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Performance of hybrid rice grown from separated tillers

F.N. Kamarum Munira¹, Md. Parvez Anwar^{1,2✉}, Sabina Yeasmin^{1,2}, M. Harun Rashid¹, Mst Farzana Rahman¹, Israt Urmee³

¹Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

²Agro Innovation Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

³Department of Agricultural Extension, Mymensingh, Bangladesh

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Correspondence:

Md. Parvez Anwar

✉: parvezanwar@bau.edu.bd



ABSTRACT

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during July to November 2016 to investigate the performance of separated tillers of hybrid rice variety Dhani Gold. The experiment comprised three times of tiller transplantation viz. 3, 4 and 5 week aged tiller seedlings and four levels of number of tiller seedlings transplanted hill⁻¹ viz. 2, 3, 4 and 5 tiller seedlings hill⁻¹ laid out in a split plot design with 3 replications. The highest plant height was obtained when 3-week aged tiller seedlings were transplanted at the rate of 3 tiller seedlings hill⁻¹. The highest number of total tillers hill⁻¹ and number of effective tillers hill⁻¹ were found when 3-week aged tiller seedlings were transplanted with 5 tiller seedlings hill⁻¹. The highest grains panicle⁻¹ was obtained when 4-week aged tiller seedlings were transplanted with 5 tiller seedlings hill⁻¹. The highest grain yield was found when 3-week aged tiller seedlings were transplanted with 5 tiller seedlings hill⁻¹. The lowest grain yield was found when 5-week aged tiller seedlings were transplanted with 2 tiller seedlings hill⁻¹ in hybrid rice variety Dhani Gold. Based on the findings of the present study it may be concluded that 3-week old tiller seedlings of Dhani Gold should be transplanted at the rate of 4 or 5 tiller seedlings hill⁻¹ for higher yield. Thus present study confirms the potentiality of growing hybrid rice from separated tillers in case of unavailability of seedlings or to minimize the seed cost of high value hybrid rice seeds.

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Introduction

Rice (*Oryza sativa* L.) is the most important food crop of the world and the staple food of more than 3 billion people of the world's population including Bangladesh. Rice is grown in more than a hundred countries with a total harvested area of about 170 million hectares, producing more than 800 million tons every year (IRRI, 2016). In respect of area and production, Bangladesh ranks 4th among the rice producing countries of the world following China, India and Indonesia (FAO, 2016). About 75% of cropped area of Bangladesh is used for rice production, with annual production of 34.71 million tons from 11.38 million hectares of land. Rice is grown in Bangladesh in three distinct seasons namely; *Aus*, *Aman* and *Boro*. Transplant *Aman* rice covers 5.90 million hectares (49.08% of total rice area) of land with a production of 13.48 million tons, 22.88 million tons *Aus* rice is produced in 10.18 million hectares; and 18.93 million tons *Boro* rice is produced in 11.79 million hectares of land (BBS, 2016). Thus transplant *Aman* rice plays a significant role to meet the national food demand and to ensure food security.

World population is increasing rapidly day by day. It has become the most important challenge to provide food for the excessive number of population. To mitigate food crisis all over the world hybrid rice is developed by different countries. In 1974, the first hybrid rice variety was released in China. Hybrid rice is similar to other hybrid crops. It has a phenomenon associated with it called “heterosis”-otherwise known as ‘hybrid vigor’. Hybrid rice has the potentiality to produce more yield than popular inbred varieties because of their hybrid vigor.

Bangladesh is a flood prone country. Crop damage due to flash flood or late flood is very common in Bangladesh. Devastating flood destroys valuable crops especially transplant *Aman* rice very often in Bangladesh. When flood water recedes in the early or mid-September, farmers try to recover their losses by transplanting late *Aman* rice. During this period, seedlings of transplant *Aman* rice are not available; as a result, a large area remains fallow. Sometimes, farmers use too old seedlings which results in poor yield. But, there is an option to use tillers from rice crop from unaffected field of relatively high land or from the flood

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free areas as planting material for late *Aman* season as a post-flood crop to raise a new crop (Anwar and Begum, 2004).

This technique of transplanting of tillers is sometimes practiced in Bangladesh especially in post flood situation (Mridha *et al.*, 1991). Besides, seeds of hybrid rice are so costly that poor farmers usually do not go for hybrid rice cultivation despite its high yield potential. So, if a vegetative propagation technology for hybrid rice could be developed, it would be a huge step to produce more rice crops in Bangladesh even under devastating flood and to mitigate food crisis (Perveen *et al.*, 2008). In rice, many of the late tillers do not produce panicle due to higher population (Hanada, 1979). Removal of some tillers from the mother plant may not affect the growth and development of rice plants Biswas and Salokhe (2001). These separated tillers may be used as seedlings for transplant *Aman* rice for growing in the same season. The time of tiller separation is of prime importance for vegetative propagation in rice. The level of tiller separation *viz*; an increase or decrease in number of tillers taken away from the mother plant may be an important consideration. Further, it is likely that the tiller separation practice may evidently affect the tillering ability of both the tiller planted crop and mother plant. Tolerance of mother plants to tiller separation needs to be tested so that their yields are not adversely affected (Hossain, 1999).

Age of tiller seedlings and proper number of tillers used hill⁻¹ are important determinants for the production of rice using tiller seedlings. Age of tiller seedlings may influence the tiller production, growth, grain formation and other yield contributing characters of rice. It was found that yield of transplant *Aman* rice was the highest by transplanting tiller seedlings separated from mother plants at 35 days after transplanting (Biswas *et al.*, 1987). BRRI (1990) reported that tillers could be separated at 30-40 days after transplanting and 2/3 tiller seedling per hill give the most significant result. But the yield performance in transplant *Aman* rice based on tiller separation and age of separated tillers have to be ensured. Therefore, the present study was undertaken to evaluate the potentiality of separated tillers as tiller seedlings in hybrid rice variety Dhani Gold, and to determine the optimum age and number of tillers used hill⁻¹ for high yield of hybrid rice Dhani Gold in transplant *Aman* season.

Materials and Methods

Experimental duration and site

The experiment was conducted at the Agronomy field Laboratory, Bangladesh Agriculture University, Mymensingh during August to November 2016.

Geographically the experimental site is located at 24°75' N latitude and 90°50' E longitude at an elevation of 18 m from the sea level. It belongs to the Sonatola soil series under the Old Brahmaputra Floodplain Agro-Ecological Zone (AEZ-9) having non-calcareous dark grey floodplain soil (UNDP and FAO, 1988). The experimental field was a medium high land. Soil of the experimental field was non-calcareous having silt loam texture, almost neutral in reaction, low in organic matter content and its general fertility level was also low. The experimental area is characterized by sub-tropical climate with high temperature, high humidity and heavy rainfall from April to September and scanty rainfall from October to March associated with moderately low temperature and plenty of sunshine. During the experimental period, average maximum and minimum temperature, relative humidity, rainfall and sunshine hours ranged from 26.8 to 33.2 °C, 18.1 to 29.5 °C and 81-87%, 1.0-522.7 mm, 101.8 to 204.8 hrs month⁻¹.

Experimental treatments and design

The experiment comprised three times of tiller transplantation *viz*. 3, 4 and 5-week aged tiller seedlings and four levels of number of tiller seedlings transplanted hill⁻¹ *viz* 2, 3, 4 and 5 tiller seedlings hill⁻¹. The experiment was laid out in a split plot design with 3 replications, where different treatments were randomly assigned the age of tiller seedling to main plot and number of tillers transplanted hill⁻¹ to sub plot. The size of each unit plot was 10 m² (4.0 m × 2.5 m). Block to block and plot to plot distance were 1m and 0.5 m respectively.

Plant material

A transplant hybrid rice variety 'Dhani Gold' developed by the Bayer Bio Science Company was used as the plant material in this study. Dhani Gold offers a holistic solution to Bacterial Leaf Blight a dreaded rice disease causing considerable produce loss (20-60%) annually. The plant is green in color, flag leaf is erect and remains fade green after ripening of the grain. Average plant height of the variety is 100 cm at ripening stage and weight of 1000 grains is about 23g. The grains are medium bold with white kernels. It requires about 110 days to complete its life cycle from sowing to ripening with an average grain yield of 5 t ha⁻¹.

Crop husbandry

Raising tiller seedlings from mother crop: Quality seeds of Dhani Gold were soaked in water for 24 hours and then kept in gunny bags for 48 hours for sprouting. Sprouted seeds were then sown in the wet nursery bed for raising seedlings. A piece of land, selected for growing mother plants, was thoroughly ploughed with a power tiller followed by harrowing, puddling and laddering. Thirty days old seedlings were transplanted

maintaining the spacing of 25 cm \times 15 cm at the rate of three seedlings hill⁻¹ on 4th August. Urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate fertilizers are applied to the experimental plots at the rate of 140, 90, 70, 60 and 10 kg ha⁻¹ respectively. The entire amount of triple super phosphate, muriate of potash, gypsum, and zinc sulphate were applied before final land preparation. Urea was top dressed in three equal splits at 15, 30, 45 days after transplanting (DAT). Weeding was done manually three times at 15, 30 and 45 DAT. The crop was grown as rainfed. Due to frequent rain during the crop growth period no irrigation was given. Tillers were separated from mother crop at 3, 4 and 5 weeks after transplantation of seedling from each hill to grow in the experimental plot (tiller crop). Though this crop (mother crop) was grown to its full maturity and harvest, no data was collected for the present study.

Raising crop using tiller seedlings

Another piece of land was prepared on 16 August 2016 for raising tiller crop. The layout of the experiment was made on 22 August 2016 according to the design adopted. Finally, the unit plots were prepared with spade before transplanting of tiller seedlings. The separated tillers were transplanted as 2, 3, 4 or 5 tillers hill⁻¹ in each transplantation as per treatments maintaining the spacing of 25 cm \times 15 cm. Transplanting of separated tillers was done on 25 August, 2 September and 9 September 2016 according to the age of tiller seedlings. Urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate fertilizers are applied to the experimental plots at the rate of 140, 90, 70, 60 and 10 kg ha⁻¹ respectively. The entire amount of triple super phosphate, muriate of potash, gypsum, and zinc sulphate were applied before final land preparation. Urea was top dressed in three equal splits at 15, 30, 45 days after transplanting (DAT). Weeding and irrigation were given as recommended for the crop variety. Other intercultural operations were done to ensure the normal growth of the crop.

Observations

Observations were made on rice growth in terms of plant height and tillering ability. Different yield parameters, yield retarding characters and grain yield of rice were also observed. At the time when 80% of the panicles turned into golden yellow color, the crop was assessed to attain maturity. Five hills (excluding border rows and central 1.0 m \times 1.0 m area) were selected randomly from each unit plot and uprooted before harvesting for recording the data of yield and yield attributes of rice. After sampling a harvest area of central 1m \times 1m was selected from each unit plot. Then the harvested crops of each plot was bundled separately and properly tagged and brought to the threshing floor. Grains were separated from the plants by pedal thresher. The collected grains and straw were cleaned and weighed. The moisture

content of the collected grains was measured by grain moisture meter. Then the grain moisture content was adjusted to 14% moisture content. Finally grain and straw yields per unit area were converted to t ha⁻¹.

Statistical analysis

Analysis of variance (ANOVA) was done with the help of computer package MSTAT-C to investigate significant differences in the recorded parameters. The mean differences among treatments were adjudged by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results

Plant height and tillering ability

Plant height of Dhani Gold was significantly affected by age of tiller seedlings (Table 1). Data shows that plant height of Dhani Gold gradually decreased with the increase in age of tiller seedlings. Plant height ranged from 86.22 to 104.70 cm. Compared to 3-week aged tiller seedlings, plant height was reduced by 7 cm and 18 cm respectively in case of 4- and 5-week aged tiller seedlings.

Tillering ability of Dhani Gold was significantly affected by age of tiller seedlings, number of tillers transplanted hill⁻¹ and their interaction (Table 1). Results show that number of total tillers hill⁻¹ was gradually decreased with the increase of age of tiller seedlings. The highest number of total tillers hill⁻¹ was recorded with the youngest tiller seedlings (3 weeks). Reduction in number of total tillers hill⁻¹ were recorded 1.65 and 2.31 for 4- and 5- week aged tiller seedlings compared to 3-week aged tiller seedlings. Number of total tillers hill⁻¹ was increased gradually with the increase of number of tillers transplanted hill⁻¹ up to 4 tiller hill⁻¹. The lowest number of total tillers hill⁻¹ was found when only 2 tillers were transplanted hill⁻¹, while increase in number of total tillers hill⁻¹ were recorded 0.55, 0.69 and 0.12 for 2, 3 and 4 tillers transplanted hill⁻¹. The number of total tillers hill⁻¹ decreased with the increase of age of tiller seedlings. The maximum number of total tillers hill⁻¹ (9.00) was recorded when 3-week aged tillers were transplanted at the rate of 4 tiller hill⁻¹, which was statistically identical to that produced when 3-week aged tillers were transplanted at the rate of 5 tiller hill⁻¹ while Dhani Gold exhibits the lowest tillering ability (5.03 hill⁻¹) when 5-week aged tillers were transplanted at the rate of 2 tillers hill⁻¹.

Yield parameters

Age of tiller seedlings and number of tillers transplanted hill⁻¹ exerted significant effect on number of effective tillers hill⁻¹ of hybrid rice variety Dhani Gold (Table 1). The highest number of effective tillers was recorded with the youngest tiller seedlings (3-week), while

reduction in number of effective tillers hill⁻¹ were recorded 1.05 and 1.47 for 4- and 5- week aged tiller seedlings, respectively. Table 1 shows that number of effective tillers hill⁻¹ were gradually increased with the increase of number of tiller seedlings transplanted hill⁻¹. The lowest number of effective tillers hill⁻¹ (5.66) was found when 2 tiller seedlings were transplanted hill⁻¹ and the highest number of effective tillers hill⁻¹ (6.33) was found when 5 tiller seedlings were transplanted. Interaction between age of tiller seedlings and number of tillers transplanted hill⁻¹ also produced significant effect on number of effective tillers hill⁻¹ (Table 1). The maximum number of effective tillers hill⁻¹ (7.10) was

recorded when 3-week aged tillers were transplanted at the rate of 2 tillers hill⁻¹ which was statistically similar to that produced when 3-week aged tillers were transplanted at the rate of 4 (7.00) and 5 tillers (7.03) hill⁻¹. On the other hand, the lowest number of effective tillers hill⁻¹ (5.03) when 5-week aged tillers were transplanted at the rate of 3 tillers hill⁻¹ which was statistically identical to that produced when 4-week aged tillers were transplanted at the rate of 4 tiller seedlings hill⁻¹ (5.10). It may be noted that in general, number of effective tillers was reduced gradually with the increasing age of tiller seedlings irrespective of number of tiller seedlings transplanted hill⁻¹.

Table 1. Effect of age of tiller seedlings, number of tiller seedlings hill⁻¹ and their interaction on crop characters and yield components of hybrid rice variety Dhani Gold

Seedling age (A)	Plant height (cm)	No. of total tillers/hill	No. of effective tillers/hill	No. of non-effective tillers/hill	Grains/panicle	Sterile spikelets/panicle	1000-grain weight (g)
3 weeks (A1)	104.70a	8.60a	6.76a	1.83a	141.2	10.46	23.53
4 weeks (A2)	97.63b	6.95b	5.71b	1.23b	142.8	10.53	23.46
5 weeks (A3)	86.22c	6.29c	5.29c	1.00b	140.9	10.23	23.79
SD	1.23	0.07	0.066	0.1	0.755	0.134	0.169
Level of significance	**	**	**	**	NS	NS	NS
Number of tillers transplanted per hill (B)							
2 tillers (B1)	96.04	6.49c	5.66c	0.82b	139.30b	10.33a	23.58
3 tillers (B2)	97.96	7.04b	5.65c	1.38a	142.90a	10.80a	23.66
4 tillers (B3)	96.64	7.73a	6.04b	1.68a	141.00ab	10.67a	23.56
5 tillers (B4)	94.1	7.85a	6.33a	1.52a	143.20a	9.84b	23.59
SD	1.42	0.081	0.076	0.119	0.872	0.155	0.196
Level of significance	NS	**	**	**	**	**	NS
Interaction (A × B)							
A1 × B1	105.4	8.40b	7.10a	1.30bc	141.00a-d	10.47	23.53
A1 × B2	103.4	8.03bc	5.93b	2.10a	137.00d	10.69	23.64
A1 × B3	105.7	9.00a	7.00a	2.00a	142.30a-c	10.79	23.37
A1 × B4	104.3	8.96a	7.03a	1.99a	144.30ab	9.907	23.6
A2 × B1	97.33	6.03e	5.83b	0.20d	139.00cd	10.59	23.37
A2 × B2	99.7	7.03d	6.00b	1.03c	146.00a	10.47	23.77
A2 × B3	98.43	7.10d	5.10c	1.73b	141.30a-d	10.75	23.35
A2 × B4	95.07	7.63c	5.93b	1.69b	144.70ab	10.33	23.37
A3 × B1	85.43	5.03f	4.06d	0.96c	138.00cd	9.947	23.83
A3 × B2	90.77	6.06e	5.03c	1.03c	145.70ab	11.23	23.56
A3 × B3	85.77	7.10d	6.03b	1.06c	139.30cd	10.47	23.97
A3 × B4	82.93	6.96d	6.03b	0.93c	140.70b-d	9.28	23.8
SD	2.46	0.14	0.132	0.206	1.51	0.268	0.339
Level of significance	NS	**	**	**	**	NS	NS
CV (%)	4.44	3.35	3.86	26.24	1.85	4.46	2.49

Figures in a column under each factor of treatment having the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability, NS = Not significant

Age of tiller seedlings exerted no significant effect on grain panicle⁻¹ of hybrid rice variety Dhani Gold (Table 1). However, numerically the highest grains panicle⁻¹ (142.80) was found when 4 tiller seedlings were transplanted while the lowest grains panicle⁻¹ was recorded when 5 tiller seedlings were transplanted. Grains panicle⁻¹ was significantly affected by the number of tillers transplanted hill⁻¹ (Table 1). Grains panicle⁻¹ gradually increased with the increase of number of tillers transplanted hill⁻¹. It ranged from 139.30 to 143.20. The highest grains panicle⁻¹ (143.20) was recorded in 5 tiller seedlings transplanted hill⁻¹

which was as good as 3 and 4 tiller seedlings transplanted hill⁻¹, and the lowest grains panicle⁻¹ (139.30) was recorded in 2 tiller seedlings transplanted hill⁻¹. Interaction between age of tiller seedlings and number of tillers transplanted hill⁻¹ shows significant effect on grains panicle⁻¹ (Table 1). The highest grains panicle⁻¹ (146.00) was observed from 4-week aged tiller seedlings coupled with 3 tillers transplanted hill⁻¹. The lowest number of grains panicle⁻¹ (137.00) was observed from 3-week aged tiller seedlings coupled with 3 tillers transplanted hill⁻¹.

Yield retarding parameters

Non-effective tiller and sterile spikelet are the two yield retarding parameters of rice. Number of non-effective tillers hill^{-1} was significantly affected by age of tiller seedlings, number of tillers transplanted hill^{-1} and their interaction (Table 1). Number of non-effective tillers hill^{-1} was decreased with the increase in age of tiller seedlings. The highest number of non-effective tillers hill^{-1} (1.83) was observed by transplanting 3-week aged tiller seedlings and the lowest number of non-effective tillers hill^{-1} (1.00) was found by transplanting 5-week aged tiller seedlings. It was observed that the highest number of non-effective tillers hill^{-1} (1.68) was produced when 4 tiller seedlings were used hill^{-1} which was statistically similar to 5 and 3 tiller seedlings hill^{-1} . The lowest number of non-effective tillers hill^{-1} (0.82) was produced when 2 tiller seedlings transplanted hill^{-1} . Three-week aged tiller seedlings coupled with 3 or 4 or 5 tiller seedlings planted hill^{-1} resulted in the highest non-effective tiller production. Only number of tillers transplanted hill^{-1} exerted significant effect on sterile spikelets panicle^{-1} . The highest number of sterile spikelets panicle^{-1} (10.80) was observed when 3 tillers transplanted hill^{-1} which is statistically similar to 2 and 4 tillers transplanted hill^{-1} . The lowest number of sterile spikelets panicle^{-1} (9.84) was observed when 5 tiller seedlings transplanted hill^{-1} .

Yield performance

Grain yield of Dhani Gold was significantly affected by age of tiller seedlings, number of tillers transplanted hill^{-1} and their interaction (Figure 1). Results show that grain yield was gradually decreased with the increase of age of tiller seedlings. Grain yield ranged from 3.57 to 4.49 t ha^{-1} . Compared to 3-week aged tiller seedlings, grain yield was reduced by 17% and 20% respectively in case 4- and 5-week aged tiller seedlings. In this case since grains panicle^{-1} and 1000-grain weight were insignificant, therefore only effective tillers hill^{-1} contributed to the grain yield of Dhani Gold. The highest grain yield (4.31 t ha^{-1}) was obtained when 5 tillers were used hill^{-1} and the lowest (3.43 t ha^{-1}) was found when 2 tiller seedlings used hill^{-1} . Transplanting of 5 tiller seedlings hill^{-1} resulted in 3% yield reduction compared to 4 tiller seedlings hill^{-1} while for 3 tiller seedlings hill^{-1} the yield reduction was as high as 11%. In case of interaction, the highest grain yield (4.83 t ha^{-1}) was obtained from 3-week aged tiller seedlings transplanted at the rate of 5 tillers hill^{-1} which was statistically similar (4.67 t ha^{-1}) to 3-week aged tiller seedlings transplanted at the rate of 4 tillers hill^{-1} . On the contrary, the lowest grain yield (2.67 t ha^{-1}) was found from 5-week aged tiller seedlings coupled with 2 tillers used hill^{-1} .

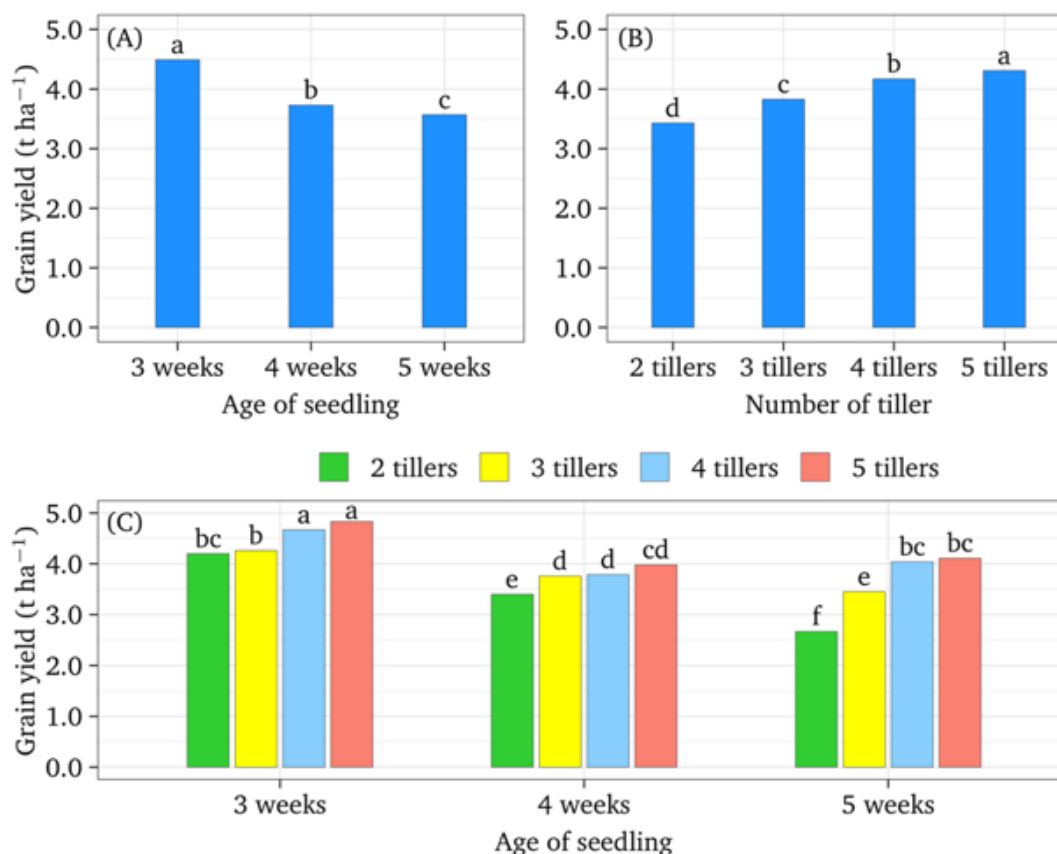


Fig. 1 Effect of age of tiller seedlings, number of tiller seedlings hill^{-1} and their interaction on yield of hybrid rice Dhani Gold

Discussion

Natural hazards like flood is very common in Bangladesh. Devastating flood washes away transplant *Aman* rice, the main rice crop of Bangladesh, causing significant damage almost every year. Thus flood is a serious threat to the food security of Bangladesh. After recession of flood water farmers cannot replant rice due to unavailability of seedlings. Sometimes too young or too old seedlings are available which cannot ensure satisfactory yield, and therefore farmers keep their land fallow. Therefore it's a huge challenge to make rice seedlings available for proper rehabilitation of flood affected *Aman* rice crop.

Separated tillers from the unaffected rice field of higher topography could be a potential alternative to nursery seedlings. Fortunately, rice has the unique ability of profuse tillering as every leaf axil has the potential to produce a tiller, and many of the late tillers fail to produce panicles due to dense population (Hossain *et al.*, 2011). Removal of those excessive tillers from the mother plant could help better development of the remaining tillers, and at the same time the separated tillers can be replanted for growing post-flood transplant *Aman* rice (Anwar and Begum, 2004; Khan *et al.*, 2008; Sarkar *et al.*, 2011; Rahman *et al.*, 2015; Sarkar *et al.*, 2017). But age of tiller seedlings and number of tillers to be planted hill⁻¹ are among the two important issues that determine the growth and yield performances of the tiller crop. In this study an attempt was made to identify the optimum age and number of tiller seedlings hill⁻¹ of hybrid rice variety Dhani Gold to grow it as a post-flood *Aman* rice crop.

In this study, growth of the tiller crop was evaluated in terms of plant height and tillering ability. It was observed that plant height of Dhani Gold decreased gradually with the increase in age of tiller seedlings, but number of tiller seedlings planted hill⁻¹ had no significant effect on plant height. Younger tiller seedling (3 weeks) got long duration for vegetative growth which might have influenced plant height. On the other hand, the reduction in plant height in case of aged tillers was mainly due to the availability of short vegetative growth period. Rahman *et al.* (2015) also observed in their study that 25 days old tiller seedlings resulted in taller plants than 35 days old tiller seedlings. Sarkar *et al.* (2011) also opined that plant height of rice decreased with the increase in age of tillers planted.

It was observed in this study that tillering ability of Dhani Gold decreased with the increasing tiller age but increased with the number of tillers planted hill⁻¹. Although 21 days old tiller seedlings showed highest tillering ability in this study, but other researchers concluded that 35 days is the optimum age for producing maximum tillers (Biswas *et al.*, 1987; Rahman *et al.*, 2015). In general, tillering ability of rice is decreased with the increasing competition for resources (Ishizuka

and Tanaka, 1963) and therefore, planting of more tillers usually results in less tillering. But, here contrast findings were observed. However, the differences might be due the variation in genetic characteristics between hybrid and inbred rice studied.

As observed in this study, among the yield contributing characters only effective tiller number was significantly affected by age of tiller seedlings, while effective tiller number and grains panicle⁻¹ were affected by number of tillers transplanted hill⁻¹. Thousand-grain weight was unaffected because it is mostly governed by the varietal genetic makeup, and thus environmental and/or agronomic management cannot influence that. Younger tillers produced higher number of panicles compared to older tillers, and as the consequence younger tillers out yielded older ones. Better performance of younger tiller seedlings compared to older ones in terms of rice productivity have been confirmed by many researchers (Sarkar *et al.*, 2011). Contrasting findings have also been reported by others (Kirttania *et al.*, 2013). Straw yield also followed the similar trend because of taller plants and higher number of tillers resulted from the transplanting of younger seedlings.

With the increasing density of tiller seedlings yield contributing parameters and grain yield of Dhani Gold were gradually increased. This might be due to the cumulative contribution of tillers transplanted. Rahman *et al.* (2015) also observed in their study that 5 tiller seedlings hill⁻¹ produced higher grain yield than 1 or 3 tillers hill⁻¹. In contrast, Sarkar *et al.* (2011) recorded the highest grain yield when only 2 tiller seedlings were transplanted hill⁻¹. As stated by Biswas and Salokhe (2001), higher densities of tillers transplanted hill⁻¹ gave lower panicle number and grain weight because of intra-tiller seedlings competition for above and below ground resources resulted in the reduced grain yield. However, the variation might be attributed to the differences in the genetic characteristics among the varieties used and variation in agro-climatic conditions along with soil fertility levels in experimental sites.

Conclusion

Present study confirms that feasibility of growing separated tillers of Dhani Gold in case of scarcity of seedlings. For higher yield, 3-week old tiller seedlings may be transplanted at the rate of 4 or 5 tillers hill⁻¹. Aged tillers (>3 weeks) and lower seedling density hill⁻¹ will result in poor performance. Moreover, vegetative propagation through separated tillers can also be recommended to save the cost of hybrid rice seeds which are highly expensive.

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