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RESEARCH ARTICLE

Mould board weeder for dryland field crops

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ABSTRACT

Weeding is an important agricultural practice that involves the removal of unwanted plants or weeds from cultivated land. A manually operated mould board weeder (MB) was developed at the National Institute of Plant Health Management (NIPHM), Hyderabad for small-scale farming. The major components of the developed weeder are frame, mould board, handle, U-clips and bolts, share point and wheels. The MB weeder is operated by push force applied to the handle to move the weeder forward. While operating, the share point penetrates into the soil and share blade uproots the weeds. The performance of the MB weeder was evaluated at three different speeds *i.e.*, 0.2 m/s (0.72 kmph), 0.31 m/s (1.11 kmph) and 0.42 m/s (1.51 kmph) in sorghum crop. The experimental field soil type was sandy loam, with an average soil moisture content of 12.8% (dry basis). The MB weeder of average draft was found to be 11.8 kg, field capacity 0.048 ha/h, overall weeding efficiency 86%, overall plant damage 2%, and the performance index 521.99. It is suitable for sorghum, chili, maize, cotton, and all vegetable crops but it could also be used for other crops with a row spacing of 300 mm or above, which can be adjusted in the machine.

Keywords: Manually operated, Mould board, Weeder, Weeding efficiency, sorghum.

INTRODUCTION

Weeding is an important agricultural practice that involves the removal of unwanted plants or weeds from cultivated land. Weeds compete with crops for resources such as water, nutrients, and sunlight, and can significantly reduce crop yield and quality (Fernandez-Quintanilla *et al.* 2008). Weed control is therefore crucial for the success of any agricultural production system, and various methods are used to achieve it.

Manual weeding is a traditional method that involves the use of hand tools such as hoes or sickles to remove weeds. This method is time-consuming and labour-intensive, but it is still commonly used, especially in small-scale farming systems (Anwar *et al.* 2021). Mechanical weeding, on the other hand, involves the use of machines to remove weeds. These machines can be powered manually, electrically, or by tractors (Kramer *et al.* 2015). Mechanical weeding is faster and more efficient than manual weeding but requires a higher initial investment.

Weed control is important not only for crop yield and quality but also for the sustainability of agricultural production. Improper weed management can lead to soil degradation and erosion and increased use of synthetic herbicides that can have negative environmental impacts (Oerke *et al.* 2012, Potdar *et al.* 2023). Proper weeding practices can help to control weeds, improve crop yield and quality, and ensure the sustainability of agricultural production. Therefore, an effort has been made to develop a manually operated mould board weeder for dryland crops and to evaluate the performance in field conditions.

MATERIALS AND METHODS

Development of mould board weeder

The manually operated mould board weeder was developed at the National Institute of Plant Health Management (NIPHM), Hyderabad for small-scale farming. The major components of the developed weeder are frame, mould board, handle, U-clips and bolts, share point and wheels. The frame was made of mild steel flat with a length of 600 mm and a width of 200 mm. U-clamps and bolts are provided on the square rod to adjust the different depths of the mould board during the operation (**Figure 1c**). The square rod (20 mm thickness) was fitted to the body of the frame at a distance of 310 mm from the wheels. The mould board (**Figure 1a**) was made of MS (Mild steel) sheet of 18 gauge and 12mm thickness. The MS sheet was cut into a mould board shape and it was tuned and twisted to an angle of 25-30º and the length of curvature was 268 mm. The share points of

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(a) Mould board **(b) Handle** **(c) U-clamp and bolts** **(d) Wheels**

Figure 1. Major components of mould board weeder (a) Mould board (b) Handle (c) U-clamp and bolts (d) Wheels

the two mould boards are facing opposite to each other. The distance between the two mould boards was 150 mm. The share was made of MS sheet and attached with an angle of 25-30º to the mould board. The Share point (**Figure 1a**) was made of MS square rod with a length of 250 mm and 16 mm thickness and attached to mould board to provide a 10 º tapered angle. The share point penetrates into the soil up to 25 mm deep. The share blades were sharpened at the lower end for easy penetration into the soil during the weeding operation. The handle (**Figure 1b**) was made of MS square hollow pipe (25 × 25 × 3 mm). The length of the handle 1000 mm, horizontal handle length 500 mm and the diameter of round bar was 20 mm. U-clamps (**Figure 1c)** were made of a 6 mm thickness MS sheet. These clamps were used to connect the mould board and frame with the help of ½ inch (12.5 mm) length and 40 mm thickness of bolts. The holes were made in a frame every 50 mm heights to adjust the different depths of the mould board during the operation. The Wheels (**Figure 1d)** are made of MS flat (20 × 6 mm) and the diameter was 300 mm. These wheels were attached to the frame on both sides. Both wheels are firmly fixed on a round bar with the help of a washer. The spokes were provided for attaching the hub in the center of the wheel. Spokes are made of 8mm square rod and 130mm in length. The final assembled view and overall specifications of the mould board weeder are shown in **Figure 2** and **Table 1**.

Operating procedure of MB weeder

The weeding operation has to start from the corner of the selected field having more than 300 mm row-to-row spacing crops. The MB weeder is placed in between the two rows of the crop. The operating procedure of the MB weeder is holding the handle with two hands and push force was applied to move the weeder in a forward direction. For easy operation, the handle should grip with stretched hands. While operating the weeder the share point was penetrated into the soil about 2-3 inches and then the share blade gets penetrated for uprooting the weeds. As the weeder moves in the forward direction uprooting of the weeds and inversion of the soil and burried along with the curvature of the mould board. The uprooted weeds are inverted into the soil.

Figure 2. Assembled view of developed mould board weeder

Table 1. Overall Specifications of the developed mould board weeder

Parts	Type of material	Length	Breadth	Thickness	Quantity
Frame	MS flat	590	40	6	1
Handle	MS round bar	500		25∅	1
Mould board	MS sheet (18gauge)		Angle 25-30º	1.2	2
U-clips	MS	30	-	6	2
Nut Bolts	MS		Nominal size (M1.6)	1.3	2
Share point	MS square rod (taper10º)	250	16	16	2
Wheels	MS flat	300∅	20	6	2
Square rod	MS	250	20	20	2

Performance evaluation of developed MB weeder

The performance of the MB weeder was evaluated in the field of sorghum crop at the National Institute of Plant Health Management (NIPHM), Hyderabad. According to Ramadan *et al.* (2022), Manjunatha *et al.* (2014), soil parameters were taken such as soil type, soil moisture content, machine parameters; operating speed, draft, actual field capacity, theoretical field capacity, crop parameters: type of crop, row-to-row distance of crop, weed root zone depth, and weed density. The performance parameters: weeding efficiency, plant damage, field efficiency and performance index (Yadav and Pund. 2007).

The experimental field was 40 m^2 (10 × 4 m) and soil type sandy loam, with an average soil moisture content of 12.8% (dry basis). The developed MB weeder was operated at three different speeds *i.e.*, 0.2 m/s (0.72 kmph), 0.31 m/s (1.11 kmph) and 0.42 m/s (1.51 kmph).

Weeding efficiency

The weeding efficiency was calculated using a quadrant (50 × 50 cm) with an area of 0.25 m^2. A quadrant was thrown in the experimental field with three different locations and counted the number of weeds available before weeding and after weeding. The weeding efficiency was calculated by using following equation

$$WE = \frac{W_1 - W_2}{W_1} \; \ldots (1)$$

Where,

WE = Weeding efficiency (%)

W_1 = No.of weeds in a quadrant of an area 0.25m^2 before weeding

W_2 = No. of weeds in a quadrant of an area 0.25m^2 after weeding

Plant damage

The plant damage was calculated before and after the developed MB weeder weeding. The number of damaged plants was observed and counted in a 10 m row length before and after weeding with three operating speeds. The percentage of plant damage was calculated during field operation using the following equation:

$$\text{Plant damage (\%)} = \left(1 - \frac{q}{p}\right) \times 100 \; \ldots (2)$$

Where,

q = No. of plants in a 10 m row length after weeding

p = No. of plants in a 10 m row length before weeding

Power requirement

The input power required to operate the MB weeder during the weeding operation was calculated by using the following equation and considering the draft and maximum operating speed.

$$\text{Power (hp)} = \frac{D \times S}{75} \; \ldots (3)$$

Where,

D = Draft, kg

S = operating speed, m/sec

Draft

The draft was measured by using spring-type dynamometer fixed in the horizontal handle bar during the weeding operation. Before fixing, Springs are calibrated with the help of knowing weights and observing how much compression of spring takes place for each knowing weight. Based on that draft was calculated by using the following equation.

$$D = p \cos\theta \; \ldots (4)$$

Where,

D – Draft of the weeder (horizontal soil resistance, N)

p – Force exerted along the handle,

θ– Handle angle (degrees)

Performance index

The performance index of the MB weeder was calculated by using the following equation (5).

$$P.I. = \frac{A \times E \times (100 - R)}{P} \; \ldots (5)$$

Where,

PI = Performance Index

A = Field Capacity of weeder, ha/hr

E = Weeding efficiency (%),

R = Plant damage (%),

P = Power input, HP

RESULTS AND DISCUSSION

The performance evaluation of the developed machine was carried out under field conditions. The experimental field was taken length 10 m and width 4 m with an area of 40 m^2. Before operating the MB weeder, the soil parameters were observed such as soil type; sandy loam and average soil moisture content was found 12.8% (dry basis). The crop parameters were observed such as type of crop; sorghum, average row-to-row distance 320 mm, average weed root zone depth 28.4 mm and average weed density 68.33.

The developed MB weeder was operated at three different speeds *i.e.*, 0.2 m/s (0.72 kmph), 0.31 m/s (1.11 kmph) and 0.42 m/s (1.51 kmph) in the field was evaluated each dependent variable.

Weeding efficiency

The operating speed of a developed mouldboard weeder can significantly affect its weeding efficiency. The maximum weeding efficiency was found 88% at the operating speed of 0.42 m/s because if the speed is high, it may not penetrate deeply enough to effectively uproot the weeds. The minimum weeding efficiency was 83.3% at the operating speed of 0.2 m/s because if the operating speed is too low, it might dig too deeply, potentially damaging crops and unnecessary soil disruption. If it goes more than 25 mm deep, the amount of soil lifting increases, the required force also increases and it will affect the weeding efficiency. The range of weeding efficiency was found 83.3% to 88% and overall efficiency was 86% (**Figure 3a**).

Plant damage

The maximum plant damage was found at 2.9% at the operating speeds of MB weeder 0.31 and 0.42 m/s because operating the weeder at high speeds increases the likelihood of inadvertently hitting or damaging sensitive parts of the plants, such as stems, leaves, or roots, leading to reduced yields or even crop loss. The skill and experience of the operator play a vital role in mitigating plant damage. The overall plant damage was 2% (**Figure 3b**).

Power requirement

The draft is an important parameter for manually operated implements because it should be within the physical limits of the operator. The average draft of MB weeder required for weeding was found to be 11.8 kg. However, the maximum pushing force for Indian agricultural work ranges from 25 to 30 kg (Mehta *et al.* 2022). The average power requirement for the MB weeder was estimated to be 0.775 hp, which was higher because of the wider width of the cut. The performance index for the developed weeder was 521.99. It was observed that the mould board weeder was suitable for use in sorghum, chili, maize, cotton, and all vegetable crops but it could also be used for other crops with above 300 mm row spacing, which can be adjusted in the machine. The depth of operation of mould board can be changed as per the requirement. The field capacity of the mould board weeder was found to be 0.048 ha/h, which was similar to the existing weeder (Yadav and Pund, 2007).

Conclusions

The weeding efficiency of the developed MB weeder was satisfactory and it is easy to operate. It works up to 50 mm depth with a field capacity of 0.048ha/hr and overall weeding efficiency was obtained up to 86%. The weight of the mould board weeder was 13.5 kg. The overall performance of the weeder was satisfactory. The depth of the weeder can be changed as per the requirement of the depth of the weed. The recommendation for a 2 hp motor to increase the efficiency of weeding.

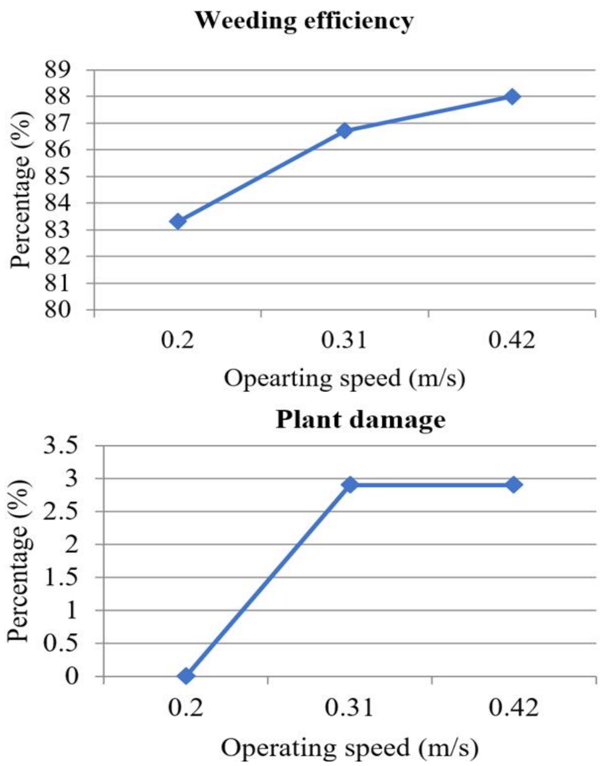

Figure 3. Effect of operating speed developed MB weeder (a) Weeding efficiency (b) Plant damage

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