Int.J.Curr.Microbiol.App.Sci (2018) *7*(4): 2373-2380

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 04 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.704.272

Tractor Drawn Rotavator - A Comparative Study

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Keywords

Tractor, Rotavator, Cultivator, Harrow, MMD

Article Info

Accepted:
20 March 2018
Available Online:
10 April 2018

A B S T R A C T

The field experiment was carried out at college farm to evaluate the performance of tractor drawn rotavator. Based on observations, the soil bulk density after tillage treatment by rotavator (T_1) was found 1.299 g/cm^3 which was much lower than that after tillage treatment by harrow (T_2) 1.330 g/cm^3 and by cultivator (T_3) 1.314 g/cm^3, the soil moisture value was found to be 23.10 g per 100 g before tillage and 23.24 g per 100 g after tillage operations which shows soil moisture content did not differ significantly between treatments, the rotavator improved soil tilth which was evaluated by measuring the MMD of soil clods. The MMD (mean mass diameter) of soil clods in tillage treatments by rotavator (T_1) was 14.77 mm. MMD was found significantly larger for harrow (T_2) 17.30 mm and for cultivator (T_3) 23.57 mm, the operational time was higher by 247.2% and 147.2% in the case of T_2 and T_3 and the diesel consumption was higher by 103.2% and 31.9% in case of T_2 and T_3.

Introduction

Rotavators perform well in suitable soil conditions. One rotary tillage operation may be equivalent to several conventional tillage operations as far as the quality of the seedbed is concerned (Verma *et al.,* 1980). Rotary tillers can replace the plow, disk and harrow (Manesh *et al.,* 2002). A negative draft produced by the rotary action results in lower power requirement, and soil compaction (Salokhe *et al.,* 1994). The farmers have started using rotavator for seed bed preparation and puddling operation (Avila *et al.,* 1992). The local manufacturers have started manufacturing rotavators. The small scale manufacturers do not have the facilities for testing of rotavators to access the quality and performance. So it was planned to undertake the testing of a rotavator on uniform pattern. This study also aimed at investigating the effect of enamel coating on C-shaped tines of a rotavator on power consumption, and how it will affect the seedbed quality (Tojo *et al.,* 1993). The results of this study will have practical significance and be beneficial directly to the farmers.

Materials and Methods

The present research "Performance Evaluation of Tractor Drawn Rotavator" was carried out at agronomical conditions of Etawah (U.P.) tillage treatments were carried out using rotavator, harrow and cultivator as per recommended package of practices for tillage (Anon. 1983). All the treatments were carried out at the same time in different plots.

Rotavator

Rotary tillage tools applied tractor engine power directly to the soil through tractor P.T.O. shaft rather than tractive force to tyre (Ota *et al.*, 1994). Therefore, there is less wheel slippage, reduce soil compaction and need for low weight tractor for operation. The rotavator operated by tractor P.T.O. shaft having horizontal axis of rotation and side rotary drive was used for performance evaluation (Wilkinson *et al.*, 1988).

Measurements and computation of different parameters

Operating speed

For calculating of the operating speed, time was recorded using watch to cover 50m length of the field by the tractor under actual field condition for each operation separately.

The travel length was measured with the help of measuring tape. There after speed was calculated in km/h.

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 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 to full capacity 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 empty space in the tank. For checking 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 particular operation. The effective field capacity was calculated as follows:

$$\text{Effective Field Capacity } (C_E) = \frac{A}{(T_p+T_1)}$$

Where:

C_E = Effective field capacity, ha/h.

A=Area covered, ha.

T_P=Productive time, h.

T_1=Non Productive time, h.

Table.1 Technical programme for performance evaluation of Rotavator

Sl. No.	Treatment	Description
1.	T_1	Tilling operation with Rotavator.
2.	T_2	Tilling operation with Disk harrow.
3.	T_3	Tilling operation with Cultivator along with patella.

(1) Plot size (T): 6x30 m^2
(2) Experimental design: RBD (randomized block design)
(3) Replications: 4

Table.2 Specification of tractor drawn rotavator

Sl No.	Specification	Dimensions
1.	Manufacturer	Govind agro industries, Barabanki
2.	Type of power transmission	Tractor P.T.O.
3.	Location of drive	One end
4.	Rotar drive size	6.50 cm
5.	Number of disc	5
6.	Disc spacing	9.30 cm
7.	Number of blade per disc	6
8.	Blade type	L
9.	Length of leg	1.30 cm
10.	Width of blade	3.50 cm
11.	Direction of rotation	Same as the direction of travel
12.	Overall dimensions	Length=145cm Height=90cm Width=92cm
13.	Prime mover hp required	35 hp
14.	Forward speed	2.50 kmph
15.	Field efficiency (recommended)	80%
16.	Price	Rs 60,000

Table.3 Performance of Rotavator under different field conditions

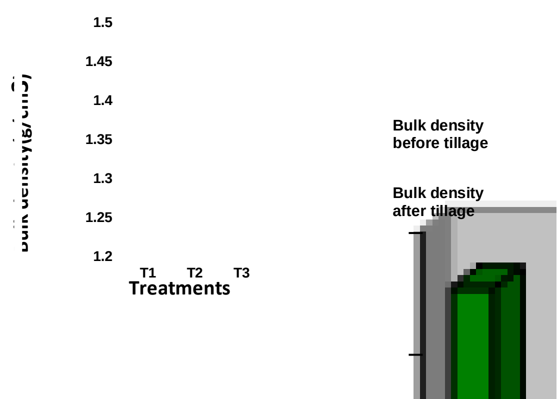
SL. No.	Parameters	Barrenland	Ploughed land	Mixing of crop residues
1	Field Capacity (ha/h)	0.31	0.45	0.36
2	Fuel consumption (l/ha)	21.7	13.28	18.72
3	Speed of Operation (km/h)	2.46	4.02	2.35
4	Width of cut (cm)	148	157	140
5	Depth of cut (cm)	10	14-17	15
6	Slip (%)	-1.85	-2.06	-1.4
7	Bulk Density Index (%)	0.26	0.15	0.13
8	Pulverization index (%)	2.69	2.3	---
9	Mixing of crop (%)	---	---	89.56

Table.4 Soil bulk densities as influenced by various tillage treatments for seed bed preparation for wheat

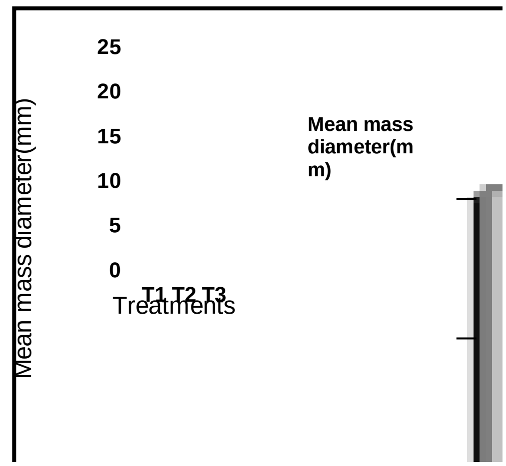
Tillage treatment	Bulk density before tillage(g/cm^3)	Bulk density after tillage(g/cm^3)
T_1	1.477	1.299
T_2	1.477	1.330
T_3	1.478	1.314

Table.5 Soil moisture content and MMD as influenced by various tillage treatments for seed bed preparation for wheat

Tillage treatment	Soil moisture content (g/100g)		MMD of clods (mm)
	Before tillage	After tillage	
T_1	23.10	23.24	14.77
T_2	23.10	23.24	17.30
T_3	23.10	23.24	23.57



G: 1Bulk density (g/cm^3)



G: 2Mean mass diameter of soil clods

Table.6 Operational time and fuel consumption, for different operations

Tillage treatment	Total time required to cultivate one hectare area (hour)	Total diesel Consumption required to cultivate one hectare area (liter)
One operation of rotavator (T_1)	3.6	22.9
Four operations of disk harrow(T_2)	12.5	46.5
Three operations of cultivator(T_3)	8.9	30.2 (+31.9)

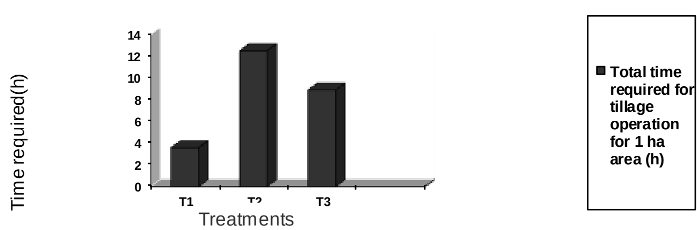


Table.7 Cost for different operations

TILLAGE IMPLEMENTS	COST OF OPERATION	
	Rs/ha	**Rs/ha**
1. One operation of rotavator (T_1)	237.80	**403**
2. Four operations of disk harrow (T_2)	231.42	**1184**
3. Three operations of cultivator along with patella (T_3)	**222.21**	**766**

Field efficiency

It was calculated as follows from the field test data.

$$\text{Field Efficiency (\%)}, E_f = \frac{C_E}{C_T} X100$$

Where:

E_F = Field Efficiency,
%C_T = Theoretical field capacity, ha/h.
= S x W/10, ha/h.
S = Average speed of travel, km/h.
C_E = Effective field capacity, ha/h.

Soil bulk density

It is the oven dried soil mass per unit volume. For measurement of bulk density soil sample from three locations selected randomly in each test plot were taken with the help of cylinder core sampler.

Volume of soil samples was determined after measuring the diameter and length of the core sampler. The samples were kept in oven at 105^0Cfor about 12h. The samples were taken out and weighed after their cooling.

$$\text{Soil bulk density (BD)} = \frac{M}{V} \text{ g/cc}$$

$$= \frac{4M}{Pi\ D^2 L} \text{ g/cc}$$

Where:

M = Mass of oven dried soil of core sampler, g

V = Volume of core sampler, cm^3

D = Inside diameter of core sampler, cm^3

L = Length of core sampler, cm

Soil moisture

Moisture content (%) on dry basis was computed for soil. For measurement of soil moisture, soil samples were taken with core sampler at different locations of test plots selected randomly. Each soil sample was weighed by physical balance and their weights were recorded. Samples were kept in a hot air oven at 105^0C for 8 hours for drying. At the end of 8 hours, samples were taken out and cooled in the desiccators and weighed. The soil moisture (% dry weight basis) was calculated using the formula given below:

$$\text{Soil moisture (\% dry weight basis)} = \frac{\text{Weight of wet soil sample} - \text{Weight of oven dried soil sample}}{\text{Weight of oven dried soil sample}} \times 100$$

The average operating width of rotavator was 150cm. the field capacity was in range of 0.30 to 0.37 ha/hr. The depth of operation varied from 10-16 cm. The average fuel consumption was 21.7, 13.28, 18.72 l/ha. The mixing of green manuring crop was 89%. Field evaluation test results of tillage treatments by rotavator (T_1) in comparison to harrow (T_2) and cultivator (T_3) is discussed in the following heads: 1. Quality of seed bed 2. Energy requirement 3.Operational time and fuel consumption. 4. Economic aspects.

Quality of seedbed

The quality of seedbed under the three tillage treatments was assessed by measuring bulk density and mean mass diameter (MMD) of clods. Table 1 indicates that soil bulk density measured before the tillage treatments did not differ significantly. The soil bulk density after tillage in heat was significantly lower for treatment T1 than for T2 and T3. Table 1 shows that it was possible to achieve a considerable reduction in the bulk density of the seedbed with one operation with the rotavator. Soil moisture content did not differ significantly between treatments in the crop. Average soil moisture content at the time of sowing wheat for all three treatments was 22.6 gram per 100 gram. The rotavator improved soil tilth which was evaluated by measuring the MMD of soil clods for the wheat, MMD was significantly lower for T_1 than T_2 and T_3.

These results indicate that better soil pulverization can be achieved even with one operation of rotavator. Treatments T_2 and T_3 require a greater number of operations of conventional tillage equipments but the mean mass diameter was still greater than that achieved by the rotavator. The rotavator also offers the advantage of some control of soil clod size by proper synchronization of rotor speed and forward traveling speed (Table 2-5).

Operational time and fuel consumption

The results of the study with regard to total operational time and fuel consumption required to cultivate one hectare area are reported in table 6 as evident, the operational time was higher by 147.2 and 247.2% in case of T_1 and T_2, respectively under wheat crop. The total operational time and diesel consumption were more in T_2 and T_3 than T_2. The savings in total operational time and diesel consumption, with the use of single rotavator (T_1) in relation to tillage treatments T_2 and T_3, were 59.6 to 71.2% and 24.2 to 50.8%, respectively. Thus, rotavator offers greater advantage over other tillage equipment in use both in terms of operational time and fuel consumption

Economic aspects

With a view to ascertain the economics of using the rotavator, the cost of operation under various tillage treatments for wheat was computed. The hourly cost of operation of rotavator was higher than other tillage equipment primarily due to high initial cost of rotavator. However the cost of operation in terms of area basis was minimum for single rotavation (T_1). The cost of operation for T_1, T_2 and T_3 worked out to be Rs. 766, Rs. 1184, Rs. 403 (Table 7).

The quality of seed bed following preparation with a single operation of rotavator (expressed in terms of bulk density and mean mass diameter) appeared to be better than that obtained using conventional methods, which involved a number of tillage operations.

The use of rotavator is advantageous for seed bed preparation both and terms of saving in operational time and fuel (diesel) consumption on area basis. The total operational time and diesel consumption per unit area basis by minimum in case of single rotavation of all the three tillage treatments. The hourly cost of operation of tractor and rotavator was comparatively higher than the other tillage equipment. However the cost of operation on area basis was minimum for single rotavation of all the tillage treatments.

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How to cite this article:

Maheshwari, T.K. and Uday Veer Singh. 2018. Tractor Drawn Rotavator - A Comparative Study. *Int.J.Curr.Microbiol.App.Sci.* 7(04): 2373-2380.
doi: https://doi.org/10.20546/ijcmas.2018.704.272