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Design and Performance Evaluation of Mechanical Weeder

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ABSTRACT: Soil tillage, crop production, and animal husbandry are all part of agriculture. Weed management with herbicides and tractors is only possible if the plants are seeded in straight and parallel rows, as weeds grow between them. It is critical to prepare the field before planting in order to achieve optimal outcomes. Manual labour necessitates a large workforce and accounts for roughly 25% of overall labour demand, which is typically 900-1200 M hours per hectare. By breaking the surface crust, aerating the soil, encouraging the microflora of the soil, minimizing soil moisture evaporation, and promoting infiltration of rainwater, mechanical control of the grass successfully prevents weeds and promotes cultivation. To cultivate using a cultivator mechanically. Following these issues, a multi-stage weeder was designed and constructed in Creo 2.0 software for multi-stage weed treatment. The performance of this newly created equipment was tested both in the lab and in the field. The field capacity was 0.30 ha/h, and the field efficiency was 83.06 percent at a speed of 1.36 km/h. At a wheel slippage of 4.62 percent, the multi-stage weeding efficiency was 80.47 percent for single pass and 68.26 percent for double pass.

KEYWORDS: Weed control, Multi-stage weeding, wheel slippage, weeding efficiency.

1. INTRODUCTION

Agriculture has always been and will continue to be the backbone of the Indian economy. Agriculture, which includes soil tillage, crop production, and animal husbandry, is an area of applied science and art. It is the world's most important business. Small farmers with 2 to 3 hectares have used human labour and traditional implements such as the plough, yoke, leveller, harrow, hammer, spade, and huge sickle to carry out farming techniques over the years. Weed control with animals or tractors is only practicable if the plants are planted in straight and parallel rows, as weeds grow between the rows. It is critical that the field be thoroughly prepared before planting in order to achieve optimal results. Manual labour necessitates a large workforce and accounts for roughly 25% of overall labour demand, which is typically 900-1200 M hours / ha (weide et al., 2008). Weed control is one of the most cost-prohibitive agricultural chores. In fact, the negative consequences of weeds on agriculture in underdeveloped nations far outnumber the negative effects of all crop pests combined. Weed growth that is uncontrolled affects the yield of principal crops, while irregular weeds reduce yields from total agricultural investment (Noku, 1996). Effective mechanical drug traffickers should enable existing farmers to enhance productivity and, as a result, eliminate poverty (Olukunle and Oguntunde, 2006). By breaking the surface crust, encouraging soil microflora activity, lowering soil moisture evaporation, and promoting rainwater infiltration, mechanical control of the grass effectively reduces weeds and enhances cultivation (Ratnaweera et al., 2010). For successful plant and intercultural operations, developed countries have created universal machines. Because most Indian farmers are small farmers with a tiny regulated area, the utilisation of such equipment in the Indian agricultural landscape is problematic. Mechanical herbicides include everything from simple hand tools to complex towed or self-propelled machines (Gavali and Kulkarni, 2014). Tractor cultivators are typically employed on farms for weed control and intercultural activities. The rotating seed drill more precisely mixes the soil, interferes with grass roots, and takes it from the ground.

Different types of weeders are required for different crops at different stages of cultivation. 'Development and Performance Evaluation of Multi Stage Weeder' is the title of a planned research project.

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2. MATERIAL AND METHODS

Parametric Creo 2.0 software was used for the design and development of the Multi-stage weeder. The different component of the weeder was fabricated and assembled in the workshop of Vignan's Foundation for Science Technology and Research, Vadlamudi. Assembled view of Multi-stage weeder was shown in figure 1 & figure 2

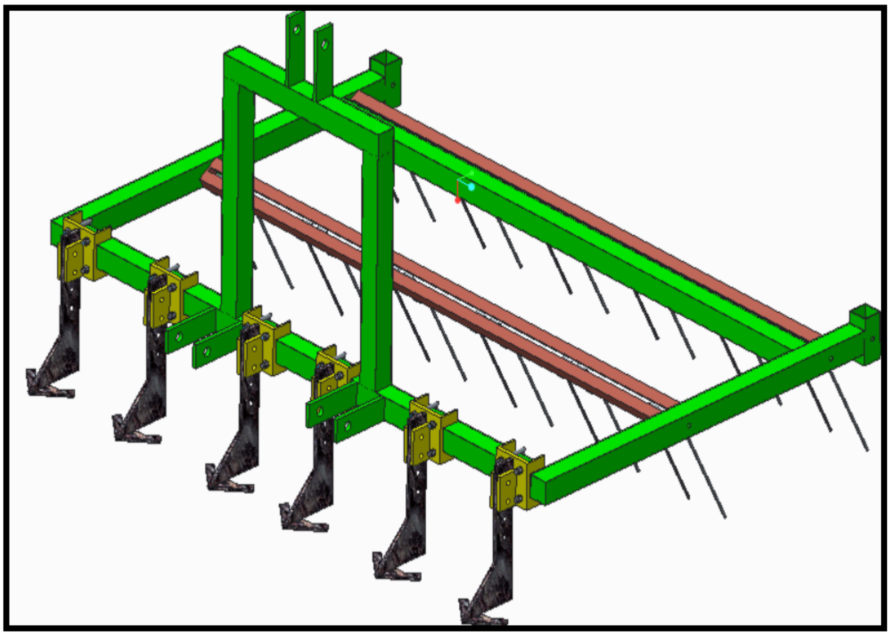

Figure 1: Creo model of multi stage weeder

Figure 2: Developed Multi stage weeder

2.1 Testing of the Multi-stage weeder

A Multi-stage weeder was developed and fabricated at theVignan's Foundation for Science Technology and Research, Vadlamudi was tested for different crop seed at the field to generate data. For testing of the machine standard methodology was adopted as per BIS test code IS 7927:1975.

The techniques and procedure for measurement of various parameters associated with the evaluation of the machine under laboratory and field condition have been presented. For testing of developed Multi-stage weeder, plots size of 1.8 x 10 m^2 was selected at the research farm of VFSTRU, Vadlamudi.The soil bed was prepared with one pass of the cultivator and one pass of rotavator.

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2.1.1 Verification of the operating speed

Outside the long boundary of the test plot, two poles 10 m apart (A, B) are placed approximately in the middle of the test run. On the opposite side also two poles are placed in a similar position, 10 m apart (C, D) so that all four poles form comers of a rectangle, parallel to at least one long side of the test plot. The speed is be calculated from the time required for the weeder to travel the distance (20 In) between the assumed line connecting two poles on opposite sides AC and BD.

2.1.2 Total Operating Time

Total operating time should be measured once the machine/implement starts to weed up to the time it finished weeding the test area. Time losses for adjustment, turning and machinery breakdown shall be deducted from the total operating time.

2.1.3 Wheel Slip

The weeders driving wheel was marked with colored tape. For a given distance, the number of revolutions of the driving wheels with load (N}) and without load (No) shall be recorded.

2.1.4 Weeding Efficiency

Prior to the weeding operation, ten strips with I-meter length shall be randomly selected and marked on the unweeded land. All the weeds on each strip shall be recorded as W_1. After weeding operation, the weeds on each of the ten marked strips were be recorded as W_2. Weeding efficiency can be computed based on the following formula.

$$\mathcal{E}_w = \frac{w_1 - w_2}{w_1}\ x\ 100 \qquad \ldots\ldots\ldots 2.1$$

Where,

$\mathcal{E}_w$is the weeding efficiency, %

w_1 is the number of weeds before operation per unit area

w_2 is the number of weeds after operation per unit area

2.1.5 Percent Damaged Plants

Ten meter row length was marked prior to weeding operation. The number of plants on each row shall be recorded. After weeding, the number of damaged plants on each of the marked rows was recorded. Percent of damaged plants can be computed based on the following formula:

$$\text{PDP} = \frac{q}{p}\ x\ 100 \qquad \ldots\ldots\ldots..2.2$$

Where,

PDP is the percent damaged plants, %

p is the number of plants in 10-meter row length before weeding

q is the number of damaged plants in 10-meter row length after weeding

2.1.6 Effective working width

Effective working width was determined by measuring the total width per row of the weeder.

2.1.7 Moisture content

Moisture content (%) on a dry basis of soil was measured by the oven dry method. The soil samples from different locations within a plot were taken using core sampler 80 mm diameter and 120 mm in length and a soil auger. The collected soil samples from each location were weighed initially and then kept in an oven for 24 hours at 105°c for obtaining the dry weight of soil and moisture content was calculated as follows:

$$\text{Moisture content,Mc (\%)} = \frac{(W_1 - W_2)}{W_2} x 100 \qquad \ldots\ldots 2.3$$

Where,

Mc= Moisture content of soil on a dry weight basis,

W_1 = Weight of wet soil and

W_2 = Weight of dry soil

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2.1.8 Bulk density

Bulk density of the soil is the oven dry mass per unit volume of the soil. The bulk density of soil was measured by core sampler. The core sample of the soil of known volume was collected and weighed. The bulk density was calculated by using formula

Bulk density, (g/cm^3) = (BD) = $\frac{M}{V}$ ………2.4

Where,

BD = Bulk density of soil, g/cm2

M = Oven dry mass of soil contained in core sampler, g

V = Volume of core sampler, cm3

2.1.9 Field capacity

Theoretical field capacity was measured as per following formula. (Bainer*et al.,* 1987),

Theoretical Field capacity, (ha/h) = $\frac{WxS}{10}$ ……...3.5

Where,

W = Effective width of implement, m; and

S = Speed of operation, km/h.

2.1.10 Actual field capacity

Actual field capacity was measured by considering an area of 45x25 square meter i.e. 0.112 ha and measuring the time in actual field condition. It includes turning loss, filling time and break down time also. There was continuouslyoperated in the field for 0.112 ha to assess its actual coverage. The time required for the complete application was recorded and effective field capacity was calculated.

Actual Field capacity, (ha/h) = $\frac{A}{T}$ …………3.6

Where,

A = Actual area covered, ha

T = Time required to cover the area, h

2.1.11 Field efficiency

From the actual and theoretical field capacity, the field efficiency was calculated. (Bainer, *et al.*,, 1987),

Field efficiency, % =$\frac{AFC}{TFC}\ x\ 100$ ………3.7

Where,

FE = Field efficiency, %

AFC =Actual field capacity, ha/h

TFC =Theoretical field capacity, ha/h

The data were recorded for all number of trails under actual field conditions.

3. RESULTS AND DISCUSSIONS

The experiments were conducted for Multi stage weeder in the laboratory as well as in the field. The performance of this machine was evaluated at the field of Faculty of Agricultural Engineering, VFSTRU, Vadlamudi**.**

3.1 Verification of Operating Speed:

The tractor was operated in the field of area 10 m^2 at various speed. Two poles were A and B the distance between the two poles were 10m. Swaraj – 855 FE tractor was taken for speed calibration finally the data was tabulated in table 1 andplotted on the graph as shown in figure 3 and 4.

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Table 3.1: Operating speed of the tractor

Speed (KMPH)									
Tortoise						**Rabbit**			
RPM	**Distance, m**	**G1**	**G2**	**G3**	**G4**	**G1**	**G2**	**G3**	**G4**
500	10	0.7	1.0	1.5	1.8	2.8	3.6	5.8	7.0
1000	10	1.8	2.2	3.5	4.5	5.9	6.9	10.2	14.6
1250	10	2.2	2.9	4.6	6.0	7.2	8.9	15.9	19.0
1500	10	2.9	3.3	5.9	7.5	8.6	11.9	15.1	21.0
2000	10	3.3	4.4	7.7	9.9	10.6	12.2	18.0	30.0

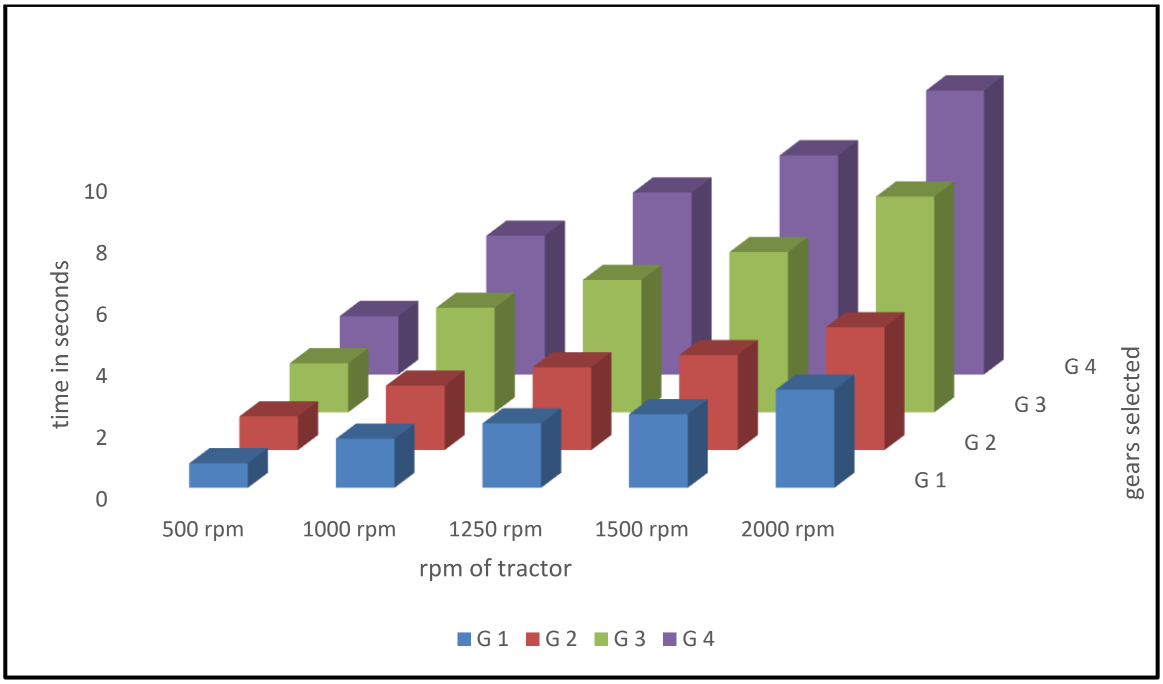

Figure 3: Operational speed of tractor at tortoise range selected

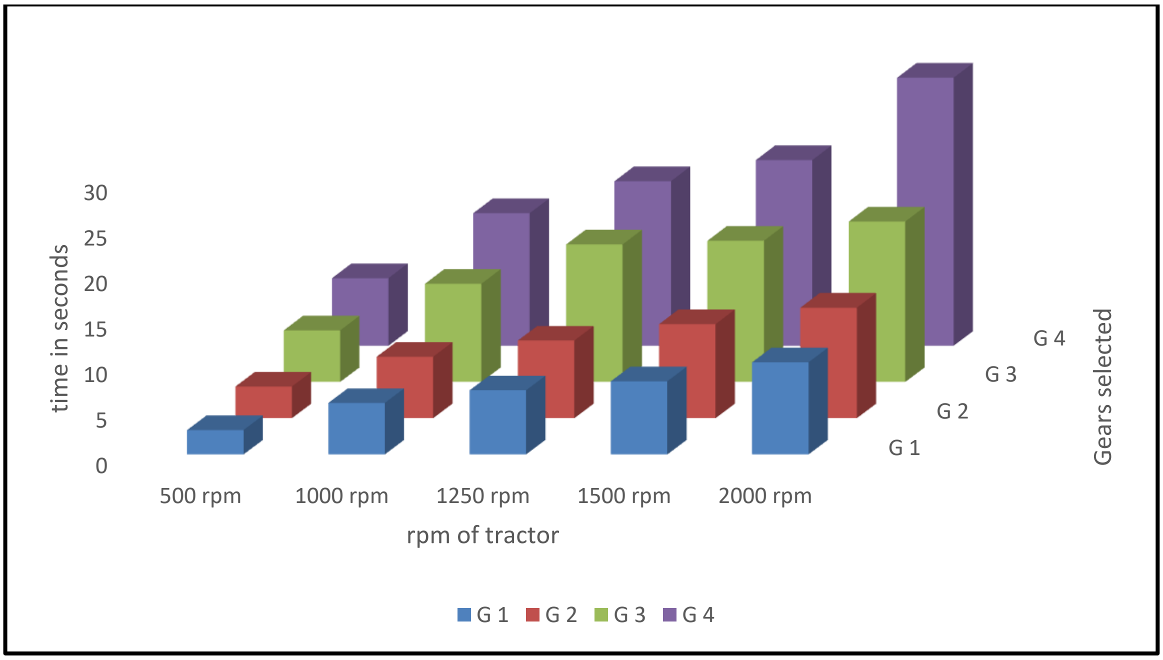

Figure 4: Operational speed of tractor at rabbit range selected

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For operating the Multi Stage weeder at 1500 rpm on low Gear G1 was suitable for the field conditions**.**

3.2 Total Operating Time

The tractor was operated at 1500 Rpm at load 1st Gear in 100 m^2 area between two poles were arranged at distance of 10m between them. The mean total operating time was recorded as 50.2 sec.

3.3 Wheel Slippage

The tractor was operated in 100 m^2 area in that two Poles A and B were arranged at 10 m distance. After hitching the implement the tractor was passed on the field for five times. The tractor was operated at 1500 Rpm at load 1st Gear from Pole A to Pole B at with load and without load condition by counting the number of lugs of the tractor for slippage of the wheel.The mean value was recorded as 52.6 at with load condition and at without load condition is 50. So the wheel slippage of the tractor is 4.94 %.

3.4 Weeding Efficiency

The Weeding efficiency was calculated in the area of 25 m^2 in the field plants were planted by using the drilling method at 90 x 50 cm plant spacing as the weeds were grown. Marking of five plots of 1 m^2 area taken the count of the number of weeds before passing the weeder and after passing the weeder like that the tractor was passed for two times for weeding. The tractor was operated at 1500rpm on load 1st gear the values recorded for a single pass of weederthe mean value is 80.47 % weeding efficiency.In the double pass, the mean value is 68.26 % the recorded values were tabulated in table 2 and plotted in graph which as shown in figure 5.

Table 2: Weeding efficiency of the Multi stage weeder

S.No	Single pass, %	Double pass, %
1.	88.01	76.66
2.	86.55	81.00
3.	83.99	75.00
4.	82.92	57.14
5.	63.63	62.50
Average	80.47	68.26

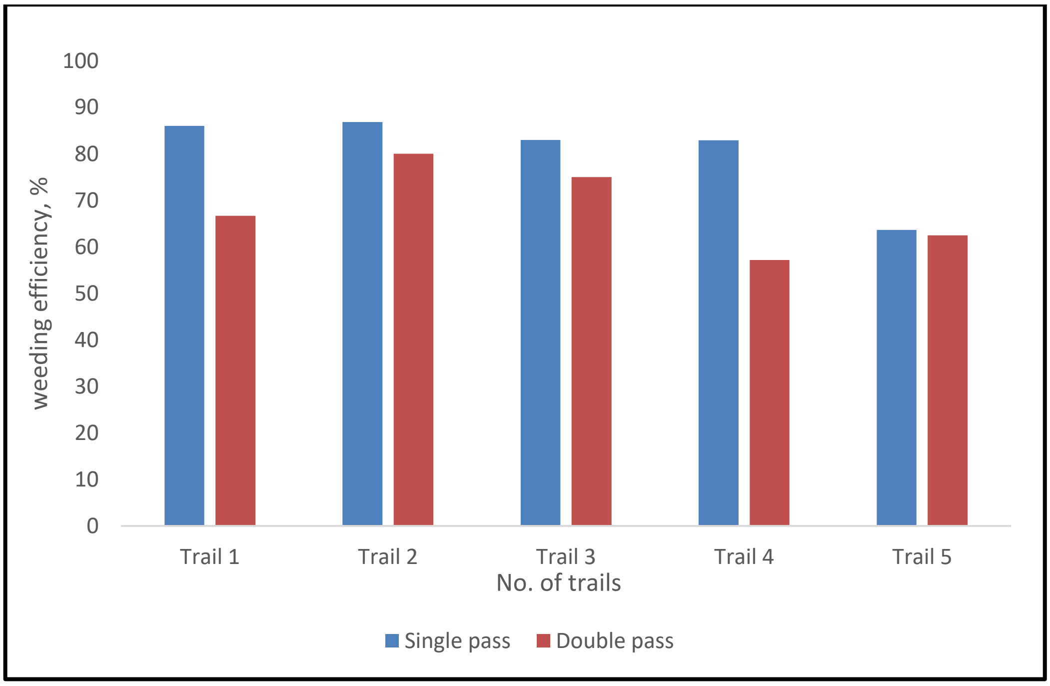

Figure 5: Weeding efficiency of the multi stage weeder

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3.5 Percent of Damaged Plants

The percent of damaged plants was calculated in the field of area 25 m^2 by passing the tractor at 1500 rpm on load 1^{st} gear with weeder the no. of damaged plants were counted after passing the weeder in the field. The percentage of damaged plants is 2 %.

3.6 Effective working width

The tractor was passed in the field with weeder the working width of the weeder is approximately 210 cm.

3.7 Moisture content and bulk density

Moisture content on a dry basis of soil was measured by using oven dry method five soil samples were taken randomly at five different places.The moisture content at five different places was found to be 32.08%, 40.66%, 36.30%, 46.67% and 36.13% on dry basis respectively. Bulk density of soil was measured by core sampler. Bulk density of soil was found to be 1.45 gm/cm^3, 1.64gm/cm^3, 2.11gm/cm^3,1.80 gm/cm^3 and 2.12gm/cm^3. The mean value of moisture content and bulk density of experimented plot was found 38.37% (dry basis) and 1.82 gm/cm^3 respectively.

3.8 Field efficiency

The field capacity and field efficiency were calculated for weeder using the standard methodology described earlier. The multi stage weeder was tested in the field conditions as shown in figure 6.The theoretical field capacity was determined as 0.37 ha/h, whereas the actual field capacity of the planter was found to be 0.30 ha/h. From the actual and theoretical field capacity, the field efficiency of the Multi stage weeder was found to be 83.06 %.

Figure 6: Testing the Multi stage weeder at field conditions.

4. CONCLUSION

This work focused on the design and fabrication of the Multi stage weeder that is made up of easily and locally available materials which is easy to maintain and less labour to use. All the parts of weeder are fabricated with the Mild steel material and the design was made of Creo 2.0 software. As the performance of weeder was taken by conducting experiments whose field efficiency is 80.06 %, field capacity 0.30 ha/h and weeding efficiency is 80.47 % respectively. By fabricating the multi stage weeder may reduce the complexity and increases the efficiency at highly reduced cost for weeding**.**

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