



## Pedal cum solar powered paddy thresher for small farms

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Received: 23 September 2020; Accepted: 08 February 2021

**Keywords:** Paddy thresher, Solar energy

Worldwide total rice production reached about 495.9 MMT in the year of 2018–19 (Anonymous. 2018), out of this India achieved production of about 112.91 MT (Anonymous. 2018). India is second largest producer and consumer of paddy next to China (Samreen *et al.* 2017, Anonymous 2018). Threshing plays a very crucial role after its harvest for further processing. Thresher is used to detach grain from the harvested crop and separate clean threshed grain from chaff without much loss or damage grain. It can be operated manually as well as mechanically. Most of thresher now-a-days run by use of fossil fuels. Due to limited reserve stock of fossil fuels (Mohammad and Atefah 2017) the price are continuously hiked. In India almost 82% of farmers belong to small and marginals (Anonymous 2018), unavailability grid-connected electricity and supplies of other non-renewable sources of energy many rural areas may be too expensive. They are also inaccessible to the hilly areas because of its heavy weight of complicated design (Akshay *et al.* 2018) as well as it requires regular service and maintenance. Therefore, to reach small and marginal farmers on field there is need of low cost with simple thresher design. In India, solar energy is readily available free source of energy, this call for the use of photovoltaic (PV) system for threshing (Adonis *et al.* 2016). Sometimes due to change in weather conditions solar energy may not be available, under this circumstances there is need of additional pedal unit to run thresher. Keeping the above points in view, Pedal cum Solar Operated Paddy Thresher for Small Farms was designed and developed.

Mutai *et al.* (2018) designed and developed pedal powered paddy thresher fitted with winnowing equipment. Patel *et al.* (2019) studied design parameter of pedal operated paddy thresher such as drum peripheral speed, number of

strips, tip height and loop spacing in the threshing drum to achieve optimum capacity thresher using Response surface methodology in Design Expert tool. The coefficient of determination (R<sup>2</sup>) of 0.95 indicated a good fit between the experimental value and predicted value. Amare *et al.* 2015 developed a pedal rice thresher, which was simple to operate with leg muscle powered by chain drive mechanism. The results showed threshing output of pedal type (127.5 kg/h) was more as compared to the traditional method (92 kg/h). Akshay *et al.* 2018 designed and developed a solar operated through-flow type thresher of 700 mm length, 400 mm diameter threshing cylinder with pegs. It was operated with the help of high torque DC motor of 200 rpm speed. Baruah *et al.* (2018) stated that development of manual rice threshing machines provide the scope for establishment of small scale cottage industries concerned to threshing and packing of rice.

The base frame system of the prototype was fabricated using MS. square of 32 × 32 × 2 mm size. Similarly, the Top frame of the prototype was fabricated using MS. square of 25 × 25 × 2 mm size. By mounting both frame form main frame. At the main frame, the various components were assembled using nuts and bolts. The shaft was mounted to the frame for transmitting power from both pedal and DC motor to threshing unit through a power transmission system with the support of bearings. There is no provision for collecting the threshed grains in existing pedal powered paddy threshers. Hence, during threshing process, grains scatter over a large area, incurring additional physical effort to bag them. Threshing shield was provided in this thresher covering all sides except grain feeding and grain outlet to prevent grains scatter over a large area, incurring additional physical effort to bag them. The shield is made up of 18 gauge MS sheet.

The components of paddy thresher were designed as per Bureau of Indian standard (IS: 3327-1982 and 1985) (Anonymous 1982 and 1985). The specification of designed thresher such as diameter of threshing drum, length of threshing drum, number of strips, tip height and loop spacing in the threshing drum parameter were taken as 400 mm, 500 mm, 12, 50 mm and 40 mm respectively. The complete designed thresher was fabricated in workshop of Division

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Fig 1 Pedal cum Solar powered paddy thresher.

of Agricultural Engineering, IARI, New Delhi during 2019–20. The developed thresher (Fig 1) has the provision for adjustment of the height for male-female system from 750 mm up to 1267 mm. and pedal can also be adjusted with respect to their required step height.

The pedal stroke is typically 20–21 strokes/min used to get a speed of between 290–310 rpm measured using tachometer. The parameters of physiology also depend on the number of strokes per min. Hence, 21 strokes per min was selected and given the required chain mechanism to maintain a threshing cylinder speed of 300 rpm at output of 24 voltages connected to DC motor.

Performance test as per IS: 6284-1985 (Anonymous 1985), achieved the average threshing efficiency of 97.41%. The average length of the paddy plant measured is 85.83 cm. The average moisture content of paddy grain was 18.45% (wb). The evaluation of different mode of operation paddy thresher was carried out in terms of machine parameters such as threshing rate (kg/h) and threshing efficiency. During performance of both pedal and solar mode of operation paddy thresher threshing rate was calculated to know the capacity of thresher. The threshing rate was determined based on the paddy holding capacity for feeding load per unit time. Data (Table 1) showed that with the increase in paddy holding capacity the threshing rate increased for both mode of operation and at all paddy holding capacity

Table 1 Threshing rate at different paddy holding capacity for feeding

| Paddy holding capacity (kg) | Threshing rate (kg/h) |                |
|-----------------------------|-----------------------|----------------|
|                             | Pedal mode            | Solar mode     |
| 0.5                         | 60.62 ± 1.07          | 195.65 ± 4.26  |
| 0.75                        | 65.17 ± 1.17          | 204.60 ± 4.06  |
| 1                           | 66.63 ± 1.12          | 231.67 ± 11.79 |
| Mean ± SD                   |                       |                |

from 0.5–1 kg, the threshing rate were highest for solar and lowest for pedal mode.

The mean threshing rate values for solar mode varied from 195.71–231.67 kg/h at different paddy holding capacity. In case of pedal mode, the mean value of the threshing rate varied from 60.62–66.63 kg/h at different paddy holding capacity, respectively. ANOVA for threshing rate of paddy thresher indicated that the threshing rate in different mode of operation was significantly different ( $P < .0001$ ) as compared to paddy holding capacity.

The performance of both pedal and solar mode of operation paddy thresher was evaluated on the basis of machine parameters (such as threshing efficiency). The Threshing efficiency was determined using the equation as given below.

Threshing efficiency = 100-Percentage of unthreshed grain

Based on the paddy holding capacity for feeding, three levels of load conditions such as 0.5, 0.75 and 1 kg were considered for evaluation of thresher. Data (Table 2) showed that with the increase in paddy holding capacity the threshing efficiency decreased for both mode of operation. It was also found that at all paddy holding capacity conditions from 0.5–1 kg, the threshing efficiency were lowest for pedal and highest for solar mode. The mean threshing efficiency values at solar mode varied from 99.58–98.67% at different paddy holding capacity. In case of pedal mode, the mean value of the threshing efficiency varied from 98.54–97.01% at different paddy holding capacity, respectively. ANOVA for threshing efficiency indicated that the threshing efficiency was significantly different ( $P < .0001$ ) as compared to paddy holding capacity.

The mode of operation and paddy holding capacity for feeding was found significantly affect threshing efficiency

Table 2 Threshing efficiency for different mode of operation paddy thresher

| Paddy holding capacity (kg) | Threshing efficiency (%) |              |
|-----------------------------|--------------------------|--------------|
|                             | Pedal mode               | Solar mode   |
| 0.5                         | 98.54 ± 0.42             | 99.58 ± 0.33 |
| 0.75                        | 97.77 ± 0.16             | 98.98 ± 0.12 |
| 1                           | 97.01 ± 0.01             | 98.67 ± 0.12 |
| Mean ± SD                   |                          |              |

from least significant difference. Threshing efficiency in solar mode was found as 99.58–98.67% compared to 98.54–97.01% for pedal. The threshing rate of in solar mode was achieved as 231.67 kg/h as compared to 66.63 kg/h in pedal mode. Hence, solar mode threshing rate is 3.47 times more than pedal mode.

#### SUMMARY

The performance of pedal operated paddy thresher was evaluated in the field. During threshing operation the optimum speed of threshing drum 290–310 rpm was achieved by 21 strokes. The paddy was threshed at a moisture content of 18.45%. The threshing efficiency of the thresher was found up to 99%. The optimum paddy holding capacity achieved was 0.5 kg, 1 kg and 0.75 kg. The optimum foot pedal size was 14.35 cm. The optimum threshing cylinder height was 101.25 cm. Threshing efficiency in solar mode was found as 99.58–98.67% compared to 98.54–97.01% for pedal. The threshing rate in solar mode was achieved as 231.67 kg/h as compared to 66.63 kg/h in pedal mode. Hence, solar mode threshing rate is 3.47 times more than pedal mode. This thresher will be very useful for small poor farmers in rural areas where there is no electricity or its supply is erratic. Due to its small weight it will also be very useful for farmers in hilly regions due to its easy transport from one place to another.

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