Madras Agric. J., 100 (4-6): 619-622, June 2013
https://doi.org/10.29321/MAJ.10.001369

Performance of a Portable Power Paddy Thresher: A Comparative Study of Mechanical Vs Traditional Threshing Methods

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A portable power paddy thresher was developed for small farmers. A cross flow portable power paddy thresher cum winnower was fabricated based on cylinder- concave mechanism and its performance was assessed in terms of threshing efficiency, grain damage and output capacity and compared with conventional methods of threshing. The portable paddy thresher was field tested and its threshing efficiency, damaged grains and output of the thresher were found to be 99.85 %, 2.85 % and 235.65 kg h^{-1}, respectively. The saving in cost and time of the portable power paddy thresher were 86.5 % and 95 %, respectively as compared to manual threshing. The break-even point for the developed portable power paddy thresher was 205 hours of use per year.

Key words: Paddy threshing, Conventional threshing methods, Power thresher, Threshing efficiency

Out of the total cultivated area of 193 million hectare in India, paddy is grown in 42.41 million ha. This amounts to 28 per cent of the world's total area of 151 million ha under paddy cultivation. India shares about 22.3 per cent of paddy cultivation with an annual production of 132 million tones (Agricultural Statistics at a glance, 2011). The farm holdings in India are classified as marginal (less than 1 ha), small (1 to 2 ha), semi medium (2 to 4 ha), medium (4 to 10 ha) and large (more than 10 ha). More than 75 % of farmers belong to marginal and small category and the following methods namely Manual treading, Hand beating, Bullock treading, Pedal thresher and Power thresher - hold on type were adopted by these farmers for the paddy threshing.

Threshing is the detachment of the paddy kernels from the panicle of the rice plant. The separation of grains from the panicle occurs due to the rubbing action, impact and stripping. The rubbing action occurs when a paddy is threshed by trampling by man, animal or tractors. Impact action takes place during drum beating, but both impact and stripping action is followed by pedal thresher and power thresher (Miah *et al*., 1994; Das and Das 1989; Kailappan *et al.,* 1993). Various designs of threshing mechanisms have been developed to thresh cereals crops and to obtain maximum threshing efficiency with reasonably less grain damage. The physico-mechanical properties of the crop like the type of ear head and bond strength of the grain in the panicle are the main characteristics which determine the selection of proper threshing mechanism for getting maximum results.

The threshing mechanism of mechanical threshers utilizes either rasp bars or wire loops as a functional component of the threshing mechanism. Concave clearance and cylinder peripheral speed are the operational parameters associated with threshing mechanism and are to be optimized for maximum and damage free threshing. In order to investigate the compatibility of wire loop and rasp bar cylinders, a comparative study was conducted and the results revealed that the threshing efficiency was more in the rasp bar cylinder compared to wire loop cylinder. According to Chandrakanthappa and Batagurki (2001) Rasp bar type thresher was the best among different methods of threshing. Based on the above study a portable power thresher consisting of a threshing mechanism along with winnowing capability was developed.

Materials and Methods

Evaluation of paddy threshing methods

Manual treading method

A man of good physique with previous experience in threshing was selected as power source. Known quantity of paddy panicles having moisture content ranging from 13 to 20 % (d.b) was used as test material. The time taken to thresh the known quantity by treading under men foot was recorded. Threshing efficiency, percentage of grain damage and output capacity was analyzed from the

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threshed material using standard procedures (Miah *et al*., 1994). The same procedure was repeated for the Hand beating method (Kailappan *et al.,* 1993), Bullock treading method, Pedal thresher and Power thresher (hold on type).

Bullock treading method

The bullock treading, all the paddy bundles were spread thoroughly on the threshing floor. Usually 2 to 6 bullocks and one man are used for treading the paddy stalk for hours.

Pedal thresher

This pedal thresher consisted of wire loop cylindrical drum, which was operated by men foot. Holding the bundle of panicles over the rotating threshing cylinder, threshing process carried out (Miah *et al*., 1994).

Power thresher: hold on type

The hold on type power thresher was operated by 3 hp electric motor and wire loop threshing cylinder was used for threshing the paddy crop. Known quantity of paddy crop was hold on over the threshing cylinder manually (Figure 1).

Cylinder-concave mechanism: cross flow

Cylinder concave mechanism of threshing was done by the different type of threshing cylinders namely, spike tooth, wire loop and rasp bar threshing cylinders. Among those the rasp bar cylinder consumes less power than the others (Sarvar and Khan, 1987; Ramteke and Sirohi, 2003). A cross flow portable paddy thresher was fabricated based on cylinder- concave mechanism.

Development of portable power paddy thresher cum winnower

The overall dimension of the portable paddy thresher was 1500 × 900 × 1140 mm. The weight of the portable paddy thresher was 102 kg with engine and thresher alone 83 kg. The portable paddy thresher was developed with the following components.

Feed chute

In order to uniformly feed the harvested paddy crop in to the concave, an inclined feed chute was fitted at one end of the concave. The shape, slope and size were determined based on physical properties of the crop. The safe feeding was fabricated as per the IS 9129- 1979. The chute is made up of 20 gauge mild steel sheet having 450 × 100 mm opening in different and 300 × 100 mm opening at the inlet.

Threshing cylinder

The thresher was mounted with a rasp bar cylinder. The cylinder of 300 mm diameter 300 mm length having four rasp bars on the periphery supported by a shaft fixed to the main frame of the thresher with the help of bearings. One end of the shaft is fitted with a stepped V-pulley to take power from the engine with the help of V-belts, to throw the threshed materials at the outlet. Four numbers of commercially available rasp bar of 300 × 40 × 25 mm were fitted on the threshing drum of 255 mm diameter, maintaining outer diameter as 300 mm with necessary wooden piece for proper seating between the rasp bar and cylinder (Figure 2).

Concave

The semicircular concave was made up of mild steel flats and 8 mm diameter rods fitted below the threshing drum and width of concave was 330 mm. The provision has been made to adjust the clearance between the concave and the cylinder drum based on the properties of the plants and panicles of the paddy varieties for effective threshing (Figure 3).

Outlet and grain collection assembly

The grain outlet was used to collect the threshed grain. The outlet size was 135 × 130 mm and grain collector tray was 420 × 320 × 100 mm and Chaffed-straw outlet was the outlet where the threshed straws were blown in case of the throw-in type thresher (Figure 4.)

Winnower

Centrifugal blower having drum diameter of 350 mm and width of 240 mm and air outlet of 240 × 150 mm was fabricated and fitted in below the threshing cylinder. One end of the shaft is fitted with a stepped V pulley to facilitate for drawing power from the engine at varying speeds through a V-belt (Figure 4.) The winnowing velocity was varied from 2 to 12 m/sec (Yuanguo *et al.,* 1999). The blower speed of 900 rpm was maintained.

Main frame

The main frame was made up of 25 × 25 × 6 mm mild steel 'L' angle. It supported the different components of thresher such as feed chute, threshing cylinder, concave, sieves and blower with air ducts. The three wheels of 130 mm diameter were fitted to the thresher for transporting purpose (Figure 3).

Power unit

A 2.28 kw petrol start kerosene operated engine was fitted to the threshing unit at an appropriate place. The stepped pulleys fitted to the engine, the cylinder shaft and blower shaft helps in varying the required speed of the cylinder and the blower. The working drawings of the portable paddy thresher developed are presented in Figure 4, which included the elevation and side view of the thresher.

Performance evaluation of portable power paddy thresher cum winnower

The portable power paddy thresher was field tested for threshing freshly harvested panicles of

paddy. The thresher was set to run at fixed level of operational parameters by adjusting the concave clearance at 15 mm and cylinder peripheral speed 16.50 m s^{-1} as identified in the evaluation studies conducted by Sudajan *et al.,* (2002). The thresher was operated for a period of six hours and the performance was evaluated following the test procedure described by IS: 11234: 1985. During each one hour run period, three sets of samples were collected at main grain outlet, chaff outlet and straw outlet for duration of 60 sec.

Cost economics

The total cost of the portable power paddy thresher was arrived and the fixed and variable costs for operating the unit per hour was calculated as per the procedure described by ARE: 9164: 1979. From the field capacity of the unit, the cost of operation per 100 kg of grain was calculated. This cost was compared with manual method of threshing for 100 kg grain. The saving in cost and time using the portable paddy thresher was also arrived.

Results and Discussion

Manual treading method

The paddy panicles were harvested when they mature and threshed by treading under men foot. The threshed material had a moisture content ranging between 13 to 17 % (db) of grains. The data are presented in Table 1. This method had several advantages as it works out cheaper and cause less

Table 1. Comparative performance of portable power paddy thresher cum winnower

Threshing methods	Threshing efficiency, %	Damaged grain, %	Output capacity, kg h^{-1}
Treading under men foot	97.45	0.64	12.45
Hand beating- Apractical device	94.50	1.25	17.50
Bullock treading	95.64	2.17	64.50
Pedal thresher	98.00	1.05	103.40
Power thresher-Hold on type	98.35	1.15	180.00
Developed portable power paddy thresher	99.85	2.85	235.65

damage to the grains. However, it was a very slow process and suitable only for threshing small quantity that too for seed purpose for their own use.

Hand beating method

The paddy panicles were harvested when they mature and threshed by hand beating for its threshing efficiency, percentage of damaged grain and output capacity of paddy are presented in Table 1. However, it was a very slow process and suitable only for threshing small quantity. Hand beating threshing method had higher output capacity and lower threshing efficiency than the manual treading method.

Bullock treading

This method is generally applied for large quantity of harvested crop. This method of threshing gave higher output capacity and grain damage than

Fig. 1. Power thresher – Hold on type

above two methods. The data are presented in Table 1. It had several disadvantages like requirement of special threshing yard, transportation of harvested crop from the field to the threshing floor.Delay in operation lead to wastage due to unexpected rains and other natural vagaries.

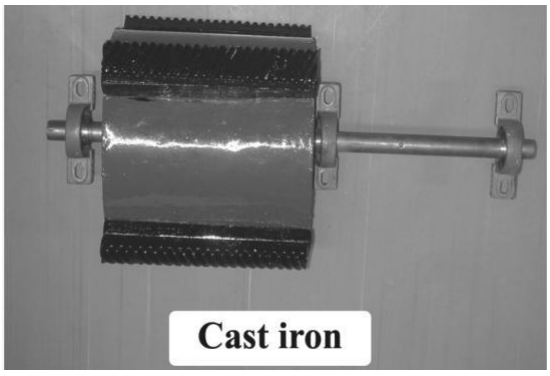

Fig. 2. Threshing cylinder

Pedal thresher

The data are depicted in Table 1. Pedal thresher gave higher threshing efficiency, output capacity and lower grain damage than the Manual treading, Hand beating and Bullock treading methods and also lower than the hold-on-type and portable paddy thresher.

Fig. 3. Thresher-Concave

Hold- On type thresher

The data are presented in Table 1. Threshing efficiency and output capacity were higher than all the above conventional threshing methods (Manual

treading, Hand beating, Bullock treading, Pedal thresher) and less threshing efficiency and output capacity than the developed portable paddy thresher.

Developed portable paddy thresher cum winnower

The field performance studies with the developed portable paddy thresher were carried out for threshing paddy. The mean values for test results in terms of threshing efficiency, grain damage and

Fig. 4. Portable power paddy thresher

output capacity were 99.85 %, 2.85 % and 235.65 kg h^{-1} respectively at Grain moisture content of 13.5 %. The performance of the developed portable paddy thresher was compared with the performance of all conventional methods of threshing. The results are furnished in Table 1. By optimizing concave clearance (20 mm), cylinder speed (16.5 m s^{-1}) and feed rate (600 kg h^{-1}), the portable paddy thresher had the higher threshing efficiency and output capacity than all conventional threshing methods.

Cost economics

Cost of threshing by manual method

Weight of grain threshed by women in one hour, kg : 10

Total women hours per 100 kg : 10

Cost of women labour per day, Rs.: 80

Cost of threshing per 100 kg, Rs. : 80/8 x 10 = 100

Cost of threshing by portable power paddy thresher

Cost of threshing per 100 kg using portable paddy thresher(Considering output as 240 kgh^{-1}) : 13.15

Cost of threshing per 100 kg by conventional method : 100

Saving in cost, percent : 86.5

Saving in time, percent : 95

The break-even point analysis was carried out by taking the cost of the unit as Rs. 9,800 and total life period as 6 years at the average annual use of 720 hours. The break-even point for the developed portable paddy thresher was 205 hours of use per year.

Conclusion

The developed portable power paddy thresher was field tested and its threshing efficiency and output capacity were 99.85 % and 235.65 kg h^{-1}, respectively. The grain damage was found to be 2.85 %. The saving in cost and time were 86.5 and 95 % respectively as compared to conventional method of manual threshing. The break-even point for the developed portable paddy thresher was found to be 205 hours of use per year. Though the developed thresher recorded higher grain damage when compared with conventional threshing methods it is the need of the hour since it recorded highest threshing efficiency and output capacity which in turn saved time and cost of threshing.

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Received: November 11, 2012; Accepted: March 3, 2013