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Performance Evaluation of Tractor Drawn Rotavator

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Abstract: *The Indian farming employs 225 million workforces to cover 140 million hectares of total cultivated land. In spite of rapid farm mechanization the vast resource-poor family farming has primary dependence on traditional method. The effective farm mechanization contributes to increase in production in two ways firstly the timeliness of operation and secondly a good quality of work. Even the Indian agriculture can be achieved by increasing land under cultivation, timely farm operation, reduction of cost of operation, adoption of tractor drawn rotavator. Farmers presently using implements for seedbed preparation so there is necessity to study all the parameters by which we can reduce cost of operation and increase the net profit. For performance evaluation of rotavator in terms of width and depth of cut, speed of operation, fuel consumption, theoretical and effective field capacity. Also soil parameters like soil moisture content like, type of soil, bulk density etc were calculated. The performance of rotavator was evaluated for medium black and trashy soil. The cost of operation of uncultivated land was 1987.92 ₹ /ha and that of cultivated land was 1667.29 ₹ / ha. It is found that the field efficiency for cultivated land was found to be more than uncultivated land.*

Keywords: *Bulk density, Rotavator, Field capacity etc.*

INTRODUCTION

The scientific and technological innovations have been the basis for promoting agricultural development. The effective mechanization contributes to increase in production in two major ways. First is the timeliness of operation and secondly a good quality of work. Tillage is the most important unit operation in agriculture. It is done mainly to loosen the upper layer of soil, to mix the soil with fertilizer land to remove weeds. As a result of this processing the water-air thermal and nutrient regimes of the soil are improved in the interest of the growth and development of crops. Rotavators works in three main different ways like ploughing, pulverizing and leveling. After these operations plough, disc harrow, and levelers replace it. To perform these operations rotavator is the best implement which will do ploughing, pulverizing and leveling of field by saving time, fuel, labour cost.

Rotavators application is costly operation, as it requires energy for its use. It requires about 70% of the power used in farm. Although it requires high energy, its operational cost can be minimized by proper selection, adoption and matching of various tillage implements with power source. The use of rotavator, which is powered by PTO shaft of the tractor, reduces cost of cultivation as well as increasing the returns of farmers.

As the present implements used for the seed bed preparation by farmers there is necessity to study best alternate option either operation wise or equipment wise, by which we can reduce the operational cost and improve the use of system effectively.

MATERIAL AND METHODS

Theoretical Consideration

Different Tillage Practices and Implements Used For Seed Bed Preparation

The working tool of rotary machine executes complex motion consisting of relative rotary motion

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around the axis of cutter drum with a velocity of Vr and translatory forward motion with a velocity of Vt.

Theory of Rotary Tillage

Different ratio of the rotary and translatory velocities of motion λ = Vr/Vt give different trajectories of the motion of the working tools. If the cutter drum turns at angular velocity ù and has a velocity of translation Vt, then a point A on the edge of the cutter wheel moves along the trochoid curve. In fact if O the centre of the cutter drum is taken as the origin, the segment of OO1 will represent the path traversed by centre of the drum during the time interval t and will be equal to Vt. During the same period the cutter drum will rotate through an angle ωt and the point A will assume the position A1. The co-ordinates of the points A1 are given by the parametric equation of Trochoid.

$$X = Vt + R\cos\omega t,$$

$$Y = R\sin\omega t.$$

Working of Rotavator

The preferable working depth is between 5 and 15 cm. For seedbed preparation, however the tilling depth should not exceeds 10 cm.

Soil Parameters

The observations on type, soil characteristics, moisture content, cone index and bulk density of soil in which the rotavator was tested have been recorded.

1. Type of Soil: The soil type was medium black and covered partly with trashes of last crops grown.
2. Soil Moisture Content: The samples were put in a hot air oven maintained at 105°C for 8 hours. After oven drying they weighted. The soil moisture (% d.b.) was calculated by using the formula;

   Soil moisture (% d.b.)

$$= \frac{(weight\ of\ wet\ soil\ sample) - (weight\ of\ oven\ dry\ sample)}{Weight\ of\ oven\ dry\ sample} \times 100$$

3. Bulk Density: Bulk density was measured by using given formula:

$$\text{Bulk density of soil} = \frac{M}{V} = \frac{4M}{\pi D^2 L}$$

Where,

M = mass contained in core sample of oven dry soil (gm).

V = volume of cylindrical core sample (cm^3)

D = diameter of cylindrical core sample (cm)

L = length of cylindrical core sample (cm)

MACHINE PARAMETERS

Specification of Rotavator

The machine parameters like overall dimensions, types & no. of blades, width of operation, weight of machine, thickness of blade etc. was tabulated

FIELD PARAMETERS

In this section the observations for uncultivated land cultivated land are considered separately.

1. Operating Speed

$$\text{Travel speed (km/h)} = \frac{D \times 3.6}{Tp}$$

Where,

D = Distance (m)

Tp= Productive time (sec.)

2. Working Width and Working Depth

After rotavator operation, the working width was measured at three random places at an interval of approximately 5 m apart.

3. Wheel Slip

The Percentage of wheel slip is also called travel reduction ratio.

$$\text{Wheel slip (\%)} = \frac{(A - B)}{A} \times 100$$

4. Rotating Speed of Blades on Axle

The rpm of the blades on the axle is equal to the half of the PTO rpm, which is continuously reduced from the engine towards the PTO. The rpm of the blades on the axle is directly proportional to the rpm of the PTO.

5. Theoretical Field Capacity

The theoretical field capacity was measured by given formula

$$\text{Theoretical field capacity} = \frac{W \times S}{10}$$

Where,

W = Working width of the implement (m)

S = Travel speed of tractor (km/h)

6. Effective Field Capacity

The effective field capacity was calculated by given formula.

$$\text{Effective field capacity (s)} = \frac{A}{(Tp + Ti)}$$

Where,

S = Effective field capacity (ha/hr)

A = Area covered (ha)

Tp= Productive time (h)

Ti = Non productive time (h)

7. Field Efficiency

This gives an indication of the time lost in field and the failure to utilize the full working width of the machine. It was calculated as follows:

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

8. Power Consumption

It is calculated according to the fuel requirement i.e. the fuel consumed during the rotavator operation and according that the power requirement is calculated.

9. Soil Inversion

It is quantitatively expressed as the ratio of no of weeds or stubbles of last crop left on soil surface after the operation to that before it.

$$F = \frac{Wp - We}{Wp} \times 100$$

Where,

F = Indicator for soil inversion: ratio of weed or crop stubble being filled up.

Wp = No. of weeds or crops or stubble before operation per unit area

We = No. of weed or stubble exposed on the surface after operation

A square frame having slides 50 cm or 100 cm is convenient for counting weed or the stubble.

10. Operational Cost Evaluation

There are two types of operating costs

(A) Fixed cost

(B) Variable cost

(A) Annual Fixed Cost

(1) Depreciation $= \frac{C - S}{L \times H}$

Where,

C = Purchase price

S = Salvage price (normally 10% of the purchase price)

L = Total life in years

H = Annual working hours (1000hrs)

(2) Interest

$$\text{Interest} = \frac{C + S}{2} \times \frac{i}{H} \times 100$$

Where,
i = Interest rate (normally up to 10%)

(3) Repair and maintenance cost

=10% of initial capital per year

(4) Housing+Taxes+Insurance

=3% of initial cost per year

(5) Hourly Fixed Cost

It is obtained by dividing annual fixed cost by operating hoursperyear.

Variable Cost

Variable cost per hour, unit area and unit weight of crop are calculated with test data. Variable cost includes following expenses

(1) Fuel and lubricating oil and electric power

(2) Other expenses

(3) Labour charges

RESULTS AND DISCUSSION

1. Soil Moisture Content

By oven drying method the moisture content of the soil for uncultivated land as well as cultivated land was measured for three different locations within the field and the result of m. c. for uncultivated land were 4.94, 4.14 & 5.14% and its average was 4.73% (d.b.) and moisture content for cultivated land was measured to be 7.15, 7.38 & 7.25% thus the average moisture content was measured as 7.26%.

2. Bulk Density of Soil

Bulk density was measured for two fields for uncultivated land and cultivated land. In the uncultivated land readings of density were taken, it gave 1.56 gm/cm^3 as bulk density before rotavator operation. And in the same field after rotavator operation, it was 1.39 gm/cm^3. It indicated the increase of pore space due to loosening of soil and bulk density of soil was reduced to about 10.9% by rotary tiller operation and after that bulk density was measured in the cultivated land where the testing was done after harvesting where also two readings for bulk density were taken before and after rotavator operation which were 1.40 % and 1.24% respectively.

FIELD OBSERVATIONS

1. Operating Speed

During field operation of rotavator, in the uncultivated the distance of traveling was kept as 20 m, and it was fixed for all passes. The time taken by tractor to cover the distance was recorded as 544, 539 & 543 sec. respectively. So, the speed was 2.19, 2.21& 2.23 km/h respectively. And its average was taken as the traveling speed, which was 2.21 km/h. in the cultivated land, the distance was fixed as 20m, and the time taken by the tractor to cover the distance was recorded as 459,463 & 464 sec. respectively. So, the speed was 2.58, 2.62& 2.60km/h respectively and its average was taken as operating speed, which was 2.60km/h.

2. Percentage Wheel Slip

The percentage of tractor wheel slip, in the uncultivated land the wheel slip was measured to be -0.93, - 0.94 and -0.95 the average was -0.94%. Similarly observations for cultivated land were also taken, in cultivated land the wheel slip was measured to be - 0.88, -0.90 and -0.92 the average was -0.90%.

3. Rotating Speed of Blades on Axle

The rotating speed of blades on the axle was measured to be reduced by about 50% from the PTO rpm, so the speed of the shaft was measured to be 270 rpm in the rotavator.

4. Working Width and Depth

At the time of operation in the field, the average width of cut by rotavator was found as 120 cm where as the dimensional measurement of width of rotavator was 140 cm. The average working depth of cut off rotavator was found as 7 cm at 4.73 % (d.b.) moisture content.

5. Theoretical Field Capacity

The average theoretical field capacity, for uncultivated land was measured as 0.27 ha/ and the average field capacity for the cultivated land was measured as 0.31 ha/h. The theoretical field capacity of cultivated land is more than that of uncultivated land.

6. Effective Field Capacity

The average effective field capacity, for uncultivated land was calculated as 0.22 ha/h similarly the average effective field capacity for cultivated land was calculated as 0.28 ha/h. It was found to be better than other tillage practices for seedbed preparation.

7. Field Efficiency

The average Field efficiency for uncultivated land was calculated as 84%. Similarly the average effective field capacity for cultivated land was calculated as 90%.

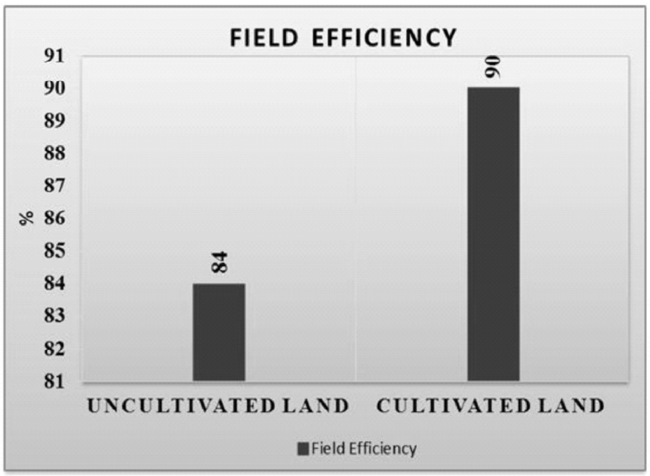

Figure 1: Field efficiency

8. Power Consumption

The power consumption of rotavator for uncultivated and cultivated lands was measured and it was found that the power requirement for uncultivated land was 7.12 hp and for cultivated land it was 6.09 hp.

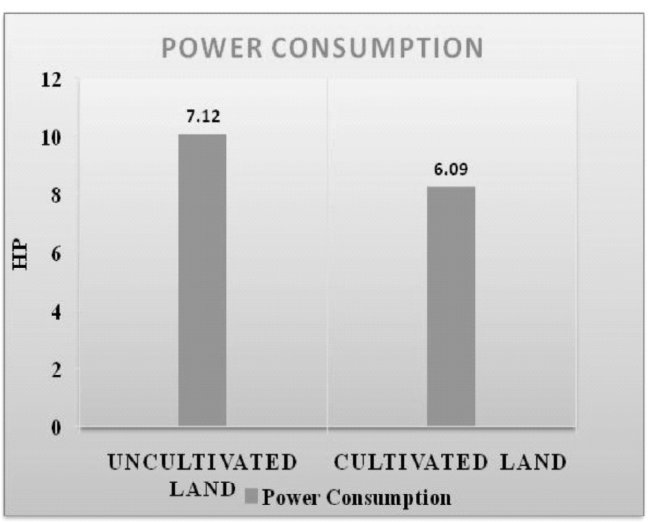

Figure 2: Power Consumption

9. Soil Inversion

The soil inversion was measured in both the uncultivated and cultivated lands, and the readings of both the lands were found to be 77.7% and 84% respectively.

CONCLUSION

(1) Total power consumption for rotavator operation in the uncultivated land was measured to be 7.12 hp whereas in case of cultivated land it was 6.09 hp. It shows that the time required for rotavator operation in the uncultivated land was more than the time required for the cultivated land.

(2) The field capacities of rotavator were observed as 0.22 and 0.28 with the field efficiency as 84% and 90% in case of uncultivated land and cultivated land respectively

(3) The percentage of soil inversion was measured as 77.7% and 84% in uncultivated land and cultivated land respectively.

(4) The cost of operation was calculated as 1987.92 [1] /ha and 1667.29 [1] /ha for uncultivated land and cultivated land respectively.

(5) The tillage operation by traditional method was calculated as 1520 [1] /ha.

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