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Evaluation of Soil-Traffic Test in Vertical Axis Rotary Tiller for Tillage System

D. Ganapathi*[1], V. M. Duraisamy[2], B. Suthakar[3] and N. Karpoora Sundara Pandian[4]

[1] Department of Agriculture Engineering, Saveetha Engineering College, Chennai - 602 105, Tamil Nadu, India
[2] Tamil Nadu Agricultural University, Coimbatore - 641 003, India
[3] Agricultural Machinery Research Centre, AEC & RI, Tamil Nadu Agricultural University, Coimbatore - 641 003, India
[4] College of Food and Dairy Technology, Tamil Nadu Veterinary and Animal Sciences University, Chennai - 600 052, Tamil Nadu

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Abstract

The Indian agriculture tillage system is in the stage that Moldboard plough, disc plough are replaced with horizontal axis rotary tillers. Vertical axis rotary tiller has been introduced in recent years by some farm equipment manufacturers. Farmers claim difference between horizontal and vertical axis rotary action but there are no scientific work compare them. In this research single row vertical axis rotavator has been developed and evaluated the soil traffic in soil bin located at farm machinery workshop of Tamil Nadu Agricultural University. Soil traffic measurements are made with the soil-trafficability test set. This set consists of one digital display with handle, load cell, circular aluminium rod with 600 mm length and 322 square millimeters cone. Result showed that in so in deeper depth more force is needed i.e., 1950, 2320, 2560 and 2970 kPa for 100, 150, 200 and 250mm are shown respectively.

***Key words*:** Soil, Rotavator, Vertical axis, Tillage, Rotary tiller, Implement, Cone index

India is an agrarian country with the existence of all agro-climatic conditions. A total production of 279.5 million tonnes and 305.4 million tonnes of agricultural and horticultural commodity, respectively are accounted during the year 2017-18 [1]. Tillage can be defined as mechanical manipulation of soil with the help of implements to obtain fine tilth condition and is the foremost important operation in any crop production, which consumes highest amount energy next to irrigation. Tillage involves serious of operations such as primary tillage, secondary tillage and levelling of the land. Mould board plough and disc plough are commonly used primary tillage implements to open up the cultivable land. Disc harrow, cultivator and rotavator are the most used secondary tillage implements. However, mould board plough and disc plough are replaced with rotavator in the recent Indian agriculture tillage system [2]. Application of engineering in agriculture is to reduce the human drudgery, timelines of operation and increased productivity. To achieve these benefits number of implements were used in the field. Implements mounted with tractor passes over the field in number of times compaction is crated in the bottom soil. Soil compaction or densification is accomplished by pressing the soil particles together into a close state of contact with air being expelled from the soil mass in the process. Compaction, as used here, implies dynamic compaction or densification by the application of moving loads to the soil mass. This is in contrast to the consolidation process for fine-grained soil in which the soil is gradually made denser as a result of the application of a static load. With relation to compaction, the density of a soil is normally expressed in terms of dry density or dry unit weight. The common unit of measurement is kPa. Occasionally, the wet density or wet unit weight is used. In this research single row vertical axis rotavator has been developed, soil cone index is measured and compared with existing horizontal axis rotavator. The axis of rotavator may rotate in vertical axle of rotor shaft.

Rotavator is becoming popular among the farmers for land preparation where two or more crops taken in a year. Result shows that rotavator saves 30-35 per cent of time and 20-25 per cent in the cost of operation as compared to tillage by cultivator and it produces a perfect seedbed in fewer passes. It is well known that one operation of rotavator equal to one MB plough and two harrow operations [3]. The main reasons for the popularity of rotavator among the farmers are i. Present-day tractors develop more power than they can transmit efficiently to a draft implement through the tyres; ii. The soil break-up created and the easy combination with other machines (e.g. sowing machines) allows a reduced number of passages.

Vertical axis rotavator

In general, rotavator blades may be rotated on vertical-axis or horizontal-axis rotary shafts. The resulting texture of rotavator-tilled soil is a function of the soil condition, blade kinematics and soil flow dynamics [4]. The soil flow dynamics depends on the rotor axis of the cultivator and on the direction of rotation of the blades. For the horizontal rotor axis, the blades may be rotated in the down-cut or up-cut direction; while for the vertical axis, the direction of rotation may be clockwise or anti-clockwise. In same depth, vertical axis rotavator cut down more soil than horizontal axis rotavator.

***Correspondence to:** D. Ganapathi, E-mail: durairaj.ganapathy@gmail.com; Tel: +91 9787982231

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MATERIALS AND METHODS

Soil type

The experiments were done in farm machinery workshop soil bin, Tamil Nadu Agricultural University, India. The soil bin has two compartments one side is filled with clay soil and the other side is filled with sand. The clay soil is taken for the experiment (Fig 1).

Fig 1 Soil bin

Fig 2 Soil moisture meter

Soil moisture content and bulk density measurements

Soil moisture content was determined using the standard oven drying procedure. The soil sample for the determination of the moisture content collected immediately upon the completion of test run. At least 12 soil samples were collected in metallic containers had a specified volume for each test run from different located strata of the soil whose moisture content was to be determined. The mass of the collected moist samples was determined using a scale balance with an accuracy of 0.01g, and placed in a constant temperature oven for drying at a temperature of about 105 °C for a minimum drying period of 24 hours as described by ASAE standards. Also soil moisture meter were used, it directly digit the moisture content of soil (Fig 2). Finally found that moisture content and bulk density was 16.2% and 1.72g/cm^3 respectively.

Experimental layout

Factorial experiments based on a complete block with 72 treatments four different forward speeds of 2.0, 2.5, 3.0 and 3.5 kmph; three different depths of 150, 200 and 250 mm; three different rotor rpm of 220, 270 and 310 and with two rotary tillers were used. All experiments have been done in three replications. Yuvraj 215 tractor was used in all experiments.

Fig 4 Single row vertical axis rotary tiller

For each experiment rotavator were mounted on tractor and their power was provided through PTO shaft of the tractor. Determining mean weight diameter and cone index of soil was done after ploughing (Fig 4).

Soil cone index measurements

The cone penetrometer was used to measure soil cone index in different depths. This device consists of four main parts an aluminium rod with detachable cone, load cell, digital display and sensor. The sensor measures the depth and shown in the display. Data were collected in the soil bin and then transferred to computer (Fig 5a-b).

Fig 5a Cone penetrometer

Fig 5b Soil cone index measurement

RESULTS AND DISCUSSION

Cone index measurement

In this test the effects of two different type rotavator in different forward speed, rotor rpm and depth on soil cone index were statically analyzed.

Table 1 Cone index measurement

Vertical axis plough		Horizontal axis plough	
Depth, mm	Force, kPa	Depth, mm	Force, kPa
100	1950	100	2120
150	2320	150	2760
200	2560	200	3050
250	2970	250	3480

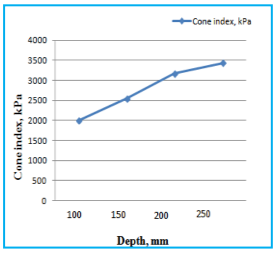

Fig 6a Soil cone index for vertical axis rotavator

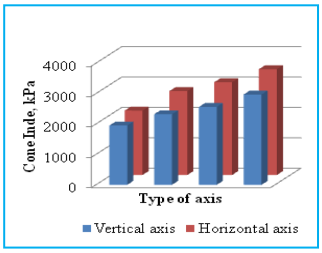

Fig 6b Comparison of soil cone index according to rotavator type

As it clear in (Fig 6a) cone index increases with increase in depth. Values of 1950, 2320, 2560 and 2970 kPa for 100, 150, 200 and 250mm are shown respectively. According to (Fig 6b) soil resistance in vertical axis rotavator is less than horizontal axis rotavator [5]. So, tillage with this plough creates more resistant soil. Values of 2970 and 3480 kPa for vertical axis rotavator and horizontal axis rotavator are shown in (Fig 6b).

In order to confirm the results obtained as discussed above, statistical analysis of the data was performed to assess the significance of the variables viz., forward speed (F), rotary speed (S), depth of operation (D) on soil cone index. The analysis of variance on soil mean weight diameter is furnished in (Table 2). The results of ANOVA showed that there was significant difference among the treatments. The individual effect of the variables viz., forward speed (F), rotary speed (S) and depth of operation (D) were significant at 1 percent level of probability. In the treatment effect, the order of significance was highest for forward speed (F), followed by depth of operation (D) and rotary speed (S) and on soil cone index for vertical axis rotavator at the soil bin having clay. The interaction effect of forward speed (F1), rotary speed (S3) and depth of operation (D1) has a high significant effect on reducing cone index of soil among other treatments [6-7].

Table 2 ANOVA for cone index for vertical axis rotavator

S. No	SV	df	SS	MS	F	P- value
1.	Forward Speed (F)	3	1955013.52	651671.1742	1213.96**	0.0000
2.	Error (a)	8	4294.51	536.8145		
3.	Rotary speed (S)	2	216438.06	108219.0312	696990.26**	0.0000
4.	Depth (D)	2	1356191.89	678095.9473	4367311.95**	0.0000
5.	F × S	6	206.36	34.3938	221.52**	0.0000
6.	F × D	6	427.19	71.1995	458.56**	0.0000
7.	S × D	4	41.00	10.2523	66.03**	0.0000
8.	F × S × D	12	94.57	7.8814	50.76	0.0000
9.	Error (b)	64	9.93	0.1553		
10.	Total	107	3532717.07			

CV(a) = 0.9014 per cent, CV = 0.0153 per cent, Yield Mean = 2570.31

CONCLUSION

Considering the number of passes over the field will lead to increase soil compaction in horizontal axis rotavator compared to vertical axis rotavator. Cone index increases with increase in depth both in vertical and horizontal axis rotavator. The highest cone index is achieved in horizontal axis rotavator. Increase in rotary speed from 2.3 ms^{-1} (S1) to 3.2 ms^{-1} (S3) resulted in 10.4 per cent reduction in cone index for the selected levels of forward speed and depth of operation for horizontal axis rotavator. The cone index for the horizontal axis rotavator is measured by 10.7 per cent with increase in forward speed from 2.0 to 3.5 km h^{-1}. Increase in depth of operation for horizontal axis rotavator from 50 mm to 150 mm resulted in 12.5 per cent increase in cone index for the selected levels of forward speed and rotary speed. The minimum value of soil cone index of 2223.3 kPa was registered at 50 mm (D1) depth of operation with 3.2 ms^{-1}(S3) and 2.0 km h^{-1} (F1), whereas maximum value of soil cone index of 3209.9 kPa was registered at 150 mm (D3) depth of operation with 2.3 ms^{-1} (S1) and 3.5 km h^{-1} (F4) for the horizontal axis rotavator. The regression coefficient R2 value obtained for soil cone index was 0.94. It indicated that 94 per cent variation in Y (soil cone index) for horizontal axis rotavator was influenced by the variables viz., forward speed, rotary speed and depth of operation.

Conflicts of interest

The authors declare that they have no conflict of interest.

Data availability

The datasets used and analyzed during the current study are available from the corresponding author on request.

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LITERATURE CITED

1. Anonymous. 2018. India at a Glance. Food and Agriculture Organization of the United Nations.
2. ASAE Standards, ASAE EP291.2 DEC98. Terminology and Definitions for Soil Tillage and Soil-Tool Relationships. American Society of Agricultural Engineers. St. Joseph, Mich. USA. 2000.
3. Azadbakht M, Azadbakht B, Galogah RJ, Kiapei A, Jafari H. 2014. Soil properties after plowing with vertical and horizontal axis rotavator. *International journal of Environmental, Ecological, Geological and Mining Engineering* 8(1): 61-65.
4. Azadbakht M. 1999. Design, development and evaluation of rotary plow. *M. Sc. Thesis*, College of Agriculture, Shiraz University, Shiraz, Iran (in Farsi with English Abstract).
5. Destan MF, Houmy K. 1990. Effects of design and kinematic parameters of rotary cultivators on soil structure. *Soil and Tillage Research* 17: 291-301.
6. Gill WR, Vanden Berg GE. 1967. *Soil Dynamics in Tillage and Traction*. Agricultural Handbook No. 316. Washington D.C., US GPO.
7. Potekar JM, Tekale DD. 2004. Comparative performance of tractor drawn implements tillage system with rotavator tillage system. *Karnataka Jr. Agric. Sciences* 17(1): 76-80.