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Performance evaluation of reaper-binder in rice crop

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■ **ABSTRACT :** Field performance of reaper-binder was assessed in rice crop and compared with manual method of harvesting by sickle at farmer's field under farm implements and machinery scheme during *Rabi* 2013. The effective field capacity of the reaper-binder was found 0.294ha h^{-1} with a field efficiency of 67 per cent at an average operating speed of 3.6 kmph compared to 0.025 ha h^{-1} for manual harvesting. The fuel consumption was found 5.27 l ha^{-1}.Labour requirements for mechanical and manual harvesting were 36 and 176 man-h ha^{-1}, respectively. The harvesting losses for mechanical and manual harvesting were 1.44 and 1.88 per cent, respectively. The cost of harvesting operation was Rs.5500/ha for manual harvesting and Rs.2241/ha for mechanical harvesting. The harvesting cost of reaper binder was reduced by 40.74 per cent compared to manual harvesting method with sickle. The feedback of machine operation was collected by some farmer's at the time of harvesting and the performance of the reaper-binder at the farm was satisfactory.

■ **KEY WORDS :** Rice, Reaper binder, Harvesting, Manual harvesting, Paddy

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Rice (*Oryza sativa* L.) is one of the most important crop and staple food of millions of people which is grown in many countries of the world. The total rice production of the world was 527 Mt. India is the largest grower of rice in the world and it occupies the largest cropped area of 44.2 M ha with a total production of 87.5 Mt and an average productivity of 1.9 t ha^{-1} (Duraisamy *et al.*, 2011). However, it ranks second to China in terms of production. The efforts are required to extend the quantum of rice production to 120 Mt by 2020 AD from its present value for sharing the national food grain production basket to meet out the requirement of the burgeoning population of the country.

In spite of the fact that the production of rice is increasing as a result of improved methods of farming, the harvesting techniques employed are still primitive. Rice harvesting by manual method require about 25 per cent of the total labour requirement of the crop. Depending upon the crop yield, 120 to 250 man-h is required for cutting, bundling and on-field stacking of one hectare of rice field by using traditional sickle (Nadeem Amjad, 1983). Due to rapid industrialization and large scale migration to urban areas labour is becoming increasingly scarce and also proving costly. This labour shortage during harvesting resulted in delayed harvest and consequent field grain losses. Mechanization of harvesting is an alternative solution. Farm mechanization will also result in lesser cost of operation.

Where farmers have adopted combines for harvesting, alternative straw handling and disposal technology may have to be developed and promoted, as burning of straw is creating environmental pollution and farmers are losing valuable animal feed material. Reaper harvesters on the other hand are other alternative

harvesting equipment, provided straw is considered as economic by-product for animal feed and/or industrial applications (Manjunatha *et al*., 2009).

Reaper binders are also introduced as harvesting equipment which reduces the human drudgery by the binding of the harvested stalks itself. So the handling of straw can made easy. The suitable combination of harvesting machinery is dependent on the economic and climate conditions and type of crop variety in each area. There is no doubt that the cost of machinery and the labour requirement for each method of harvesting are also effective factors that determine the choice of harvesting method. Choice of suitable harvesting method not only reduces production costs but also increases yield and quality of the produce. Keeping these in view, a feasibility study of reaper binder was undertaken to reduce the cost of harvesting in paddy crop through mechanization of harvesting.

This study was, therefore, under taken with the following objectives :

- To evaluate the performance of reaper-binder.
- To compare the economics of operation for reaper-binder with the manual harvesting method.

METHODOLOGY

The performance evaluation of reaper binder was conducted in farmer's field at Nagireddypet village and mandal, Nizamabad district under the Farm Implements and Machinery Scheme, Rajendranagar, Hyderabad during *Rabi* 2013. The details of materials used, experimental methodology and measurement techniques adopted during the course of investigation are presented as follows.

Salient features of reaper binder :

The reaper binder is powered by 8 kW air cooled single cylinder diesel engine. The machine has a cutter bar width of 1.22 m. The function of this reaper binder is harvesting and binding of grain crops having height of 85-110 cm in single operation. The reaper-binder harvests crops like paddy, wheat, oats and other crops closed to ground and simultaneously bind the sheaves by using twines. The crop sheaves were ejected in straight line, one behind the other. A good twine is important for a proper operation of reaper-binder. The twine should be smooth, uniform and slightly oily. The cutter bar height and angle is adjustable by adjusting skid screw. The machine has been provided with three wheels. Out of these three wheels two wheels for driving wheels located to the machine and one wheel for steering located at the rear of the machine. The cutter blades are driven by oscillating head which converts rotary motion into reciprocation through the shaft and connecting rod. The machine has a mechanical constant mesh type gear box with four forward speeds (4.32, 5.84, 7.7 and 10.8 kmph) and one reverse speed (4.6 kmph). The reaper-binder is shown in Fig. A and the specifications of the machine are given in Table A.

Fig. A : View of reaper-binder

Table A : Specifications of reaper-binder

Sr. No.	Descriptions	Details
1.	Name of machine	Reaper-binder
2.	Manufacturer	M/s. BCS India Pvt. Ltd., Manngarh, Ludhiana
3.	Model	BCS Standard
4.	Overall dimensions (L x W x H), mm	3600 x 1850 x 1300
5.	Weight, kg	450
6.	Cost of equipment, RS.	2,80,000/-
7.	Power source	10 HP diesel engine
8.	Fuel used	Diesel
9.	Cutter bar width, m	1.22
10.	Number of strokes/min.	775

Evaluation procedure :

The preliminary testing of reaper-binder was carried out in the laboratory to check its functional performance,

such as working of cutter bar, gathering and knotting devices, speed of cutter bar etc. at Farm Implements and Machinery scheme, Rajendranagar, Hyderabad. The field performance and evaluation was carried out in farmer's (Raj reddy) field at Nagireddypet, Nizamabad district for harvesting of rice crop in the medium type soil. To evaluate the performance of reaper-binder the field parameters such as speed of operation, width of operation, total time taken to cover the area, height of cut, effective field capacity, harvesting losses, field efficiency, fuel consumption, labour requirement and economics was worked out as per BIS test code (Singh *et al.*,2007). The crop parameters like plant height, plant population, condition of crop stand were also recorded.

Measurement of all parameters :

Machine and operational parameters :

Operating time for the harvesting operation :

To determine operating time, time was noted from start and finish time of harvesting was recorded. So that actual time required for harvesting by reaper-binder was computed in terms of ha h^{-1}. Time losses while harvesting crop such as time for the adjustments, turning, fuelling etc. were also recorded.

Speed of operation :

To determine the speed of operation, mark the length of 30 m and the reaper-binder was operated in the marked run length. A stop watch was used to record the time for the harvest to traverse the marked run so that the speed of travel was computed in m s^{-1}.

Effective field capacity :

Effective field capacity was measured by the actual area covered by the reaper-binder, based on its total time consumed and its width. Effective field capacity was determined by the following relationship :

$$\text{Effective field capacity, ha h}^{-1} = \frac{\text{Total area covered, ha}}{\text{Total timetake, h}}$$

Field efficiency :

Field efficiency is the ratio of effective field capacity to theoretical field capacity. It was determined by the following formula :

$$\text{Field efficiency, \%} = \frac{\text{Effective field capacity, (ha/h)}}{\text{Theoretical field capacity, (ha/h)}} \text{ x 100}$$

Theoretical field capacity :

Theoretical field capacity is the rate of field coverage of the machine, based on 100 per cent of time at the rated speed and covering 100 per cent of its rated width. The theoretical field capacity was determined by using the following relationship :

$$\text{Theoretical field capacity, ha h}^{-1} = \frac{\text{Width (m)} \times \text{Speed (km/h)}}{10}$$

Fuel consumption :

The fuel consumption has direct effect on economics of the machine. The fuel consumption was measured by top fill method. The fuel tank of the reaper-binder was filled at its full capacity. The machine was run in the field at constant speed. After completion of harvesting operation, the fuel was refilled in the tank upto the top level. The quantity of refilled fuel was measured by measuring cylinder. This observation was used for computation of fuel consumption in l h^{-1} and l ha^{-1}.

Crop parameters :

Harvesting losses :

In order to estimate harvesting losses in manual and reaper-binder harvesting, first the losses that occur before harvesting (pre-harvest) must be measured. To do this, in four parts of each plot with the usage of a wooden frame with 1mx1m dimensions, all grains fallen within the frame are collected and weighed and the mean of the four measured values were recorded. Harvesting losses include shattering and uncut losses were determined by the following equation (Mohammad Reza *et al.*, 2007).

$$W_t = W_1 + W_2 + W_3$$

where,

W_t = Total losses, g m^{-2}

W_1 = Pre-harvest losses, g m^{-2}

W_2 = Shattering losses, g m^{-2}

W_3 = Uncut losses, g m^{-2}

After measuring the amount of losses at different stages, the percentage of harvest losses were determined by following equation :

$$H = \frac{Wt - W1}{Yg} \times 100$$

where,

H = Percentage of harvest losses, %

W_1 = Post harvest losses, g m^{-2}

W_t = Total harvest losses, g m^{-2}

Y_g = Grain yield, g m^{-2}

Average plant population :

The average plant population was determined by count the number of plants per square meter at five random places and the mean value was determined to represent the average plant population.

Plant height :

Plant height was measured from the base of stem to the tip of the top most panicle at five randomly selected areas. The plant height was recorded at the harvesting stage. The mean plant height was calculated and expressed in cm.

Number of hills :

Total number of hills from the labeled plants at harvesting stage were counted and expressed as total number of hills per m^2.

Number of panicles :

Number of panicles per hill was counted from 10 hills in each square meter area, already demarcated for taking observations and converted into panicles per m^2 by multiplying with the number of hills per m^2. Five observations were taken at the time of harvesting.

Grains per panicle :

Grains were collected from 10 randomly selected panicles from earlier collected samples. Filled grains were separated. The filled grains were counted to determine the number of grains per panicle.

Cost analysis :

The total cost of operation of the reaper-binder in Rs. /h was estimated by considering the fixed cost and operational cost of the machine by making following assumptions. The cost of operation was based on the prevailing market rates during the season and location.

Fixed cost :

Fixed cost includes depreciation, interest, housing, insurance and taxes.

Depreciation :

It is the loss of value a machine with the passing of time :

$$D = \frac{C - S}{LH}$$

where,

C = Capital cost

D = Depreciation, Rs. /h

S = Salvage value, 10 per cent of capital

H = Number of working hours per year, and

L = Life of machine, year

Interest :

Interest was calculated on the average investment of the machine taking into consideration the value of in first and last year :

$$I = \frac{C + S}{2} \times \frac{i}{H}$$

where,

I = interest per year

i = interest rate per year, per cent

C = Capital cost

Housing, insurance and taxes :

Housing, insurance and taxes for the reaper-binder were taken as the 1 per cent of the initial investment of the machine.

Operating cost :

Operating cost includes fuel cost, lubricants, repairs, maintenance, and other costs.

Fuel cost :

Fuel cost was calculated on the basis of actual fuel consumption of the machine.

Repairs and maintenance :

Cost of repairs and maintenance was taken as 5 per cent of the initial investment of the machine.

Other costs :

It includes wages for operator, labour cost based on the prevailing market rates per day of 8 hours.

■ RESULTS AND DISCUSSION

The reaper-binder was evaluated for its field performance by harvesting of paddy during *Rabi* 2013. The experiments were carried out in the extent of 0.25 ha at the farmer's (Raj reddy) field, Nagireddypet village and mandal, Nizamabad Dist underFIM Scheme,

Rajendranagar, Hyderabad. The results obtained during this study such as crop parameters, operating parameters of the machine, pre and post harvesting losses and cost of operation were presented as follows.

Testing of reaper binder in laboratory :

The preliminary testing of reaper-binder was conducted in FIM Scheme laboratory at Rajendranagar, Hyderabad for checking the reaper-binder before gone into the field study. During the preliminary study the mechanisms of reaper-binder was observed that quite satisfactory. The company twine and locally available twine was also tested. The company twine gave better knotting than local available twine. The problem found that the local twine in the machine was strucked at the time of knotting and even breaks the twine. Then the machine was ready for field evaluation.

Evaluation of reaper binder in the paddy field :

Crop parameters :

The crop parameters required for evaluation of reaper-binder were observed. The crop parameters such as crop variety, height of crop, number of hills m^{-2}, number of panicles per hill, grains per panicle, condition of crop stand and plant population per hill were recorded. The details were presented in Table 1.

Operating parameters :

During the field study the actual field capacity of the reaper-binder was observed as 0.294 ha h^{-1} with field efficiency of 67 per cent at an average operating speed

Table 1 : Details of crop parameters

Sr. No.	Crop parameters	Particulars
1.	Crop variety	BPT-5204
2.	Height of crop, mm	860
3.	Number of hills m^{-2}	22
4.	Number of panicles per hill	43
5.	Grains per panicle	195
6.	Condition of crop stand	Erected
7.	Plant population per hill	46

Table 2 : Operating parameters of reaper-binder compared with manual harvesting by sickle

Sr. No.	Parameters	Harvesting type	
		Harvesting with reaper-binder	Manual harvesting by serrated sickle
1.	Effective working width, mm	1220	
2.	Speed of operation, kmph	3.6	
3.	Area covered, ha	0.25	0.25
4.	Effective field capacity, ha h^{-1}	0.294	0.025
5.	Theoretical field capacity, ha h^{-1}	0.439	
6.	Field efficiency,%	67	
7.	Fuel consumption, l h^{-1}	1.55	
8.	Fuel consumption, l ha^{-1}	5.27	

Table 3 : Pre and post harvesting parameters of different harvesting methods

Sr. No.	Parameters	Harvesting type	
		Harvesting with reaper-binder	Manual harvesting by serrated sickle
1.	Pre harvesting losses, (g m^{-2})	4.63	4.63
2.	Shattering harvesting losses, (g m^{-2})	37.2	48.64
3.	Uncut losses, (g m^{-2})	0	0
4.	Total losses, (g m^{-2})	41.83	53.27
5.	Harvesting losses, %	1.44	1.88

of 3.6 kmph. The fuel consumption was observed as 5.27 l ha^{-1} whereas the effective field capacity for conventional method of harvesting by sickle was observed as 0.025 ha h^{-1}. The results are presented in Table 2 and the operation of reaper-binder is shown in Fig. 1.

Fig. 1 : Reaper-binder in operation

Pre and post-harvesting parameters :

The pre-harvesting losses of the crop was 4.63 g m^{-2}. The shattering losses during harvesting with reaper binder was 37.2 g m^{-2}whereas 48.64 g $m^{-2}$for manual harvesting by sickle. The per cent of harvesting losses were recorded for reaper binder was 1.44 per cent whereas 1.88 per cent was recorded for manual harvesting by sickle. The results were presented in Table 3.

Cost analysis :

The cost analysis for reaper-binder was observed and compared with conventional method of harvesting by sickle. The cost of operation for mechanical harvesting was Rs.2241/ha as compared Rs. 5500/ha in the case of manual harvesting. The total labour required for harvesting and collection of bundles in the case of mechanical harvesting were 36 man-h ha^{-1} whereas the total labour required for harvesting, collection and bundle making in case of manual harvesting were 176 man-h ha^{-1}. Based on the obtained results the harvesting cost of reaper binder was reduced by 40.74 per cent compared to manual harvesting method with sickle.The results are presented in Table 4.

Summary and conclusion :

The performance of the reaper-binder at the farm was satisfactory. Based on the experimental results following conclusions are drawn.

- The effective field capacity of the reaper-binder was found 0.294ha h^{-1} with a field efficiency of 67 per cent at an average operating speed of 3.6 kmph compared to 0.025 ha h^{-1} for manual harvesting.
- The fuel consumption was found 5.27 l ha^{-1}.
- Labour requirements for mechanical and manual harvesting were 36 and 176 man-h ha^{-1}, respectively.
- The harvesting losses for mechanical and manual

Table 4 : Results of operating cost for mechanical and conventional method

Sr. No.	Observations	Harvesting with reaper binder	Manual harvesting by serrated sickle
1.	Initial cost (C), Rs.	280000	
2.	Salvage value (S), Rs.	28000	
3.	Life of the machine (L), years	10	
4.	Working hours per year (H), h	800	
5.	Total fixed cost, Rs./ha	201.19	
6.	Wages for operator, Rs./h	50	
7.	Twine cost (2.5 bundles required, each bundle cost is Rs. 500), Rs./ha	1250	
8.	Number of labours required for harvesting , man-h/ha	4	120
9.	Labour required for collection and bundle making, man-h ha^{-1}	32	56
10.	Total labour required, man-h ha^{-1}	36	176
11.	Labour cost, Rs./h	31.25	31.25
12.	Fuel cost, Rs./h (Rs.61/l)	94.55	-
13.	Total variable cost, Rs./ha	2039.5	5500
14.	Total cost of operation, Rs./ha	2241.	5500
15.	Cost reduction compared to manual weeding, %	40.74	

harvesting were 1.44 and 1.88 per cent, respectively.

– The cost of harvesting operation was Rs.5500/ha for manual harvesting and Rs.2241/ha for mechanical harvesting. The harvesting cost of reaper binder was reduced by 40.74 per cent compared to manual harvesting method with sickle.

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