



Field evaluation of tractor-operated seeder for sowing mat type paddy nursery

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ABSTRACT

Mat-type nursery having uniform growth is a prerequisite for mechanized paddy transplanting. Generally, this type of nursery is sown manually in the open field or in trays. It requires several simultaneous operations and hence is laborious and time-consuming. The performance of tractor-operated mat-type nursery seeder was evaluated at the Research Farm of Punjab Agricultural University, Ludhiana, Punjab during 2019–20 with an objective to obtain the finest speed of operation to get the uniform seed and soil spread. Study was carried out on three different types of soil (sandy loam, loam and silt loam) for three different forward speeds (1.7, 2.2 and 2.7 km/h). Results have shown that the soil type had a non-significant effect on the performance of the machine, whereas forward speed had significant ($P < 0.05$) effect. In overall, with an increase in forward speed of the machine, there was a reduction in uniformity for both seed and soil spread. The best results were obtained at a forward speed of 1.7 km/h with the overall seed spread of 90.93%, overall soil mat thickness 99.70%, fuel consumption 4.36 l/h and effective field capacity 0.092 ha/h. Therefore, the developed tractor-operated seeder can be operated on sandy loam to silt loam soils with a forward speed of 1.7 km/h with 59.5% saving in cost and 62.6% saving in labour for sowing mat type nursery as compared to manual method with MS frames.

Keywords: Farm mechanization, Mat type nursery, Nursery seeder, Paddy nursery

Paddy transplanting is the most prevalent method in India, performed by the traditional method that requires more (200–250) man-h/ha, higher energy input and expected human drudgery due to bending posture. Labour shortage during the peak season of transplanting is being experienced in north-west India which poses a huge constraint to transplanting of seedlings in time. Farmers confront that difficulties in timely paddy transplanting resulted in reduction of yield (Mahajan *et al.* 2009). To cope up with this limitation, mechanical transplanting is found to be an efficient substitute for traditional transplanting with 78–88% labour savings (Manes *et al.* 2013). Paddy transplanters are now available in the market that can transplant the seedlings in a line for better inter-cultural operation. In Punjab, about 760 paddy transplants were procured on subsidy from farmers as well as from cooperative societies in association with the State Government (Modi *et al.* 2022a). States in north-west India have adopted mechanized farming to a good extent except transplanting of paddy (20% mechanization level) due to lack of knowledge and required skill for growing mat type nursery (Mehta *et al.* 2019). To uplift the mechanization, mechanical paddy transplanting should

be boosted by developing a mechanized method of sowing mat-type nursery in field itself (Modi *et al.* 2020). Uniformity of mat thickness and uniform growth is the pre-requisite for efficient performance of mechanical paddy transplanters. Thus, there was need to mechanize the sowing operation of raising mat-type nursery. The research done on mechanical method of sowing mat type nursery directly in the field is limited in India as well as abroad except for the stationary method as stated above (Modi 2020). To address this issue, a simple and cost-effective tractor-operated seeder for raising mat-type seedlings of paddy was designed and developed (Modi *et al.* 2022a, Modi *et al.* 2022b). Thus, the study was undertaken to evaluate the developed tractor-operated mat type nursery seeder under different soil types for the finest speed of operation and to optimize the uniformity of seed spread at a particular bite of transplanter cut with appropriate width of soil bed.

MATERIALS AND METHODS

Description of the machine: It is a tractor-operated trailed type machine for sowing mat type nursery of paddy. The machine cuts the soil of 240 mm width and up to 80 mm depth (adjustable) from both sides and transfers it at an angle of 40° to auger conveyor with the help of belt conveyor having cleats. The auger conveyor has auger fitted in opposite direction to convey the soil received from both belt conveyors to fall uniformly on the sieving system. The

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Fig 1 Field evaluation of tractor-operated seeder for mat-type paddy nursery (a) soil placement, (b) seed placement, (c) measurement of seed spread and (d) measurement of soil spread.

sieving system has rectangular opening of $25\text{ mm} \times 20\text{ mm}$ and operates at 398 oscillations/min. After sieving, the soil falls in the soil metering system which meters the soil to fall uniformly on the polythene sheet. The soil metering mechanism was made of fluted type roller with 13 flutes and has a diameter of 180 mm. Before the soil metering unit, a roller with having 220 mm diameter was provided to compact the soil surface to lay polythene sheet. A roller of 50 mm diameter was provided in between the soil metering unit and compaction roller for wrapping polythene sheet to lay down the polythene sheet on this compacted soil surface. Simultaneously, a fluted roller type seed metering mechanism having 14 flutes and a diameter of 40 mm was provided rear of soil metering unit to meter the seed on the prepared soil bed in a uniform manner. All these operations are done by the machine simultaneously in a single go.

Evaluation procedure: The field evaluation of tractor-operated mat-type nursery seeder was conducted at the research farm of Punjab Agricultural University, Ludhiana, Punjab during 2019–20. Experiment was conducted at three locations having different soil types, viz. sandy loam (ST1), loam (ST2) and lilt loam (ST3) at three forward speeds, viz. 1.7 km/h (FS1), 2.2 km/h (FS2) and 2.7 km/h (FS3) for sowing nursery of paddy cultivar PR-126. At all locations, the fields were prepared with the same method after leveling with laser land leveler and then tilling with

two passes of rotavator followed by plunger. During field evaluation of the machine, the soil moisture content varied from 10.0–14.0% (d.b.). The experimental layout and treatments were designed in randomized block design (RBD). Manual sowing of mat type nursery of paddy on a polyethylene sheet using frames was taken as a control (C) treatment for the comparison using Dunnett's test. The front and rear views of tractor-operated seeder for mat-type paddy nursery in operation for soil and seed placement are shown in Fig 1a and 1b, respectively.

The effect of soil type and forward speed of the machine was evaluated on the performance of the machine in terms of uniformity of seed spread (SP), uniformity of soil mat thickness (M), fuel consumption and field capacity. Uniformity of seed spread was measured by counting the seeds in a particular wire opening area by placing three different wire mesh sieves having wire opening area ($11.70 \times 8.22\text{ mm}$, $14.11 \times 11.70\text{ mm}$ and $20.00 \times 11.70\text{ mm}$, respectively) corresponding to width and length of bite of transplanting finger of transplanter at minimum, middle and maximum bite of transplanter cut (Fig 1 c).

The soil mat thickness was measured by scraping the soil on the polythene sheet lateral to direction of travel with the help of 1000 mm wide blade randomly (Fig 1 d). The bed thickness varied at the outermost sides, thus the last segment of 100 mm on both sides was divided into 4 sub-

Table 1 Categorisation of uniformity of seed spread and uniformity of soil mat thickness

Class of category	Uniformity of seed spread (SP)	Uniformity of soil mat thickness (M)
	Number of seeds	Mat thickness, mm
Inadequate	0-1 (SP1)	< 20 (M1)
Proper	2-4 (SP2)	20-30 (M2)
Over	> 4 (SP3)	> 30 (M3)
Overall	≥ 2 (SP4)	≥ 20 (M4)

segments of 25 mm each, to get more clarification about soil mat thickness (1000, 950, 900 and 850 mm, respectively). Uniformity of seed spread and soil mat thickness was categorized as inadequate, proper, over and overall, based on number of seeds in a particular mesh opening and thickness of soil mat for particular bed width, respectively (Table 1). Fuel consumption was measured by fitting a fuel meter (least count 1.0 ml) in fuel line for 20 m length. Statistical analysis was carried out at 5% level of significance using statistical software “SAS 9.3” for Analysis of variance and post hoc (Tukey’s) test for comparisons of different treatment combinations. The pooled data of various parameters were analyzed using Chi-square test and difference within the pairs of bite of transplanter cut using Z test.

RESULTS AND DISCUSSION

Uniformity of seed spread: Data corresponding to forward speeds and type of soil was pooled for bite of transplanter cut to find the effect of bite of transplanter cut on uniformity of seed spread (Fig 2a). Data showed that bite of transplanter cut (BT) had a significant ($P<0.05$) effect on the uniformity of seed spread. Inadequate seed spread was more (36.75%) at the minimum bite, whereas over seed spread was more (55.38%) at maximum bite of transplanter cut. This could be due to lesser number of seeds with a lesser area of cut at minimum bite of cut contributed to higher percentage inadequate seed spread and lesser percentage

of over seed spread and vice versa. Higher percentage of proper seed spread (73.68%) was observed for middle bite of transplanter cut (BT2) as inadequate and over seed spread was higher at minimum and maximum bite of transplanter cut, respectively.

Further analysis was done for middle bite of transplanter cut for analyzing the effect of soil type and forward speed on uniformity of seed spread (Table 2). The effect of soil type was found to be non-significant for proper seed spread (Table 2). This might be due to fact that all the three fields were well pulverized and soil is sieved hence formed a similar surface quality of soil mat for seed. The effect of FS1 and FS2 was found non-significantly different, whereas the effect of FS3 was significant ($P<0.05$). The mean higher proper seed spread uniformity at FS1 and for control treatment was 79.93% and 83.20%, respectively. A similar trend of overall seed spread was observed for all the soils and forward speeds. The mean higher overall seed spread uniformity at FS1 and for control treatment was 90.93% and 93.60%, respectively. The uniformity of seed spread at FS1 and FS2 was statistically comparable to control treatment ($P<0.05$) for both SP2 and SP4. Sharma and Singh (2008) could achieve the desired seed uniformity but required 4–5 passes of the manual seed spreading device on the same mat.

Uniformity of soil mat thickness: Data corresponding to three forward speeds and three bites of transplanter cut was pooled to assess the effect of soil bed width on different categories of uniformity of soil mat thickness (Fig 2b). Data showed that percentage of inadequate soil mat thickness decreased and percentage of proper soil mat thickness increased significantly ($P<0.05$) with decrease in soil bed width from 1000–900 mm. But the effect of bed with 950 mm (W3) and 850 mm (W4) was not significantly different (93.74 and 93.84%, respectively). This could be due to the fact that at outer edges, the depth of soil is lesser due to fall of soil from a certain height and having no overlap. The effect of bed width on M3 was non-significant and negligible ($<0.81\%$). Hence, taking into account the field capacity and cost of sowing further analysis was carried on

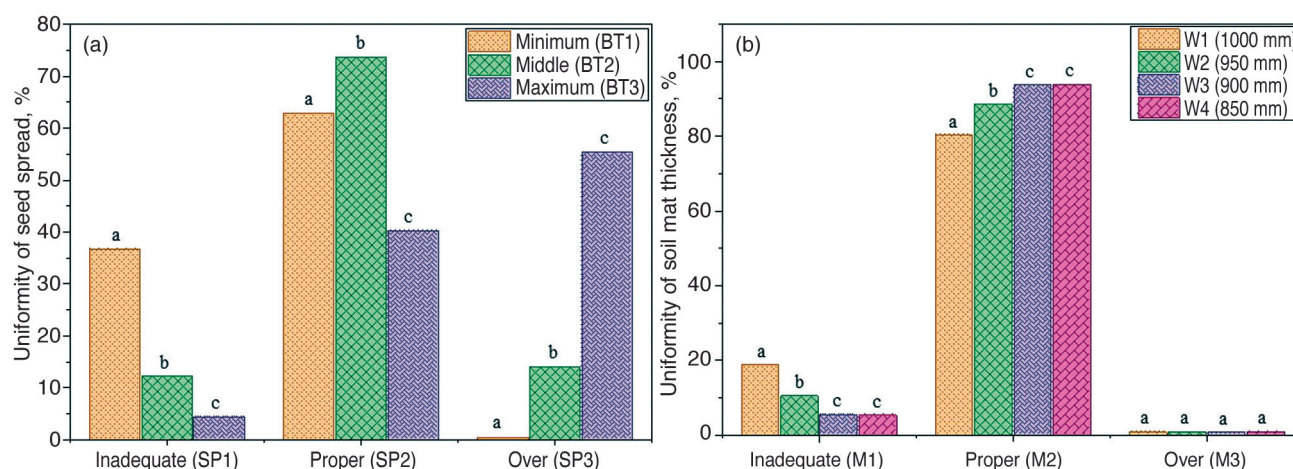


Fig 2 Pooled data of uniformity of seed and soil spread; (a) per cent frequencies for a particular quality of seed spread and (b) quality of soil mat thickness with same letter are not significantly different at $Z_{\alpha/2} = 1.96$, for $\alpha=0.05$; two-tail).

Table 2 Effect of soil type and forward speed on performance of the machine

Soil type (ST)	(a) Proper seed spread (SP2)				(b) Overall seed spread (SP4)			
	Mean ST × FS			Mean ST	Mean ST × FS			Mean ST
	FS1	FS2	FS3		FS1	FS2	FS3	
Uniformity of seed spread (%) at middle bite of transplanter cut (BT2)								
ST1 (Sandy loam)	80.80 ^{aA}	79.20 ^{abA}	62.40 ^{cB}	74.13 ^a	93.60 ^{aA}	92.00 ^{aA}	81.60 ^{aB}	89.07 ^a
ST2 (Loam)	80.00 ^{aA}	76.00 ^{abcA}	68.00 ^{abcB}	74.67 ^a	92.00 ^{aA}	90.40 ^{aA}	85.60 ^{aA}	89.33 ^a
ST3 (Silt loam)	78.40 ^{abA}	73.60 ^{abcA}	64.80 ^{bcB}	72.27 ^a	87.20 ^{aA}	86.40 ^{aA}	80.80 ^{aB}	84.80 ^a
Mean FS	79.73 ^a	76.27 ^a	65.07 ^b		90.93 ^a	89.60 ^a	82.67 ^b	
Mean control (C)		83.20 ^A				93.60 ^A		
Uniformity of soil mat thickness (%) at of soil bed width 900 mm								
Soil type (ST)	(a) Proper soil mat thickness (M2)				(b) Overall soil mat thickness (M4)			
	Mean ST × FS			Mean ST	Mean ST × FS			Mean ST
	FS1	FS2	FS3		FS1	FS2	FS3	
ST1 (Sandy loam)	99.09 ^{aA}	98.18 ^{aA}	85.45 ^{aA}	94.24 ^a	99.09 ^{aA}	98.18 ^{aA}	85.45 ^{aB}	94.24 ^a
ST2 (Loam)	97.27 ^{aA}	94.54 ^{aA}	82.73 ^{aB}	91.51 ^a	100.00 ^{aA}	98.18 ^{aA}	82.73 ^{aB}	93.64 ^a
ST3 (Silt loam)	100.00 ^{aA}	98.18 ^{aA}	86.36 ^{aA}	94.85 ^a	100.00 ^{aA}	98.18 ^{aA}	86.36 ^{aA}	94.85 ^a
Mean FS	98.79 ^a	96.97 ^a	84.85 ^b		99.70 ^a	98.18 ^a	84.85 ^b	
Mean control (C)		98.57 ^A				100.00 ^A		
Fuel consumption (l/h)								
Soil type (ST)	Mean ST × FS			Mean soil type (ST)				
	FS1	FS2	FS3					
ST1 (Sandy loam)	4.23 ^c	4.71 ^{ab}	5.09 ^a	4.68 ^a				
ST2 (Loam)	4.45 ^{bc}	4.81 ^{ab}	5.14 ^a	4.80 ^a				
ST3 (Silt loam)	4.42 ^{bc}	4.76 ^{ab}	5.11 ^a	4.76 ^a				
Mean FS	4.36 ^a	4.76 ^b	5.11 ^c					
Mean control (C)		-						

Means with same small letter are not significantly ($P>0.05$) different and same capital letter are not significantly ($P>0.05$) different from control.

for soil bed width of 900 mm.

Means of uniformity of soil mat thickness at soil bed width 900 mm (W3) corresponding to three different soil types (ST) and three different forward travel speeds (FS) are given in Table 2. The effect of soil type on uniformity of proper soil mat thickness and overall soil mat thickness was non-significant at 5% level of significance. This could be attributed to the well-pulverized soil that was sieved to remove soil clods for all soil types (at all locations), resulting in a uniform flow from the soil metering system. The effect of forward speeds FS1 and FS3, FS2 and FS3 was significantly ($P<0.05$) different. The effect of forward speeds FS1 and FS2 was non-significant and uniformity of proper soil mat thickness and overall soil mat thickness for these speeds varied from 96.97–98.79% and 98.18–99.70%, respectively. The uniformity of proper and overall mat thickness at FS1 and FS2 was found statistically same as that of control treatment (98.57% and 100.00%, respectively).

Rate of work and economics: The effect of soil type on fuel consumption was non-significant, whereas the effect of forward speed was found significant ($P<0.05$) (Table 2).

The fuel consumption increased from 4.36–5.11 l/h with increase in forward speed from 1.7–2.7 km/h, respectively. The increase in fuel consumption was due to seeding of more area per unit time at higher speed.

Since the uniformity of seed spread, uniformity of soil mat thickness was found statistically similar for FS1 and FS2, the field capacity of the machine for soil bed width of 900 mm was 0.092 ha/h, taking field efficiency of 60% as compared to control (0.001 ha/h). The machine can sow such a large area and hence a lot of labour is required (which is not available in a day) to do the remaining operations after seeding such as putting thin layer of soil on seed, putting water on the mat, making bunds (*kiara*) and water channels for irrigating. Also, the entire nursery is not to be sown in one day at one location and must move to other location. Hence, saving in cost was worked out for sowing nursery to transplant 20 ha in a day. Saving in cost of sowing mat type nursery and labour using mat type paddy nursery seeder was 59.48% and 62.65%, respectively as compared to manual method of sowing.

The results obtained from actual field evaluation

indicate that the effect of forward speed significantly ($P < 0.05$) affects the seed spread, soil mat thickness, fuel consumption and actual field capacity. The best performance of the machine was obtained at a forward speed of 1.7 km/h with overall seed spread of 90.93%, overall soil mat thickness 99.70%, fuel consumption 4.36 l/h and effective field capacity 0.092 ha/h. Saving in cost and labour for sowing mat type nursery using mat nursery seeder was observed 59.5% and 62.6%, respectively as compared to the conventional method with frames.

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