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TRAY SOIL MANAGEMENT IN RAISING SEEDLINGS FOR RICE TRANSPLANTER

*MAA Mamun, MM Rana and AJ Mridha
Agronomy Division, Bangladesh Rice Research Institute, Bangladesh

ABSTRACT

Transplanting using rice transplanter is a cost effective technology. It is a promising technology in Bangladesh due to labor shortage during peak period of rice transplanting. We conducted two experiments in Bangladesh Rice Research Institute, Bangladesh in *aman* season (Sptember, 2012) and *boro* season (January, 2013) to find out suitable seedling raising materials for rice transplanter. Seedlings were raised on plastic trays using soil alone, 75% soil + 25% decomposed cow dung, 75% soil + 25% ash, 75% soil + 25% saw dust, 75% soil + 25% rice husk and 75% soil + 25% decomposed poultry manure. The sprouted and dry seed of BRRI dhan49 and BRRI dhan29 were sown for *aman* and *boro* season, respectively. The recommended seedling number (3 leaves per seedling) and suitable seedling height (12cm) could be achieved from 12 days old seedling in *aman* and 25 days old seedling in *boro* for transplanting using rice transplanter. Both sprouted and dry seeds showed satisfactory performance with soil media alone. Greener leaves, longer shoot and root length, more seedling vigor and strength, and better nutrient composition as well as field performance was obtained from seedling grown on soil media containing 25% cow dung or rice husk or poultry manure mixture. Using rice transplanter farmers could be saved US $ 5.0-9.0 per 33 decimal of land.

Keywords: Seedling raising material, rice transplanter, nutrient composition, labor crisis, cost effective.

INTRODUCTION

Historically, rice cultivation is a labor-intensive task that could not be accomplished easily. Land preparation, transplanting and harvesting are the expensive and time-consuming operations for successful rice cultivation. Labor cost accounts the biggest input cost for rice production (Clayton, 2010). Rice covers nearly 75% of cropped area contributing over 95% of total food grain production in Bangladesh (BARC, 1983). So, about 90% of labor has been engaged in rice cultivation in Bangladesh. Industrialization, migration of agricultural labor to other job and high labor wage are the threat for sustainable rice production as well as food security. Labor crisis and high wage is particularly critical during peak labor-need periods, which typically occur during rice transplanting and harvesting. To overcome these, farm mechanization has been considered as an important remedial measure. In recent time, transplanting and harvesting machinery are considered top priority for sustainable rice production.

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 by 1970s and 1980s in Japan and Korea, respectively (Haytham *et al*., 2010). 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. Usually, a plastic tray called a nursery box (58 × 28 × 2.5cm) is used for raising rice seedlings. Soil is packed into it, and seeds are sown. Nursery boxes are then arranged plain land and the seedlings are raised. When the seedlings are sufficiently grown, the nursery boxes are put on a van and taken to the paddy fields. The seedlings are then transplanted by a transplanter (Haytham *et al*., 2010). But 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 (Kitagawa *et al*., 2004). So, for Bangladesh condition what will the suitable soil material for seedling raising in plastic trays for rice transplanter still unknown. Considering the mentioned situation, we conducted two experiments to find out suitable soil material (recipe) to raise seedling for rice transplanter.

*Corresponding author email: aamamunbrri@yahoo.com

MATERIALS AND METHODS

Plant and growth condition

We conducted two experiments, first one in September (*aman*), 2012 and second one in January (*boro*), 2013 at the Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh to find a suitable soil material for seedling raising 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 plastic trays using 100% soil (T1), 75% soil + 25% decomposed cow dung (T2), 75% soil + 25% ash (T3), 75% soil + 25% saw dust (T4), 75% soil + 25% rice husk (T5) and 75% soil + 25% decomposed poultry manure (T6). The size of each tray was 58- x 28- x 2.5cm. 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, S 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, ash, saw dust, rice husk and poultry manure are presented in table 2. Initially the trays were placed in a plain field. Then one fourth of each tray was filled with clod free soil and organic materials. The sprouted and dry seed of BRRI dhan49 and BRRI dhan29 were sown for *aman* and *boro* season, respectively. The amount of seed was 130g (dry) and 150g (sprouted) per tray. Then the seeds were covered with clod free soil mixture and irrigate to keep moistened. 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 in *aman* season and cold during *boro* season the trays were covered with polyethylene sheet. Seedlings of different soil media were analyzed for NPK uptake at the end of the nursery period (Jones, 1991). Samples were dried at 70°C for 24 hours and grinded to pass through a 20mm-mesh screen to estimate NPK uptake. A given amount of grinded samples were wet-digested with H_2SO_4, and potassium concentrations in the digested solution were determined using a flame spectrophotometer. The P concentration was determined by double beam spectrophotometer (Murphy and Riley, 1962). Total N was determined on composite plant samples by the Kjeldahl distillation method (Bremner, 1965).

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 split plot design putting soil materials in main plot and seed (sprouted vs. dry) in sub-plot 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 and Gomez, 1984).

Field evaluation

To evaluate the field performances we used walking type rice transplanter made by Republic of Korea, model: DP480. During transplanting we collected data on seedling number per hill, hills per m^2, missing hill and area coverage by 4 tray seedlings.

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 decimal of land. The costs for seed = US$ 0.44 per kg, labor = US$ 3.75 per man day, hiring a tractor = US$ 2.5 per 33 decimals of land. The currency conversion factor used was 1 US$ = 80 Bangladeshi Taka.

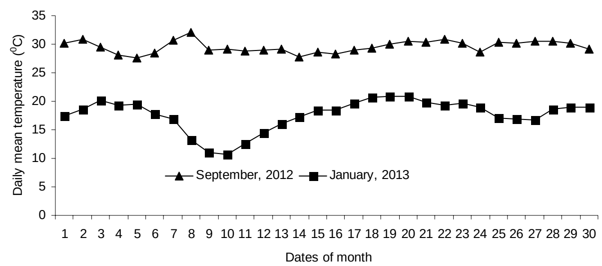

Fig. 1. Temperature data of growing season.

Table 1. Physical and chemical properties of soil.

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

Table 2. Nutrient composition of organic materials used.

Materials	MC (%)	%N	% P	% K
Cow dung	33	1.1	0.9	1.3
Ash	20	-	-	2.0
Saw dust	30	0.4	0.3	1.1
Rice husk	27	0.6	0.4	1.3
Poultry manure	54	1.7	0.4	0.06

RESULTS AND DISCUSSION

Leaf color

In *aman* season, soil management options exerted significant effect on leaf color (Table 3). Seed and interaction effect was not statistically significant. Greener leaf was obtained when soil was mixed with poultry manure followed by rice husk (Fig. 2: a-1). The leaf color was satisfactorily green when we used soil alone as well as mixture of soil with cow dung, saw dust in both type of seed. We found relatively yellow colored leaf using mixture of soil and ash. It might be because of ash contain no N which is responsible for greenness of plant leaf. During *boro* season, soil management options exerted significant effect on leaf color (Table 3). Seed and interaction effect was not statistically significant. Relatively greener leaf was observed when soil was mixed with rice husk followed by cow dung (Fig. 2: b-1). Slight leaf yellowing occurred in the trays of saw dust and poultry manure. Relatively yellow leaves were observed on trays where soil alone and ash mixture were used. The starting month of *Boro* season (December-January) is the coolest period in Bangladesh. Seedling damage is a common scenario in *boro* because of cold. But rice husk may act as an insulator or mulch to preserve soil temperature.

Leaf number

In *aman* season, soil management options exerted significant effect on leaf number (Table 3). Seed and interaction effect was not statistically significant. The highest leaf number was calculated for sprouted and dry seed with the mixture of saw dust and poultry manure, respectively (Fig. 2: a-2). The leaf number was more than 2 per plant with soil alone and mixture of organic matter. During *boro* season, soil management options exerted significant effect on leaf number (Table 3). Seed and interaction effect was not statistically significant. The highest number of laves were recorded from sprouted and dry seed with soil alone and mixture of poultry manure, respectively. More than 2 leaves per plant were recorded from all cases of organic matter mixture (Fig. 2: b-2).

Shoot length

In *aman* seasons, shoot length influenced significantly due to individual effect of soil management options and seed. Interaction effect of two factors was not statistically significant (Table 3). The tallest seedling was obtained from soil mixture with poultry manure (Fig. 3: a-3). Sprouted seeds produced tallest seedling in all soil mixture. About 12.66 and 12 cm seedling were obtained from sprouted and dry seed, respectively. More than 11cm tall seedling was obtained from soil alone, mixture of cow dung, saw dust and rice husk. We recorded the shortest seedling with ash mixture. In *boro* season, soil management options exerted significant effect on shoot length (Table 3). Seed and interaction effect was not significant. The tallest seedling was obtained from soil mixture with poultry manure. The tallest seedling was obtained from the mixture of rice husk followed by

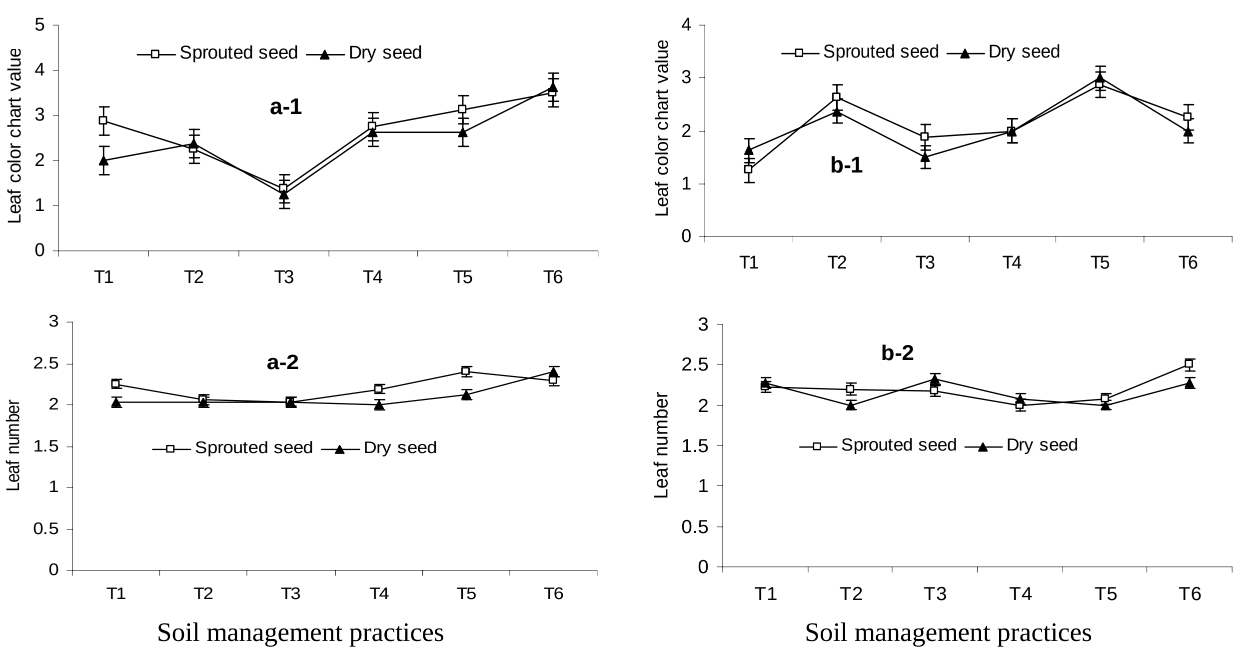

Fig. 2. Leaf color and number as affected by seed and soil management practice, a = Aman and b = Boro season, T1 = 100% soil, T2 = 75% soil + 25% decomposed cow dung, T3 = 75% soil + 25% ash, T4 = 75% soil + 25% saw dust, T5 = 75% soil + 25% rice husk and T6 = 75% soil + 25% decomposed poultry manure.

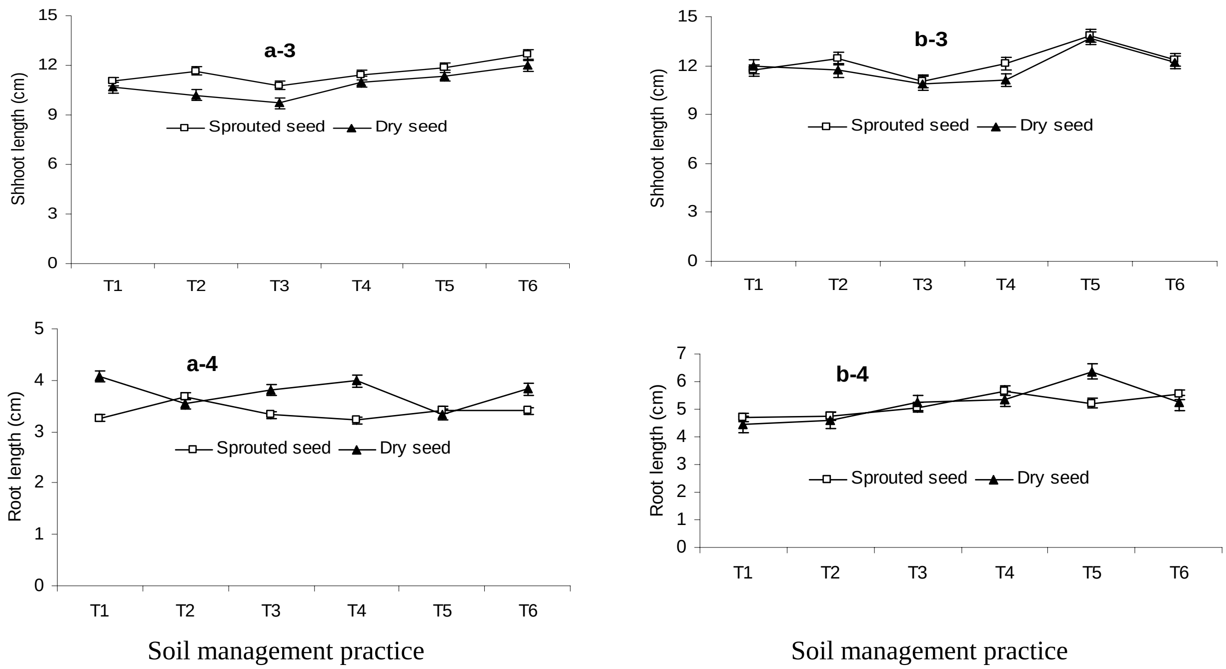

Fig. 3. Shoot and root length as affected by seed and soil management practice a = Aman and b = Boro season, T1 = 100% soil, T2 = 75% soil + 25% decomposed cow dung, T3 = 75% soil + 25% ash, T4 = 75% soil + 25% saw dust, T5 = 75% soil + 25% rice husk and T6 = 75% soil + 25% decomposed poultry manure.

poultry manure and cow dung (Fig. 3: b-3). The length of tallest seedling was more than 13cm where above 12cm for second highest. The ash mixture produced the shortest seedling.

Root length

Seed exerted significant effect of seedling root length. The individual effect try management options and interaction of two factors did not show statistically significant effect on root length (Table 3). The longest root was recorded from sprouted and dry seed by for soil mixture of cow dung and soil alone, respectively (Fig. 3: a-4). Dry seeds produced longer root length than sprouted seeds. Sprouted seeds produced longest root length with the mixture of cow dung. Soil and other soil mixture produce similar root length. More than 4cm root length was calculated with soil alone and about 4cm was recorded from mixture of saw dust for dry seeds. Similar root length was recorded from the mixture of ash and poultry manure. Effect of soil management options and interaction of seed and soil management options was statistically significant during *boro* season for root length (Table 3). The individual effect of seed was not significant for root length. More or less similar root length was calculated from sprouted and dry seeds (Fig. 3: b-4). Above 6cm root was obtained from the mixture of rice husk. Soil mixture with ash or saw dust or poultry manure gave more than 5cm root. Soil alone and cow dung mixture produce lowest root length.

Dry matter production

In *aman* seasons, dry matter production influenced by seed but individual effect of soil management practice and interaction was not statistically significant (Table 3). Sprouted seeds produced more dry matter than dry seeds per 20 seedlings in all cases of soil management practice (Fig. 4: a-5). In sprouted seed, the highest dry matter (426 mg) was recorded from saw dust mixture followed by soil alone. Soil mixed with poultry manure or cow dung or ash or rice husk produced similar dry matter in case of sprouted seed. Dry seed produced maximum dry matter (365mg) when seedlings are grown on soil mixed with poultry manure followed by rice husk and saw dust. Soil alone and cow dung mixture produced similar dry matter per 20 seedlings. Dry matter production influenced significantly due to individual effect of soil management and seed as well as interaction effect of two factors (Table 3) in *boro* season. Sprouted seeds gave maximum dry matter per 20 seedlings when grown on mixture of saw dust and it was 424 mg followed by poultry manure mixture (326 mg). Soil alone or mixture with cow dung or saw dust or ash produce similar amount of dry matter per 20 seedlings for sprouted seeds (Fig. 4: b-5). Dry seeds gave highest amount of dry matter (312mg per 20 seedlings) with cow dung mixture followed by rice husk mixture (291mg per 20 seedlings). The rest soil media produce similar amount of dry matter per 20 seedlings. The shoot dry weight mainly depends on the concentration of nutrients in the media, and the physical, chemical and microbiological conditions for root activity and formation of new roots. In natural vegetation the shoot dry weight decreases as soil fertility decreases (Marschner, 1995).

Seedling vigor

In *aman* season, seedling vigor influenced significantly due to individual effect of soil management practice. Seed and interaction effect of two factors was not statistically significant (Table 3). More or less similar seedling vigor index was obtained for sprouted and dry seeds. In case of sprouted seed, the highest vigor index was found from the mixture of poultry manure (13.65) followed by cow dung or rice husk mixture (13). Seedling vigor was more or less similar for soil alone or mixture of saw dust and the value was above 12 (Fig. 4: a-6). In case of dry seeds, the highest vigor index was calculated for soil mixture with poultry manure and it was above 13. The second highest vigor was calculated for seedling raising on soil mixture with saw dust followed by soil alone or rice husk. The lowest vigor index of rice seedling was calculated for soil with ash or cow dung. In *boro* season, seedling vigor influenced significantly due to individual effect of soil management practice. Seed and interaction effect of two factors was not statistically significant (Table 3). In sprouted seeds, the highest seedling vigor was obtained from seedlings produced on soil mixture with rice husk (>16) followed by saw dust and poultry manure (15). More or less similar vigor index was obtained from soil alone or soil mixture with cow dung or ash (Fig. 4: b-6).

Seedling strength

In *aman* season, seeds exerted significant influence on seedling strength (Table 3) but soil management options

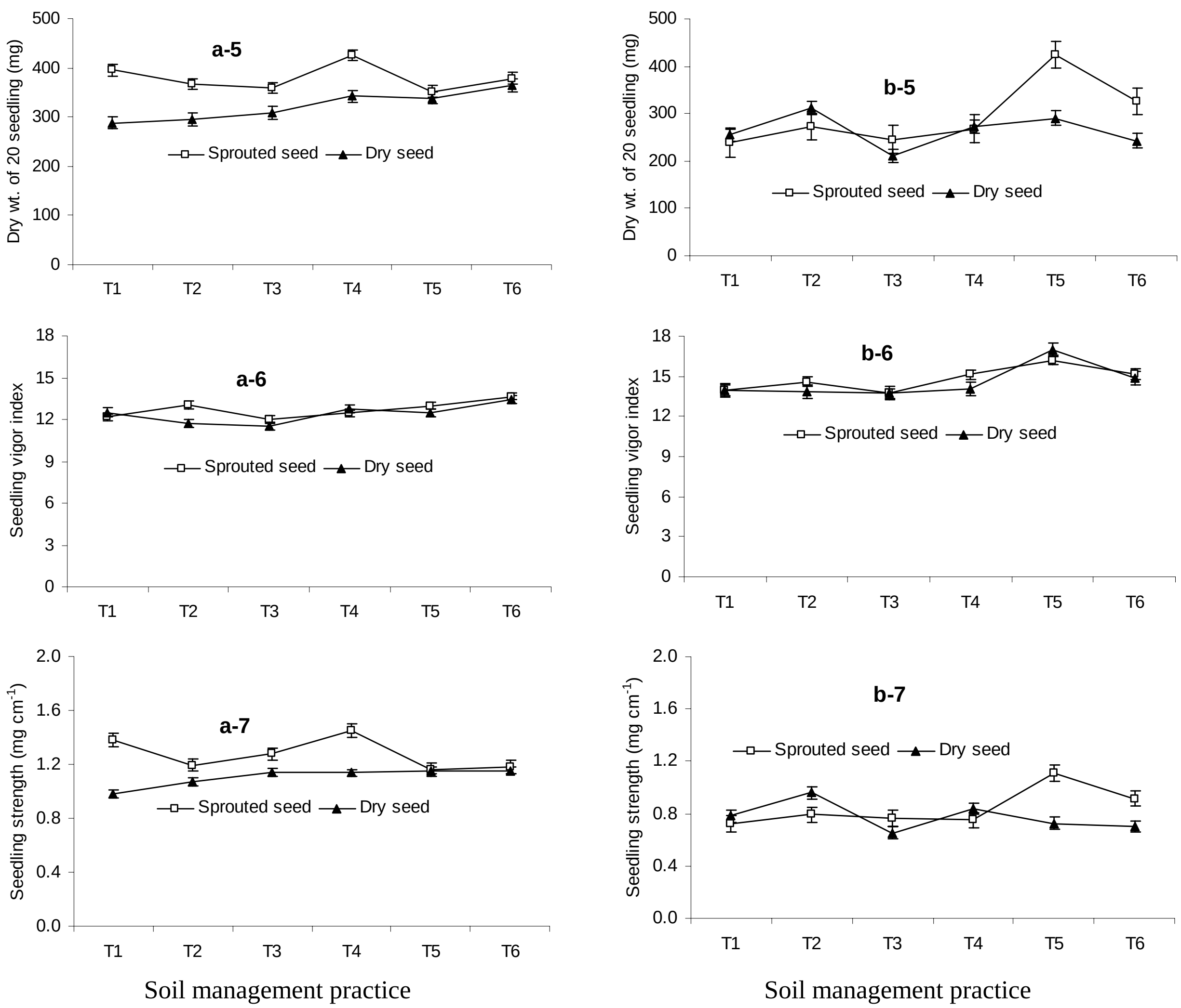

Fig. 4. Dry matter production, seedling vigor and strength as affected by seed and soil management practice, a = Aman and b = Boro season, T1 = 100% soil, T2 = 75% soil + 25% decomposed cow dung, T3 = 75% soil + 25% ash, T4 = 75% soil + 25% saw dust, T5 = 75% soil + 25% rice husk and T6 = 75% soil + 25% decomposed poultry manure.

Table 3. 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						
Soil management	**	*	**	NS	NS	**	NS
Seed	NS	NS	**	*	**	NS	**
Soil management x Seed	NS	NS	NS	NS	NS	NS	NS
	Boro, 2013						
Soil management	**	*	**	**	**	**	NS
Seed	NS	NS	NS	NS	*	NS	NS
Soil management x Seed	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.

Table 4. Nutrient composition of seedlings.

Age of seedling (days)	Aman, 2012					
	Sprouted seeds			Dry seeds		
	N (%)	P (µg/g)	K (meq/100g)	N (%)	P (µg/g)	K (meq/100g)
T1	0.28	1.61	2.78	0.30	1.72	2.88
T2	0.40	2.71	3.02	0.38	1.82	3.05
T3	0.29	1.78	3.11	0.34	1.45	3.16
T4	0.35	1.75	3.10	0.32	1.62	3.00
T5	0.36	1.92	3.00	0.37	1.73	3.02
T6	0.43	2.10	2.88	0.42	1.75	2.89
	Boro, 2013					
	Sprouted seeds			Dry seeds		
T1	0.24	1.67	2.67	0.28	1.20	2.64
T2	0.31	1.88	3.12	0.43	1.87	3.15
T3	0.23	1.34	3.24	0.34	1.45	3.30
T4	0.35	1.40	3.03	0.33	1.51	3.07
T5	0.34	1.43	3.12	0.38	1.56	3.14
T6	0.37	1.50	2.87	0.44	1.67	2.15

T1 = 100% soil, T2 = 75% soil + 25% decomposed cow dung, T3 = 75% soil + 25% ash, T4 = 75% soil + 25% saw dust, T5 = 75% soil + 25% rice husk and T6 = 75% soil + 25% decomposed poultry manure.

and interaction effect was not statistically significant. The sprouted seeds produced seedlings with more strength than dry seeds. The seedling strength was highest when seedlings were grown on soil mixture with saw dust followed by soil alone (Fig. 4: a-7). More or less similar seedling strength was obtained from seedlings produced on soil mixture with cow dung or ash or saw dust or rice husk. Seedling strength was maximum when they were grown on soil mixture with poultry manure which statistically similar with seedling strength when they were grown on ash or saw dust or rice husk. The lowest seedling strength was found from seedling grown on soil alone and cow dung.

In *boro* season, individual effect of soil management options and seed was not significant for seedling strength (Table 3) while interaction effect was significant. Sprouted seeds gave seedling with highest strength when grown on soil with rice husk followed by poultry manure (Figure 4: b-7). Other treatments gave similar seedling strength. Dry seeds gave maximum seedling strength with cow dung mixture followed by saw dust and soil alone.

The minimum seedling strength was obtained from poultry manure followed by seedling grown on soil alone or rice husk. Seedlings grown in the soil with cow dung or rice husk or poultry media displayed better seedling quality in terms of seedling vigor and its characteristics and suitability for rice mechanical transplanting. This result is similar to that observed by Wang *et al*. (1999).

Nutrient composition of seedlings

For sprouted seeds, nitrogen content was high on seedlings were grown on soil mixed with poultry manure followed by cow dung during *aman* season (Table 4). Seedlings from sprouted seeds contain higher amount K

Table 5. Field performance of different seedling during transplanting by machine.

Age of seedling (days)	Aman, 2012							
	Sprouted seed				Dry seed			
	Seedlings ($hill^{-1}$)	Hills (m^{-2})	Missing or floating hills (m^{-2})	Area covered by 4 trays (m^2)	Seedlings ($hill^{-1}$)	Hills (m^{-2})	Missing or floating hills (m^{-2})	Area covered by 4 trays (m^2)
T1	7	24	2	200	7	22	1	208
T2	7	25	1	202	7	24	2	210
T3	8	23	2	200	8	24	2	199
T4	6	24	2	205	7	23	2	205
T5	6	23	2	198	7	24	2	198
T6	7	25	2	199	6	24	1	200
	Boro, 2013							
	Sprouted seed				Dry seed			
T1	6	24	2	205	7	25	4	210
T2	6	23	1	202	8	24	2	208
T3	7	24	3	198	6	23	3	196
T4	5	25	2	200	6	23	2	205
T5	9	24	2	200	8	24	1	200
T6	5	25	2	200	9	23	2	196

T1 = 100% soil, T2 = 75% soil + 25% decomposed cow dung, T3 = 75% soil + 25% ash, T4 = 75% soil + 25% saw dust, T5 = 75% soil + 25% rice husk and T6 = 75% soil + 25% decomposed poultry manure.

Table 6. Economic analysis of transplanting by rice transplanter vs. hand transplanting for 33 decimal of land.

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

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

and P when grown on cow dung or saw dust mixture. Nitrogen content was more in seedlings grown on poultry manure mixture followed by cow dung or rice husk mixture media. In *boro* season, seedling grown on media of poultry manure or saw dust or rice husk mixture contained higher amount of N for sprouted and dry seeds (Table 4). The amount of P was high for media containing cow dung or poultry manure. The amount of K was higher for ash containing media. The organic matter based substrate had a notable N availability, which would cause a consistent N–P synergism on P uptake. The positive effect of organic matter based media on P uptake was evident. On the other hand, increases of P uptake in plants in response to N supply have also been reported in the literature (Matsushima, 1980). The growth traits may be attributed to the presence of amino acids and important nutrients such as NPK in the organic based substance compared with the soil alone which potentially enhance the initial radical growth; radical cell elongation depends on the accumulation of solutes such as potassium and nitrate (Taiz and Zeiger, 2003). The most important advantage of the organic matter based media over the soil alone is in releasing the macro and micro-nutrients slowly during the growth period.

Field performance

Field performance was satisfactory with both seed type in two seasons. In *aman* season, maximum number of seedlings per hill and missing hill was obtained from seedling grown with mixture of ash in both type of seeds but minimum area coverage for transplanting was recorded from seedlings from poultry manure or rice husk (Table 5). Less number of seedlings per hill and missing hill as well as maximum land area coverage was obtained from seedlings of cow dung or saw dust. In *boro* season, maximum number of seedlings per hill and missing hill as well as minimum area coverage for transplanting was recorded from seedlings obtained from ash mixture media (Table 5). Less number of seedlings per hill and missing hill as well as maximum land area coverage was obtained with the seedling of soil or mixture of cow dung or saw dust. Seedlings of about 25 to 27 trays were required for transplanting in an area of 33decimal and 190-200 trays for one hectare. About 200 nursery boxes were necessary for paddy fields of one ha (Tasaka, 1999).

Economic performance evaluation

For transplanting 33 decimal of land by rice transplanter, one farmer need US$ 15.0 in *aman* and US$ 19.0 during *boro* season while US$ 24.0 is required for traditional system (Table 6). So farmers could be saved US$ 9.0 in *aman* and 5.0 during *boro* season per 33 decimal of land using rice transplanter.

CONCLUSION

Transplanting using rice transplanter requires younger seedling for transplanting. Farmers could use soil alone as a media for raising seedling for rice transplanter with sprouted or dry seeds. For getting good quality seedling and better field performance, farmers should be used a media containing 25% cow dung or rice husk or poultry manure mixture with 75% soil. Using rice transplanter farmers could be saved US$ 5.0-9.0 per 33 decimal from seedling raising to transplanting.

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

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