

**Performance Evaluation of Different Jawahar Lister Tiller
Primary Tillage Tools Under Actual Field Conditions**
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Abstract

Studied on performance evaluation of four different Jawahar lister tiller primary tillage tools by using digital dynamometer in vertisol. Performance evaluation on the basis of draft, unit draft, power requirement, energy requirement, performance index measurements were investigated at two level of moisture content, 25% and 16%db through split plot design. Minimum value of draft (4.20 and 4.41 kN), unit draft (17.05 and 16.52 N/cm²), power requirement (2.90 and 3.04 kW) and energy requirement per unit volume (4.65 and 4.40 kW h/ha-cm) were obtained with moisture content of 25% and 16%db, respectively, with Jawahar tiller (T₄) compared to other tillers. Maximum value of performance index was obtained at moisture content of 25%db(55.28) and 16%db (53.49) with Jawahar tiller (T₄). Interaction effect of Jawahar tillers on unit draft, energy requirement per unit volume and moisture content were significant at 5% but performance index significant at 1% level. A significant increase in draft, power requirement were observed for all the Jawahar tillers with decrease in moisture content of soil.

Key words: Tool carrier, digital dynamometer, performance index

1. Introduction

India is a country of villages, more than 50% people live in villages (Census of India 2010-11, FAO) and their main occupation is farming. Agriculture is backbone of our country's economy and our villagers mainly depend upon agriculture. In crop production system, tillage is an important field operation. About 20% of the total energy required for crop production is utilized in tillage operation.

Till now many primary tillage implements have been developed, but still the use of primary tillage implement is limited.

Farmers having tractor generally use cultivator for primary tillage operation, but cultivator is a secondary tillage implement and designed for lighter and finer intercultural operation. Basic operation required for cultivation of any kind of crop done by primary and secondary soil manipulation is the. The tools for Soil manipulating should withstand adverse field conditions, such as the existence of a hardpan, small rocky formations, stumps and stubble during soil engagement without failure. Under average field conditions various types of tools such as mould board ploughs, disc ploughs and ridgerhas long been accepted and successfully used by farmers. The duck foot sweep is different kind of soil engaging tool that is popular amongst farmers for secondary field operations due to its large wing width, which causes better coverage of soil manipulation between two furrows.

Many tools can be used with cultivator like a spear point shovel, double point shovel, spear head shovel, sweep, half sweep, hoof and furrower etc. All the tools are designed to operate at shallow depth. Sweeps are used extensively for weed control, since shallow cultivation is generally desired. The cultivator with shovel or other tool which is

designed for the shallow tillage operation, when used for primary tillage purpose cannot give the proper results which is necessary for the primary tillage.

The cultivator with shovel cannot cover the whole width of implement (i.e. spacing between tines), so it is operated three-four times to till the field completely and it leads to consumption of extra energy.

As the local farmers are using cultivator as a primary tillage implement, but the cultivator is well suited for the shallow depth operation and it is basically designed for the secondary tillage purpose. Therefore, a tool is needed, which can cover desire depth and width. Therefore, it was decided to work on the project “Performance evaluation of tillage tools for tractor drawn cultivator”, with following objectives: Performance evaluation of different Jawahar lister tiller primary tillage tools under actual field conditions.

2. Material and Methods

The experiment was conducted at research field of CAE, JNKVV, Jabalpur (M.P.)

2.1 Details of experiment

Design	:	Spit plot design
Main plot treatment	:	4 different Jawahar tillers
Subplot treatment or split plot	:	2 different moisture content
Number of replications	:	4
Total area of field	:	0.17ha
Gross plot size	:	83.0 m X 21.0m
Net plot size	:	20.0 m X 20.0 m
Types of soil	:	Black cotton (vertisol)

Last crop harvested	:	Uncultivated land
Topography of field	:	Plane
Soil moisture (% db)	:	16%, 25%
Bulk density (kg/m ³)	:	1980
Cone index (kPa)	:	395.34

2.2 Tools and tool carrier used in test

This experiment, four different Jawahar tillers existing at the Department of FMP, CAE, JNKVV, Jabalpur (M.P.), were selected, fig 1.

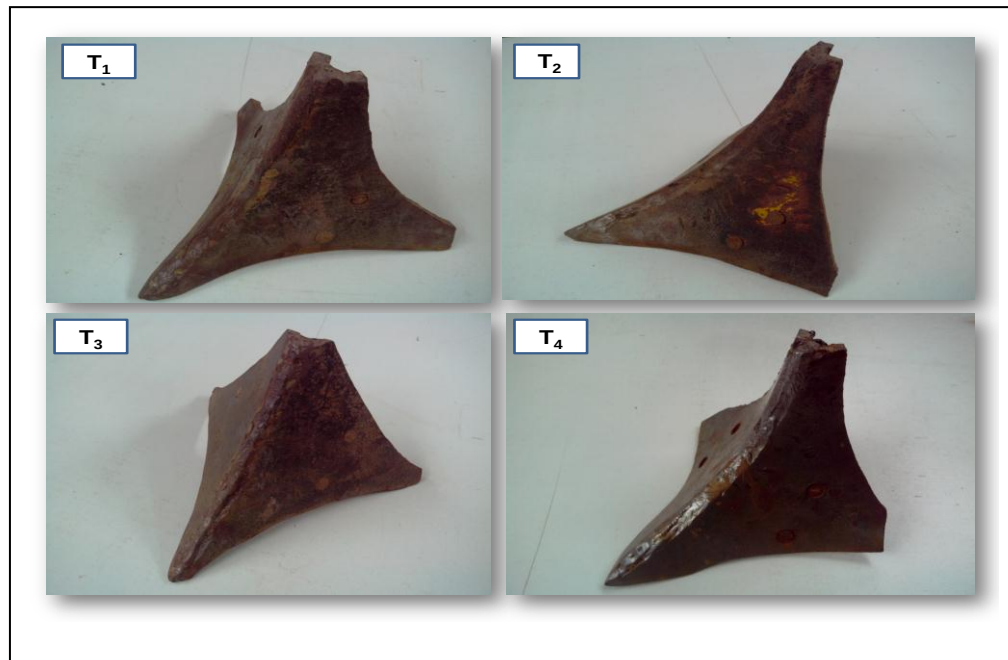


Plate1: Four different Jawahar lister tiller primary tillage tools

Table1: Specification of different Jawahar tillers undertaken for study

S. No.	Name of tools	Length (mm)	Width (mm)	Height (mm)	Loading angle	Setting angle	Vertical suction
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					(degree)	(degree)	(mm)
1.	T ₁	256	254	173	30	31	17
2.	T ₂	230	249	183	31	33	12
3.	T ₃	217	246	180	32	30	5
4.	T ₄	212	230	170	33	37	4

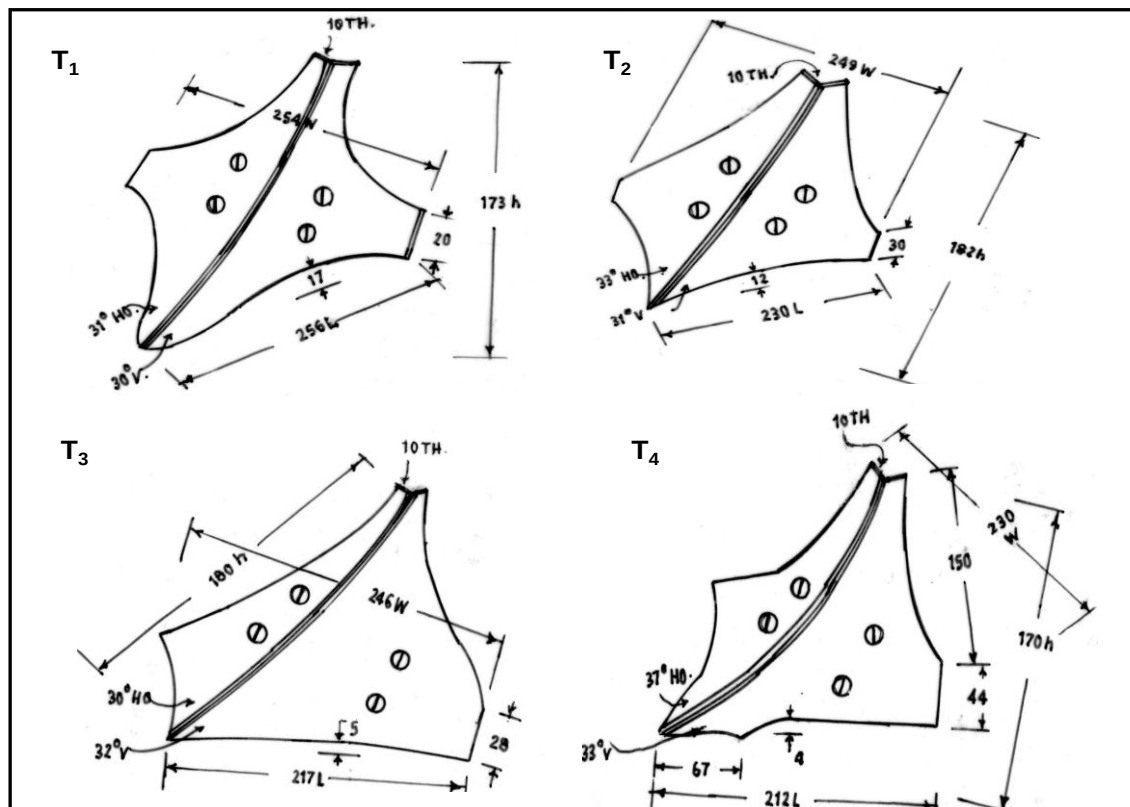


Fig. 1: Schematic diagram of Jawahar tillers

The tests were conducted with tool carrier. It is a mild steel rectangular trolley supported with four wheels. A Weight box was fitted on the trolley to carry additional weights up to 300 kg. The size of trolley with weight box is (1155 × 800 × 999), size of weight box is (607 × 400 × 300) and diameter of wheels is 300 mm. The weight of the

tool carrier with weight box is 125 kg. For fixing the cultivator tine, there is provision in the centre of the tool carrier. Height of the tine is adjustable in the frame with the help of nut and bolt. There is a provision to attach dynamometer horizontally in centre of the tool carrier, fig 2 and fig. 3.

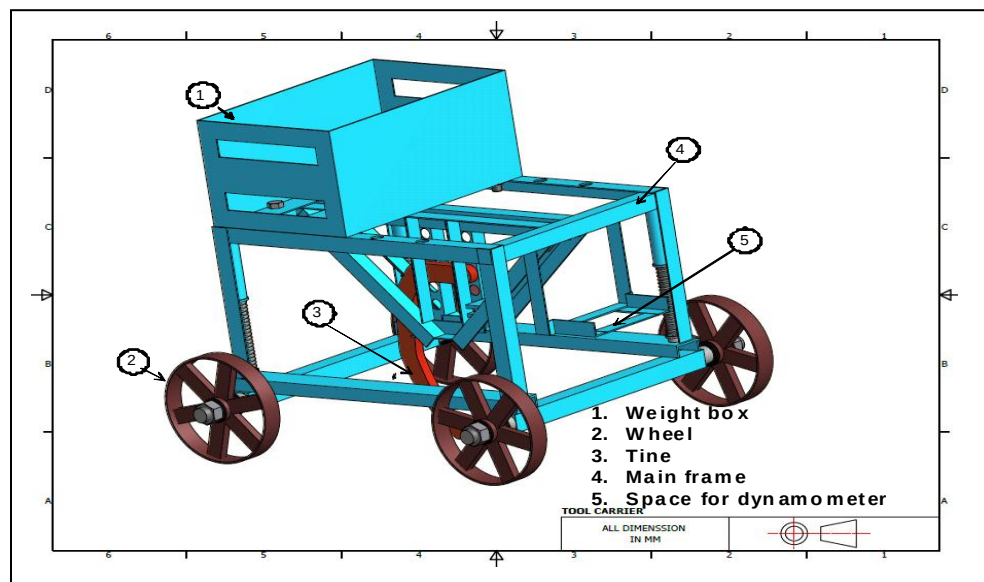


Fig. 2: Pictorial view of tool carrier

2.3 Experimental layout and test procedure

During research, the experiment was conducted in two different levels of soil moisture content, 16% and 25%db, and at the same operating speed, 2.5 km/h.

Experimental plots were designed, according to the split-plot scheme and were used for statistical analysis. The experiment was conducted with four main plot treatments, Jawahar tillers T_1 , T_2 , T_3 and T_4 and two sub plot treatments, moisture content of M_1 (16%db) and M_2 (25%db) and four replications (R_1 , R_2 , R_3 , and R_4). The size of main plot and sub plot was 10.0 m $\times$ 5.0 m. The plots were selected randomly.

2.4 Testing procedure

Before stating the test, soil samples were collected (with help of core cutter) in each plot for determination of bulk density and moisture content. Soil cone index were measured with the help of cone penetrometer up to the tillage depth in each plot.

One rigid tine was attached to the tool carrier and adjusted the rigid tine for maximum depth of cut. After that, tillage tool (T1) was attached to the tine. A dynamometer was fixed horizontally between the tractor hitch point and the tool carrier. The dead load of tool-carrier 125 kg + added weight of 270 kg in the weight box were pulled by tractor after running-in. The test field was divided into four different equal areas because of split plot design. There were four replications (R1, R2, R3 and R4), four main plot treatments i.e. four different Jawahar tillers (T1, T2, T3 and T4) and two sub plot treatment i.e. two different moisture content of M1 (16%db) and M2 (25%db). Distance between each replication was 1 m. Each replication plot size was 20 m X 20 m and each replication were divided into two equal plot size 20 m X 10 m. At the starting and ending point of each plot, poles were fixed, for recording the starting time and ending time. Time was recorded by stop watch. A dynamometer was fixed horizontally between the tractor hitch point and the tool carrier, so that, it can directly give the value of draft through digital dynamometer. The dead load of tool-carrier 125 kg + added weight of 270 kg in the weight box were pulled by tractor as shown in plate 1. When tractor and tool-carrier passed the first pole, the readings of dynamometer were recorded and the time required to traverse 10 m length was recorded with the help of stop watch. After that the furrow was cleaned at five places, depth and widths of furrow were recorded with the help of scale. Soil samples were collected by core cutter for measurement of bulk density and moisture content. Cone index was measured by penetrometer.

The same procedure was adopted for other Jawahar tillers (T2, T3 and T4). The positions of throttle and gear was same for each test with different tillers.

2.5 Measurement of soil parameters

2.5.1 Soil moisture percentage

The draft is dependent on soil moisture to great extent. Soil sample were taken up to maximum ploughing depth of tillage. The soil moisture analysis was done by oven drying method. Moisture content was found out on dry weight basis. Soil sample were collected at different places. Firstly, measured the weight of wet soil sample then put in an oven at 105°C for 24 hours and then the weight of dry sample was measured. By the help of given formula soil moisture content were calculated. (Javadi and Hajiahmad, 2006).

$$\text{Moisture content of the soil (\% db)} = \frac{W_w - W_d}{W_d} \times 100 \dots \text{eq (1)}$$

Where,

W_w = Weight of the wet soil (g)

W_d = Weight of the dry soil (g)

2.5.2 Draft

It is defined as the horizontal component of the pull, parallel to the line of motion. As the dynamometer was fitted horizontally in the line of pull, therefore, draft measured in kgf.

2.5.3 Power requirement

$$\text{Power requirement, kW} = \frac{\text{Speed (m/s)} \times \text{Draft (N)}}{1000} \quad \dots\text{eq (2)}$$

2.5.4 Theoretical field capacity

On the basis of the width of furrow and speed, field capacity was following calculated by following formula:

$$\text{Theoretical filed capacity, ha/h} = \frac{S \times W}{10000} \times 36 \quad \dots\text{eq (3)}$$

Where,

S = Speed of travel, km/h

W = Width of furrow (cm)

3. Result and Discussion

3.1 Draft requirement

The draft of Jawahar tillers primary tillage tools i.e. four treatments T₁, T₂, T₃ and T₄ at two level of moisture content, 25% and 16%db, are given in fig 3. Maximum draft of 4.76 and 5.0 kN were recorded at moisture content of 25% and 16%db, respectively, with tiller (T₁). Minimum draft of 4.20 and 4.41 kN were recorded at moisture content of 25% and 16% db, respectively, with tiller (T₄). Tiller (T₄) has a modified downward projected share nose, therefore, it penetrated and cut the soil easily compared to other tillers, hence, the draft requirement was minimum. In all the tillers, the draft requirement was higher for 16%db moisture content.

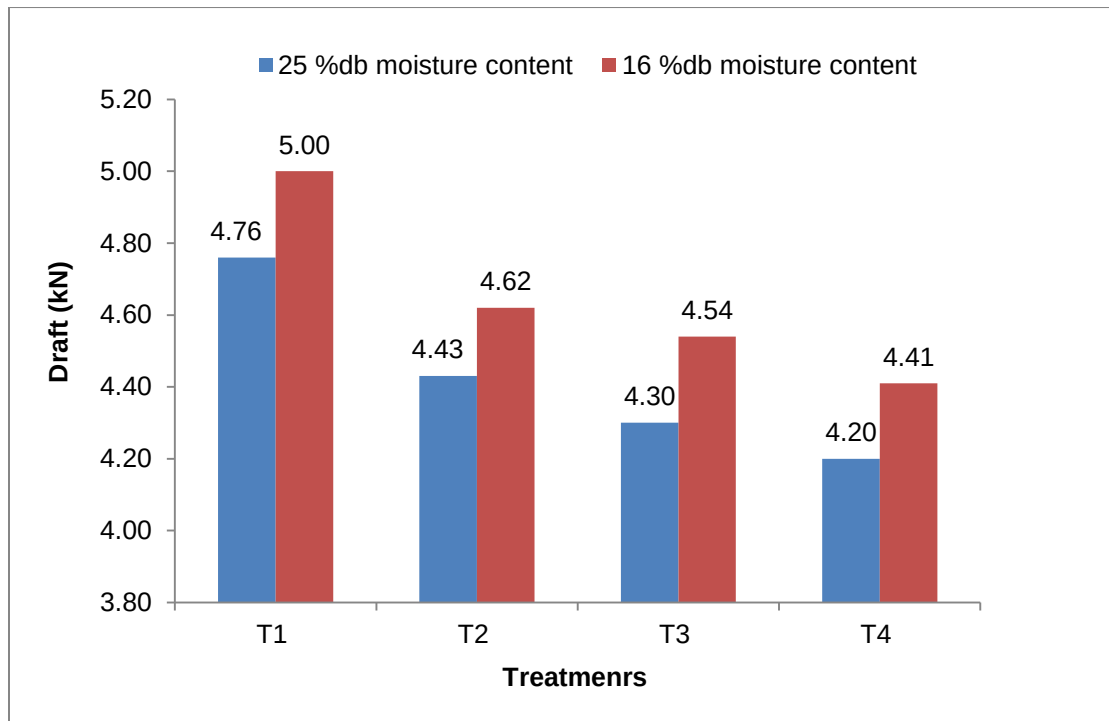


Fig. 3 Draft in different Jawahar tillers at two levels of moisture content

3.2 Performance index

The performance index of Jawahar tillers i.e. four treatments T_1 , T_2 , T_3 and T_4 at two level of moisture content, 25% and 16%db, are given in fig 4. Maximum value of performance index of 55.28 and 53.49 were recorded at moisture content of 25% and 16% db, respectively, with tiller (T_4). Minimum performance index of 27.33% and 28.69% were recorded at moisture content of 25% and 16% db, respectively, with tiller (T_1). Tiller (T_4) has a modified downward projected share nose, therefore, it penetrated and cut the soil easily compared to other tillers, hence, the performance index was maximum. In all the tillers, the performance index was highest for 25%db moisture content. Looking to the results of performance parameters (draft, unit draft, power requirement, energy requirement, mean mass diameter, bulk density, cone index and performance index) the performance of Jawahar tiller (T_4) was best compared to other tillers, therefore, selected for further test.

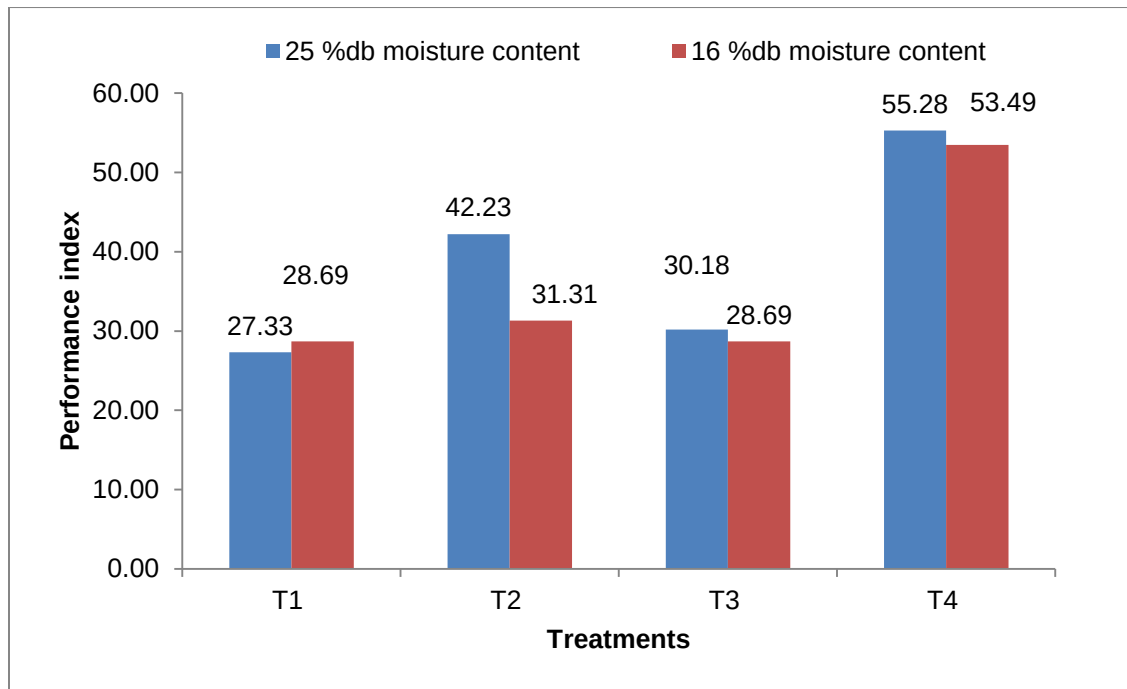


Fig. 4: Performance index in tillers at two level of moisture content

4. Conclusion

Minimum value of draft (4.20 and 4.41 kN), unit draft (17.05 and 16.52 N/cm²), power requirement (2.90 and 3.04 kW) and energy requirement per unit volume (4.65 and 4.40 kW h/ha-cm) were obtained with moisture content of 25% and 16%db, respectively, with Jawahar tiller (T₄) compared to other tillers. Minimum value of mean mass diameter (10.43, 11.13 mm), bulk density (965.00, 954.25 kg/m³) and cone index (252.50, 327.00 kPa) were obtained at 25% and 16%db moisture content, respectively, with Jawahar tiller (T₄). Maximum value (55.28, 53.49) of performance index were obtained at moisture content of 25% and 16%db, respectively, with Jawahar tiller (T₄). Significant variation in pulverization was not observed with moisture content of the soil. With the increase in soil moisture from 16% to 25%db, draft, unit draft, power requirement decreased in all

Jawahar tillers. Power requirement was minimum and pulverization was maximum with Jawahar tiller (T_4), therefore, it was selected for further test. A significant increase in draft, power requirement was observed for all the Jawahar tillers with decrease in moisture content of soil. Interaction effect of Jawahar tillers on unit draft, energy requirement per unit volume and moisture content were significant at 5% but performance index significant at 1% level.

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