International Journal Of Advanced Research In Engineering Technology & Sciences
ISSN: 2394-2819
July- 2015 Volume 2, Issue-7
Email: editor@ijarets.org www.ijarets.org

Performance Evaluation of Small and Large Tractor Drawn Rotavator for Dry and Wet Land Preparation

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ABSTRACT:
The study was carried out in the research farm of Indira Gandhi Agricultural University Raipur Chhattisgarh in June 2014. To evaluate the performance of large and small rotavator in clay soil for field preparation in wet and dry condition. Field capacity in wet land condition revealed of large and small rotavator was 0.56 ha/hr and 0.29 ha/hr while in dry land condition significantly 0.61 ha/hr and 0.35 ha/hr with field efficiency 93% and 85%. The bulk density before operation 1.52g/cm^3 and after operation 1.27g/cm^3 and 1.43g/cm^3 of large(R1) and small rotavator(R2) operated by 50hp and 22hp tractor in dry land operation. It was revealed that energy and cost of operation of small rotavator is higher than of large rotavator. Due to high power and large working width of large rotavator R1 gave the better performance as compared to small rotavator R2 in terms of field performance, breaking clods and weeding.

KEYWORDS: Rotary tiller, Pulverization, Bulk density, field capacity, Field Efficiency, fuel consumption, energy and cost.

INTRODUCTION:

The rotavator, derived from rotary cultivator, or rotary tiller is a tillage tool primarily comprising L shaped blades mounted on flanges, which are attached to a shaft that is driven by the tractor power-take-off (PTO) shaft. It is suitable for shallow cultivation and weed control. It is an active tillage tool that processes the soil at a speed that is different from the forward travel speed of the tractor. With respect to 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 and Plessis, 2011). Rotary tiller is a tillage machine designed for preparing land suitable for sowing seeds, for eradicating weeds, mixing manure or fertilizer into soil, to breakup and renovates pastures for crushing clods etc. it offers an advantage of rapid seedbed preparation and reduced draft compared to conventional tillage. It saved 30-35% of time and 20-25% in the cost of operation as compared to tillage by cultivator. The rotavator is the most efficient means of transmitting engine power directly to the soil with no wheel slip and a major reduction in transmission power loss.The performance of a rotavator is affected by many factors including the blade configuration, direction of rotation, set tillage depth and kinematic parameter. As with any other tillage tool, the depth of operation has significant influence on the power requirement and performance of a rotavator (Hendrick and Gill 1971b). Rotavator is an effective modern implement suitable for all types and textures of soil. It effectively and economically replaces the combined functions of cultivator, disc harrow, leveler and manual labour. It can be effectively used as a puddler. It produces green manure by cutting roots/weeds in small fragments and mixing with soil. It creates better aeration, rapid germination of seeds.

It was reported that increasing the depth of operation, while holding other rotavator design parameters and soil conditions constant, resulted in increased energy requirement for both directions of rotation (Hendrick and Gill 1971b). 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 (Hand book 2013).

Puddling in small paddy fields with the help of tractors had hitherto been impossibility. It has now been made possible with the help of the Rotavator ' attachment. This is an operation through which the soil is thoroughly mixed with water prior to transplanting of the rice seedling. It. is a laborious job when done with bullocks; with the help of tractors with Rotavator attachment it can be done much faster during the critical period after sufficient rainfall and thereby more land can be brought under paddy cultivation.

Farmers will find no difficulty in keeping their rotavators usefully employed even during summer, Fallow lands can be regularly cultivated and put into good shape by uprooting old stubbles and by chopping up and mixing them with the soil for fast humus formation. Another use for it would be to chop up green manure crops, to turn them into the soil in a form in which they would be fully effective. Rotavating ensures a quick microbic action in the building up of humus contents of the soil, which after all is the main object in growing green manure crops. It can replace ploughing and harrowing to advantage for the cultivation of a variety of crops.

MATERIAL AND METHOD:

Filed experiment was conducted on Agri.Engg farm of Indira Gandhi Agricultural University Raipur C.G. in clay soil to evaluate and comparison of a 22hp tractor rotavator and 50 hp tractor rotavator in same field of two replica.The experiment was conducted in wet land condition in a 30m X 40m area. The depth of operation has significant influent on the power requirement and performance of rotavator. Increasing depth of operation, while holding other rotavator design parameter and soil conditions constant, increase the power requirement for both the direction of rotation up cutting and down cutting of rotavator.

MACHINE SPECIFICATIONS:

Both R1 and R2 rotavator are P.T.O operated tractor mounted implement which are used for the pulverization of soil as secondary tillage operation as well as weeding purpose in paddy filed. It operates in field by mounting on three point linkage mechanism and tractor is used as prime mover. A view of offset rotavator is shown in Fig. (1). An important feature of the unit is side shift system (perpendicular to the line of motion), based on a hydraulic cylinder, that is activated by a senser fitted in side of the rotavator. Two double acting hydraulic cylinder is provided to adjust the offset position and depth of operation of rotavator according to requirement. For depth control a hydraulic ram cylinder is attached with the tractor hydraulic which is activated by a lever operated by the tractor driver. The hydraulic power is supplied from tractor hydraulic system. The stroke length of hydraulic cylinder is 600 mm at fully extended position. Therefore the rotavator is able to get the lateral displacement of 600 mm. Tractor PTO power is transmitted to the rotor shaft through universal shaft, gear box and the chain drive mechanism. The rotor shaft has six flanges 110 mm apart. The flanges are welded with the rotor shaft. C – Shaped six blades are mounted on first five flanges in each flange alternately in right and left hand direction with nut bolt joint and at outermost flange only three unidirectional blades are attached. A curved shield is provided at the rear of rotavator blades as a safety device and for better pulverization. Specifications of the rotavator are given in (Table 1).

OBSERVATION RECORDED:

Moisture content on dry basis- The moisture content was determined on dry basis, soil sample were collected randomly in field with the help of the core sampler of 10 cm diameter and height 13 cm. Soil sample were dried in oven for 24 hours at 105º. 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).

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

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

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

PUDDLING INDEX: Soil water suspension samples volume of 500 ml were collected during puddling from different spots behind the puddling equipment with the help of 1.25 cm diameter steel pipe. The soil water suspension was allowed to settle for 48 hours and the volume of soil settled was recorded. Puddling index was determined by the following relationship (Baboo 1976).

$$\text{Puddling index (PI)} = \frac{Vs}{V} \text{x } 100$$

Where,
Vs = Volume of settled soil, ml
V = Total volume of the sample, ml

CONE INDEX: To determine cone index, a dial gauge cone penetrometer having 3.6 cm diameter of cone base with cone angle of 30°, was used. Cone penetrometer was calibrated with known weights and the relationship between applied load and dial gauge deflection was established. Hence, the weight of cone penetrometer (3485 g) per unit area of cone base was also taken into account while determining the cone penetrometer resistance (Bhadoria 1995). The cone penetrometer resistance (CPR) per unit area (sq.-cm) was determined by the following relationship:

CPR, = 0.648 + 0.025X, kg cm^2

Where,
X = dial gauge deflection, small divisions

The average cone penetrometer resistance over a depth range (0-15 cm) has been termed as cone index. The calculated value of CPR and CI was multiplied by a constant factor 98.067 to get CPR and CI in kPa**.** Cone penetrometer readings at different depths were taken randomly from five different places in each treatment at an increment of 2.5 cm and converted into CPR by the above formula. Cone index values were determined by taking the average of CPR values at different depths (0-15 cm).

WEEDING EFFICIENCY: Number of weeds per unit area was counted before and after the experiment and the weeding index was calculated as follows-

$$\text{Weeding efficiency (\%)} = \frac{\text{Number of weeds per unit area before operation}}{\text{Nomber of weeds per unit area after operation}}$$

FIELD CAPACITY AND FIELD EFFICIENCY: It was calculated as

Theoretical field capacity (ha/hr) = (Speed (km/hr) ×Width of implement (m))/10

$$\textbf{Actual field capacity (ha / hr)} = \frac{\textbf{Total area covered (ha)}}{\textbf{Total time taken (hr)}}$$

$$\text{Field efficiency \%} = \frac{\text{Actual field capacity}}{\text{Theoretical field capacity}} \times 100$$

FUEL CONSUMPTION: The tractor tank of john deer 5050 and Mitsubishi tractor of diesel tractor was filled up to top level before testing of rotavator in field .After ploughing a specific area the fuel tank of the tractor was refilled up to same fuel level. The total quantity of fuel needed to refill the fuel tank up to the same mark was recorded and total time was taken plough the test plot.

Table 1. Specification of tractor drawn rotavator

S.N.	Particulars	Specification	
		R_1	R_2
1	Model	Gyrovator Z1-X	180 DI
2	Make	Mahindra&Mahindra	Mitsubishi
2	RPM	210	210
3	Width of implement	1870 mm	1360 mm
4	Effective width of implement	1750 mm	1160 mm
5	No. of blades	60	28
6	Type of blades	L – Type	L- type
7	No. of flanges	10	7
8	No. of blades per flange	6	4
9	Distance between consecutive flanges	230 mm	200 mm
10	Gear box type	Bevel pinion gear	Bevel pinion gear
11	No. of bearings	2	2
12	Weight of machine	350 kg	225 kg
13	Tractor hp required	More than 40 hp	22
14	Adjustments of working depth	Tractor hydraulic	Hydraulic control
15	Power transmission system	Tractor PTO	PTO
16	Safety aspect	Cover provided on tynes	Covered Provided

Fig.1 view of tractor drawn Mahindra and Mahindra and Mitsubishi Rotavator

OPERATIONAL ENERGY-

Sufficient availability of the right energy and its effective and efficient use are prerequisites for improved agricultural production. Through using farm machines and implements can be increased productivity and minimize cost. The reduction, elimination or combination at machinery operation will reduce energy (fuel) input and also may reduce the uses of labor and time (Karale et al. 2008).To compare the performance for land preparation, operating the rotavator in both field conditions wet and dry land .The energy used in wet land and dry land preparation is human, machinery and petroleum energy was engaged. Energy coefficient that are used in given (Table no 2) and following formulas were used (Singh and Mittal1992).

Human Energy (MJ/ha) = no of labor ×energy coefficient × time (hr)

Rotavator (machinery energy) (MJ/ha) = [wt.(kg)×coefficient ×time(hr)] ÷[life(Y)×annual use(hr)]

Petrol energy (MJ/ha) = consumption × coefficient ×time (hr)

Table No.2 Energy co-efficient of different

Particulars	Units	Equivalent energy, MJ
Human	Man-hour	1.96
Diesel	Litre	56.31
Farm machinery excluding self propelled machine	Kg	62.70

Source: Mittal et al; (1985). Research digest on energy requirement in Agriculture Sector (1971 – 1982), PAU, Ludhiana.

OPERATIONAL COST:

Cost analysis is major important for farmer to analyze profit and loss in any particular operation for improving the field efficiency and production with minimum cost. Rotavator is operated for land preparation in include (Fuel+wages) cost from tractor engine and labour can computed by following expression:

Fuel cost for rotavating = Fuel consumption (lit/hr) × diesel rate (Rs/lit) time (hr)

Labour cost = Number of labour × labor rate (Rs/day)

Cost of ploughing Rs/ha = Machinery cost (Rs/hr) / field capacity (ha/hr)

RESULT AND DISCUSSION:

The experiment was carried out in IGKV Raipur farm in two replica, where R_1 and R_2 rotavator are used to modify in order to deepen the root and water penetration zone, loosen dense subsoil layers, for better root growth, water movement and aeration and mixing of soil profile to provide to uniform texture. Rotavator is operated two passes by 50hp and 22hp tractor in the field were investigated for soil bulk density, soil moisture, wheel slippage, effective field capacity, and fuel consumption**.** The details of treatment plots and obtained results are given in table no.3. The statistically analyzed data on the above parameter are interpreted under the following headings.

ROTAVATOR PERFORMANCE DURING WET LAND PREPARATION:

The mean values of different parameter presented in Table(4) revealed that there was no significant difference on soil moisture content after puddling operation by both the rotavators. However, the recorded data for soil moisture content was 45.63%. The bulk density for saturated unpuddled soil was also taken and determined as 1.32g/cc. The effect of rotavator showed changes in the values of bulk density after wet land preparation i.e. puddling. Lower value of bulk density 0.987 g/cc was observed under rotavator R1, this may be due to the higher weight of the machine and higher no of blade per flange on larger sized rotavator R1 which facilitates more churning of soil. It was observed that soil strength reduced considerably after puddling by both the rotavator was observed in the range of 3.7-5.6 kg/cm^2.

Higher depth of tilling or producing 144 mm was obtained by larger sized rotavator as compared to tilling depth of 112 mm by small sized rotavator. Speed of operation was also observed higher in case of larger sized rotavator R1, this may be due due to the fact that rotavator R1 was operated by higher hp tractor.

During wet field preparation larger size rotavator perform better with high field capacity 0.56 ha/h while rotavator R2 performed with less field capacity of 0.29 ha/h. Similarly, higher field efficiency 86.7 % was observed under rotavator R2 compared to 82.4% of weeding efficiency obtained under rotavator R1. This may be due to the distance between consecutive flanges in rotavator R2 is less which uprooted and cut more number of weeds as compared to rotavator R1. The wheel slippage for R1 and R2 rotavator were recorded as 6.71 % and 10.56 % respectively, the wheel slippage of tractor was mainly associated with the depth and width of machine. Minimum wheel slippage was recorded on R1. Fuel consumption in wet tillage was 3 l/h and 4 l/h for rotavator R1 and R2 respectively, which indicated that rotavaor R2 consumes 33.33% more fuel per hour during wet land preparation. Higher puddling index 56.37 % was recorded under rotavator R1 while rotavator R2 gave lower value of puddling index as 47.94%.

Note; R_1 and R_2 are the Mahindra and Mahindra Rotavator and Mitsubishi Rotavator

TABLE NO.3 CONDITION OF TEST FIELD

S.N.	Particulars	Result	
Test conditions			
1	Area and shape of field	40×30 m^2 rectangular	40×30 m^2 rectangular
2	Type and character of soil	Vertisol	Vertisol
3	Last crop in the field	Paddy	Paddy
4	Height of stubbles of last crop,	8-12 cm	8-12 cm
5	Condition of weeds/m^2	486	435
6	Soil moisture condition, %	16-18	16-18
7	Bulk density, g/cm^3	1.52	1.52
8	Cone index, kg/cm^2	7.2 – 10.8	7.2-10.8

fig.2 measurement of puddling index and cone index

table no. 4 field performance results of tractor drawn rotavator test (wet land)

S no	Particulars	Mahindra &Mahindra	Mitsubishi 180DI
1	Width of tilling, mm	1400	1100
2	Depth of tilling, mm	114	112
3	Speed of operation, km/h	3.2	2.5
4	Fuel consumption, lit/h	3	4
5	Moisture content, %	45.63	45.63
6	Bulk density, g/cc	0.987	1.11
7	Cone index, kg/cm^2	3.7	5.6
8	Theoretical Field capacity, ha/h	0.60	0.34
9	Actual Field capacity, ha/h	0.56	0.29
10	Field efficiency, %	93	85
11	Percent wheel slip, %	6.71	10.56
12	Puddling Index, %	56.37	47.94
13	Weeding efficiency, %	82.4	86.7

table no. 5 field performance results of tractor drawn rotavator test (dry land)

S no	Particulars	Mahindra & Mahindra	Mitsubishi 180DI
1	Depth of operation, mm	132	92
	Moisture content, %	18	18
2	Bulk density, g/cm^3	1.27	1.32
3	Cone index, kg/cm^2	4.3	6.1
4	Weed efficiency, %	81.74	76.33
5	Speed of operation, km/h	3.5	3
6	Fuel consumption, lit/ha	3.5	4.8
7	Theoretical field capacity, ha/h	0.65	0.40
8	Actual Field capacity, ha/h	0.61	0.35
9	Field efficiency, %	93	85

PERFORMANCE IN DRY LAND:

The mean values of different parameters presented in Table 4 revealed that maximum depth of tilling 132 mm was achieved in larger sized rotavator R_1 compared to rotavator R_2 with tilling depth of 92 mm. This may be due to the fact that rotavator R_1 has larger weight of 350 kg which helps the machine to penetrate more in to the soil. During dry land preparation, it was observed that soil strength reduced after tillage operation as bulk density of the soil reduces from 1.52 g/cc to 1.27 g/cc and 1.32 g/cc in rotavator R_1 and rotavator R_2 respectively. Similarly the values of cone index were also reduced from 7.2 kPa to 4.3 kPa and 6.1 kPa in rotavator R_1 and R_2 respectively. Due to the larger width of the machine and higher power involved in rotavator R_1, higher actual field capacity (0.61 ha/h) and field efficiency (93%) was recorded while in rotavator R_2 values of 0.35 ha/h and 85% for both the parameters was noted down. Maximum weeding efficiency 81.74% was observed under tillage operation with rotavator R_2 followed by 76.33% under rotavator R_1. For dry land preparation fuel consumption of the tractor was higher (4.8 l/h) while operating rotavator R_2, while the fuel consumption was only 3.5 l/h to operate rotavator R_1. Rotavator R_2 consume more fuel because of less working width and less power as compare R_1.

OPERATIONAL ENERGY:

Operational energy of both rotavator in wet and dry land conditions energy consumptions of R_2 are more than R_1 rotavtor in which petroleum energy more cover. The energy used in land preparation, human, machinery and petroleum energy was engaged. Following table no 3 are given.

Table no.6 Energy consumption in wet and dry conditoin

Condition	Operation	Mahndra & Mahindra (R_1) MJ/ha	Mitshubishi (R_2) MJ/ha
Wet Land	Machine Energy	12.63	17.24
	Human Energy	1.63	3.23
	Petroleum Energy	139.36	560.84
	Total Energy	153.52	392.08
Dry Land	Machine Energy	18.98	21.68
	Human Energy	2.45	4.06
	Petroleum Energy	246.35	371.65
	Total Energy	267.78	586.58

OPERATIONAL COST-

It was observed that comparing the cost of operation more in both wat and dry land condition. Tractor cost, and ploughing cost are higher than R2 instead of machinery cost.

Table no.7 Cost analysis in wet and dry conditoin

Condition	Particular	Mahindra & Mahindra (R_1)	Mitsubishi (R_2)
Wet land	Fuel cost Rs/hr	185.00	244
	Labour cost Rs/day	210.00	210.00
	Cost of ploughing Rs/ha	747.40	1739.89
Dry land	Fuel cost Rs/hr	213.50	292.80
	Labour cost Rs/day	210.00	210.00
	Cost of ploughing Rs/ha	821.37	1328.34

CONCLUSION:

In this study large rotavator more efficient over the small rotavator in field preparation. Due to the high power 50 hp and effective width Mahindra and Mahindra promising rotary cultivation and cleaning the weeds, leveled soil surface, energy consumption and cost as compare small rotavator. Weeds are cut in pieces and mixed with soil; it helps to less fuel consumption and effective field capacity is greater in Mahindra rotavator.

REFERENCES:

1. MARENYA M. O. and DU PLESSIS, H. L. M (2011), "Characterizing the performance of a deep tilling down-cut rotavator fitted with L-shaped blades", An ASABE Meeting Presentation Paper Number: 1110936.
2. HENDRICK, J.G. and. GILL, W.R (1971b). "Rotary tiller design parameters: Part II – Depth of tillage". Transactions of the ASAE, 14(4): 675-678.
3. Hand book of Agricultural Engineering 2013, ICAR New Delhi.
4. MARI, G.R., CHANDIO, F. A., LEGHARI, N., RAJPER, A. G., SHAH, A. R (2011) "Performance Evaluation of Selected Tillage Implements Under Saline-Sodic Soils", American-Eurasian J. Agric. &Environ. Science, 10(1); 42-48
5. BABOO, B (1976). "Effect of lug angle of cage wheel on traction and puddling performance of dual wheels". M. Tech. diss., Dept. of Farm Machinery and Power Engineering, G. B. Pant Univ. of Agriculture and Technology. Pantnagar, India.
6. BHADORIA, P. B. S (1995). "Measurement of soil physical properties". In Lecture Note of IRRI Training Programme on Engineering for Rice agriculture. IIT, Kharagpur, India.
7. KARAL, D.S., KHAMBALKAR, V.P.,BHENDE,S.M.,AMLE,S.B. and WANKHEDE, P.S (2008). "Energy economic of small farming crop production operations". World Journal of Agricultural Science, 4 (4):476-482.
8. SINGH,S., and MITTAL, J. P (1992) "Energy in Production Agriculture" MITTAL PUBLICATION NEW DELHI.
9. MITTAL, V. K., MITTAL, J. P. and DHAWAN, K. C (1985). "Research Digest on Energy Requirements in Agricultural Sector". Punjab Agricultural University, Ludhiana.