Performance evaluation of manually operated weeder

Shambhu Singh, Dr. AK Dave, Dr. D Padhee, Saurabh Kumar Kulhariya and Narendra Kumar Yadav

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 tested 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 2.166 and 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 an 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 doses (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 microclimate 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
A 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

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of implement</th>
<th>Wheel operated weeder</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type of Weeder.</td>
<td>Manually operated</td>
</tr>
<tr>
<td>2</td>
<td>Type of sprayer</td>
<td>Wheel operated</td>
</tr>
<tr>
<td>3</td>
<td>Manufacturing’s Address</td>
<td>BRSM CAET &amp;RS Mungeli, CG.</td>
</tr>
<tr>
<td>4</td>
<td>Crop for Which suitable.</td>
<td>Chickpea, mustard, wheat, safflower.</td>
</tr>
</tbody>
</table>

**Overall dimension in mm**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Length</td>
</tr>
<tr>
<td>6</td>
<td>Width</td>
</tr>
<tr>
<td>7</td>
<td>Height</td>
</tr>
<tr>
<td>8</td>
<td>Weight in kg</td>
</tr>
</tbody>
</table>

**Detail of weeding component**

<table>
<thead>
<tr>
<th>9</th>
<th>Type:</th>
<th>Straight blade</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Dimension</td>
<td>25<em>10</em>1.5</td>
</tr>
<tr>
<td>11</td>
<td>Working width</td>
<td>25</td>
</tr>
<tr>
<td>12</td>
<td>Material of construction:</td>
<td>Mild steel</td>
</tr>
</tbody>
</table>

**Detail of frame weeder**

<table>
<thead>
<tr>
<th>13</th>
<th>Construction</th>
<th>Adjustable type</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Dimension of major members:</td>
<td>1200<em>260</em>30</td>
</tr>
</tbody>
</table>

**Detail of mono wheel (cycles wheel)**

<table>
<thead>
<tr>
<th>15</th>
<th>Diameter, cm</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Width, cm</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
<td>Material</td>
<td>Stainless steel</td>
</tr>
</tbody>
</table>

**Detail of ground wheel**

<table>
<thead>
<tr>
<th>18</th>
<th>Diameter, cm</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Width, cm</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>Material,</td>
<td>Mild steel</td>
</tr>
</tbody>
</table>

**Detail of handle**

<table>
<thead>
<tr>
<th>21</th>
<th>Construction</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Height of handle from ground level, cm</td>
<td>0-66.8 to 0-96.8</td>
</tr>
<tr>
<td>23</td>
<td>Details of adjustment</td>
<td>Adjustment through nut and bolt</td>
</tr>
<tr>
<td>24</td>
<td>Ground clearance</td>
<td>36.4 (ground surface to main frame)</td>
</tr>
<tr>
<td>25</td>
<td>Details of transporting system</td>
<td>Mono wheel as well as ground wheel</td>
</tr>
<tr>
<td>26</td>
<td>Safety aspects</td>
<td>No required</td>
</tr>
</tbody>
</table>

### Design calculation

**Design of frame (Deshpande, 2017)**

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

Height of frame = 30 mm

Width of frame = 240 mm

**Selection of wheel (Deshpande, 2017)**

Distance between two plant = 1.25 feet = 38 cm

Line covered by one rotation of wheel = 4

38 x 4 = 52 cm

r = 152/2π

r = 25 cm

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 weeder, animal drawn hoe and also tractor drawn scraper 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](image)
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.

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) \[8\].

\[
D = W \times dw \times S_R
\]

(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 cm²).

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)

\[
\text{Speed (kmph)} = \frac{3.6 \times \text{Distance traveled (m)}}{\text{time (s)}}
\]

(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) \[5\].

\[
\text{Power (hp)} = \frac{\text{draft (kg)} \times \text{speed}^{m}}{75}
\]

(3)

Theoretical field capacity
Theoretical field capacity (Dubey, 2001) \[21\] (ha h⁻¹) = \[S \times W\] / 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) \( [2] \)

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

Plant damage

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

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

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. (Yadav and Pound, 2007)

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

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).

\[ P. \text{ I} = \frac{axaqxe}{P} \] \( (9) \)

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>
<thead>
<tr>
<th>Sr. No</th>
<th>Distance covered (m)</th>
<th>Time (min.)</th>
<th>Speed (m/min.)</th>
<th>Average speed (m/min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>0.36</td>
<td>27.8</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>0.50</td>
<td>33.4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>0.43</td>
<td>23.3</td>
<td></td>
</tr>
</tbody>
</table>

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

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

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.

References

6. RNAM. Regional Network for Agricultural machinery, RNAM Test codes and procedure For Farm Machinery, 1995, 171.