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Mini tractor-drawn multi-tillage tool performance evaluation

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Abstract
Performance Evaluation of mini tractor drawn multi tillage implements tool has been suitable for seed bed preparation at wapsa conditions under sandy loam soil of middle Gujarat Agro-climatic zone in a single operation. The implement consisting of iron ploughs for tillage and clod crusher for breaking clods which is useful for preparation of seed bed in a single pass with a saving of about 20% in the cost of the operation as compared to the cultivator. The fuel consumption was found 9.6 lit/ha in multipurpose tillage implement with clod crusher one pass and 13.4 lit/hr in M.B. Plough one pass Cultivator one pass. The seedbed preparation by Multipurpose Tillage Implement is cost efficient due to less initial capital investment cost as well as less operating cost. According to the cost analysis, the total cost of operation (Rs/hr) for Multipurpose Tillage Implement is lowest followed by Cultivator and M. B. plough. Therefore, it is recommended for farmers of the region to prepare the seedbed by using the developed implements.

Keywords: Tiny tractor, multipurpose, tillage tool, clod crusher, M. B. plough

Introduction
India is agriculture based country. Agricultural mechanization refers to interaction of improved tools, implements and machines between farm workers and materials handled by them. Independent India ushered in a process of agricultural mechanization and revival of rural agro processing which got acceleration during post-Green Revolution period. India ranks second worldwide in farm output. Agriculture and allied sectors like forestry, logging and fishing accounted for 17% of the GDP in 2012 (Source: Wikipedia Economy of India). Despite a steady decline of its share in the GDP, it is still the largest economic sector and plays a significant role in the overall social-economic development of the country. Although, India ranks second in world in crop production, still, there is a need to increase the agriculture production as well as productivity to feed the population which is increasing at very fast rate. International comparisons reveal the average yield in India is generally 30% to 50% of the highest average yield in the world. Indian states Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Andhra Pradesh, Bihar, West Bengal, Gujarat and Maharashtra are key agricultural contributing states of India.

Materials and Methods
This chapter deals with the procedure of determining the design aspects of various components and constructional details of mini tractor drawn multipurpose tillage implement. It also describes methodology of testing the implement in the field.

Parameter Studied
Three Commonly used implements were selected to investigate their effect on soil with respect to soil physical properties and implements performance for seedbed preparation operation. The various soil parameters like soil texture, soil moisture content, bulk density and machine parameters like field capacity, fuel consumption, draft and energy requirement, draft power requirement, travel reduction etc. were recorded and evaluated.

Plate 1: Multi purpose till age implement with clod crusher during operation

Plate 2: Multi purpose till age implement with Planker during operation

Plate 3: Mould board ploughduring operation

Plate 4: Cultivator during operation

Soil moisture content

Moisture content for soil is computed on dry basis. Soil samples were collected from 0 to 20 cm depth of soil surface before operations for determination of moisture content and bulk density. The samples were collected from five randomly selected sites across the field in each plot. The moisture content was determined in the laboratory by oven dry method and the samples were collected by core samples from the soil.

The moisture content (Dry basis) was determined by the following formula:

$$\text{Moisture content \%} = \frac{W2 - W3}{W3 - W1} \times 100$$

Moisture content % = W2 - W3/W3 - W1 ×100

Where,
W1= Weight of core sampler
W2= Weight of wet soil sample + sampler
W3 = Weight of dry soil sample + sampler

Bulk density

The bulk density is the weight of soil is to its volume. The bulk density depends upon various factors *viz*., soil, texture and organic matter, history of tillage and moisture content.

$$\text{Bulk Density (g/ cc)} = \frac{\text{Weight of dry soil sample (g)}}{\text{Volume of the core sample (CC)}}$$

Operating speed

Outside the long boundary of the test plot, two poles 30 m apart were placed approximately in the middle of the test run. On the basis opposite side also two poles were placed in a similar position 30 m apart so that all four poles form corners of a rectangle, parallel to one long side of the test plot. The speed was calculated as the ratio of the distance (30 m) to time taken for the machine to travel the distance.

Travel reduction (wheel slip)

A mark was made on the tractor drive wheel with colored tapes and the distance the tractor moves forward at every 10 revolutions under no load and the same revolution with load on same surface was measured. It can be expressed mathematically as:

$$\text{Travel reduction (\%)} = \frac{\text{M2} - \text{M1}}{\text{M2}} \times 100$$

Where,
M2=Distance covered at every 10 revolutions of the tractor drive wheel at no load (m),
M1=Distance covered at every 10 revolutions of tractor drive wheel with load (m).

Draft

Draft was measured using a digital drawbar dynamometer attached to the front of the tractor on which the implement was mounted (Al-Janobi *et al*., 1988) [1]. Another auxiliary tractor was used to pull the implement mounted tractor through the drawbar dynamometer. The auxiliary tractor pulls the implement-mounted tractor with the latter in neutral gear but with the implement in the operating position. Draft was recorded in the measured distance of 30 m. On the same field, the implement was lifted off the ground and the draft recorded. The difference between the two readings, gives the draft of the implement. This procedure was repeated for each of the tractors evaluated.

Fuel consumption

The fuel consumption for seed bed preparation under each treatment was measured by the standard method, the fuel tank was filled up to top level by keeping the tractor on level land and after completing the operation, the fuel tank was filled up again. The difference of two observations gave the fuel consumed in the concerned operation.

Field capacity

The effective field capacity of machine can be expressed as the actual rate at which, it can do work, taking into account such non-productive operations as turning at the ends of the field, stopping to add seed or fertilizer and stopping to check the performance of a particular equipment.

The Theoretical field capacity (TFC) was determined by the following formula:

$$\text{T.F.C(ha/ hr)} = \frac{\text{Width of coverage (m)} \times \text{Speed of travel (km hr)}}{10}$$

The effective field capacity (EFC) was determined by the following formula:

$$\text{E.F.C (ha/ hr)} = \frac{\text{Area covered (ha)}}{\text{Time Taken (hr) x100}}$$

The Field Efficiency (FE) was determined by the following formula:

$$\text{F.C (ha/ hr)} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100$$

Soil volume disturbed

The soil volume disturbed in m^3/hr was calculated by multiplying the field capacity with the depth of cut (Ahaneku *et al*., 2011) [2].

V =10000SD

Where,
V = Soil volume disturbed (m^3/hr)
S = Effective field capacity (ha/hr)
D = Depth of cut (m)

Soil pulverization

Soil pulverization is the process of breaking of soil into small aggregates resulting from the action of tillage forces. The mean mass diameter (MMD) of the soil aggregates is considered as index of soil pulverization and can be determined by the sieve analysis of the soil sample through a set of standard test sieves (IS: 460-1982). Sieve provides a simple means for measuring the range of clod size and relative amount of soil in each size class. For this the soil sample was passed through a set of sieves and weighing of the soil retained on the largest aperture sieve passed through each sieve and retained on the next sieve and passed through the smallest aperture sieve is done.

$$\text{MMD} = \frac{1}{w} \times \text{A} + 1.2\text{B} + 1.7\text{C} + 2.4\text{D} + 3.7\text{E} + \text{XF}$$

Where,
MMD = Mean Mass Diameter, (mm)
W = A+B+C+D+E+F
X = Mean of measured diameter of soil clods retained on the largest sieve, (mm)

Results and Discussions

The results of the field experiments are presented in this chapter along with its discussion. The data pertaining to soil moisture content, bulk density, operating speed, travel reduction, draft, fuel consumption, field capacity, energy requirement, soil volume disturbed, soil pulverization and drawbar power are subjected to analysis. Result parameters are presented under the following main heads (Kapil Mandloi *et al*., 2017) [6].

Physical properties of soil

The results (table 1) revealed that the average moisture content is as recorded at 0 - 20 cm depth is 14.18%. The result (table 2) show that the average bulk density was as recorded at 0 - 20 cm depth is 2.02 g/cc.

Table 1: Soil moisture content (Dry Basis)

Sample No.	Weight of Wet Soil(gm)	Weight of Dry Soil(gm)	Soil Moisture Content (%)	Average (%)
1	289.4	267.2	13.88	14.18
2	277.5	254.4	15.69	
3	263.1	245.2	12.97	

Table 2: Bulk Density (gm/cc)

Sample No.	Weight of Wet Soil (gm)	Weight of Dry Soil (gm)	Volume of Core Sampler (cc)	Bulk Density (g/cc)	Average (g/cc)
1	289.4	267.2	125.85	2.12	2.02
2	277.5	254.4	125.85	2.02	
3	263.1	245.2	125.25	1.94	

Performance Parameters

The operating speed was measured under each treatment and found that the average speed for respective operation under treatment T1, T2, T3, T4, T5 and T6 is presented in table 3. The operation speed of multipurpose tillage was compare to speed of other treatments and similar operating condition and it was found Cultivator single pass and Cultivator with planker and second pass increase. Travel reduction was found 4.76 % of tractor wheel which is under permissible limit. The results showthatdraftishighestincaseofM.B.ploughduetohigherdeptho fcutincomparisontootherimplements. The fuel consumption was found 7.7 lit/ha in multipurpose tillage implement with clod crusher one pass 9.16 lit/ha multipurpose tillage implement two pass with planker, 10.66 lit/ha in M.B. Plough one pass, And 8.16 1it/ha Cultivator two pass. Field capacity and soil disturbance has been reported as two major factors in determining the performance of tillage implements (Bukhari *et al*., 1988) [3]. The field capacity of a machine is a function of its width, speed, efficiency of operation and soil parameter. The medium with relatively higher values of width of cut, speed of operation and field efficiency achieved better results for field capacity. The treatment T3 resulted highest value of field efficiency due to only signal operation. The soil volume disturbed for maximum value in the T1 and minimum value in the multipurpose tillage tool + c.c T3. There is considerable improvement in soil pulverization with the use of the clod crusher due to the ability to break the clod formed in the operation. The mean mass diameter of clods in seedbeds under different treatments was: average MMD was 11.09 mm followed by multipurpose tillage implement with planker with diameter of 9.49 mm.

Table 3: Speed of operations during treatments

Treatment		Pass	Distance Covered (m)	Time Taken(s)	Speed (m/s)	Speed (km/h)
T1	Cultivator	1	30	24	1.25	4.5
	Cultivator + Planker	1	30	19	1.57	5.6
T2	M.B Plough	1	30	32	0.93	3.3
	Cultivator + Planker	1	30	21	1.42	5.1
T3	multipurpose tillage implement + CC	1	30	30	1	3.6
T4	multipurpose tillage implement + CC	1	30	29	1.03	3.7
	multipurpose tillage implement + Planker	1	30	23	1.3	4.5

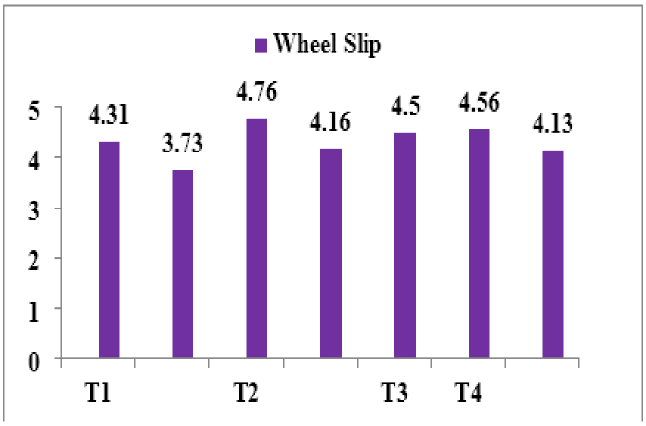

Fig 1: Wheel Slippage

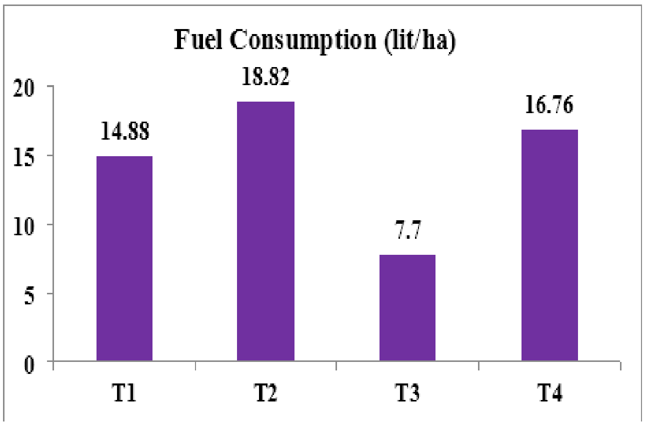

Fig 3: Fuel consumption

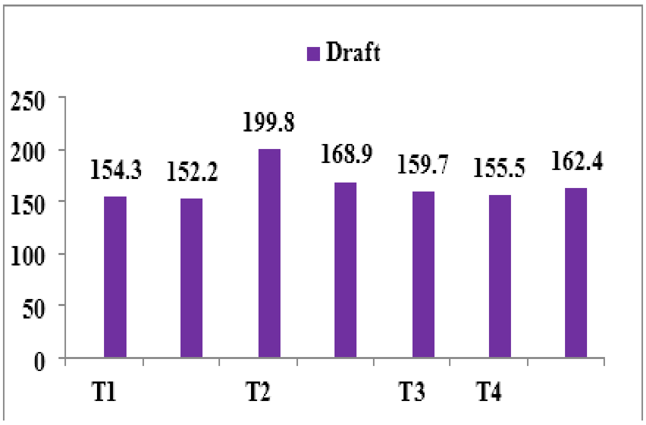

Fig 2: Draft Measurement

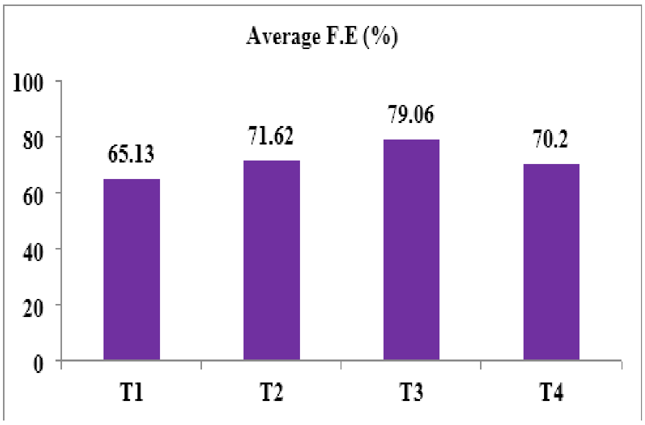

Fig 4: Field capacity

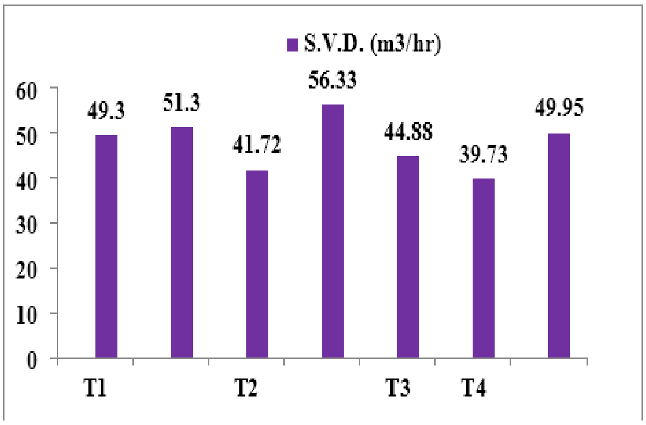

Fig 5: Soil volume disturbed

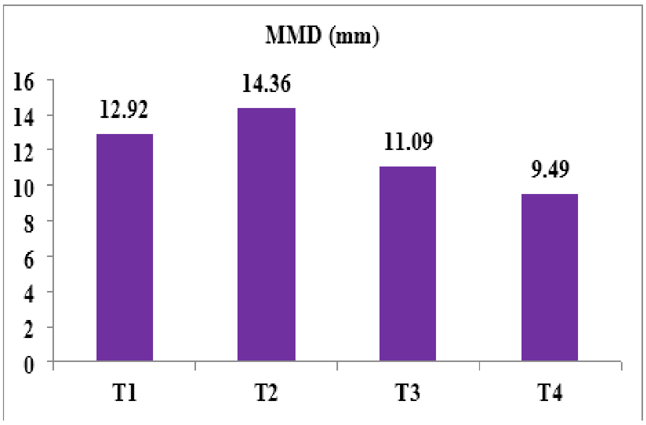

Fig 6: Mean mass diameter

Cost Analysis

The cost analysis under each treatment for seed bed preparation involves the fixed cost of the machines and the variable cost due to fuel and labour charges which is shown in table 4. The highest cost of M. B. plough in the any other implements. The seedbed preparation by Multipurpose Tillage Implement is cost efficient due to less initial capital investment cost as well as less operating cost. According to the cost analysis, the total cost of operation (Rs/hr) for Multipurpose Tillage Implement is lowest followed by Cultivator and M. B. plough.

Table 4: Cost analysis

Treatments	Cost Rs/hr	E.F.C	Time req. (Hr/ha)	Cost or Rs/ha	Total Cost (Rs/hr)
T1	322.56	0.43	2.32	748.33	1406.35
	.22.56	0.49	2.04	658.02	
T2	324.56	0.20	5.0	1622	2322.04
	322.78	0.46	2.17	700.04	
T3	316.01	0.34	2.94	929.06	929.06
T4	316.01	0.32	3.12	985.95	1719.09
	316.01	0.43	2.32	733.14	

Conclusions

Mini Tractor operated multipurpose tillage implement was developed with the cost 10723/- Rs. It was found suitable for tillage operation as compare to other combinations of tillage tool. The speed of operation of multipurpose tillage implement was compare to speed of other treatments and similar operating condition and it was found multipurpose tillage implement with clod crusher and multipurpose tillage implement with planker and second pass increase. Travel reduction of multipurpose tillage implement with clod crusher was found 6.09 % of tractor wheel which is under permissible limit. The total draft of the implement is lowest in case of Multipurpose Tillage Implement with Clod Crusher and Multipurpose Tillage Implement with Plankler with compare to other treatment. The draft is highest in case of M. B. plough due to higher depth of cut in comparison to other implements. The fuel consumption was found 9.6 lit/ha in multipurpose tillage implement with clod crusher one pass and 13.4 lit/hr in M.B. Plough one pass Cultivator one pass. Multipurpose tillage implement with clod crusher gave finest tilth of the field and the average MMD was 12.56 mm followed by multipurpose tillage implement with planker with diameter of 12.58 mm. The seedbed preparation by Multipurpose Tillage Implement is cost efficient due to less initial capital investment cost as well as less operating cost. According to the cost analysis, the total cost of operation (Rs/hr) for Multipurpose Tillage Implement is lowest followed by Cultivator & M.B.plough.

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