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Development and Performance Evaluation of Tractor Front Mounted Pigeon Pea Stem Cutter

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Abstract: Pigeon pea or tur (*Cajanus cajan* L. Mills.) is one of the important pulse crops of India and ranks second to chickpea in area and production. Traditionally the harvesting of pigeon pea is done manually by sickle, which demands considerable amount of labour, drudgery, time and cost to harvest, which reflects on total production cost of the crop. In view of this a tractor operated front mounted pigeon pea stem cutter was developed and being front mounted implement it facilitated better visibility and control to operator. The power was transmitted from pto to gear box. Arrangement of hydraulic cylinder and hydraulic motor was provided on the equipment to facilitate the height of cut and to rotate the conveyer belt. During comparative performance evaluation of developed equipment, the average cutting efficiency and field capacity was found 96.30 % and 0.176 ha/hr respectively. There was increase in fuel consumption and plant damage with increase in speed of operation. The average operation cost of newly developed tractor operated front mounted pigeon pea stem cutter was 64.71% less as compared with manual harvesting of pigeon pea crop. The time saved was almost 1/3rd to that of manual harvesting.

Key words: Efficiency % Harvest % Performance % Hydraulic % Field capacity

INTRODUCTION

Pigeon pea or tur (*Cajanus cajan* L. Mills.) is one of the important pulse crops of India and ranks second to chickpea in area and production [1]. Pigeon pea is grown throughout the tropical countries of world especially in Africa, West Indies, Ceylon, Australia and Malaya. In India, it is grown mainly in Uttar Pradesh, Maharashtra, Madhya Pradesh, Gujarat and Rajastan both kharif and rabi season. It is important source of protein (22-24 per cent) especially for vegetarian and economically poor population of this country. Though India ranks first in area and production of pigeon pea, the average productivity of the crop is low at around 685 kg/ha [11].

In Vidarbha region pigeon pea is one of the important cash crop (6 to 15 quintal per hectares) for the farmers, mainly in Yeotmal, Amravati, Akola, Wardha and Nagpur districts and generally, pigeon pea is taken as intercrop in soybean, cotton in pair row cropping system [1]. Traditionally harvesting of pigeon pea is done manually with sickle which demands considerable amount of labour, drudgery and time to harvest.. It was estimated that harvesting operation of crop consumes about the 25-30 per cent of total labour requirement of the crop production system. Total 176 man-hours per hectare was required to harvest pigeon pea crop. The shortages of labour during season and vagaries of the weather cause high losses to the farmer's. Timely harvest of the crop is vital to reduce losses and achieve quality produce. This reflects on harvesting cost and the total production cost of the crop.

An area under cultivation of pigeon pea crop is increasing 486400 ha (1997-98) to 523300 ha (2004-05) and at the same time the labour is shifting towards non-agricultural jobs, which needs an immediate attention [1]. The combine harvesters are being used for harvesting of pigeon pea but the limitations are 1) crop should be ready for one time harvesting and 2) small land holding of farmers in India.

The shortage of labour is thus to be bridged by mechanization. A suitable tractor operated machine for

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harvesting of pigeon pea crop is an immediate need which can remove drudgery, reduce losses and increase productivity, reduce turn about time in two crop season, avoid weather risk, achieve low cost of harvesting and derive benefit from early marketing of produces. The rear-mounted harvester may causes visibility problems to operator while operation may also faces loss of control from tractor.

In view of above, the present study was aimed to develop a small tractor operated front mounted machine, which cut and windrow the stem of pigeon pea efficiently and economically.

MATERIALS AND METHODS

The newly developed pigeon pea stem cutter (Fig. 1) was fabricated in the Research Workshop of Department of Farm Power and Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra (India).

Parts of Pigeon Pea Stem Cutter

Mainframe: A frame of length 1260 mm x 510 mm width was fabricated from M.S. 'C' channel of size 70x40x6 mm. All components described below were mounted on the frame to form tractor front mounted pigeon pea stem cutter.

Implement Mounting: To mount the implement in front of tractor, a frame of square sections was made. This frame was combination of trapezoidal and rectangular shapes when viewed from top. These square sections were made by welding the m.s. angle (40 x 35 x 4 mm). Hydraulic cylinder was attached with inverted 'U' section. At the center of inverted 'U' section a vertical plate was provided to adjust the height of implement.

Drive System: Power was transmitted from pto of tractor to gear box of implement by means of shaft and belt pulley arrangement (Fig. 2), which was further transmitted to gear box of implement through two universal joints. The shaft of length 1440 cm and diameter 25 mm was attached to chassis of tractor from lower side with the help of two pedestal bearings.

Gear Box: A gear box, available commercially was selected for transmission of power from the tractor power take off drive to the stem cutter. The gear box was fixed with the frame on the stand fabricated from m.s. angle of size 50 x 50 x 4 mm. The stand was provided to facilitate the level of gear box with power take off of tractor.

Power Transmission System: The power transmission unit was a combination of gear box, main shaft, chain, sprockets etc, which receives power from tractor pto. The power transmitted from the gear box (1:2 gear ratio) to main shaft and then to chain and sprockets assembly. This chain and sprocket assembly helps to provide motion to cutting blade assembly. The sprockets of 24 teeth and 12 teeth were used on main drive and cutting blade assembly respectively.

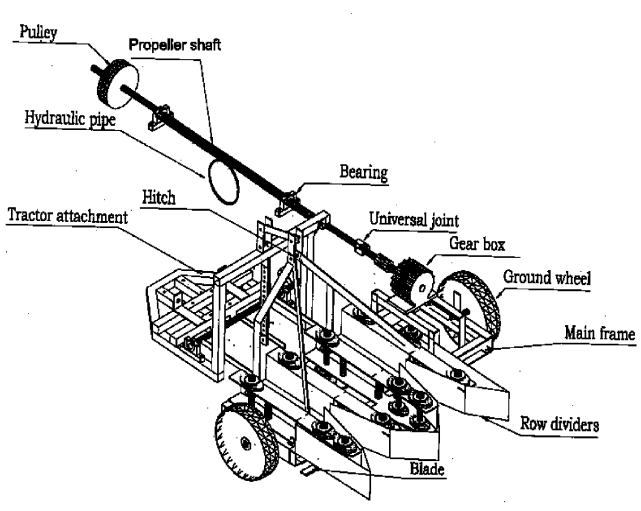

Fig. 1: Newly developed pigeon pea stem cutter

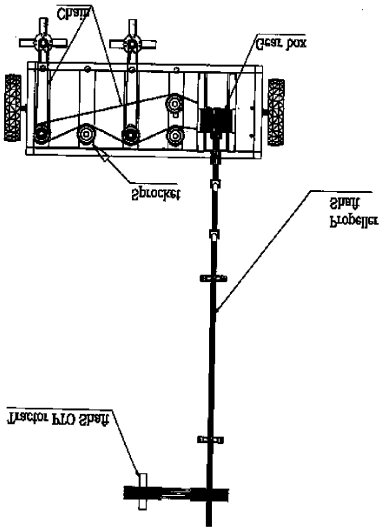

Fig. 2. Power drive of pigeon pea stem cutter

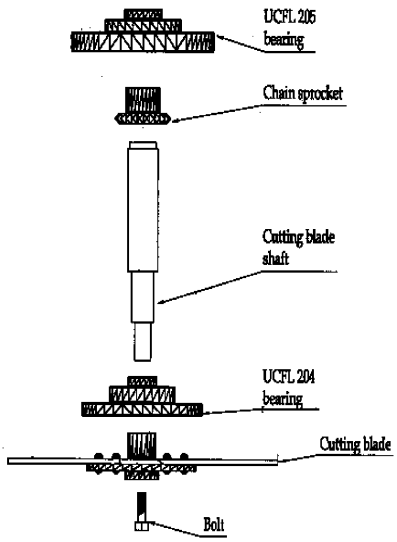

Fig. 3: Shaft of cutting blade

Cutting Unit: The m.s. bar was turned in four steps of diameter 24 mm, 27 mm, 20 mm and 14 mm having length 5 mm, 95 mm, 40 mm and 30 mm respectively. The rotation of the shaft was supported with the help of two ball bearings one at the top of the shaft (UCFL 205) and another at a distance of 250 mm from the top mounted bearing. In between these two bearing a chain and sprocket arrangement was provided to rotate the shaft on which cutting blades assembly was mounted.

Cutting Blade: High carbon steel impact shearing type cutting blade was used for fabrication of cutter. Cutting blade having width 40 mm, thickness 4 mm and bevel angle 30^0 was selected and were fixed on 5 mm thick m. s. plate of diameter 100 mm with the help of rivets (Fig. 3).

Row Divider and Collectors: Row dividers were fabricated from the C.R. sheet of size 1219.2 x 1219.2 x 1 mm. These dividers were mounted on the main frame to feed the crop to the cutting blade. Row Collector plays same role as star wheel in reaper. Row collector was fabricated from M.S. circular flanged of diameter 139.7 mm having 5mm thickness. In order to fix flanged on shaft and 25 mm bored was drilled at centre of flanged. Eight M.S. square bar (8 x 8 mm) 203.2 mm long were welded symmetrically on the circular flanged.

Conveying Unit for Developed Pigeon Pea Stem Cutter: Conveying mechanism of pigeon pea stem cutter consist of conveying tray, lugged belt, belt tensioner unit, pulley, driving shaft, hydraulic motor, hydraulic mounting arrangement, row divider, row collector (star wheels) as shown in Figure 4.

Conveying tray was made from M.S. sheet supported on rectangular frame of M.S. angle have dimensions 35 X 35 X 4 mm. Other components such lugged belt, belt tensioner unit, pulley, driving shaft were mounted on conveying tray. A lugged belt of 3410 mm length having dimension 76.2 X 5 mm were installed on pulleys around the conveying tray. Two types of lugs were installed on conveying belt. Big size lugs were installed on top belt and small size lugs were installed on lower belt. Lugs were made from trapezoidal and rectangular section with a height of 101mm for bigger naps. Sixteen such naps were attached on each belt at the spacing of 215.9 mm. The tension of the belt was maintained by adjusting the nut bolts resulting in tightening and loosening of the belt. All the four nuts were tightened or loosen simultaneously to adjust the belt equally.

Four pulleys were installed on the shafts for supporting the conveying belt. Pulley was fabricated from M.S. circular pipe of diameter 101.6 X 4 mm. Circular plates of 127 X 4 mm were welded on both side of circular pipe. Also bushes were welded on two opposite circular plates so as to support the pulley on the shaft. The lugged belt was supported on the conveying tray with three supporting shafts. Shaft serves two purposes of supporting the belts as well as giving drive to belt.

Hydraulic Motor and Mounting Arrangement: Hydraulic motor was fixed on mounting arrangement. It was used to rotate the conveying belt. The 34 toothed sprocket was installed on hydraulic motor and power transmitted to the 17 toothed sprocket installed on driving shaft with the help of steel alloy chain.

Evaluation of Field Performance of Developed Pigeon Pea Stem Cutter: The performance of developed pigeon pea stem cutter was evaluated in the field of pigeon pea crop on field of Department of Entomology, Dr. PDKV, Akola. The different parameters like field capacity, field efficiency, cutting efficiency, plant damage, cost economics, ease of operation, etc. were noted.

Effective Field Capacity (EFC): The time taken for actual work and time lost for other activities such as turning, cleaning, filling, etc. The data was recorded for Test I (low Ist gear) and test II (low IInd gear).

$$EFC=\frac{A}{T_p+T_1}$$

Where,
EFC- Effective field capacity, ha/hr
A- Area covered, ha
T_p- Productive time, hr
T_1- Non productive time, hr (time lost for other activities such as turning, cleaning, filling, etc.)

Plant Damage (PD): It was calculated by counting the number of plants in 10 m row length before cutting and plants damaged in 10 m row length after cutting.

$$PD(\%)=\frac{q}{p}\times 100$$

Where,
q = Number of plants damaged in 0 m row length after cutting
p = Number of plants in 10 m row length before cutting.

Cutting Efficiency (CE): Number of pigeon pea plants in 10 m length was counted before operation and the plants left in same 10m length was counted after operation.

$$CE\ (\%) = \frac{W_1-W_2}{W_1}\times 100$$

Where,
W_1 = Number of plants before cutting
W_2 = Number of plants after cutting

Speed of Operation: For obtaining the speed of operation, two poles 20 m apart were placed in the middle of the test run. The speed of travel was calculated from the time required for tractor to travel the distance of 20 m.

Cost Economics: The cost of operation can be calculated on basis of fuel required for the operation, labour for collecting cut crops, labour charges, etc.

RESULTS AND DISCUSSION

The physical characteristics of pigeon pea stem, diameter of stem ranges from 8 mm to 30 mm. The moisture content of stem at the time of harvesting found 35% to 42% (wb). The front mounted pigeon pea stem cutter was tested for different gear. The height of cut was adjusted by using Hydraulic cylinder up to 300 mm from ground. Three replications were taken for each test. The performance characteristics of the tractor front mounted pigeon pea stem cutter were shown in Table 1.

Field Capacity: Average field capacity of newly developed pigeon pea stem cutter for test was 0.176 ha/hr. Increase in field capacity may be due to increases coverage area with time.

Cutting Efficiency: Cutting efficiency for test-I was 96.30 per cent whereas for test II it was 92.80 per cent. Cutting efficiency in test I was found more than test-II, due to low speed of blade provided more torque at the edge of blade so stems cut easily but at high speed, low torque it was difficult to cut the stems.

Table 1: Comparative performance characteristics of newly developed pigeon pea stem cutter with manual harvesting.

		Harvesting			
		Newly developed pigeon pea stem cutter		Manual(10 labour @ Rs150/day)	
Sr.No	Particulars	Test I (low I)	Test II (low II)	Average	
1	Effective field capacity, ha/hr	0.154	0.198	0.176	0.021
2	Cutting efficiency, %	96.30	92.80	94.55	---
3	Plant damage, %	5.2	7.4	6.3	---
4	Fuel consumption, lit/ha	4.67	4.82	4.74	---
5	Speed of operation km/hr	2.4	3.0	2.7	---
6	Time required, hr /ha	6.49	5.05	5.77	15.24
7	Speed of operation (km/hr)	2.40	3.00	2.7	---
8	Cost of operation, Rs/ha	1161.94	955.11	1058.52	3000

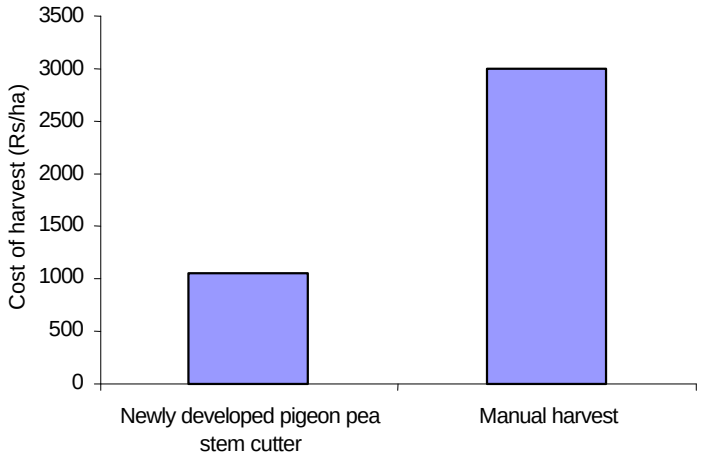

Fig. 4: Cost economics of pigeon pea harvesting

Plant Damage: The plant damage was increased 29.72 % as speed of operation increased. It may be due to at higher speed the plant wrap around the plant collector. To avoid the plant damage optimum speed of blade and plant collector required.

Cost Economics: The cost of cutting the pigeon pea stem 17.80 per cent less in test I than that of test II. This decrease in the cost of operation because in test-II the field capacity, speed of operation was found more than test-I. Whereas compare with manual harvesting it observed that 64.71 percent less cost than the newly developed pigeon pea stem cutter (Fig. 4).

CONCLUSIONS

On the basis of the results obtained form the laboratory experiment and field evaluation the following conclusion were drawn.

- The average cutting efficiency and field capacity was found 94.55 % and 0.176 ha/hr in test-I and test-II.
- The fuel consumption and plant damage was increased with 3.11% and 29.72 % as speed of operation increased.
- On an average the time required for cutting pigeon pea by newly developed stem cutter was recorded 1/3rd to that of manual harvesting.
- The cutting cost of tractor front mounted pigeon pea stem cutter was 64.71 % less than with manual harvesting of pigeon pea stem.

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