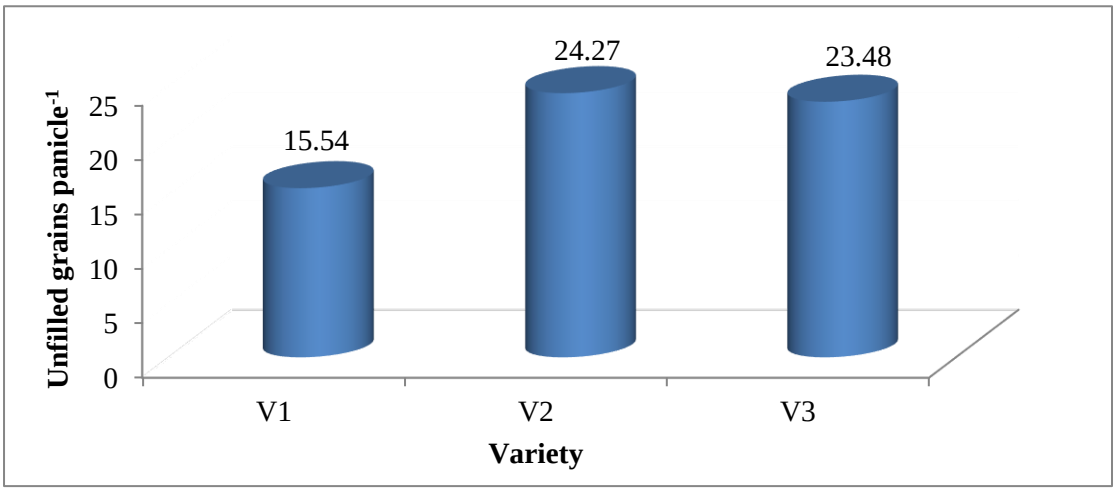
4.5.3 Interaction effect of variety and seedling age

Significant influence was observed on number of filled seeds panicle^{-1} due to interaction of variety and different age of seedling treatment of T. aman rice (Table 4). The highest number of filled seeds (136.2) panicle^{-1} was observed from V_1A_3 which was statistically different from other treatments. The lowest (83.0) was recorded from combination V_2A_1 treatment.

4.6 Unfilled seeds panicle^{-1}

4.6.1 Effect of variety

The number of unfilled seeds panicle^{-1} of T. aman rice was significantly influenced by different varieties (Figure 10). The result revealed that the variety BRRI dhan32 produced the lowest number of unfilled seeds panicle^{-1} (15.54) and the variety BRRI dhan62 gave highest number of unfilled seeds panicle^{-1} (24.27). Tyeb *et al.*, (2013) observed that BRRI dhan41 produced the highest number of unfilled seeds panicle^{-1}(28.71) followed by BRRI dhan51 (24.88) and BRRI dhan45 (22.50) which corroborates with the present finding in the unfilled seeds panicle^{-1} among the varieties.



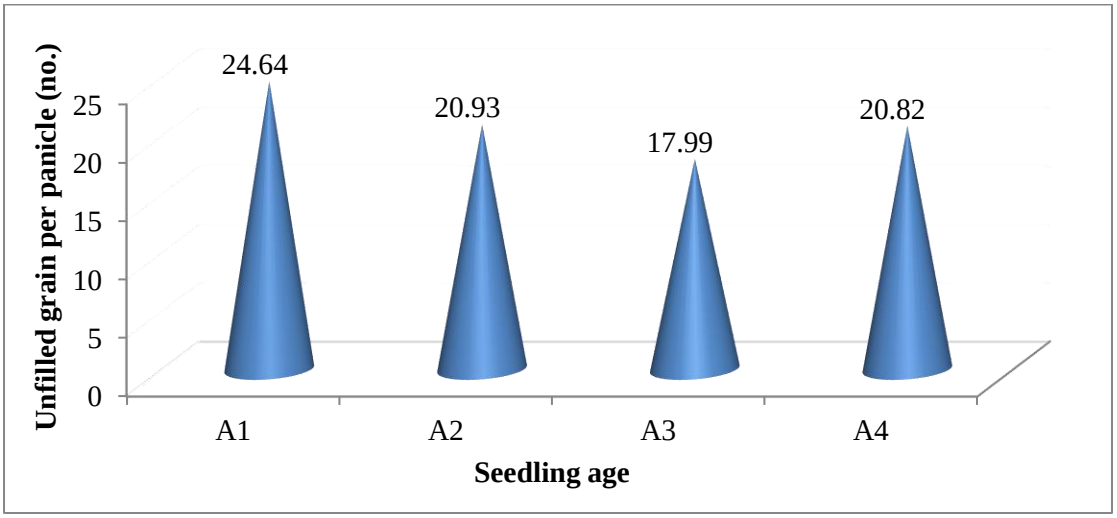
V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 10. Effect of different T. aman rice varieties on number of unfilled seed per panicle ($LSD_{0.05}$ = 0.53)

4.6.2 Effect of seedling age

Number of unfilled seeds panicle^{-1} of T. aman rice showed statistically significant variation due to the application of various seedling age treatment (Figure 11). The minimum number of unfilled seeds pancle^{-1} (17.99) was recorded from A_3 (30 days

old seedling). On the other hand, the maximum number of unfilled seed per plant (24.64) was recorded from A_1 (20 days old seedling).



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 11. Effect of different age of seedling on number of unfilled seed per panicle of T. aman rice ($LSD_{0.05}$ = 0.61)

4.6.3 Interaction effect of variety and seedling age

Interaction of variety and different age of seedling showed significant influence on number of sterile or unfilled seeds panicle^{-1} (Table 4). From the interaction of V_1A_3 (BRRI dhan32 with 30 days old seedling), the lowest number of unfilled seed panicle^{-1} (10.73) was obtained whereas the highest (31.07) was recorded from V_2A_1 (BRRI dhan62 with 20 days old seedling). In case of interaction effect of both factors, BRRI dhan32 along with 30 days old seedling gave lowest unfilled seeds panicle^{-1}. This may be due to better efficiency and better genetic characters of the varieties.

Table 4. Interaction effect of variety and different age of seedling on filled seeds panicle^{-1} and unfilled seeds panicle^{-1} of T. aman rice

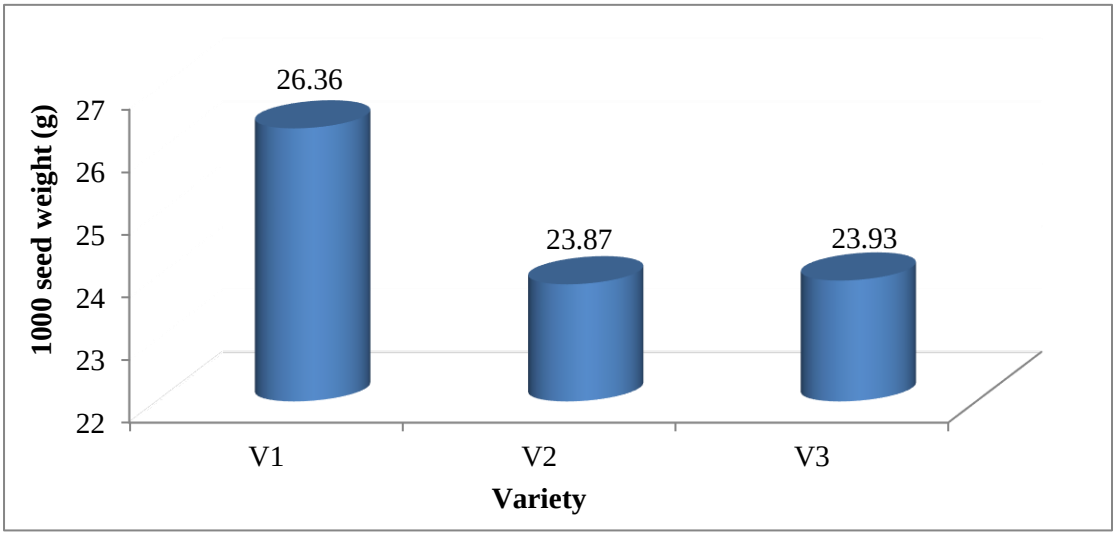
Treatment	Filled seeds panicle^{-1} (no.)	Unfilled seeds panicle^{-1} (no.)
V_1A_1	101.4 cd	18.28 g
V_1A_2	119.4 b	15.90 h
V_1A_3	136.2 a	10.73 i
V_1A_4	111.6 bc	17.26 g
V_2A_1	83.0 e	31.07 a
V_2A_2	99.2 d	23.79 c
V_2A_3	115.6 b	20.31 f
V_2A_4	96.6 d	21.89 e
V_3A_1	97.0 d	22.28 de
V_3A_2	113.7 b	23.10 cd
V_3A_3	123.0 b	22.93 c-e
V_3A_4	111.4 bc	22.60 b
LSD $_{(0.05)}$	**11.10**	**1.05**
CV%	**4.12**	**2.94**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
[V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80; A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling]

4.7 Weight of 1000 seed

4.7.1 Effect of variety

Weight of 1000-seed of T. aman rice was significantly influenced by different varieties (Figure 12). The result revealed that the variety BRRI dhan32 produced the highest 1000- seed weight (26.36 g) and the variety BRRI dhan62 gave lowest 1000-seed weight (23.87 g). Islam *et al.,* (2013) observed that the highest 1000 seed weight recorded from BRRI dhan46 (28.17 g) and the lowest from BRRI dhan33 (24.19 g). BR 11 and BRRI dhan39 showed statistically similar result, which testifies the present findings.

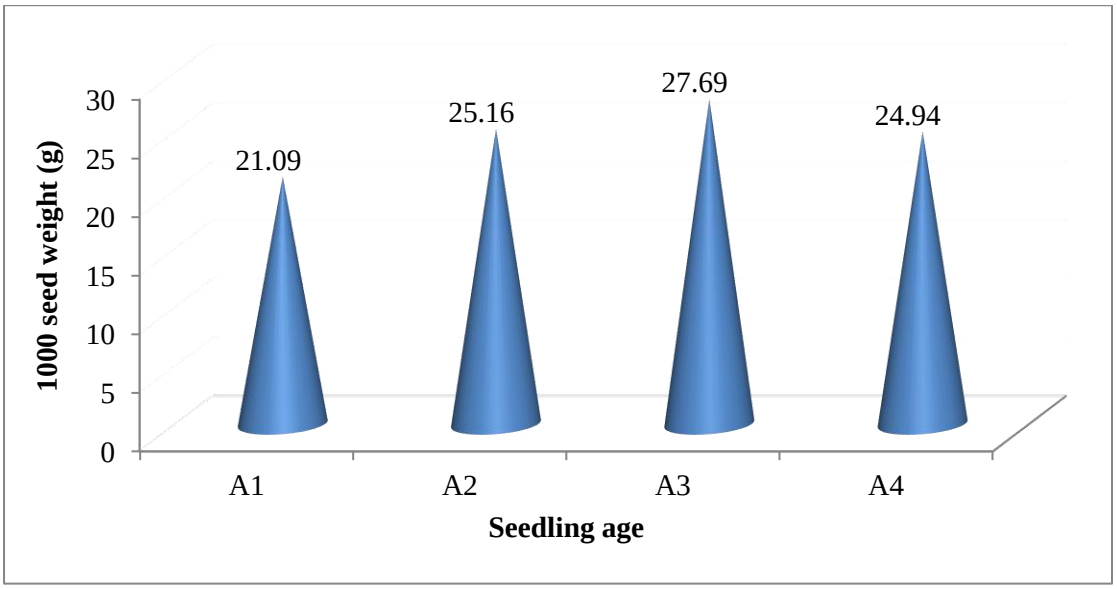


V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 12. Effect of variety on 1000 seed weight of T. aman rice ($LSD_{0.05}$ = 1.03)

4.7.2 Effect of seedling age

Weight of 1000 seed of T. aman rice showed statistically significant variation due to different age of seedling (Figure 13). The highest weight of 1000 seeds (27.69 g) was found from A_3 (30 days old seedling). On the other hand, the minimum weight of 1000 seeds (21.09 g) was observed from A_1 (20 days old seedling).



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 13. Effect of different age of seedling on 1000 seed weight of T. aman rice ($LSD_{0.05}$ = 1.19)

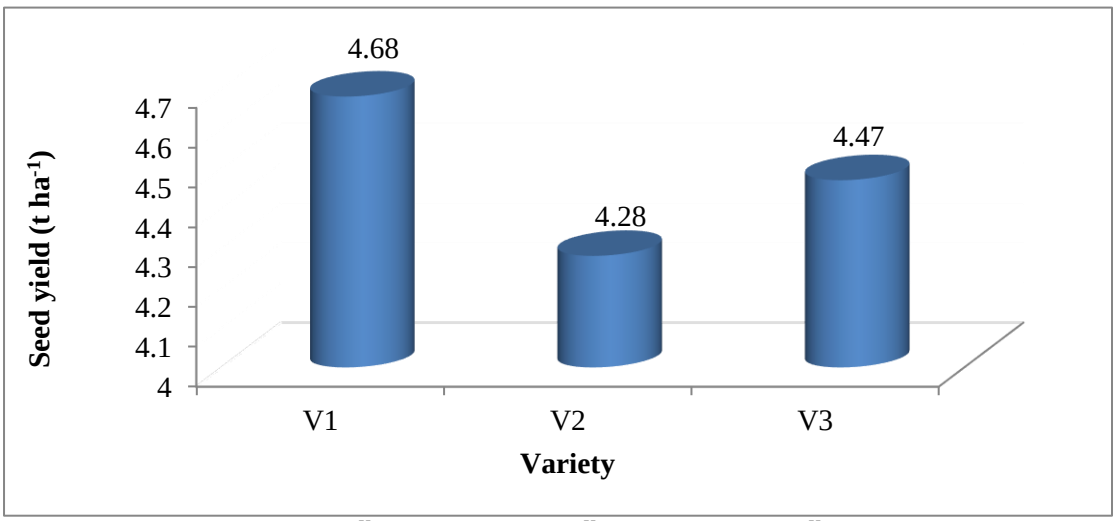
4.7.3 Interaction effect of variety and seedling age

Thousand seed weight of T. aman rice significantly influenced by the interaction effect of variety and different age of seedling (Table 5). The height 1000-seed weight (29.67 g) was recorded from V_1A_3 (BRRI dhan32 with 30 days old seedling) which was statistically higher from others. On the other hand, V_3A_1 (BRRI dhan80 with 20 days old seedling) which was statistically similar with V_2A_1. Azam *et al.* (2012) observed similar result with the present experiment in that variety and fertilizer application had significant effect on 1000 seed weight.

4.8 Seed yield

4.8.1 Effect of variety

Seed yield (t ha^{-1}**)** of T. aman rice was significantly influenced by different varieties (Figure 14). The result revealed that the variety BRRI dhan32 produced the highest seed yield (4.68 t ha^{-1}) and the variety BRRI dhan62 gave lowest seed yield (4.28 t ha^{-1}), which indicates that BRRI dhan32 out yielded over BRRI dhan80 and BRRI dhan62 by producing 4.70% and 9.35% higher yield, respectively. Zohra *et al.*, (2013) observed that the highest number of effective tillers $hill^{-1}$ (11.42) which eventually contributed to higher seed yield (5.46 t ha^{-1}) of BRRI dhan46 compared to (4.44 t ha^{-1}) BINA dhan7, which indicates that yield variation among the varieties may be attributes to the genetic makeup of the varieties.

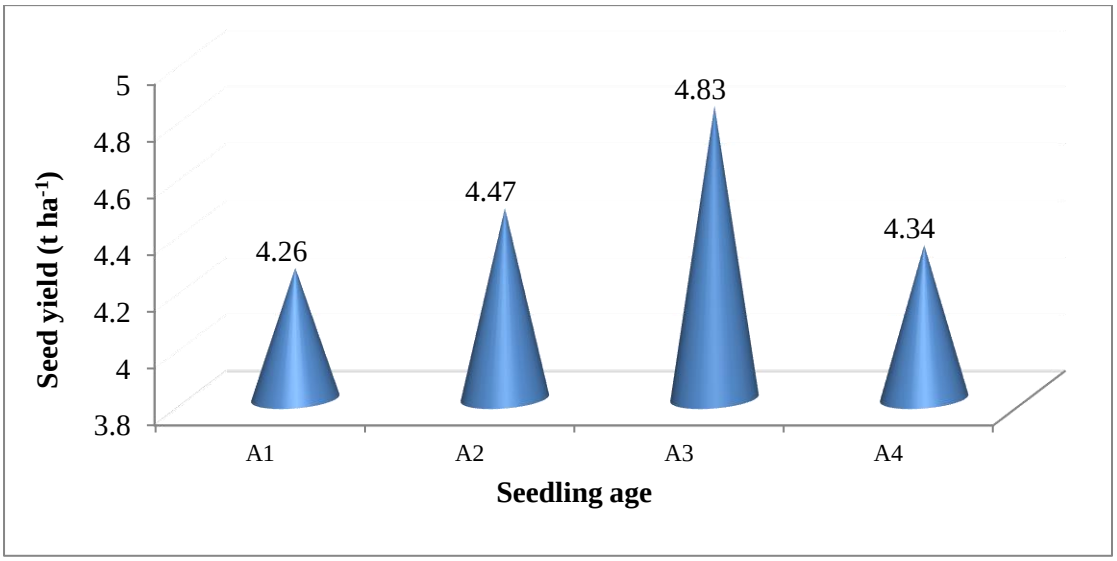


V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 14. Effect of variety on seed yield of T. aman rice ($LSD_{0.05}$ =0.19)

4.8.2 Effect of seedling age

Due to different age of seedling seed yield of T. aman rice showed statistically significant differences (Figure 15). The figure indicates that A_3 (30 days old seedling) treatment was superior in producing higher yield than A_1 (20 days old seedling), A_2 (25 days old seedling) and A_4 (35 days old seedling). The highest seed yield (4.83 t ha^{-1}) was obtained from A_3 (30 days old seedling). On the other hand, the lowest seed yield (4.26 t ha^{-1}) was found from A_1 (20 days old seedling). Similar result was reported by Devivedi and Thakur (2000) stated that the seed yield was significantly increased due to different age of seedlings. This is also in agreement with the findings of Rajni Rani *et al*. (2001) and Haque *et al.* (2001).



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 15. Effect of different age of seedling on seed yield of T. aman rice ($LSD_{0.05}$ = 0.21)

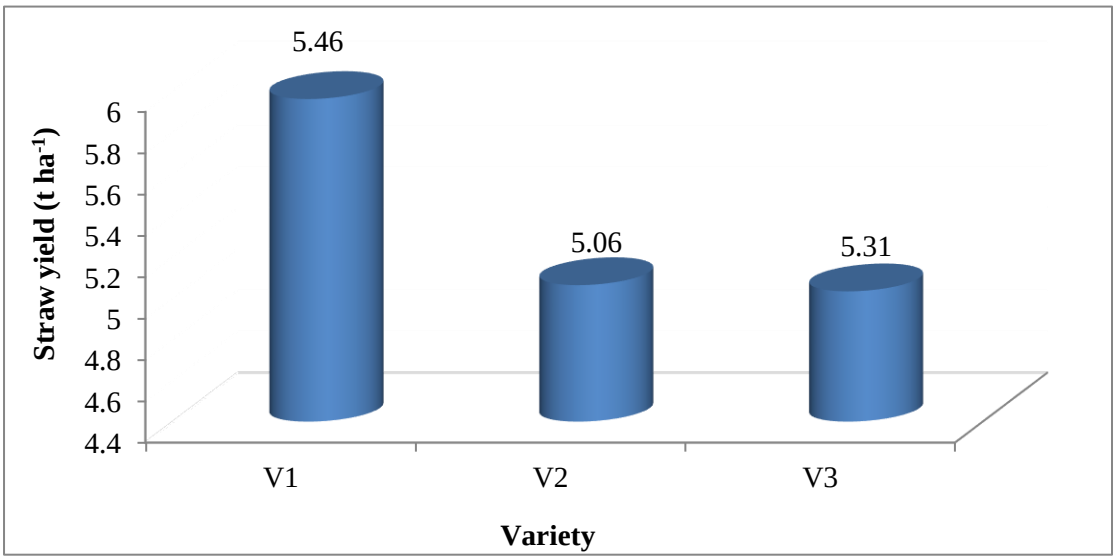
4.8.3 Interaction effect of variety and seedling age

Interaction of varieties and different age of seedling have significant effect on seed yield of T. aman rice (Table 5). The highest seed yield (5.12 t ha^{-1}) was obtained from V_1A_3 treatment. On the other hand, V_2A_4 showed the lowest result (4.12 t ha^{-1}).

4.9 Straw yield

4.9.1 Effect of variety

Straw yield of T. aman rice was significantly influenced by different varieties (Figure 16). The result revealed that the variety BRRI dhan32 produced the highest straw yield (5.46 t ha^{-1}) and the variety BRRI dhan62 gave lowest straw yield (5.06 t ha^{-1}). Islam *et al.* (2013) observed that the highest straw yield was found from BR11 and lowest from BRRI dhan33, which confirms the present findings. This result was in agreement with the finding of Patel (2000) who reported that yield performance varied among the varieties.

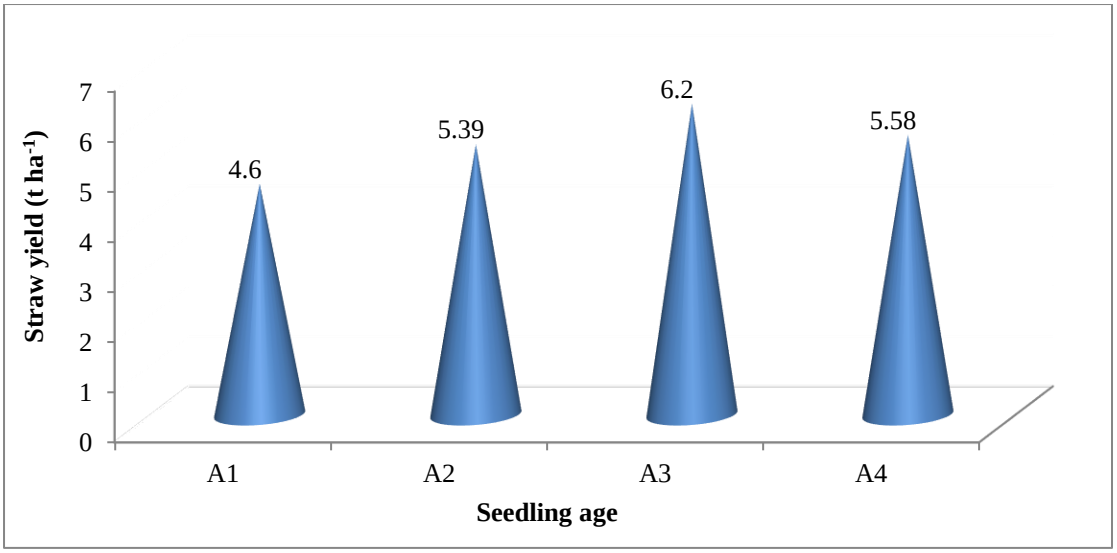


V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 16. Effect of variety on straw yield of T. aman rice ($LSD_{0.05}$ =0.23)

4.9.2 Effect of seedling age

Straw yield of T. aman rice varied significantly due to the different age of seedling (Figure 17). The highest straw yield (6.20 t ha^{-1}) was obtained from A_3 (30 days old seedling). On the other hand, the lowest straw yield (4.60 t ha^{-1}) was found from A_1 (20 days old seedling). Azam *et al.* (2012) conducted an experiment and find out more or less similar result on growth and yield of T. aman rice and result showed significant effect on straw yield.



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 17. Effect of seedling age on straw yield of T. aman rice ($LSD_{0.05}$ =0.27)

4.9.3 Interaction effect of variety and seedling age

Interaction of varieties and different age of seedling have significant effect on straw yield of rice (Table 5). The highest straw yield (6.93 t ha^{-1}) was obtained from V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment which was statistically different from other treatments and followed by V_1A_4, V_2A_3 and V_1A_2. On the other hand, V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment showed the lowest result (4.01 t ha^{-1}) which was statistically similar with V_3A_1.

Table 5. Interaction effect of variety and seedling age on 1000 seed weight, Seed yield and straw yield of rice

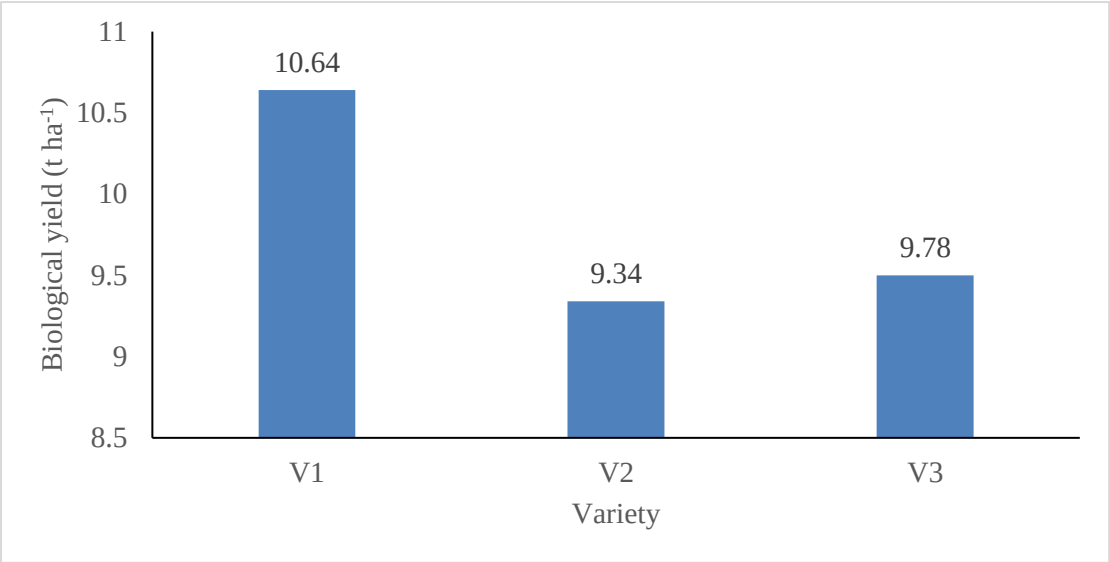
Treatment	1000 seed weight (g)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
V_1A_1	23.03 d	4.41 c-e	4.91 e
V_1A_2	26.86 b	4.60 cd	5.76 c
V_1A_3	29.67 a	5.12 a	6.93 a
V_1A_4	25.88 bc	4.59 c	6.25 b
V_2A_1	20.64 e	4.08 e	4.01 g
V_2A_2	24.37 cd	4.31 de	4.96 e
V_2A_3	26.53 b	4.61 cd	6.04 bc
V_2A_4	23.93 cd	4.12 e	5.23 de
V_3A_1	19.60 e	4.29 f	4.89 fg
V_3A_2	24.26 cd	4.50 cd	5.45 ef
V_3A_3	26.87 b	4.77 b	5.63 cd
V_3A_4	25.01 b-d	4.30 e	5.27 de
LSD $_{(0.05)}$	**2.06**	**0.37**	**0.47**
CV%	**4.93**	**4.81**	**5.14**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
[V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80; A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling]

4.10 Biological yield

4.10.1 Effect of variety

Biological yield of T. aman rice was significantly influenced by different varieties (Figure 18). The maximum biological yield (10.64 t ha^{-1}) was produced from BRRI dhan32 and minimum biological yield (9.34 t ha^{-1}) was observed from BRRI dhan62.

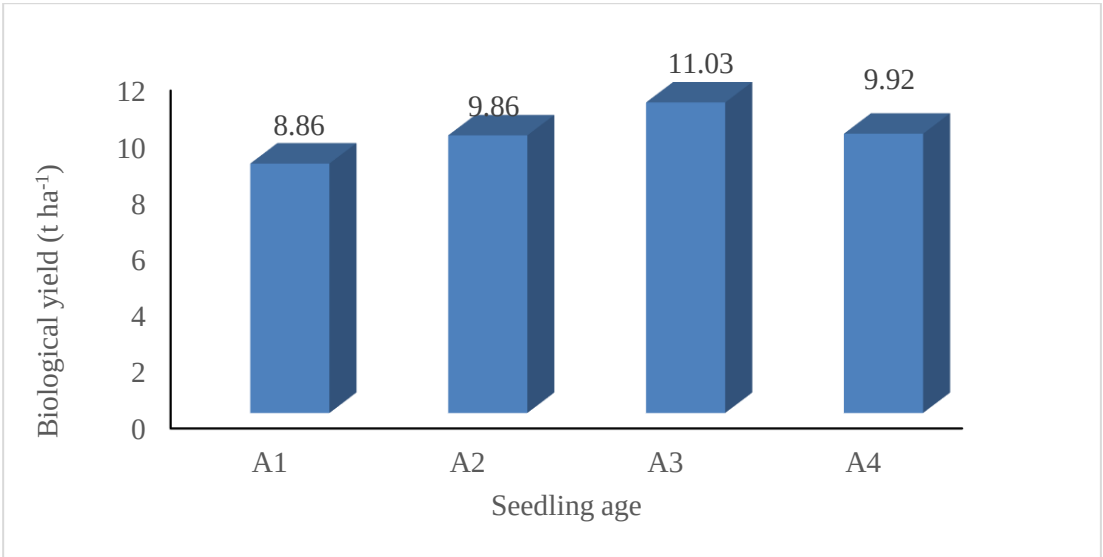


V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 18. Effect of variety on biological yield of T. aman rice ($LSD_{0.05}$ =0.42)

4.10.2 Effect of seedling age

Biological yield of T. aman rice showed statistical significant variation due to the different age of seedling (Figure 19). The highest biological yield (11.03 t ha^{-1}) was obtained from A_3 (30 days old seedling). On the other hand, the lowest biological yield (8.86 t ha^{-1}) was found from A_1 (20 days old seedling).



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 19. Effect of seedling age on biological yield of T. aman rice ($LSD_{0.05}$ = 0.48)

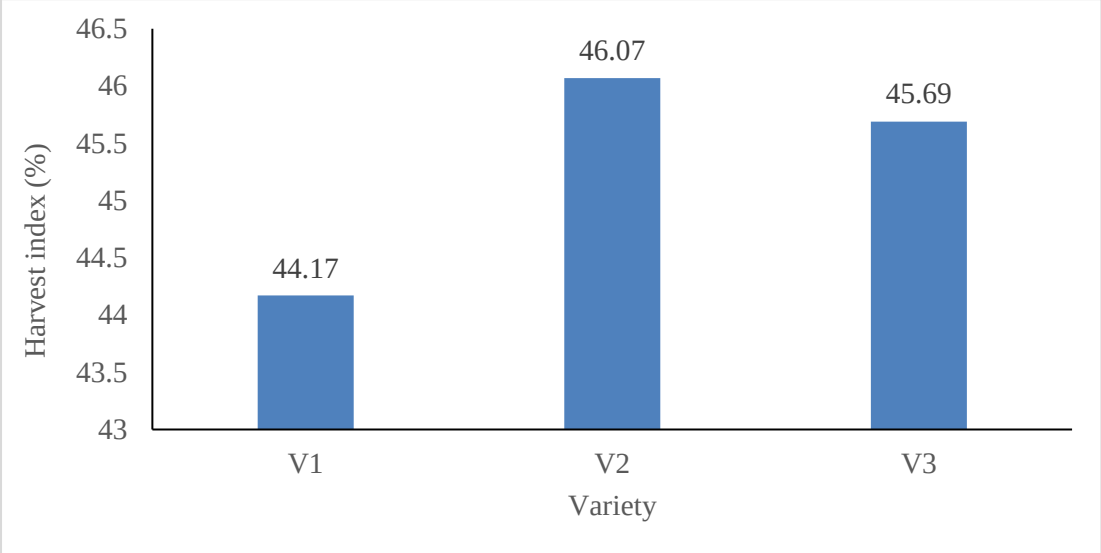
4.10.3 Interaction of variety and seedling age

Interaction of variety and different age of seedling have significant effect on biological yield of rice (Table 6). The highest biological yield (12.05 t ha^{-1}) was obtained from V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment. On the other hand, V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment showed the lowest result (8.09 t ha^{-1}).

4.11 Harvest index

4.11.1 Effect of variety

Harvest index values were different among the varieties (Figure 20). The highest harvest index value was found in BRRI dhan62 (46.07%) followed by BRRI dhan80 (45.69%). The lowest harvest index value was found in BRRI dhan32 (44.17).

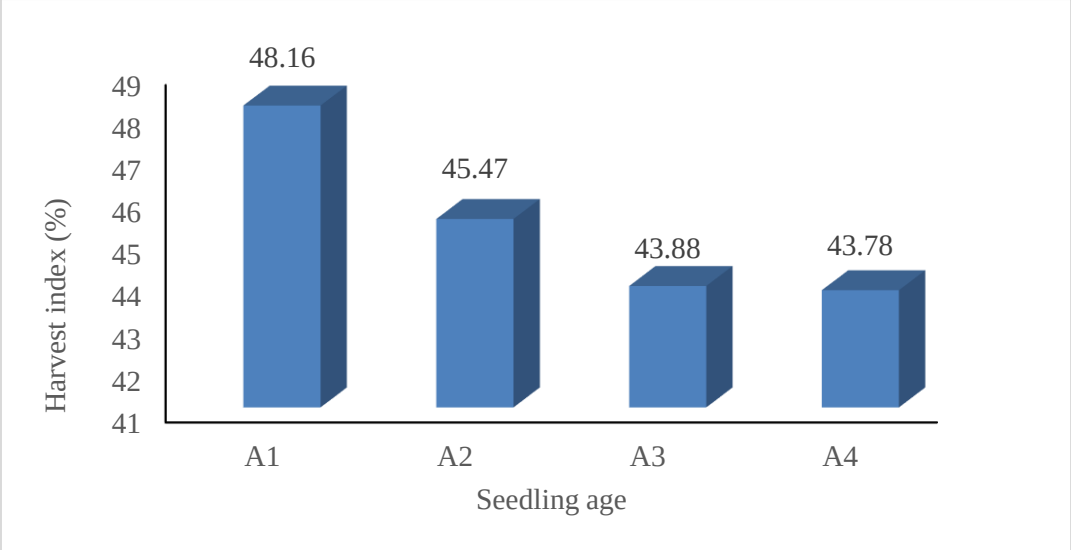


V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80

Figure 20. Effect of variety on harvest index of T. aman rice ($LSD_{0.05}$ =0.04)

4.11.2 Effect of seedling age

Harvest index of T. aman rice showed statistically significant variation due to different age of seedling (Figure 21). The highest harvest index (48.16%) was found from A_1 (20 days old seedling) which was followed by A_2 (25 days old seedling). On the other hand, the lowest harvest index (43.78%) was observed from A_4 (35 days old seedling).



A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling

Figure 21. Effect of seedling age on harvest index of T. aman rice ($LSD_{0.05}$ =0.04)

4.11.3 Interaction effect of variety and seedling age

Interaction of variety and different age of seedling have significant effect on harvest index (HI) of rice (Table 6). The highest HI value (50.43%) was observed in the treatment V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment. On the other hand, V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment showed the lowest result (42.49%).

Table 6. Interaction effect of variety and seedling age on biological yield and harvest index of rice

Treatment	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
V_1A_1	9.32 d	47.32 d
V_1A_2	10.36 c	44.40 g
V_1A_3	12.05 a	42.49 k
V_1A_4	10.84 b	42.34 k
V_2A_1	8.09 e	50.43 a
V_2A_2	9.27 d	46.49 e
V_2A_3	10.65 b	43.29 i
V_2A_4	9.35 d	44.06 h
V_3A_1	9.18 d	46.73 e
V_3A_2	9.85 c	45.23 f
V_3A_3	10.4 b	45.87 f
V_3A_4	9.57 c	44.93 g
LSD $_{(0.05)}$	**0.84**	**0.08**
CV%	**4.96**	**0.36**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
[V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80; A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling]

4.12 Germination percentage

4.12.1 Effect of variety

The germination (%) showed statistically non-significant impact due to different variety of rice (Table 7). However, it can be inferred from the table that the value of germination (%) was higher (88.33%) in V_1 variety (BRRI dhan32). However, the minimum germination percentage (83.65%) was recorded in V_2 variety (BRRI dhan62).

4.12.2 Effect of seedling age

The germination (%) exerted significant effect due to different age of seedling in rice (Table 7). The highest germination (%) (92.01%) was recorded in A_3 (30 days old seedling) treatment which was statistically similar with the A_2 (25 days old seedling)

treatment. On the other hand, the lowest germination percentage (83.13%) was found in 20 days old seedling (A_1), which was statistically at par with A_4.

4.12.3 Interaction effect of variety and seedling age

Combine effect of variety and different age of seedling produced statistically significant variation in germination (%) of rice (Table 7). The germination (%) ranges from 78.60% to 92.86% among the combination. The maximum germination (92.86 %) was found in V_1A_3 (BRRI dhan32 with 30 days old seedling) which was statistically at par with V_1A_2, V_3A_3, V_3A_2 and V_2A_3. The minimum germination (78.60%) was found in V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment combination.

Table 7. Effect of variety, seedling age and their interaction on germination percentage of T. aman rice

Treatment	Germination (%)
Variety	
V_1 (BRRI dhan32)	88.33
V_2 (BRRI dhan62)	83.65
V_3 (BRRI dhan80)	86.39
LSD (0.05)	**NS**
CV (%)	**4.87**
Seedling age	
A_1 (20 days old seedling)	83.13 b
A_2 (25 days old seedling)	86.19 b
A_3 (30 days old seedling)	92.01 a
A_4 (35 days old seedling)	83.17 b
LSD (0.05)	**4.10**
CV (%)	**4.87**
Interaction of variety and seedling age	
V_1A_1	83.88 bc
V_1A_2	92.36 a
V_1A_3	92.86 a
V_1A_4	84.23 bc
V_2A_1	78.60 c
V_2A_2	82.36 bc
V_2A_3	91.41 a
V_2A_4	82.25 bc
V_3A_1	83.14 bc
V_3A_2	87.12 ab
V_3A_3	92.25 a
V_3A_4	83.03 bc
LSD (0.05)	**7.10**
CV%	**4.87**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
[V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80; A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling]

4.13 Root length

4.13.1 Effect of variety

The root length showed statistically non-significant impact due to different variety of rice (Table 8). The highest root length (8.44 cm) was recorded in V_3 variety (BRRI dhan80) while the lower root length (8.13 cm) was in V_2 variety (BRRI dhan62).

4.13.2 Effect of seedling age

Due to different age of seedling root length showed significant variations of rice (Table 8). The highest value of root length (9.07 cm) was recorded in A_3 (30 days old seedling) treatment, which was statistically similar with A_2 and A_4 treatment. On the other hand, the lowest value of root length 7.86 cm was found from A_1 (20 days old seedling) treatment.

4.13.3 Interaction effect of variety and seedling age

Combined effect of variety and different age of seedling produced statistically significant root length in rice (Table 8). The maximum root length (9.20 cm) was found from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment, which was statistically similar with V_3A_3 (9.17 cm), V_2A_4 (8.84 cm) and V_3A_2 (8.53 cm). Whereas, the minimum root length (7.66 cm) was found in V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment.

4.14 Shoot length

4.14.1 Effect of variety

The shoot length showed statistically significant impact due to different variety of rice (Table 8). However, the highest shoot length (14.35 cm) was recorded in V_1 variety (BRRI dhan32) which was followed by V_3 (13.44 cm), while the lowest shoot length (13.19 cm) was in V_2 variety (BRRI dhan62).

4.14.2 Effect of seedling age

Due to different age of seedling shoot length showed significant variations of rice (Table 8). The highest value of shoot length (14.44 cm) was recorded in A_3 (30 days old seedling) treatment, which was statistically similar with A_2 treatment. On the other hand, the lowest value of shoot length (12.81 cm) cm was found from A_1 treatment (20 days old seedling).

4.14.3 Interaction effect of variety and seedling age

Combined effect of variety and different age of seedling produced statistically significant shoot length in rice (Table 8). The maximum shoot length (15.07 cm) was found from the V_1A_3 (BRRI dhan32 with 30 days old seedling) which was statistically similar with V_1A_2, V_1A_4, V_2A_3 and V_3A_3 treatment. Whereas, the minimum shoot length (12.34 cm) was found in V_2A_4 treatment, which was statistically similar with V_2A_1, V_1A_1, V_3A_1, V_2A_2, V_3A_4 and V_3A_2 treatment.

4.15 Shoot dry weight of seedling

4.15.1 Effect of variety

Varietal difference on rice showed significant variations for shoot dry weight of seedling (Table 8). The maximum value of shoot dry weight (17.41 mg) was found in V_1 (BRRI dhan32) and the minimum value of shoot weight (12.93 mg) was recorded in V_2 variety (BRRI dhan62).

4.15.2 Effect of seedling age

The shoot dry weight showed significant variations due to different Seedling age on rice (Table 8). The highest value of shoot dry weight (17.20 mg) was recorded in A_3 (30 days old seedling) treatment, which was statistically similar with A_2 (25 days old seedling) treatment. On the other hand, the lowest value of shoot dry weight 14.30 mg was found from A_1 (20 days old seedling) treatment, which was statistically at par with A_4.

4.15.3 Interaction effect of variety and seedling age

Combined effect of variety and different age of seedling exerted significant shoot dry weight of rice (Table 8). The maximum shoot dry weight (19.29 mg) was found from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment. Whereas, the minimum shoot dry weight (10.73 mg) was found in V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment.

4.16 Root dry weight of seedling

4.16.1 Effect of variety

Varietal difference on rice showed non-significant variations for root dry weight of seedling (Table 8). The maximum value of root dry weight (17.99 mg) was found in

V_3 (BRRI dhan80) which was statistically at par with A_1 (17.70 mg) and the minimum value of root dry weight (17.47 mg) was recorded in V_2 variety (BRRI dhan62).

4.16.2 Effect of seedling age

The root dry weight showed significant variations due to different age of seedling on rice (Table 8). The highest value of root dry weight (19.62 mg) was recorded in A_3 (30 days old seedling) treatment, which was statistically different from other treatments. On the other hand, the lowest value of root dry weight 15.94 mg was found from A_1 (20 days old seedling) treatment.

4.16.3 Interaction effect of variety and seedling age

Combined effect of variety and different age of seedling produced statistically significant root dry weight of rice (Table 8). The maximum root dry weight (20.00 mg) was found from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment. Whereas, the minimum root dry weight (15.46 mg) was found in V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment.

4.17 Vigor index

4.17.1 Effect of variety

The vigor index showed statistically significant impact due to different variety of rice (Table 8). The highest vigor index (1991.72) was recorded in V_1 variety (BRRI dhan32) while the lower vigor index (1827.96) was in V_2 variety (BRRI dhan62).

4.17.2 Effect of seedling age

Due to different age of seedling vigor index showed significant variations of rice (Table 8). The highest value of vigor index (2001.54) was recorded in A_3 (30 days old seedling) treatment, which was statistically similar with A_2. On the other hand, the lowest value of vigor index 1722.86 was found from A_1 (20 days old seedling) treatment.

4.17.3 Interaction effect of variety and seedling age

Combined effect of variety and different age of seedling produced statistically significant vigor index in rice (Table 8). The maximum vigor index (2152.49) was found from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment. Whereas, the minimum vigor index (1685.51 cm) was found in V_2A_1 (BRRI dhan62 with 20 days old seedling) treatment.

Table 8. Effect of variety, seedling age and their interaction on seedling characteristics of different T. aman rice cultivars

Treatment	Seedling Characteristics				
	Root length (cm)	Shoot length (cm)	Shoot dry weight (mg)	Root dry weight (mg)	Vigor index
Variety					
V_1	8.34	14.35 a	17.41 a	17.70	1991.72
V_2	8.13	13.19 c	12.93 b	17.47	1827.96
V_3	8.44	13.44 b	16.77 a	17.99	1903.37
LSD (0.05)	**NS**	**0.57**	**0.66**	**NS**	**NS**
CV%	**4.76**	**4.87**	**4.93**	**4.91**	**9.77**
Seedling age					
A_1	7.86 b	12.81 c	14.30 d	15.94 c	1722.86 b
A_2	8.36 b	13.82 a	16.07 b	18.01 b	1928.13 a
A_3	9.07 a	14.44 a	17.20 a	19.62 a	2001.54 a
A_4	7.91 b	13.51 b	15.25 c	17.31 b	1878.21 b
LSD $_{(0.05)}$	**0.39**	**0.66**	**0.76**	**0.85**	**182.5**
CV (%)	**4.76**	**4.87**	**4.93**	**4.91**	**9.77**
Interaction of different variety and seedling age					
V_1A_1	7.71 d	12.96 de	15.73 de	15.67 de	1733.80 b
V_1A_2	8.35 b-d	14.83 ab	17.40 bc	18.29 bc	2129.82 a
V_1A_3	9.20 a	15.07 a	19.29 a	20.00 a	2152.49 a
V_1A_4	8.09 cd	14.53 a-c	17.22 bc	16.82 c-e	1950.77 ab
V_2A_1	7.66 d	12.64 e	10.73 g	15.46 e	1685.51 b
V_2A_2	8.21 b-d	13.38 c-e	13.39 f	17.76 c	1696.97 b
V_2A_3	8.84 ab	14.23 a-c	14.38 ef	19.46 ab	2013.76 ab
V_2A_4	7.80 cd	12.34 e	13.22 f	17.20 cd	1915.60 ab
V_3A_1	8.20 b-d	12.84 de	16.45 cd	16.69 c-e	1749.27 b
V_3A_2	8.53 a-c	13.27 c-e	17.41 bc	17.97 bc	1957.59 ab
V_3A_3	9.17 a	14.01 a-d	17.92 b	19.39 ab	2138.36 a
V_3A_4	7.85 cd	13.62 b-e	15.30 de	17.89 bc	1768.27 b
LSD $_{(0.05)}$	**0.67**	**1.12**	**1.14**	**1.47**	**316.2**
CV%	**4.76**	**4.87**	**4.93**	**4.91**	**9.77**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[V_1=BRRI dhan32; V_2=BRRI dhan62; V_3=BRRI dhan80; A_1= 20 days old seedling; A_2= 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July 2019 to December 2019 to study the effect of seedling age on yield and seed quality of T. aman rice variety. The three varieties included in this study were BRRI dhan32, BRRI dhan62 and BRRI dhan80. There were four age of seedlings, such as A_1= 20 days old seedling; A_2 = 25 days old seedling; A_3 = 30 days old seedling and A_4 = 35 days old seedling. The experiment was laid out in a 2 factor Randomized Complete Block Design (RCBD) with three replications. Data on growth, yield attribute, yield and seed quality was recorded.

At 30, 60, 90 DAT and at harvest the tallest plant (36.10, 96.25, 122.10 and 123.40 cm, respectively) was found in BRRI dhan32 and the lowest (29.29, 79.94, 97.08 and 98.33 cm, respectively) was found in BRRI dhan62. At 30, 60, 90 DAT and at harvest the maximum number of tillers per hill (3.80, 13.42, 15.31 and 20.22 tillers, respectively) was recorded from V_2 and again the minimum (2.95, 11.07, 13.39 and 17.92 tillers, respectively) was observed from V_1.

At 30, 60, 90 DAT and at harvest, the tallest plant (33.98, 93.50, 113.90 and 115.20 cm) was recorded from A_3 (30 days old seedling) and the lowest (31.07, 86.11, 108.60 and 109.90 cm) was found in A_1 (20 days old seedling). At 30, 60 and 90 DAT the maximum number of tillers per hill (3.69, 12.94, 16.26 and 20.68 tillers) was recorded from A_3 and again the minimum (2.76, 11.46, 13.42 and 18.38 tillers) was observed from A_1.

In most of the cases, the interaction effect between variety and different age of seedling was significant. At 30, 60, 90 DAT and at harvest the tallest plant (38.65, 104.00, 127.00 and 128.20 cm, respectively) was recorded from V_1A_3 (BRRI dhan32 with 30 days old seedling) and the lowest (27.64, 76.90, 92.33 and 93.58 cm, respectively) was found in V_2A_1 (BRRI dhan62 with 20 days old seedling). At 30, 60, 90 DAT and at harvest the maximum number of tillers per hill (4.78, 14.71, 18.39 and 21.70 tillers, respectively) was recorded from V_1A_3 and again the minimum (2.51, 10.66, 12.55 and 17.57 tillers, respectively) was observed from V_2A_1.

Number of effective tiller, length of panicle, number of filled seeds, weight of 1000 seeds, seed yield, straw yield and biological yield was greatly influenced by different varieties. The maximum number of effective tillers hill^{-1} (17.30), longest panicle (28.53 cm), highest number of filled seeds panicle^{-1} (117.1), lowest number of unfilled seed panicle^{-1} (15.54), highest 1000-seed weight (26.36 g), highest seed yield (4.68 t ha^{-1}), highest straw yield (5.46 t ha^{-1}) and maximum biological yield (10.64 t ha^{-1}) was observed in the V_1 (BRRI dhan32). Similarly, maximum seed germination percentage (88.33%), highest root length (8.34 cm), highest shoot length (14.35 cm), maximum shoot dry weight (17.41 g), maximum root dry weight (17.70 g) and highest vigor index (1991.72), was observed in the V_1 (BRRI dhan32) variety.

The minimum number of effective tillers hill^{-1} (14.90), shortest panicle (25.40 cm), lowest number of filled seeds panicle^{-1} (98.6), highest number of unfilled seeds panicle^{-1} (24.27), lowest 1000-seed weight (23.87 g), seed yield (4.28 t ha^{-1}), straw yield (5.06 t ha^{-1}), biological yield (9.34 t ha^{-1}), germination percentage (83.65%), root length (8.13 cm), shoot length (13.19 cm), vigor index (1827.96), shoot dry weight (12.93 g) and root dry weight (17.47 g) were obtained from the variety V_2 (BRRI dhan62) variety.

The number of effective tillers per hill, length of panicle, number of filled seeds, weight of 1000 seeds, seed yield, straw yield and biological yield was significantly influenced by application of different organic manures. The maximum number of effective tillers per hill (16.69), longest panicle (28.15 cm), maximum number of filled seed per panicle (124.9), lowest number of unfilled seed per panicle (17.99), highest weight of 1000 seeds (27.69 g), highest seed yield (4.83 t ha^{-1}), highest straw yield (6.20 t ha^{-1}), highest biological yield (11.03 t ha^{-1}), maximum seed germination percentage (92.01%), highest root length (9.07cm), highest shoot length (14.44 cm), highest vigor index (2001.54), maximum shoot dry weight (17.20 g), maximum root dry weight (19.62 g) was found from A_3 (30 days old seedling).

The minimum number of effective tillers per hill (15.48), lowest length of panicle (25.90 cm), minimum number of filled seed per panicle (93.8), maximum number of unfilled seed per panicle (24.64), minimum weight of 1000 seeds (21.09 g), lowest seed yield (4.26 t ha^{-1}), lowest straw yield (4.60 t ha^{-1}), lowest biological yield (8.86 t ha^{-1}), minimum germination percentage (83.13%), lowest root length (7.86 cm),

lowest shoot length (12.81 cm), lowest vigor index (1722.86), lowest shoot dry weight (14.30 g) and lowest root dry weight (15.94 g) was recorded from A_1 as 20 days old seedling.

All the parameters were significantly influenced by the interaction of varieties and plant organic manures. The highest number of effective tillers hill^{-1} (18.39), highest length of panicle (30.48 cm), highest number of filled seeds (136.2) panicle^{-1}, lowest number of unfilled seeds per panicle (10.73), highest 1000-seed weight (29.67 g), highest seed yield (5.12 t ha^{-1}), highest straw yield (6.93 t ha^{-1}), highest biological yield (12.05 t ha^{-1}), maximum seed germination percentage (92.86%), highest root length (9.20 cm), highest shoot length (15.07 cm), highest vigor index (2152.49), maximum shoot dry weight (24.09 g), maximum root dry weight (17.90 g) was observed from the V_1A_3 (BRRI dhan32 with 30 days old seedling) treatment whereas, the lowest tiller hill^{-1} (14.43), lowest number of panicle length (24.03 cm), lowest number of filled seeds per panicle (83.0), highest number of unfilled seed per panicle (31.07), lowest seed yield (4.08 t ha^{-1}), lowest straw yield (4.01 t ha^{-1}), lowest biological yield (8.09 t ha^{-1}), minimum seed germination percentage (78.60%), lowest root length (7.66 cm), lowest shoot length (12.64 cm), lowest vigor index (1685.51), lowest shoot dry weight (10.73 g) and lowest root dry weight (15.46 g) was observed from V_2A_1 (BRRI dhan62 with 20 days old seedling).

CONCLUSION

Considering the above result of this experiment the following conclusions can be drawn:

- Among the T. aman rice varieties, BRRI dhan32 gave higher seed yield and best seed quality.
- Among the different age of seedling, 30 days old seedling gave maximum yield and best quality seed.
- Variety BRRI dhan32 with 30 days old seedling gave high seed yield and best seed quality.
- BRRI dhan32 should be transplanted at 30 days old seedling for obtaining highest seed yield and quality.

CHAPTER VI

REFERENCES

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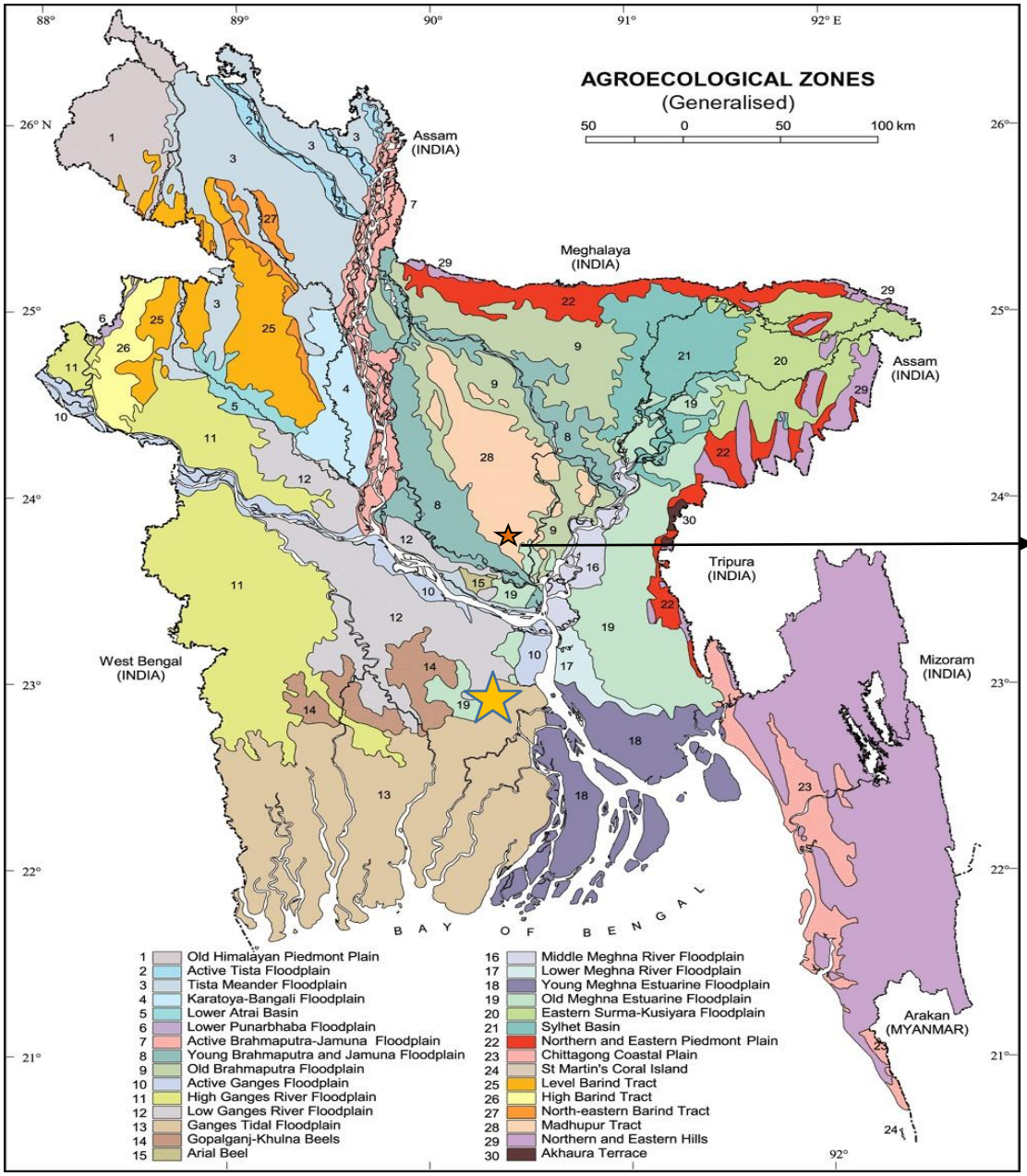
CHAPTER VII

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from July 2019 to December 2019.

Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
July 2019	31.4	25.8	81	542
August 2019	32.0	26.6	82	361
September 2019	32.7	26.0	81	514
October 2019	30.5	24.3	80	417
November 2019	29.0	19.8	72	3
December 2019	27.0	15.6	66	0

Source: Sher-e-Bangla Agricultural University Weather Station and Bangladesh Meteorological Department.

Appendix III. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0-15 cm depth)

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Source: Soil Resources Development Institute (SRDI)

Chemical composition:

Soil characters	Value
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.54
Total nitrogen (%)	0.027
Phosphorus	6.3 µg/g soil
Sulphur	8.42 µg/g soil
Magnesium	1.17 meq/100 g soil
Boron	0.88 µg/g soil
Copper	1.64 µg/g soil
Zinc	1.54 µg/g soil
Potassium	0.10 meg/100g soil

Source: Soil Resources Development Institute (SRDI)

Morphological Characteristics of the Experimental Field

Morphology	Characteristics
Location	SAU farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ-28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Appendix IV. Factorial ANOVA for plant height at 30 DAT

Source of variances	DF	SS	MS	F	P
Replication	2	0.28	0.14	0.0511	
Variety	2	287.133	143.567	52.4374	0.00
Different age of seedling	3	42.968	14.323	5.2314	0.0071
Variety*Different age of seedling	6	31.644	5.274	1.9263	0.1213
Error	22	60.233	2.738		

Appendix V. Factorial ANOVA for plant height at 60 DAT

Source of variances	DF	SS	MS	F	P
Replication	2	1.45	0.725	0.0787	
Variety	2	1690.529	845.264	91.7807	0.00
Different age of seedling	3	259.926	86.642	9.4078	0.0003
Variety*Different age of seedling	6	96.441	16.073	1.7453	0.1576
Error	22	202.611	9.21		

Appendix VI. Factorial ANOVA for plant height at 90 DAT

Source of variances	DF	SS	MS	F	P
Replication	2	2.720	1.360	0.0636	
Variety	2	4019.090	2009.545	93.9135	0.0000
Different age of seedling	3	156.841	52.280	2.4433	0.0911
Variety*Different age of seedling	6	803.424	133.904	6.2578	0.0006
Error	22	470.752	21.398		

Appendix VII. Factorial ANOVA for plant height at harvesting stage

Source of variances	DF	SS	MS	F	P
Replication	2	2.054	1.027	0.0469	
Variety	2	4040.348	2019.174	92.2700	0.0000
Different age of seedling	3	159.916	53.305	2.4347	0.0919
Variety*Different age of seedling	6	807.573	134.596	6.1476	0.0007
Error	22	481.671	21.894		

Appendix VIII. Factorial ANOVA for tiller hill^{-1} at 30 DAT

Source of variances	DF	SS	MS	F	P
Replication	2	0.005	0.003	0.0802	
Variety	2	4.420	2.210	65.0837	0.0000
Different age of seedling	3	4.721	1.574	46.3427	0.0000
Variety*Different age of seedling	6	3.741	0.623	18.3584	0.0000
Error	22	0.747	0.034		

Appendix IX. Factorial ANOVA for tiller hill^{-1} at 60 DAT

Source of variances	DF	SS	MS	F	P
Replication	2	0.033	0.016	0.0425	
Variety	2	33.700	16.850	43.5529	0.0000
Different age of seedling	3	11.585	3.862	9.9819	0.0002
Variety*Different age of seedling	6	4.141	0.690	1.7838	0.1490
Error	22	8.511	0.387		

Appendix X. Factorial ANOVA for tiller hill^{-1} at 90 DAT

Source of variances	DF	SS	MS	F	P
Replication	2	0.031	0.016	0.0274	
Variety	2	26.198	13.099	22.9908	0.0000
Different age of seedling	3	43.379	14.460	25.3783	0.0000
Variety*Different age of seedling	6	14.304	2.384	4.1843	0.0059
Error	22	12.535	0.570		

Appendix XI. Factorial ANOVA for tiller hill^{-1} at harvesting stage

Source of variances	DF	SS	MS	F	P
Replication	2	0.021	0.010	0.0112	
Variety	2	46.092	23.046	24.8213	0.0000
Different age of seedling	3	25.797	8.599	9.2615	0.0004
Variety*Different age of seedling	6	13.840	2.4844	2.307	0.0547
Error	22	20.427	0.928		

Appendix XII. Factorial ANOVA for effective tiller

Source of variances	DF	SS	MS	F	P
Replication	2	0.030	0.015	0.0234	
Variety	2	35.798	17.899	27.4739	0.0000
Different age of seedling	3	8.972	2.991	4.5906	0.0121
Variety*Different age of seedling	6	1.143	0.191	0.2924	
Error	22	14.333	0.651		

Appendix XIII. Factorial ANOVA for panicle length

Source of variances	DF	SS	MS	F	P
Replication	2	0.051	0.026	0.0141	
Variety	2	62.916	31.458	17.3705	0.0000
Different age of seedling	3	26.234	8.745	4.8286	0.0099
Variety*Different age of seedling	6	8.571	1.428	0.7887	
Error	22	39.842	1.811		

Appendix XIV. Factorial ANOVA for number of filled seeds per panicle

Source of variances	DF	SS	MS	F	P
Replication	2	58.245	29.123	0.6777	
Variety	2	2149.726	1074.863	25.0132	0.0000
Different age of seedling	3	4447.634	1482.545	34.5004	0.0000
Variety*Different age of seedling	6	144.098	24.016	0.5589	
Error	22	945.380	42.972		

Appendix XV. Factorial ANOVA for number of unfilled seed per panicle

Source of variances	DF	SS	MS	F	P
Replication	2	0.460	0.230	0.5971	
Variety	2	558.903	279.452	726.1025	0.0000
Different age of seedling	3	201.098	67.033	174.1721	0.0000
Variety*Different age of seedling	6	122.646	20.441	53.1121	0.0000
Error	22	8.467	0.385		

Appendix XVI. Factorial ANOVA for 1000 seed weight

Source of variances	DF	SS	MS	F	P
Replication	2	0.131	0.066	0.0442	
Variety	2	48.290	24.145	16.2790	0.0000
Different age of seedling	3	200.163	66.721	44.9843	0.0000
Variety*Different age of seedling	6	6.650	1.108	0.7473	
Error	22	32.630	1.483		

Appendix XVII. Factorial ANOVA for seed yield

Source of variances	DF	SS	MS	F	P
Replication	2	0.005	0.002	0.0533	
Variety	2	0.969	0.484	10.4556	0.0006
Different age of seedling	3	5.266	1.755	37.8921	0.0000
Variety*Different age of seedling	6	2.316	0.386	8.3324	0.0001
Error	22	1.019	0.046		

Appendix XVIII. Factorial ANOVA for straw yield

Source of variances	DF	SS	MS	F	P
Replication	2	0.005	0.002	0.0533	
Variety	2	0.969	0.484	10.4556	0.0006
Different age of seedling	3	5.266	1.755	37.8921	0.0000
Variety*Different age of seedling	6	2.316	0.386	8.3324	0.0001
Error	22	1.019	0.046		

Appendix XIX. Factorial ANOVA for biological yield

Source of variances	DF	SS	MS	F	P
Replication	2	0.040	0.020	0.0842	
Variety	2	12.097	6.048	25.4237	0.0000
Different age of seedling	3	36.037	12.012	50.4937	0.0000
Variety*Different age of seedling	6	0.755	0.126	0.5290	
Error	22	5.234	0.238		

Appendix XX. Factorial ANOVA for harvest index

Source of variances	DF	SS	MS	F	P
Replication	2	0.033	0.016	0.6171	
Variety	2	45.426	22.713	852.7123	0.0000
Different age of seedling	3	71.380	23.793	893.2749	0.0000
Variety*Different age of seedling	6	140.242	23.374	877.5181	0.0000
Error	22	0.586	0.027		

Appendix XXI. Factorial ANOVA for percent germination

Source of variances	DF	SS	MS	F	P
Replication	2	1.301	0.651	0.0370	
Variety	2	132.504	66.252	3.7724	0.0390
Different age of seedling	3	470.829	156.943	8.9363	0.0005
Variety*Different age of seedling	6	187.342	31.224	1.7779	0.1503
Error	22	386.374	17.562		

Appendix XXII. Factorial ANOVA for root length

Source of variances	DF	SS	MS	F	P
Replication	2	0.001	0.001	0.0046	
Variety	2	1.191	0.596	3.8156	0.0378
Different age of seedling	3	2.478	0.826	5.2908	0.0067
Variety*Different age of seedling	6	5.868	0.978	6.2652	0.0006
Error	22	3.434	0.156		

Appendix XXIII. Factorial ANOVA for shoot length

Source of variances	DF	SS	MS	F	P
Replication	2	0.014	0.007	0.0150	
Variety	2	8.211	4.106	9.0803	0.0013
Different age of seedling	3	6.391	2.130	4.7114	0.0109
Variety*Different age of seedling	6	7.350	1.225	2.7093	0.0400
Error	22	9.947	0.452		

Appendix XXIV. Factorial ANOVA for shoot dry weight

Source of variances	DF	SS	MS	F	P
Replication	2	0.215	0.108	0.1791	
Variety	2	140.924	70.462	117.352	0.0000
Different age of seedling	3	40.818	13.606	22.6605	0.0000
Variety*Different age of seedling	6	12.037	2.006	3.3413	0.0171
Error	22	13.209	0.600		

Appendix XXV. Factorial ANOVA for root dry weight

Source of variances	DF	SS	MS	F	P
Replication	2	0.215	0.108	0.1791	
Variety	2	140.924	70.462	117.352	0.0000
Different age of seedling	3	40.818	13.606	22.6605	0.0000
Variety*Different age of seedling	6	12.037	2.006	3.3413	0.0171
Error	22	13.209	0.600		

Appendix XXVI. Factorial ANOVA for vigor index

Source of variances	DF	SS	MS	F	P
Replication	2	2938.30	1469.15	0.0421	
Variety	2	140314.119	70157.059	2.0122	0.1576
Different age of seedling	3	576961.658	192320.553	5.5159	0.0056
Variety*Different age of seedling	6	334431.676	55738.613	1.5986	0.1947
Error	22	767067.607	34866.709		

Appendix 8: Some pictorial view of the experiment

Plate 1: Plot preparation

Plate 2: Seedling transplanting in main field

Plate 3: Intercultural operation in the experimental field

Plate 4: Growing seedling in the main field

Plate 5: Signboard of the experiment


Plate 6: Crop ready to harvest

Plate 7: Data collection

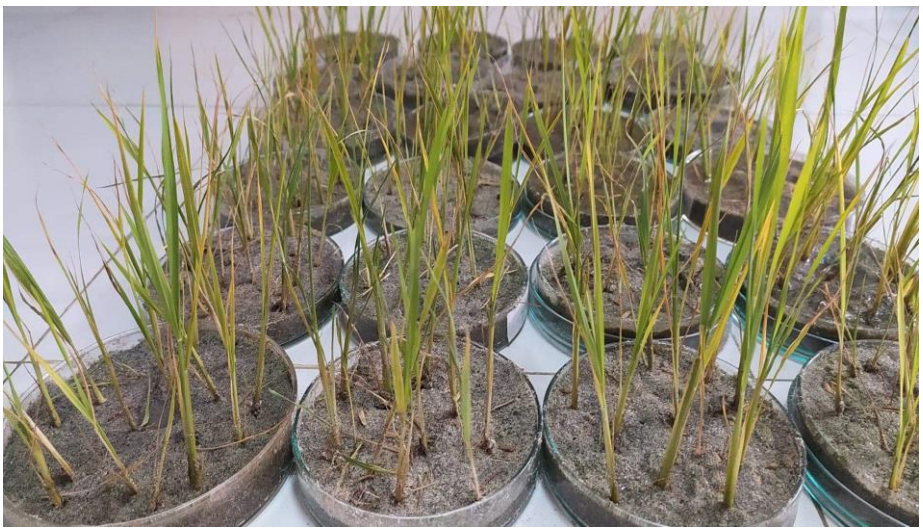


Plate 8: Data collection for seed quality analysis