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Development and Evaluation of E-Brush Cutter for Harvesting of Pigeon Pea Crop

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To develop a battery-operated variable speed electric brush cutter (E-brush cutter) for Indian farmers with small size landholdings to reduce the fuel consumption and ultimately the cost of cultivation.
Place and Duration of Study: ICAR-Central Research Institute for Dryland Agriculture, Hyderabad 500 059, India.
Methodology: The e-brush cutter, which is developed, consists of one rotary blade as cutting unit, gearhead, DC motor, drive shaft, shoulder belt, handle assembly, motor controller and battery pack. The performance of e-brush cutter was evaluated for its power requirement at control and variable

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field conditions. The parameters like different plant stem diameter ranges (10-12, 17-19 and 24-26 mm), three cutting blade speeds (46, 53, 60 m/s) and two-crop moisture contents (47% and 37%) were selected to study the performance of e-brush cutter under control field condition. Further, comparative evaluation of both the brush cutters was conducted to find out average effective field capacity, cutting efficiency, grain loss and energy consumption under field conditions.

Results: The average power requirement of e-brush cutter for harvesting pigeon pea changes from 97.22-99.89 W, 134.22-158.11 W and 151.67-184.11 W for the three diameter ranges from 10-12, 17-19 and 24-26 mm as moisture content reduces from 47% to 37%, respectively, irrespective of blade speed. Similarly, net power requirement varies from 21.89-24-56, 58.89-82.78 and 76.33 - 108.78 W. Further, the average effective field capacity of 0.034 and 0.037 ha/h, cutting efficiency of 95.66 % and 96.66% and grain loss of 1.47% and 1.55% was observed with engine operated brush cutter and e-brush cutter respectively at modified field condition. The energy consumption of 68.80 MJ/ha was recorded with e- brush cutter, which is 13% of the energy required by the engine operated brush cutter.

Conclusion: The performance evaluation revealed that adoption of electric brush cutter could be technically feasible, energy efficient and eco-friendly.

Keywords: Electric brush cutter; battery; DC motor; power requirement; cutting efficiency.

1. INTRODUCTION

Pigeon pea (Cajanus cajan) is an international valued product in most Asian and African countries. Globally, pigeon pea is grown in an area of 6.03 million hectares with a production of 5.33 million tonnes during 2022 [1]. In India, it is the second most important pulse crop next to chickpea, covering an area of around 4.9 million hectares, with a production of 5.32 million tonnes and a productivity of about 861 kg/ha [1]. The pigeon pea plant is tall, bushy, lodge-prone, and its stem is woody in nature. So, the harvesting of this crop involves drudgery and becomes time-consuming. It was estimated that the harvesting operation of crop consumes about 25–30 percent of the total labour requirement of the crop production system. Further, it also stated that total 176 man-hours per hectare were required to harvest pigeon pea crop [2]. At present, in India, this crop is harvested manually with a sickle in majority of small holding farms and the crop is left in the field in the form of heaps for 7–10 days for sun drying. After sun drying, the crop is threshed with a suitable thresher [3].

The adoption of high level of mechanization like combine harvester may lead to improve cropping intensity and productivity which may incur high fuel consumption. However, promotion of eco-friendly agricultural implements and machinery are increasing with the aim of optimal-utilization of the available sources with a reduced drudgery level at various agricultural operations [4]. Eco-friendly technology and alternate power sources are the identified mechanization gaps for small farm mechanization [5]. In India, small and marginal farmers are the most vulnerable to climate change and price inflation. Hence, the development of electric energy-based, smaller equipment for harvesting the crop can help them to make agriculture sustainable in both ways, i.e., economically and environmentally. It is also stated that any modification that can increase fuel efficiency or that may cut down fuel consumption and reduce CO_2 emissions may result in reduction of energy consumption and environmental pollution, thereby contributing to cleaner production [6]. Presently, engine-operated brush cutters are well popular among farmers for various operations like paddy harvesting [7], grass cutting, etc. The portable harvester (brush cutter) developed for wheat worked satisfactorily with an average value of 1.23% for post-harvesting losses with the actual field capacity of 0.038 ha/h and the field efficiency was 62.99% [8]. Many researchers are modifying the brush cutter ergonomically for multipurpose operations [9,10,11].

The brush cutter is mostly run with fossil fuels like petrol. However, depletion of fossil fuels, day-by-day increase in their price, and pollution are the main challenges in the use of fossil fuels [12]. Further it is stated that existing brush cutters suffer from high fuel consumption rates, a high level of engine noise, and high operator fatigue in the long run [13]. It is also reviewed from different test reports of brush cutters, weed trimming, wheat, and paddy harvesting, which consume 10–30 litres of petrol per hectare. It shows that there is a need to modify existing brush cutter with less noise, less vibration, and minimum or zero fuel consumption.

Many researchers are developing electric equipment for agricultural purposes. The recent scenario has increased the scope of battery technology for carrying out some agricultural activities like weeding, harvesting, etc. Further, it was observed that most battery-operated machinery has less noise and vibration compared to engine-based machinery. An electric vertical conveyor reaper for cereal crops was developed and tested for paddy harvesting [14]. The developed e-reaper did not produce any exhaust emission. Another battery-operated small-scale reaper was developed with standard cutter bar which cuts the crop by impact and shear action and useful for wheat and paddy [15]. Furthermore, a battery-powered brush cutter was developed to reduce vibration, noise, energy consumption, etc. [16]. It was tested in the laboratory for its performance, like voltage, current, speed, motor temperature, etc. It was observed that the developed electric brush cutter would be very suitable for people who want to execute the cutting work at home, but a field study was not conducted for any crop [16]. Further, the operational parameters of tangential axial flow type combine harvester was optimized for mechanized harvesting of pigeon pea in sole cropping [3]. Pigeon pea crop is widely planted as intercropping crops with legumes, cereals, oilseed crops, etc. which restricts the efficient use of combine harvester at some extent. Hence, manual harvesting of pigeon pea is still being practiced by farmers. Moreover, it was observed that in a remote place with low acreage, the service providers of the combine harvester are not ready to give their service because of the high transportation charge or to compensate that they demand more money. By considering all the facts and figures mentioned above, there is a need to bring partial mechanization that can be adopted by small farmers, so that developed intervention will reduce the labour requirement, energy requirement, and drudgery. Therefore, it was decided to develop a battery-operated variable speed electric brush cutter (E-brush cutter) for Indian farmers with small landholdings to reduce fuel consumption and the cost of cultivation and enable farmers to harvest pigeon pea crop in time.

2. MATERIALS AND METHODS

An E-brush cutter was developed and fabricated in research workshop and performance evaluation was carried out in the pigeon pea field of ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, India. The details of the prototype developed, components, specifications, experimental design, etc. were given below;

2.1 Development of E-Brush Cutter Prototype

The commercially available petrol engine operated brush cutters are used mostly for plant cutting operations carried out in agricultural fields, thus they prevalent among the Indian small farmers. In this prototype development, commonly available brush cutter’s engine was replaced with compact DC motor and the other necessary fitments were developed to make it compatible for regular cutting operations.

2.1.1 Development of fitments

A circular plate was developed to fix the motor hub with mounting bracket of brush cutter. The developed circular plate was 70 mm in diameter and 3 mm thickness. A 10 mm diameter hole was formed at the centre of plate for motor shaft. Further, three equidistant holes were formed on the plate to tighten the motor hub with plate. In addition to that four equidistant holes were created on circular plate to tighten the mounting bracket with circular plate at a distance of 40 mm from centre. A connector was developed to connect and transmit the power from motor shaft to drive shaft of the brush cutter. Finally a prototype was developed as shown in Fig. 1.

2.1.2 Dynamic balancing of E-brush cutter

The dynamic balancing is important to maintain the balance of machine. The engine operated brush cutter was dynamically balanced for harvesting of paddy [7]. Similar methodology was followed for dynamic balancing of prototype of E brush cutter. The centre of mass point was selected on the hallow pipe where handle was fixed. Details of weight distribution as given below.

M_1= Weight of circular blade, M1= 330 grams
M_2= Weight of gear head, M2= 430 grams
M_3= Weight of guider, M3= Nil
M_4= Weight of DC Motor including all fittings, M4= 2000 grams
M_5= Weight of shaft with pipe between gear case and handle, M5= 1363 grams
M_6= Weight of shaft with pipe between motor and handle, M6= 781 grams

W_1=Maximum weight of attachment can be added towards motor side
L_1= Length of rod between motor and handle (630mm)
L_2= Length of rod between gear case and handle (960 mm)
W_2= Weight of attachments on gear case side = M1+M2+M3+M5=2123 grams
W_1=?

$$W_1 \times L_1 = W_2 \times L_2$$

W_1×630=2123×960
W_1= 3369 grams

Therefore, maximum weight of attachments required for balancing, W_1=3369 grams

W= Weight already added towards motor side.

W= Weight of DC Motor including all fittings + Weight of shaft with pipe between motor and handle.

W = 2000 +781 = 2781 grams

Difference of weight, W_D = 3369-2781=589 grams

It was found that there was a 589-gram weight difference between W1 and W. Hence it the required weight is to be added towards the motor side for balance. However, it has been noted that adding more weight may make the brush cutter heavier. As this weight differential is minimal, this can be adjusted with a high-quality harnessing belt instead of adding some more weight. This difference in weight, W_D may provide kinetic energy during impact, improving cutting efficiency and therefore this design was adopted. Further, this design was having the added benefit of reducing the weight of brush cutter.

2.1.3 Selection of DC motor and battery

Cutting blade is generally driven by an internal combustion of two or four stroke engine through a shaft in the regular brush cutters. Engine of brush cutter is replaced by DC motor in the prototype. It is compact in size, lower in weight and affordable in price. Moreover, speed of DC motor can also be controlled easily with speed controller without any complexity [16]. Therefore, by considering the advantages of DC motor, it was adopted as the prime mover in E brush cutter.

2.1.4 Motor controller

A motor controller consists of micro-controller, resistors, sensors, pulse width modulation (PWM) generator circuit, MOSFET, signal acquisition and processing circuit, over-current and under-voltage protection circuit etc. PWM generator which gives voltage from 12 to 24 volt was used in the prototype to control the rotational speed of cutting blade. It gives provision to operate E-brush cutter with variable speed during evaluation.

2.2 Experimental Design

The study was carried out in two parts i.e. (i) controlled field conditions to determine the various power requirements and, (ii) real field conditions for crop parameters and associated machine performance. The cutting trials were conducted on selected range of plant stem diameter, cutting blade speed and crop moisture content in controlled field conditions. The details of controlled field condition parameters are given in Table 1. Experimental field trials were conducted in RBD (Randomized Block design) with three replications in the pigeon pea field (100 m^2 for each replication). Details of machine specifications and crop parameters are given in Table 3 and Table 4 respectively.

Table 1. Details of operational and performance parameters for control field condition

Independent variables	Levels	Details	Dependent variables
Moisture content of stem, %	2	47 (M1) and 37 (M2)	1. Power requirement, W (Watt)
Dia. of stem, mm	3	10-12 (D1), 17-19 (D2) and 24-26 (D3)	2. Net power requirement, W
Blade speed, m/s	3	46 (S1), 53 (S2) and 60(S3)	

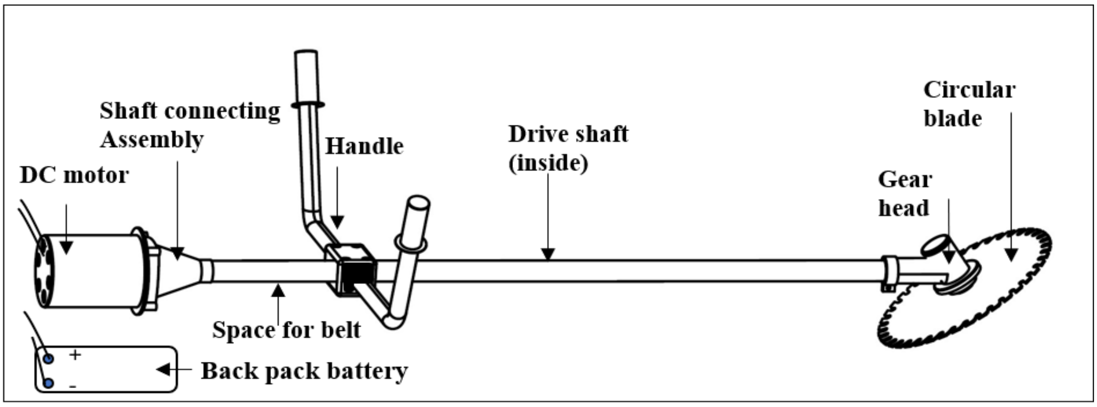

Fig. 1. Parts in E-brush cutter

Table 2. Details of operational and performance parameters for field experiment

Independent variables	Levels	Details	Dependent variables
Type of machine	2	1. Electric brush cutter 2. Engine brush cutter	1. Effective field capacity, ha/h 2. Cutting efficiency, %
Crop standing status	2	1. Regular, (R) 2. Modified (M)	3. Grain loss, % 4. Energy consumption, MJ/ha

Table 3. Detail specifications of engine and electric brush cutter

Particulars	Specification	
Machine type	**Engine brush cutter**	**Electric brush cutter**
Weight, kg	9.1	4.90 (10.6 kg including battery)
Fuel/Battery capacity	0.65 lit	12 volt 18 Ah
Engine/Motor Type	Petrol operated	DC motor,
Power, watt	1500	120 (for experimental purpose)
Engine/Motor speed, rpm	6000	2700-4500 rpm, Variable
Length of shaft, m	1.5	1.5 m
Handle type	Bike style	Bike style
Harnessing belt	Single shoulder strap	Backpack style
Battery position	Nil	Backpack

Table 4. Field crop parameters

Crop Parameters	Details
Name of crop	Pigeon pea
Cropping system	Raised bed
Height of crop, cm	120
Crop density, plant/m^2	15
Row to row spacing on bed, cm	80
Row to row spacing near to furrow, cm	45
Plant to plant spacing, cm	15-30
Stem diameter, mm	10-30
Average number of pods per plant	200

A field experiment was planned to compare the performance of newly developed prototype i.e. E-brush cutter with engine operated brush cutter at field level conditions. The details of independent variables and performance parameter are given in Table 2. The performance of both the brush cutters were studied at two crop standing status i.e. (i) regular and modified status. The crop status is considered as independent variable based upon actual crop condition during the harvesting of pigeon pea crop. The regular status indicates the natural standing position of crop (lodged or straight). Modified status indicates sets of two crop rows by bending them towards each other to form a clear path.

2.2.1 Controlled field condition

2.2.1.1 Determination of power consumption parameters

A high precision power, watt meter was connected in between the power source and E-brush cutter motor through a controller to measure the power required (Watt) to harvest pigeon pea. The peak power requirement at the time of cutting was determined with various load conditions in terms of wattage by using watt meter. Further, net power requirement was calculated based on the difference between the power required to run the brush cutter with load and no load.

2.2.2 Variable field condition

2.2.2.1 Effective field capacity, ha/h

The effective field capacity is the actual rate of coverage of field by the machine, based on the total field time taken. Both the machines were operated with almost fixed speed for a fixed time and the area covered during the period was measured to determine the average area covered per hour [17,7].

$$Fc = \frac{A}{To}$$

Where, Fc= Effective field capacity, ha/h (hectare/hour), A=Area Covered, ha; To=Total Operating time in hours (h)

2.2.2.2 Cutting efficiency, %

Cutting efficiency (Ec) was calculated based on the number of pigeon pea stems/plants got full cut in single impact in area 1 m^2 during the cutting operation [7].

$$Ec, \% = \frac{P1 - P2}{P1} X100$$

Where, P1 = No. of plants before operation per m^2 area; P2 = No. of plants got full cut in single impact per m^2 area; Ec= Cutting efficiency, %.

2.2.2.3 Grain loss, %

The grain loss percentage was determined based on pre-harvest and post-harvest loss. It was determined based on samples collected from each treatment. The results were then expressed in the form of percentage of grain loss.

$$Grain\ loss, \% = \frac{(G_2 - G_1), kg/ha}{Yield, kg/ha} X100$$

where, G_2=losses during and after harvesting (kg/ha); G_1 = losses occur before harvesting (kg/ha)

2.2.2.4 Energy Consumption, MJ/ha

Energy consumption was calculated from actual energy input used i.e. electricity through battery and petrol consumed by engine for harvesting of 100m^2 pigeon area using electric brush cutter and engine operated brush cutter. Further, it was converted into MJ/ha by using standard energy equivalent i.e.11.93MJ for one kWh for electricity and 48.23 MJ for one litre petrol used respectively [18].

2.3 Statistical Data Analysis

All the recorded data were analysed separately for control field condition and variable field condition. The control field experiment was analysed with completely randomized block design and variable field was analysed with randomized block design at a 5% significance level. ANOVA was conducted to evaluate effect of stem diameter, blade speed and moisture content on power requirement and net power requirement. Further, two–way ANOVA analysis was done to study the effect of machine type and crop status under variable field condition. Details of performance parameter of both experiments are mentioned in Table 1 and Table 2.

3. RESULTS AND DISCUSSION

3.1 Controlled Field Evaluation

The effect of stem moisture content, stem diameter and blade speed on all the dependent parameters are mentioned below with the statistical analysis given in Table 5.

3.1.1 Power requirement, watt (W)

The average power requirement obtained during control field evaluation of the electric brush cutter at different level of independent parameter are represented in Fig. 3a. The power requirement was found to increase with an increase in level of stem diameter and blade speed. The maximum mean peak power requirement of 214.33 watt was observed at M2 (37%), diameter D3 (24-26) and blade speed S3 (60 m/s) while, minimum mean power requirement of 69 W was observed at moisture content M1 (47%), diameter D1 (17-19 mm) and blade speed S1 (46 m/s). The sub mean of power requirement irrespective of blade speed varied from 97.22-99.89, 134.22-158.11 and 151.67-184.11W as moisture content reduced from 47% to 37%, at stem diameter of 10-12, 17-19 and 24-26 mm respectively. Similarly, sub mean of power requirement irrespective of stem diameter varied from 106.8-112.22, 125.56-157.00 and 150.67-172.89W as moisture content reduced from 47% to 37% at blade speed of 46, 53 and 60 m/s respectively. It was observed from the analysis that the moisture content, stem diameter and blade speed were significantly ($p<0.05$) affected the power requirement. Further, none of the interactions of operating parameters were found to be significant. It was also observed that the power requirement was inversely proportional to stem moisture content since power requirement decreased with increase in stem moisture content irrespective of blade speed and stem diameter. The moisture content was observed to have an increasing effect on force. Increase in moisture content leads to decrease the force to cut the pigeon pea stem up to 45% moisture content [19]. It may be due to pigeon pea stem having vascular bundles of the stem that are collateral and arranged in form of a ring [20]. Moreover, the power requirement increased with increase in blade speed. It may be due to more voltage required to speed up the blade that may increase power requirement. Further, it is also observed that as diameter of pigeon pea stem increases, power requirement also increases which may be due presence of more vascular bundles. More maturity gives more strength to stem.

3.1.2 Net Power requirement, watt (W)

The graphical representation of average net power requirement corresponding to three levels of blade speed, three levels of diameter and two levels of moisture content is given in Fig. 3b. The maximum mean net power requirement of 136.66 W was observed at M2 (37%), diameter D3 (24-26) and blade speed S2 (53 m/s) while the minimum net power requirement of 13.00 W was observed at moisture content M1 (47%), diameter D1 (17-19 mm) and blade speed S1 (46 m/s). Further, with every increase in the level of stem diameter, net power requirement varied from 21.89-24.56, 58.89-82.78 and 76.33-108.78W and moisture content reduced from 47% to 37%, irrespective of blade speed. Similarly, with the increase in level of blade speed of three levels as mentioned above, net power requirement varied from 50.89-56.22, 53.56-85.00 and 52.67-74.89 W and moisture content reduced from 47% to 37%, irrespective of stem diameter. The statistical analysis of net power requirement showed that, the model was significant with $F = 5.62$ ($P < 0.05$) as shown in Table 6. Similarly, moisture content and stem diameters were statistically significant with $P < 0.05$. However, blade speed was not significant with $F = 11.54$ and $P=0.22 > 0.05$. It was observed that net power requirement was inversely proportional to stem moisture content since net power requirement decreased with an increase in stem moisture content irrespective of blade speed and stem diameter. In case of stem diameter, net power requirement increased with diameter and it may be due to presence of more vascular bundles as explained earlier. Further, in case of blade speed, maximum net power requirement was observed at blade speed of 53 m/s irrespective of moisture content and diameter.

3.2 Comparative Evaluation under Variable Field Condition

The graphical representation and statistical analysis (F values) of comparative evaluation of engine and electric brush cutter given in Fig. 4 and Table 5 respectively.

3.2.1 Effective field capacity, ha/h

The statistical analysis of effective field capacity showed that the crop standing status was statistically significant with $P <.05$. However, machine type (electric and engine brush cutter) and interaction of both independent parameters were not significant with $F = 4.486$ ($P=.078 >.05$) and $F=.66$ ($P=.45>.05$) respectively. The mean effective field capacity of 0.033 and 0.037 was observed for electric brush cutter at regular and modified field conditions respectively. Further, mean effective field capacity of 0.030 and 0.034 ha/h was observed for engine brush cutter at regular and modified field conditions respectively. The maximum effective field capacity of 0.037 and 0.034 ha/h was observed for electric brush cutter and engine operated brush cutter, respectively in modified crop condition. The lowest field capacity of 0.033 and 0.030 was observed for electric and engine operated brush cutter in regular crop condition respectively. It may be due to as the crop was lodged which created hindrance for operator to move freely into the field of regular crop stand.

Fig. 2. Harvesting of pigeon pea with electric brush cutter

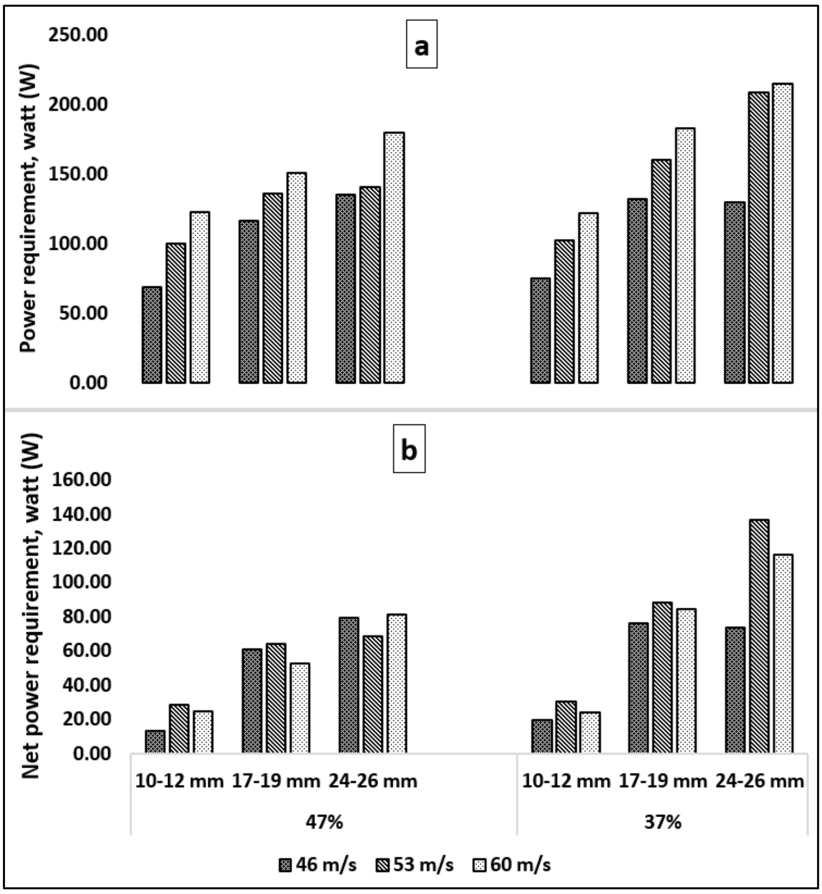

Fig. 3. Effect of stem diameter (mm), blade speed (m/s) and moisture content (%) on (a) power requirement, watt and (b) net power requirement, watt

Table 5. ANOVA for effect of independent parameters on performance parameters of control field condition (F and P values)

	Power requirement, watt (W)		Net power requirement, watt (W)	
Source	**F value**	**P value**	**F value**	**P value**
Model	7.87	<.0001	5.72	<.0001
Moisture	8.44	0.0062	8.44	0.0062
Dia	36.61	<.0001	36.61	<.0001
Blade Speed	20.15	<.0001	1.85	0.1714
Moisture*Dia	1.71	0.1952	1.71	0.1952
Moisture*Speed	1.28	0.2915	1.28	0.2915
Dia*Speed	0.37	0.8262	0.37	0.8262
Moisture*Dia*Speed	1.11	0.3661	1.11	0.3661

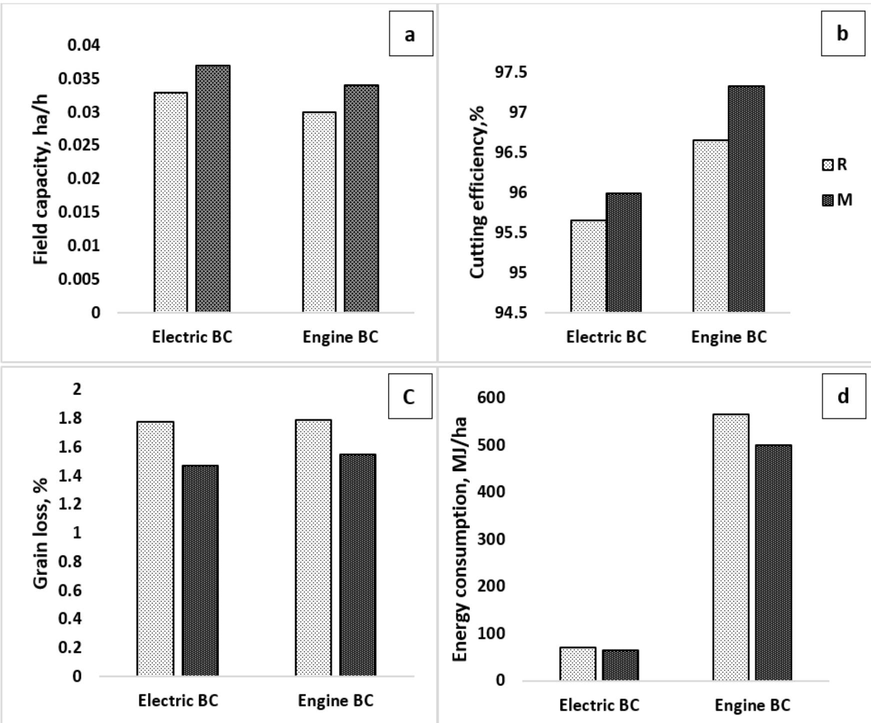

Fig. 4. Comparison of electric and engine operated brush cutter (BC) under regular (R) and modified crop condition (M) on (a) Field capacity, ha/h (b) Cutting efficiency, % (c) Grain loss % (d) Energy consumption, MJ/ha

Table 6. ANOVA for effect of independent parameters on performance parameters of variable field condition (F values)

Source	**DF**	**Effective field capacity**	**Cutting efficiency**	**Percent grain loss**	**Energy consumption, MJ/ha**
Replication	**2**	**F-Calculated**			
Machine type	1	4.486^{NS}	12.789*	0.025 ^{NS}	2,701.08*
Crop standing status	1	19.352*	1.421 ^{NS}	0.919 ^{NS}	16.579*
Machine type* Crop standing status	1	0.664^{NS}	0.158 ^{NS}	0.013 ^{NS}	11.288*
Error	6	-	-	-	-
Total	11	-	-	-	-

**: Significant at 5% level. ^{NS}: Not significant. DF: Degree of Freedom.*

3.2.2 Cutting efficiency, %

The results of statistical analysis showed that harvesting machine had significant impact on cutting efficiency. The crop standing status and its interaction had non-significant effect on cutting efficiency. The mean cutting efficiency of 96 % and 95.67 % was observed for electric brush cutter at regular and modified field conditions, respectively. Further, it was 97.33 % and 96.67% for engine brush cutter at regular and modified field conditions, respectively. The maximum cutting efficiency of 96.00 and 97.33 percent were observed for electric brush cutter and engine operated brush cutter, respectively at regular crop condition. For engine operated brush cutter, higher cutting efficiency was observed. It may be due to higher power and rpm of engine operated brush cutter.

3.2.3 Grain loss, %

The statistical analysis of percent grain loss showed that the both the independent parameters and their interaction were not statistically significant with $F = .025$ ($P > .05$), $F = .91$ ($P > .05$) and $F = .013$ ($P > .05$). The mean percent grain loss of 1.78 and 1.47% was observed for electric brush cutter and 1.79 and 1.55% was observed for engine brush cutter at regular and modified field conditions, respectively. The maximum percent grain loss of 1.78 and 1.79 percent was observed for electric brush cutter and engine operated brush cutter respectively at regular crop condition. The lowest percent grain loss of 1.47 and 1.55 percent was observed for electric and engine operated brush cutters at modified crop condition, respectively. Overall percentage of grain loss of 1.62 and 1.67 was observed for electric and engine operated brush cutter respectively.

3.2.4 Energy consumption, MJ/ha

From the statistical analysis of energy consumption, it was observed that treatments of machine type, crop standing status and their interaction were significantly different with $F = 2701$ ($P < .05$), $F = 16.579$ ($P < .05$) and $F = 11.288$ ($P < .05$) respectively. During the operation of electric brush cutter, maximum energy consumption of 71.58 MJ/ha was observed at regular crop stand and the minimum energy consumption of 65.61 MJ/ha was occurred at modified crop status. It may be due to the modified crop standing status that provided enough space to move without obstacles covering more area and reducing the energy consumption. Moreover, in case of engine operated brush cutter, the maximum mean value of energy consumption of 566.43 MJ/ha was observed for regular crop stand; while the minimum mean value of energy consumption of 500.02 MJ/ha was observed for modified crop. The overall mean energy consumption of 68.59MJ/ha and 533.22 MJ/ha were observed for electric brush cutter and engine operated brush cutter, respectively.

4. CONCLUSIONS

Battery-operated E-brush cutter was developed and its performance was presented in this paper with an objective to reduce the fuel consumption and reduce cost of operation. The developed E brush cutter showed that blade speed, stem diameter and moisture content has significant effect on power requirement. The overall power requirement and net power requirement of 137 W and 62 W was observed for cutting pigeon pea stem, respectively. During comparative evaluation, the effective field capacity and percent grain loss observed in both the machines were not significantly different. The maximum cutting efficiency of 95.67% was observed under Electric brush cutter. Energy consumption in case of engine brush cutter was 533.33 MJ/ha whereas it was 68.59 MJ/ha only in case of E-brush cutter. Further, the field evaluation showed that E brush cutter has potential to be a good alternative to save the fuel consumption, which ultimately reduced the cost of operation and eliminated the direct emissions of harmful exhaust gases. The operational compatibility of the e-brush cutter reduced the drudgery normally encountered with the engine operated brush cutter. The operator also felt that vibration effect on the hands was less compared to the engine operated one. Hence it can be encouraged in small holding farms very effectively. However, long duration batteries are to be explored for making it more viable.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAOSTAT: Available:https://www.fao.org/faostat/en/#data/QCL: retrieved from the website on 21.05.2024.
2. Dange AR, Thakare SK. Development and Performance Evaluation of Tractor Front Mounted Pigeon Pea Stem Cutter. Iranica J of Energy & Env. 2010;1(3):200-204.
3. Kumar D, Dogra B, Dogra R, Singh I, Manes GS. Optimization of operational parameters for mechanised harvesting of pigeon-pea (Cajanus cajan) with combine harvester. Legume Research. 2019;42(2): 198-204.
   DOI: https://doi.org/10.18805/LR-3216.
4. Mishra D, Satapathy S. Technology adoption to reduce the harvesting losses and wastes in agriculture. Clean Techn Environ Policy. 2021;23(3):1947–1963.
   DOI: https://doi.org/10.1007/s10098-021-02075-2.
5. Pandey HS, Tiwari GS, Sharma AK. Design and development of an e-powered inter row weeder for small farm mechanization. J Sci Ind Res. 2023;82: 671-682.
   DOI:https://doi.org/10.56042/jsir.v82i06.1907.
6. Robert P, Raffaele S, Natascia M, Johanna R, Antti A. Modifying the settings of CTL timber harvesting machines to reduce fuel consumption and CO2 emissions. J Clean Prod. 2018;197 (1): 208-217.
   DOI:https://doi.org/10.1016/j.jclepro.2018.06.210
7. Dixit J, Hakak FA, Saxena A. Adaption of modified brush cutter for rice harvesting. Agric Eng Int: CIGR J. 2022;24(1):90-101.
8. Gupta Bhashkar, Sharma Sushil, Khar Sanjay, Sinha AK, Gupta Vinod, Gupta Saurav. Field evaluation of a portable crop harvester in wheat crop. Int J Curr Microbiol App Sci. 2020;11: 3923-3934.
9. Parthasarathy M, Pradeep D, Senthil Kumar P, Sivakumar M. Design and Development of Multi-Purpose Brush Cutter for Agricultural Operations. International Journal of Engineering Research & Technology (IJERT). ETEDM – 2022 Conference Proceedings. 2022;10 (08):252-255.
   DOI: 10.17577/IJERTCONV10IS08057
10. Mali PR, Aware V, Shahare PU, Powar R, Aware SV. Ergonomic Considerations for Development of Grass Cutter-Cum-Paddy Harvester. Journal of Biosystems Engineering. 2022;47:468-479.
   DOI:10.1007/s42853-022-00160-y
11. Aswathi, K. Ergonomic investigations on hand arm vibration of brush cutter for the development of a vibration reducing aid. Unpublished Thesis; 2016.
   Available:https://krishikosh.egranth.ac.in/items/ec2f70bd-1b67-4a82-8862-c1883a87e5fc
12. Guru PK, Shrivastava AK, Tiwari P, Khandai S, Chandel NS. Estimation of carbon emissions of agricultural machinery use in India. Oryza. 2022;59 (3):260-268.
   DOI:https://doi.org/10.35709/ory.2022.59.3.1
13. Reddy KA, Mahesh Babu N, Harini L, Srikanth R, Srinivas J. Design and analysis of a revised grass trimming device. J Sci Ind Res. 2021;69:39-42.
14. Sahoo AU, Raheman H. Development of an electric reaper: a clean harvesting machine for cereal crops. Clean Techn Environ Policy. 2020;22:955-964.
   DOI:https://doi.org/10.1007/s10098-020-01838-7.
15. Kiran IKM, Awal AM, Ali RM. Development and performance evaluation of a battery operated small-scale reaper. Agric Eng Int CIGR J. 2017;19(2):217–223.
16. Chieh-Tsung Chi. A new electric brush cutter. WSEAS Trans Syst Control. 2012; 7(3):75-86.
17. Oyelade OA, Oni KC. Farm tractor testing and evaluation for Nigeria's economic transformation: A case study of TAK tractors, Proc Int Conf of Nigerian Institution of Agril Engineers, Ilorin. 2011; 17-20:123-132.

18. Singh S, Mittal JP. Energy in production agriculture. Mittal Publications:New Delhi, India. 1992;8.
19. Dange AR, Thakare SK, Rao BI. Cutting energy and force as required for pigeon pea stems. J Agril Tech. 2011;7(6):1485-1493.
20. Shahanara Begum, Azharul IM, Azad-ud-doula Prodhan AKM. Anatomy of the stem of pigeonpea (*Cajanus cajan*). Asian J Plant Sci. 2007;6: 276-281.

    DOI:https://scialert.net/abstract/?doi=ajps.2007.276.281.

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