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Performance evaluation of manually operated weeder

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Abstract
An experiment was conducted to evaluate the field performance of developed manually operated weeder in Chhattisgarh, India. For dry land crop, the machine was test on chickpea crop various parameters such as field capacity, weeding efficiency, draft requirement and performance index of the weeder was measured during the test. The developed weeder machine can work up to 3.0-4.0 cm depth of operation with actual field capacity of weeder 0.031 ha/h, theoretical field capacity of weeder was average .0428 ha/h, field efficiency of weeder 65.54 percent, plant damage was found 2.166and The draft requirement was 193N (0.079 hp) for 25 cm width of weeder. The weeding efficiency of the weeder machine was found to be 88.15 per cent with performance index of 12622.1. Experiment also revealed that the weeding operation time requirement for developed wheel operated weeder was much less than the manual weeding. It was easy to operate and most importantly involved less human drudgery during its operation.

Keywords: Flexible weeder, multi nozzle adjusted sprayer, time, and cost, pressure, field efficiency

Introduction
In India the annual losses due to weeds in food grains is about 82 million tons, pulse 14 million tons, oil seeds 12 million tons and commercial crops about 52 million tons (P. K. Singh, 2013) [7]. Weeding is a time consuming and labour intensive operation which accounts for about 25 % of the total labour requirement (900–1200 man-hours/hectare) during a cultivation (Yadav and Pund, 2007) [8].

As far as Indian scenario is concerned, more than 75 percent farmers are belonging to small and marginal land carrying. The economic conditions of average Indian farmers are poor and hence they cannot afford large automatic effortless mechanization for their farms. In this agriculture sector, out of the different field operations, weeding is a important operations to be performed by the farmer to protect the cultivated crops from weeds and unwanted plant. The growing concern to control plant from weeds for qualitative yield of agricultural products is increasing speedily in many developing countries like India.

The quality and quantity of crop yield depends upon effective and timeliness of weed removal from the field. Weeds causes highest annual yield loss of about 45 per cent compared to dieses (20%), insects (30 %) and pests (5 %) (Gupta *et al.*, 2014). Depending on weed intensity, 20 to 30 per cent loss in yield is quite usual, if crop management practices are not followed properly (Gill and Kollar, 1981).Weeds are unwanted and undesired plants, which compete with the main crop in the field for space, water and plant nutrients and adversely affect the micro-climate around the plant and removes 30 to 40 per cent of applied nutrients (Behera *et al.*, 1996; Rao, 1999; Nojavan, 2001;

There is need for development of effective weeding machine for increasing the productivity. In order to overcome these difficulties, we have proposed a wheel driven weeder, it is a suitable device and no need of any fuel to operate, which is easy to move the wheel as well as also remove weeds through weeder blade.

Methodology
The sprayer prototype was consists of the main frame, spray tank, pump prime mover, traction wheel, draft adjustable wheel, straight weeder blade and clamp. Components of the developed sprayer cum weeder are shown in Fig.1. While pushing the handles, the handles were adjustable as a requirement by providing nut and bolt. When ground wheel rotates, it transfers rotary power to chain-sprocket, which drives a smaller sprocket that is attached to a shaft through the chain drive. The rotary motion of the smaller sprocket is converted into the reciprocating motion by four bar crank mechanism, which actuates the single acting

reciprocating piston pump integrated in the tank. This piston pump deliver the liquid to the boom and same time weeder cut the weeds by shearing action through weeder blade.

Constructional details of mono wheel operated sprayer cum weeder

Specification sheet of mono wheel operated sprayer cum weeder

S. No	Name of implement	Wheel operated weeder
1	Type of Weeder.	Manually operated
2	Type of sprayer	Wheel operated
3	Manufacturing's Address	BRSM CAET &RS Mungeli, CG.
4	Crop for Which suitable.	Chickpea, mustard, wheat, safflower.
Overall dimension in mm		
5	Length	1677
6	Width	900
7	Height	1394
8	Weight in kg	35kg
Detail of weeding component		
9	Type:	Straight blade
10	Dimension	25*10*1.5
11	Working width	25
12	Material of construction:	Mild steel
Detail of frame weeder		
13	Construction	Adjustable type
14	Dimension of major members:	1200*260*30
i) Mono wheel (cycles wheel)		
15	Diameter, cm	50
16	Width, cm	5
17	Material	Stainless steel
ii) Detail of ground wheel		
18	Diameter, cm	18
19	Width, cm	2
20	Material,	Mild steel
Detail of handle		
21	Construction	Adjustment
22	Height of handle from ground level, cm	0-66.8 to 0-96.8
23	Details of adjustment	Adjustment through nut and bolt
24	Ground clearance	36.4(ground surface to main frame)
25	Details of transporting system	Mono wheel as well as ground wheel
26	Safety aspects	No required

Design calculation

Design of frame (Deshpande, 2017)

Length of frame = Centre distance between two sprockets + width of tank + excess = 230+440+570 = 1200mm

Height of frame = 30 mm

Width of frame = 240mm

Selection of wheel (Deshpande, 2017)

Distance between two plant = 1.25 feet = 38cm

Line covered by one rotation of wheel = 4

38×4= 52cm

$152=2\pi r$

$r=152/2\pi$

r=25cm

Diameter of wheel= 50 cm

Selection of bearing

The roller contact consist of four part inner and outer faces a rolling element like ball, roller or needle and cage with hold the rolling element together and space them evenly around periphery

Selection of shaft

A drive shaft, driveshaft, driving shaft, propeller shaft (prop shaft), or cardan shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them.

Straight blade

Straight blades are used in manual weeders, animal drawn hoe and also tractor drawn scrapper weeder. Straight blade, following optimum values were obtained working width (A), Blade width (B), blade thickness (t), rake angle (δ), cutting angle (γ) and blade sharpness angle (ϕ).

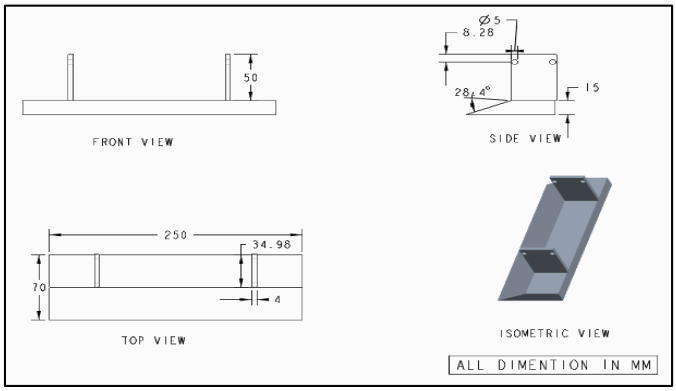
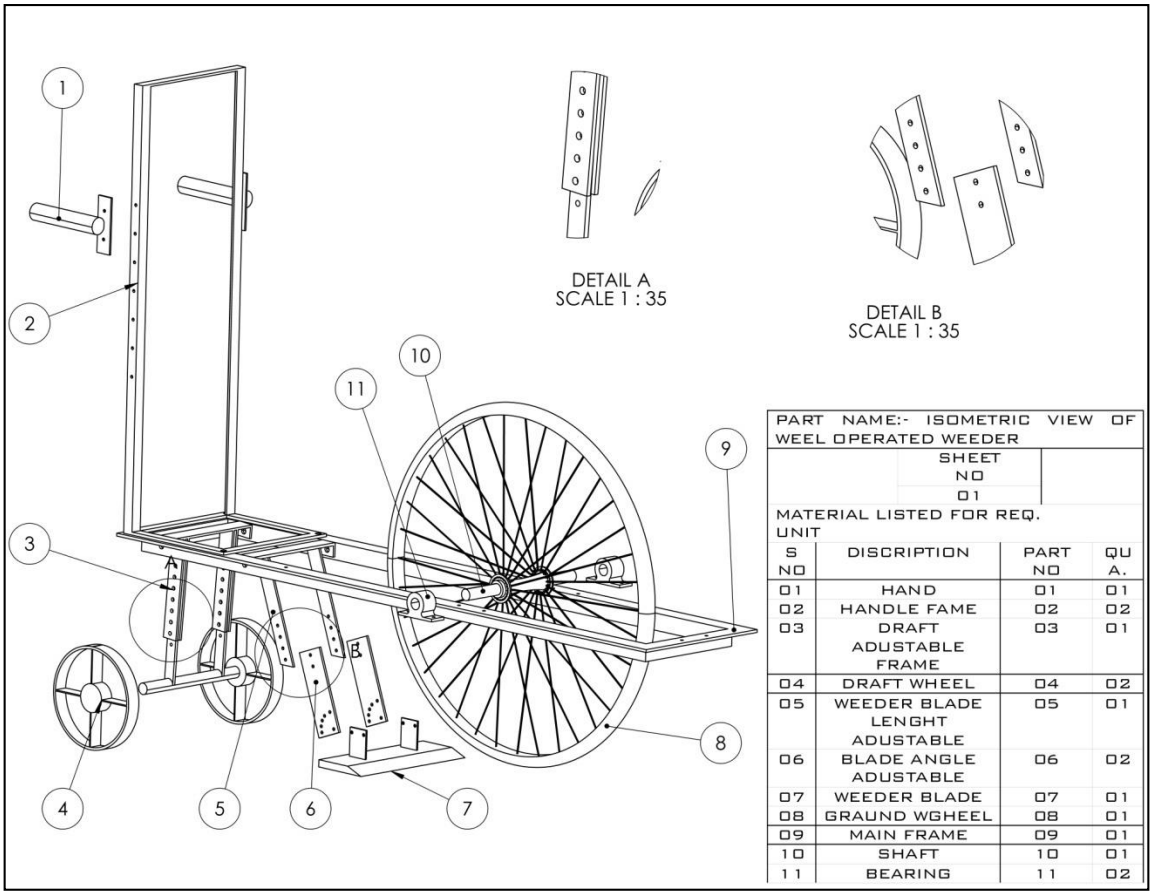


Fig 1: line diagram of straight blade

Clamp

The clamp was fabricated to fix the tine. It was made of 85mm long angle iron (85×40×10 mm). On the either side of this angle iron one M.S. Flat (95×40×10mm) of 95mm length was welded. The M.S. flats were provided with two and bottom an angular hole to adjust the depth of the tine as well as angle.



PART NAME:- ISOMETRIC VIEW OF WEEL OPERATED WEEDER

SHEET NO 01

MATERIAL LISTED FOR REQ. UNIT

S NO	DISCRIPTION	PART NO	QU A.
01	HAND	01	01
02	HANDLE FAME	02	02
03	DRAFT ADUSTABLE FRAME	03	01
04	DRAFT WHEEL	04	02
05	WEEDER BLADE LENGHT ADUSTABLE	05	01
06	BLADE ANGLE ADUSTABLE	06	02
07	WEEDER BLADE	07	01
08	GRAUND WGHEEL	08	01
09	MAIN FRAME	09	01
10	SHAFT	10	01
11	BEARING	11	02

Fig 2: Isometric view of weeder

Field performance of wheel operated weeder

The developed wheel operated weeder was evaluated in Chhattisgarh, chickpea crop in the line sown of variety vaibhav-JG-30 month of November during crop season 2017-18, row to row spacing of 30 cm and plant to plant spacing randomly. The soil in the experiment site was clay soil, area of 100 m2 and. The field tests were conducted at 15-25-45 days of crop age with height of plants ranging from 5-10 cm. The different performance of sprayer and weeder, test like speed of travel, field capacity, draft, weeding efficiency, power requirement and performance index were calculated.

Performance test

The following observations were taken during the field test.

Measurement of draft

Draft is the power important to push or draw the implement for weeding task. For physically worked soil working instruments the draft should to be inside the physiological limit of the operator. The draft force of weeder can be determined by (Yadav and Pund 2007) [8].

$$D = W \times dw \times S_R \quad (1)$$

Where,

D = Draft power of the weeder (N),

Dw = depth of cut (cm),

W = width of cut (cm)

S_R = particular soil opposition (N cm^{-2}).

Speed of operation

Speed of operation of wheel operated sprayer cum weeder was measured the time required to cover 8m distance. By recording speed was calculated by using following formula. (RNAM procedure)

$$\text{Speed (kmph)} = \frac{3.6 \times \text{Distance traveled (m)}}{\text{time(s)}} \quad (2)$$

Power requirement

Calculation of power is needed to determine the efficient use of man power. A man can produce power equal to 0.05 to 0.1 hp operated for day long work. It was the power requirement to the implement by the man with average pushing force and speed. It was calculated by using the following formula (Michael and Ojha, 1966) [5].

$$\text{Power (hp)} = \frac{\text{draft (kg)} \times \text{speed} \frac{\text{m}}{\text{s}}}{75} \quad (3)$$

Theoretical field capacity

Theoretical field capacity (Dubey, 2001) [2] (ha h^{-1}) = $\frac{S \times W}{10}$ (4)

Where,

S = Speed of operation, kmph

W = Theoretical width covered and is equal to number of furrow openers multiplied by distance between two consecutive furrow openers.

Effective field capacity

Effective field capacity (Dubey, 2001) [2] (ha h^{-1}) = $\frac{A}{T_1 - T_2}$ (5)

Where,
A = actual area covered, ha
T_1 = Total time require for operation, h
T_2 = non-productive time, h

Field efficiency

It was calculated by using the following formula. (Dubey, 2001) [2]

$$\text{Field efficiency} = \frac{\text{Effective field capacity}}{\text{theoretical field capacity}} \times 100 \quad (6)$$

Plant damage

Plant damage percentage is measured using the following equation. (Yadav and Pund, 2007) [8].

$$Q = \left[1 - \frac{q}{p}\right] \times 100 \quad (7)$$

Where
Q = plant damage
q = number of plants in a 10 m row length after weeding
p = number of plants in a 10 m row length before weeding

Weeding efficiency

The number of weeds present in one m^2 area before and after weeding operation was counted. The weeding efficiency was calculated by using the following formula. (Yadaw and Pound, 2007)

$$\text{Weeding efficiency (\%)} = \frac{W_1 - W_2}{W_1} \times 100 \quad (8)$$

Where,
W_1 = Number of weeds counted before weeding
W_2 = Number of weeds counted after weeding

Performance Index

Performance Index of the weeder was found using the formula, as suggested by Gupta (1981).

$$P.I = \frac{a \times q \times e}{P} \quad (9)$$

Where,
a = Field capacity of the weeder, ha h^{-1}
q = 100 – (percent plant damage)
e = weeding Index, percentage
P = power input, hp

Results and Discussion

The manually operated weeder is easy to operate due to cycle wheel as its ground wheel and suitable for shallow weeding up to the depth of 5.0 cm. The developed weeder is not only suitable for single crop but it can also be used for other line sown upland crops and vegetable crops, as row spacing can be adjusted. As far as physiological aspect is concern it is light in weight i.e. 20 kg and its handle height and angle of operation can be adjusted as per operator requirement.

Speed of travel of mono wheel operated sprayer cum weeder

The test was conducted by selecting a distance of 10 m and time for travel this distance was noted. Readings of travel speed were recorded and average speed of travel was calculated and presented in Table 1.

Table 1: Speed of travel of mono wheel sprayer cum weeder

Sr. No	Distance covered (m)	Time (min.)	Speed (m/min.)	Average speed (m/min.)
1	10	0.36	27.8	28.2
2	10	0.50	33.4	
3	10	0.43	23.3	

Field capacity of mono wheel operated sprayer cum weeder

The average travelling speed was found to be 28.2 m/min. The field capacity was measured by selecting plots of size 10x 10 m and observations were recorded while operating the weeder in these plots (Table 2).

Table 2: Field capacity of mono wheel operated sprayer cum weeder

Weeder-

Sr. No	Area of plot (m^2)	Time to cover the area (min)	Field capacity (ha/h)	Average F.C. (ha/h)
01	100	20.8	0.031	0.031
02	100	20.7	0.032	
03	100	21.21	0.030	

The average value of weeding efficiency was found to be 88.15 per cent. It can be concluded that the weeder is more efficient because efficiency is more than 80 per cent and also more comfortable to work with due to cycle wheel and small tines (straight blade). The average draft of the weeder is 193N (0.079 hp) and it within the physical limit of the operator. The draft depends on the types of soil, effective cutting width and depth of cut. The working width of the weeder was 25 cm and depth of operation was kept as 3-5 cm. The plant damage was observed to be 2 per cent due to better stability and control of weeder during its operation. The average power requirement for the developed mono wheel operated sprayer cum weeder was estimated to be 0.079 hp. The performance index was calculated to be 12622.1.

Conclusion

It can be concluded from above, that the performance of developed mono wheel operated sprayer cum weeder is superior in terms of time and cost requirement to that of conventional weeding using manually operated knapsack sprayer and Khurpi.

It is easy to operate and the weeding efficiency is also satisfactory. It is suitable to use the seeds at 15 days of crop age in between rows and about 80 to 85 per cent weeds can be controlled throughout this machine. The rest 10 to 15 per cent of the weed flora has to be removed manually.

Weeding with this machine reduces human drudgery, reduces labour, fuel and reduces time etc.

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