Fabrication of a low-cost drum seeder for paddy

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Abstract: Rice is a staple food crop. Bangladesh produces it extensively which raised the nation into the fourth-largest rice-grower in the world. Transplanting or direct seeding is a major task in rice cultivation where the manual transplanting method requires a huge labor cost which is beyond control in a peak season. Although mechanical rice transplanters become popularization land preparation and seedling rising as a pre transplanting task is costly and labor-intensive. On the other hand, manual broadcasting and machine seeding direct method still exist due to the above method's problem. Considering spacing accuracies for intercultural operation, drum seeders are an easy and convenient method for Bangladeshi farmers. This research was carried out to design and develop a drum seeder considering existing problems related to the spacing accuracies and cost optimization. It was tested for paddy seeds under laboratory setup. The developed drum seeder has double-rows with 20 cm row spacing which has a 2.4 m working width and weighs only 15 kg. The calibration test of the seeder reveals that the seed rate increased with the decrease in amount of seeds filled with hopper. Filling with one-fourth of drum's full capacity results in the optimum seed rate (86.33 kg ha^{-1}). On the other hand, an unacceptable seed rate was found (26.68 kg ha^{-1}) when the drum was filled of its full capacity. The performance of the seeder in the laboratory setup was satisfactory and the overall cost to fabricate the drum seeder was found 18.15 USD which is acceptable for farmers. An extension is needed to adopt the drum seeder to the Bangladeshi farmers.

Keywords: drum seeder, low-cost, calibration test

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1 Introduction

Rice is the most important and extensively grown food crop in Bangladesh, and it is the major food for more than half of the world's population. The total milled rice production and rice-cropped areas were 161.48 million hectares and 481.54 million tons in the world, respectively in 2016 (International Rice Research Institute [IRRI], 2018). Bangladesh has now obtained the fourth largest rice-growing nation after China, India, and Indonesia occupying 11.38 million hectares of land with a milled rice production of 34.71 million MT (BBS, 2017).

There are two ways for rice cultivation starts with namely transplanting and direct seeding. The

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transplanting method usually is practiced for paddy, and it involves huge labor with the long process. It is done either by mechanical transplanting or manually. For manual transplanting, rice seedlings are first raised into seedbed before they are carried into the main field. This method results in a uniform crop stand but it is expensive, requires huge labor forces. Besides, the method involves stressful drudgery and it requires approximately 25% of the total labor requirement of the crop (Senthilkumar and Thilagm, 2012). In Bangladesh, the major problem is the unavailability of labor during peak time. As a result, labors are hired with high wages which ultimately increases overall production cost. On the other hand, mechanical rice transplanting is now promoted by government and different non-government authorities as it saves labor, ensures timely transplanting, and attains optimum plant. But special care is required in the transplanting method for raising nursery either in the tray or mat type seedlings. Though mechanical transplanting of rice has been considered the most promising option, it is often said as a problem where the land is not uniform and huge cost is involved with land preparation (Chandrasekhararao et al., 2013; Singh, 2008)

Another conventional method is the direct seeding of paddy seeds into the field. Both manual broadcasting and drum seeders have been used in Bangladesh in the last few decades. There are some improved drum seeders are recommended for direct sowing of rice seeds to overcome the labor shortage problem in rice-growing areas. Moreover, a mechanized method of seeding rather than manual broadcasting saves time, seeds, and cost of cultivation (Sarker et al., 2019). Additionally, maintaining proper quantity, distance, depth and in a short period also increases sowing efficiency and reduces losses of seed and reduces the labor required to a large scale (Mohanta et al., 2019).

The drum seeders have some advantages over transplanting such as faster and easier establishment, reduced labor and less drudgery, and often higher profit (Rashid et al., 2009).

It has been used in Bangladesh but is very limited in scale. The farmers in Bangladesh still practice their old broadcasting methods of seed sowing in which line to line distance and row to row distance are not maintained (Rao et al., 2020; Prasanna et al., 2009). It is necessary to maintain uniform placement of seeds at proper depth with proper spacing, which is time and cost-saving especially for intercultural operation (Kachroo and Bazaya, 2011). Furthermore, to ensure better germination, and to achieve more plants population a quality drum seeder design is required (Raghavendra et al., 2015). Limited numbers of drum seeders are available in Bangladesh, however, due to the high cost of individual seeders, farmers of Bangladesh are reluctant to use. A manually operated mechanical drum seeder was developed considering designs and their problems (Ratnayake and Balasoriya, 2013). The developed conical drum seeder was evaluated in a paddy field where the saving of pre-germinated paddy rice seed was about 75% and the increase in yield was about 37% in conical drum seeder as compared to manual broadcasting. A pull-type manually operated drum seeder was designed and developed with urea super granule application considering human stress and drudgery in rice cultivation (Karim et al., 2015). The machine was very easy to pull because pulling force was only 108 N. Moreover, the influence of the machine and operational parameters viz., drum shape, the diameter of the drum, the diameter of seed metering hole, number of seed metering holes, and forward speed of operation on seed rate of the rice drum seeder are the important parameters which ultimately influence the design optimization (Sivakumar et al., 2005). They concluded that the hyperboloid drum performed better when compared to the existing seeder.

The advantage of drum seeder is that row-row spacing can be easily maintained and the dropping of seeds in hills is possible. Lack of labor during peak periods of transplanting may cause a delay in the operations which is a present concern in Bangladesh. In such situations, the drum seeder is an effective means for the timely sowing of rice. However, it is often claimed that the existing drum seeders in Bangladesh are not efficient enough and costly for farmers which needs to be improved. Therefore, this research was conducted to design and develop a low-cost drum seeder by which paddy seeds could be sown. To design and fabricate a cost-effective drum seeder using locally available materials and to evaluate its performance in a laboratory setup is the key objective of this research.

2 Materials and methods

2.1 Fabrication of drum seeder

The necessary materials (as Table 1) were purchased from the local market with the persons of workshops for making the drum seeder.

Table 1 List of necessary materials for making the drum seeder

Name of the parts	Specification of materials	Quantity	Unit
Drum (6 Nos.)	M.S. Sheet; gauge 28, size 3.35m × 1.8m	6	Kg
Wheel (2 Nos.)	a) M.S. Sheet; gauge 22, size 3.9m×0.15m. b) M.S Rod; Size 6mm dia; length 3m	3 4	Kg Kg
Shaft	2.54 cm × 2.54 cm square pipe; length 2.7 m	3	m
Handle	M.S. Rod; Size length 2m, dia 9.5mm	5	Kg
Drum separator	P.V.C. Pipe dia 3.2 cm company name; National	1	m
	Paint	250	mL

2.1.1 Fabrication of drum

The length and the diameter of the drum seeder are 30 cm and 17.78 cm respectively. Therefore, the peripheral length of the small sheet was determined by using the following equation;

$$L = \pi D = 3.1416 \; x \; 17.78 = 55.85 \; cm$$

Six small sheets, each of them 55 cm × 30 cm were cut by sharp scissors from the big sheet. A section of 8.9 cm × 8.9 cm was removed from one side of each small sheet. Four lines and 48 points were marked in any one of six sheets. Then six sheets are fixed in a bundle with a C- clamp keeping the marked sheet on the top. A drill bit having a size of 9.5mm diameter (11/32 Nos.) was fixed with a drill machine. Then, 48 holes were made on the bundle of six small sheets by the drill machine. The stretch out of the drum is shown in Figure 1.

The drill sheets were ground by the grinding machine to make the holes smooth and uniform. Then, the sheets were rolled and fixed it by the rivet joint. As a result, a cylindrical drum was prepared which was 17.78 cm diameter and 30 cm long with both sides open. There was an opening in the middle of the drum for filling the seeds. Thus, the other 5 drums were made. Twelve square sheets, each of them of 19 cm × 19 cm, were cut to close the opening of the drums. Different views of drums are shown in Figure 2.

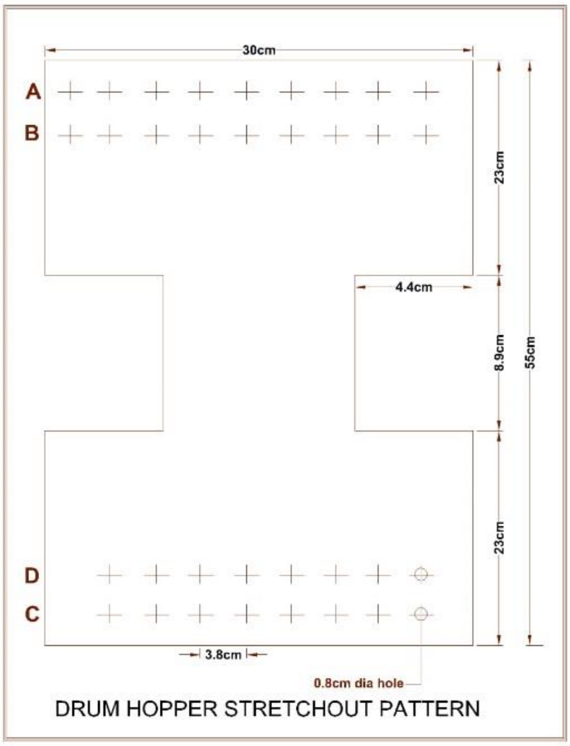

Figure 1 Stretch out of the drum

Six sheets, each of them 17.78 cm × 17.78 cm, were used for making a cover on the opening of the drums. It was joined by a repeat mechanism in such a way that it can open and close easily.

Figure 2 Different views of a drum hopper (All dimensions are in cm)

2.1.2 Procedure to make axle shaft

A 2.74 m long square hollow shaft of 2.54 cm× 2.54 cm was cut for the axle shaft of the drum seeder. It was used as an axle shaft (Figure 3).

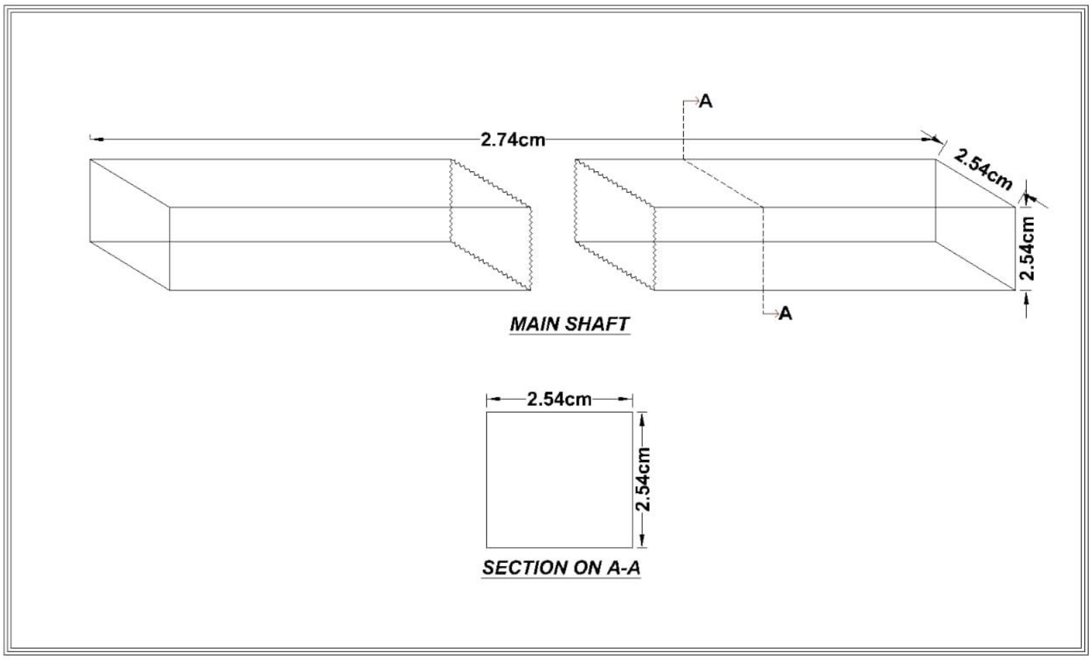

Figure 3 Different views of shaft (*All dimensions are in cm)*

2.1.3 Procedure to make a handle

Two rods (0.95 cm diameter) of 74.93 cm long and were cut to make a handle and bent the rod at a distance of 13.97 cm at one side. Then an extra rod of 76.2 cm long was cut and it was added by welding with the rods (Figure 4).

Figure 4 Photographic view of handle

2.1.4 Procedure to make wheel

A long M.S. sheet of 22 gauge was taken to make a wheel. Two pieces of MS sheet, each 2.0m long and 7.6 cm wide, were cut from a large sheet. Then, three lines were drawn 2.54 cm apart at a distance of 15.25cm. Then, an enfolded log of 2.54 cm was made at the middle of each mark by hammering slightly with a wooden hammer. Similarly, another 9 numbers of the enfolded log were made at the same distance. Then, a ring was made by bending the enfolded log sheet. A hollow square shaft of 3.175 cm×3.175 cm × 3.175 cm was made and fixed at the center of the ring by welding four M.S. rods. Thus, a wheel was made. The photographic view of a wheel is shown in Figure 5.

Figure 5 Photographic view of wheel

2.1.5 Procedure to make Drum separator

A P.V.C pipe of 91 cm long and 3.175 cm diameter was taken to make the drum separator. Five pieces were cut from it, each of them was 10.16 cm long. Each pipe was placed between two drums to maintain row to row distance 20 cm. Another 2 pieces, each of them 1.27 cm, were cut and placed beside the wheels. Finally, all the parts of the drum seeder were assembled.

The seeder developed by the recently trained manufacturers is presented in Figure 6.

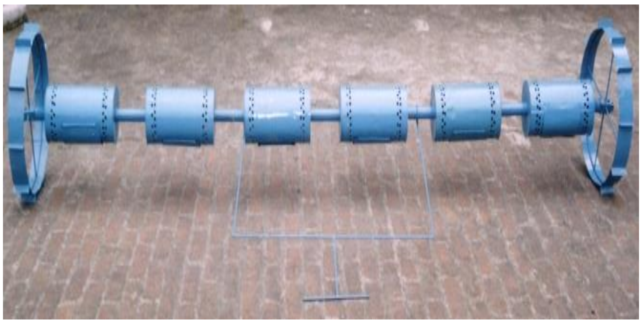

Figure 6 A photographic view of drum seeder developed by the trained manufacturer

2.2 Physical characteristics of seed

The variety of experimental seeds was MUKTA (BRRI-12). The physical characteristics (seed weight and size) of paddy were determined before the design and calibration test of the seeder. The weight of the seed was determined by weighing 10 samples of 100 grains. The seed was measured by an electric weighing machine. From this figure, the average weight of 100 grains was calculated to determine the weight of the seed and included in the report. The length, thickness, or diameter of the seed was measured. The size of the seeds was measured by a slide caliper. The averages of 50 seeds were calculated to determine the size of the seed and included in the report. The seed was kept by soaking for 2 days and then kept in a pot with covering. The percentage of germination was also counted and recorded.

2.3 Calibration of seeder

Before starting the calibration test of the seeder in the laboratory, the numbers of revolutions of the wheel for 1/100 hectare was determined by using the following Equation 1:

$$N = \frac{10000}{100 \times x \times n \times \pi d} \quad (1)$$

Where, $x = row\ spacing\ in\ meters$

$n = numbers\ of\ rows\ of\ the\ seeder$.

$d = rolling\ diameter\ of\ the\ wheel\ in\ meters.$

Germinated seeds were filled into the drums and then the whole body was fixed with an arrangement so that the wheel could be rotated freely with the hand. By turning the wheels with hand for N times the amount of seed was collected from the below of each drum and then weighed. The weight of seed delivered per hectare was calculated together with the number of revolutions of the drive wheels and the width of the machine. The photographic view of the calibration of the seeder is shown in Figure 7. The Effect of sprouting time on seed rate and germination percentage was also determined.

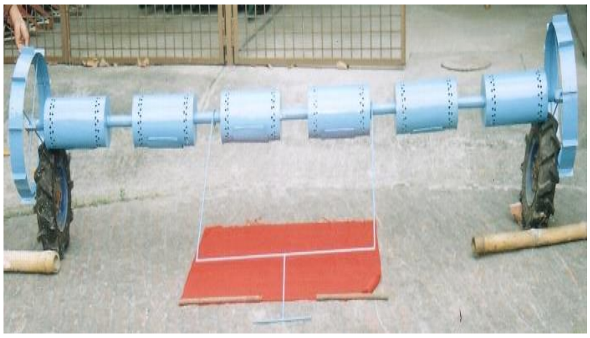

Figure 7 Photographic view of calibration test of seeder

3 Results and discussion

3.1 Cost calculation of drum seeder

The details of materials and cost are presented in Table 2. However, the cost of materials and making charge varied from region to region, (Table 3). The manufacturing charge was maximum (10.07 USD) at Mymensingh and it was lowest (8.075 USD) in

Rangpur. The average making charge was 8.474 USD. As a result, the total cost of drum seeders including materials and labor charge was 18.45 USD.

Table 2 Cost of Materials for making the drum seeder

Name of the parts	Specification of materials	Quantity	Unit	Unit cost (USD)	Total cost (USD)
Drum (6 Nos.)	a) M.S. Sheet; gauge 28, size 3.35m × 1.8m	6	Kg	0.54	3.27
Wheel (2 Nos.)	a) M.S. Sheet; gauge 22, size 3.9m×0.15m.	3	Kg	0.54	1.63
	b) M.S Rod; Size 6mm dia; length 3m	4	Kg	0.27	1.09
Shaft	a) 2.54 cm × 2.54 cm square pipe; length 2.7 m	3	M	0.59	1.77
Handle	a) M.S. Rod; Size length 2m, dia 9.5mm	5	Kg	0.34	1.72
Drum separator	a) P.V.C. Pipe dia 3.2 cm company name; National	1	M	0.18	0.18
	Paint	250	Ml	0.32	0.32
	Total Materials cost				9.98 (USD)

Table 3 Variations of labor cost for making parts of the drum in different areas of Bangladesh

Name of the parts	Mymensingh		Gaibandha		Rangpur	
	Unit cost (USD)	Total cost (USD)	Unit cost (USD)	Total cost (USD)	Unit cost (USD)	Total cost (USD)
Drum (6 Nos.)	0.82	4.90	0.73	4.35	0.64	3.81
Wheel (2 Nos.)	1.81	3.63	1.59	3.18	1.36	3.63
Shaft	0.23	0.23	0.18	0.18	0.18	0.18
Handle	0.23	0.23	0.27	0.27	0.27	0.27
Drum separator	0.09	0.09	0.09	0.09	0.09	0.09
Paint	0.09	0.09	0.09	0.09	0.09	0.09
Total Labor cost		9.16		8.17		8.07

3.2 Performance test

The direct seeder had been tested extensively in the laboratory. The result is shown in tables and figures.

Table 4 Characteristics of seeds used in laboratory

Type of seed	Rice
Variety	BRRI-12
Average size of seed:	
Length	8.15 mm
Thickness	1.98 mm
Weight of 1000 grains	27.16 gm
Moisture content (wet basis)	19.0%
Germination percentage	86%
Germination time	72 hours

3.2.1 Characteristics of seeds used in laboratory test

The variety of experimental seeds was BR11 (MUKTA) developed by Bangladesh Rice Research Institute (BRRI). The average length and thickness of the seed were 8.15 mm and 1.98mm respectively. The average moisture content of seeds was 19.0% (wet basis). The germination percent of seed was 89% after 72hrs sprouting. The average weight of 1000 grains was 27.16gm. the results are shown in Table 4.

3.2.2 Effect of sprouting time on seed rate and germination percentage

The seed was 127 kg ha^{-1} after 24 hrs of sprouting and the germination rate was 73%. The germination rate was maximum (89%) after 72 hrs of sprouting, but the seed rate was minimum (56.11 kg ha^{-1}). The seed rate is decreasing with the increase of sprouting time. Because the length of the root is increased with an increase of sprouting time. The effect of sprouting time on seed rate and germination percentage is shown in Table 5.

Table 5 The effect of sprouting time on germination percentage and seed rate

Sprouting time, hrs	Obs. No	Avg. root length, mm	Avg. length of seed, Mm	Avg. Thickness of seeds, mm	Avg. Weight of seed, gm	Avg. Germination, %	Avg. Seed rate, K g^{-1}
24	1	0.35	8.25	2.00	0.5538	73%	127.36
48	2	6.68	8.25	2.00	0.5386	85%	84.16
72	3	15.23	8.25	2.00	0.5597	89%	56.11

3.3 Calibration test of seeder

The calibration test was done by hand-operated metering. The seed rate was determined for different filling conditions of drum and forward speed of the seeder. The test result showed us that the level of filling condition into each drum has a significant impact on the seed rate. From Table 6, the filling with one-fourth of drum's full capacity results the optimum seed rate (86.33 kg ha^{-1}). On the other hand, an unacceptable seed rate was found (26.68 kg ha^{-1}) when the drum was filled of its full capacity.

Table 6 Calibration test results from hand operated metering

Condition of hopper and Amount of seed	No. of Obs.	Seed collected from each drum (gm)						Time (s)	Seed collected from each drum (kg hr^{-1})							Total (kg hr^{-1})	No. of turn	Avg. (kg hr^{-1})	Avg. total (kg ha^{-1})
		1	2	3	4	5	6												
Full fill up, 2.0 kg	1	33	29	33	29	27	31	130	0.92	0.79	0.90	0.81	0.76	0.85	3.60	8.63			
	2	32	29	31	30	28	30	126	0.92	0.83	0.88	0.85	0.81	0.86	3.60	8.74			
	3	31	28	31	29	26	30	123	0.91	0.81	0.91	0.83	0.78	0.88	3.60	8.72	30	8.70	26.68
	Avg.								0.92	0.81	0.90	0.83	0.78	0.86	3.60	8.70			
Three fourth fill up, 1.5 kg	1	94	89	79	91	87	88	120	2.83	2.68	2.37	2.74	2.60	2.65	3.60	19.46			
	2	92	90	82	90	92	87	116	2.87	2.80	2.56	2.78	2.86	2.71	3.60	20.18			
	3	92	92	84	87	90	86	118	2.80	2.82	2.56	2.64	2.76	2.61	3.60	19.79	30	19.81	60.77
	Avg.								2.83	2.77	2.50	2.72	2.74	2.66	3.60	19.81			
Half fill up, 1 kg	1	129	127	126	102	106	96	112	4.14	4.08	4.04	3.29	3.40	3.10	3.60	25.64			
	2	128	118	120	111	109	98	115	4.00	3.80	3.87	3.57	3.51	3.14	3.70	25.59			
	3	126	121	123	107	111	100	118	3.83	3.88	3.94	3.45	3.55	3.22	3.79	25.66	30	25.63	78.62
	Avg.								3.99	3.92	3.95	3.44	3.49	3.15	3.70	25.63			
One fourth fill up, 0.5 kg	1	153	143	136	130	112	97	116	4.76	4.43	4.23	4.03	3.48	3.02	3.60	27.55			
	2	149	145	138	125	110	101	109	4.91	4.79	4.57	4.14	3.64	3.34	3.60	28.99			
	3	145	148	132	123	116	105	114	4.59	4.68	4.18	3.87	3.65	3.32	3.60	27.89	30	28.14	86.33
	Average								4.75	4.64	4.32	4.01	3.59	3.23	3.60	28.14			

4 Conclusion

Considering spacing accuracies and manufacturing cost a drum seeder was designed and fabricated which has double-row with 20 cm row spacing which has 2.4 m working width weighing 15 kg. The level of filling the hopper has a negative impact on the seed rate. The seed rate of plastic drum seeder was 82 kg ha^{-1} when the drum was filled 75% with the germinated seeds. This result indicated that the performance of developed and imported seeders was very close to each other. These results also indicated that our manufacturers can fabricate a drum seeder whose performance as good as the imported drum seeder. On the other hand, the cost of imported seeder is varied between 27.22-36.30 USD. However, the average cost of a developed drum seeder is only 18.15 USD. Therefore, it can be concluded that the technology could be transferred very easily to the Bangladeshi farmers by local manufacturers in Bangladesh.

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References

BBS. 2017. *Yearbook of Agricultural Statistics–2016*. Location: Bangladesh Bur Stat.

Chandrasekhararao, C., S. Jitendranath, and T. G. K. Murthy. 2013. Resource optimisation in rice through direct seeding by drum seeder. *International Journal of Food Science and Technology*, 4(3): 239–246.

International Rice Research Institute. 2018. Available at: http://ricestat.irri.org:8080/wrs. Accessed 2018 Nov 12.

Kachroo, D., and B. R. Bazaya. 2011. Efficacy of different herbicides on growth and yield of direct wet seeded rice sown through drum seeder. *Indian Journal of Weed*

Science, 43(2): 67–69.

Karim, M. F., M. Alam, M. R. Ali, and O. Kozan. 2015. Design and development of a drum seeder with urea supergranule application for rural farmers in Bangladesh. *Agricultural and Food Sciences,* 17(3): 61-71.

Mohanta, B., A. Nath, and T. Pattnaik. 2019. Drum seeder–A labour saving technology. *International Journal of Agricultural and Biological Engineering*, 12(2): 223–227.

Prasanna, K. G. V., B. Srivastava, and D. S. Nagesh. 2009. Modeling and optimization of parameters of flow rate of paddy rice grains through the horizontal rotating cylindrical drum of drum seeder. *Computers and Electronics in Agriculture*, 65(1): 26–35.

Rashid, M. H., M. M. Alam, M. A. H. Khan, and J. K. Ladha. 2009. Productivity and resource use of direct-(drum)-seeded and transplanted rice in puddled soils in rice-rice and rice-wheat ecosystems. *Field Crops Research*, 113(3): 274–281.

Rao, R. S., M. Venkatramulu, J. H. Kumar, and P. R. Reddy. 2020. Evaluation of drum seeder in rice (Oryza sativa L.) under different spacing's. *International Journal of Current Microbiology and Applied*, 9(4): 2765–71.

Raghavendra, B. M., R. Susheela, V. P. Rao, M. Madhavi, and J. Telangana. 2015. Efficacy of different weed management practices on growth and yield of direct wet seeded rice sown. *Agricultural Systems*, 10(1): 97–101.

Ratnayake, R. M. C., and B. M. C. P. Balasoriya. 2013. Re-design, fabrication, and performance evaluation of manual conical drum seeder: a case study. *Applied Engineering in Agriculture*, 29(2): 139–47

Sarker, T. R., M. Alam, M. R. Ali, C. K. Saha, and M. A. Haque. 2019. Design and development of a multi-crop manual seed drill. *CIGR Journal*, 21(3): 51–60.

Senthilkumar, T., and V. K. Thilagm. 2012. Comparative study on improved TNAU drum seeder with SRI and conventional methods of transplanting. *Madras Agricultural Journal*, 99(7/9): 629–30.

Singh, T. P. 2008. Performance of no-till drill for establishment of rice and its comparison with drum seeder and conventional method. *Technical Sciences*, 614(470): 11–34.

Sivakumar, S. S., R. Manian, K. Kathirvel, and G. S. V. Raghavan. 2005. Investigation on the influence of machine and operational parameters for the development of a manually-drawn rice seeder for direct sowing. *Journal of Agricultural Engineering Research*, VII:1–12.