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Efficiency of Cotton Stalk Puller as Influenced by Forward Speed, Wheel Rotational Speed and Wheel Tilt Angle

by

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Abstract

Cotton is a versatile fibre crop, grown commercially in 111 countries throughout the world. India ranks first in cotton area, which constitutes 20 per cent of the world's cotton area but ranks third representing 12 per cent of the global production. Pulling the cotton stalk using a hand puller is slow, laborious and tedious. An investigation was carried out to mechanize the cotton stalk pulling. The developed unit consists of a gearbox for power transmission and a set of counter rotating pulling wheels. The power for pulling wheels was drawn from the tractor PTO shaft through gearbox. The developed cotton stalk puller was evaluated for its performance in terms of pulling efficiency and per cent breakage of cotton stalk at three levels of (i) forward speed of operation (1.2, 1.6 and 2.0 kph), (ii) wheel rotational speed (140, 180 and 220 rpm) and (iii) wheel tilt angle (10, 20 and 30 degree). The pulling efficiency was maximum at 1.2 kph forward speed of operation followed by mixed results at 1.6 and 2.0 kph forward speed of operations. The maximum pulling efficiency of 86.63 per cent was obtained at 140 rpm wheel rotational speed, 1.2 kph forward speed of operation and 30 degree wheel tilt angle combination. Minimum breakage of cotton stalk (7.74 %) was observed at 180 rpm wheel rotational speed, 1.2 kph forward speed of operation and 30 degree wheel tilt angle followed by 220 and 140 rpm wheel rotational speeds. It was observed that the stalk removal with cotton stalk puller resulted in 3.85 and 94.39 per cent savings in cost and time, respectively, compared to the manual method of cotton stalk removal.

Introduction

Cotton plant residue left in the field following harvest must be removed to prevent it from serving as breeding site for insects and diseases. For another reason, the cotton plant residue can produce considerable amount of thermal energy as it is used as a fuel. The annual removal of cotton stalk after harvest has been established as an essential operation in order to control the pests and diseases and involves considerable labour and money. Clearing the cotton stalk has three basic processes, namely; uprooting the stalk, gathering and stacking them and removing them from the field. Pulling of stalk using a hand puller is slow, laborious and tedious. Some of the farmers use repeated heavy disking to uproot and cut cotton plant residue and cover it with soil. The collection of cotton stalk manually to the desired extent requires 20 man-days per ha apart from being tiresome and time consuming. It has been proven that 15 to 20 per cent higher yields are possible with the mechanized sowing. This is possible if the field is free from

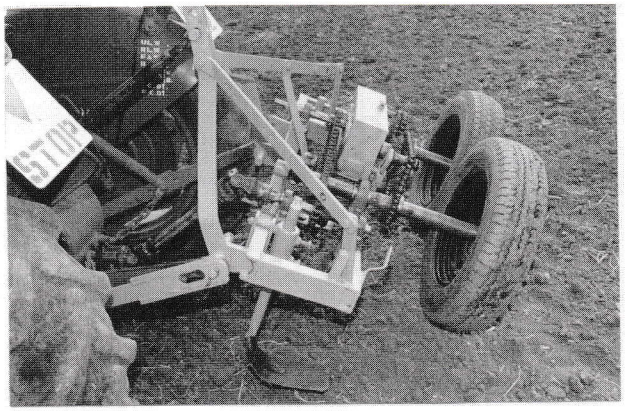

Fig. 1 Tractor-operated cotton stalk puller.

Fig. 2 Operational profile of cotton stalk puller.

stubble and roots. The problems faced by cotton growers in removing cotton stalk and forcing for mechanization are pulling cotton stalk. The production of tractors in India is the largest in the world. As a global power in the international tractor industry, India must ensure efficient utilization of such a heavy recurring investment in the agricultural engineering inputs. With this view, a tractor operated cotton stalk puller, if developed, will result in enhanced utility of tractors besides reducing the drudgery and eliminating the labour shortage during peak seasons.

Reveiew of Literature

Demian (1979) studied the existing pulling machines and root pullers and reported that the NIAE four-row pulling machine has two gauge wheels and power is through PTO shaft. The gripping and pulling devices are the two driven inclined pneumatic tyres. Kemp and Mathews (1982) developed a tractor mounted four-row machine for uprooting cotton stalk. The pulling principle of the machine is that of gripping the plant stem between a pair of counter rotating pneumatic wheels driven from the tractor PTO shaft and jerking it upwards by the combined peripheral motion of the wheels and forward travel of the machine. The eight pulling wheels were inflated to a maximum pressure of 4.8 bar rotated at 160 rpm by enclosed shafts, inclined at 45^0 to the horizontal. The work rates were in the range of 1.5 to 2.2 ha/h with pulling efficiencies in excess of 95 per cent. Sumner *et al., (1987)* evaluated the counter rotating wheel plant puller as a method to harvest cotton stubble from the soil. The existing two-row counter rotating wheel plant puller was modified by replacing the existing pulling wheels with smaller diameter tyres to minimize the height of the tyre contact point above the ground for pulling cotton plant stubble. The power is required to rotate the pulling wheels increased with a decrease in tyre pressure and increase in force between the wheels. Ben (1990) developed a machine (uprooter - shredder - mulcher) for cotton stalk harvesting. The U.S.M can be used to spread chopped stalk, to bury the chopped material into the soil and to have the chopped material blown through an elbow into an accompanying trailer.

Materials and Methods

The developed stalk puller consists of a gearbox, power transmission system and a pair of pulling wheels. The gearbox and pulling wheels were mounted on the centre of the main frame. The hitch point of the implement was shifted 0.375 m towards left when viewing from the rear side to make offset the implement. The power from the tractor PTO shaft was transmitted to a counter shaft through propeller shaft assembly and on to the gearbox input shaft using chain and sprocket (**Fig.1**). From the gearbox, the power is transmitted to the counter rotating pulling wheels through chain and sprockets to obtain the required speed. The ground clearance is adjustable from 0 to 100 mm using a float mechanism. The overall dimensions of the cotton stalk puller are as follows: length, 1,575 mm; height, 1,150 mm; width, 1,050 mm; and weight, 232 kg. The operational profile of the cotton stalk puller is shown in **Fig.2**. The developed cotton stalk puller was evaluated for its performance in terms of pulling efficiency and per cent breakage of cotton stalk evaluated at three levels of (i)forward speed of operation (1.2, 1.6 and 2.0 kph), (ii)wheel rotational speed (140, 180 and 220 rpm) and (iii) wheel tilt angle (10, 20 and 30 degree). The inflation pressure of the pulling wheels was maintained at 2.0 ksc throughout the field trials. The pulling efficiency and percent breakage of cotton stalk were computed from the data collected. The cost of mechanical

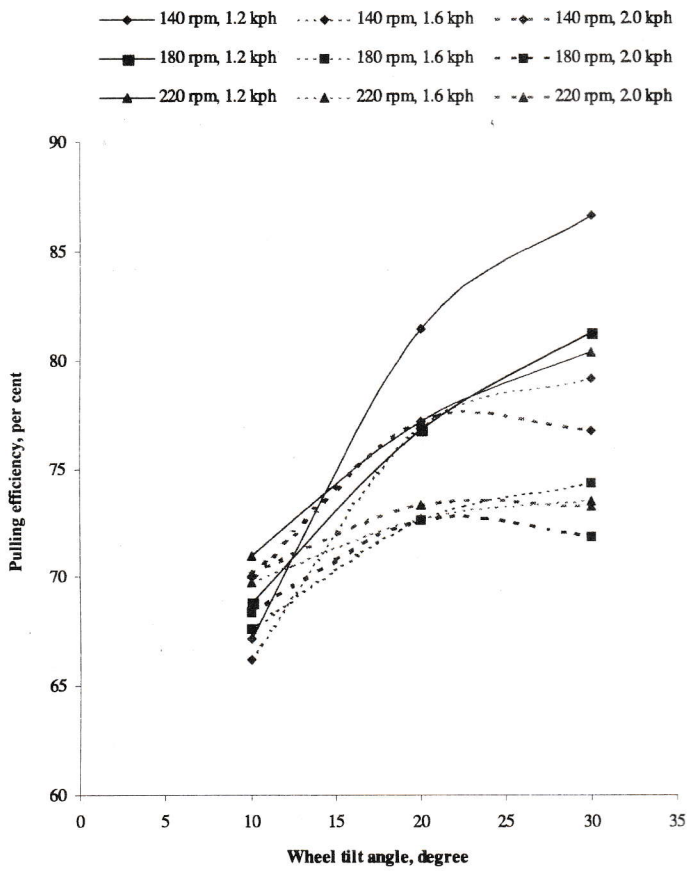

Fig. 3 Effect of wheel tilt angle on pulling efficiency at different wheel rotational speed and forward speed of operation

pulling with stalk puller was compared with manual method of cotton stalk removal. The cost and time saved by the cotton stalk puller against the manual method was compared.

Results and Discussion

Fig. 3 summarizes the effect of wheel tilt angle on pulling efficiency at different wheel rotational speed and forward speed of operation. It was noticed that the pulling efficiency increased with an increase wheel tilt angle. The 1.2 kph forward speed of operation displayed better pulling efficiencies followed by mixed results at 1.6 and 2.0 kph forward speeds. The pulling efficiency at 1.2 kph forward speed of operation and 140 rpm wheel rotational speed was 20 and 30 degree wheel tilt angles and the efficiency increased suddenly when the wheel tilt angle was changed from 10 to 20 degree and gradual increase in pulling efficiency when the tilt angle changed from 20 to 30 degree which indicated that further increase in tilt angle would not have that much effect on pulling efficiency. The wheel rotational speed of 140 rpm showed better results than 180 and 220 rpm wheel rotational speeds. The maximum pulling efficiency (86.63 %) was observed at 140 rpm wheel rotational speed, 1.2 kph forward speed of operation and 30 degree wheel tilt angle which indicated that wheel rotational speed and forward speed of operation should be minimum and wheel tilt angle should be optimum.

The effect of wheel tilt angle on per cent breakage of cotton stalk at different wheel rotational speed and forward speed of operation are summarized and showed in **Fig. 4**. It was observed from the figure, that 1.2 kph forward speed of operation resulted in low breakage of cotton stalk at 10 and 20 degree wheel tilt angle. At 30 degree tilt angle the breakage was less at the wheel rotational speed of 180 rpm and at 1.2 kph forward speed of operation followed by 220 and 140 rpm wheel rotational speeds respectively. The minimum breakage of cotton stalk (7.74 %) was 180 rpm wheel rotational speed, 1.2 kph forward speed and 30 degree wheel tilt angle combination followed by 220 rpm (9.23 %) and 140 rpm (9.80 %) wheel rotational speeds.

The comparison of cost and time requirements by the manual method of stalk removal and the prototype cotton stalk puller are showed in **Table 1**. The cost of removing the cotton stalk from one hectare field using cotton stalk puller was Rs. 2,326.00 whereas it was Rs. 2,419.35 for the manual method. The time required for removal of cotton stalk using cotton stalk puller from an area of one hectare was 13.55 hours whereas it was 241.93 man-hours in manual method. The stalk removal with cotton stalk puller resulted in 3.85 and 94.39 per cent savings in cost and time, respectively, when compared to the manual method of cotton stalk removal. Though the cost of operation with cotton stalk puller is almost equal to that of the manual method of stalk removal, it is highly efficient in terms of time savings and cleanliness of operation. It also eliminates drudgery in manual operation and alleviates problems of labour non-availability, the problem presently being experienced by cotton growers who even switched over to other easy crops.

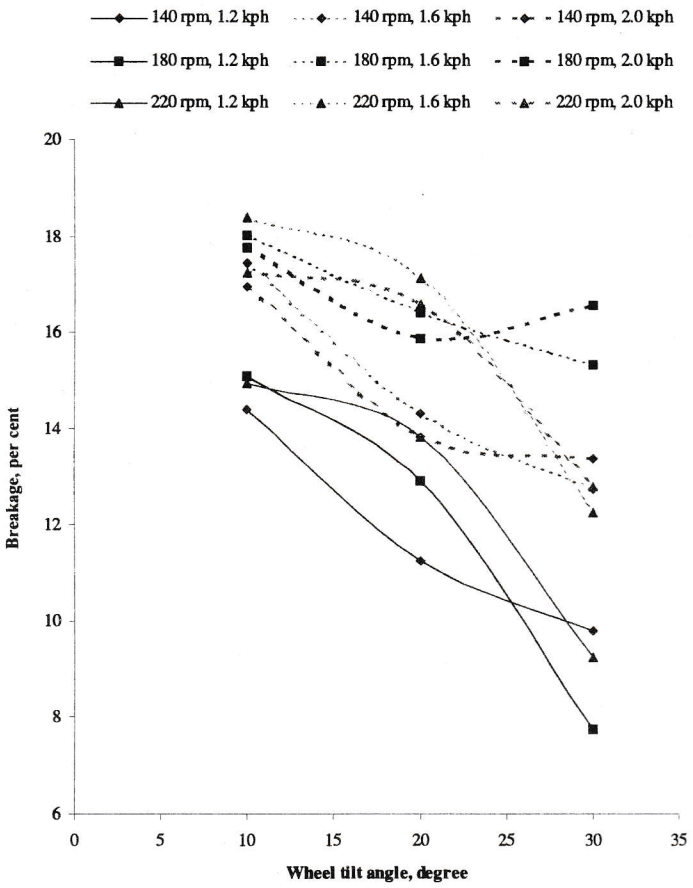

Fig. 4 Effect of wheel tilt angle on per cent breakage of cotton stalk at different wheel rotational speeds and forward speed of operation.

Conclusions

The pulling efficiency increased with an increase in wheel tilt angle. The pulling efficiency increased considerably when the wheel tilt angle was changed from 10 to 20 degree and increased gradually when the tilt angle was changed from 20 to 30 degree. The maximum pulling efficiency (86.63%) was obtained at 140 rpm wheel rotational speed, 1.2 kph forward speed of operation and 30 degree wheel tilt angle combination. The operation of the cotton stalk puller at 1.2 kph forward speed of operation resulted in better pulling efficiency when compared with 1.6 and 2.0 kph forward speeds. The per cent breakage of cotton stalk was reduced with an increase in wheel tilt angle from 10 to 30 degree. The minimum breakage of stalk (7.74 %) was 180 rpm wheel rotational speed, 1.2 kph forward speed and 30 degree wheel tilt angle combination followed by 220 rpm (9.23 %) and140 rpm (9.80 %) wheel rotational speeds. The cost and time saved by the cotton stalk puller in comparison to manual stalk removal was 3.85 and 94.39 per cent, respectively.

Table1. Abstract of Appraisal of Cost and Time

Method of cotton stalk removal	Cost, Rs. / ha	Time, h / ha	Per cent saving in	
			Cost	Time
Manual	2419.35	241.93	-	-
Mechanical	2326.00	13.55	3.85	94.39

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