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Design, development and performance evaluation of manually operated soil conditioner in vertisol

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Abstract
Tillage has many roles in crop production (Cornish and Pratley, 1987; Titi, 2003). The most widely recognized function of tillage is seedbed preparation. This research work involved the design, develop and evaluation of modified soil conditioner after discovering that tools such as spade and hoes require high drudgery, time consuming and high labour force (Sridhar, 2013). It is necessary to design the implements which minimize the human effort and provide efficient work output. As a solution to these problems, the soil conditioner was designed and constructed at the AKS University, Satna M.P. The preliminary design of manually operated soil conditioner had been done in Autodesk Inventor version 2017, developed by U.S. based software company Autodesk. The soil conditioner was made of two implements attachment primary one is pegs which open the soil and the secondary one is clod crusher which breaks the soil. The performance of modified soil conditioner were conducted at three different levels of each parameter viz, soil moisture content (8.10 and 18.18%, db), length of pegs (14 and 28 cm) and width of implements (0.48 and 0.60 m). The results were analyzed statistically, interaction due to use of W×S×M did not touch the level of significance at 5% probability. On the basis of results obtained soil conditioner was selected and cost economics of selected soil conditioner with Kudali was carried out. The cost of cultivation (Rs/hr) with soil conditioner is slightly (3.80 %) greater than Kudali. The modified soil conditioner has pronounced effect on cost of operation per unit area.

Keywords: Triclosan, TCS, determination, detection, sensor

1. Introduction
Soil physical factor is one of the major factors that can limit crop production. Poor soil physical condition can restrict water intake into the soil and subsequent movement, plant root development, and aeration of the soil (R Horn, 1994) [9]. For satisfactory plant growth, it is essential that the soil must provide a favorable environment can exploit the soil sufficiently to provide the physical support, water and nutrients to the plants. The soil conditioner was fabricated with pegs and clod crusher which makes soil conditioner to perform tillage and weeding operation. Women generally adopt squatting and bending posture while doing the activity and maintain it for long hours, which cause musculo-skeletal problems (Sharma, 1999) [8]. It is necessary to design the implements which minimize the human effort and provide efficient work output. As a solution to these problems, the soil conditioner was designed in such way that it should be operated by standing posture. Weeds are responsible for significant crop yield losses and for financial losses in agricultural production, in the order of 10% per year worldwide (Oerke, 2006) [6]. As reported by Nag and Dutt (1979) [7], manual weeding is very predominant in India. Output of a worker with traditional hand tools is very low, i.e. upto 80 m^2/h as against that of manual weeders i.e. 100 to 200 m^2/h. Hence this research work has been conducted to increase the work output with following objectives:
1. Design and fabrication of manually operated soil conditioner.
2. Performance of operation of modified soil conditioner; and
3. Economical study of selected modified soil conditioner with Kudali.

2. Material and Methods
The fabrication of manually operated existing soil conditioner was done at engineering workshop of AKS University Satna, Madhya Pradesh. The experiment was laid out in factorial random block design with three replications having two levels of moisture content of soil. The cost economics of manually operated modified soil conditioner was evaluated with existing

Kudali at farm of AKS University Satna. The soil conditioner is facilitated with adjustable width and depth so that it can be used for different crops. The detail procedures are described as under:

2.1 Design and develop of manually operated soil conditioner

The design and development of manually operated soil conditioner was divided in three main sections they are as described as follow:

1. Design of soil conditioner;
2. Fabrication of soil conditioner; and
3. Performance evaluation of modified soil conditioner

2.1.1 Design of soil conditioner

The preliminary design of manually operated soil conditioner had been done in Autodesk Inventor version 2017, developed by U.S. based software company Autodesk. It is a computer-aided design application for creating 3D digital prototypes used in the design, visualization and simulation of products.

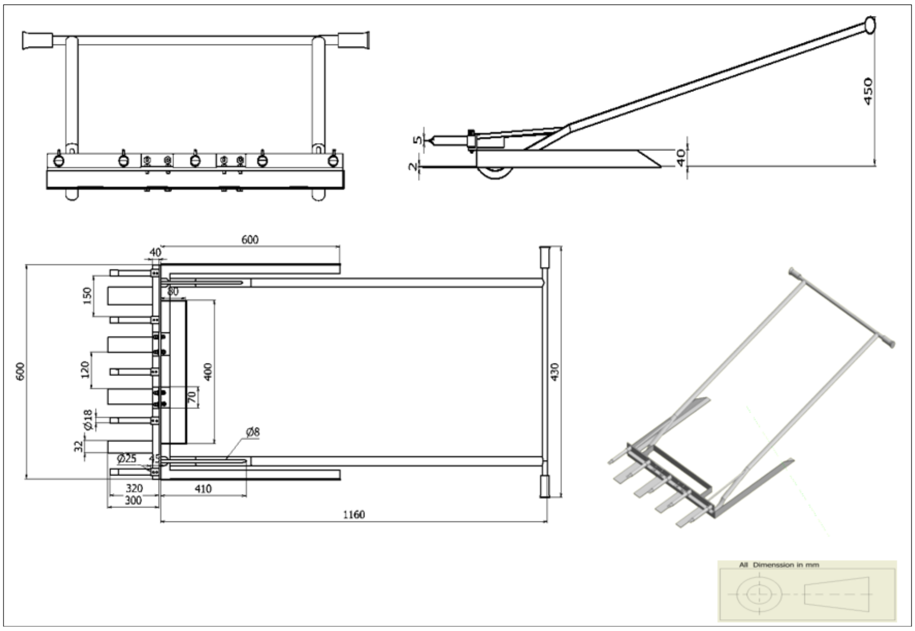

Fig 1: Orthographic projection of soil conditioner

2.1.2 Fabrication of soil conditioner

The manually operated modified soil conditioner for different depth of operation and different width of operation was fabricated at engineering workshop of A.K.S. University Satna, Madhya Pradesh. The constructional details of the soil conditioner and the parameter involved in the field performance of the soil conditioner have been explained as below. The Soil Conditioner consists of the five no. of pegs which penetrate in the soil surface. The five bushes were connected with the frame by the welding process, in which pegs can be fastened by nuts and bolts. The effective length of pegs can be adjusted by nuts and bolts. Frame was connected with two L-angles which is fixed with clod breakers. This implement should be used in proper moisture for the easy penetration in the soil surface. Reduction in moisture can affects the performance of the implement as well as energy required and time required. Mild steel was selected for construction of L-angles, frame, clod breakers, connecting L-angles and Toe-hold, whereas galvanized iron was used for construction of connecting rods, handle, and Bushes. Pegs and supporting rods were made by Thermo mechanically treated steel (TMT), whereas nuts and bolts were made by carbon steel. Table 1 shows properties of selected materials for construction of modified soil conditioner.

Table 1: properties of selected materials (Metal selection as BIS standard).

S. No.	Materials	Properties
1.	Galvanized Iron (IS:2629)	Zinc coating on iron or steel.
2.	Thermo mechanically treated steel (IS:1786: 2008)	Outer surface is hard, soften core
3.	Mild steel (IS:2062)	0.05-0.25% of carbon, ductile, malleable
4.	Carbon steel (IS:1570)	Impact resistance, ductile, yield strength

2.1.3 Performance evaluation of soil conditioner

To evaluate the performance of operation of modified soil conditioner feasible parameter such as field efficiency, weeding efficiency and mean mass diameter were selected. The performance was measured at different depth and width at two levels of moisture contents. The soil parameter such moisture content of soil, bulk density and mean mass diameter was measured with standard procedure. The specification of soil conditioner is given in Table 2. The soil moisture was measured by oven drying method on dry weight basis using following relation:

$$= \frac{\text{Weight of the wet soil(g)} - \text{Weight of the dry soil(g)}}{\text{Weight of the dry soil(g)}} \times 100$$

(Hausenbuiller, 1975.) [10]

Table 2: Specification of soil conditioner

S. No	Particular	Measured value
1.	Type	Manually operated
2.	Size, mm	1480×600×1160
3.	Working width, m	0.48 (W_0) and 0.60 (W_1)
4.	Length of pegs, m	0.14 (M_0) and 0.28 (M_1)
5.	Distance between two pegs, mm	150
6.	Distance between two clod breaker, mm	120
7.	Diameter of pegs, mm	18
8.	Diameter of supporting rod, mm	8
9.	Diameter of bush, mm	25
10.	Diameter of connecting rod and handle, mm	20
11.	Length of pegs, mm	300
12.	Length of clod breakers, mm	320
13	Length of L-angle, mm	600
14.	Length of Toe-hold, mm	400
15.	Length of frame, mm	600
16.	Length of handle, mm	430
17.	Length of connecting L-angle, mm	70
18.	Length of connecting rod, mm	1160
19.	Length of bush, mm	45
20.	Width of clod breaker, mm	32
21.	Width of L-angle and frame, mm	40
22.	Width of Toe-hold, mm	80

Plate 3.1: Measurement of weeding and field efficiency

3. Results and Discussion

The performance of operation of manually operated modified soil conditioner was carried out on the basis of dependent variables such a field capacity, field efficiency, weeding efficiency and soil pulverization. All the parameter was measured by standard procedure at two levels of moisture content (8.10% and 18.18%), two levels length of pegs (0.14 and 0.28m) and two levels of width of operation (0.48 and 0.60 m). The bulk density of soil before any operation was found 1.41 and 1.75 g/cc at moisture content of M_0 and M_1 respectively.

3.1 Effect of width of operation and length of pegs on field capacity of modified soil conditioner

Table 3 revealed that in moisture content M_0 the field capacity of soil conditioner at S_0 was 0.64 and 0.82% more than S_1 at width of operation W_0 and W_1 respectively whereas in moisture content M_1 the field capacity of soil conditioner at S_0 was 6.96 and 1.99% and that was more than S_1 at width of operation W_0 and W_1 respectively.

Table 3: Effect of length of pegs and moisture content on field capacity

	M_0	M_1	Mean
S_0	45.76	47.87	46.81
S_1	45.47	45.91	45.69
Mean	45.61	46.89	

		S	M
SEm ±	=	0.34	0.34
CD (P = 0.05)	=	1.05	1.05

The Table 3 revealed that at soil moisture M_0 and M_1 the field capacity was found 45.61 and 46.89m^2/h respectively. The field capacity of soil conditioner in moisture content M_1 was found significant over the other moisture M_0. Due to the effective length of pegs S_0 and S_1, the field capacity of soil conditioner varied from 45.69 to 46.81 m^2/h and maximum field capacity was noted S_0 which is found to be significant over the other S_1.

Table 4: Effect of length of pegs and width of operation on field capacity

	W_0	W_1	Mean
S_0	43.62	50.01	46.81
S_1	42.01	49.36	45.69
Mean	42.81	49.69	

		S	W
SEm ±	=	0.34	0.34
CD (P = 0.05)	=	1.05	1.05

It is evident from Table 4 the field capacity due to width of operation W_0 and W_1 was found 42.81 and 49.69 m^2/h respectively. The field capacity of soil conditioner in width of operation W_1 was found significant over the other width W_0. Due to the effective length of pegs S_0 and S_1 field capacity of soil conditioner varied from 46.81 to 45.69 m^2/h and maximum field capacity was noted at S_0 which is found to be significant over the other S_1. It is clear from the data obtained, due to use of different factor i.e. S, M and W caused significantly better response and values got in levels were also found to be significant. Thus it indicates that S_0, M_1 and W_1 proved to be better than S_1, M_0 and W_0.

3.2 Effect of width of operation and length of pegs on field efficiency of modified soil conditioner

It is evident from Table 5 in M_0 the field efficiency of soil conditioner at W_0 was 6.76 and 6.77% more than W_1 at S_0 and S_1 respectively whereas in M_1 the field efficiency at W_0 was 11.19 and 6.02 % more than W_1 at S_0 and S_1 respectively.

Table 5: Effect of length of pegs and moisture content on field efficiency

	M_0	M_1	Mean
S_0	68.03	71.34	69.68
S_1	67.67	68.23	67.92
Mean	67.27	69.78	

		S	M
SEm ±	=	0.42	0.42
CD (P = 0.05)	=	1.29	1.29

The Table 5 shows that the field efficiency due to soil moisture content M_0 and M_1 was found 67.27 and 69.78% respectively. The field efficiency of soil conditioner in moisture content M_1 was found significant over the other moisture M_0. Due to the effective length of pegs S_0 and S_1 field efficiency of soil conditioner varied from 69.68 to 67.92% and maximum field efficiency was noted S_0 which is found significant over the other S_1.

Table 6: Effect of length of pegs and width of operation on field efficiency

	W_0	W_1	Mean
S_0	72.69	66.68	69.68
S_1	70.03	65.82	67.92
Mean	71.36	66.25	

		S	W
SEm ±	=	0.42	0.42
CD (P = 0.05)	=	1.29	1.29

It is evident from the Table 6 the field efficiency due to width of operation W_0 and W_1 was found 71.36 and 66.25% respectively. The field efficiency of soil conditioner in width of operation W_0 was found to be significant over the other width of operation W_1. Due to the effective length of pegs S_0 and S_1 field efficiency of soil conditioner varied from 69.68 to 67.92% and maximum field efficiency was reported at S_0 which is found significant over the other S_1. It is clear from the data obtained, due to use of different factor i.e. S, M and W caused significantly better response and values got in levels were also found to be significant. Thus it indicates that S_0, M_1 and W_0 proved to be better than S_1, M_0 and W_1.

3.3 Effect of width of operation and effective length of pegs on soil pulverization

It is evident from the Table 7, in moisture M_0 the mean mass diameter at W_0 was 3.91 and 9.90% more than W_1 at S_0 and S_1 respectively whereas in moisture M_1 the mean W_0 and W_1 was 29.63 and 27.94% more at S_0 and S_1 respectively.

Table 7: Effect of length of pegs and moisture content on mean mass diameter

	M_0	M_1	Mean
S_0	7.63	9.18	8.41
S_1	8.16	12.18	10.17
Mean	7.89	10.68	

		S	M
SEm ±	=	0.07	0.07
CD (P = 0.05)	=	0.23	0.23

The Table 7 shows that the mean mass diameter at soil moisture content M_0 the mean mass diameter was found 7.89 and 10.68 mm respectively. The mean mass diameter of soil conditioner in moisture M_1 was found significant over the other moisture M_0. Due to the effective length of pegs S_0 and S_1 mean mass diameter of soil conditioner varied from 8.41 to 10.17 mm and maximum mean mass diameter was reported S_1 which is found significant over the other S_0.

Table 8: Effect of length of pegs and width of operation on mean mass diameter

	W_0	W_1	Mean
S_0	8.24	8.57	8.41
S_1	9.74	10.60	10.17
Mean	8.99	9.58	

		S	W
SEm ±	=	0.07	0.07
CD (P = 0.05))	=	0.23	0.23

The Table 8 shows that the mean mass diameter due to width of operation W_0 and W_1 found 8.99 and 9.58 mm respectively. The mean mass diameter of soil conditioner in width of operation W_1 was found to be significant over the other width of operation W_0. Due to the effective length of pegs S_0 and S_1 mean mass diameter of soil conditioner varied from 8.41 to 10.17 mm and maximum mean mass diameter was noted at S_1 which is found to be significant over the other S_0.

3.4 Economical analysis of modified soil conditioner with Kudali

The obtained results were analyzed statistically and soil conditioner with operating width W_0 and length of pegs S_0 was found suitable for operation at moisture content M_0. The Table 9 shows comparison of cost of operation per 100 m^2 between selected soil conditioner and Kudali. It was calculated from the Table 9, the cost of operation of soil conditioner was 38.21% less than Kudali.

Table 9: Economical analysis of modified soil conditioner with Kudali, Rs/unit area

S. No.	Treatments	Cost of operation Rs/100m^2
1.	T_0	97.60
2.	K_0	157.96

4. Conclusion

The developed manually operated modified soil conditioner was found superior over existing Kudali. It was clearly depicted by results, the modified soil conditioner minimizes the cost of operation and also reduces the time and energy consumption for cultivation than the existing Kudali. Hence, modified soil conditioner can be recommended for the small land holding, garden and nurseries as compare to existing Kudali.

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