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Performance Evaluation of Small Tractor Operated Crop Residue Slasher for Sunflower Crop

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A B S T R A C T

Burning of crop residues generates large amount of pollutants leads to the cardiorespiratory diseases. Also, it has negative impact on organic matter, nitrogen and other micro and macro soil nutrients. Soil incorporation of crop residues is one of the best alternatives to the crop residue burning. Sunflower, having most of the cultivable area in Karnataka and Maharashtra has proved to be very beneficial for the improvement of soil productivity. The current research work focuses on the evaluation of the small tractor operated crop residue slasher for incorporation of sunflower stalks into the soil. The various performance parameters were tested on the field. It was found that mean length of cut during the test was11.5 cm. Average slashing efficiency was observed to be 88.20 per cent. The effective working speed of slasher was found to be 1.99 km/h. The fuel consumption litre per hour was observed to be 4.6 lit/h. The effective field capacity, theoretical field capacity and field efficiency of machine was found to be 0.11 ha/h, 0.17 ha/h and 64.7 per cent respectively for forward speed of 2.90 km/h.

Keywords

Crop residue, Slasher, Soil incorporation

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Introduction

In recent years crop residue burning created major environmental issues. Burning of crop residues exposes peoples nearby to the harmful particulate matter (PM) that leads to the cardiorespiratory diseases. It has been estimated that burning of crop residues generating 211 Tg/yr of greenhouse gases in India (Khaiwal *et al.*, 2019). Besides air pollution, crop residue burning has negative impact on organic matter, nitrogen and other micro and macro soil nutrients (Dey *et al.*, 2020).

However, Government has banned on field burning of crop residues but practice still continues in some areas. There several ways through which crop residues can be managed effectively such as they can be used as alternative energy sources (Biogas, Biochar), can be buried into the soil to increase the soil fertility, soil moisture retention capacity and it can save 7-40 cm of irrigation water (Bhattacharyya and Barman, 2018).The crops residues have importance and value if get converted appropriately in the field. The cotton, sunflower, sorghum, sugarcane and pulses are regularly sown crops in Maharashtra produces 46 million tons of crop waste per year (Devi *et al.*, 2017). After the harvesting of the standing crop residue is thrown away from the field or collected by the villagers for domestic purpose. In many cases, this agro residue is burnt directly on farm by the farmers without intervention of conversion of waste in to organic material.

Sunflower is the one of the important crops cultivated in Maharashtra, Karnataka and Andhra Pradesh accounts for 61.3 per cent of total area under sunflower cultivation in India (GOI, 2018). Sunflower crop generates around 8.78 ± 0.5 tons of crop residues perhectare (Torma *et al.,* 2018). Conventionally, these residues are burned on the field or taken away from the field to use as a domestic fuel. Few researchers found that burying of sunflower residues in soil is having a positive effect on the soil. Ullah *et al.*, 2018 reported that sunflower residue incorporation caused 44-57per cent reduction in weed density and 58-70per cent reduction in weed dry weight. As well as he also got to know that the organic matter and nitrogen content of the soil is increased by 86 and 74per cent respectively.

After harvesting of sunflower crop residues are left in form of whole stalk. It became very difficult incorporate the whole stalk into the soil. Therefore, there is a need to preprocess the sunflower stalk before actually incorporate them into the soil by size reduction of sunflower stalks. The slasher is the machine which fulfill above said task very effectively. Amer *et al.*, 2011compared the different slashers used for the cutting and fragmentation of vegetative portion of the sweet potato to facilitate the harvesting of tubers. They found that the vertical type and flail type mowers are most effective in removing vegetative growth. The objective of this work is to evaluate the performance of developed crop residue slasher. Karale *et al.*, 2014 developed a tractor operated slasher and evaluated its performance for size reduction of cotton, wild grass and sun hemp stalks. They found that the developed slasher was performing satisfactorily.

The present study formulated with objective of performance evaluation of the crop residue slasher developed by Karale *et al.,* 2014 for size reduction of sunflower crop residues.

Materials and Methods

The chapter discuss about the overview of technical specifications and features of the developed crop residue slasher and methodology followed to evaluate its performance while working with the residues of sunflower crop. The tractor operated slasher was developed at department of Farm Machinery and Power Engineering, Dr. PDKV, Akola. Performance evaluation of the given slasher was conducted on research field of Dr. PDKV Akola.

Technical features

The vital components of the developed crop residue slasher are

1. Gear box
2. PTO shaft
3. Main frame
4. Body cover
5. Rotor assembly and
6. Transmission assembly.

Technical specifications

The technical specifications of the developed crop residue slasher are given in Table 1.

Performance evaluation of small tractor operated crop residue slasher

To evaluate the performance of the crop residue slasher it is operated in the sunflower field at research field of Dr. PDKV Akola. The field observations i.e. speed of operation, operating width and fuel consumption are noted to evaluate the field performance and to check its feasibility for the crop residue management. The methodology was followed to evaluate different performance parameters of the crop residue slasher are given as below.

Operating speed

To determine the speed of operation of the crop residue slasher two poles at distance of 10 m apart are placed approximately middle of the test field. On the other side of the test field two poles are placed at distance of 10 m same as placed earlier. This will form a rectangle with long sides parallel to the test field. In order to calculate the speed of operation tractor mounted with slasher kept near two of the poles. The time required to cover the distance of 10 m between two poles were noted using stopwatch. The given procedure is replicated for three times. Based on the distance traveled and time required the average speed of the operation was calculated using following equation

$$S = \frac{L}{T}$$

Where,
S = Speed of the operation, m/s
L = Distance between two poles, m
T = Time required to cover distance between two poles, s

Actual width of operation

Actual width of operation of crop residue slasher was measured at different locations selected randomly. Actual width of operation gives the idea about how much width of the slasher that actually getting utilized. It is denoted by W_a

Actual or effective field capacity

It is the area covered by a crop residue slasher per unit time required. The time required may include time required for turning, time required for adjustments etc. It can be calculated by using following equation.

$$F_a = \frac{A_a}{T_a + T_l}$$

Where,
F_a = Actual field capacity ha/hr
A_a = Actual Area covered, ha
T_a= Actual time of operation, hr
T_l= Time lost during turning, adjustments etc., hr.

Theoretical field capacity

It is rate of field coverage assuming that slasher is working with 100per cent of its rated width and time as well as at its rated speed. It can be calculated by using following equation

$$F_T = \frac{S \times W_T}{10}$$

Where,
F_T = Theoretical field capacity, ha/hr
S = Speed of operation, km/hr
W_T = Theoretical width of operation, m

Field efficiency

Field efficiency is the ratio of the actual field capacity to the theoretical field capacity expressed in percentage. It can be calculated by using following equation

$$\text{Field Efficiency (per cent)} = \frac{F_a}{F_T} \times 100$$

Fuel consumption

Fuel consumption during operation of the slasher is measured by using auxiliary fuel tank fitted to the tractor. The auxiliary fuel tank was having fuel level marks to know the level of fuel. The fuel level of the before and after testing was noted. The difference between two fuel levels is the fuel consumed during entire test period.

Slashing efficiency

Slashing efficiency calculated by counting and taking ratio of number of sunflower stalks from unit area before commencing slasher operation and number of sunflower stalks after commencing slasher operation. It can be expressed as follows.

$$\text{Slashing efficiency} = \frac{\textit{Number of stalks after slasher operation}}{\textit{Number of stalks before slasher operation}} \times 100$$

Working of crop residue slasher

The *in-situ* crop residue disintegrator is operated by small tractor having 18.5 hp power. A suitable power transmission system has been developed to deliver the optimum power. The power is transferred through the gear box of suitable number of teeth which coupled with the intermediate shaft. An intermediate shaft is connected to the big size pulley of appropriate power delivering capacity and to maintain the revolution of the main shaft. This pulley transmits the power through the v-belt to another pulley with maintaining the required rotation to the shaft. Finally, the crop cutting mechanism is drive and slashes the standing crop residues

The selected tractor has 540 and 1000 standard RPM but for better operation it requires higher RPM. Therefore, by using belt pulley arrangement RPM is increased from 1000 rpm to 1700 rpm. In first stage of power transmission, power is transmitted through the gear box having 1:1.76 gear ratio and reduces rpm from 1000 to 565 and transfer to 30 cm pulley through intermediate shaft.

This RPM is increased at rotor through 10 cm pulley. At the end, this assembly gives output of 1700 rpm at rotor shaft to which blades are attached. These blades rotate with 1700 rpm in opposite direction of travel speed. In one second one blade strikes 28 times on crop. One blade rotates 360° angle, in which in 0°-120° it cut the crop and remaining 120° – 240° crushing operation is done while 240°-360° angle is idle zone of the blade in which it throws cut material of the crop.

Results and Discussion

The field selected for conducting trials was having size of 2.5 hectare. Figure 1 shows the field evaluation of slasher. Field observations like operational speed, width of operation, the data collected during field evaluation trails were analyzed to determine the actual field capacity, field efficiency, fuel consumption. The time lost during turning at head land was 45 minutes. While no time was lost for adjustments and repairs.

The data pertaining to field evaluation trials of small crop resides slasher. The average values of speed of operation (with no load) of machine was 2.90 km/h while the effective working speed of slasher was found to be 1.99 km/h.The theoretical field capacity of the slasher was 0.17 ha/h.

Table.1 Technical specifications of crop residue slasher (Karale *et al.*, 2014)

Sr. No.	Component	Description
1.	Gear box	Gear box is fitted on the main frame of slasher. Speed reduction is the main function of the gear box.
2.	Universal Joint	Telescopic universal joint is provided to transmit power between PTO shaft of tractor to the input shaft of gear box.
3.	Main frame	Made up of square section having length of 1200 mm and provided with three-point linkage.
4.	Body cover	Made up of MS sheet of 10 gauge having size of 1200×700 mm with attachment of support frame for shaft.
5.	Rotor assembly	It has shaft mounted with 36 'L' shaped blades made up of high carbon steel.
6.	Transmission	Power is transmitted through PTO shaft- Gear box- Belt and pulley- Rotor assembly

Fig.1 Field evaluation of crop residue slasher handling sunflower crop residues

While, the average actual field capacity of 0.11 ha/h with operational width of 120 mm and maximum fuel consumption observed in for this was 4.6 lit/h. The field efficiency of the developed slasher was 64.70 percent. It was found that mean length of cut during the test was 11.5 cm.

The slashing efficiency of the developed crop residue slasher was 88.20 percent while handling sunflower crop residues. The small tractor operated crop residue slasher has been developed at Department of Farm Power and Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Field test trials on small tractor operated crop residue slasher were carried out at various crops. From the performance result of these trials following conclusions could be drawn.

– The average speed of operation was observed to be 1.99 to 2.90 km/h.
– The average actual field capacity was 0.17 ha/h
– Average fuel consumption was 4.6 lit/h
– Incorporation of residue gives immediate utilization to enrich the soil for the immediate season.

– The average field efficiency of the slasher was 88.20 per cent.

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