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Performance evaluation of the tractor operated paddy thresher as affected by feeding rate and cylinder speed

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Abstract
The experiment was conducted on tractor operated paddy thresher at Lohar Khera and Sanga in Fatehabad (Haryana). The main purpose of this research work was to estimate the operational cost and performance evaluation for spike tooth type paddy thresher. In this study, the paddy thresher was tested at different cylinder speeds (12, 15, 20, 25, 30 and 35 m/sec) and feeding rates (0.38, 0.45, 0.49, 0.56, 0.62, 0.68 and 0.74 kg/sec). The variation in speed was achieved by using stepped pulley system. The operational cost of paddy thresher was estimated by the straight-line method of depreciation. The operational cost and fuel consumption of tractor operated paddy thresher was found to be about 380 Rs/hr and 2.75 litre/hr, respectively. The maximum threshing efficiency and cleaning efficiency were obtained as 98.80 % and 99.10 % at feed rate of 0.56 kg/sec and 0.38 kg/sec, respectively. The total minimum loss was obtained as 1.12 % and 2.80 % at feeding rate of 0.38 kg/sec and 25 m/sec cylinder speed, respectively. From this study, it was concluded that the threshing efficiency of the thresher increases with cylinder speed up to 25m/sec and then decreases. The cleaning efficiency increases continuously with threshing cylinder speed. It may be as such, because at higher speeds, the blower delivers more volume of air which helps to clean the output of the thresher.

Keywords: Cylinder speed, feed rate, cleaning efficiency, threshing efficiency, operational cost, tractor operated paddy thresher, spike tooth thresher

Introduction
Manual threshing of rice crop was very cumbersome, time consuming and less efficient process and harvesting of over matured paddy crop, leads to increase in shattering losses. (Pathak & Bining 1985) [1] Concluded that more than 80% of the rice crop on farms was threshed manually, so the mechanization is needed essentially to harvest the crop at the right time. Nowadays, for most of the crops; thresher has been developed and is available in the market. Many experiments have been conducted to optimize thresher performance. (Radwan *et al.* 2009) [2] Studied on developed El-Shams type tangential axial flow cereal thresher and it was found that threshing efficiency increases with increase in rotor speed. When rotor speed was increased from 500 to 700 rpm at air speed (4.8 m/s) and moisture content (10.36%) and then the threshing efficiency was also increased from 70.2 to 73.7%. (Desta and Mishra 1990) [3] had conducted the study to evaluate the performance of a sorghum thresher and tried to find out its performance at three different feed rates (6, 8, 10 kg /min), at two levels of concave clearance (7 and 11 mm) and three different levels of threshing cylinder speed (300 rpm, 400 rpm & 500 rpm). The results of their study showed that the threshing efficiency was increased with an increase in cylinder speed for all levels of feed rate and concave clearance. The threshing efficiency was found in the range of 98.3% to 99.9%. (Chandra kanthappa *et. al.* 2001) [4] had conducted a test using a rasp bar type multi-crop thresher to thresh finger millet and found threshing efficiency of 79.61% and total damage of 2.95 % was obtained at 4 mm concave clearance, 1000 rpm threshing cylinder speed and grain moisture content of 10% wet basis. (Behery *et. al.* 2000) [5] had performed threshing tests on El-Shams rice thresher and done using a range of drum speeds, crop feed rates and length of conveyor chain tension at four different levels of capsule moisture content. The optimum performance was found at threshing cylinder speed, feed rate and length of conveyor at about 31.43 m/s, 20 kg/min and 48 mm, respectively at 18.45 % moisture content of crop.

Most of these researchers had performed their study to evaluate the performance of motor operated thresher and effect of different parameters on its performance, but the aim of present research work was to estimate the operational cost and evaluate performance of tractor operated paddy thresher.

Materials and Methods

The experiment was conducted on the paddy thresher at Lohar Khera and Sanga village in Fatehabad (Haryana). Before conducting the experiment, some technical observations were taken which is shown in Table 1.

Table 1: Some technical specifications of tractor operated paddy thresher

Sr. No.	Technical parameters	Dimensions
1.	Length of cylinder (mm)	1775
2.	Diameter of cylinder (mm)	803
3.	Concave clearance (mm)	26
4.	No. of sieves	2
5.	Type of cylinder	Spike tooth
6.	Working height of spike (mm)	130
7.	Length of feed chute (mm)	940
8.	Thresher length (m)	4.2
9.	Thresher Height (m)	2.63
10.	Thresher Width (m)	1.99

In the present study, for the measurement of threshing cylinder speed, Magnetic Tachometer and Digital Tachometer were used according to exposed suitable location of the shaft of threshing cylinder. The small strip of reflective mark was pasted at the periphery of shaft and then switch on the Non-Contact type digital tachometer. When laser beam struck with this pasted strip, it gives pulse and then the pulse analyzed and processed in the software to be incorporated in the digital tachometer. The threshing cylinder speed was measured using digital tachometer. The one and two liters beakers were used to measure fuel consumed per hour for each thresher with varied threshing cylinder speed and feed rate. The fuel consumed per hour for each thresher was estimated by filling the fuel tank of the tractor and care of time taken was done by the stop watch. The weighing Machine was used to weigh the sample to be taken for threshing efficiency, cleaning efficiency, cylinder loss and broken loss. Four samples were taken, about 1kg of grain for threshing efficiency, cleaning efficiency, cylinder loss and broken loss at different threshing cylinder speed and feed rate. The variation in threshing cylinder speed was obtained using stepped pulley system and feed rate on the basis of applying the varied quantity of threshing material.

2.1. The determination of performance parameters of paddy thresher

The performance parameters of paddy thresher were calculated like threshing efficiency, cleaning efficiency, cylinder loss, broken loss, fuel consumption rate and operational cost. The grain sample size, about 1kg was taken from the main outlet of the thresher and weigh the cleaned paddy grain after removal of unwanted material from the sample. The equation 1st was used to estimate cleaning efficiency.

$$\text{Cleaning efficiency} = \frac{\text{weight of clean grains in sample (gm)} \times 100}{1000\ \text{(gm)}} \quad \ldots\ldots 1$$

For the measurement of threshing efficiency, 1 kg sample was taken from the bhusa outlet of the thresher and collected the unthreshed grain from the sample. The equation 2nd was used to calculate threshing efficiency.

$$\text{Threshing efficiency \%} = [100 - \text{percentage of unthreshed paddy grain}] \quad \ldots 2$$

For the estimation of broken loss, the grain sample size about 1kg was taken from the main outlet of the thresher and then broken grains were drawn out from the sample manually on the basis of visibility. The broken, sieve and total grain loss were calculated by using 3rd, 4th and 5th equation respectively.

$$\text{Broken grain \%} = \frac{\text{weight of broken grain found in 1kg sample} \times 100}{\text{1kg sample}} \quad \ldots 3$$

$$\text{Sieve loss} = \frac{\text{weight of grain collected from over flow and under of the sieve} \times 100}{\text{Total grain input}} \quad \ldots 4$$

$$\text{Total grain loss \%} = \text{blown loss\%} + \text{damaged grain\%} \quad \ldots 5$$

2.2. Determination of operational cost for the machine

The straight line method was used to estimate the operational cost for tractor operated paddy thresher. In the straight line method, two types of cost was involved, one is fixed cost and other variable cost.

2.1 Fixed cost

$$a)\ \text{Depreciation} = \frac{(C - S)}{L \times P}, \text{Rs/hr} \quad \ldots 6$$

Where, C is capital cost, Rs.
S is salvage value, Rs.
L is life of machine, yrs
P is annual use of machine, hrs

$$\text{b) Interest cost, Ic} = \frac{(C + S) \times I}{2P}, \text{Rs/hr} \quad \ldots 7$$

Where, I is rate of interest, %

$$c)\ \text{Insurance, taxes \& shelter chargers} = \frac{\text{3 \% of total of cost of machine}}{\text{Annual hours use}}, \text{Rs/hr} \quad \ldots 8$$

$$\text{Total fixed cost} = [\text{depreciation} + \text{interest} + \text{insurance} + \text{taxes} + \text{shelter}], \text{Rs/hr} \quad \ldots 9$$

2.2 Variable cost

$$\text{I) Repair and maintenance} = \frac{7\ \%\ \text{total cost of machine}}{\text{Annual hours use}}\ ,\text{Rs/hr} \quad \dots 10$$

$$\text{II) Labour cost, Rs/hr} = \text{Wage rate per person} \times \text{No. of persons involved} \quad \dots 11$$

$$\text{III) Fuel cost, Rs/hr} = \text{Fuel consumed per hour} \times \text{cost of fuel 1litre} \quad \dots 12$$

$$\text{Total variable cost, Rs/hr} = [\text{Repair and maintenance} + \text{Labour cost} + \text{Fuel cost}] \quad \dots 13$$

$$\text{Total operational cost, Rs/hr} = \text{Total fixed cost} + \text{Total operating cost} \quad \dots 14$$

3. Results and discussion

The purpose of the research was to determine the effect of feed rate and threshing cylinder speed and estimation of the operational cost of the machine. In this study, the paddy thresher was tested at different threshing cylinder speeds (12, 15, 20, 25, 30 & 35 m/sec) and feeding rate (0.38, 0.45, 0.49, 0.56, 0.62, 0.68 & 0.74 kg/sec), corresponding to these speeds and feed rates, its performance was evaluated. The variation in speed was achieved by using stepped pulley system and feed rate was varied by increasing the applied material to the input of the machine. The operational cost of the machine was estimated by the straight line method of depreciation and was found to be about 380 Rs/hr. The maximum performance parameters were obtained for paddy thresher in this experiment is shown in Table 2.

Table 2: The performance parameters of the machine

Sr. No.	Parameters	Values
1.	Fuel consumption rate l/h	2.750
2.	Cleaning efficiency, %	98.2
3.	Threshing efficiency, %	98.80
4.	Total loss, %	1.80
5.	Operational cost, Rs/hr	380

After the evaluation of its performance, graph was plotted for the paddy thresher by keeping cylinder speed at X abscissa and threshing efficiency, cleaning efficiency and total loss, at Y abscissa which are shown in Figure 2 (a), 2 (b) and 2 (c), respectively.

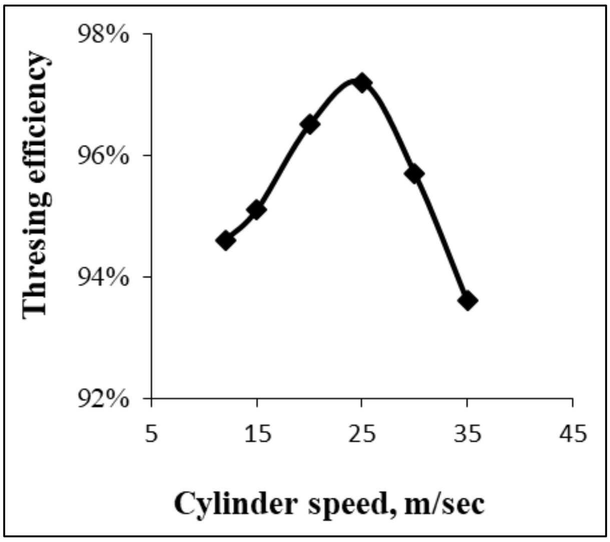

Fig 2a: Thresing Efficiency

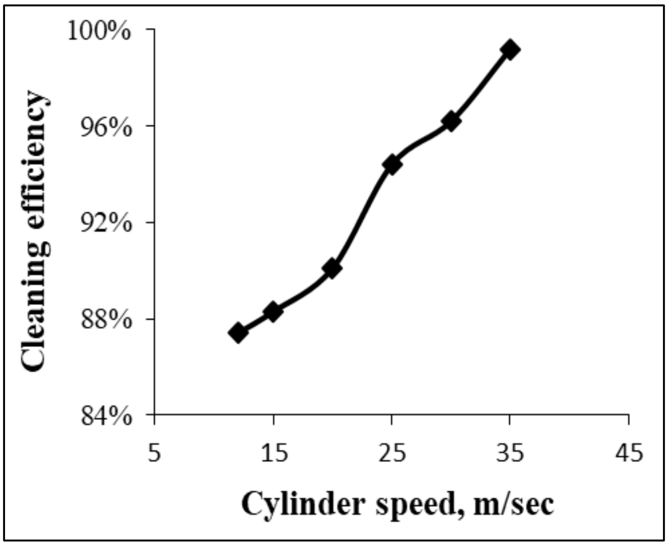

Fig 2b: Cleaning Efficiency

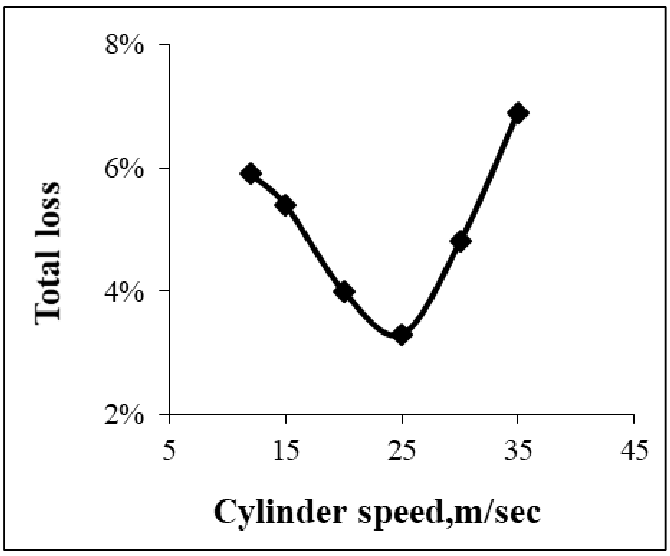

Fig 2c: Total Loss

Figure 2 illustrates the performance of the paddy thresher at different threshing cylinder speeds 12, 15, 20, 25, 30 and 35 m/sec. It was observed that the threshing efficiency of the thresher was increasing with increase in cylinder speed up to 25m/sec, because at this speed, spikes will give more beating action to panicles of paddy crop, to do so cylinder loss will reduce. After 25 m/sec. cylinder speed, the threshing efficiency was decreasing with increase in speed because damage losses also increase. The cleaning efficiency was raised up continuously with cylinder speed, because higher blower speed produces the high voluminous of air and it helps to clean the output of the thresher.

The another graph was plotted by keeping feed rate at X abscissa and threshing efficiency, cleaning efficiency and total loss at Y abscissa which are shown in Figure 3(a), 3(b) and 3(c), repectively.

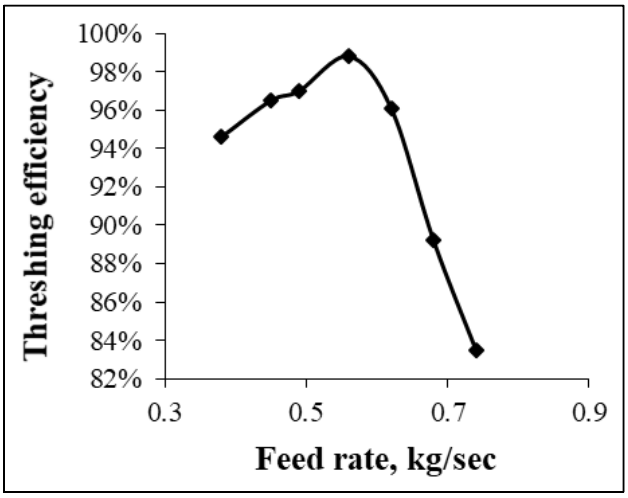

Fig 3a: Thresing Efficiency

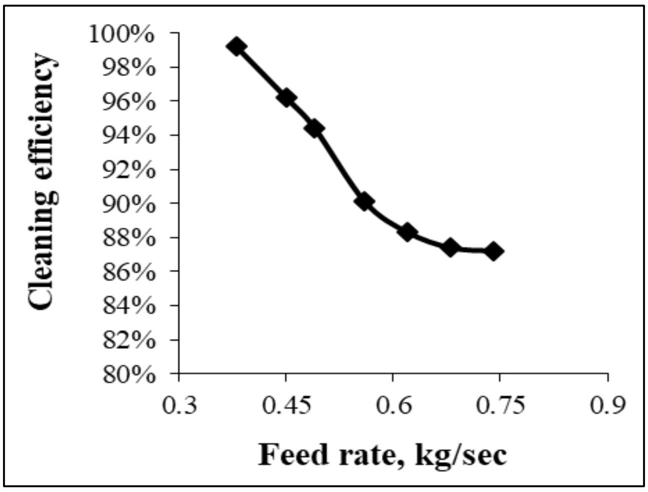

Fig 3b: Cleaning Efficiency

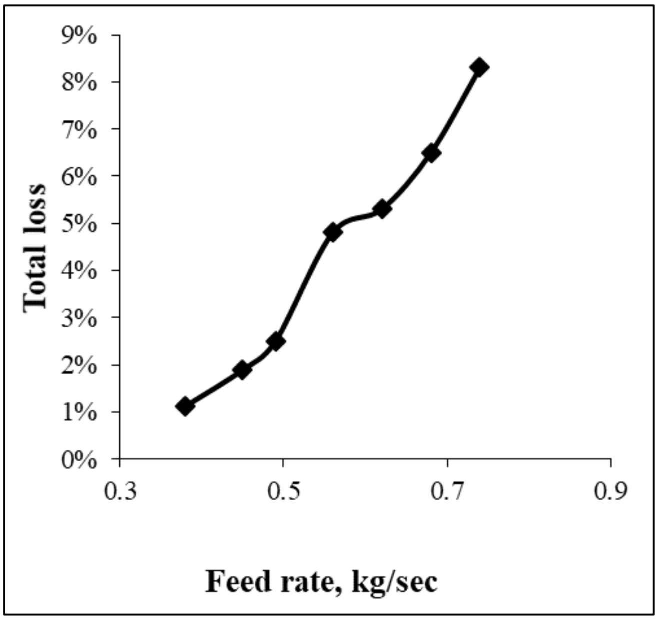

Fig 3c: Total Loss

Figure 3 illustrates the performance of the paddy thresher at different feeding rates 0.38, 0.45, 0.49, 0.56, 0.62, 0.68 and 0.74 kg/sec. It was observed that threshing efficiency was increasing initially because machine had have ability to thresh the material and then decreasing with feed rate because excess feeding lead to more damage loss of grain. The cleaning efficiency was decreasing continuously with increasing feeding rate, because blower has certain range within that it can clean the material better but after that certain unwanted material remains in the output of the thresher. Total losses was also increasing with feeding rate because of more shearing force developed between grains and periphery of threshing cylinder and damaged the rice grains.

Conclusions

In this study, tractor operated paddy threshers was tested at different threshing cylinder (12, 15, 20, 25, 30 & 35 m/sec) and feeding rate (0.38, 0.45, 0.49, 0.56, 0.62, 0.68 & 0.74 kg/sec) corresponding these speeds and feed rates, its performance was evaluated. From the observed data, it was found that the maximum threshing efficiency and cleaning efficiency was recorded 98.80 and 98.2 percent, respectively. The threshing efficiency was increased with cylinder speed up to 25m/sec and then declined. The cleaning efficiency was escalated continuously with cylinder speed, because at higher blower speed produced more voluminous of air and helped to clean the output of the thresher. The increasing trend of total losses was also noticed with feeding rate possibly because of more shearing force induced between grains and periphery of threshing cylinder. The operational cost for the paddy thresher was found to be about 380 Rs/hr and fuel consumption as 2.75 litre/hr.

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