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Modification of power transmission system of pigeonpea stem cutter

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■ **ABSTRACT :** A pigeonpea (*Cajanus cajan* L. Mills) stem cutter was developed in the department and its performance was evaluated in the field. During testing of equipment the problem were observed in the transmission of power from PTO to cutter unit and conveying of cut plant. Thus, modification of power transmission system of the equipment was carried out in the department of Farm Power and Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Among with the modification in power transmission system, the conveying system was also modified. The cut plant were bending in opposite direction of travel during the conveying and getting chocked between the conveying tray and cutting unit. In view to avoid this a plant guiding arrangement was introduced on the equipment. The modified pigeonpea stem cutter was tested in the field at the operating speed of 3 and 3.5 km/h. and was found working satisfactory. The cutting efficiency of the modified implement was increased due to the change in position of cutter bar and efficiency of conveying was improved tremendously with the modification of conveying tray and introduction of plant guiding arrangement. The maximum cutting efficiency was found 81.25 per cent and 80.00 per cent at 3 km/h and 3.5 km/h speeds, respectively. Whereas the field efficiency was observed as 72.59 per cent and 74.28 per cent at the above mentioned speeds, respectively. The plant damage was found 10.29 per cent and 10.93 per cent at 3 km/h and 3.5 km/h speed of operation, respectively. The cost of operation was observed 42.07 per cent less as compared to the manual harvesting of the pigeonpea crop.

■ **KEY WORDS :** Power transmission system, Stem cutter, Plant guiding arrangement, Cutting efficiency, Field efficiency

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Pigeonpea (*Cajanus cajan*) is an important multi-use shrub legume of the tropics and subtropics. The crop originated from India and moved to Africa about 4,000 years ago. Unlike other grain legumes, pigeonpea production is concentrated in developing countries, particularly in a few South and Southeast Asia and Eastern and Southern African countries. It is the preferred pulse crop in dryland areas where it is intercropped or grown in mixed cropping systems with cereals or other short duration annuals (Joshi *et al.*, 2001; Kepner *et al.*, 1987 and Anonymous, 2011).

Pigeonpea has a wide range of products, including the dried seed, pods and immature seeds used as green vegetables, leaves and stems used for fodder and the dry stems as fuel. It also improves soil fertility through nitrogen fixation as well as from the leaf fall and recycling of the nutrients (Snapp *et al.*, 2002; Mapfumes, 1993 and Krutz and Thompson, 1984). It is an important pulse

crop that performs well in poor soils and regions where moisture availability is unreliable or inadequate (Reddy *et al.*, 1993 cited in Kimani, 2001; Itzhak, 2010; Khurmi and Gupta, 1998 and Nene *et al.*, 1990). Pigeonepea is a perennial erect bush, 0.5 to 4 m tall, and has strong stem. Traditionally the harvesting of pigeonpea is done by manually by sickle which requires more labours, time and drudgeries.

The tractor front mounted pigeonpea stem cutter was developed in department of Farm Power and Machinery, Akola in the year 2008. The pigeonpea stem cutter was tested preliminary in the field and observed improper transfer of power from PTO to propeller shaft and cut plant was not conveyed properly, the study was undertaken with following objective.

- To modify the power transmission system of pigeonpea stem cutter.
- To evaluate the performance of modified pigeonpea stem cutter in the field.

Problems with existing machine :

Power transmission system :

During the field operation problems observed in power transmission system were :

- Frequently there was break down in transmission of power from PTO to gear box.
- The height of cut was 15 cm above the ground level and the height of chain drive of the holding unit was 35 cm above ground level. Which creates obstacle in travel of cut plant from cutting mechanism to conveying tray.

Conveying tray :

Upper belt on the conveying tray was placed at top position and hence, not getting engaged with the plant and, therefore, the proper force was not acting on the plant for conveying. The position of belts *i.e.* vertical distance between two belts and horizontal distance of belt from the conveying tray was not suitable to create conveying action of cut plant.

Bending of plant during conveying :

Due to heavy weight of plant canopy on the top it was bending in opposite direction during conveying. There was no arrangement provided on implement to avoid bending of plant at the time of conveying of cut plant and, therefore, plant was getting chocked between cutter and conveying tray.

METHODOLOGY

Crop parameter :

Agro technical requirements for pigeonpea stem cutter:

The physical characteristics of some important varieties (AK8811, BDN2, TAT10, etc.) of pigeonpea was studied for various observations like main stem diameter at bottom position, plant height, number of branches, height of first branch from ground and number of pods.

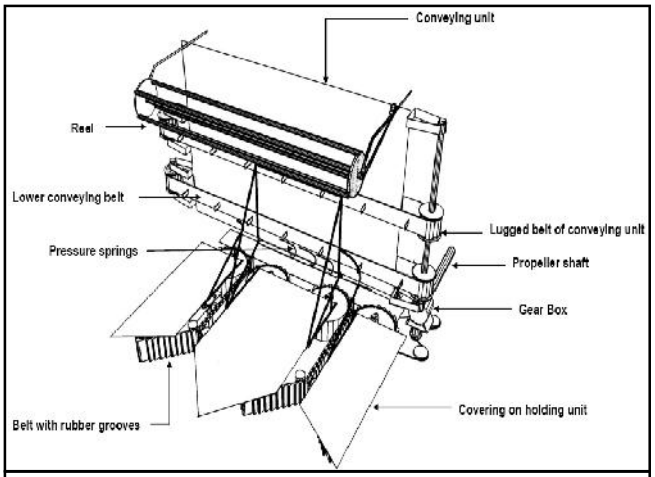

Fig. A: Isometric view of pigeonpea stem cutter

Determination of moisture content :

The moisture content in the stem of pigeonpea is important for determining the time of harvesting. The pigeonpea stem was cut into sample pieces and kept in an oven at 105° C for 24 hours. The moisture content was computed from the formula :

$$M = \frac{W_1 - W_2}{W_1} \times 100$$

where,

M = Moisture content on wet basis, per cent

W_1 = Initial weight of sample before drying, g.

W_2 = Final weight of sample after oven drying, g.

Modification in pigeonpea stem cutter :

Modification in power transmission system :

Following changes were done in the power transmission system :

- The position of shaft joining the universal joint and motor shaft shifted 100 mm below to

facilitate the conveying of power from PTO to gear box without breakdown as shown in the Fig B.

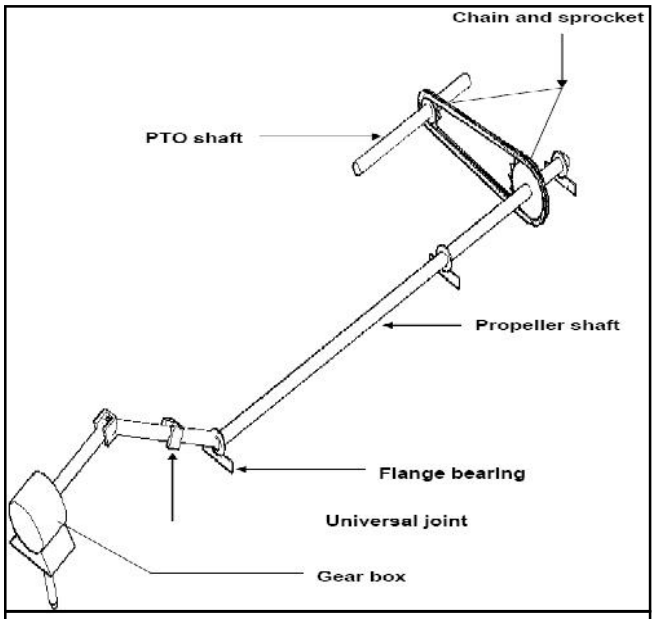

Fig. B: Power transmission system from PTO to gear box

– The cutter bar position was changed by 200 mm and shifted upward as shown in Fig. C. This helps in proper travel of cut plant from cutting mechanism to conveying tray without hindrance of chain drive. The modified power drive system of holding and cutting unit as shown in Fig. E.

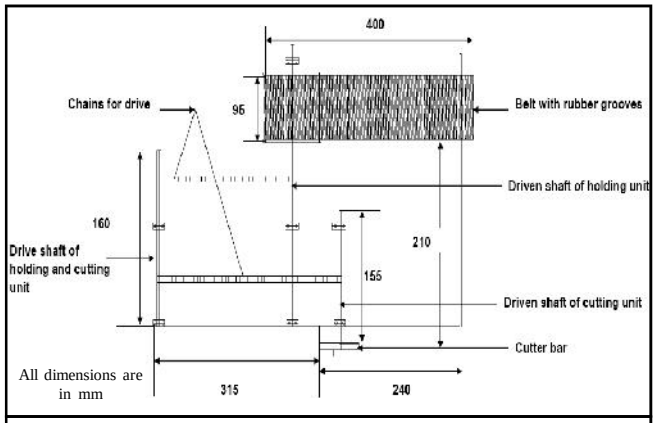

Fig. C: Cutter bar position before modification

Modification in conveying tray :

In view to have proper conveying of crop following modifications were carried out on conveying tray.

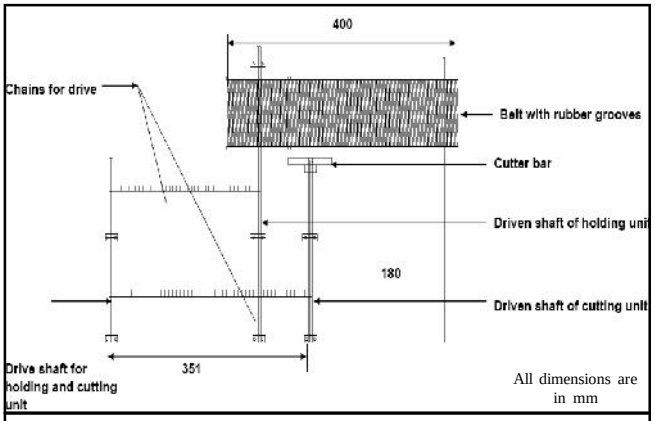

Fig. D: Cutter bar position after modification

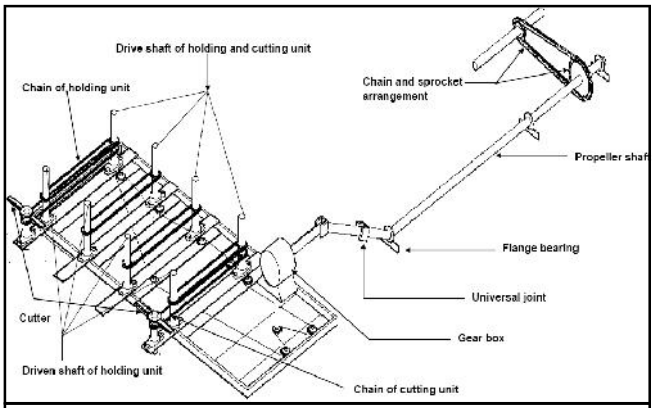

Fig. E: Isometric view of power drive system of holding and cutting unit

– The conveying belt was placed at the upper position of the conveying tray at a distance of 170 mm from the top and distance between upper and lower conveying belt was 450 mm as shown

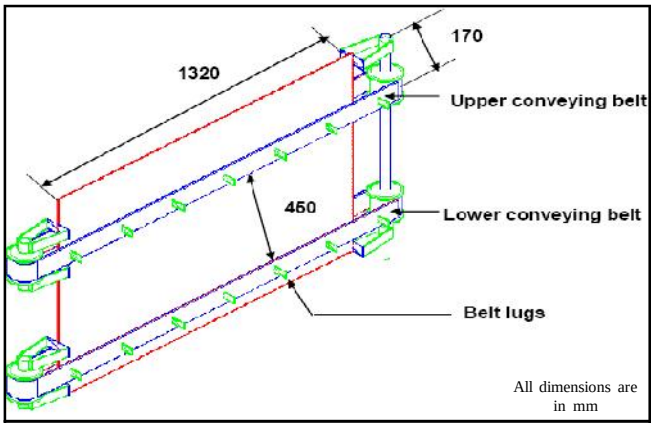

Fig. F: Conveying belt position before modification

in Fig. F. During modification upper conveying belt was shifted down side by 230 mm with pulley arrangement. Therefore, the distance between these two belts was reduced and it was 220 mm after modification as shown in Fig. G.

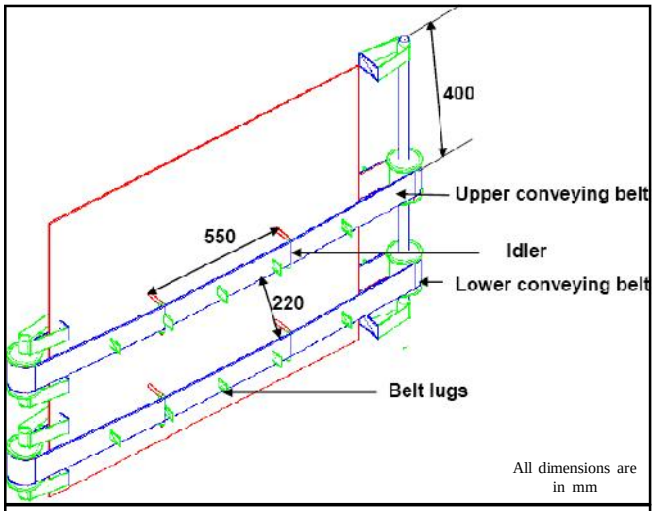

Fig. G: Conveying belt position after modification

– The horizontal distance of belt from conveying tray was not proper and it was very close to the conveying tray and hence, not engaging the plant to be conveyed. To increase the horizontal distance between belt and conveying tray two idlers for each belt was fabricated. For fabrication of idler iron pipe was selected having 20 mm diameter and 90 mm height. These idlers were welded on conveying tray at proper position. The distance between two idlers was 550 mm as shown in Fig.G. This increases horizontal distance of conveying belt by 30 mm from conveying tray as shown in Fig. I.

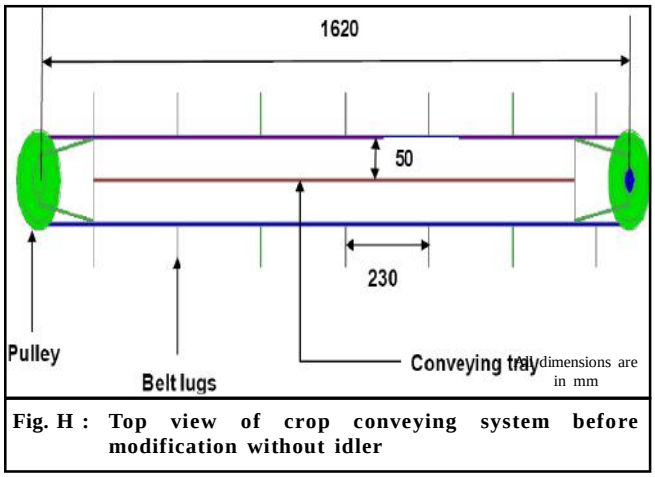

Fig. H : Top view of crop conveying system before modification without idler

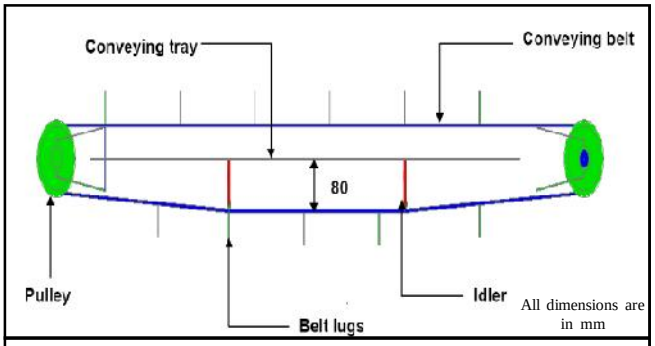

Fig. I: Top view of crop conveying system after modification

Provision of plant guiding arrangement :

Specific arrangement was also fabricated for proper conveying of plant. With the help of M.S. rod having diameter 8 mm plant guiding arrangement was fabricated. Two M.S. rods having 600 mm length and 8 mm diameter was welded at the base plates of two outer rollers of holding unit. Another two M.S. rods having same dimensions were welded at the base plates of inner two rollers of the holding unit. So that two proper paths were created for guiding the crop. One horizontal rod provided at the height of 540 mm from the roller. Three springs were fabricated in middle of the conveying belt above the centre of holding unit. The first spring bolted at 35 mm from right side of the spring plate, second spring bolted at 140 mm and third spring bolted at 260 mm. In plant guiding arrangement all M.S. rods having diameter 8 mm having different length and provided at specific height. Plant guiding arrangement as shown in Fig. J.

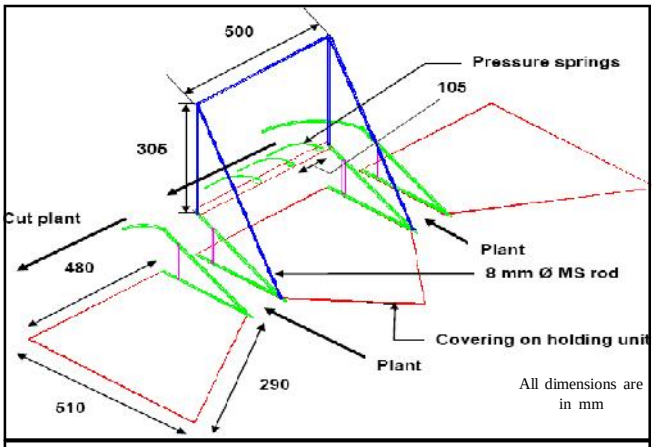

Fig. J: Plant guiding arrangement

Performance evaluation of developed pigeonpea stem cutter :

The performance of developed pigeonpea stem cutter was evaluated in the field of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The observations such as speed of operation, effective field capacity, theoretical field capacity, field efficiency, cutting efficiency, harvesting losses, slip of wheel, fuel consumption, cost of operation were noted during field test.

Test plot :

The test plot was selected as per RNAM test code. According to this code power operated machines can produce best performance only in rectangular field having side in the ratio of 2 : 1 as far as possible. Hence, a rectangular test plot of size 60 m × 30 m was selected for testing developed pigeonpea stem cutter.

Instrumentation :

Stop watch :

It was used to record the travel speed and time required to cover the measured area during the test.

Metallic and steel tape :

A metallic tape of 30 m and steel tape of 3 m were used for measuring and marking the layout of test plot. A steel tape was also used for measuring the working width of tractor front mounted pigeonpea stem cutter.

RESULTS AND DISCUSSION

The most prominent parameters responsible for the design of machine were the height of first branch from the ground level and the stem diameter of plant and its moisture content (Table 1).

The performance of modified pigeonpea stem cutter was evaluated in the laboratory. During the laboratory testing, the pigeonpea stems of different diameter (*i.e.* 8, 10, 12, 16, 18, 24, 30 mm diameter) were fixed on the platform and allow passing through holding unit. The unit successfully holds the crop and feed to conveying unit. In this way, each component of holding unit were tested in the laboratory and found working satisfactorily.

The performance of modified pigeonpea stem cutter was evaluated in the field. The performance of implement without holding unit and with holding unit was compared. Following observation were taken (Table 2).

The cost of operations of tractor front mounted pigeonpea stem cutter were Rs. 1448.20 and 1312.64 Rs. per hectare with operation speed of 3.0 and 3.5 km/h, respectively, whereas manually harvesting required Rs. 2500/ha (Table 2).

Table 1 : Physical characteristics of pigeonpea crop

Sr. No.	Parameters	Variety		
		AKT-8811	BDN-2	AKT-9817
1.	Av. stem diameter, mm	17.7	18.5	17.8
2.	Av. plant height, mm	1917	1920	1907
3.	Av. number of branches	5.8	5	5.6
4.	Av. number of pods	89	90.4	85
5.	Av. height of first branch from ground, mm	365.2	373.8	381.6
6.	Moisture content %, (w.b)	38.24	40.24	39.72

Table 2 : Performance of pigeonpea stem cutter

Sr. No.	Particulars	Implement before modification		Modified implement	
		Test I	Test II	Test I	Test II
1.	Speed of operation, km/h	3.0	3.5	3.0	3.5
2.	Effective field capacity, ha/h	0.184	0.220	0.196	0.234
3.	Theoretical field capacity, ha/h	0.270	0.315	0.270	0.315
4.	Field efficiency, %	68.88	69.84	72.59	74.28
5.	Cutting efficiency, %	78.57	75.00	81.25	80
6.	Plant damage, %	13.33	14.81	10.29	10.93
7.	Wheel slip %	2.72	3.33	1.81	2.5
8.	Fuel consumption, lt./ha	4.82	4.96	4.5	4.8
9.	Cost of operation, Rs./ha	1173.48	1114.54	1448.20	1312.64

Conclusion :

On the basis of the experiment conducted, a comparative study was done with the modified implement with holding unit and implement without holding unit, the results were obtained and the following conclusions were drawn.

- The field efficiency of modified implement was found to be 72.59 per cent and 74.28 per cent at 3 km/h and 3.5 km/h speed of operation, respectively. The overall field efficiency of the modified implement was increased by 5.11 per cent and 5.97 per cent at 3.0 km/h and 3.5 km/h speed of operation, respectively when compared with unmodified implement.
- The cutting efficiency of modified implement was found to be 81.25 per cent and 80.00 per cent at 3.0 km/h and 3.5 km/h speed of operation, respectively. The overall cutting efficiency of modified implement was increased by at 3.29 per cent and 6.25 per cent at 3.0 km/h and 3.5 km/h speed of operation, respectively when compared with implement before modification.
- The harvesting losses of the modified implement were found to be 10.29 per cent at 3.0 km/h and 10.93 per cent at 3.5 km/h speed of operation. The harvesting losses of modified implement were reduced by 22.80 per cent at 3 km/h and 26.19 per cent at 3.5 km/h speed of operation when compared with unmodified implement.
- The fuel consumption of modified implement was found to be 4.5 lt./ha and 4.8 lt./ha at 3.0 km/h and 3.5 km/h speed of operation, respectively. The overall fuel consumption of modified implement was reduced by 6.63 per cent and 3.22 per cent at 3.0 km/h and 3.5 km/h speed of operation, respectively when compared with implement before modification.
- The cost of operation of modified tractor front mounted pigeonpea stem cutter was 42.07 per cent less when compared with manual harvesting of pigeonpea crop.

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