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Effect of Mat Type Rice Seedling Growing Media on Block Formation and Fungal Infection

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ABSTRACT

Rice seedling for mechanical transplanting must meet the requirements of standard seedling block with uniform distribution of seedlings and inter-twisting roots for rolling. This study was carried out at the Farm Power and Machinery Department, Sylhet Agricultural University, Sylhet during Boro season/2018-19 with the objective of evaluating the different seedling growing media for raising quality mat type rice seedling. Two-ways factorial design with 3 replications was followed to conduct the study. Seedling were raised on plastic tray using two types of soil (sandy clay loam and sandy clay) mixing with four different categories of organic substance (decomposed cow dung, rice bran, rice husk and tea wastage) at the rate of 0.0, 5, 10, 15 and 20%, respectively to get the desired combinations as per treatments. Rolling quality of the seedling mat decreased and fungal infection increased with the increase of mixing rate of organic substance except cow-dung. Sandy clay loam showed better performance on rolling quality of the seedling mat over sandy clay soil. Tea wastage and rice husk organic substance indicated poor bonding of the seedling mat in both type of soils because of restricting the roots growth which loosen the bonding of the tray soil. There was a tendency of crack forming on the sandy clay soil. In general, 10 to 15% of cow-dung or rice bran mixture with both type of soils was found suitable as growing media to get quality seedling in mat for mechanical transplanting. The findings of the study could be promoted widely in farmer's field to raise better quality of mat type seedling for better performance of the mechanical rice transplanter which ultimately led to get better rice yield.

Introduction

Rice (*Oryza sativa*) is the major food crop of Bangladesh and occupied the highest area among all the crops grown in the country. About half of the world population depends on rice as its energy supplyingfood grain. In Asia, more than two billion people depend on rice and its products for 60-70 percent of their calorie requirement (FAO, 2015). In Bangladesh, about 75% and 63% of the total crop production and sales, respectively and 75% of the total cultivated area is captured by rice (Klytchnikova and Diop, 2006). Historically, rice cultivation is a labor-intensive task and labor cost accounts the biggest input cost for rice production (Clayton, 2010). The total labor requirement for rice production in one hectare of land is about 156.2 man-days of which 44.5 man-days is needed by seedling raising and transplanting which is 28.24% of the total labor requirement (Hossen *et al.*, 2018a). Labor scarcity is a vital problem and need to explore establishment methods for rice production. The use of mechanical rice transplanter for rice transplanting purpose is an alternative way to address this issue.

Mechanization of rice cultivation, i.e. seedling raising and transplanting, is improving in Bangladesh in order to reduce the cost of rice production. Rice is cultivated either by direct sowing or by transplanting. Mechanical transplanting requires considerably less time and labor (1-2 ha/person/day) than manual transplanting (0.07 ha/person/day) (IRRI, 2007). It is very difficult to cover large area within a short span of time by manual labor for transplanting. Normally 40-50 days old rice seedling is used in traditional manual transplanting whereas 18-30 days old mat type seedling is used in mechanical transplanting (Hossen *et al.*, 2018b). Delay in transplanting from normal date of sowing causes reduction in rice yield by 9 percent (Islam *et al.*, 2008). Mechanical rice transplanting is an alternate and promising technology, as it saves labor force, ensures timely transplanting and also contributes to higher yield (Sreenivasulu, 2014).

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Research work regarding effective growing media for mat type rice seedling raising is still in the infant stage. A suitable growing media is needed for raising good quality mat type rice seedling. Possibilities of using different media as an alternative to conventional soil media (Ko *et al.,* 2005; Shiratsuchi *et al.,* 2008; Ikeura *et al.*, 2012). Soil collection and filling the seedling tray with soil (around 5-6 kg/tray) is the major problem of mat type seedling raising for mechanical transplanting because more than 200 trays is required for 1 ha of land, necessary to carry to the main field. If soil medium can be replaced by any light weight, low cost and easily available materials that would be a great help to the rice farmers. Rice husk, a by-product of rice processing industry, found to be a suitable medium for soilless culture due to the properties of good aeration and light weight (Islam, 2015). Also, it can be overcome by rolling up the seedling as seedling mat to carry easily. Adequate quality of the seedling mat is required for rolling up. Rolling quality of the seedling mat is important parameter to carry seedling from nursery bed to the main rice field and to feed in the seedling tray of the rice transplanter. It is influenced by seedling growing and covering media, moisture content, organic matter and root growth. Cow dung, rice husk, rice bran, tea wastage etc. are well known nutrient sources used in crops as they enhance the growth of plants. Haytham *et al.* (2010) noticed that rolling up of the seedling mat is important to reduce the seedling volume that helps to carry bulk volume to the main field.

Appropriate seedling height, number of leaf during transplanting, stem thickness are also important parameters for quality transplanting to minimize the missing hills by reducing buried hills, picker missing, floating hills and mechanical damage hills. Hoshino (1978) suggested that 80-150 mm height of mat type seedling is suitable for mechanical transplanting.

About 3 leaf stages are required for machine transplanting (Kitagawa *et al*., 2004). In Bangladesh condition, the suitable soil material for raising mat type seedling for rice transplanter is still unknown. Seedling growing media in the seedling tray would have great influence on seedling height, number of leaf, stem thickness and hence on plant establishment with minimum missing hills. Soil and manure type¸ ratio of manure mixture with soil and different covering media are of considerable importance factors for quality seedling. Thus, the study needs to be conducted to identify the suitable growing and covering media in combination with soil (sandy clay loam and sandy loam) and organic substances (rice husk, rice bran, waste of tea etc.). Mechanical standards seedling raising ultimately helps to popularize mechanical transplanter in Bangladesh.

Materials and Methods

The study was conducted in the Farm Power and Machinery Department, Sylhet Agricultural University, Sylhet in the irrigated dry season of Boro 2018-2019 from 10 December, 2018 to 15 January and the latitude and longitude of the location is 24°54'33.9"N 91°54'05.2"E.

Experimental design and treatments

Two-way factorial design with 3 replications was followed to conduct the study. Organic substance was used as factor A and percentage of soil mixture was used as factor B for both type of soil separately (Table 1). Four different categories of organic substance (cow dung, rice bran, rice husk, tea wastage) and two types of soil (sandy clay loam and sandy clay) were mixed separately at different rate (100%, 95%, 90%, 85% and 80%) to get the desired combinations as per the treatments (Fig. 1). Table 2 shows the different experimental information. The temperature and relative humidity during the seedling growing period were collected from local weather station and presented in Fig. 2 & Fig. 3, respectively.

Physical properties of the growing media

Cow dung, rice bran, rice husk and tea wastage were used as organic substance with two different type of soil. These substances were air dried and passed through 2 mm sieve. A representative amount of soil sample was used for analyzing to identify the physical characteristics of the soil. Soil samples were analyzed in the SRDI (Soil Resource Development Institute) lab at Bypass road, Chondipul, Pirijpur, Sylhet and presented in the Table 3.

Sample preparation and seedling raising on plastic tray

All additional substance (cow dung, rice bran, rice husk and tea wastage) were mixed with sandy clay loam and sandy clay soil manually on volume basis and filled up the trays. Seedling tray filled up with mixed soil at a thickness of 20 mm which is 3/4th of the trays. Seeds of BRRI dhan28 @ 140 g per tray were spread uniformly on the trays. After sowing, soil mixture was spread over the seeds (3–4 mm thick) to cover the seeds.

Data collected

Based on mechanical characteristics of rolling capacity, pests and diseases were measured after 30 days of sowing during Boro season by different parameter. Rolling capacity of the seedling mat and seedling strength was also measured at 30 days after seeds sowing. Total 50 undergraduate students and 02 faculties were evaluated the rolling quality of the seedling mat and given score. Rolling quality of the seedling mat were measured in terms of scored 10 for

excellent (no crack during rolling), 8 for good (single and minor crack), 6 for medium (more than one crack but possible to roll up: medium crack), 4 for bad (more than one crack and difficult to roll up: major crack), 2 for very bad (more than one and large size crack and very difficult to roll up: extreme crack) and 1 for not possible to roll up in any way. The pest and disease incidence were also observed at 30 days after seeds sowing. It was measured as number of infected plants and expressed in percentage. Collected data were analyzed as a 2-way factorial design (factor A × factor B) according to Gomez and Gomez (1984) using Statistix 10 program (Statistix 10 software, 2013).

Results

Rolling quality of mat

Rolling quality of the seedling mat at 30 days after sowing (Soil type I)

Observation scored did not varied significantly with the interaction effect of organic substance and percentage of soil mixture while scored varied significantly with the single effect of the both factor (Table 4 and Fig. 4 & Fig. 5). Soil without any organic substance scored higher values on rolling quality followed by cow dung and rice bran along with 95% soil mixture whereas rice husk along with 85 to 80% soil mixture showed lower scored on rolling quality (Fig. 6 to Fig. 9). Cow dung scored significantly higher value followed by rice bran while rice husk gave significantly lower value (Fig. 4). Significantly lower value was observed for 80% soil mixture with organic substance (Fig. 5). Rolling quality decreased with the increase of organic substance with sandy clay loam soil. Pictorial views of rolling quality of seedling mat of sandy clay loam soil while mixing with different organic substance at different ratio are showing in Fig. 6 to Fig. 9.

Rolling quality of the seedling mat at 30 days after sowing (Soil type II)

Two-way interaction of organic substance and percentage of soil mixture did not show significant effect on rolling quality of the seedling mat. The single effect of both organic substance and soil mixture percentage showed significant effect on rolling quality (Table 5 and Fig. 4 & Fig. 5). Soil without any organic substance showed higher score on rolling quality followed by cow dung along with 95% soil mixture and tea wastage along with 95 to 90% whereas rice husk along with 80% soil mixture showed lower score on rolling quality (Fig. 10-Fig. 13). Single effect of cow dung, rice bran and tea wastage scored significantly higher value while rice husk gave significantly lower value on rolling quality (Fig. 4). 100% soil scored significantly higher value followed by 95% soil mixture. Significantly lower score on rolling quality was observed for 80% soil mixture with organic substance (Fig. 5). Pictorial views of rolling quality of seedling mat of sandy clay soil while mixing with different organic substance at different ratio are showing in Fig. 10 to Fig. 13.

Fungal infection

Fungal infection at 30 days after sowing (Soil type I)

The organic substance and percentage of soil mixture showed significant effect on intensity of fungal infection as were both the single effect of organic substance and soil mixture percentage (Table 6 and Fig. 14 to 16). Rice bran along with 80% soil mixture gave significantly higher fungal infection followed by cow dung and tea wastage along with 90 to 80% soil mixture and 100% soil, whereas 95% soil mixture with rice bran gave significantly lower fungal infection. It can be concluded that 95% soil with cow-dung and tea wastage, 95 to 85% soils with rice bran and rice husk gave significantly less fungal infected seedling.

Among the organic substances, fungal infection was observed significantly higher for rice bran followed by tea wastage while rice husk gave significantly lower value followed by cow dung (Fig. 14). On the other hand, 80% soil mixture with organic substance scored significantly higher value of fungal infection while 100 to 85% soil mixtures with organic substance gave significantly lower value (Fig.15).

Fungal infection at 30 days after sowing (Soil type II)

The organic substance and percentage of soil mixture showed significant effect on fungal infection as were both the single effect of organic substance and soil mixture percentage (Table 7 and Fig. 14 to Fig. 16). Rice bran along with 80% soil mixture gave significantly higher fungal infection followed by cow dung along with 80% soil mixture whereas 90% soil mixture with cow dung and soil without organic substance gave significantly lower fungal infection. It can be concluded that 90% soil with cow-dung, 95 to 100% soil with rice bran, 90% soil with rice husk and 90 to 95% soil with tea wastage gave significantly less fungal infected seedling.

Among the organic substances, cow dung, rice bran and tea wastage scored significantly higher value while rice husk gave significantly lower value (Fig. 14). In the five mixture, 80% soil with organic substance scored significantly higher value while 95 to 90% soil mixtures with organic substance gave significantly lower value followed by soil without organic substance (Fig. 15).

Table 1. Experimental arrangement

Soil type	Organic substance (Factor A)	Percentage of soil mixture (Factor B)
Sandy clay loam (Type I)	Cow dung (CW)	100% soil (Control)
Sandy clay (Type II)	Rice bran (RB)	95% soil
	Rice husk (RH)	90% soil
	Tea wastage (TW)	85% soil
		80% soil

Table 2. General information of the experiment

Season	Variety	1,000 grains weight (g)	Soaking date	Sowing date	Germination (%)	Growing period
Boro/ 2018–19	BRRI dhan28	23.10	08 Dec, 2018	12 Dec, 2018	86	12 Dec, 2018 to 12 Jan, 2019

Table 3. Physical characteristics of the studied two different soils

Properties	Value	
	Soil 1	Soil 2
Fine sand (%)	59.2	49.2
Silt (%)	14	12
Clay (%)	26.08	38.08
Texture	Sandy clay loam soil (SCLS)	Sandy clay soil (SCS)

Table 4. Combined and single effect of organic substance and percentage of soil mixture (Type I) on rolling quality of mat

Percentage of soil mixture	Average score out of 10				Mean
	Cow dung	Rice bran	Rice husk	Tea wastage	
100	10.00	8.67	8.00	8.00	8.67
95	8.67	8.67	6.00	8.00	7.83
90	8.00	8.00	6.00	7.33	7.33
85	8.00	6.00	4.67	7.33	6.50
80	6.67	6.67	4.67	6.67	6.17
Mean	8.27	7.60	5.87	7.47	-
CV, %	13.01				
LoS	O= **, S= ** and O× S= NS				
$LSD_{0.05}$	O=0.70 and S=0.79				

Note: NS- Not significant, *- significant at 5 %, **- significant at 1 %, LoS- Level of significance, O-Organic substance and S-Soil mixture (%)

Table 5. Combined and single effect of organic substance and percentage of soil mixture (Type II) on rolling quality of mat

Percentage of soil mixture	Average score out of 10				Mean
	Cow dung	Rice bran	Rice husk	Tea wastage	
100	9.33	8.67	7.33	8.00	8.33
95	8.67	7.33	6.67	8.00	7.67
90	7.33	6.67	6.67	8.00	7.17
85	6.67	7.33	5.33	6.00	6.33
80	6.00	5.33	4.00	6.00	5.33
Mean	7.60	7.07	6.00	7.20	-
CV, %	16.29				
LoS	O= **, S=** and O× S= NS				
$LSD_{0.05}$	O=0.84 and S=0.94				

Note: NS- Not significant, *- significant at 5 %, **- significant at 1 %, LoS- Level of significance, O-Organic substance and S-Soil mixture (%)

Table 6. Combined and single effect of organic substance and percentage of soil mixture (Type I) on fungal infected seedlings (%)

Percentage of soil mixture	Average score out of 10				Mean
	Cow dung	Rice bran	Rice husk	Tea wastage	
100	3.33	6.67	1.67	3.33	3.75
95	5.00	0.00	3.33	5.00	3.33
90	6.67	3.33	3.33	6.67	5.00
85	5.00	3.33	3.33	5.00	4.17
80	8.33	28.33	5.00	11.67	13.33
Mean	5.67	8.33	3.33	6.33	-
CV, %	60.85				
LoS	O= **, S= ** and O× S= **				
$LSD_{0.05}$	O=2.66, S=2.98 and O× S=5.95				

Note: NS- Not significant, *- significant at 5 %, **- significant at 1 %, LoS- Level of significance, O-Organic substance and S-Soil mixture (%)

Table 7. Combined and single effect of organic substance and percentage of soil mixture (Type II) on fungal infected seedlings (%)

Percentage of soil mixture	Average score out of 10				Mean
	Cow dung	Rice bran	Rice husk	Tea wastage	
100	10.00	5.00	3.33	8.33	6.67
95	5.00	5.00	6.67	5.00	5.42
90	3.33	6.67	5.00	5.00	5.00
85	8.33	10.00	6.67	6.67	7.92
80	18.33	20.00	6.67	15.00	15.00
Mean	9.00	9.33	5.67	8.00	-
CV, %	35.07				
LoS	O= **, S=**and O× S= **				
LSD $_{0.05}$	O=2.07, S=2.32and O× S=4.64				

Note: NS- Not significant, *- significant at 5 %, **- significant at 1 %, LoS- Level of significance, O-Organic substance and S-Soil mixture (%)

1 2 3 4

Figure 1. Plastic tray along with soil and organic substances mixture (tray 1: Cow dung mixed with soil, tray 2: Rice bran mixed with soil, tray 3: Rice husk mixed with soil and tray 4: Tea wastage mixed with soil)

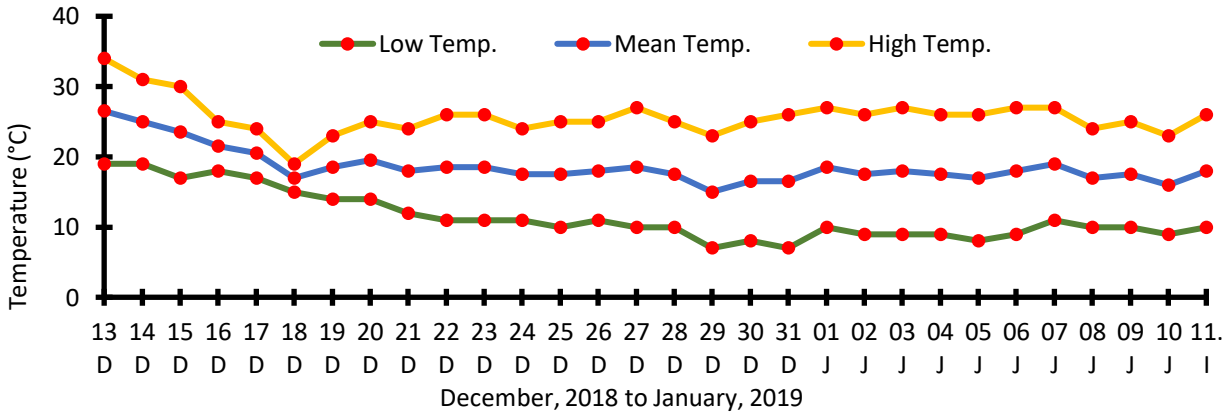


Figure 2. Temperature during seedling growing period

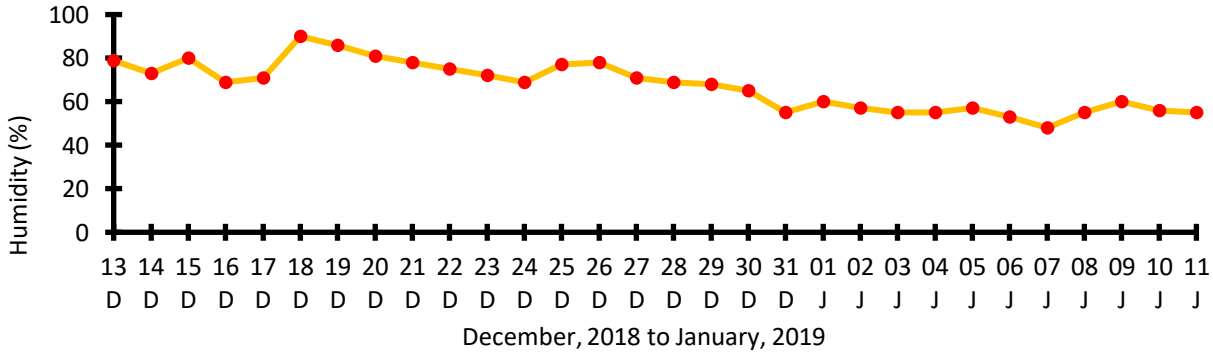


Figure 3. Air humidity during seedling growing period

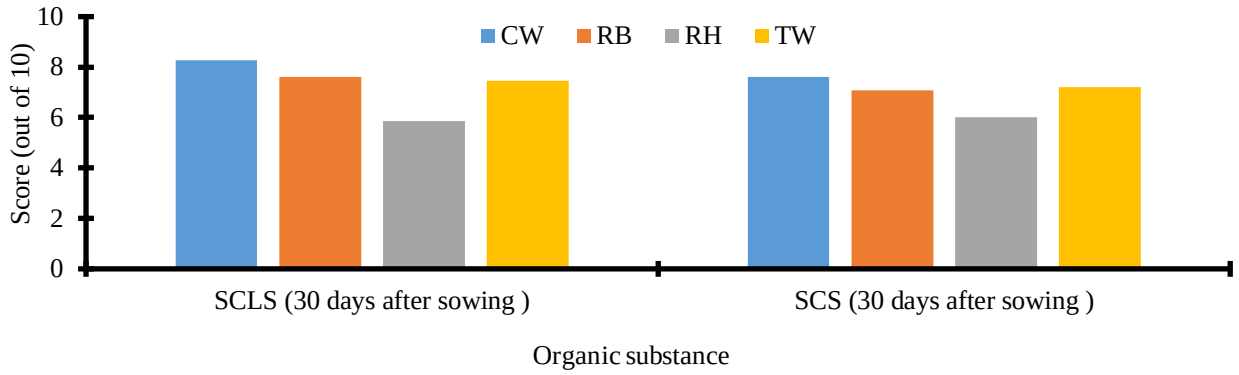


Figure 4. Effect of organic substance on rolling quality

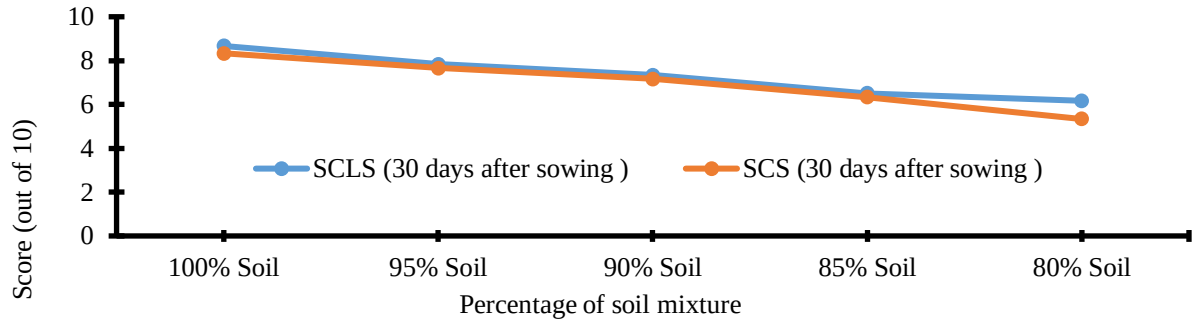


Figure 5. Effect of percentage of soil mixture with organic substance on rolling quality

1: 100% soil (zero cow-dung) | 2: 95% soil (5% cow-dung) | 3: 90% soil (10% cow-dung) | 4: 85% soil (15% cow-dung) | 5: 80% soil (20% cow-dung)

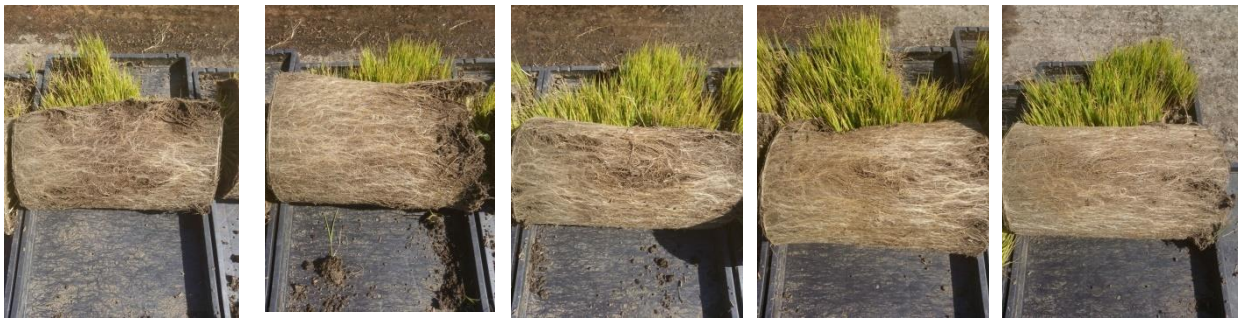
Figure 6. Effect of sandy clay loam soil on rolling quality of seedling mat while mixing with cow-dung at different ratio

1: 100% soil (zero rice bran) | 2: 95% soil (5% rice bran) | 3: 90% soil (10% rice bran) | 4: 85% soil (15% rice bran) | 5: 80% soil (20% rice bran)

Figure 7. Effect of sandy clay loam soil on rolling quality of seedling mat while mixing with rice bran at different ratio

1: 100% soil (zero rice husk) 2: 95% soil (5% rice husk) 3: 90% soil (10% rice husk) 4: 85% soil (15% rice husk) 5: 80% soil (20% rice husk)

Figure 8. Effect of sandy clay loam soil on rolling quality of seedling mat while mixing with rice husk at different ratio



1: 100% soil (zero tea wastage) 2: 95% soil (5% tea wastage) 3: 90% soil (10% tea wastage) 4: 85% soil (15% tea wastage) 5: 80% soil (20% tea wastage)

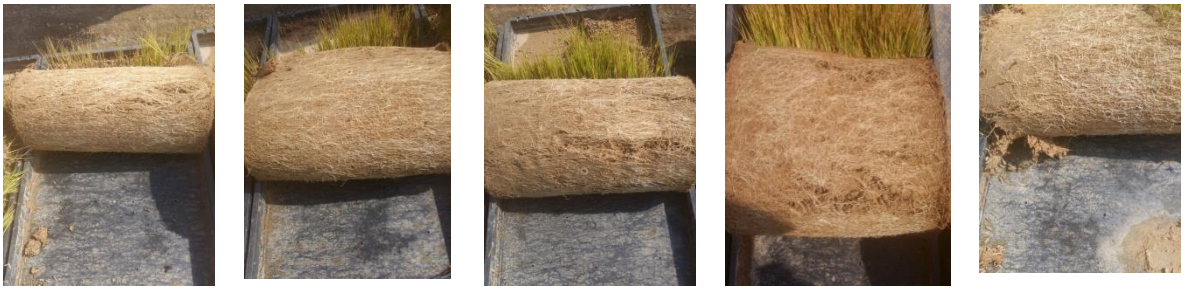
Figure 9. Effect of sandy clay loam soil on rolling quality of seedling mat while mixing with tea wastage bran at different ratio

1: 100% soil (zero cow-dung) 2: 95% soil (5% cow-dung) 3: 90% soil (10% cow-dung) 4: 85% soil (15% cow-dung) 5: 80% soil (20% cow-dung)

Figure 10. Effect of sandy clay soil on rolling quality of seedling mat while mixing with cow-dung at different ratio

1: 100% soil (zero rice bran) 2: 95% soil (5% rice bran) 3: 90% soil (10% rice bran) 4: 85% soil (15% rice bran) 5: 80% soil (20% rice bran)

Figure 11. Effect of sandy clay soil on rolling quality of seedling mat while mixing with rice bran at different ratio



1: 100% soil (zero rice husk) 2: 95% soil (5% rice husk) 3: 90% soil (10% rice husk) 4: 85% soil (15% rice husk) 5: 80% soil (20% rice husk)

Figure 12. Effect of sandy clay soil on rolling quality of seedling mat while mixing with rice husk at different ratio

1: 100% soil (zero tea wastage) 2: 95% soil (5% tea wastage) 3: 90% soil (10% tea wastage) 4: 85% soil (15% tea wastage) 5: 80% soil (20% tea wastage)

Figure 13. Effect of sandy clay soil on rolling quality of seedling mat while mixing with tea wastage bran at different ratio

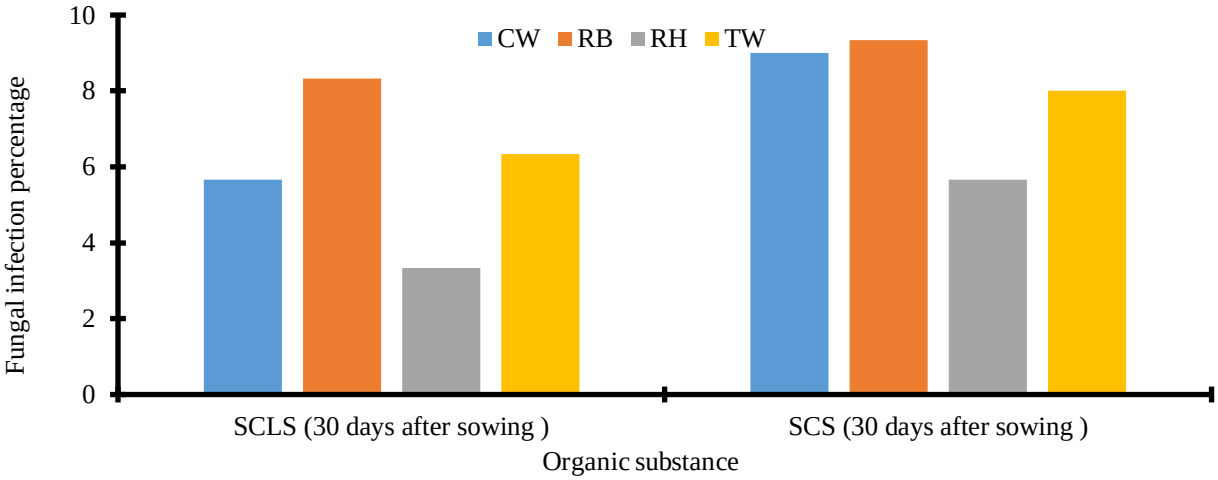


Figure 14. Effect of organic substance on fungal infection

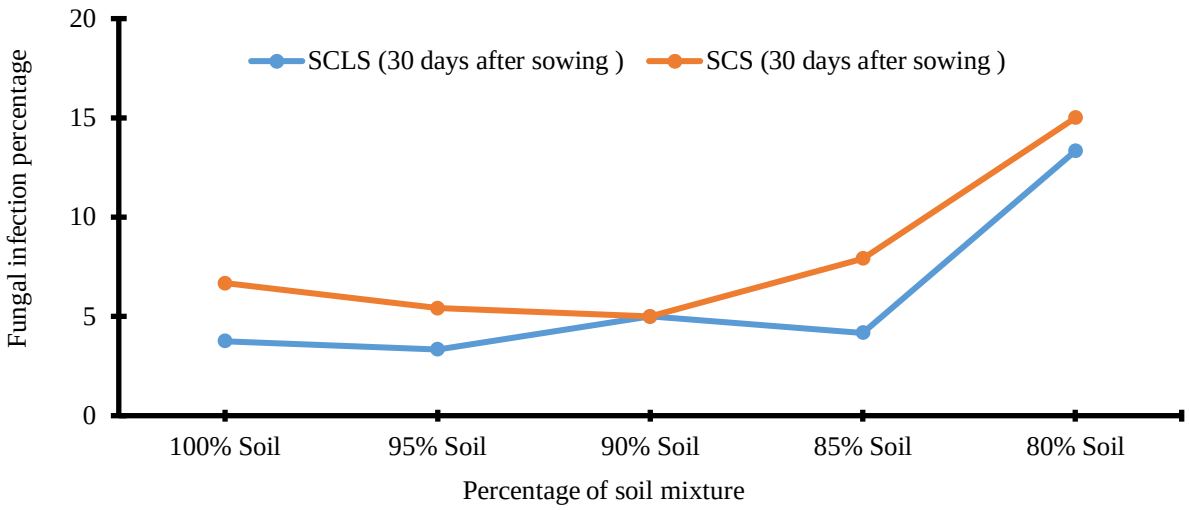
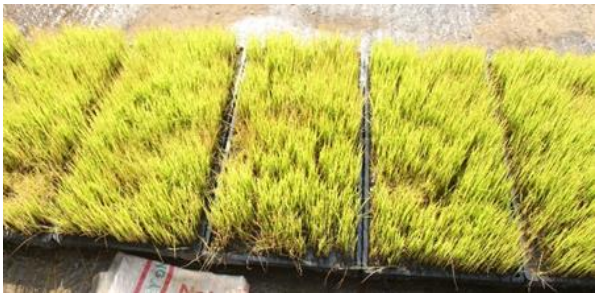


Figure 15. Effect of percentage of soil mixture with organic substance on fungal infection

Healthy seedling



Fungal infected seedling

Figure 16. Healthy and fungal infected seedling

In the present study, interaction and single effect of soil type, organic substance and mixing rate were observed during the dry (Boro) season/2019. With respect to mechanical characteristics, rolling capacity (seedling mat) decreased and fungal infection increased with the increase of mixing rate of organic substance with base soil. Sandy clay loam soil showed better performance on rolling quality of the seedling mat over sandy clay soil. Rolling quality of the seedling mat decreased with the increased of organic substance except rice bran because bonding strength of soil decreased with the increases of the organic substance (Hossen *et al.*, 2018b). The decrease of soil strength with the increase of organic inputs agrees with other studies (Arthur *et al.,* 2012; Schjonning *et al.,* 2007).

Tea wastage and rice husk organic substance gave poor bonding of the seedling mat in both type of soil because of restricting the roots growth and loosen the bonding of the tray soil. Haytham *et al.* (2010) reported that rice straw seed bed can be rolled up easily that helps to reduce working hours by one-third. Physical and chemical compositions of different organic fertilizer likely affect the roots growth and roots strength to fix the soil of tray (Sasaki *et al.,* 1981).

Conclusion

For mechanical transplanting, seedbed preparation on a plastic tray or on a polythene sheet for mat type seedling raising is important. Quality seedling in terms of good rolling capacity and pests and diseases free seedling are important factors for widely used of rice transplanter. The rolling quality of the seedling mat decreased and fungal infection increased with the increase of mixing rate of organic substance with base soil. On average, both types of soil up to 10% of cow-dung and tea wastage, and 5% of rice bran and rice husk gave good results for rolling quality of seedling mat as well as a less fungal infection.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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