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Vala VS
Department of Farm Machinery and Power Engineering, CAET, Junagadh Agricultural University, Junagadh, Gujarat, India

Kathiria RK
Associate Research Scientist, Directorate of Research, Junagadh Agricultural University, Junagadh, Gujarat, India

Bheda AK
Department of Farm Machinery and Power Engineering, CAET, Junagadh Agricultural University, Junagadh, Gujarat, India

Correspondence
Vala VS
Department of Farm Machinery and Power Engineering, CAET, Junagadh Agricultural University, Junagadh, Gujarat, India

Performance evaluation of mini tractor operated rotary weeder

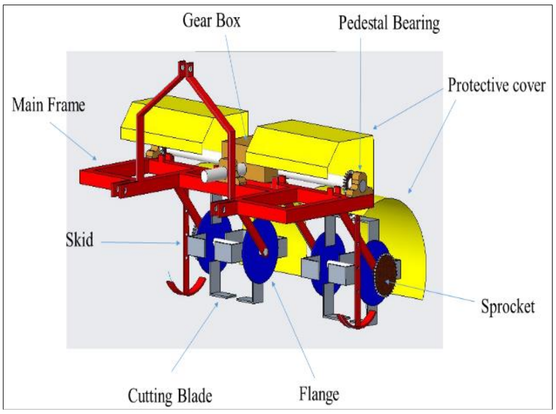
Vala VS, Kathiria RK and Bheda AK

Abstract
Every year India faces the total loss of 33% of its economy from weeds which accounts an average of 1980 Cr of rupees is wasted due to weeds. The Losses are due to some of the following reasons; total loss of 26% from Crop Diseases, total loss of 20% from Insects and Worms, total loss of 6% from Rats has been surveyed (Sridhar, 2013). Removal of weeds consumes 25% labour i.e. 900-1200 man–hour during the cultivation season (Kumar *et al*., 2002). Average weeding cost by traditional method is nearby Rs. 945/ha out of the total cost of cultivation Rs. 3000/ha for agricultural crop (Tajuddin *et al*., 1991). The overall dimension of rotary weeder was 1200×600×760 mm and fabricated with square pipe of 40 × 40 × 5 mm. The weeder was tested with 'L 'type blade and three different rotor RPM of 40, 60 and 80 RPM. For three different of 40,60 and 80 rotor rpm at operating speed of 1.5 km/h weeding efficiency were 98.28 %, 96.70 % and 96.28 % respectively and plant damage were 1.12%, 3.36% and 4.48 % respectively. Fuel consumption was obtain 2.10 l/h at operating speed of 1.5 km/h and effective field capacity and field efficiency were obtain 0.14 ha/h and 82 % respectively. Fabrication cost of rotary weeder was ₹ 39,700 and operational cost ₹ 328.25 /h and benefit cost ration and payback period were 3.54 and 2.84 year.

Keywords: rotary weeder; weeding operation; weeding efficiency; plant damage

Introduction
Weeds are the undesirable plants which grow with desired crop in the wrong place and in wrong time and doing harm to the desired crops. Weeds compete with the desired crops for water, sunlight, nutrient and available CO_2 (Rao, 1999) [7]. Weed removal has progressed from a system totally based on the physical efforts of humans through the use of animals, mechanical implements, and chemicals and to some extent biological methods. There are some weeds which have advantages but not when they are growing between the desired crops. Weeds reduce the productivity, increase the cost of cleaning and overall adversely affect the value of the land and thereby affecting the farmer's energy, time or money. Weeding operation is the process of elimination of unwanted plants so that the regular crops can be grown profitably. The quantitative and qualitative production of crop depends upon the effectiveness and timeliness of weeding operation. Weeds cause 45% of annual yield loss as compared to the disease 20%, insect 30% and pest 5%. Variant losses due to weeds are given as annual monetary loss of Rs. 19800 million (Mukhopadhyay, 1992) [4], in major crops Rs. 4200 million (Natarajan, 1987) [5] and in food grain 60 million tonnes (Biswas, 1984) [1].
The cultural practices the farmers indulge in depend upon socio- economic conditions of the farmer.
1) Chemical method
2) Cultural methods
3) Biological method
4) Solar control method
5) Manual uprooting of weeds
6) Mechanical method

Materials and Methods
Location of experiment
Field experiments were conducted at Vegetable Research Station, Junagadh Agricultural University, Junagadh during the academic year 2017-2018. Some laboratory experiments were conducted in the Department of Farm Machinery and Power Engineering.



Schematic view of mini tractor operated rotary weeder

Isometric view of Developed rotary weeder

Functional performance evaluation of the developed rotary weeder

The developed rotary weeder was tested in the field of okra sown at 60 cm row to row spacing. During its performance evaluation, its field capacity, weeding efficiency, plant damage, fuel consumption, speed of operation, cost of operation etc. were determined.

Soil parameters

Soil moisture (%)

Moisture content of the soil was determined by standard oven dry method. Five samples was taken from the different locations of the test plots in different moisture boxes. These was kept in oven for 24 hours at the temperature of 105^{0}C. The mass of wet and dry samples was determined and average moisture content on dry basis was calculated. (IS: 2720-2-1973) [2].

$$\text{Moisture Content (d.b.)\%} = \frac{W_w - W_d}{W_d} \times 100$$

Where;

Ww = Weight of the wet soil, g

Wd = Weight of the dry soil, g

Bulk density of soil

Metallic core cylinder was used to take sample from the field. Samples was taken in 100 mm diameter and 128 mm long core sampler. The samples was weighed with an accuracy of 0.1 gram. The dry weight of the samples was calculated from the moisture content (w.b.). The ratio of the dry weight of the soil to the volume gives the bulk density (Punmia *et al.*, 2009) [6].

$$\text{Bulk density of soil } \left(\frac{g}{cm^3}\right) = \frac{W - \left(W \times \frac{MC}{100}\right)}{V}$$

Where,

W= Weight of moist soil collected (g)

V= Volume of metallic core (cm3)

MC= Moisture content of the soil (%)

Machine performance parameters

Width of cut

The width of cut was determined by measuring the horizontal distance cut by implement with the help of measuring tape.

Depth of cut

The depth of cut was determined by measuring the distance between horizontal soil surfaces to the bottom of dug out furrow with the help of steel scale.

Plant damage

Number of plants present before the weeding (p) was counted. After the weeding, No. of plants damaged (q) was counted for the same row length. The percentage of plant damage was calculated with the help of formula given below.

$$\text{Percentage of plant damage (\%)} = \frac{q}{p} \times 100$$

Fuel consumption

The fuel consumption used by the machine was measured as per the standard prescribed method. The fuel tank of tractor was filled to its full capacity before and after test run. The quantity of fuel filled at the end of test divided by the total time of operation will give the fuel consumption.

Operating time

Operating time shall be measured once the machine started working to the time it finished working of the test area. Time losses for adjustment, turning and machinery breakdown shall be deducted from the total operating time.

Weeding efficiency

Weeds uprooted by the operation of the implement before and after the weeding operation was counted to calculate weeding efficiency. The weeding efficiency was calculated with the help of formula given below.

$$\text{Weeding efficiency (\%)} = \frac{X - Y}{X} \times 100$$

Where,

X= No. of weeds before operation per m^2 area

Y= No. of weeds after operation per m^2 area

Theoretical field capacity

$$\text{Theoretical field capacity } \left(\frac{ha}{h}\right) = \frac{\text{Width of coverage (m)} \times \text{Speed} \left(\frac{km}{h}\right)}{10}$$

Effective field capacity

It is the actual rate of work which includes the time lost in turning at the end of rows, making adjustments etc.

$$\text{Effective field capacity } \left(\frac{ha}{h}\right) = \frac{\text{Width of coverage (m)} \times \text{Length of strip (m)}}{\text{Time taken (h)} \times 10{,}000}$$

Field efficiency

Field efficiency is defined as the percentage of time the machine operates at its full rated speed and width while in the field.

$$\text{Field efficiency (\%)} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100$$

Results and Discussion

Field testing and evaluation

Field testing was conduct at Vegetable Research Station at Junagadh Agricultural University. The developed rotary weeder was tested in the field of okra sown at 60 cm row to row spacing. During its performance evaluation, its field capacity, weeding efficiency, plant damage, fuel consumption, speed of operation, cost of operation etc. were determined. The developed tractor operated rotary weeder was tested with an available 15 hp tractor for its performance evaluation.

Table 1: Field parameters

S. No	Particular	Observation
1	Name of the crop	okra
2	Variety of crop	Sankar okra-3
3	Type of soil	Medium black soil
4	Plant geometry	R – R: 60 cm
5	Day of weeding after sowing	40 day
6	Soil bulk density	1.18 g/cc
7	Area of operation	1152 m2
8	Height of crop at time of weeing operation	15 to 20 cm
9	Depth of weeding	4 to 6 cm
10	Width of weeding	40 cm
11	Rpm of power drive	540
12	Rpm of cutting blade	40,60,80

Soil parameters

Soil moisture (%)

The soil moisture content of the experimental field at the time of operation was determined and it was found as 14.18 % on dry basis.

Bulk density

The bulk density of soil of experimental plot was determined as presented in and it was found as 1.18 g/cm^3.

Machine performance parameters

Width of cut

The working width of rotary weeder was observed as 40 cm for single row and 80 cm for two row operation.

Depth of cut

The working depth of cut was found as 4 to 6 cm during the operation by the developed rotary weeder.

Plant damage

For developed rotary weeder, plant damage depended rpm of the rotor shaft. If the RPM of rotor shaft was high, then plant damage was found. Found highest plant damage was observed at 80 rpm of rotor shaft. Plant damage at 40, 60 and 80 rpm was found as 1.12, 3.36 and 4.48 respectively. Number of plants present before the weeding (p) were counted. After the weeding, the number of plants damaged (q) was counted for the same row length.

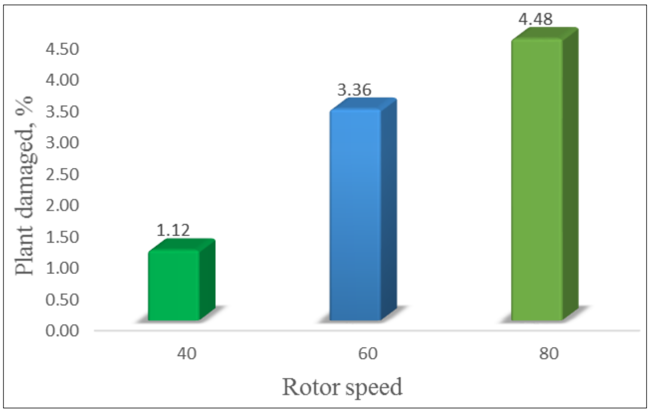


Fig 1: Graphical representation of plant damage Vs rotor speed

Fuel consumption

Fuel consumption was measured by top up method. The fuel tank was filled full before the staring of operation and after one hour of its operation, the tank was filled again. The quantity of refuelling fuel after 1 hr was measured. The fuel consumption of the tractor with rotary weeder was determined as 2.10 l/h.

Operating time

Operating time was measured once the machine started working to the time it finished working of the test area. Time losses for adjustment, turning and machinery breakdown were deducted from the total operating time.

Table 2: Turning time

Particular	Test No.				Average
	1	2	3	4	
Time loss in turning, s/turn	10	13	12	10	11.25

Weeding efficiency

Weeds uprooted and mixed in soil by the operation of the implement, before and after the weeding operation was observed to calculate weeding efficiency. Weeding efficiency for 40, 60 and 80 rotor rpm were 98.28, 96.7 and 96.28 % respectively. The higher weeding efficiency was observed due to its weeding mechanism, number of blade on flange and type of blade. In all three speeds, the weeding efficiency was found higher.

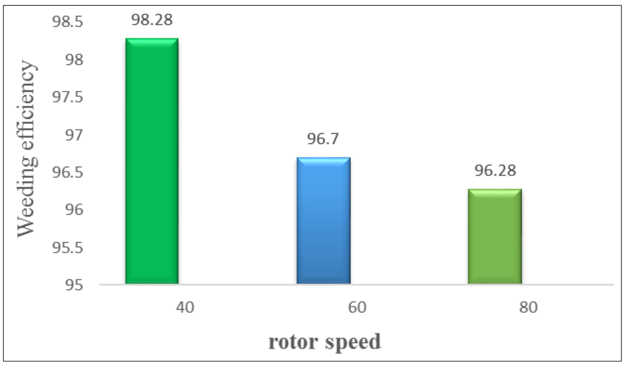


Fig 2: Graphical representation of weeding efficiency Vs rotor speed

Theoretical field capacity

Theoretical field capacity depends on the width of weeding and speed of operation. The theoretical field capacity of the developed rotary weeder was found as 0.18.

Effective field capacity
It is the actual rate of work which includes the time lost in turning at the end of rows, making adjustments etc. Effective field capacity of developed rotary weeder was found as 0.1476 ha/h.

Field efficiency
The field efficiency of the developed rotary weeder was determined as 82 %.

Performance index
The performance index was calculated to know the overall performance of the weeder. It is the function of the weeding efficiency, field capacity, power required and plant damage. The performance index was determined with the help of formula given below.

$$P.I. = \frac{A \times E \times (1- D)}{P} = \frac{0.14 \times 98.28 \times (1- 0.0112)}{15} = 0.907$$

Conclusions
1. The developed rotary weeder tested in field and it has worked satisfactory.
2. The parts and components were strong enough to work with great efficiency.
3. The developed rotary weeder was found best and safe for weeding operation.
4. Fuel consumption was obtain 2.10 l/h at operating speed of 1.5 km/h and effective field capacity and field efficiency were obtain 0.14 ha/h and 82 % respectively.
5. For three different of 40,60 and 80 rotor rpm at operating speed of 1.5 km/h weeding efficiency were 98.28 %, 96.70 % and 96.28 % respectively and plant damage were 1.12%, 3.36% and 4.48 % respectively.
6. Fuel consumption was obtain 2.10 l/h at operating speed of 1.5 km/h and effective field capacity and field efficiency were obtain 0.14 ha/h and 82 % respectively.

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