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CONTENTS

Performance evaluation of battery-operated push type pigeon pea stem cutter

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ABSTRACT: Pigeon pea *[Cajanuscajan L. Millsp.]* is second important pulse crop of the country after chickpea in India. Harvesting by engine operated self-propelled reaper involves very high vibration and noise which creates adverse effect on operator and combine harvester unable to work properly in small fragmented land. Considering all above, a study was planned to develop battery operated pigeon pea stem cutter in which the cutting may be done by an electric power through motor. Developed pigeon pea stem cutter was tested in research farm with two independent parameter of forward speed and blade type at SagdividiResearch Station, Junagadh Agricultural University, Junagadh in March 2022. The overall performance of the machine was evaluated on the basis of field capacity, field efficiency, cutting efficiency, uncut and damage per centage by two different levels of forward speeds and three types of cutting blade. The field data were statistically analysed using analysis of variance (ANOVA) for the Factorial-complete randomized design (FCRD) with three replications. The value of field capacity was 39.06 h/ha for two labors, hence total 78.12 man-h/ha required for traditional method whereas the total time required was 9.10 h/ha (18.20 man-h/ha) using two labors for mechanical harvesting method using developed pigeon pea stem cutter. Total harvesting cost was 3000 ₹/ha for manual harvesting method. Whereas total harvesting cost was 993.79 ₹/ha for developed pigeon pea stem cutter. In stem cutter harvesting method, there was 76.70% time decreased and 66.87% reduction in cost as compared with manual pigeon pea harvesting.

Key words: Performance evaluation, pigeon pea, stem cutter

India is major grower of pulses contributing 26% of the global production. About 72% of the global pigeonpea, 61% of gram and 16% of lentil area falls in India. A large number of pulses are grown in India under a wide range of agro-climatic zone. The major pulse producing states are Madhya Pradesh (33%), Maharashtra (13%), Rajasthan (12%), Uttar Pradesh (9%), Karnataka (8%), Andhra Pradesh (5%) Gujarat (4%) and remaining 16% from the rest of states,(Anon., 2019).

Pigeon pea [*Cajanus cajan L. Millsp.]* also known as red gram or arhar, is second important pulse crop of the country after chickpea. It accounts for about 15% of total pulses produced in the country. Maharashtra is the largest producer in the country, accounting for about 32% of total production
Harvesting of crops is one of the most labor-intensive operations, which is to be carried out at an appropriate stage of crop maturity to minimize the field losses, thereby, to increase the crop yield. Nowadays, the agricultural operations become more intensive requiring higher amount of man power. Manual harvesting of pigeon pea is done by sickle, which demands considerable amount of labor drudgery, time and cost of harvest which reflects on total production cost of the crop. In developing countries including India, farmers are not being encouraged for using combine harvester because of its high cost, complexity, land fragmentation, lack of skilled labor, spare parts facilities for repairs etc. Harvesting by engine operated self-propelled reaper involves very high vibration and noise which creates adverse effect on operator. Considering all above, a study was planned to develop battery operated pigeon pea stem cutter in which the cutting may be done by an electric power through motor.

The plants are usually cut with a sickle at 250-750 mm above the ground. Harvested plants should be left in the field for sun drying for 3–6 days depending on the season. The harvested plants are bundled and placed upright to dry for a week depending on the weather conditions. Threshing is done either by beating the pods with stick or using thresher. In some places by cattle trampling seeds are

separated.(Anon., 2020).

Gore and Thakare (2015) tested the modified pigeon pea stem cutter powered by PTO shafts of tractor in the field at the operating speed of 3 and 3.5 km/h and was found working satisfactory.the field efficiency was observed as 72.59% and 74.28% at the above-mentioned speeds, respectively.

Thaker (2017) developed engine operated push type pigeon pea harvester in which three-tooth cutting blade gave best performance at 4000-4500 rpm. It was found that the harvester gave 0.34 ha/h average effective field capacity and 88% field efficiency with minimum plant damage of 6.8%. Suggested that harvester should have provisions for harvesting the crops at low range of rpm and it should be able to harvest the crops at the different heights for better performance.

Right time for harvest of pigeon pea is when grains become hard and contain less than 25% moisture (Pavanraj and Bhaiswar, 2016). Use of serrated sickles reduced the workload and work time loss in harvesting, The productivity of serrated sickles was always higher than those using non-serrated sickles (Sutjana, 2000).

Self-propelled vertical conveyor reapergave 0.2 ha/h average effective field capacity and 80% field efficiency with minimum labor requirements of 5 man-h/ha (Gawali, 2005).

Cutting assembly is an essential parameter because the main output of mechanism mainly depends on the cutter mechanism components (Kongre *et al.,* 2016).

For minimum physiological cost and muscular fatigue, the handle height of weeder should be within 0.7 to 0.8 times of shoulder height. According available anthropometric data, 100 cm handle height of machine is recommended for Indian workers (Gite and Yadav,1990).

Low-cost sugarcane harvester gave 0.1005 ha/h average effective field capacity with 5 man-h/ha The cost of operation by low-cost sugarcane harvester was found to be 3043.50 ₹/ha which is much less when compared to traditional harvesting which costs around 11200 ₹/ha (Naik *et al.,* 2016).

By considering all these factors, there is a need for a small and efficient cutter machine which could be more accessible, cheaper and eco-friendly.

MATERIALS AND METHODS

The manually drawn battery operated pigeon pea stem cutter was fabricated in workshop of Department of Farm Machinery and Power Engineering, College of Agricultural Engineering & Technology, Junagadh. Field experiments of developed pigeon pea stem cutter were conducted at SagdividiResearch Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. The crop sown in greyish black sandy loam soil having medium pH range having good drainage. Selected field area have average annual rainfall of 312 mm with average humidity of 52.56%. sowing time of crop was first week of July 2021. Performance evaluation of the developed stem cutter was carried taking independent and dependent parameters.

The overall performance of the machine was evaluated on the basis of field capacity, field efficiency, cutting efficiency, uncut and damage per centage by two different levels of forward speeds (1.1–1.5 km/h and 1.6–2.0 km/h) and three types of cutting blade with varying number of teeth (60-teeth, 80-teeth and 100-teeth).

Harvesting by stem cutter

A battery-operated push type pigeon pea stem cutter was used for harvesting of pigeon pea in the experimental field in which cutter covers only single row of pigeon pea as shown in Fig. 1 and effect of different types of blade with varying number of teeth and different ranges of forward speed were recorded in terms of effective field capacity and cutting efficiency. Two rechargeable 12 V lead acid batteries suitable for high cyclic and stand-by applications are used in stem cutter. The electric current supplied

to DC motor to rotates the shaft and finally the cutting blade rotates at high speed which is used to cut stem.

Physical properties of the plants sown for experiment purpose was measured randomly at 5 places. The stem diameter ranged from 52 to 148 mm with an average value of 84.6 mm. whereas the height of plants ranged from 1540 to 1770 mm with an average value of 1620 mm.

Total time required and cost of operation is also determined. Two labors are used on for operating stem cutter whereas other one for collecting harvested stems. Measurement of crop parameter after harvesting shown in Fig. 2.

Harvesting by manual method

In traditional method, harvesting by manual labor, sickle is used for cutting pigeon pea stem by holding upper part on one hand and harvested stem laid on field. After cutting, stems are collected in one place for drying and threshing.

Performance parameters studied for both the methods under this study, are as follows:

1. *The Effective field capacity*

The Effective field capacity is the actual rate of coverage by the machine, based upon the total field time. Effective field capacity (ha/h) was determined using following formula.

$$\text{EFC, ha/h} = \frac{\text{Actual area covered, ha}}{\text{Time required to cover field, h}} \quad \ldots(1)$$

Field Efficiency

It is the ratio of effective field capacity to theoretical field capacity, in %. It includes the effect of time lost in the field and failure to utilize the full width of the machine.

$$\text{Field Efficiency, \%} = \frac{\text{Effective field capacity, ha/h}}{\text{Theoretical field capacity, ha/h}} \ldots(2)$$

Cutting efficiency

Cutting efficiency of the stem cutter is determined as the ratio of total no of cut plant to the total no. of plant present before cutting operation in the field.

$$\text{Cutting Efficiency, \%} = \frac{W1-W2}{W1} \quad \ldots(3)$$

Where,

W1 = No. of plants standing before cutting

W2 = No. of uncut plants after cutting

Fig. 1: Harvesting of pigeon pea by stem cutter method

Fig. 2: Measurement of crop parameters after harvesting.

Uncut per centage

After a pass of machine through crop row, number of uncut plants was counted and the per centage of plants remaining uncut in the field were calculated from the total plants in that area before machine operation.

Un-cut per centage (%) = 100 -Cutting Efficiency % …(4)

Operational Cost

The cost of operation of the machine in terms of 'per hectare' and 'per hour' will be determined considering fixed cost and variable cost. The variables like fixed cost and variable cost will be considered in determining the cost of operation of the machine.

Calculation of cost for stem cutter harvesting

Total operating cost, TOC = Total fixed cost + Total variable cost

Total cost for stem cutter harvesting, ₹/ha = Actual time required (h/ha) x Total operating cost (₹/h)

Calculation of cost for manual harvesting

Total cost for manual harvesting = Actual labor required x labor cost

Performance evaluation of battery-operated push type pigeon pea stem cutter

Pigeon pea stem cutter was tested in research farm with two independent parameter of forward speed and blade type at Sagdividi Research Station, Junagadh Agricultural University, Junagadh in

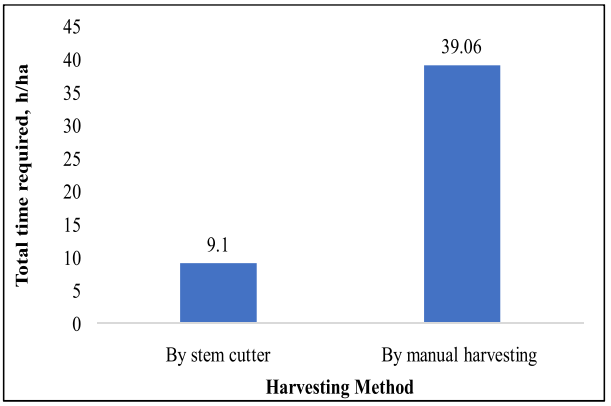

Fig. 3: Comparison of total time required for harvesting by manual and developed stem cutter

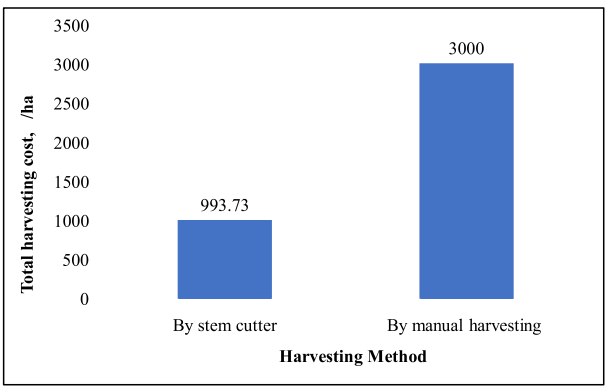

Fig. 4: Comparison of total harvesting cost by manual and developed stem cutter

March 2022. Pigeon pea stem cutter having dimensions of length, width and height of frame are 1400 mm, 900 mm and 1000 mm respectively. The frame is light and strong enough to accommodate various components of the machine-like DC motor, transportation wheels, handle and crop cutting unit. Total weight of machine is 21.6 kg including all components. The results obtained during field performance evaluation of developed battery-operated pigeon pea stem cutter were compared with that of traditional method in terms of time required and cost of operation.

Average values obtained by performance evaluation of developed pigeon pea stem cutter at speed of 1 km/h as given in Table 1.

Table 1: Average values of dependent parameter of developed stem cutter

Effective field capacity	0.131 ha/h
Field Efficiency	85.85%
Cutting efficiency	86.09%
Uncut per centage	13.90%

Time required

The value of total time required was 39.06 h/ha for two labors, hence total 78.12 man-h/ha required for traditional method whereas the total time required was 9.10 h/ha (18.20 man-h/ha) using two labors for mechanical harvesting method using developed pigeon pea stem cutter as shown in Fig. 3. Total time required for developed stem cutter is found to be 76.70% less than that of manual harvesting method

Operational Cost

Total harvesting cost is found to be 3000 ₹/ha for manual harvesting method. Whereas total harvesting cost was 993.79 ₹/ha for developed pigeon pea stem cutter. Operational cost of developed stem cutter is 66.87 % less than that of manual harvesting method.

Since, Harvesting of pigeon pea by using manual harvesting method was found to be most labor intensive operation, also continuous working results in drudgery of labors. Manual harvesting of pigeon pea is done by sickle, which demands considerable amount of labor drudgery, time and cost of harvest which reflects on total production cost of the crop compared to mechanical method using pigeon pea stem cutter as given in Table 2. Therefore, observations of the study showed that stem cutter method is better than traditional harvesting method of pigeon pea.

Table 2: Economical Comparison of stem cutter harvesting with manual harvesting of pigeon pea crop

Comparative parameters	Stem cutter method	Manual harvesting
Total time required, h/ha (For two labors)	9.10	39.06
Total harvesting cost, ₹/ha	993.73	3000

The overall performance of the pigeon pea stem cutter was found better than that of manual harvesting method. Developed pigeon pea stem cutter is suitable in main harvesting seasons where demand of labors is at peak stage, majority of farmer facing problems of labor unavailability. Use of battery-operated machine gives advantages compare to engine operated machine in terms of noise and vibration. Comparative analysis of both the methods showed that pigeon pea harvesting by using stem cutter method is time and labor saving operation, which helps to farmer to adopt this method easily.

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