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ORIGINAL RESEARCH ARTICLE

Growth and yield of short duration *Aman* rice (*Oryza sativa*) cultivars as influenced by age of seedlings

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ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh during the period from July to December 2019 to study the effect of cultivar and seedling age on the performance of short duration transplant *Aman* rice. The experiment comprised four *Aman* rice cultivars, viz., BRRI dhan49, BRRI dhan56, BRRI dhan66 and BRRI dhan71, and four seedling ages viz. 20, 25, 30 and 35-day old seedlings. The experiment was laid out in a randomized complete block design with three replications. Results of the study showed that growth, yield and yield contributing characters were significantly influenced by cultivars, seedlings age and their interactions. At growth stage, BRRI dhan49 with 20-day old seedlings produced the tallest plant (57.67 cm and 67.33 cm, respectively), the highest number of total tillers hill^{-1} (15.00 and 13.67, respectively) and total dry matter (8.03 g m^{-2} and 11.50 g m^{-2}, respectively) at 30 and 50 DAT. At harvest, the highest number of total and effective tillers hill^{-1} (12.82 and 12.00), longest panicle (24.50 cm), highest number of grains panicle^{-1} (128.80), heaviest 1000-grain weight (23.17 g), highest grain yield (5.35 t ha^{-1}) and highest harvest index (51.69 %) were obtained from the cultivar BRRI dhan66. While, thirty-day old seedlings produced the highest number of total and effective tillers hill^{-1} (13.46 and 12.70), longest panicle (24.67 cm), highest number of grains panicle^{-1} (136.90), highest grain (5.62 t ha^{-1}) and straw yields (5.81 t ha^{-1}) and harvest index (51.67 %). In case of interactions, BRRI dhan66 with 30-day old seedlings produced the highest number of total and effective tillers hill^{-1} (14.67 and 13.97), longest panicle (26.00 cm), highest number of grains panicle^{-1} (146.7), highest grain yield (6.31 t ha^{-1}) and highest harvest index (52.72 %). So, result of the present study reveals that BRRI dhan66 with 30-days old seedlings was found to be the best for obtaining maximum grain yield.

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INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food grain in the diets of billions of people of Asia, Africa and Latin America and also possibly will continue to be in the future. Bangladesh is the third-largest rice producer in the world (Rahman *et al*., 2021). Rice is the leading staple food of the people of Bangladesh, accounting for more than 80% of total food supply, and provides 66% of total protein requirements for daily food intake (Rahaman *et al*., 2020). Geographic and agro-ecological conditions of Bangladesh are favorable for rice cultivation. Agriculture of Bangladesh is characterized by intensive crop

production with rice-based cropping system. Rice is grown on 11.4 million hectares of land, accounting for 77% of total cropped area and yielding 36.6 million tons of rice per year (BBS, 2020a), which is very poor compared to other advanced rice growing countries (FAO, 2014). The demand of rice increases as the population increases in the country. It is a small country with a large population, and each year, nearly 1.47 million people are added to its current population of about 164.4 million, and at present, population growth is 1.37% (BBS, 2019). The pressure on Bangladesh's land resources to produce more rice will aggravate in the coming years due to the increasing population and demand for food. In Bangladesh, rice is grown in three distinct growing seasons namely *Aus* (March to June) *Aman* (June to November) and *Boro* (November to May). Among these seasons, *Aman* is the second largest rice crop in the country in respect to acreage. It is notable that the area coverage of *Aman* is the largest as a single crop. *Aman* rice covers the area of 5.5 million hectares with a production of 27.91 million metric tons (BBS, 2020). Average yield of *Aman* for the financial year 2020-2021 has been estimated 2.5 metric tons per hectare which is 0.46% higher than that of previous year (BBS, 2021). The potential for increasing rice yield strongly depends on the ability to integrate a better crop management for the different cultivars into existing cultivation systems. Cultivar is one of the most important factors which contribute much in producing yield and yield components of rice. Higher yield could be achieved from the suitable cultivar if appropriate method of planting is used (Akhtar *et al.*, 2007; Liu *et al.*, 2022). Traditionally, long duration rice varieties are cultivated in *Aman* season and many research reports are available on their management practices (Chakrobarty *et al.*, 2021; Al Mamun *et al.*, 2021; Mia *et al.*, 2022). Recently short duration rice varieties for *Aman* season have been developed to overcome Monga (workless period) situation and to facilitate early *Rabi* crop cultivation. Cultivation of short duration *Aman* rice can create an opportunity to intensify the cropping intensity from double cropping to triple cropping. Therefore, attempts should be taken to increase the yield per unit area by applying improved technologies. Moreover, cropping intensity should be increased by adopting short duration *Aman* rice cultivars. BRRI has developed some short duration rice cultivars like BRRI dhan56, BRRI dhan66 and BRRI dhan71 (Rahman *et al.*, 2021). Seedling age is also an important factor due to its tremendous influence on the plant height, tiller production, panicle length, grains per panicle and other yield contributing characters (Luna *et al.*, 2017; Sinha *et al.*, 2018; Virk *et al.*, 2020; Islam *et al.*, 2021). The practice of transplanting seedling at different days having different ages is termed as staggered planting. This is difference practice than simultaneous transplanting. The farmers of Bangladesh do not give proper attention to the age of seedlings at transplanting. The use of over aged seedling ultimately affects the general performance of crop and the yield of the crop reduces drastically. So, it is very important to find out the optimum age of seedlings of a variety for a particular season. The Bangladesh Rice Research Institute has recommended the seedlings age of rice for transplanting based on the growing season, such as 20-30 days for *Aus* season, 20-35 days for transplant *Aman* season and 45 days for *Boro* season (BRRI, 1991; BRRI, 1992). But the farmers are less experienced regarding the effect of seedling age on the yield and yield contributing characters for HYV. However, the potential for increasing rice production strongly depends on various factors like as cultivar, seedling age, planting method, sowing time, seed rate, etc. Among them, selection of a better cultivar concerning the regional condition of the cultivated area and seedling age is the most important features for maximizing the rice yield. But informing regarding cultivar and seedling age, and their response to yield are very limited in the literature. That's why, it is necessary to find out the optimum age of seedlings of a particular cultivar for a particular season for higher yield. Therefore, the present study was therefore undertaken to find out the effects of cultivar and age of seedlings along with their interaction effects on growth, yield and yield attributes of transplant *Aman* rice.

MATERIALS AND METHODS

Experimental site and experimentation

The experiment was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the transplant *Aman* season from July to November 2019 to ascertain the growth and yield of short duration *Aman* rice cultivar as influenced by age of seedlings. The experimental field was located at 24°75´N latitude and 90°50´E longitude at an average altitude of 18 m. It belongs to the Non-calcareous Dark Grey Floodplain Soil (Old Brahmaputra Alluvial Soil Tract) under the Old Brahmaputra Floodplain Agro Ecological Zone (AEZ 9) (UNDP and FAO, 1988). The field was a medium high flat land with well drained loamy soil having pH (6.5), total nitrogen (0.13%), available phosphorus (P_2O_5) (16.3 ppm), potassium (0.28%) and low organic matter (0.93%), respectively and the land was above the flood level (Chakraborty *et al.*, 2020). The experimental area was under the sub-tropical climate characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). The experimental treatments consisted of four rice varieties, viz. BRRI dhan49 (check), BRRI dhan56, BRRI dhan66 and BRRI dhan71, and four ages of seedling, viz. 20-day old, 25-day old, 30-day old and 35-day old. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each replication was divided into 16-unit plots. Thus, the total number of unit plots was 48 (4×4×3). The size of unit plot was 2.5 m × 2.0 m. The distances between blocks and plots were 1.0 m and 0.5 m, respectively.

Crop husbandry

Seeds of BRRI dhan49, BRRI dhan56, BRRI dhan66 and BRRI dhan71 were collected from the Bangladesh Rice Research Institute, Joydebpur, Gazipur. A piece of high land was selected

at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh for raising seedlings. Proper care was taken to raise the seedlings in the nursery bed. The final land was prepared thoroughly by tilling once with a power tiller and subsequently ploughing three times with country plough followed by laddering. The experimental plots were fertilized with urea (150 kg ha^{-1}), triple super phosphate (55 kg ha^{-1}) muriate of potash (105 kg ha^{-1}), gypsum (70 kg ha^{-1}) and zinc sulphate (10 kg ha^{-1}). The full dose of triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate were applied at the time of land preparation. Urea was top dressed in three equal splits at 10, 25 and 40 days after transplanting. All management practices were done as and when necessary.

Data collection

The data on different crop characters were collected both at vegetative and in maturity stage. To record data on growth parameters, five hills were randomly selected soon after transplanting and marked with bamboo sticks in each plot excluding border rows to record the data on plant height and number of tillers $hill^{-1}$ at 30 DAT and 50 DAT. To determine the total dry matter, plants were randomly selected excluding border rows and central area at 30 and 90 DAT. Then, roots of each plant were removed and the whole plants were washed with tap water. Then, the plant samples were packed in labeled brown paper bags and dried in the oven at 70±5^{0}C for 72 hours until constant weight was reached and the samples were weighed carefully after oven drying to measure the dry weight of plant. At maturity, five hills (excluding border hills) from each unit plot were taken randomly to record yield contributing attributes and the whole plots harvested to obtain grain and straw yields. The harvested crop of each plot was separately bundled, properly tagged and then brought to the threshing floor. The harvested crops were threshed manually and the grain was cleaned and dried to a moisture content of 14 %. Straws were sun dried properly. Final grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}. The harvest index was calculated as follows:

Biological yield = Grain yield + Straw yield

Harvest index (%)= Grain yield/Biological yield×100

Statistical analysis of data

Data were analyzed using the analysis of variance technique with the help of computer package program MSTAT-C and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effects of cultivars on growth parameters at vegetative stage

The plant height, tillering pattern and dry matter of rice varied significantly due to different variety (Figure 1). The plant height development pattern revealed that all the varieties increase their height progressively with the advancement of growth stages. At 30 and 50 DAT, BRRI dhan56 attained the tallest plant (58.75 cm and 75.50 cm), respectively. Though BRRI dhan49 produced the shortest plant (51.17 cm) at 30 DAT but at 50 DAT it produced the second tallest plant (74.25 cm) which was statistically identical to BRRI dhan56 and BRRI dhan71 (Figure 1A). The difference was probably due to the genetic make-up of particular varieties. The present result was agreed well with the results of BINA (2018) and Saha *et al.* (2019). At 30 DAT, BRRI dhan66 produced the highest number of total tillers $hill^{-1}$ (12.83) and the lowest number of total tiller $hill^{-1}$ (11.17) was obtained from BRRI dhan49. Similarly, at 50 DAT, BRRI dhan66 produced the highest number of total tillers $hill^{-1}$ (13.23) and BRRI dhan49 produced the lowest number of total tillers $hill^{-1}$ (10.17) (Figure 1B). Roy *et al.* (2014) and Jisan *et al.* (2014) also found such varietal differences of tillering in the medium and traditional varieties. The dry matter development pattern revealed that all the varieties increase their dry matter progressively with the progress of growth stages. At 30 and 50 DAT, BRRI dhan66 produced the highest total dry matter (6.871 and 10.61 g m^{-2}). On the other hand, at 30 and 50 DAT, BRRI dhan49 produced the lowest total dry matter (5.81 and 8.62 g m^{-2}) (Figure 1C). The difference was probably due to the genetic makeup of particular varieties.

Effects of age of seedlings on growth parameters at vegetative stage

The plant height, tillering pattern and dry matter of rice varied significantly due to the seedlings age at 30 and 50 DAT (Figure 2). At 30 DAT, almost every 35-day old seedlings produced the tallest plant (57.33 cm) which was statistically identical to 30-days old seedlings. Whereas, at 50 DAT, 30-days old seedlings produced the tallest plant (75.25cm) which was at par with 25-days old seedlings (Figure 2A). Therefore, the tallest plant in 30 DAT and 50 DAT were observed in 35-day old seedlings and 30-days old seedlings, respectively. This might be due to the fact that optimum age of seedlings helped crop to complete its vegetative phase in favorable climatic conditions. Similar results were also noticed from the findings of Pathania *et al.* (2016) and Faruk *et al.* (2009) where, the tallest plant was recorded from the older seedlings. Result also showed that in most of the cases gradual increase of tillers $hill^{-1}$ with the increase of seedling age at 30 DAT. The result also revealed that at 30 DAT, the 30-days old seedlings and 35-days old seedlings gave the highest total tillers $hill^{-1}$ which were statistically similar too. On the other hand, at 50 DAT, 35-days old seedlings showed the highest number of total tillers $hill^{-1}$ (12.18) and 20-days old seedlings showed the lowest number of total tillers $hill^{-1}$ (11.08) (Figure 2B). The result also indicates that the older seedlings had a tendency to produce a greater number of tillers $hill^{-1}$ than the younger ones up-to 35 days after transplanting. Interestingly, 35-day old seedlings also produced the highest total dry matter (7.28 and 10.28 g m^{-2}) at 30 DAT and 50 DAT, respectively which was statistically identical to 30-day old seedlings. At the end of 50 DAT, 20-day old

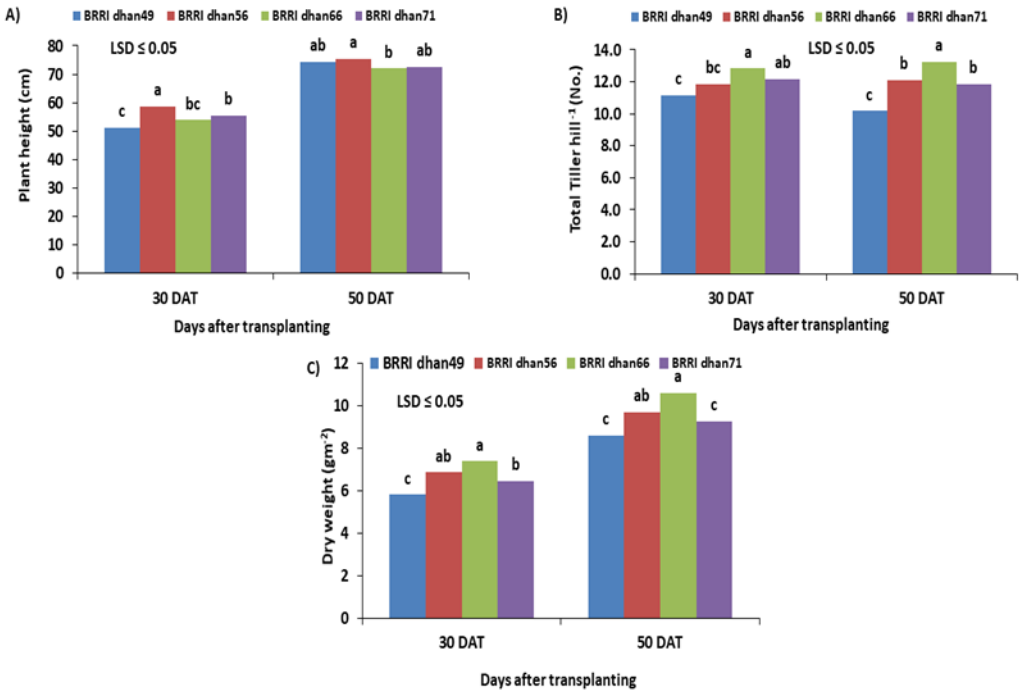

Figure 1. *Effect of cultivars on plant height (cm), number of total tiller hill^{-1} and dry matter (g m^{-2}) at 30 and 50 DAT (A-C).*

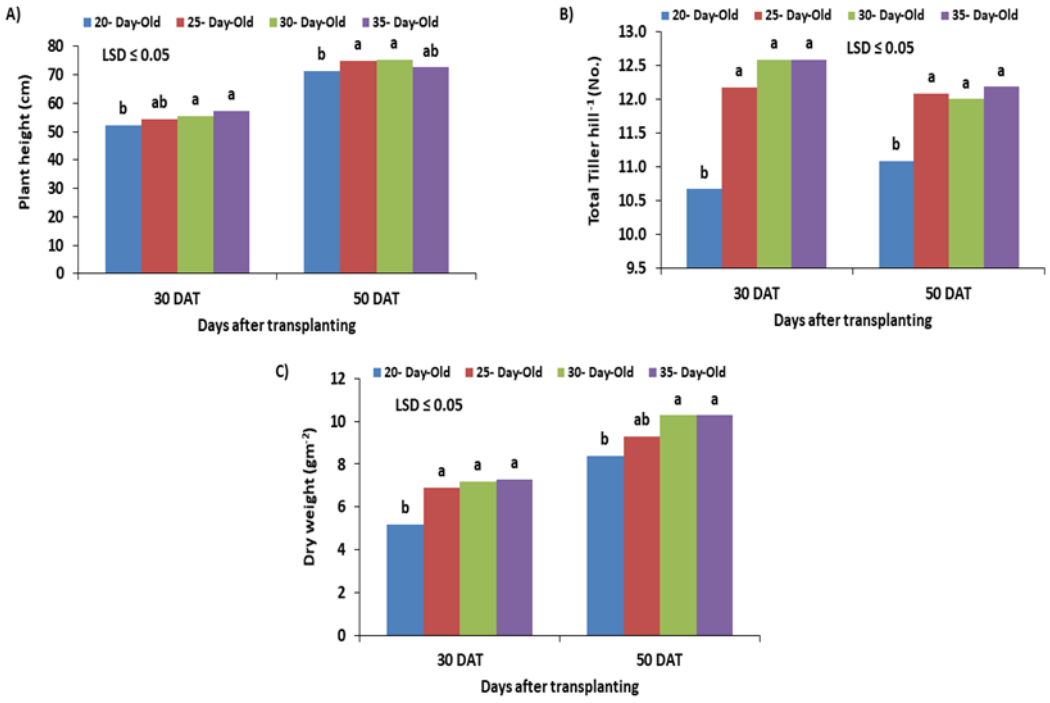

Figure 2. *Effect of age of seedlings on plant height (cm), number of total tiller hill^{-1} and dry matter (g m^{-2}) at 30 and 50 DAT (A-C).*

seedlings produced the lowest total dry matter (8.39 g m^{-2}) (Figure 2C). This also might be due to the reduced development of younger seedling in the soil and poor uptake of nutrient. A study was conducted by Pathania *et al*. (2016) who also observed that comparatively older seedlings produced more effective tillers hill^{-1}.

Interaction effects of cultivars and age of seedlings on growth parameter at vegetative stage

Interaction of cultivars and age of seedlings had significant effect on plant height, total tiller hill^{-1} and dry matter at 30 DAT and 50 DAT (Table 1). Numerically, at 30 and 50 DAT, the tallest plant (57.67 and 67.33 cm) was found in BRRI dhan49 with 20-day old seedlings, respectively and the shortest plant (45.33 and 56.67cm) was found in BRRI dhan71 with 35-day old seedlings, respectively. It was evident that younger seedlings produced better plant growth. Result also indicated that at 30 and 50 DAT, BRRI dhan49 with 20-day old seedlings also produced the highest number of tillers hill^{-1} (13.67 and 15.00) and the lowest number of tillers hill^{-1} (9.67 and 10.00) was found BRRI

Table 1. Interaction effects between variety and seedling age on plant height, number of total tillers hill^{-1} and dry matter at 30 DAT and 50 DAT in *Aman* rice.

Variety × Age of seedling	Plant height (cm)		Total tillers hill^{-1} (no.)		Dry matter (g m^{-2})	
	30 DAT	50 DAT	30 DAT	50 DAT	30 DAT	50 DAT
V_1A_1	57.67a*	67.33a	15.00a	13.67a	8.03a	11.50a
V_1A_2	56.33ab	64.67ab	14.00ab	13.33a	8.03a	11.19ab
V_1A_3	56.33ab	63.33abc	13.00abc	13.00ab	7.73ab	10.40ac
V_1A_4	56.00ab	63.33abc	12.67abc	13.00ab	7.40abc	10.35ac
V_2A_1	56.00ab	62.67abc	12.67abc	13.00ab	7.37ac	10.33ac
V_2A_2	53.67ab	61.33abc	12.00abc	12.67ac	7.00 ad	10.07ac
V_2A_3	53.67ab	60.33abc	12.00abc	12.33ad	6.93ad	9.93ac
V_2A_4	53.33ab	60.00bc	12.00abc	12.33ad	6.87ad	9.75ac
V_3A_1	53.00ab	59.67bc	11.67abc	11.67ad	6.70bd	9.67ac
V_3A_2	53.00ab	59.67bc	11.67abc	11.67ad	6.57be	9.37ac
V_3A_3	52.33ab	59.67bc	11.67abc	10.67bd	6.50be	9.33ac
V_3A_4	52.33ab	59.67bc	11.67abc	10.67bd	6.33ce	9.17bc
V_4A_1	52.33ab	59.00bc	11.33abc	10.67bd	5.77de	8.47cd
V_4A_2	52.00ab	59.00bc	11.33abc	10.33cd	5.77de	8.45cd
V_4A_3	51.33b	58.00bc	10.33bc	10.33cd	5.40e	8.40cd
V_4A_4	45.33c	56.67c	9.67c	10d	3.73f	6.63d
CV (%)	7.08	17.28	6.98	13.84	9.92	11.69
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01

*In a column, values having similar letter do not differ significantly whereas values with dissimilar letter differ significantly as per DMRT.
V_1= BRRI dhan49, V_2=BRRI dhan56, V_3=BRRI dhan66, V_4= BRRI dhan71; A_1= 20-days old seedlings, A_2= 25-days old seedlings, A_3= 30-days old seedlings; A_4= 35-days old seedlings.

Table 2. Effects of cultivar on yield and yield contributing characters of *T. Aman* rice.

Variety	Plant height (cm)	Panicle length (cm)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Straw yield (t ha^{-1})	Harvest index (%)
BRRI dhan49	114.7a*	24.50	16.25a	23.008a	6.0792a	50.838a
BRRI dhan56	112.5a	24.25	15.33a	23.1a	5.8208ab	50.78a
BRRI dhan66	113.2a	24.50	13.67a	23.175a	5.5275ab	51.697a
BRRI dhan71	108.3b	24.33	16.17a	22.767a	5.2417b	49.614b
CV (%)	3.35	3.97	19.24	3.97	15.56	46.73
Level of significance	0.01	NS	NS	NS	0.01	0.01

*In a column, values having similar letter do not differ significantly whereas values with dissimilar letter differ significantly as per DMRT.
Here, NS = Non-Significant; CV= Coefficient of variation.

dhan71 with 35-day old seedlings (Table 1). Moreover, the experimental result showed that at 30 DAT, the highest total dry matter of *Aman* rice (8.03 g m^{-2}) was found in both BRRI dhan49 with 20-day old seedlings and BRRI dhan49 with 25-day old seedlings and the lowest total dry matter (3.73 g m^{-2}) was found in BRRI dhan71 with 35-day old seedlings. Similarly, at 50 DAT the highest total dry matter of *Aman* rice (11.50 g m^{-2}) was found in BRRI dhan49 with 20-days old seedlings and the lowest total dry matter (6.63 g m^{-2}) was found BRRI dhan71 with 35-day old seedlings (Table 1).

Effect of cultivars on yield and yield contributing characters at harvest

Variety exerted significant effect on most of the yield and yield contributing characters except panicle length, sterile spikelets panicle^{-1} and 1000-grain weight (Figure 3 and Table 2). Results show that BRRI dhan49 produced the tallest plant (114.70 cm) which was statistically similar to BRRI dhan56 and BRRI dhan66 and the shortest plant was recorded from BRRI dhan71 (108.30 cm) (Table 2). These findings are in conformity with the findings of Naha (2007) and Kamal (2006) who also observed significant variation among the cultivars. This variation in plant height was probably due to the genetically makeup of the cultivars. The highest number of total tillers hill^{-1} (12.82) was found in BRRI dhan66 and the lowest number of tillers hill^{-1} (11.40) was observed in BRRI dhan71. BRRI dhan56 had the second highest number of total tillers hill^{-1} (12.15) (Figure 3A) Variable effect of variety on number of total tillers hill^{-1} was also reported by Hasan *et al.* (2017) who noticed that total tillers hill^{-1} differed significantly among the cultivars. The variation in number of total tillers hill^{-1} might be due to varietal attributes and genetical characters. The results show that the highest number of effective tillers hill^{-1} (12.00) was produced by the cultivar BRRI dhan66 which was at par with BRRI dhan56 and the cultivar BRRI dhan49 produced the lowest number of effective tillers hill^{-1} (9.73) (Figure 3B). The variation in number of effective tillers hill^{-1} might be due to varietal differences and genetic variation among the cultivar. Moula (2018) found same results in nine *Aman* cultivars of rice in rain-fed condition and concluded that the effective tillers hill^{-1} significantly influenced by culti-

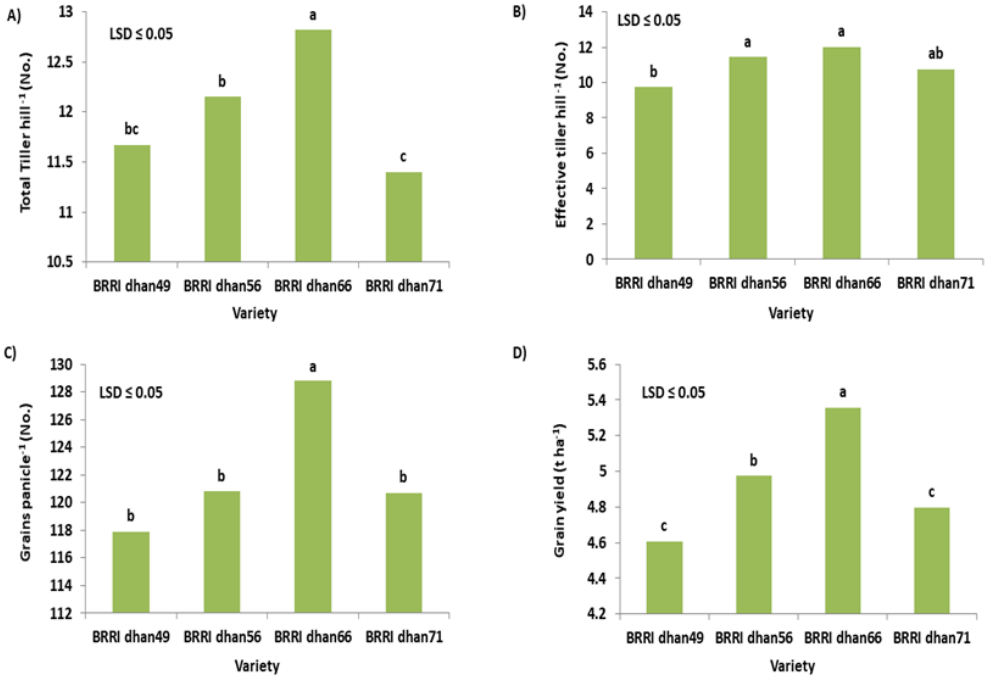

Figure 3. *Effect of cultivars on number of total tillers hill*$^{-1}$*, effective tillers hill*$^{-1}$*, grains panicle*$^{-1}$ *and grains yield (t ha*$^{-1}$*) (A-D).*

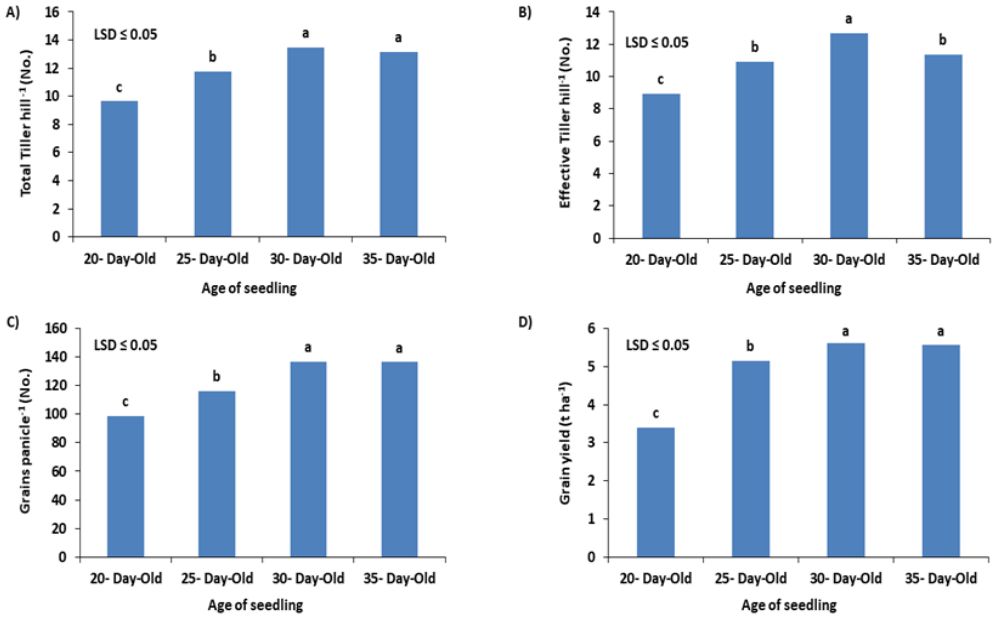

Figure 4. *Effect of age of seedlings on number of total tillers hill*$^{-1}$*, effective tillers hill*$^{-1}$*, grains panicle*$^{-1}$ *and grains yield (t ha*$^{-1}$*) (A-D).*

var. These findings also corroborate the findings of Ninad *et al.* (2017). Numerically the longest panicle (24.50 cm) was found in BRRI dhan49 and BRRI dhan66, and the smallest panicle (24.25 cm) was found in BRRI dhan56 (Table 2). Alam *et al.* (2012) reported same results in *Aman* rice cultivars of rice and have concluded that the panicle length was not significantly influenced by variety. Again, the highest number of grains panicle^{-1} (128.80) was recorded from BRRI dhan66 and BRRI dhan49 was the variety which produced the lowest number of grains panicle^{-1} (117.90) (Figure 3C). Variable number of grains panicle^{-1} among varieties was observed by Srinagar (2012). Varietal differences regarding the number of grains panicle^{-1} might be due to varietal difference in photosynthetic assimilate accumulation especially after heading. Numerically, the lowest number of sterile spikelets panicle^{-1} (13.67) was found from BRRI dhan66 and the highest number of sterile spikelets panicle^{-1} (16.25) was recorded from BRRI dhan49 (Table 2). While, BRRI dhan66 produced the heaviest 1000-grain weight (23.17 g) and the lowest 1000-grain weight (22.77 g) was observed from BRRI dhan71 (Table 2). Varietal variation regarding 1000-grain weight might be due to their variation in genetic constituents. Sohel *et al.* (2009) stated that weight of thousand grains of modern high yielding T. *Aman* varieties did not differ significantly. Again, the results showed that BRRI dhan66 produced the highest grain yield (5.35 t ha^{-1}) and the lowest grain yield (4.60 t ha^{-1}) was obtained from BRRI dhan49 (Figure 3D). The

Table 3. Effects of age of seedling on yield and yield contributing characters of *Aman* rice.

Age of seedling	Plant height (cm)	Panicle length (cm)	Sterile spikelet panicle^{-1} (no.)	1000-grain weight (g)	Straw yield (t ha^{-1})	Harvest index (%)
20-day old	115.6a*	24.5	19.08a	23.00ab	5.815a	50.258ab
25-day old	111.0b	24.25	14.92b	22.98ab	5.8042a	50.991a
30-day old	111.6b	24.667	13.25b	22.57a	5.7458a	51.676a
35 -day old	110.4b	24.167	14.17b	23.51b	5.3042a	48.005b
CV (%)	3.35	3.97	19.24	3.97	15.56	6.73
Level of significance	0.01	NS	0.01	0.01	NS	0.01

*In a column, values having similar letter do not differ significantly whereas values with dissimilar letter differ significantly as per DMRT.
NS = Non-Significant.

highest grain yield from BRRI dhan66 was mainly due to cumulative effect of higher number of effective tillers hill^{-1} and highest number of grains panicle^{-1}. Grain yield differences due to varieties were recorded by Chamely *et al.* (2015), Dangi *et al.* (2017) and Koireng *et al.* (2019) who observed variable grain yield among varieties. The highest straw yield (6.80 t ha^{-1}) was recorded from BRRI dhan49, while the lowest straw yield (5.24 t ha^{-1}) was attained by BRRI dhan71 (Table 2). The variation of straw yield is probably due to the genetic make-up of the cultivars. These results were consisted with those of Hussain *et al.* (2014) and Sarkar *et al.* (2014) who also observed significant variation among the varieties. Again, the highest harvest index (51.69 %) was obtained by BRRI dhan66 and the lowest harvest index (49.61 %) was attained by BRRI dhan71 (Table 2). It was the genetical attributes that have shown variation in harvest index of different varieties. Tyeb (2012) and Mahmud *et al.* (2017) observed the similar results and concluded that harvest index depended on inherent genetical attributes on same environmental conditions.

Effect of seedlings age on yield and yield contributing characters at harvest

Most of the yield and yield contributing characteristics differed significantly due to seedlings age except panicle length and straw yield (Figure 4 and table 3). The tallest plant (115.60 cm) was observed from 20-days old seedlings and the shortest plant (110.4 cm) was recorded from 35-day old seedlings which was statistically identical to 20-day old seedlings (Table 3). The highest number of total tillers hill^{-1} (13.46) was found in 30-day old seedlings and the lowest number of total tillers hill^{-1} (9.64) was found from 20-days old seedlings (Figure 4A). The result of this study indicates that the older seedlings had a tendency to produce a greater number of tillers hill^{-1} than older ones up-to 35-day old seedlings. This confirms the reports of Haque *et al.* (2002). Similarly, 30-day old seedlings produced the highest number of effective tillers hill^{-1} (12.70) and 20-day old seedlings produced the lowest number of effective tillers hill^{-1} (8.92) (Figure 4B). Numerically, the longest panicle (24.67 cm) was produced from 35-day old seedlings and the shortest panicle (24.17cm) was obtained from 30-day old seedlings (Table 3). Again, the highest number of grains panicle^{-1} (136.90) was produced by 30-day old seedlings and the lowest number of grains panicle^{-1} (98.83) was produced by 20-day old seedlings (Figure 4C). Here, the lowest number of sterile spikelets panicle^{-1} (13.25) was found from 30-day old seedling and twenty-days old seedling produced the highest number of sterile spikelets panicle^{-1} (19.08) (Table 3). The results indicate that the older seedling had a tendency to produce less sterile spikelets panicle^{-1} than the younger ones. This result was supported by Faruk *et al.* (2009). The highest 1000-grain weight (23.51 g) was produced by 35-day old seedling and the lowest 1000-grain weight (22.57 g) was produced by 30-day old seedlings (Table 3). While the result showed that the highest grain yield (5.62 t ha^{-1}) was obtained from 30-days old seedlings and the lowest grain yield (3.39 t ha^{-1}) was attained from 20-day old seedlings. The improvements of yield component such as longest panicle (24.25 cm), highest number of grain panicle^{-1} (136.9) and heaviest 1000-grain weight were responsible for the increased grain yield in 30-day old seedling (Figure 4D). The highest grain yield was obtained from younger seedlings. Similar results were also reported by Thapa *et al.* (2019) and Vijayalaxmi *et al.* (2016). Again, the highest straw yield (5.81 t ha^{-1}) was attained by 20-day old seedlings but it was at par with 25-days old seedlings and the lowest straw yield (5.30 t ha^{-1}) was attained by 35-day old seedlings (Table 3). While, the highest harvest index (51.67 %) was attained by 30-day old seedlings which was statistically identical to other seedling ages except 35-day old seedlings and the lowest harvest index was (48.00%) was attained by 35-day old seedlings (Table 3).

Interaction effect of cultivars and age of seedlings on yield and yield contributing characters at harvest

Effect of interaction of variety and age of seedlings on yield and yield contributing characters were significant except panicle length and 1000-grain weight (Table 4). The tallest plant (122.30cm) was recorded from cultivar BRRI dhan66 with 30-day old seedlings and the shortest plant (105.3 cm) was found in BRRI dhan66 with 35-days old seedlings (Table 4). Similarly, the highest number of total tillers hill^{-1} (14.67) was observed in the cultivar BRRI dhan66 with 30-day old seedlings while the lowest number of total tillers hill^{-1} (9.33) was observed in the variety BRRI dhan49 with 20-day old seedlings (Table 4). In addition, the highest number of effective tillers hill^{-1} (13.97) was obtained from the variety BRRI dhan66 with 30-day old seedlings. On the contrary, the lowest number of effective tillers hill^{-1} (8.13) was recorded from BRRI dhan49 using 35-

Table 4. Interaction effects of cultivar and age of seedling on yield and yield contributing characters of *T. Aman* rice.

Variety × Age of seedling	Plant height (cm)	Total tiller hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1A_1	119.00ab*	9.333f	8.40ef	24.33	93.67f	16.67a	23.20	3.21g	6.93a	52.33a
V_1A_2	114.30be	11.33e	10.33bcf	25.00	114.3d	15.00ab	23.23	4.81f	6.78ab	51.94ab
V_1A_3	107.30eh	13.00bcd	12.07ad	24.33	130.0c	12.67ab	21.97	5.31cf	6.30ac	51.93ab
V_1A_4	118.00ac	13.00bcd	8.13f	24.33	133.7bc	15.33ab	23.63	5.07ef	6.20ac	51.71ab
V_2A_1	117.00ad	9.60f	9.00df	24.67	99.00ef	18.00ab	23.33	3.54g	6.10ad	51.47ab
V_2V_2	110.70dh	11.67de	10.80af	24.00	114.7d	14.67ab	22.97	4.83ef	6.04ad	51.19ab
V_2A_3	111.00ch	13.83ab	13.20ab	23.67	134.7bc	15.00ab	22.33	5.76bc	6.03ad	51.10ab
V_2A_4	111.30ch	13.50abc	12.70abc	24.67	135.0bc	13.67ab	23.77	5.75bc	5.58ad	51.08ab
V_3A_1	113.70bf	9.97f	8.80def	24.33	99.67ef	18.67ab	22.83	3.45g	5.50ad	50.90ab
V_3A_2	111.30ch	12.17cde	11.37af	25.00	126.0c	16.00ab	22.97	5.60bcd	5.33bd	50.78ab
V_3A_3	122.30a	14.67a	13.97a	26.00	146.7a	10.33ab	23.20	6.31a	5.20cd	52.72a
V_3A_4	105.30h	14.50a	13.87a	24.00	142.7ab	15.00ab	23.70	6.07ab	5.13cd	49.60abc
V_4A_1	112.70bg	9.67f	9.50cf	24.67	103.0ef	23.00a	22.63	3.34g	5.01cd	49.03abc
V_4A_2	107.70eh	11.93de	11.20af	24.67	109.0de	14.00ab	22.73	5.35ce	5.00cd	48.81abc
V_4A_3	105.70gh	12.33cde	11.57ae	25.00	136.3bc	13.67ab	22.53	5.33cf	4.85cd	46.51bc
V_4A_4	107.00fh	11.67de	10.73af	23.67	134.3bc	14.00b	23.17	5.16df	4.67d	44.57c
CV (%)	3.35	6.36	15.32	5.07	4.63	19.24	3.97	5.58	15.56	6.73
Level of significance	0.01	0.01	0.01	NS	0.01	0.01	NS	0.01	0.01	0.01

*In a column, values having similar letter do not differ significantly whereas values with dissimilar letter differ significantly as per DMRT. Here, V_1 = BRRI dhan49, V_2=BRRI dhan56, V_3=BRRI dhan66, V_4= BRRI dhan71; A_1= 20-days old seedlings, A_2= 25-days old seedlings, A_3= 30-days old seedlings, A_4= 35-days old seedlings.

day old seedlings (Table 4). Meanwhile, BRRI dhan49 produced the longest panicle (25.00 cm) with 25-day old seedlings which was statistically similar to BRRI dhan66 with 25-days old seedlings and BRRI dhan71 with 30-day old seedlings. While, the shortest panicle (23.67 cm) was obtained from BRRI dhan71 with 35-day old seedlings (Table 4). Again, BRRI dhan66 with 30 -day old seedlings produced the highest number of grains panicle^{-1} (146.70) and the lowest number of grains panicle^{-1} (93.67) was recorded from BRRI dhan49 with 20-day old seedlings (Table 4). Similar research findings were also stated by Roy *et al.* (1992) and Datta and Gautam (1998). Again, the lowest number of sterile spikelets panicle^{-1} (10.33) was found from BRRI dhan66 with 30-day old seedlings and the variety BRRI dhan71 with 20-days old seedlings produced the highest number of sterile spikelets panicle^{-1} (23.00) (Table 4). BRRI dhan56 with 35 -day old seedlings produced the highest 1000-grain weight (23.77 g) and the lowest 1000-grain weight (21.97 g) was recorded from BRRI dhan49 with 30-days old seedlings (Table 4). Again, the result showed that the highest grain yield (6.31 t ha^{-1}) was obtained from BRRI dhan66 transplanted with 30-day old seedlings which was statistically differed from all other interactions and the lowest grain yield (3.21 t ha^{-1}) was obtained from BRRI dhan49 with 20-day old seedlings (Table 4). The improvements of yield component such as longest panicle (25 cm), the highest number of effective tiller hill^{-1} (13.97), number grains panicle^{-1} (146.7) were responsible for the increased grain yield in BRRI dhan66 with 30-day old seedlings. While, BRRI dhan49 with 20-day old seedlings produced the highest straw yield (6.93 t ha^{-1}) and the lowest straw yield (4.67 t ha^{-1}) was recorded from BRRI dhan71 with 35-day old seedlings (Table 4). The highest harvest index (52.77 %) was recorded from BRRI dhan66 with 30-days old seedlings and the lowest harvest index (44.57 %) was found from BRRI dhan71with 35-day old seedlings (Table 4).

Conclusion

The results of the study indicate that growth characters of short duration transplant *Aman* rice cultivars response better from 20-day old seedlings of BRRI dhan49, and most of the yield and yield contributing characters of short duration transplant *Aman* rice cultivars response better from 30-day old seedlings of BRRI dhan66. Again, the results showed that BRRI dhan66 with 30-day old seedlings produced the highest number of effective tillers hill^{-1}, highest number of grains panicle^{-1}, highest grain and straw yields. Therefore, it can be concluded that BRRI dhan66with 30-day old seedlings appears as the best choice to get maximum grain yield of T. *Aman* rice in Old Brahmaputra Floodplain (AEZ-9).

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