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Development and performance evaluation of manually operated spear peg rotary weeder

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Abstract
Weeds are the serious issue in all crop season that competes with crops for water, nutrient and light. Various study and research work has carried out on various manually, mechanically and chemically method for the effective control of weed. The present study includes design and development of a manually operated rotary weeder with spear shaped peg. Also, the performance of the weeder was evaluated on different performance parameter. The average field capacity, field efficiency, weeding efficiency and plant damage were found as 0.0153 ha/hr, 68.33%, 58.11% and 6.53% at the average speed of 1.146 km/hr.

Keywords: Rotary weeder, weeding, weeding efficiency, spear peg

Introduction
Weeds is a plant that competes with crops for water, nutrients and light and can effect the production. A weed can be thought of as any plant growing in the wrong place at the wrong time and doing more harm than good (Parish, 1990) [3]. Weeds waste excessive proportions of farmers' time, thereby acting as a brake on development (Lavabre, 1991) [7].

Weeding is the removal of unwanted plants in the field crops. Weeding account for about 25% of the total labour requirement during a cultivation season. Weed control is one of the most expensive operations in crop growth. Depending on the weed density, 20-30% loss in grain yield is the quite usual which may increase upto 80%, when crop management practices are not properly followed Rajvir Yadav (2007) [10].

Weed can be control in many ways like hand manually and by herbicides or weedicides. In India this operation mostly performed manually with khurpi or hoe that have low field capacity, time consuming, overwhelming and hurt workers. Nowadays, the usages of herbicides increasing day by day that are quick and effective weed control method without damaging the plants. But it can harm the human health. The mechanical or power weeders are not beneficial for small farmers as these machine contributes large input. In this paper, manually operated rotary weeder with spear peg was developed and fabricated. Also, the performance of weeder was evaluated on different performance parameter.

Materials and method
This chapter deals with the materials and methods used for the fabrication and performance evaluation of manually operated spear peg rotary weeder. The Weeder was designed taking consideration that it should be light, simple, easy to operate, better to handle and having less drudgery. It consist the following main parts:

1. Handle
2. Main frame
3. Wheel
4. Cylinder with peg

Handle
Two handles are provided at the rear of the weeder which is used to steer, balance and to apply the forces for the weeding. The handles was attached and supported to main frame in such a ways that operator can utilize maximum power by lifting transport wheel from ground. Handles are made of 25 mm conduit pipe. Other design parameters for the handle was designed based on ergonomics condition as given in table no.1.

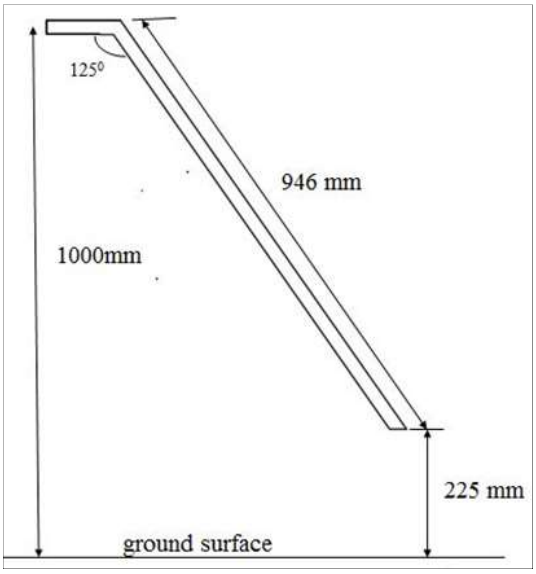

Fig 1: Handle dimensions of rotary weeder

Table 1: Design parameters of handle based on ergonomic condition. (Data Book, 2010) [2]

Design parameter	Range	Taken value
Height of handle grip from ground	900 to 1100 mm	980 mm
Handle cross bar length	400 to 600 mm	500 mm

Main frame
The main frame was made of flat iron plate. These plates were 30mm wide and 6 mm thick. Some holes were made in order to support and accommodate the transport wheel, handle and the cylinder.

Transportation wheel
The transportation wheel is used for the transportation and operation of weeder in the field. Wheel should be capable to bear the weight of vertical load of the weeder and also the self-weight (wheel). A 450 mm diameter rubber wheel was fitted at the front of the weeder.

Cylinder with peg
A 20cm long, 10cm outer diameter and 5mm thick hollow conduit pipe is used as a rotating cylinder. Two bearing is fitted at the two extreme end of rotating cylinder. These bearings is fitted on the shaft having 2cm diameter. And this shaft is bolted on the main frame.
The spear shaped pegs is used as a cutting tool and are welded on the periphery of the rotating cylinder as shown in fig 2.

No. of spear peg
Spear peg is main cutting tool that enters in the soil gradually. Weed is cut and trapped by the peg and detached from soil. The peg is made of cast iron. The base width of this peg is taken as 2.5 cm. Assume depth of operation to be taken as 3cm and inclination of peg to the tangent on cylinder is 30 degree.

$$\text{Length of peg } = \frac{3}{sin30^0} = 6\ cm$$

Width of the peg is taken as 2.5 cm

$$\text{Total no. of peg in one row} = \frac{\text{width of cylinder}}{\text{width of peg}} = \frac{20}{2.5} = 8$$

Method of working
Weeder was operated in the field (40 m in length and 30m width) planted with black gram. The weeding operation was done after three days of 1st application of irrigation. Row to row distance of black gram was 0.25m. Two row of each 40m length was selected for the weeding. First weeding was done at a slower rate. Time to cover the row length and time loss (nonproductive time) was calculated using stop watch. Same procedure was followed for normal and higher speed of operation. Also, the 3D cad model was designed for rotary cylinder as shown in fig 2 and fig 3.

Performance parameter
Operating speed
A 40m row length is selected and weeder is operated. The time required to cover this length is recorded with the help of stop watch. The speed of operation was calculated by dividing distance travelled to the recorded time.

Theoretical field capacity
Theoretical field capacity can be calculated by following equation

$$\text{Theoritical field capacity} = \frac{w \times s}{10000}$$

where,
w = width of cut in meter
S = speed of travel in kilometer per hour

Actual Field Capacity
Actual field capacity is determine by the following equation:

$$\text{Theoritical field capacity(ha /hr)} = \frac{W * L}{T}$$

Where,
W = Width of the weeder = 20cm
L = Total length of cover
T = Actual time to cover the entire length (hr) = (T_p + T_n)
T_p= Productive time, hr
T_n= Nonproductive time, hr
Nonproductive time include the turning time, shifting time of weeder and rest period time of operator.

Field Efficiency
The field efficiency is the ratio of the actual field capacity to the theoretical field capacity and it is expressed in percent

$$\text{Field Efficency (fe)} = \frac{\text{actual field capacity } (\frac{\text{ha}}{\text{hr}})}{\text{theoritical field capacity}(\frac{\text{ha}}{\text{hr}})}$$

Weeding efficiency
Weeding efficiency can be defined as the percentage of weeds that can be removed from the soil. The number of weeds is counted in 0.5 m^2 area along the row (20 cm * 250 cm) before and after the weeding. The weeding efficiency can be calculated by the following equation:

$$We = \frac{(W1-W2)}{W2} \times 100$$

Where,

W1= Number of weeds before weeding
W2=Number of weeds after weeding
We=Weeding efficiency

Plant damage

Plant damage can be calculated by following equation:

$$Q = \left[1 - \frac{q_f}{q_i}\right] \times 100$$

Where,
Q = plant damage percentage
q_i = number of plant before the weeding.
q_f = number of plant after the weeding.

Result and Discussion

A 3D CAD model was designed for rotary cylinder shown in fig 2 and 3.

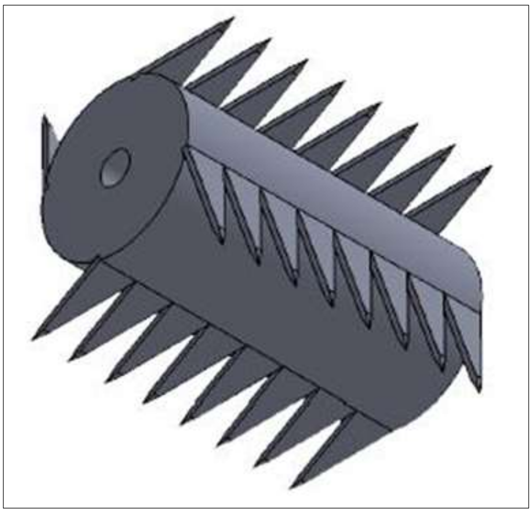

Fig 2: CAD model of rotary cylinder with peg

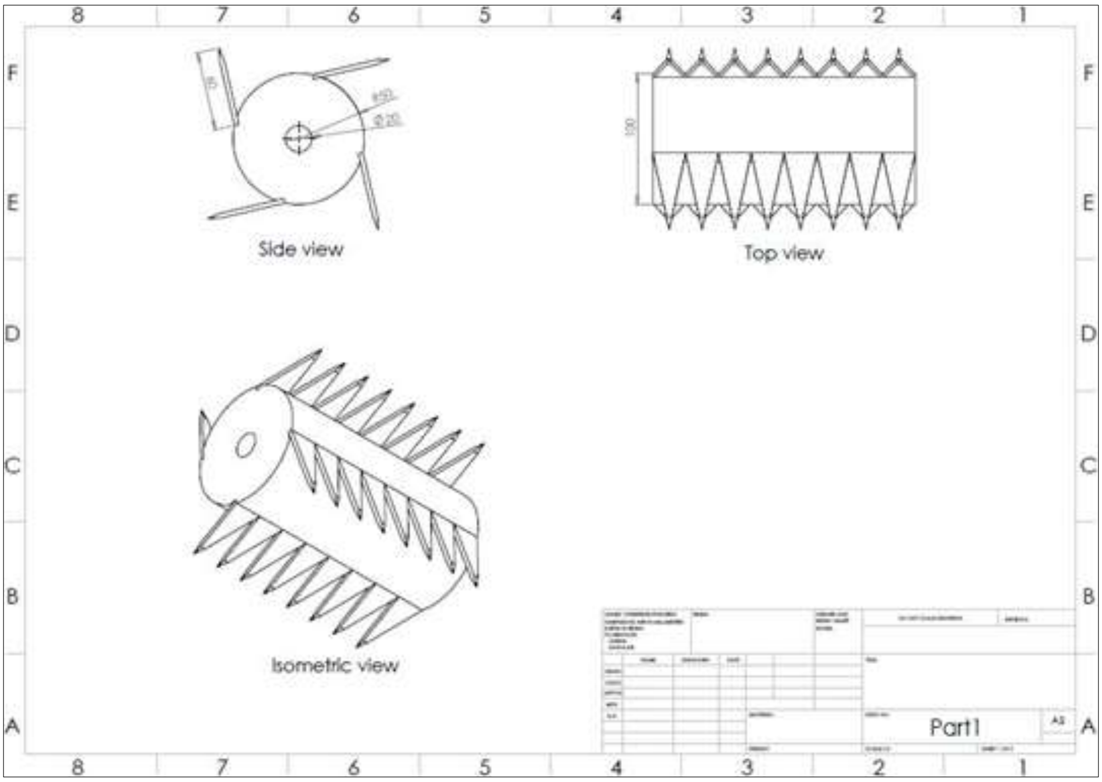

Fig 3: Section view of rotary cylinder with peg

Fig 4: Developed rotary weeder

Performance parameter

Field capacity

The actual field capacity were 0.013, 0.015 and 0.018 ha/h at the forward speed of 0.9, 1.1 and 1.44 km/h respectively. The highest actual field capacity was found out of 0.018 ha/h and the lowest actual field capacity was found to be 0.013 ha/ha at forward speed of 1.44 km/h and 0.9 km/ h respectively. From table no 2. It can observed that the actual field capacity is increases with increase in forward speed.

Table 2: Calculate value of performance parameter at different forward speed

parameters	Forward speed of weeder			Average
	0.9 km/hr	1.1 km/hr	1.44 km/hr	1.146 km/hr
Actual field capacity (ha/h)	0.013	0.015	0.018	0.0153
Field efficiency (%)	73	69	63	68.33
Weeding efficiency (%)	61.09	58	55.26	58.11
Plant damage (%)	3.1	6.8	9.7	6.53

Field efficiency

Field efficiency for the forward speed of 0.9, 1.1 and 1.44 km/hr were found to be 73, 69, 63%. The maximum field efficiency 73% obtained at 0.9 km/hr forward speed. At a higher speed of operation, it was difficult to operate and balance the weeder, also at the higher speed the operator rest time is comparatively more at the end of the row.

Weeding efficiency

The highest weeding efficiency was found to be 61.09% at the forward speed of 0.9 km/hr. The data in revealed that the weeding efficiency decreases with increase in forward speed and vice versa. Because at the higher speed, the operation was difficult and in between some area was left out and unweeded.

Plant damage

The plant damage was found to be 3.1, 6.8 and 9.7% at the forward speed of 0.9, 1.1 and 1.44 km/hr respectively. Plant damage occurs due to the extreme end of cylinder as the leaf of the plant was trapped in the peg. From table 2, it can be observed that plant damage will be higher at higher forward speed. Because at higher speed of operation, the path of the weeder may deviated from the target area that contribute in higher plant losses.

This weeder can be used for removing weeds in intercultural row weeding, vegetable garden, paddy field and also in orchard trees.

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