Development And Performance Evaluation Of Low Cost Portable Paddy Thresher For Small Farmers

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Running title: Low Cost Portable Paddy Thresher for Small Farmers

ABSTRACT

The low cost paddy thresher was developed in Tamil Nadu Agricultural University and its performance was evaluated in the farmer's field for the research purpose. The portable paddy thresher was tested for its performance in terms of threshing efficiency, grain damage and output capacity at different levels of factors namely concave clearance (15, 20 and 25 mm), cylinder peripheral speed (11.7, 14.1 and 16.5 ms^{-1}), grain moisture (13.5, 16.5 and 19.5 per cent) and feed rate (200,400 and 600 kg h^{-1}). Comparing the maximum threshing efficiency, minimum grain damage and maximum output capacity in different combinations the minimum loss was achieved at a combination of 20 mm concave clearance, 16.5 m s^{-1} cylinder speed, 13.5 per cent moisture content and at a feed rate of 600 kg h^{-1}. The threshing efficiency, grain damage and output capacity occurred at this combination was 99.95 per cent, 2.76 per cent and 248.27 kg h^{-1} respectively for cast iron rasp bar threshing cylinder. The saving in cost and time were 86.5 per cent and 95 per cent respectively as compared with conventional method of manual threshing.

Keywords: Thresher – Paddy - Low cost – small farmers

INTRODUCTION

India has moved from food scarcity to food surpluses in the last four decades. This is possible due to the growth of science coupled with quick adoption of technology by the farmers. Out of the total cultivated area of 193 million hectare in India paddy is grown in 42.41 million ha. This amongst 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 tonnes.

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. In developing countries there are places where small area farmers do their threshing using muscle power- either human or animal for example by foot treading or by bundle beating. Big western-style threshers and combines are not unknown, but they are considered too costly and heavy, or ill suited to small and inaccessible paddy fields. Based on this portable thresher that can be used by even small farmers will find a major breakthrough in farm mechanization. The threshing mechanism of mechanical threshers utilizes either rasp bars or wire loops as a functional component of the threshing mechanism. Sarvar and Khan (1987) stated that the various threshing mechanism, rasp bar mechanism will give best out let. According to Chandrakanthappa kammar *et al*, (2001) Rasp bar type thresher was the best among different methods of threshing and the threshing efficiency is more in the rasp bar cylinder compared to wire loop cylinder. Concave clearance and cylinder peripheral speed are the operational parameters associated with threshing mechanism. Therefore mechanical threshers utilizing either of the threshing mechanism; concave clearance and peripheral speed are to be optimized for maximum and damage free threshing.

A portable thresher consisting of a threshing mechanism along with winnowing capability will be developed. The thresher available requires high horse power motor or PTO of tractor. Hence during threshing one farm tractor owned by the farmer is not available for other farm operations such as seedbed preparation. The existing thresher cannot be taken to the interior fields of the farmer where we do not have proper approach roads to the fields. The crops from the interior fields have to be carried by the farm labours for the threshing yards, which is a labor consuming activity. In order to overcome the above problems it was thought of to develop a portable thresher. Two persons can take it to any corner of the interior paddy fields. The prime mover is petrol start kerosene driven 2.28 kW engine or a suitable diesel engine. Keeping in view of the problems arising in threshing of paddy, the project is proposed to develop a portable thresher cum winnower for threshing paddy with following objectives.

i. To develop a prototype portable thresher cum winnower based on the study.

ii. To study the performance characteristics of portable paddy thresher.

iii. And workout the cost economics.

MATERIALS AND METHODS

Development of portable paddy thresher cum winnower

Feed chute: To uniformly feed the crop in to the concave, a 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 (Figure 1).

Threshing cylinder: The thresher was mounted with a rasp bar cylinder. The cylinder of 300 mm diameter 300 mm length having four number of commercially available rasp bar of 300 × 40 × 25 mm was fitted on the threshing drum of 255 mm diameter, maintaining outer diameter as 300 mm with necessary wooden piece for proper sitting between the rasp bar and cylinder. Weight of the each rasp bar is 2 kg, and four rasp bars are 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 (Singh and Joshi 1977).

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 is 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.

Outlet and grain collection assembly: The Main grain outlet is used to collect the threshed grain. The outlet size is 135 × 130 mm and grain collector tray is 420 × 320 × 100 mm and the chaffed-straw outlet is the outlet where the threshed straws are blown in case of the throw-in type thresher and is shown in Figure.1.

Winnower: Centrifugal blower having drum diameter of 350 mm and width if 240 mm and air outlet of 240 × 150 mm was fabricated and fitted in below the threshing cylinder. The direction and airflow rate could be adjusted at will. A blower consists of four wings supported by a common shaft and mild steel cover is fitted to the main frame at an appropriate place with the help of the bearings. 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 and is shown in fig.1 & fig 3. The winnowing velocity was varied from 2 to 12 m/sec (Zhao 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 frame was fabricated taking into account the stability of the unit during operation, space requirement for threshing unit and the strength required for supporting all components and transportation of the machine. The three wheels of 130 mm diameter are fitted to the thresher for transporting purpose.

Power unit: A 2.28 kw petrol start kerosene operated engine is fitted to the threshing unit at an appropriate place shown in Figure.1 and Figure 2. Provision is made at the base point to move the engine to and fro to create a belt tension with the help of stepped V-pulley fitted to the engine and V-belts. It also provided the tension mechanism to create belt tension or slack at necessary time. The power is taken from the engine to the threshing unit and to the blower. 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 overall dimension of the portable paddy thresher is 1500 × 900 × 1140 mm and is depicted in Figure 1. The weight of the portable paddy thresher is 102 kg with engine and thresher alone 83 kg.

Performance characteristics of portable paddy thresher

The threshing performance of the paddy in the rasp bar system was studied using a portable paddy thresher. The various parameters to be optimized were the operational parameters *viz*., cylinder speed, concave clearance and the crop parameters *viz*., moisture content and feed rate.

Experimental procedure

The thresher fitted with cast iron rasp bar cylinder surface was set to run at a fixed speed and concave clearance. The portable paddy thresher was run by electric motor for conducting trials. A quantity of 3.4 kg of paddy panicles at a moisture content of 19.50 per cent (d.b) was fed uniformly in to the thresher during a period of 60 seconds so as to get a feed rate of 200 kg h^{-1}. The grains collected at different outlet were weighed and the readings were recorded. This was replicated three times and all the readings were recorded. The above experiment was repeated for the feed rate of 400 kg h^{-1} and 600 kg h^{-1}. The cylinder speed was varied from 11.7 to 16.5 m s^{-1} with help of variable speed motor, fig.4. Similarly, the concave clearance was changed to other levels and the observations were recorded for the three feed rates given above. Similarly for the other moisture levels of 16.50 and 13.50 per cent, the above procedure was repeated and the observations were recorded and tabulated.

An experiment with Factorial Completely Randomized Design (FCRD) was laid out. The factors considered and their levels are furnished in Table 1. IRRISTAT was used to analyze the data. This was done to obtain the necessary analysis of variance of the main and interaction effects of variables on the output capacity, threshing efficiency, grain damage and output capacity. The treatment, which gave good threshing efficiency with least grain damage and maximum output capacity, was selected as the best.

Table 1. Design layout of experiment

Factors:	Feed rate (F)	: 3 levels (200, 400, 600 kg h^{-1})
	Grain moisture (M)	: 3 levels (13.5, 16.5, 19.5 %)
	Concave clearance (C)	: 3 levels (15, 20, 25 mm)
	Cylinder speed (S)	: 3 levels (11.7, 14.1, 16.5 m s^{-1})
	Replication	: 3 levels
Affected response variables:	Threshing efficiency	
	Grain damage	
	Output capacity	

Figure 2. Performance evaluation of low cost portable paddy thresher

RESULTS AND DISCUSSION

Performance evaluation of threshing efficiency of portable paddy thresher

The effects of cylinder speed, concave clearance, feed rate and grain moisture on threshing efficiency were shown below.

Effect of cylinder speed and concave clearance on threshing efficiency

Table 2. S x C Table of means for threshing efficiency, percent.

Concave clearance (C), mm	Cylinder speed (S), m s^{-1}			
	11.7	14.1	16.5	C-Mean
15	98.644	98.762	98.850	98.752
20	98.561	98.654	98.889	98.701
25	98.263	98.363	98.439	98.355
S-Mean	98.489	98.593	98.726	98.603

From Table 2, it is seen that the increase in cylinder speed at each concave clearance had significant effect on threshing efficiency, increasing the threshing efficiency from 98.489 to 98.726 per cent. A maximum threshing efficiency of 98.889 per cent could be achieved at a cylinder speed of 16.5 m s^{-1} with 20 mm concave clearance. Whereas it was 98.263 per cent at a cylinder speed of 11.7 m s^{-1} with 25 mm concave clearance.

Effect of moisture content and feed rate on threshing efficiency

From Table 3, it is seen that that the increase in moisture content from 13.5 to 19.5 percent and results in decrease in the threshing efficiency from 99.596 to 97.605 percent. The data are conformity with the results of Javaregowda *et al*. (1986). A maximum threshing efficiency of 99.677 per cent could be achieved at a moisture content of 13.5 per cent with 200 kg h^{-1} feed rate. Whereas it was 97.532 per cent at moisture content of 19.5 per cent with 600 kg h^{-1} feed rate.

Table 3. F x M Table of means for threshing efficiency, percent.

Grain moisture (M), per cent	Feed rate (F), kg h^{-1}			
	200	**400**	**600**	**M-Mean**
13.5	99.677	99.591	99.521	99.596
16.5	98.695	98.597	98.525	98.605
19.5	97.679	97.605	97.532	97.605
F-Mean	98.684	98.597	98.526	98.602

Interaction effects of S x C x F factor means on threshing efficiency.

Table 4. S x C x F Table of means for threshing efficiency, per cent.

Feed rate (R), kg h^{-1}	Cylinder speed (S), m s^{-1}			F-Mean
	11.7	**14.1**	**16.5**	
C= 15 mm				
200	98.740	98.857	98.957	98.851
400	98.645	98.769	98.829	98.748
600	98.546	98.659	98.763	98.656
C= 20 mm				
200	98.643	98.749	98.848	98.747
400	98.570	98.651	98.859	98.693
600	98.471	98.563	98.961	98.665
C=25 mm				
200	98.355	98.467	98.541	98.455
400	98.273	98.347	98.438	98.353
600	98.161	98.274	98.337	98.258
S-Mean	98.489	98.593	98.726	98.603

Table 4, showed the combined effect of cylinder speed, concave clearance and feed rate. It is seen that the increase in cylinder speed and increase in feed rate at each concave clearance had significant effect on threshing efficiency varying the mean threshing efficiency from 98.258 to 98.851 per cent. The maximum threshing efficiency of 98.961 per cent could be achieved at a cylinder speed of 16.5m s^{-1} with a feed rate 600 kg h^{-1} and concave clearance 20 mm. The minimum threshing efficiency was 98.161 per cent at a cylinder speed of 11.7 m s^{-1} with feed rate of 600 kg h^{-1} and concave clearance of 25 mm. The data are in conformity with the results of Sharma *et al*, (1983)

Performance evaluation of grain damage of portable paddy thresher

The effect of cylinder speed, concave clearance, grain moisture and feed rate on grain damage for cast iron rasp bar threshing cylinder discussed and compared in this section. The individual and interaction effect of above mentioned variables on grain damage were shown in Fig 3 to 5. The trend of increase in grain damage with increase in cylinder speed at each concave clearance, grain moisture and feed rate. From Figure 3, shows that the trend of increase in grain damage with increase in cylinder speeds at each concave clearance. Figure 3a, it is clear that the grain damage increases from 3.167 to 3.268 per cent, with increasing cylinder speed from 11.7 to 16.5 m s^{-1} at 13.5 per cent grain moisture, 15 mm concave clearances and 200 kg h^{-1} feed rate for the cast iron rasp bar threshing cylinder. The same trend was shown in the other two concave clearances of 20 mm and 25 mm. Figure 3.a shows that the maximum grain damage of 3.268 per cent with 16.5 m s^{-1} cylinder speed, 15 mm concave clearance, 13.5 per cent grain moisture and 200 kg h^{-1} feed rate for cast iron rasp bar threshing cylinder.

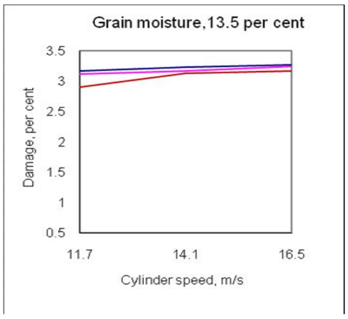
From Figure 4, shows that the trend of increase in grain damage with increase in cylinder speeds at each concave clearances. Figure 4b, the grain damage increases from 2.259 to 2.371 per cent, with increasing cylinder speed from 11.7 to 16.5 m s^{-1} at 16.5 per cent grain moisture, 15 mm concave clearance and 400 kg h^{-1} feed rate for the cast iron rasp bar threshing cylinder. The same trend was shown in the other two concave clearances of 20 mm and 25 mm. Figure 6 shows that the maximum grain damage of 2.930 per cent was observed with 16.5 m s^{-1} cylinder speed, 15 mm concave clearances, 13.5 per cent grain moisture and 400 kg h^{-1} feed rate of cast iron rasp bar threshing cylinder.

From Figure 5, shows that the trend of increase in grain damage with increase in cylinder speeds at each concave clearances. Figure 5c, An increasing the grain damage from 1.669 to 1.761 per cent occurs with increasing cylinder speed from 11.7 to 16.5 m s^{-1} at 19.5 per cent grain moisture, 15 mm concave clearances and 600 kg h^{-1} feed rate for the cast iron rasp bar threshing cylinder. The same trend was shown in the other two concave clearances of 20 mm and 25 mm. Figure 7 shows that the maximum grain damage of 2.79 per cent with 16.5 m s^{-1} cylinder speed, 15 mm concave clearances, 13.5 per cent grain moisture and 600 kg h^{-1} feed rate of cast iron rasp bar threshing cylinder.

The minimum mean grain damage of 2.2064 per cent was observed for cast iron rasp bar threshing cylinder. Figure 3 to 5; shows the trend of variation in grain damage with respect to cylinder speed, concave clearance and grain moisture.

Concave clearance, mm

15 20 25



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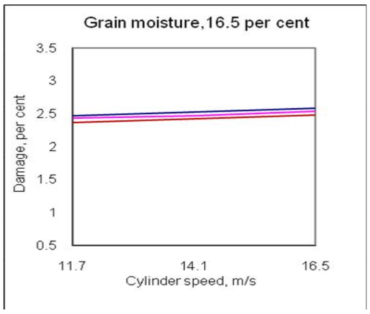

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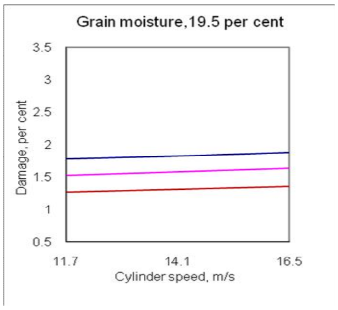
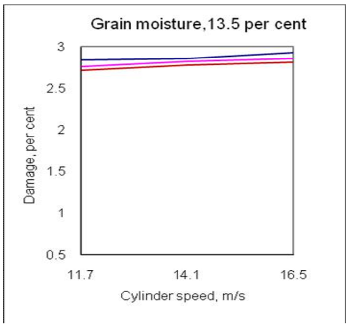


(c)

Fig.2. Effect of cylinder speed on grain damage at different concave clearances and grain moisture at feed rate of 200 kg/h.



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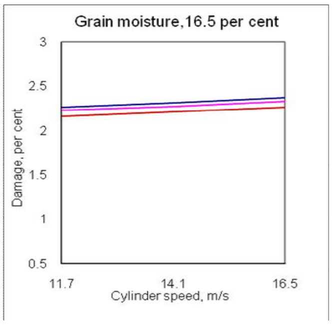

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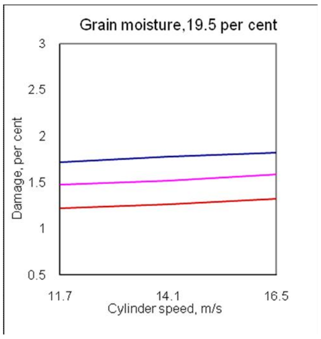

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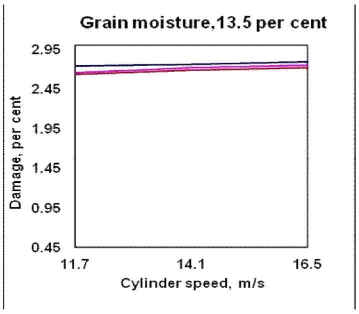
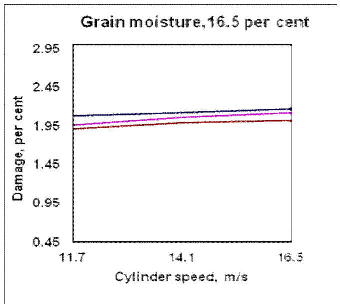
Fig.3. Effect of cylinder speed on grain damage at different concave clearances and grain moisture at feed rate of 400 kg/h.



(a)



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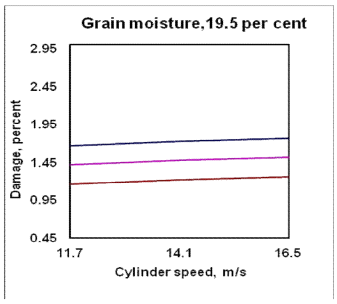

(c)

Fig.4. Effect of cylinder speed on grain damage at different concave clearances and grain moisture at feed rate of 600 kg/h.

Performance evaluation of output capacity of portable paddy thresher

Effect of moisture content and feed rate on output capacity at different feed rate

Table 5. F x M Table of means for output capacity, per cent

Grain moisture (M), per cent	Feed rate (F), kg h^{-1}			
	200	**400**	**600**	**M-Mean**
13.5	81.42	162.45	239.85	161.24
16.5	66.09	141.71	202.10	136.64
19.5	55.88	118.96	168.08	114.27
F-Mean	67.77	141.04	203.34	137.39

From Table 5, it is inferred that the increase in feed rate at each grain moisture had significant effect on output capacity varying from 67.77 to 203.34 kg h^{-1}. The minimum output capacity observed was 55.88 kg h^{-1} at a feed rate of 200 kg h^{-1} at 19.5 per cent moisture content. The maximum output capacity was obtained as 239.85 kg h^{-1} at 600 kg h^{-1} feed rate at 13.5 per cent moisture level.

Effect of cylinder speed concave clearance on output capacity at different concave clearances

Table 6. S x C Table of means for output capacity, per cent.

Concave clearance (C), mm	Cylinder speed (S), m s^{-1}			
	11.7	**14.1**	**16.5**	**C-Mean**
15	139.14	141.63	144.00	141.59
20	135.63	137.85	139.70	137.73
25	130.64	132.88	135.00	132.84
S-Mean	135.14	137.45	139.57	137.39

From Table 6, it is seen that the increase in cylinder speed at each concave clearance had significant effect on output capacity, increasing the output capacity from 132.84 to 141.59 kg h^{-1}. A maximum output capacity of 144.00 kg h^{-1} could be achieved at a cylinder speed of 16.5 m s^{-1} with 15 mm concave clearance. Whereas it was 130.64 kg h^{-1} at a cylinder speeds of 11.7 m s^{-1} with 25 mm concave clearance.

CONCLUSIONS

Comparing the total loss occurred at the best combination of crop and operation parameters for maximum threshing efficiency, minimum grain damage and maximum output capacity was obtained at a combination of 20 mm concave clearance, 16.5 m s^{-1} cylinder speed, 13.5 per cent moisture content and at a feed rate of 600 kg h^{-1}. The threshing efficiency occurred at this combination was 99.95 per cent for cast iron rasp bar threshing cylinder. The grain damage and output capacity occurred at this combination was 2.76 per cent and 240 kg h^{-1} respectively. The cost of threshing with portable paddy thresher was Rs.13.15 per 100 kilogram of grains. The saving in cost and time were 86.5 per cent and 95 per cent respectively as compared to conventional method of manual threshing.

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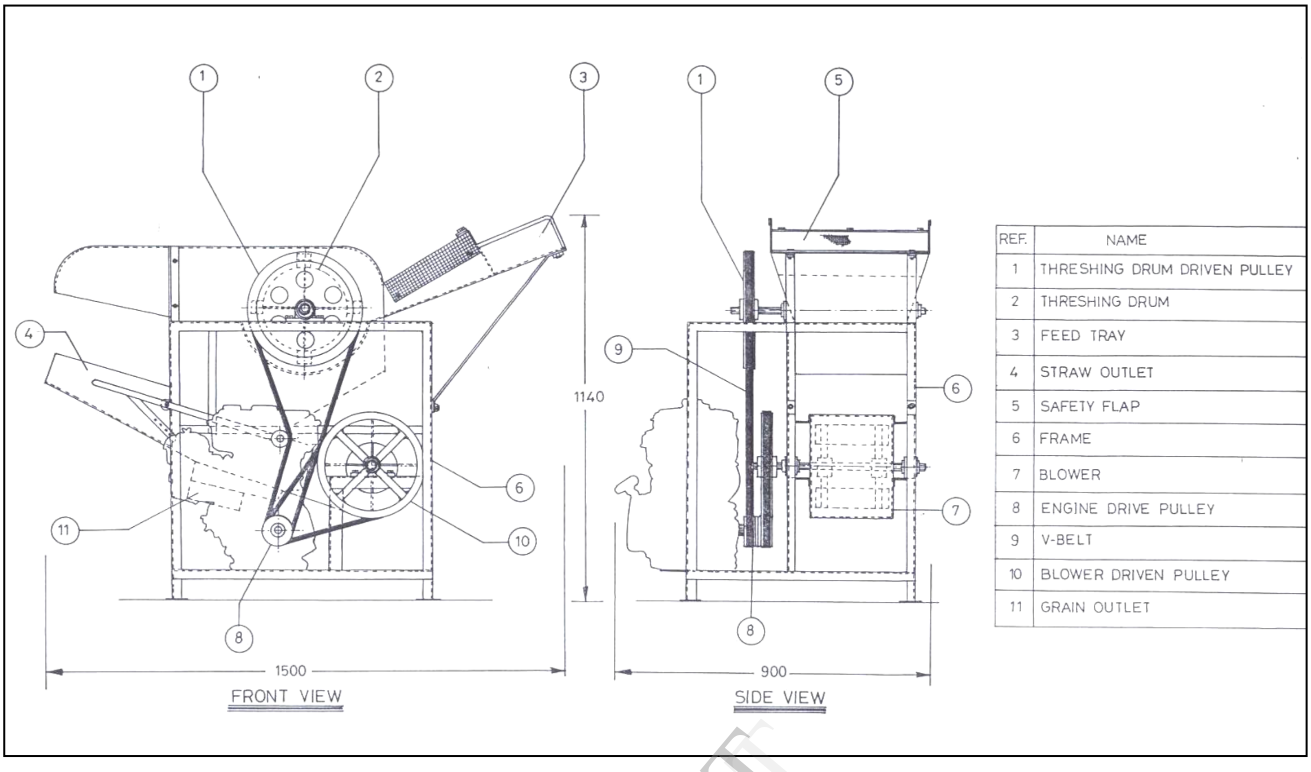

Fig. 1. Rasp bar mounted low cost portable paddy thresher