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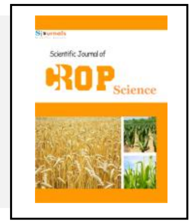

Original article

Determination of seedling age for rice transplanter

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A B S T R A C T

Rice transplanter is a labor saving technology. To find out suitable seedling age for rice transplanter two experiments were conducted in Bangladesh Rice Research Institute, Bangladesh in aman season (Sptember, 2012) and boro season (January, 2013). Seedlings were raising in plastic trays using sandy loam soil mixed with 25% well decomposed cow dung. We evaluated 8, 12, 16 and 20 day's old seedling of BRRI dhan49 and BRRI dhan46 in aman and 15, 20, 25 and 30 day's old seedling of BRRI dhan29 and BRRI dhan45 in boro season. BRRI dhan45 and BRRI dhan46 were bold; BRRI dhan29 and BRRI dhan49 were fine grain rice cultivar. Leaf number, shoot and root length, seedling vigor and strength increased with the advances of age in both years in all varieties. But bold type grain rice cultivar produced desirable leaf number and attained suitable height earlier than fine grain rice cultivars. The recommended seedling number (3 leaves per seedling) and suitable seedling height (12cm) could be achieved from 12 to 16 days old seedling in aman and 25 to 30 days old seedling in boro for transplanting using rice transplanter. Farmer's could be saved 4 to 5 US$ per 33 decimal from seedling raising for transplanting by rice transplanter.

1. Introduction

World population has been increasing day by day. But population growth rate of Bangladesh is much higher than world growth rate. Demand for food is proportion to the population growth. Scientists are trying to develop new production technologies and the people related to food production try to increase production to feed the ever increased populations. Bangladesh is a part of South Asia and rice is the main crop that covers nearly 75% of cropped area contributing over 95% of total food grain production (BARC, 1983). Historically, rice cultivation is a labor-intensive task that could not be accomplished easily. Labor cost accounts the biggest input cost for rice production (Clayton, 2010). In Bangladesh, about 90% of labor has been engaged in rice cultivation. But, the number of agriculture labor is decreasing day by day. As industries are being developed, however, rural exodus has mechanization of agriculture. Labor scarcity being the major reason for the decline in rice production and to overcome this, farm mechanization has been considered as an important remedial measure. One of the most important factors affecting farm mechanization is the wage of farm labor. The wage is particularly critical during peak labor-need periods, which typically occur during rice transplanting and harvesting.

Agricultural machines have replaced human force in many rice cultivation practices such as land preparation, transplanting, harvest, and post-harvest process in many developed countries. Though land is prepared mechanically but seedling raising and transplanting is still done traditionally in Bangladesh. About 156 man-days per hectare are required for producing rice. Forty five man-days are consumed for seedling raising and transplanting which is about 29% of the total labor requirement. Rice transplanting was mechanized in the 1970s and 1980s in Japan and Korea, respectively. They also developed new technologies of seedling raising for rice transplanter (Tasaka et al., 1996). Now more than 99% of paddy fields are cultivated by mechanized transplanting in both countries. Mechanical rice transplanting is being introduced in Bangladesh and gaining popularity through the different intervention of some governmental and non-governmental organizations. Many technical issues must be considered for successful operation of rice transplanter.

For example, in machine transplanting, seedling should be raised with special care in tray. Raising seedling for transplanting requires suitable seedling age, materials and advanced practices including tray and nursery bed soil, seed preparation for pre-germination and disease disinfection. About 3 leaf stage and 12 to 15cm height seedlings are required for machine transplanting. Due to climatic difference, seedling age may vary to get optimum leaf number and height for Aman and Boro season. Considering the mentioned situation the two experiments were conducted to find out suitable seedling age for rice transplanter.

2. Materials and methods

2.1. Plant and growth condition

Two experiments were conducted, experiment I in September (aman), 2012 and the experiment II in January (boro), 2013 at Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh to find a suitable seedling age for rice transplanter. The temperature of the two growing season was shown in Figure 1. Boro season was relatively cooler than aman season. The seedlings were raised on plantic trays using soil mixed with cow dung. The size of each tray was 58- x 28- x 2.5cm. The ratio of soil and cow dung was 3:1. The mixture of the material was sieved to remove the clods. The characteristics of soil were: pH 7.06, organic matter 1.07%, organic C 0.62%, N 0.046%, K 0.08 meq/100g, P 10.88 µg/g, sulpher 11.45 µg/g and zinc 0.70 µg/g. The soil was sandy loam where the percentage of sand, silt and clay were 61.91, 33.33 and 4.76, respectively (Table 1). The nutrient status of cow dung was N 1.1%, P 0.9% and 1.3%. Initially the trays were placed in a plain field. Then one fourth of each tray was filed with clod free soil and cow dung mixture. The sprouted seed of BRRI dhan49 (fine grain) and BRRI dhan46 (bold grain) for aman season and BRRI dhan29 (fine grain) and BRRI dhan45 (bold grain) for boro season were sown on the trays. The thousand grain weight was 22g and 24g for fine grain and bold grain rice, respectively. The amount of seed was 130g (fine grain) and 140g (bold grain) per tray. Then the seeds were covered with clod free soil mixture and irrigate to keep moistened. The seeds were sown at 4 days interval during aman season to get 8, 12, 16 and 20 days old seedling. During boro season the seeds were sown 5 days interval to get 15, 20 25 and 30 days old seedling. The trays were irrigated 2 times every day. At the early stage of sowing we irrigate using knapsack sprayer. But after germination of seeds we use watering can to applied water to the trays. During rain and cold the trays were covered with polyethylene sheet.

2.2. Measurement of seedling growth and dry matter production

Seedlings were sampled from each tray. Twenty seedlings were selected randomly from each tray. The different growth parameters including leaf color, numbers, root and shoot length and dry weight, germination percent, seedling vigor and strength were taken. Leaf color was measured using leaf color chart. The were subjected to an ANOVA for the randomized complete block design by using MSTAT-C software (CIMMYT, Mexico City, Mexico) and the significance was tested by a variance ratio (i.e. F-value) at the 5% level (Gomez & Gomez 1984).

2.3. Field evaluation

To evaluate the field performances we used walking type rice transplanter made by South Korea, model: DP480. During transplanting we collected data on seedling number per hill, hill per m2, missing hill and area coverage by 4 tray seedlings.

2.4. Cost evaluation

Economic study and labour savings were calculated using Bangladeshi economic values. The cost for seed, labor for tray preparation and maintenance during seedling raising, seedling uprooting, carrying and transplanting were included for 33 decimals. The costs for seed = 0.44 US$/kg, labor = 3.75 US$/man day, hiring a tractor = 2.5 US$/33 decimals. The currency conversion factor used was 1 US$ = 80 Bangladeshi Taka.

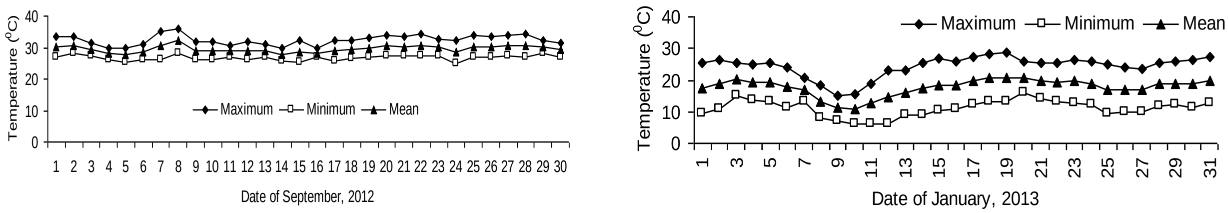


Fig. 1. Temperature data of growing season

Table 1
Physical and chemical properties of soil.

Soil characters	Unit	Amount
pH		7.06
Organic matter	%	1.07
Organic carbon	%	0.62
N	%	0.046
P	µg/g	10.88
K	meq/100g	0.08
S	µg/g	11.45
Zn	µg/g	0.70
Sand	%	61.91
Silt	%	33.33
Clay	%	4.76
Textural class	Sandy loam	

3. Results

3.1. Leaf color

In aman season, variety and interaction of variety and seedling age exerted significant effect on leaf color (Table 2). Though leaf color turns green to slight yellow with increases of seedling age but the effect was not mentionable (Figure 2: a-1). Leaf color of BRRI dhan46 was greener than BRRI dhan49 in irrespective of seedling age. The maximum leaf color chart value was recorded when seedling age was 8 days in both varieties. The values were 3 and 3.63 for BRRI dhan49 and BRRI dhan46, respectively. The lowest leaf color value was obtained (1.63) for BRRI dhan49 with 20 days old seedlings. That means the leaf of bold grain type variety remains greener for longer period than fine grain type variety during seedling stage. About two or above two leaf color value was found for 12 and 16 days old seedling when we use BRRI dhan49 but it was above three with 12 days old seedling for BRRI dhan46. During boro season, seedling age and interaction of seedling age and variety influenced leaf color significantly (Table 2). Rice variety did not exerted significant effect on leaf color. Both BRRI dhan29 and for BRRI dhan45 remains greener during 15 days old and turn yellowing with advances of seedling age (Figure 2: b-1). The leaf color value was above 3 when seedling age was 15 but it was less than 2 when seedling age was 25 or above. It was true for both the rice varieties used. But leaf color values were similar with 20, 25 and 30 days old seedling. The value of leaf color was much higher when seedling age was 15 because of high temperature during the growing period.

3.2. Leaf number

In aman season, number of leaf influenced significantly due to individual effect of seedling age and variety. Interaction effect of two factors was not statistically significant (Table 2). The leaf number increases with the advances of seedling age. But the increment of leaf number was more prominent for BRRI dhan46 than BRRI dhan49 (Figure 2: a-2). It may due to bold type grain may of BRRI dhan46. Maximum leaf number was calculated for 20 days old seedling and it was about 3 for BRRI dhan49 and 4 for BRRI dhan46. The 8 days old seedling produced only 2 leaves in both varieties. Twelve and 16 days old seedling of BRRI dhan49 gave more than 2 leaves but BRRI dhan46 produced 3 leaves (Figure 2: a-2). Leaf number was significantly influenced by seedling age and interaction of seedling age and variety during boro season (Table 3). The individual effect of rice variety on leaf number was not significant. The leaf number increases with the advances of seedling age for both varieties in similar way (Figure 2: b-2). The least number of leaves were obtained for 15 days old seedling for both varieties and it was about 2. Maximum leaf number was calculated for 25 and 30 days old seedling and it was about 3 for both varieties. Due to clod during boro season, the number did not increase with the seedling age. Kitagawa, et al. (2004) found that the 3.0 to 3.5 leaf stage is suitable for transplanting.

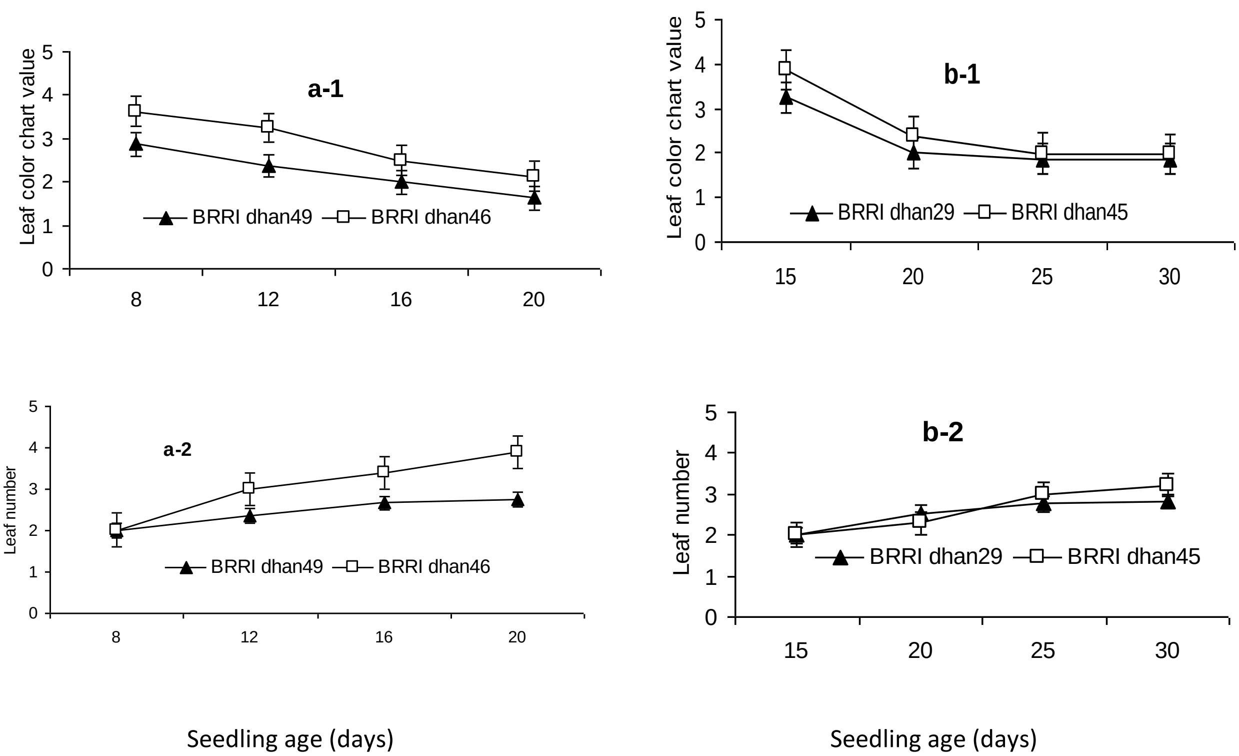


Fig. 2. Leaf color and number as affected by seedling age and variety, a = Aman and b= Boro Season.

3.3. Shoot length

In aman seasons, shoot length influenced significantly due to individual effect of seedling age and variety. Interaction effect of two factors was not statistically significant (Table 2). Irrespective of variety, seedling height increases with the increases of seedling age (Figure 3: a-3). For BRRI dhan49, the tallest seedling was recorded for 16 and 20 days old and it was about 13cm. Eight and 12 days old seedling produced seedling with 10 and 11cm. In BRRI dhan46, the 20 days old seedling gave the tallest (16.36cm) seedling where about 14cm height was obtained during 16 days old. About 11 and 12cm seedling height was obtained when seedling was 8 and 12 days old. In boro seasons, shoot length influenced significantly due to individual effect of seedling age and variety and interaction of both factors (Table 2). For both varieties, shoot length increases with advances of seedling age. Seedling height was more for BRRI dhan45 than BRRI dhan29 in all cases (Figure 3: b-3). Both varieties produced tallest seedling when seedling was 25 and 30 day old but and it about 11cm. The shortest seedling height was recorded for 15 days old and about 8cm seedling height was obtained for 20 days old seedling in boro season.

3.4. Root length

In aman seasons, root length influenced significantly due to individual effect of seedling age and variety. Interaction effect of two factors was not statistically significant (Table 2). The root length increases with the advances of seedling age. Root length of BRRI dhan46 is longer in case all seedling age than that of BRRI dhan49 (Figure 3: a-4). It may due to bold type grain may of BRRI dhan46. Maximum root length was measured for 20 days old seedling and it was above 4cm for BRRI dhan49 and 4.6cm for BRRI dhan46. The 8 days old seedling produced 2.7 and 3.18cm root length for BRRI dhan49 and BRRI dhan46, respectively. About 4cm and above 4cm root length was measured for 12 and 16 days old seedling in case of BRRI dhan49 and BRRI dhan46, respectively. Root length was significantly influenced by seedling age. Effect of variety and interaction of seedling age and variety was not statistically significant during boro season (Table 2). There is a sharp increment of root length was found with the advances of seedling age in both varieties. In boro season, more or less similar increment of root length was found for both varieties. The shorter root length was measured for 15 days old seedling for both varieties. The longest root length (>5cm) was found for 30 days old seedling followed by 25 days old seedlings (>4cm) (Figure 3: b-4). Above 3.5cm root length was measured for 20 days old seedling in both varieties.

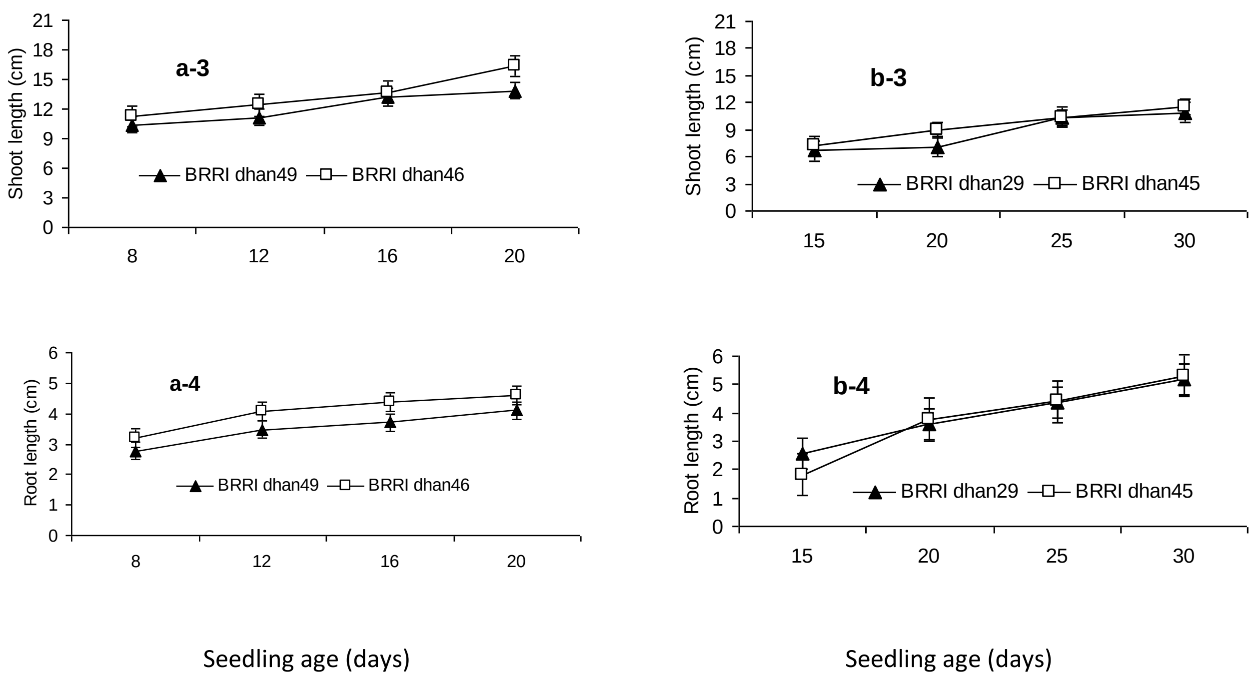


Fig. 3. Shoot and root length as affected by seedling age and variety, a = Aman and b= Boro Season.

3.5. Dry matter production

In aman seasons, dry matter production influenced significantly due to individual effect of seedling age and variety. Interaction effect of two factors was not statistically significant (Table 2). Dry matter production increases with advances of seedling age (Figure 4: a-5). The lowest dry matter production was obtained from 8 days old seedling for both varieties where it was 258mg for BRRI dhan49 and 390mg per 20 seedlings for BRRI dhan46. The highest dry matter production was recorded for 20 days old seedlings which were 474mg and 505mg per 20 seedlings for BRRI dhan49 and BRRI dhan46, respectively. BRRI dhan49 gave 364mg and 400mg while BRRI dhan46 produced 455mg and 488mg dry matter per 20 seedlings when seedling age was 12 and 16 days. In boro seasons, dry matter production influenced significantly due to individual effect of seedling age and variety. Interaction effect of two factors was not statistically significant (Table 2). Dry matter production was less in boro season than aman season (Figure 4: b-5). BRRI dhan45 produced more dry matter than BRRI dhan29. More than 200mg seedling dry matter was recorded from 20 seedling for BRRI dhan45 at 15 days old but in case of BRRI dhan29 produced more than 200mg dry matter on with 30 days old seedling. The highest dry matter production was recorded for 30 days old seedlings which were 235mg and 285mg per 20 seedlings for BRRI dhan29 and BRRI dhan45, respectively. BRRI dhan29 gave 138mg and 196mg while BRRI dhan45 produced 257mg and 269mg dry matter per 20 seedlings when seedling age was 20 and 25 days. The lowest dry matter production was obtained from 15 days old seedling for both varieties where it was 144mg for BRRI dhan29 and 215mg per 20 seedlings for BRRI dhan45.

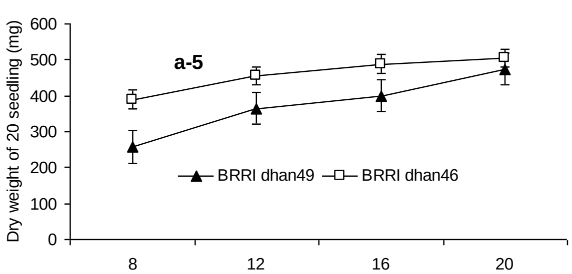
3.6. Seedling vigor

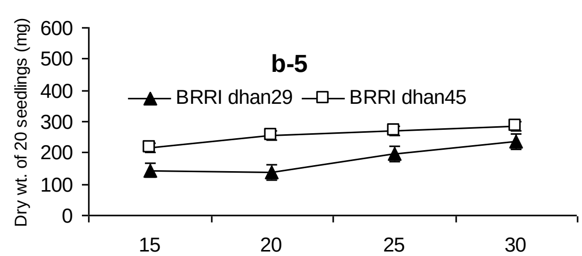
In aman season, seedling vigor influenced significantly due to individual effect of seedling age and variety. Interaction effect of two factors was not statistically significant (Table 2). There was a sharp increase in vigor due increases of seedling age (Figure 4: a-6). The highest vigor was calculated with 20 days old seedling and it was above 15 and 17 for BRRI dhan49 and BRRIdhan46, respectively. Saddling vigor was 12.41 and 14.38 for BRRI dhan49 and 13.99 and 15.39 for BRRI dhan46 when seedling age was 12 and 16 days, respectively. The lowest vigor was obtained for 8 days old seedling.

In boro season, seedling vigor influenced significantly due to individual effect of seedling age and variety. Interaction effect of two factors was not statistically significant (Table 2). Seedling vigor was slightly more for BRRI dhan45 than BRRI dhan29 in all seeding age. The highest vigor was recorded from 30 days old seedling while lowest while seedling age was 15 days. About 10 and above 12 seedlings vigor was obtained for 20 and 25 days old seedling with BRRI dhan29 and BRRI dhan45, respectively.

3.7. Seedling strength

In aman season, seedling age and variety did exerted significant influence on seedling strength (Table 2). More or less similar seedling strength was obtained from all seedling age for both varieties. Numerically, the highest seedling vigor was calculated from 20 days old seedling while lowest from 8 days old seedling in BRRI dhan49 (Figure 3: a-7). In boro season, individual effect of seedling age and variety was significant for seedling seedling strength (Table 2) while interaction was insignificant. The strength was slightly decreased with the increases of seedling age (Figure 4: b-7). Maximum seedling strength was recorded when seedling age was 15 and minimum with 30 days old seedling.





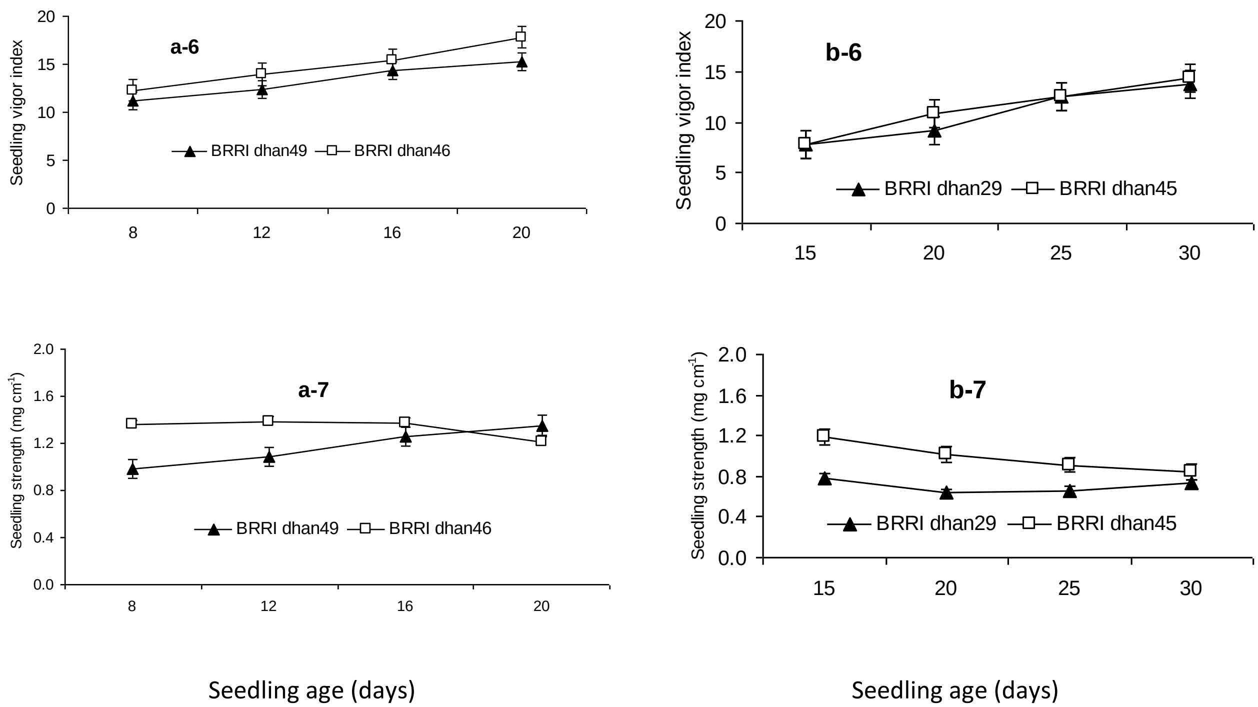


Fig. 4. Dry matter production, seedling vigor and strength as affected by seedling age and variety, a = Aman and b= Boro season

Table 2
ANOVA results of different seedling parameters.

Sources of variations	Leaf color chart value	Leaf number	Shoot length (cm)	Root length (cm)	Dry wt. of 20 seedling (mg)	Seedling vigor index	Seedling strength (mg cm-1)
				Aman, 2012			
Age	NS	**	**	**	**	**	NS
Variety	*	*	*	*	*	*	NS
Age x Variety	*	NS	NS	NS	NS	NS	NS
				Boro, 2013			
Age	**	**	**	**	**	**	*
Variety	NS	NS	**	NS	**	*	*
Age x Variety	*	*	*	NS	NS	NS	NS

* and ** indicate significant differences at P<0.05, P<0.01, respectively, and NS indicate not significant differences at the P<0.05 level

3.8. Field performance

Field performance was satisfactory with both varieties with all seeding age in both season. In aman season, maximum number of seedlings per hill and missing hill was obtained from 8 days old seedling in both varieties but minimum area coverage for transplanting was recorded from 8 and 20 days old seedling with BRRI dhan49 and BRRI dhan46, respectively (Table 3). Less number of seedlings per hill and missing hill as well as maximum land area coverage was obtained from 12 and 16 days old seedling for both varieties. In boro season, maximum number of seedlings per hill and missing hill as well as minimum area coverage for transplanting was recorded from 15 days old seedling with both varities (Table 3). Less number of seedlings per hill and missing hill as well as maximum land area coverage was obtained from 25 and 30 days old seedling for both varieties.

Table 3
Field performance of different aged seedling during transplanting by machine.

Age of seedling (days)	Aman, 2012							
	BRRI dhan49				BRRI dhan46			
	Seedlings (hill-1)	Hills (m-2)	Missing or floating hills (m-2)	Area covered by 4 trays (m2)	Seedlings (hill-1)	Hills (m-2)	Missing or floating hills (m-2)	Area covered by 4 trays (m2)
8	8	24	2	201	7	23	2	205
12	6	23	1	205	6	24	1	210
16	6	24	1	204	6	22	1	208
20	6	25	2	202	6	24	1	196
	Boro, 2013							
	BRRI dhan29				BRRI dhan45			
15	7	25	3	200	8	23	2	202
20	6	24	2	202	6	25	4	205
25	7	24	1	204	6	23	1	208
30	6	23	1	205	6	24	3	210

Table 4
Economic analysis of transplanting by rice transplanter vs. hand transplanting for 33 decimal of land.

Sl no.	Rice transplanter Heads	Cost Tk.	Cost US$	Hand transplanting Heads	Cost Tk.	Cost US$
1	Seed for 27 trays			Labor for seed and seed bed preparation - 1 man-days	300.00	3.75
	i. Fine grain (130g/tray)	125.00	1.57	Seed	175.00	2.19
	ii. Bold grain (140g/tray)	135.00	1.69	Labor for seedbed maintenance - 1 man-days	300.00	3.75
3.	Labor requirements for tray preparation, seed sowing, watering and maintenance			Labor for seedling uprooting and transplanting - 4 man-days	1200.00	15
	a. Aman (15days) - 2 man-days	600.00	7.50			
	b. Boro (30 days) - 2 man-days	900.00	11.25			
4.	Labor for seedling carrying and transplanting	300.00	3.75			
5.	Fuel for transplanting	200.00	2.5			
6.	Total cost					
	Aman season				1975.00	24.69
	i. Fine grain	1225.00	15.32			
	ii. Bold grain	1235.00	14.44			
	Boro season					
	i. Fine grain	1525.00	19.07			
	ii. Bold grain	1535.00	19.19			

Labor: 300.00 Tk./man day, Seed: 35 Tk./Kg, Fuel: 100 Tk./lit. 1 $ = 80.00 Tk.

Seedlings of about 25 trays required for transplanting in an area of 33decimal and 190 trays for one hectare. About 200 nursery boxes were necessary for paddy fields of one ha (Tasaka, 1999).

3.9. Economic performance evaluation

For transplanting 33 decimal of land by rice transplanter one farmer need 14 to 15 US$ in aman and 19 US$ for boro season while 24 US$ is required in traditional system (Table 4). So farmers cane save 4-5 US$ per 33 decimal from seedling raising to transplanting.

4. Conclusion

Rice transplanter is a new technology in Bangladesh. It requires younger seedling for transplanting. Cultivar having bold type grain could achieved desirable leaf number and seedling height earlier than cultivar with fine grain type. Seedling with 3 leaf stage and 12cm height might be achieved from 12 to 16 days old seedling during aman and 25 to 30 days old seedlings in boro season for transplanting using rice transplanter. Using rice transplanter farmers could be saved 4 to 5 US$ per 33 decimal from seedling raising to transplanting.

Further research include the following: growth parameters and rice yield and its components after transplanting for different seedling age and varieties should be assessed and compared, as well as assessing the working accuracy of the rice transplanter.

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