RESEARCH PAPER International Journal of Agricultural Engineering | Volume 10 | Issue 1 | April, 2017 | 72-77
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/10.1/72-77**

A comparative study on performance of a rotavator in barren and fertile land

■ **RAJESH MODI AND BHABANI SHANKAR DASH**

Received : 17.01.2017; **Revised :** 23.02.2017; **Accepted :** 09.03.2017

See end of the Paper for authors' affiliation

Correspondence to :

RAJESH MODI
Department of Farm Machinery and Power, Aditya College of Agricultural Engineering and Technology, BEED (M.S.) INDIA
Email : rmodi0701@gmail.com

■ **ABSTRACT :** The mechanisation of agricultural practices has resulted in increased agricultural productivity in India. As a consequence it seems that, rotary tillage implements are now being projected as important tools in obtaining fine tilth in soil. Even the Indian agriculture can be profitable by increasing land under cultivation, timely farm operation, reduction of cost of operation, adoption of tractor drawn rotavator etc. The rotavator was tested 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, type of soil, bulk density etc. were studied. The performance of rotavator was evaluated for medium black and trashy soil. The cost of operation of fertile land was found to be 1988 Rs./ha and that of cultivated land was 1668 Rs./ha. It is found that the field efficiency for cultivated land was found to be more than barren land.

■ **KEY WORDS :** Rotavator, Barren land, Fertile land, Cost of operation

■ **HOW TO CITE THIS PAPER :** Modi, Rajesh and Dash, Bhabani Shankar (2017). A comparative study on performance of a rotavator in barren and fertile land. *Internat. J. Agric. Engg.*, **10**(1) : 72-77, **DOI: 10.15740/HAS/IJAE/10.1/72-77.**

Agricultural mechanization embraces the use of implements and machines for a wide range of farm operations from land preparation to storage. Effective farm mechanization contributes to increase in production in many ways like obtaining the timeliness of operation, quality of work, reducing drudgery of operator etc. Mechanisation mostly depends on input sources such as farm power, it include hand tools, draft animals, and mechanically-powered technologies. The farm power input per unit fertile land in India is still very low compared to South Korea of 7 kW/ha, Japan 14 kW/ha and United State of America of 6 kW/ha (Mehta, 2013). The farm power availability in 2013-14 was 2.02 kW/ha (Singh *et al.*, 2014) and availability of labour to work in agriculture is crucial in sustaining agricultural production. The population dynamics of Indian agricultural workers shows that by 2020, the population of agricultural workers in the country will be about 230million of which 45 per cent will be the female workers (CIAE, 2015). In spite of rapid farm mechanisation the vast resource-poor family farming has primary dependence on traditional method. Traditionally draught animals have been used in India for seedbed preparation. With increased cropping intensity, farmers have supplemented animate power with tractors, power tillers. Farm power ensures timeliness operations, besides reducing drudgery. Available farm power and energy use per hectare are the indicators of modernization of agriculture. In developing countries like India, few farm operations have been partially mechanized and rest of the operations are done by the draught animals. The land preparation aspect of crop is energy intensive operation due to the presence of heavy soils and tendency to develop cracks. At present, because of lack of knowledge, experience and facility, farmers are stuck to the tractor operated/ bullock operated MB ploughs and blade harrows for land preparation. However, a considerable attention in recent years has been directed toward the potentialities of multipowered tillage tool, like rotavator. It obtains power from a rotary source, usually the tractor power take off (PTO). In rotavator tillage system energy consumption was less at the same time pulverization index obtained was minimum (Potekar and Tekale, 2004). Reduced draft requirements and greater versatility in manipulating the soil to obtain desired results are two reasons for considering it more complex types of implement. If draft requirements can be reduced by utilising at least part of a tractor's output through non tractive means, the tractor can be made with less mass, which will reduce its cost and soil compaction too. Farmers are presently using rotavator 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.

■ METHODOLOGY

The project was under taken to compare the cost of operation and evaluate other parameters as well, at the fields of Marathwada region in Maharashtra. A tractor mounted (PTO driven) Shaktiman make rotavator was tested in barren and fertile land as two fields for comparison. An analytical power consumption model for the typical small rotavator with L-shaped blades was deduced (Libin Zhang *et al.*, 2010) on the basis of this L-shape blade rotavator was selected.

Table A : L-shape blade rotavator

Sr. No.	Particulars	Specification
1.	Make	Shaktiman (SRT-4)
2.	Length of machine, cm	120
3.	Width of machine, cm	140
4.	Height of machine, cm	100
5.	Type of blade	L-Shaped
6.	Total no. of blade	30

Soil parameters :

Soil parameters which influence the working of rotavator with barren and fertile land, respectively, were, considered for study. The observations on type, soil characteristics, moisture content, cone index and bulk density of soil in which the rotavator was tested had recorded.

Type of soil :

The soil type was medium black and covered partly with trashes of last crops grown.

Soil moisture measurements :

Soil moisture measurements were monitored immediately after operation, samples of soil were taken from three different locations of test plot selected randomly with three replications. Weight of each soil sample was measured with the help of weight balance. The samples were put in a hot air oven maintained at 105°C for 8 hours. After oven drying they were weighted. The soil moisture (% d.b.) was calculated by using the formula;

Soil moisture (% d.b.)

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

Bulk density :

The bulk density of soil was measured with the help of cylindrical core. The diameter and length of cylindrical core was measured. The core sample was kept in hot air oven maintained at 105 °C for 8 h. At the end of 8 h, the sample was taken out from the oven and cooled down in desiccators and weighted in a physical balance. Bulk density was measured by using given formula:

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

where,

M = Mass contained in core sample of oven dry soil (g).

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

D = Diameter of cylindrical core sample (cm)

L = Length of cylindrical core sample (cm)

Specification of rotavator :

A tractor mounted Shaktiman (SRT-4) make was tested in two fields for comparison. The rotavator blades are self-sharpening under normal conditions. The blades are arranged on a rotor in spiral or scroll pattern. Due to such arrangement no more than one blade can strike the soil surface at a time. It has 30 most common type L shaped blades, which are superior to others in heavy trash conditions, for chopping of weeds, mixing of surface residues or manure and freedom from blockage.

Machine factors affecting soil pulverization :

The pulverization of soil is affected by machine parameters like rotor blade layout; position of shield, speed of rotor and forward speed of rotavator, a rotavator can have two blade layouts. A three blade provides better tilth as compared to two-blade layout. A fine tilt is obtained at higher rotor speed and slow speed with shield down whereas a higher forward speed and slow rotor speed with shield up results in coarse tilth.

Field parameters :

In this section the observations for barren land fertile land are considered separately.

Operating speed :

Outside the long boundary the test plot, two poles 20 m apart (A, B) are placed approximately in the middle of the test run. On the opposite side also two poles are placed in a similar position, 20 m apart (C, D) so that all four poles from the corners of a rectangle, parallel to at least one side of the test plot. The speed was calculated from the time required for the machine to travel the distance (20m) between the assumed line connecting two poles opposite side AC and BD. The visible point of the machine should be selected for measuring the time. The time is measured with the help of the stop watch.

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

where,

D= Distance (m)

Tp= Productive time (sec.)

Working width and working depth :

After rotavator operation, the working width was measured at three random places at an interval of approximately 5m apart. The value of working width was determined similarly, after determining the working width, the working width was measured at four random places and its average was taken as the final working depth for calculation.

Wheel slip:

The percentage of wheel slip is also called travel reduction ratio. The amount of wheel slip was determined by marking on the tractor drive wheel with coloured chalks or tapes and the distance moved by the tractor moving forward was measured, at 20 revolutions under no load (A) and on same surface with same number of revolutions with load (B).

$$\text{Wheel slip (\%)} = \frac{\text{(A - B)}}{\text{A}} \text{x100}$$

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.

Theoretical field capacity :

Theoretical field capacity means actual area covered based on actual width based on 100 per cent time consideration. The theoretical field capacity was measured by given formula :

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

where,

W = Working width of the implement (m)

S = Travel speed of tractor (km/h)

Effective field capacity :

In the data sheet time lost for event such as turning was recorded. However, in calculating field capacity the consumed for the work and also time lost for other activities such as turning and adjustment were also used. So during the operation the loss of time during the turning was calculated. The effective field capacity was calculated by given formula :

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

where,

S = Effective field capacity (ha/h)

A = Area covered (ha)

Tp= Productive time (h)

Ti = Non-productive time (h)

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:

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

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. The fuel tank was filled upto the full level and the time for rotavator operation was noted down. At the end of the operation the total time consumed for operation was noted down and the level of the fuel in the fuel tank was cheeked again. This way the power consumption for rotavator operation was determined.

Soil inversion :

It is quantitatively expressed as the ratio of number 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 = Number of weeds or crops or stubble before operation per unit area

We = Number 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.

Operational cost evaluation :

There are two types of operating costs

- Fixed cost
- Variable cost

Annual fixed cost :

$$\text{Depreciation} = \frac{C - S}{L \times H}$$

where,

C = Purchase price

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

L = Total life in years

H = Annual working hours (1000hrs)

Interest :

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

where,

i = Interest rate (normally upto 10%)

Repair and maintenance cost :

=10% of initial capital per year

Housing+Taxes+Insurance :

=3% of initial cost per year

Hourly fixed cost :

It is obtained by dividing annual fixed cost by operating hours per year.

Variable cost :

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

- Fuel and lubricating oil and electric power
- Other expenses
- Labour charge

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Soil parameters :

Type of soil :

The soil type was medium black and covered with root and trash.

Soil moisture content :

By oven drying method the moisture content of the soil for barren land as well as fertile land was measured for three different locations within the field and the result of m. c. for barren land were 4.73 per cent (d.b.) and moisture content for fertile land was measured to be 7.26 per cent (d.b.). Apparently, it is concluded that moisture content was higher as considerable, drying had not taken place as compared to previous field so moisture content in this field was higher than the barren land.

Bulk density of soil :

In the barren land readings of density were taken, bulk density before rotavator operation and in the same field after rotavator operation, it gave 1.56 g/cc and 1.39 g/cc, respectively. It indicated the increase of pore space due to loosening of soil and bulk density of soil was reduced to about 10.9 per cent by rotary tiller operation and after that bulk density was measured in the fertile 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 per cent and 1.24 per cent, respectively. The overall measurement shows that due to the moisture which was more in the fertile field which was harvested recently thus bulk density was less in the fertile land as compared to the barren land field which was not in use for 15-20 days and, therefore, having less moisture content and high bulk density.

Field observations :

Operating speed :

The operating speed obtained in the fertile and barren land was 2.21 km/h and 2.60km/h, respectively though the distance was fixed as 20m. At low travel speed, it gave intensive tillage as increased in travel speed, cross-section area and volume of slice also increased.

Percentage wheel slip :

The percentage of tractor wheel slip, in the barren land the wheel slip was measured to be -0.94 per cent. Similarly observation for fertile land was also recorded, as in fertile land the wheel slip was measured to be -0.90 per cent. The wheel slip was negative because rotavator pushes the tractor ahead during operation so, distance covered by tractor with load for specific revolutions of tractor wheel was more as compared to the distance covered without load. Eventually, power loss due to the slippage was very less.

Working width and depth :

At the time of operation in the field, the average width of cut by rotavator was found as 120 cm whereas the dimensional measurement of width of rotavator was 140 cm the average working width was somewhat less than actual width of machine due to overlapping of operation.

Theoretical field capacity :

The average theoretical field capacity, for barren land was measured as 0.27 ha/h and the average field capacity for the fertile land was measured as 0.31 ha/h. The theoretical field capacity of fertile land was more than that of barren land. It was due to that the actual working width could not be more than utilized to the maximum range, whereas in the fertile land the working width was utilized as that land was more favorable for ploughing operation than the barren land.

Effective field capacity :

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

Field efficiency :

The average field efficiency for barren land was calculated as 84 per cent. Similarly the average effective field capacity for fertile land was calculated as 90 per cent. It gives clear indication that during the operation in barren land the full working width of the machine could not be utilized thus its field efficiency was less than that

Table 1 : Comparison of cost of operation for barren and fertile land

Sr. No.	Particulars	Barren land (Rs.)	Fertile land (Rs.)
1.	Depreciation	7005	7005
2.	Interest	4280	4280
3.	Housing+ Insurance+ Tax	1828	1828
4.	Repair and maintenance	7783	7783
5.	Hourly fixed cost	65	65
6.	Fuel and lubricating oil	1000	1000
7.	Labour charges	300	300
8.	Total operating cost (Rs./ha)	1988	1668
9.	Total operating cost (Rs./h)	543	517

of the fertile land.

Power consumption :

The power consumption of rotavator for barren and fertile lands was measured and it was found that the power requirement for barren land was 7.12 hp and for fertile land it was 6.09 hp. This shows that, the power requirement for barren land was more because it took more time for the field for seedbed preparation in comparison to the time required for the fertile. After the fuel consumption was found then from the table the specific fuel consumption was found as 221 g/bhp/h.

Soil inversion :

The soil inversion was measured in both the barren and fertile lands, and the readings of both the lands were found to be 77.7 per cent and 84 per cent, respectively. It shows that the percentage of soil inversion in the barren land was less than that of the fertile land in comparison to the fertile land made it is easy for rotavator to uproot the weeds.

Cost of operation:

The cost of rotavator operation in terms of operational cost 517 Rs./h and operational cost 543 Rs./ ha for barren land was more than that of the fertile land because the effective field capacity of the barren land was less than that of the fertile land (Table 1). Thus, the operational cost of rotavator proved to be more economical in the fertile land in comparison to the barren land. The detailed description of all the relevant data have been given in Table 1.

Authors' affiliations:
BHABANI SHANKAR DASH, Division of Agricultural Engineering, Indian Agricultural Research Institute, PUSA (NEW DELHI) INDIA

REFERENCES

Libin, Zhang, Jiandong, Jiang and Yanbiao, Li (2010). Agricultural rotavator power requirement optimization using multi-objective probability parameter optimization. *Internat. Agric. Engg. J.,* **19** (3) : 15-22.

Mehta, C.R. (2013). Agricultural Mechanization Strategies in India.

Potekar, J.M. and Tekale, D.D. (2004). Comparative performance of tractor drawn implements tillage system with rotavator tillage system. *Karnataka J.Agric.Sci.,* **17**(1) : 76-80.

Report (2015). Vision 2050, Central Institute of Agricultural Engineering, Indian Council of Agricultural Engineering, Bhopal.

Singh, Surendra, Singh, R.S. and Singh, S.P. (2014). Farm Power availability on Indian Farms. Agricultural Engineering Today.