Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; Sp 9(6): 529-531
Received: 22-09-2020
Accepted: 24-10-2020

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Performance evaluation of tractor drawn rotavator for dry and wet land preparation

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Abstract
This research paper gives details about the performance of the tractor-drawn rotavator for dry and wet land preparation in the farmer's field. The rotary tiller is used as a primary as well as secondary tillage implement and having three different shapes of the blade. The L-shaped blades were attached to the rotavator's rotor to evaluate the performance. The wheel slippage was found 1.22 to 2.10% and 3.90 to 5.88% for the dry land conditions and wetland conditions, respectively. When the moisture in the soil increases the wheel slippage also increased. The research found that the puddling index varies indirectly proportional to the speed of operation. The study revealed that the average wheel slippage 3.90, 4.07, and 5.58% were found at an average speed of operation 1.5, 2.0, and 2.5 km/h, respectively on wet land field conditions.

Keywords: rotary tiller, blade, rotor, puddling index, wet land

Introduction
Rotavator (rotary-tiller) is a tractor-drawn implement that is mainly used for seedbed preparation. It is suitable in removing and mixing residual of maize, wheat, sugarcane, etc., thereby, helps to improve soil health and save fuel, cost, time & energy as well. One or two passes of this implement are adequate for good pulverization of soil and crop condition. It is not recommended for sandy soils. Depth of penetration can be adjusted up to 125mm (Handbook 2013) [3]. It is very useful and effective for puddling (paddy/rice field preparation with water). Concerning the depth of tillage, the rotavator is unique in that during its operation, the actual depth of tillage for each blade changes throughout the rotational path of the cutting operation (Marenya, 2015) [4]. Concerning the size of the rotavator, the large rotavator more efficient than the small rotavator in field preparation because weeds are cut in pieces and properly mixed with soil; it helps to less fuel consumption, and effective field capacity is greater (Pradhan *et al*., 2015) [6]. The L-shaped blades are attached to the rotavator to evaluate the performance. The L-type blades provide the greatest forward thrust to the tractor to which it was attached. A difference of about 23.74 N thrusts per bank between L and C blades was reported which was not worth considering given the 30% power reduction in using C-blades (Benny *et al*., 1970) [2]. The specific work required by the L-shaped blades was found comparatively higher than the other two types (I and C- shaped) over a similar range of operating conditions. (Prakash *et al*., 2013) [7].

Material and Methods
Rotavator (rotary-tiller) is equipped with a three-point linkage operated with a tractor power take-off (PTO) shaft. To evaluate the performance of the rotavator various tests were performed in a laboratory as well as field conditions. Hatch (L- shape) blade was used in the rotavator for evaluation of their performance. The present research "performance evaluation of tractor-drawn rotavator" was carried out at agronomical conditions of tillage treatments were carried out using L- shape blade rotavator on the farmer's field.

Fig 1: Operation view of implement

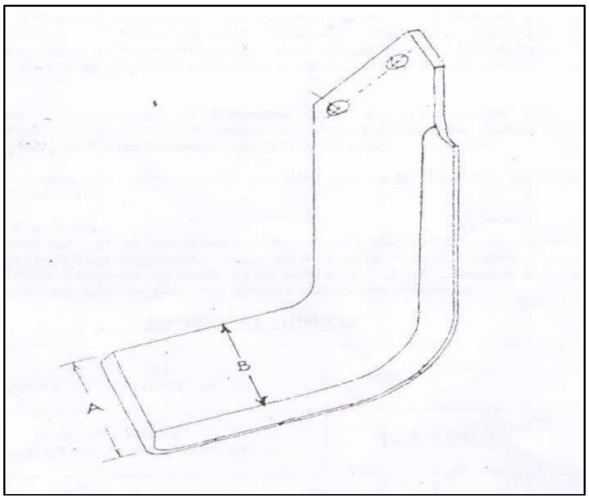

Fig 2: Sectional view of L-shaped blade

Table 2: Constructional details of implement

S. no.	Particulars	Specification
1.	Name of Implement	Tractor operated rotavator
2.	Type	Tractor PTO operated (Mounted type)
3.	Type of blade	L- shape
4.	Size, mm Rotor dia × Working width	466 × 2420
5.	No. of flanges and Diameter (mm)	9 and 260
6.	Type of flange	A circular disc of M.S. plate
7.	No. of blades on each flange	6 blades on 9 flanges
8.	Distance between two flanges (mm)	240
9.	Total No. of blades	54
10.	Tractor horsepower required	50 and above

Observation Recorded

Moisture content on a dry basis

The moisture content was determined on a dry basis, soil samples were collected randomly in a field with the help of the core sampler of 10 cm diameter and height 13 cm. Soil samples were dried in the oven for 24 hours at 105 °C. The dried sample was re-weighed and the weight was recorded. The soil moisture content (dry basis) was calculated by using the formula (Mari *et al*., 2011) [5].

$$\text{Moisture content, db(\%)} = \frac{\text{Weight of moist soil} - \text{Weight of dry soil}}{\text{Weight of dry soil}} \times 100$$

Bulk density

Undisturbed soil cores were collected by driving with an iron hammer 10 cm diameter metal cylinder into the depth in the plot. Bulk density was calculated based on volumes and dry weights of the soil samples by using a core penetrometer of 10 cm diameter and 13cm height. Bulk density (g/cc) was measured with the help of the following formula (Mari *et al*., 2011) [5].

$$\text{Bulk density, (gm/cc)} = \frac{\text{Weight of soil (gm)}}{\text{Volume of soil (CC)}}$$

Puddling Index

The puddling index was determined according to the standard procedure laid down by BIS. Samples of soil–water suspension were taken by immersing a graduated glass tube to a depth of 100 mm behind the rotavator. Samples were collected from each plot immediately during puddling. These samples were kept undisturbed for 48 h to allow the soil particles to settle down. After 48 h, the volume of settled soil, as well as total volume of soil–water suspension, was recorded and the puddling index was calculated as. (Anonymous, 1985) [1].

$$\text{Puddling Index, (\%)} = \frac{Vt}{Vs} \times 100$$

where, V_t = total volume of soil– water suspension in the test tube, and V_s = Volume of soil settled in the test tube.

Wheel slip

The wheel slip was determined by making a mark on tractor and power drive wheels with colored tape and measuring the distance traveled by wheels for a particular number of revolutions under no load on the firm surface and with the same number of revolutions under the actual field operations. The slip was calculated as given below:

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

Where:

A= the distance traveled by the drive wheel under no-load conditions in a known number of (say in 10) revolutions on the firm surface.

B= the distance traveled by the drive wheel under actual field operation in the same number of (say in 10) revolutions.

Fuel consumption

For measuring the tractor fuel consumption the fuel tank was filled before and after the test. The amount of refueling after the test was the fuel consumption for the particular operation. When filling up the tank, careful attention was paid to keep the tank horizontally and not to leave any space in the tank. For checking the proper level of the tank spirit level was used.

Effective field capacity
The actual operating time along with time lost for every event such as turning, loading, unloading, adjusting, refueling, and machine trouble were recorded for completion of a particular operation. The effective field capacity was calculated as follows:

$$\text{Effective field capacity (ha/h)} = \frac{A}{(Tp+T1)}$$

Where,
A=Area covered, ha.
T_P=Productive time, h
T_1=Non Productive time, h.

Results and Discussions
Soil moisture content and bulk density
For dryland operation, the average moisture content of the soil during tillage operation was found 11.65% (db) at 15 cm depth whereas Singh (2013) [8] evaluates the machine at a moisture content of 20.2% (db). After the one pass of rotavator, the average bulk density was observed 1.38 g/cc and porosity was 48.82%.

Performance of blade
The percentage wear of blades (L- shaped) on a mass basis during field operation of 38 h, ranged from 2.12 to 3.81% which is as per norms of IS:17045:2018. The percentage wear of blades (L- shaped) on a dimensional basis during field operation (38 h) ranged from 6.86 to 12.74% and 3.23 to 6.29% at the edge and at 62 mm from the edge, respectively which is considered as per norms.

Wheel slippage
The wheel slippage was found 1.22 to 2.10% and 3.90 to 5.88% for the dry land conditions and wetland conditions, respectively. When the moisture in the soil increases the wheel slippage also increased.

Performance in Dry Land
The mean values of different parameters presented in Table 2 revealed that the maximum PTO power requirement was found to be at a speed of 3.0 km/h so that maximum fuel consumed by tractor at the same speed of operation. During dry land preparation, it was observed that in the tilled field the average width cut higher than the untilled field. The field capacity and field efficiency were found maximum at a speed of 3 km/h.

Table 2: Performance of rotavator in dryland field operation

Particulars	Experiment No.		
	1	2	3
Average speed of operation (km/h)	2.0	2.5	3.0
Average soil moisture (%)	11.6	11.4	11.0
Wheel slip (%)	2.12	1.42	1.78
Average depth of cut (cm)	8.8*	7.1*	8.0*
Average depth of cut (cm)	10.9**	12.5**	11.1**
Area covered (ha/h)	0.43	0.44	0.47
Field efficiency (%)	79	83	88
The time required for one hectare (h)	2.31	2.27	2.14
Fuel consumption (l/h)	4.02	5.59	6.08
P.T.O. power requirement (kW)	24.7	25.5	26.0

* Untilled field
** Tilled field

Performance In Wet Land
The mean values of different parameters depicted in Table 3 showed that the maximum puddling index was found at the average speed of operation 1.5 km/h. The puddling index varies indirectly proportional to the speed of operation. The study revealed that the average wheel slippage 3.90, 4.07, and 5.58% were found at an average speed of operation 1.5, 2.0, and 2.5 km/h, respectively.

Table 3: Performance of rotavator in a wetland field operation (Puddling operation)

Experiment No.	Avg. Depth of standing water (cm)	Avg. Speed of operation (km/h)	Puddling Index (%)	Avg. Depth of puddle (cm)	Fuel consumption (l/h)	Wheel Slip (%)	Engine speed (RPM)	
							At load	At no load
1.	10.0	1.5	69	23.5	3.64	3.90	1600	1700
2.	11.0	2.0	62	22.0	3.46	4.07	1640	1700
3.	13.0	2.5	63	23.0	3.60	5.58	1580	1700

Conclusions
This study shows the performance of rotavator at dry land and wetland conditions for preparation of seedbed. For the wetland field, the puddling index of implement varies 68 to 71% and Prakash *et al*., 2013 [7] were found similar results in the performance study of various types of rotavators.

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