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Development of a Nylon Rasp Bar Threshing Cylinder for Portable Paddy Thresher and its Performance Evaluation

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A portable paddy thresher was tested for its performance in terms of threshing efficiency and grain damage for nylon rasp bar threshing cylinder 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}). The experiments were statistically designed and executed. The effect of individual factor and combined effect of different combination of factors on threshing efficiency and grain damage were statistically analyzed. Comparing the minimum grain damage in different combinations the minimum loss was achieved at a combination of 25 mm concave clearance, 11.7 m s^{-1} cylinder speed, 19.5 per cent moisture content and at a feed rate of 600 kg h^{-1}. The grain damage occurred at this combination was 0.475 and 1.16 per cent, respectively for nylon rasp bar threshing cylinder and cast iron rasp bar threshing cylinder. The threshing efficiency occurred at this combination was 98.22 per cent for nylon rasp bar threshing cylinder. It is concluded that the nylon rasp bar threshing cylinder has comparatively better performance over the existing cast iron rasp bar threshing cylinder.

Key words: Paddy, Thresher, Nylon rasp bar, Threshing efficiency, Grain damage.

Threshing is the detachment of the paddy kernels from the panicle of the rice plant. Various designs of threshing mechanisms have been developed to thresh cereals to obtain maximum threshing efficiency with reasonably lesser grain damage. The physico-mechanical properties of the crop like, type of ear head and bond strength of the grain in the panicle are the major characteristics which determine the selection of proper threshing mechanism for getting maximum results. Sarvar and Khan (1987) stated that among the various threshing mechanisms studied rasp bar mechanism gave the best result. According to Chandrakanthappa and Batagurki (2001), Rasp bar type thresher was the best among different methods of threshing.

The threshing mechanism of mechanical threshers utilizes Nylon rasp bars threshing cylinder as a functional component of the threshing mechanism. Concave clearance and cylinder peripheral speed are the operational parameters associated with threshing mechanism. Therefore mechanical threshers utilizing the above threshing mechanism; concave clearance and peripheral speed are to be optimized for maximum and damage free threshing. A threshing cylinder fitted with rasp bar was found to consume lesser power than other types (Singh and Kumar, 1976). A cross flow nylon rasp bar mounted portable paddy thresher was fabricated based on cylinder - concave mechanism. Job (1997) reported that the broken grain percentage was less for cross flow thresher than the axial flow thresher. Keeping the above points in mind it was decided to develop a portable thresher consisting of a Nylon rasp bars threshing mechanism along with winnowing capability.

Materials and Methods

Development of a nylon rasp bar threshing cylinder-concave mechanism

In order to study the functional effectiveness in relation to paddy threshing, Nylon rasp bar threshing cylinder was fabricated and fitted with portable paddy thresher cum winnower and compared with existing portable thresher. The cylinder of 300 mm diameter 300 mm length having four rasp bars on the periphery, was supported by a shaft fixed to the main frame of the thresher with the help of bearings. One end of the shaft was fitted with a stepped V-pulley to take power from the engine with the help of V-belts. 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 each rasp bar was 0.250 kg (Figure 1).

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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. 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. The overall dimension of the portable paddy thresher was 1500 × 900 × 1140 mm (Figure 2.) The weight of the portable paddy thresher was 102 kg with engine and thresher alone 83 kg.

Centrifugal blower having drum diameter of 350 mm and width of 240 mm and air outlet of 240 × 150 mm was fabricated and fitted below the threshing cylinder. The blower consisted of four wings supported by a 25 mm diameter shaft and mild steel cover was fitted to the main frame with the help of the bearings. The winnowing velocity varied from 2 to 12ms^{-1} (Yuanguo *et al.,* 1999). The blower speed of 900 rpm was maintained.

Performance evaluation of portable paddy thresher using nylon rasp bar

The threshing performance of nylon rasp bar system was studied using a portable paddy thresher (Table 1). 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. The analysis was carried out to determine the cylinder speed and concave clearance to get the maximum threshing efficiency and minimum grain damage.

Results and Discussion

Effect of cylinder speed, concave clearance, feed rate and grain moisture on threshing efficiency

The effect of cylinder speed, concave clearance, feed rate and grain moisture on threshing efficiency is shown in Figure 3. There was an increase in cylinder speed commensurate with increase in threshing efficiency at each concave clearance. Increase in moisture content at each feed rate decreased the threshing efficiency. The data were analysed statistically. The main effects of each factor, viz., cylinder speed (S), concave clearance (C), feed rate (F) and grain moisture (M) were individually influencing the threshing efficiency at 1.00 per cent level. The interaction effect of S x C, S x F, S x M, C x M, S x C x F, S x C x M, C x F x M and S x C x F x M were influencing the threshing efficiency at 1.00 per cent level. Overall performance of threshing efficiency of a nylon rasp bar threshing cylinder was compared with existing threshing cylinder.

Table 1. Levels of variables for thresher

Particulars	Cylinder surface	Factors				Affected response variables
		Feed rate (F), Kg h^{-1}	Cylinder Speed (S), m s^{-1}	Concave clearance (C), mm	Moisture content (M), %	
Paddy	Nylon rasp bar	200	11.7	15	13.5	Threshing efficiency and Grain damage
		400	14.1	20	16.5	
		600	16.5	25	19.5	

Table 2. Interaction effect of S x C factor means on grain damage, percent.

Concave clearance (C), mm	Cylinder speed (S), m s^{-1}			
	11.7	14.1	16.5	C-Mean
15	1.316	1.379	1.444	1.380
20	1.269	1.317	1.386	1.324
25	1.214	1.277	1.318	1.270
S-Mean	1.266	1.324	1.383	1.325

Table 3. Interaction effect of F x M factor means on grain damage

Grain moisture (M), per cent	Feed rate (F), kg h^{-1}			
	200	400	600	M-Mean
13.5	2.134	1.930	1.674	1.913
16.5	1.474	1.373	1.273	1.373
19.5	0.785	0.697	0.580	0.688
F-Mean	1.465	1.333	1.176	1.325

In using a nylon rasp bar threshing cylinder, higher threshing efficiency of 99.98 per cent with combination effect of 16.5 m s^{-1} cylinder speed, 15 mm concave clearance, 200 kg h^{-1} feed rate and 13.5 per cent moisture content, were observed. When using cast iron rasp bar threshing cylinder it was observed that the threshing efficiency was 99.95 per cent from the same combination. It was followed by threshing efficiency of 99.93 per cent from the combination of 16.5 m s^{-1} cylinder speed; 20 mm concave clearance, 600 kg h^{-1} feed rate and 13.5 per cent grain moisture, which was slightly lower than the cast iron rasp bar threshing cylinder (99.95 %) with same combination. Similar results were reported by Datt and Annamalai (1991). The mean threshing efficiency of nylon rasp bar threshing cylinder and cast iron rasp bar threshing cylinder were 98.55 and 98.50 per cent, respectively.

Effect of cylinder speed, concave clearance, grain moisture and feed rate on grain damage for nylon rasp bar threshing cylinder

The effect of cylinder speed, concave clearance, grain moisture and feed rate on grain damage for nylon rasp bar threshing cylinder is depicted in Table 2. Increase in cylinder speed at each concave clearance had significant effect on grain damage,

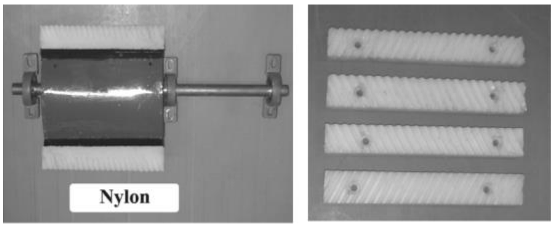

Fig. 1. Nylon rasp bar threshing cylinder

increasing the mean grain damage from 1.27 to 1.38 per cent. The minimum grain damage was observed as 1.21 at a cylinder speed of 11.7 m s^{-1} with 25 mm concave clearance. A maximum grain damage of 1.44 per cent was observed at a cylinder speed of 16.5 m s^{-1} with 15 mm concave clearance. It shows the trend of increase in grain damage with increase in cylinder speed. The similar trend was reported by Ramteke and Sirohi (2003).

The effect of moisture content on grain damage at different feed rate is given in table 3, it is inferred that the increase in feed rate at each grain moisture had significant effect on grain damage varying from 1.47 to 1.18 per cent. The minimum grain damage observed was 0.58 per cent at a feed rate of 600 kg

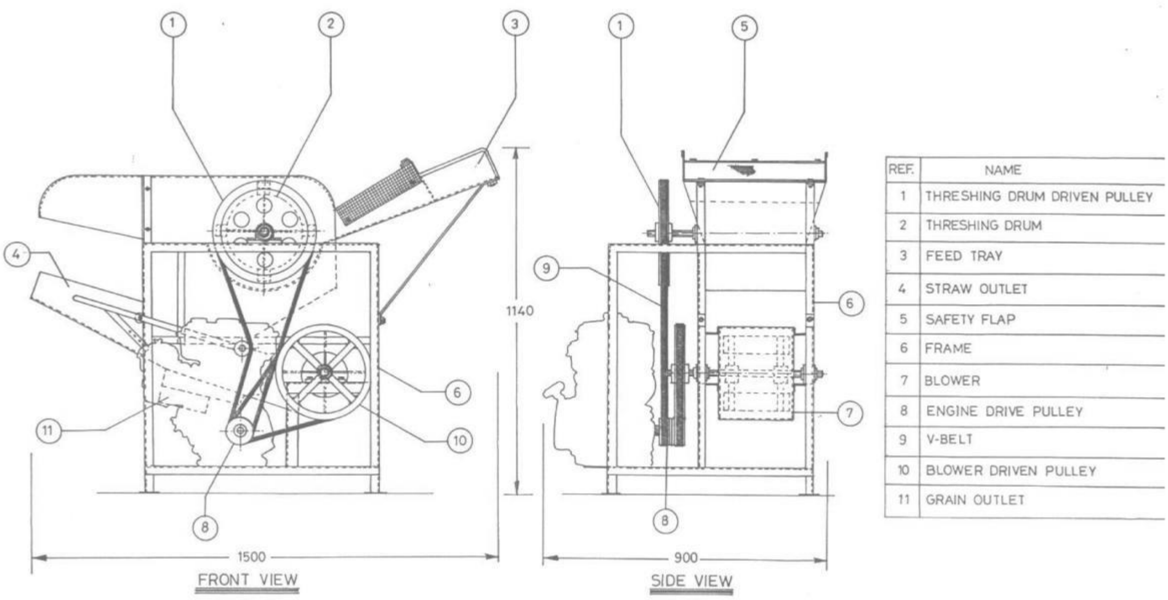

Fig. 2. Nylon rasp bar mounted paddy thresher

h^{-1} at 19.5 per cent moisture content. The maximum damage was obtained as 2.13 per cent at 200 kg h^{-1} feed rate at 13.5 per cent moisture level for nylon rasp bar threshing cylinder. A nylon rasp bar threshing cylinder gives the minimum grain damage of 1.33 per cent than the cast iron rasp bar threshing cylinder of 2.21 per cent.

Table 4. Interaction effect of S x C x M factor means on threshing grain damage, percent.

Grain moisture (M), percent	Cylinder speed (S), m s^{-1}			M-Mean
	11.7	14.1	16.5	
C= 15 mm				
13.5	1.910	1.955	2.023	1.963
16.5	1.367	1.426	1.471	1.421
19.5	0.671	0.756	0.839	0.755
C= 20 mm				
13.5	1.850	1.914	1.956	1.907
16.5	1.329	1.369	1.432	1.377
19.5	0.626	0.667	0.770	0.688
C= 25 mm				
13.5	1.816	1.864	1.926	1.869
16.5	1.268	1.328	1.370	1.322
19.5	0.559	0.640	0.660	0.619
S-Mean	1.266	1.324	1.383	1.325

Combined effect of cylinder speed, concave clearance and moisture content on grain damage.

Table 4, shows the combined effect of cylinder speed, concave clearance and moisture content. Increase in cylinder speed and increase in moisture at each concave clearance had significant effect on grain damage. Mean grain damage varying from 0.619 to 1.963 per cent. A minimum grain damage of 0.559 per cent could be achieved at cylinder speed of 11.7 m s^{-1} with 19.5 per cent grain moisture at 25 mm concave clearance. A maximum grain damage of 2.023 per cent could be achieved at a cylinder speed of 16.5 m s^{-1} with 13.5 per cent gain moisture and 15 mm concave clearance. The minimum mean grain damage of 1.325 per cent was observed for nylon rasp bar threshing cylinder than the cast iron rasp bar threshing cylinder of 2.206 per cent. The nylon rasp bar was best for all combination effects for getting minimum percentage of grain damage.

Selection of best combination for minimum grain damage

The grain damage was minimum in case of the nylon rasp bar threshing cylinder of 0.48 per cent at grain moisture of 19.5 per cent with 25 mm concave clearance, 11.7 m s^{-1} cylinder speed and 600 kg h^{-1}

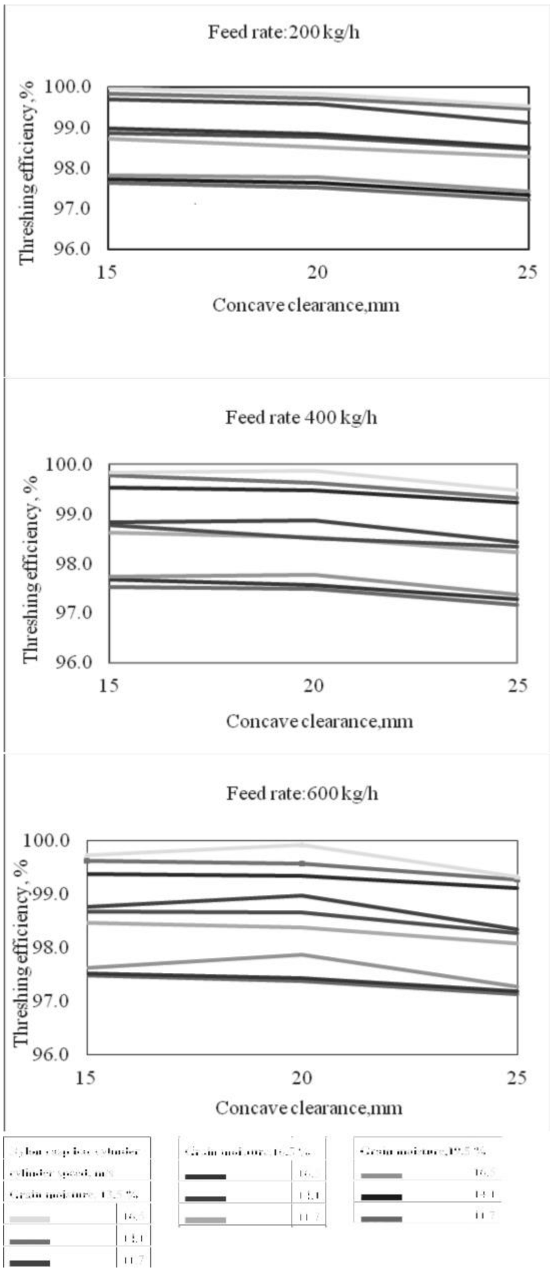

Fig. 3. Effect of concave clearance on threshing efficiency at different cylinder speeds and grain moisture

feed rate which was 1.16 per cent, in the case of the cast iron rasp bar.

Conclusion

The nylon rasp bar mounted portable paddy thresher was tested for its performance in terms of threshing efficiency and grain damage. Comparing the overall performance, the Concave clearance, Feed rate, Grain moisture and Cylinder speed are respectively 25 mm, 600 kg h^{-1}, 19.5 per cent and 11.7 m s^{-1} combination was selected as the best combination of factors at which, 0.48 per cent grain damage with threshing efficiency of 98.22 per cent were obtained. Hence, it is concluded that the nylon rasp bar threshing cylinder has comparatively best performance over the existing cast iron rasp bar threshing cylinder (1.16 % grain damage and 98.17 % threshing efficiency).

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