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Performance evaluation of selected Jawahar Lister tiller primary tool with existing shovel and sweep under actual field conditions

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Abstract
Performance evaluation of selected Jawahar Lister tiller primary tillage tools (X_1), shovel (X_2) and sweep (X_3) were studied by using digital dynamometer in vertisol. Performance evaluation on the basis of draft, unit draft, power requirement, energy requirement, performance index measurements were investigated through split plot design. In this research, the experiment was conducted in three operating speed, 1.96, 2.35, and 3.60 km/h, and at the same soil moisture content 10% db. Performance index was maximum (100.51, 125.20, 97.01) at all speeds with Jawahar tiller (X_1), compared to shovel and sweep. No signification variation in draft, unit draft, energy requirement and pulverization were obtained with variation in speed of operation, with Jawahar tiller (X_1), shovel and sweep. Power requirement was max for all the tools at higher speed of 3.60 km/h. Interaction effect of three tillage tools (selected Jawahar tillers, shovel, and sweep) on draft, power requirement, energy requirement per unit area and three forward speeds were significant at 1% but performance index was significant at 5% level. Max area of furrow (269.66 cm^2) was obtained with Jawahar tiller (X_1). Power requirement was minimum, pulverization and performance index was max with Jawahar tiller (X_1) compared to shovel & sweep, therefore, the performance of Jawahar tiller (X_1) was best.

Keywords: 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. For farming, many operations are performed by farmers, like ploughing, harrowing, transplantation of crop, weeding, irrigation, harvesting, threshing etc. and the primary operation is seed bed preparation. Soil working tools such as mould board ploughs, disc ploughs and ridges have long been accepted and successfully used by farmer under average field condition. Tillage operations are done to prepare the seedbed for sowing and for good growth of plant, may be termed as tillage operation. It is the mechanical manipulation of soil which is used to maintain, modify or promote changes in soil structure in an effort to produce more desirable soil environment for plant growth. Tillage, being the maximum energy consuming operation, in crop production, has been a field of great interest and work for agricultural engineers. 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.

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 selected Jawahar Lister tiller primary tool with existing shovel and sweep under actual field conditions.

2. Material and Methods

2.1 Selection of Land

The second experiment was at research field of College of Agricultural Engineering, JNKVV, Jabalpur (M.P.).

2.2 Details of Experiment no.01

Table 1: Details of Experiment no.01

Design	:	Split plot design
Main plot treatment	:	3 (selected Jawahar tiller, shovel and sweep)
Subplot treatment or split plot	:	3 different speeds
Number of replication	:	3
Total area of field	:	0.13 ha
Gross plot size	:	92.0 m X 15.0 m
Net plot size	:	30.0 m X 15.0 m
Types of soil	:	Black cotton (vertisol)
Last crop harvested	:	Wheat
Topography of field	:	Plane
Speed (km/h)	:	1.98, 2.35, and 3.60
Soil moisture (% db)	:	10%
Bulk density (kg/m^3)	:	1330
Cone index (kPa)	:	Did not penetrate into the soil

2.3 Tools and Tractors Used in Test

2.3.1 Tools

For second experiment, selected Jawahar tiller, shovel and sweep were selected for the test, fig 1.1, 1.2 and 1.3.

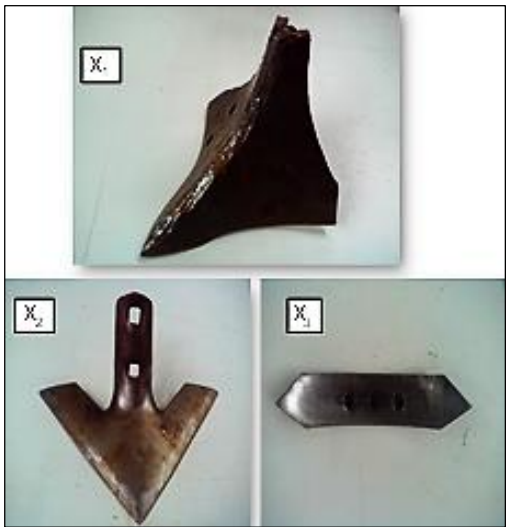

Plate 1: Selected Jawahar tiller (X_1), Shovel (X_2) and sweep (X_3)

Table 2: Specification of selected Jawahar tiller, shovel and sweep undertaken for study

S. No.	Name of tools	Length (mm)	Width (mm)	Height (mm)
1.	Selected Jawahar tiller (X_1)	212	230	170
2.	Shovel (X_2)	300	70	-
3.	Sweep (X_3)	226	300	124

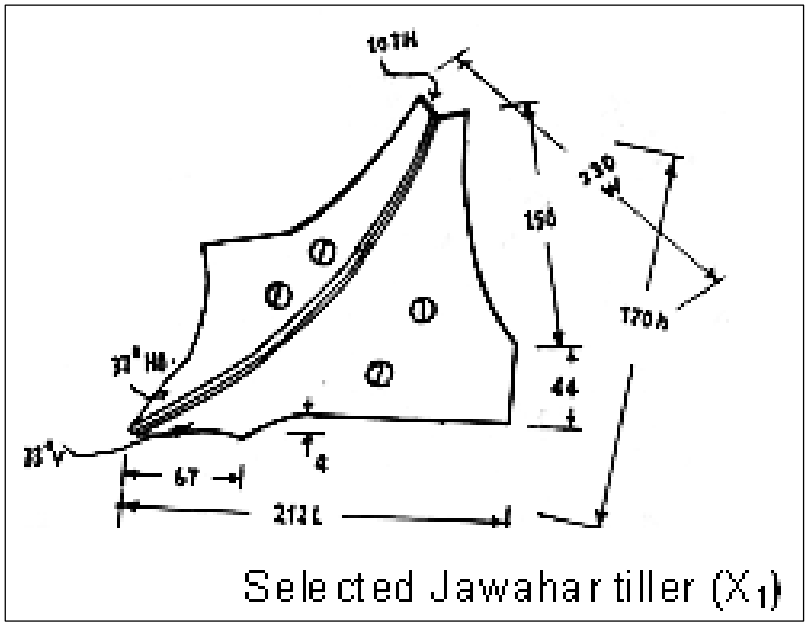

Fig 1: Schematic diagram of selected Jawahar tiller (X_1)

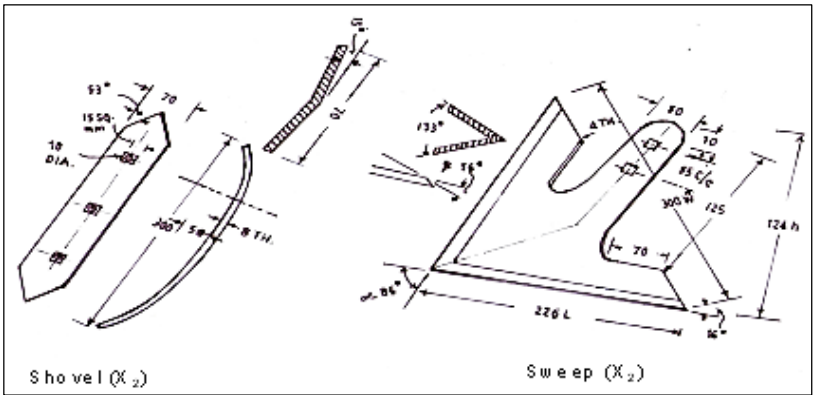

Fig 2: Schematic diagram of shovel (X_2) and sweep (X_3)

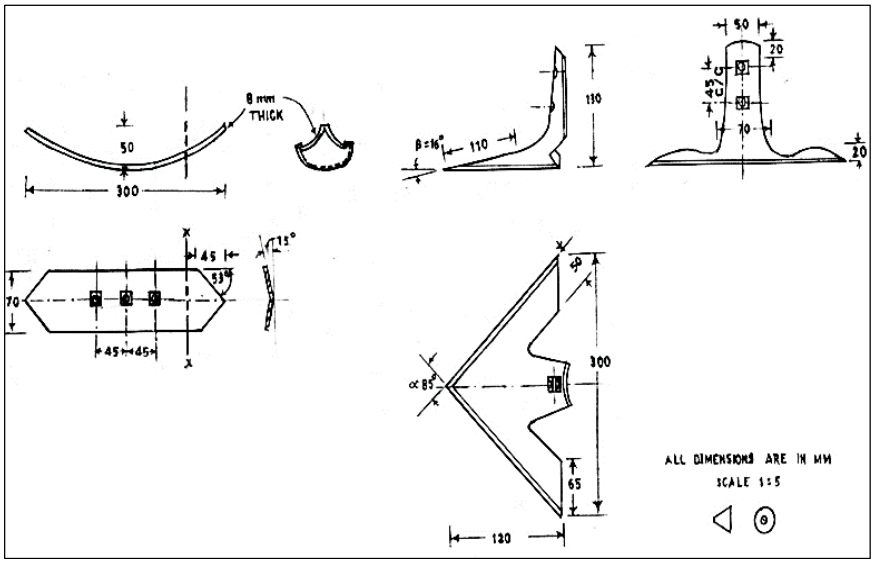

Fig 3: Orthographic views of shovel and sweep

2.4 Experimental Layout and Procedure

2.4.1 Layout of Experiment no. 02

In this research, the experiment was conducted in three operating speed, 1.96, 2.35, and 3.60 km/h, and at the same soil moisture content 10% db.

Experimental plots were designed, according to the split-plot scheme and were used for statistical analysis. The experiment was conducted with three main plot treatments, selected Jawahar tiller (X_1), sweep (X_2) and shovel (X_3) and three sub plot treatments, speeds of S_1 (1.96 km/h), S_2 (2.35 km/h) and S_3 (3.60 km/h) and three replications (R_1, R_2 and R_3). The size of main plot and sub plot was 10.0 m × 5.0 m. The plots were selected randomly. Fig 1.4 shows the layout of plan of experiment 02.

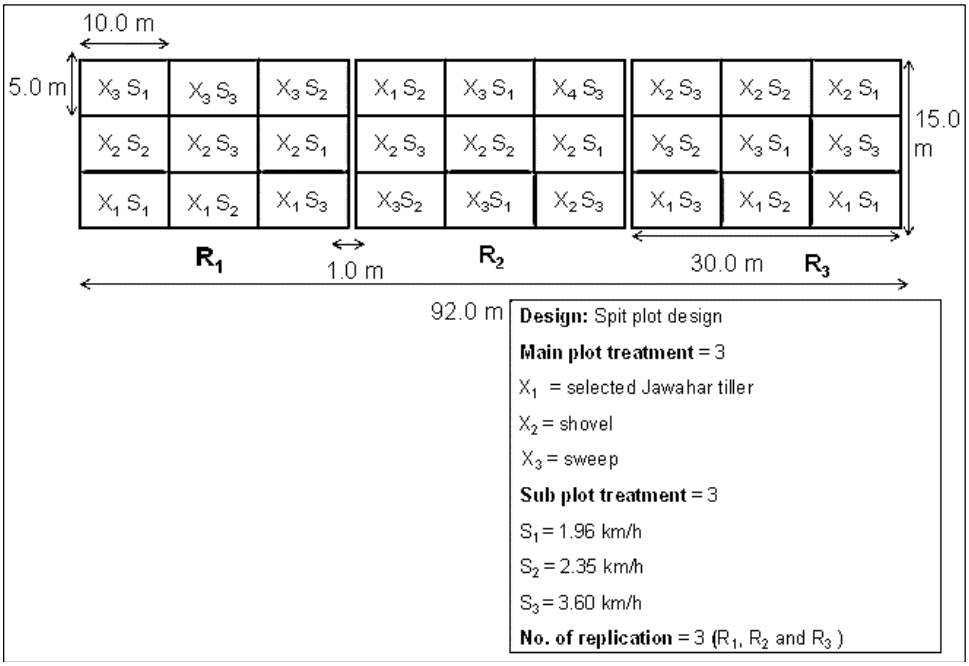

Fig 4: Layout of plan of experiment 02

2.4.2 Test Procedure of Experiment Plot No. 02

Before starting 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.

Only one rigid tine was attached to the cultivator. After that tool (X_1) was attached to the tine and cultivator was attached to tractor (Farm trac 65 EPI). A dynamometer was fixed horizontally between the tractor (John Deere 5310) hitch point and tractor (Farm trac 65 EPI) with the help of rod. The test field was divided into three different equal areas because of split plot design. There were three replications (R_1, R_2 and R_3) and three main plot treatments i.e. selected Jawahar tiller (X_1), shovel (X_2) and sweep (X_3) and three sub plot treatment i.e. three levels of operating speeds, S_1 (1.96 km/h), S_2 (2.35 km/h) and S_3 (3.60 km/h). Distance between each replication was 1 m. Each replication plot size was 30.0 m X 15.0 m and each replication was divided into three equal plot size 20 m X 10 m. Poles were fixed at the starting and ending point of each plot, for recording the starting and ending time. Time was recorded with the help of stop watch. A dynamometer was fixed horizontally between the tractor (John Deere 5130) hitch point and the tractor (Farm trac 65 EPI), so that, it can directly give the value of draft through digital dynamometer.

At first, draft of tractor (Farm trac 65 EPI) at three operating speed (1.96, 2.35 and 3.60 km/h) were recorded, when the tractor was in neutral gear. In second case, the tractor (Farm Trac 65 EPI), carrying cultivator in operating depth and in neutral gear, was pulled by another tractor (Jonh Deere 5130) at three speeds. When tractor passed the first pole, the reading of dynamometer was 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 as shown in plate 3.9. Soil samples were collected with the help of core cutter for measurement of bulk density and moisture content. Cone index was measured with the help of penetrometer. The same procedures was adopted for other tools, shovel (X_2) and sweep (X_3).The positions of throttle and gear was changed for different operating speeds. The difference of two readings gave the draft of tool.

Plate 2: Draft measurement at load

2.5 Result and Discussion

2.5.1 Draft Requirement

The draft of selected tiller (X_1), shovel (X_2) and sweep (X_3) i.e. three treatments X_1, X_2 and X_3 at three level of speeds, 1.96, 2.35 and 3.60 km/h, are given in fig 4.10. The draft requirement was minimum (1.75 kN) at the operating speed of 2.35 km/h with tiller (X_1). The draft requirement was maximum (3.01kN) at operating speed of 3.60 km/h with shovel (X_2). The draft requirement of sweep (X_3) was almost same (2.56, 2.44 and 2.67 kN) for all the three operating speeds. Looking to the fig 4.10, it was not possible to make conclusion about the effect of speed on draft requirement of tillage tools (X_1, X_2 and X_3). It may be due to the variation in the depth of furrow made by the tools at different operating speeds.

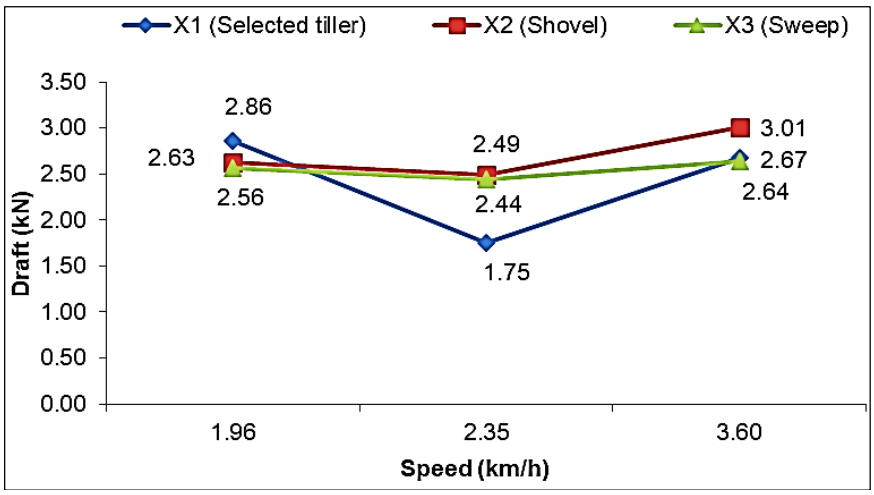

Fig 5: Draft at different speed levels in tillage tools

2.5.2 Performance Index

The performance index of selected tiller (X_1), shovel (X_2) and sweep (X_3) i.e. three treatments X_1, X_2, and X_3 at three levels of speeds, 1.96, 2.35 and 3.60 km/h, are given in fig 4.18. Maximum value of performance index 100.51, 125.2 and 97.01 were recorded at 1.96, 2.35 and 3.60 km/h, respectively, with selected tiller (X_1). Minimum performance index of 42.71, 44.04, and 42.08 were recorded at 1.96, 2.35 and 3.60 km/h, respectively, with shovel (X_2). 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 selected Jawahar tiller (X_1) was best compared to shovel and sweep.

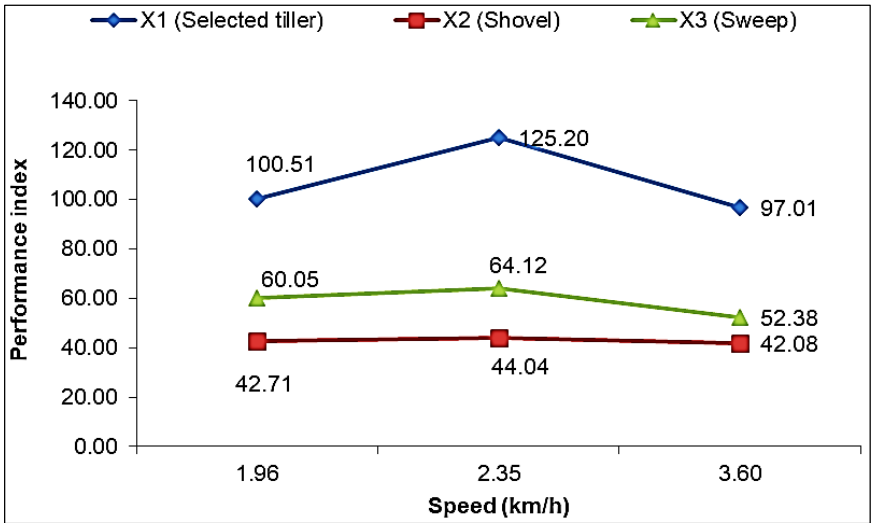

Fig 6: Performance index at different speed levels in tillage tools

Analysis of variance shown in appendix-V (I), this table depicts that the calculated value of F Statistics has been worked out as 429.156 which is greater than the corresponding table value of $F_{5\%}$ and $F_{1\%}$. The valid hypothesis for tillage tool on performance index (main treatment) and moisture content of soil (sub treatment) was found significant at 1% level but the interaction of tillage tool on performance index (main treatment) and moisture content of soil (sub treatment) was significant at 5% level.

2.5.3 Depth and Width of Furrow

Average depth of 11.48, 8.76, 7.45 cm, were obtained with Jawahar tiller (X_1), shovel (X_2) and sweep (X_3), respectively. Average width of 23.49, 16.44, 24.30 cm, were obtained with Jawahar tiller (X_1), shovel (X_2) and sweep (X_3), respectively. Average area of furrow of 269.66, 144.01, 181.03 cm^2, were obtained with Jawahar tiller (X_1), shovel (X_2) and sweep (X_3), respectively.

3. Conclusion

1. Unit draft was minimum (9.38, 7.49, 9.9 N/cm^2) at 1.96, 2.35 and 3.60 km/h, respectively, with selected Jawahar tiller (X_1) compared to shovel and sweep.
2. Energy requirement was minimum (2.61, 2.08, 2.75 kWh/ha-cm) at 1.96, 2.35 and 3.60 km/h speeds, respectively, with selected Jawahar tiller (X_1) compared to shovel and sweep.
3. Min values of MMD (10.43, 10.53, 10.26 mm), minimum values of bulk density (926.67, 916.67, 913.33 kg/m^3) and minimum values of cone index (134.57,125.47, 113.27 kPa), were recorded at speed of 1.96, 2.35 and 3.60 km/h, respectively, with selected Jawahar tiller (X_1)
4. Performance index was maximum (100.51, 125.20, 97.01) at all speeds with Jawahar tiller (X_1), compared to shovel and sweep.
5. Max area of furrow (269.66 cm^2) was obtained with Jawahar tiller (X_1).
6. Power requirement was minimum, pulverization and performance index was max with Jawahar tiller (X_1) compared to shovel & sweep, therefore, the performance of Jawahar tiller (X_1) was best.
7. No signification variation in draft, unit draft, energy requirement and pulverization were obtained with variation in speed of operation, with Jawahar tiller (X_1), shovel and sweep. Power requirement was max for all the tools at higher speed of 3.60 km/h.
8. Interaction effect of three tillage tools (selected Jawahar tillers, shovel, and sweep) on draft, power requirement, energy requirement per unit area and three forward speeds were significant at 1% but performance index was significant at 5% level.

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