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Modification, Test and Evaluation of Manually Operated Drum Type Seeder for Lowland Paddy

Md. Syedul Islam and Desa Ahmad
Faculty of Engineering
University Putra Malaysia
43400 Serdang, Selangor, Malaysia

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ABSTRAK

Kajian telah dijalankan untuk meningkat prestasi penabur benih jenis gelendong hasil rekaan Institut Penyelidikan Beras Antarabangsa bagi kawasan padi sawah. Mesin berkenaan telah dinilai dan dibuat perbandigan dengan kaedah penanaman secara manual. Kotak pengumpul bijibenih telah direkabentuk dan dipasang kepada mesin untuk mengelak kehilangan bijibenih yang jatuh setiap kali pembelokan dilakukan diawal barisan. Ia dapat menjimatkan 5-7 kg bijibenih sehektar. Walaupun beban mesin menigkat 20 peratus dengan penambahan kotak pengumpul bijibenih ianyah tidak mejejaskan. Keupayaan ladang berkesan bagi mesin tersebut adalah diantara 0.12 ke 0.15 ha/jam manakala taburan secara manual adalah 0.22 ha/jam. Analisis separa belanjawan menunjukkan bahawa dengan memiliki penanam jenis gelendong dan pencabut rumpai jenis putar, seorang petani mampu beroleh keuntungan sebanyak US$56.20 sehektar berbanding penanaman berserta pencabutan rumpai secara manual.Analisis pulang modal menunjukkan bahawa untuk memilikipenanam jenis gelendong dan pencabut rumpai jenis putar seorang petani memerlukan keluasan tanah sekurang-kurangnya 0.3 hektar.

ABSTRACT

An experiment was conducted to improve the performance of the drum type seeder developed by the International Rice Research Institute for lowland paddy. The machine was evaluated and compared with the conventional hand seeding method. A seed collector assembly was designed and incorporated to the existing prototype in order to overcome the unwanted seed dropping at the headlands during truning which saved 5-7 kg of seed per hectare. Owing to the incorporation of seed collector assembly, the weight of the seeder increased by 20 percent compared to the previous prototype, but still within the capability of an average size labour.The effective field capacity of machine seeding ranged between 0.12 to 0.15 ha/hr and that of hand broadcasting was 0.22 ha/hr. The partial budget analysis revealed that by using drum type seeder and a rotary type seeder and a rotary type weeder, a farmer could earn a net benefit of US$55.06 per hectare compared to hand seedling followed by hand weeding. The break-even analysis indicated that a farmer having only 0.3 hectare of land could economically afford a drum type seeder and a rotary type weeder.

Keywords: drum seeder, effective field capacity, pulling force, partial budget analysis, break-even analysis

INTRODUCTION

Rice is the staple food for more than half of the world's population and generally grown under wetland condition. It may be grown in direct seeded or in transplanted condition. The high yielding rice varieties had been growing in transplanted condition since its innovation. Some studies at the International Rice Research Institute (IRRI) in Philippines confirmed that there is no yield difference between direct seeding and transplanting practices of rice production if the weed control and other intercultural operations are done properly. This finding is applicable for both high yielding and traditional varieties.

Owing to rapid industrialization in Thailand and Malaysia, the labour cost has increased substantially and farm labourers have become scarce. To reduce the cost of cultivation in some of the irrigated areas, direct seeding is practiced extensively and it is expected that most farmers in the area will eventually switch to direct seeding (De Datta and Nantasamsaran 1991).

In central Luzon, Philippines, where rice has been traditionally grown in transplanted condition, the adoption of broadcast seeding is rapid, from less than 2 percent in 1979 to 16 percent in 1982 (Moody Cordova 1985). Erguisa *et al.* (1990) reported that farmers who in 1980 were practicing a combination of transplanting and wet seeding had shifted entirely to broadcast seeding by 1986. In Malaysia during 1987 off season, 99 percent of the planted area in the Muda irrigation scheme was direct seeded (Ho *et al.* 1990).

Most of the direct seeding machines broadcast seed at random, and the use of rotary weeder for weed control is not possible due to lack of specific rows. As a consequence, farmers are compelled to use chemicals for weed control which have adverse effect on environment. Therefore, a row type paddy seeder is necessary. The International Rice Research Institute (IRRI) developed a manually operated drum type seeder for lowland paddy. The IRRI seeder is cheap and easy to operate but needs improvement in design in order to popularize it among the farmers.

The objectives of the study were: (a) to modify the IRRI seeder in order to stop unwanted seed dropping at headlands while turning (b) to determine the field performances of modified seeder with two different seeding rates and (c) to compare the cumulative costs of seeding and weeding between hand and machine systems.

MATERIALS AND METHODS

IRRI Designed Drum Seeder

This is a manually operated machine suitable to sow pre-germinated paddy seeds in rows (Plate 1). It consists of 4 metallic drums, a metallic axle, a main frame, a cage wheel, two skids and a handle. It is made of M.S. pipe, M.S. rod and G.I. sheet. The drums have holes through which seeds are dropped, while the machine is pulled backward on the prepared field. It has 8 rows with a spacing of 20 cm between two consecutive rows.

Modification of the Seeder

The IRRI designed seeder had no mechanism to collect seed while turning at headlands. Therefore, a seed collector assembly made from G I sheet and rod was incorporated to overcome the unwanted seeds dropping at the headlands (Plate 2). The specifications of the modified seeder are presented in Table 1.

Drum Seeder Tray

Every drum of the seeder was provided with a tray which had length and breadth of 360 mm and 308 mm respectively (*Fig. 1*). The trays were made from 2 mm thick GI sheet. Two trays were operated by a common handle which was made of 6 mm diameter mild steel rod. The trays were engaged at headlands and disengaged in operating condition.

Field Test of Drum Seeder

An experiment was conducted on the silty clay loam soil of BRRI farm to evaluate the performances of Drum type seeder compared with the existing hand broadcasting method. The seeds were soaked, sprouted for 24 hours, and then sown in the field. The treatments were as follows:

T_1 = Seeding by drum type seeder at the rate of 60 kg/ha

T_2 = Seeding by drum type seeder at the rate of 80 kg/ha

T_3 = Hand broadcasting at the rate of 100 kg/ha

TABLE 1
Specifications of BRRI modified drum type paddy seeder

Sl No.	Particulars		Specifications
1	Make and model	:	BRRI
2	Type of machine	:	Manually operated
3	Type of seed	:	Sprouted
4	Overall dimensions	:	
	Length(cm)	:	160
	Width(cm)	:	115
	Height(cm)	:	64
5	Weight(kg)	:	19
6	Diameter of drum(cm)	:	15
7	Diameter of holes on the drum(mm)	:	9
8	Type of seed delivery	:	Gravity dropping
9	No. of rows	:	8
10	Row to row spacing(cm)	:	20
11	Operating speed(m/min)	:	16.95
12	Dimension of seed tray	:	30.8 cm X 36.0 cm
13	No. seed trays	:	4
14	Fabricating materials	:	M. S. pipe, M. S. rod and G. I. sheet

*- part added to the original designof the drum seeder

All dimensions in mm

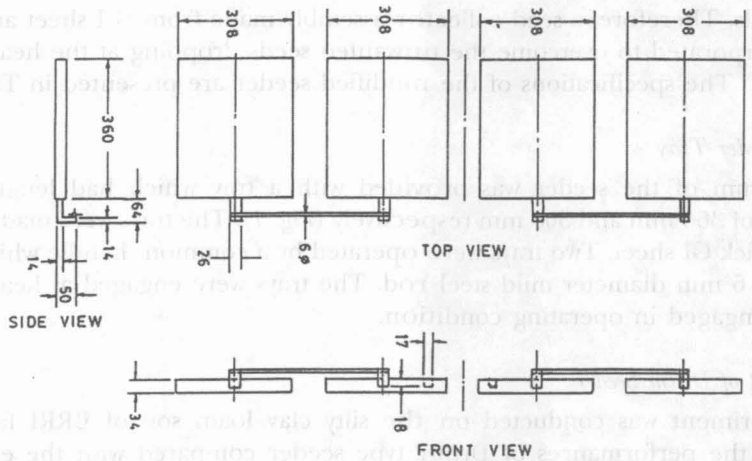

Fig 1. Modified drum seeder tray

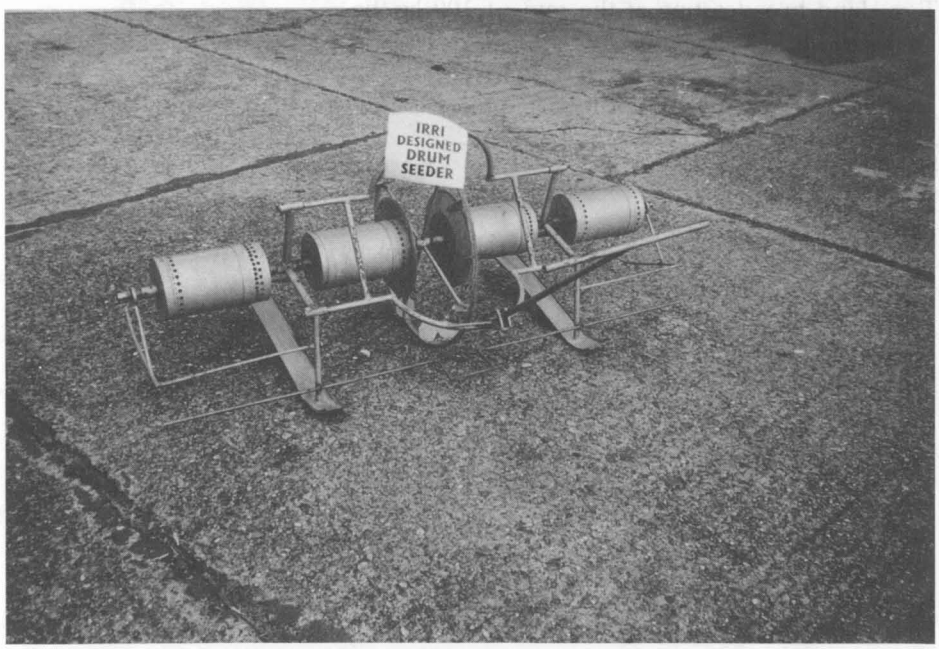

Plate 1. IRRI designed drum seeder

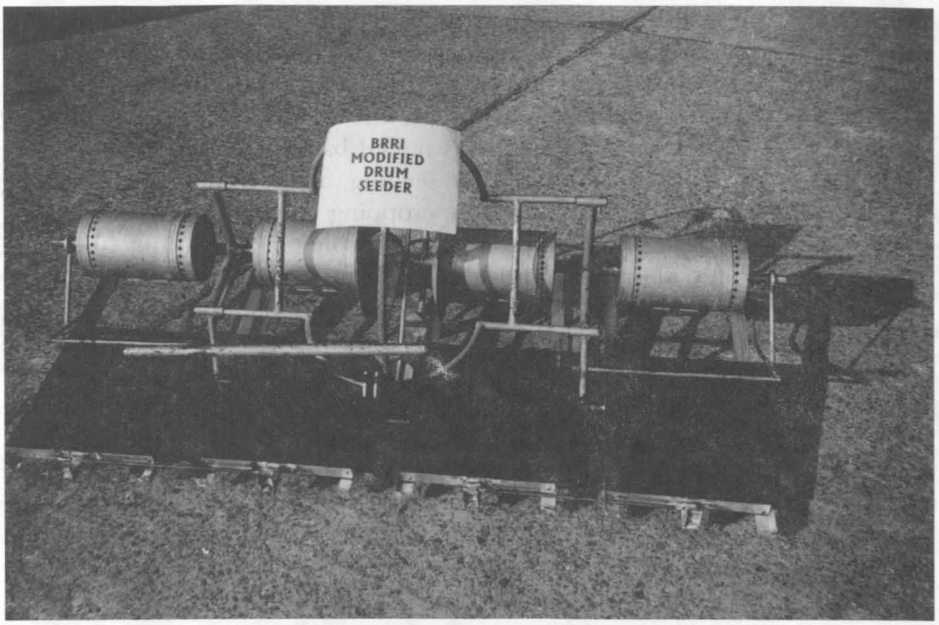

Plate 2. BRRI modified drum seeder

Design of Experiment

The experiment was conducted under a Randomized Complete Block (RCB) design and the treatments were replicated thrice in each block as per layout plan (*Fig. 2*).

T2	T2	T1
T3	T3	T2
T1	T1	T3
Block I	Block II	Block III

Fig 2. Layout plan of experiment

Experimental Procedure

Before field test, the drum seeder was tested in the laboratory which confirmed the workability of all the functional components. The seeder was tested for two seeding rates i.e. 60 and 80 kg/ha and a comparison was made with the conventional hand broadcasting method. The experimental fields were selected as per treatments and layout plan. The field was well puddled with sufficient number of ploughing and levelled by laddering. Three days before final land

preparation, the seeds were soaked in clean water. After 24 hours of soaking, the water was drained out and put into a gunny bag for sprouting. The duration of sprouting was 48 hours. The degree of sprouting was observed very carefully so that the seeds can easily pass through the seeder holes. After loading sprouted seeds in drums, the seeder was pulled backward and the seeds were dispensed by the action of gravity. After seeding, about a week bird watching was necessary which is dependent on the cropping pattern of the surrounding field. During operation the data on actual seeding time, turning time and loading times were collected in order to calculate the effective field capacity and field efficiency. Moreover, the data on plant population, plant spacing, plant height, root length, tiller per sq. m and weeding costs were recorded. The crops were managed with irrigation and drainage, weeding, fertilizer and insecticide applications. Finally the crop cut was done in a 5 sq. m area and the samples were taken from 5 places. The average value was taken as the yield of an experimental plot. After harvest, the crops were threshed, cleaned and dried and the yields were expressed in ton per hectare at 14% moisture content. The data recorded from the experiment were subjected to analysis variance and DMRT by using IRRISTAT package.

RESULTS AND DISCUSSION

Field Performance of Drum Seeder

The effective field capacities of BRRI modified drum seeder with seeding rates of 60 kg/ha and 80 kg/ha were 0.15 ha/hr and 0.12 ha/hr respectively and were not statistically significant. However, field capacity of hand broadcasting at the rate of 100 kg/ha was 0.22 ha/hr and significantly higher than drum seeder seeding at both the rates (Table 2). In the drum seeder operations, 75-78% time was actually required for seeding, 10-12% time was lost in turning and 10-13% time was lost in loading. In case of hand broadcasting, about 88% time was engaged in actual broadcasting and about 12% time was lost in loading the seed pot. The field efficiencies of drum seeder at the rate of 60 kg/ha and 80 kg/ha were 73.91 and 77.77 percents respectively, but that of hand broadcasting at the rate of 100 kg/ha was 87.30 percent. The result revealed that the field efficiency of hand broadcasting was significantly higher than those of machine seeding at both the seed rates because in case of hand seeding no time was lost in turning.

The average plant population, 18 days after seeding in the drum seeder plot at the seeding rate of 60 kg/ha and 80 kg/ha were 238.33 and 358.33 Nos/m^2 respectively, and that of hand broadcasting at the rate of 100 kg/ha was 500 Nos/m^2 which were significantly different at 5% level (Table 3). In the drum seeder plot, the distance between rows was 20 cm, however the distance between hill to hill along the rows varied with the seeding rate. In drum seeder seeding at the rate of 60 kg/ha and 80 kg/ha, the hill to hill distances were 5.86 cm and 5.73 cm. which were not statistically different, but at higher seeding rate, the seedling per hill was higher.

TABLE 2
Field performance of drum seeder compared to hand broadcasting method

Operations	Time consumed (hr/ha)		
	BRRI drum seeder (60 kg/ha)	BRRI drum seeder (80 kg/ha)	Hand broadcasting (100 kg/ha)
Seeding	4.92 (75.40)	6.66 (77.48)	3.92 (88.26)
Turning	0.73 (11.18)	0.89 (10.41)	-
Loading seed in the drum	0.87 (13.42)	1.04 (12.11)	0.52 (11.74)
Total	6.52 (100)	8.60 (100)	4.44 (100)
Effective Field capacity (ha/hr)	0.15 b	0.12 b	0.22 a
Theoretical Field capacity (ha/hr)	0.21 ab	0.15 b	0.26 a
Field efficiency (%)	75.16 b	77.77 ab	87.31 a

In a row, means followed by a common letter are not significantly different at the 5% level by DMRT. Numbers in parentheses are in percentage

Test conditions:

Soil type	: Silty clay loam	Theoretical FC (LSD 5%)	: 0.07149
Plot size	: 4 m x 20 m	Effective FC (LSD 5%)	: 0.3998
Variety	: BR1	Field efficiency (LSD 5%)	: 10.37
Cone penetration	: 5-20 cm		
Seeder speed	: 16.95 m/min		
Walking speed for hand broadcasting	: 40 m/min		

Since the diameter of drive wheel was 60 cm and the seed drum had 40 slots around its circumference, the theoretical distance between the hills along the row should be 4.71 cm. In the field operation the actual distance between hills was 5.8 cm. which was slightly higher than the theoretical value. This difference might have been caused by the wheel slippage and irregular seed dropping due to bridging and moment of inertia of the seeds within the drum. The average plant spacing in the hand broadcasting field was 8.30 cm which was higher than the hill to hill distance of the machine seeded field. The average plant height of 18 days old seedling ranged from 22.5 cm to 23.5 cm irrespective of the seeding methods statistically not significant (Table 3). However, the replication had significant effect on plant height at 5% levels. The leaf status of 18 days old seedling varied from 3.5 to 4 in numbers and they were different in the machine seeded and hand broadcasting fields.

The average root length in the drum seeder plots at the seeding rates of 60 kg/ha and 80 kg/ha were 4.41 cm and 5.53 cm respectively , however that of

TABLE 3
Agronomic characteristics of crop, 18 days after seeding by different methods

Parameter	BRRI drum seeder (60 kg/ha)	BRRI drum seeder (80 kg/ha)	Hand broadcasting (100 kg/ha)
Plant population (no/m^2)	238.3 c	358.3 b	502.5 a
Average plant spacing (cm)	5.86 b	5.86 b	8.30 a
Average plant height (cm)	23.27 a	22.60 a	23.72 a
Average root length (cm)	4.41 a	5.53 a	5.20 a

In a row, means followed by a common letter are not significantly different at the 5% level by DMRT.

Parameters	LSD(5%)
Plant population (No/m^2)	63.83
Average plant spacing (cm)	1.7224
Average plant height (cm)	2.03
Average root length (cm)	1.619

hand broadcasting plots at the seeding rate 100 kg/ha was 5.20 cm and was not statistically different. The result revealed that at 18 days old seedling, the methods of seeding had no effect on the root development. The rice yield in the drum seeder fields at the seeding rate of 60 kg/ha and 80 kg/ha were 3.13 ton/ha and 2.84 ton/ha respectively. On the other hand, the yield at the hand broadcasting field at the seeding rate of 100 kg/ha was 2.73 ton/ha (Table 4). The results indicated that there was no significant yield difference among the three seeding practices. The yield indictor like tiller per sq.m in different seeding methods was significantly different at 5% level. The tiller per sq. m. in hand broadcasting field was highest (694.3 tiller/m^2). On the other hand, the lowest value was recorded (562.3 tiller/m^2) in the machine seeding at the rate of 60 kg/ha. In terms of effective tiller or panicle/m^2 , the hand broadcasting field and drum seeder fields with increased seeding rate (80 kg/ha) seemed better than the drum seeder field with lower seeding rate (60 kg/ha). It could be concluded that the percentage of sterility in the secondary and tertiary tillers was higher i.e. the parent tillers was most likely to be the effective tillers. The field with more effective tillers should give more yield, but the drum seeder field with minimum effective tiller per unit area produced maximum yield probably due to the higher percentage filled grain per panicle. It may be concluded that the lower the seed rate the higher the percentage of filled grains. In overall consideration, the drum seeder seeding at a seeding rate of 60 kg/ha could be a better alternative to the existing hand broadcasting method.

Mechanical Performance of Drum Seeder

In the IRRI designed prototype of the drum seeder, there was no mechanism to collect seed while machine turned at the headlands. As a result in every turn, some seeds were dropped at the headland and it reduced the crop yield at the

TABLE 4
Yield parameters in the fields of different seeding methods

Parameter	BRRI drum seeder (60 kg/ha)	BRRI drum seeder (80 kg/ha)	Hand broadcasting (100 kg/ha)
Tiller/m^2	562.3 c	623.7 b	694.3 a
Panicle/m^2	435.7 b	483.7 a	503.3 a
No. filled grain/panicle	64.47 a	59.14 a	61.33 a
Filled grain(%)	70.46 a	68.55 ab	64.24 b
Grain yield(ton/ha)	3.13 a	2.84 a	2.73 a

In a row, means followed by a common letter are not significantly different at the 5% level by DMRT

Parameters	LSD(5%)
Tiller/m^2	65.58
Panicle/m^2	39.52
Filled grain/panicle	8.06
Filled grain (%)	5.76
Grain yield	0.639
Grain yield	0.639

headlands due to excess plant population. A seed collector assembly was designed and fabricated from GI sheet, and incorporated to the seeder. Owing to the presence of seed collector assembly, the problem of unwanted seed dropping at the headlands was totally overcome and that could save 5-7 kg of seed per hectare compared to IRRI seeder. Owing to incorporation of seed collector assembly, the overall weight of the seeder increased by 3 kg. As a result the pulling force increased by 20% compared to the previous prototype, but still within the capability of an average size labour (*Fig. 3*). The pulling force in the drum seeder in turning was more than that of straight pulling condition (*Fig. 4*)

Cost of Seeding by Different Methods

In conventional hand broadcasting, the seeds are scattered at random making no specific rows, so that, the operation of rotary type weeder is not possible for weed control. Therefore the economics of drum type seeder should include a rotary type weeder and the cost calculation of two operations i.e. seeding and weeding should be considered simultaneously. From the partial budget analysis, it revealed that by using a drum type seeder and a rotary type weeder, a farmer can earn a net benefit of US$56.20 per hectare compared to hand broadcasting method followed by hand weeding (Table 5). The break-even analysis showed that if a farmer has only 0.3 hectare of land, he can own a drum type seeder and a rotary type weeder (*Fig. 5*)

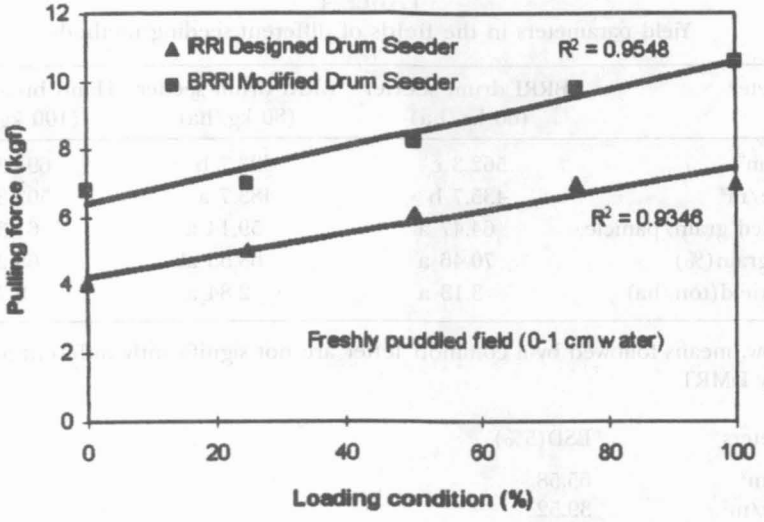

Fig 3. Relationship between pulling force and load of drum seeder with straight pulling condition

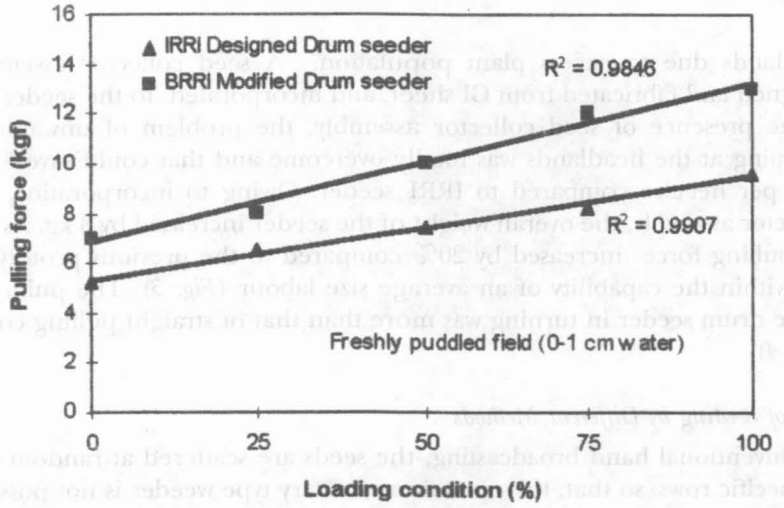

Fig 4. Relationship between pulling force and load of drum seeder with headland turning condition

CONCLUSION

The seed collector assembly in the BRRI modified drum seeder stopped unwanted seed dropping at the headlands and saved 5-7 kg of seed per hectare compared with the IRRI designed drum seeder. The Sprout-length of the seeds to be used in the drum type seeder was 1 to 2 mm achieved by incubating 24

TABLE 5
Partial budget analysis of seeding and weeding costs between machine and hand systems

Added return	(US$/ha)	Added cost	(US$/ha)
(A) EXTRA REVENUE:		(B) EXTRA COSTS	
1. Benefit from drum seeder renting	1.53	1. Cost of drum seeder (FC + VC)	16.14
		2. Cost of rotary weeder (FC + VC)	10.52
(C) SAVING IN COSTS:		(D) LOSS IN REVENUE:	
1. Labour saved from hand seeding labour	0.64		
2. Cost saved from seed in hand seeding	22.73		
3. Cost saved from hand weeding	56.82		
Total	81.72	Total	26.66

Net benefit (US$/ha) = Added return - Added cost
= (A + C) - (B + D)
= 81.72 -26.66
=55.06

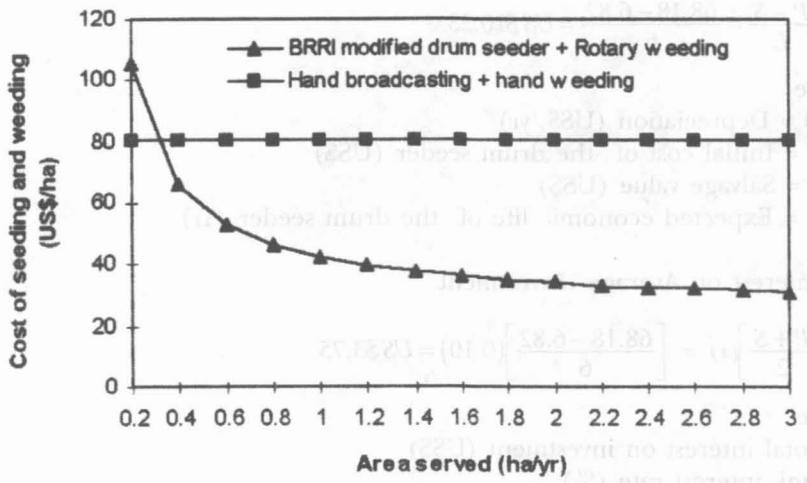

Fig 5. Cost comparison of seeding and weeding between machine and hand systems

to 36 hours after soaking during the monsoon season in Bangladesh. However, in the winter season, to achieve the above degree of sprouting, 48 to 60 hours of incubation was necessary. In case of exceptionally low temperatures, warming of the seeds in the sun during day time was also necessary. A farmer can save about US$56.00 per hectare by using BRRI modified drum seeder followed by a rotary weeder compared with hand seeding followed by hand weeding.

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APPENDIX

Cost Calculation of BRRI Drum Seeder
Fixed Cost per Year

(A) Depreciation (Straight Line Method)

$$D = \frac{P-S}{L} = \frac{68.18-6.82}{6} = US\$10.23$$

Where

D = Depreciation (US$/yr)
P = Initial cost of the drum seeder (US$)
S = Salvage value (US$)
L = Expected economic life of the drum seeder (Yr)

(B) Interest on Average Investment

$$I = \left[\frac{P+S}{2}\right](i) = \left[\frac{68.18-6.82}{6}\right](0.10) = US\$3.75$$

Where
I = Total interest on investment (US$)
i = Bank interest rate (%)

Fixed Cost per Year = A + B = 10.23 + 3.75 = US$13.98
Annual capacity of drum seeder = 30 ha
Fixed cost per ha = 13.98/30 = US$0.466/ha

Variable Cost per Hectare

(A) Repair and Maintenance Cost per year

$Rm = P(rm) = (68.18)(0.15) = US\$10.23$

Where

RM = Repair and maintenance cost (US$/yr)
rm = Reair and maintenance charge (% of P)

Repair and maintenance cost per ha= 10.23/30 = US$0.34

(B) Labour cost per ha = Drum seeder pulling + Loading
= 9 man-hr + man-hr = 12 man-hr = 1.5 man-days
= 1.5 man-days x @ US$1.14/man-days = US$1.71

(C) Seed cost per ha = 60 kg/ha x @ US$0.23/kg = US$13.63

Total variable cost per ha = A + B + C = 0.34 + 1.71 + 13.63
= US$ 15.68

Total cost of drum seeder (FC + VC) = 0.466 + 15.68 = US$16.14/ha

Cost Calculation of BRRI Rotary Weeder
Fixed Cost per Year

(A) Depreciation (Straight Line Method)

$$D = \frac{P-S}{L} = \frac{6.82-0.68}{4} = US\$1.53$$

Where
D = Depreciation (US$/yr)
P = Initial cost of the weeder (US$)
L = Expected economic life of the weeder (Yr)

(B) Interest on Average Investment

$$I = \left[\frac{P+S}{2}\right](i) = \left[\frac{6.82+0.68}{2}\right](0.10) = US\$0.38$$

Where

I = Total interest on investment (US$)
i = Bank interest rate (Yr)

Fixed Cost per Year = A + B = 1.53 + 0.38 = US$1.91
Fixed Cost per hectare = A + B = (1.53 + 0.38)/10 = US$0.19

Variable Cost per Hectare

(A) Repair and Maintenance Cost per year

$RM = P(rm) = (6.82)(0.15) = US\$1.02$

Where

RM = Repair and maintenance cost (US$/yr)
rm = Repair and maintenance charge (% of P)

Annual capacity of the weeder = 10 ha
Repair and maintenance cost per ha = 1.02/10 = US$0.102
(B) Labour cost per ha = 9 man-days x @ US$1.136/man-days = US$9.31
Total variable cost per ha = A + B = 1.02 + 9.31 = US$10.33
Total cost of rotary weeder (FC + VC) = 0.19 + 10.33 = US$10.52