



# Development and Performance Evaluation of Mini Tractor Operated Sprayer cum Weeder

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**Abstract** – Insects, diseases and weeds are the three main biological factors which mostly effect on yield losses and profit of farmers. Application of chemical and weeding are the most important operations in farming for high yielding. A mini tractor operated sprayer cum weeder was developed in the department of Farm Machinery and Power Engineering at Collage of Agricultural Engineering and Technology, Junagadh Agriculture University, Junagadh. The developed system was tested at 3 different forward speeds (1.5, 2.0 and 2.5 km/h) to evaluate performance. The maximum weeding efficiency (88.94 %), field efficiency (86.27 %), spray application rate (395.35 l/ha), lowest fuel consumption (1.15 l/h) and minimum plant damage (3.00 %) were found at forward speed of 1.5 km/h. Operational cost of the developed machine was determined as ₹ 244.73 /h and ₹ 584.90 /ha.

**Keywords** – Sprayer, Weeder, Mechanization, Weeding Efficiency, Plant Damage.

## I. INTRODUCTION

Application of chemical and weeding are the most important operations in farming to get higher yield. At present, different categories of sprayers and weeders that are manually operated, animal drawn, tractor mounted, and self-propelled types are available. Use of big and costly machines in the Indian Agricultural scenario is difficult as most of the Indian farmers are small and medium and their economic conditions are not sound to adopt these costly and advanced machines. So, large size equipment is difficult and also not advisable to adopt for small fields. Therefore, considering the overall category of the farmers, their economic status, availability of different power sources on farm and wider acceptability should be considered in designing and development of agriculture machine.

Earlier agriculture was more dependent on the nature and all the operations were carried out by using human and animal power. For profitable agriculture timely operations are the most important. Second important point is the cost of operation. Therefore, a mini tractor operated sprayer cum weeder to save working time and operational cost, was developed and its performance was evaluated in the laboratory and field conditions.

## II. REVIEW OF LITERATURE

Padmanathan and Kathirvel (2007), evaluated the performance of power tiller operated rear mounted boom sprayer for sixteen hollow cone nozzles, placed 40 cm apart and swath width of 3.2 m at forward speed of 2 km/h. The effective field capacity of the sprayer was found 0.72 ha/h at a pressure of 3 kg/cm<sup>2</sup>.

Chandel *et al.* (2014), investigated performance of rotary power weeder in vegetable crop. The effective field capacity increased with increase in speed of operation. At forward speed of 2.0 km/h, 2.3 km/h and 2.4 km/h the effective field capacities were 0.08, 0.092 and 0.096 ha/hin yard long bean, tomato and okra crops respectively.

Nagesh *et al.* (2014), evaluated the field performance of different weeders namely khurpi, push type cycle weeder and power weeder. The highest field efficiency was obtained for khurpi (91.5 %) followed by cycle

weeder (85.4 %) and power weeder (71.25 %). The field capacity of 0.065, 0.025 and 0.035 ha/h observed for power weeder, khurpi and push type cycle weeder respectively. The minimum value of cost of operation was found for push type cycle weeder while maximum was recorded for khurpi.

Kolheet al. (2021), designed and developed tractor drawn inter-cultivator cum sprayer for soybean and cotton to carry out inter-cultivation and spraying operation simultaneously. The test results revealed the effective field capacity, field efficiency, weeding efficiency, plant damage and spray application rate are 0.631 ha/h, 85.32 %, 86.12 %, 5% and 297.76 l/ha, respectively for soybean at a forward speed of 3.30 km/h and of 0.733 ha/h, 81.56 %, 84.87 %, 3.06 % and 334.50 l/ha, respectively for cotton at a forward speed of 2.50 km/h.

### **III. MATERIALS AND METHODS**

#### *Location of Experiment*

The machine was developed at Department of Farm Machinery and Power Engineering. Field experiments were conducted at Farm of Department of Soil and Water Conservation Engineering. Some laboratory experiments were conducted in the Testing Centre of Farm Machinery under the college of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh during the year 2021-2022.

#### *Developed Sprayer Cum Weeder*

These systems consist of main frame, diaphragm pump, nozzles, hose pipe, spraying tanks, boom and blades.

#### *Power Source:*

The developed system was pulled by a mini tractor of 15 kW (20 hp) and spraying system used a battery power i.e., of a 12V/75Ah lead acid battery power of the same tractor.

#### *Main Frame:*

To mount all parts of the system a main frame having the overall dimensions of 200 cm × 82 cm × 23 cm (L × W × H) was fabricated of a MS pipe and rectangular hollow pipe.

#### *Diaphragm Pump:*

To operate the sprayer an electrical Diaphragm pump unit whose maximum flow rate and maximum pressure of 5 liters per minute and 100 psi was selected. This pump has two outlets.

#### *Nozzle:*

The hollow cone nozzles were selected in the spraying system with four nozzles. The spacing between two adjacent nozzles was 50 cm. However, it was adjustable for the any required spacing.

#### *Flexible Hose Pipe:*

For carrying spray solution from storage tank to the nozzle, 8 mm diameter flexible plastic hose pipe was used.

#### *Spraying Tanks:*

Two storage tanks, made up of high-density plastic material, capacity of each tank 50 - liter were selected for

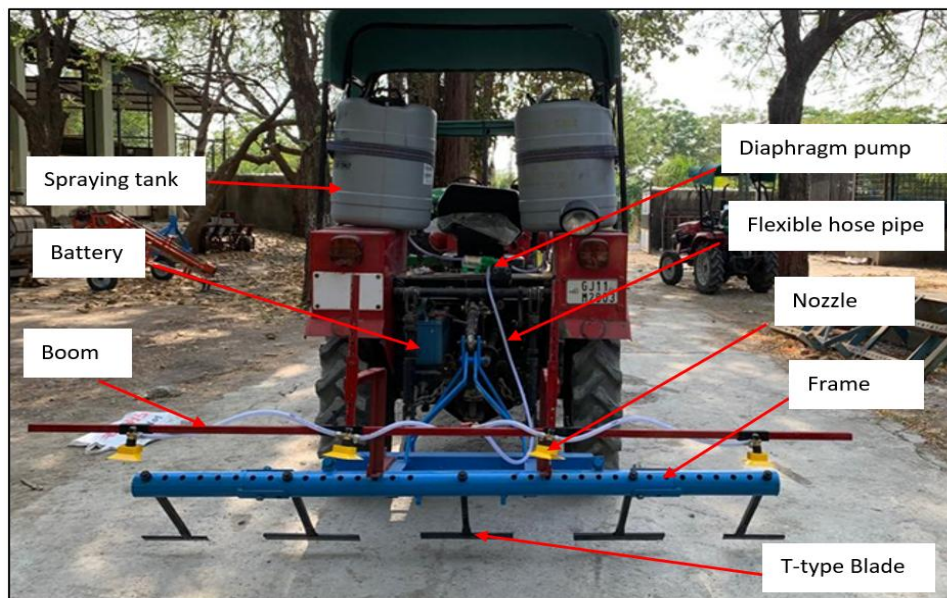
storing the spray solution. Both the tanks were placed over mudguard of each wheel of the tractor.

#### *Boom:*

Boom was made up of GI square pipe (20 mm× 20 mm). Designing of boom depend on size of the nozzle and distance between nozzle to nozzle. Boom height was adjustable as per the crop requirement.

#### *Blade:*

T- type blades were chosen as per the weeding requirement for row-to-row distance of 50 cm. Out of total five blades three blades of full size and two blades of half size width were fabricated for weeding purpose.



Developed Sprayer cum Weeder.

#### *Performance Evaluation of the Developed Sprayer Cum Weeder*

The developed machine was tested in the field of chick pea crop sown at 50 cm row to row spacing. During its performance evaluation, its spray application rate, field capacity, field efficiency, weeding efficiency, plant damage, fuel consumption, cost of operation etc. were determined.

#### *Soil Parameters*

##### *Soil Moisture (%)*

Moisture content of the soil was determined by standard oven dry method. Five samples were taken from the different locations of the test plots in different moisture boxes. These was kept in oven for 24 hours at the temperature of 105 °C. The mass of wet and dry samples was determined and average moisture content on dry basis was calculated. (IS: 2720-2-1973).

$$\text{Moisture Content (d.b.) \%} = \frac{W_w - W_d}{W_d} \times 100.$$

Where;

Ww = Weight of the wet soil, g.

W<sub>d</sub> = Weight of the dry soil, g.

### *Bulk Density of Soil*

Metallic core cylinder was used to collect soil sample from the field. Samples were taken in 100 mm diameter and 127.5 mm long core sampler. The samples were weighed with an accuracy of 0.1 gram. The ratio of the dry weight of the soil to the volume gives the bulk density (Punmia et al., 2009).

$$\text{Bulk density of soil (g/cc)} = \frac{W_d}{V}$$

Where;

W<sub>d</sub> = Weight of the dry soil, g.

V = Volume of metallic core, cm<sup>3</sup>.

### *Spraying Parameters*

Under laboratory condition Nozzle discharge, Spray angle and Spray distribution pattern were measured.

#### *Nozzle Discharge*

Nozzle discharge was determined by collecting the spray volume in a measuring cylinder over a fixed period of time and at a constant pressure (IS: 11429, 1985).

#### *Spray Angle*

Spray angle is another important parameter of nozzle performance that establishes the correct nozzle spacing, overlapping and height of the application. Spray angle of the nozzles were measured in the laboratory.

#### *Spray Distribution Pattern*

An ideal nozzle delivers uniform spray along its area of coverage. Spray distribution pattern was evaluated by the patternator. Nozzle spray volume was collected in test tubes and evenness of the spray was determined by drawing a pattern graph.

#### *Spray Application Rate*

Forward speed, operating pressure and type of nozzle are affected on the spray application rate. The spray application rate of sprayer was determined using the following formula.

$$SAR = \frac{600 \times \text{Total discharge (l/min)}}{\text{Swath width (m)} \times \text{Travel speed (m/sec)}}$$

### *Weeding Parameters*

#### *Width and Depth of Coverage*

The working width and depth of weeding were measured during operation in the field. All the 5 blades were participated in width of coverage. The depth of cut by blade was determined by measuring the distance vertically between horizontal soil surface to the bottom of dug out soil with the help of depth gauge.

### *Plant Damage*

Number of plants present before the weeding (p) were counted. After the weeding, No. of plants damaged (q) were counted for the same row length. The percentage of plant damage was calculated with the help of following formula.

$$\text{Plant damage (\%)} = \frac{q}{p} \times 100$$

#### *Weeding Efficiency*

Weeds present before and after the weeding operation were counted to calculate weeding efficiency. Weeding efficiency was calculated with the help of following formula.

$$\text{Weeding efficiency (\%)} = \frac{X-Y}{X} \times 100.$$

Where;

X = No. of weeds before operation per m<sup>2</sup> area.

Y = No. of weeds after operation per m<sup>2</sup> area.

#### *Performance Parameters*

##### *Fuel Consumption*

The fuel consumption was measured as per the standard prescribed method. The fuel tank of tractor was filled to its full capacity before and after test run. The quantity of fuel filled at the end of test divided by the total time of operation will give the fuel consumption.

##### *Theoretical Field Capacity*

It is the rate of area covered without loss of time. It was calculated by using following formula.

$$\text{Theoretical field capacity} \left( \frac{\text{ha}}{\text{h}} \right) = \frac{\text{Width of coverage (m)} \times \text{Speed} \left( \frac{\text{km}}{\text{h}} \right)}{10}$$

##### *Effective Field Capacity*

It is the actual rate of work which includes the time lost in turning at the end of rows and refilling of fertilizer. It was calculated by using following formula.

$$\text{Effective field capacity} \left( \frac{\text{ha}}{\text{h}} \right) = \frac{\text{Width of coverage (m)} \times \text{Length of strip (m)}}{\text{Time taken (h)} \times 10,000}$$

##### *Field Efficiency*

Field efficiency is defined as the percentage of time the machine operates at its full rated speed and width while in the field. It was calculated by using following formula.

$$\text{Field efficiency (\%)} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100$$

##### *Economics*

The fabrication cost of the developed machine (sprayer cum weeder) was the sum of cost of materials used a-

and cost of labour used for fabrication works. Fabrication cost was considered as purchase cost in this study. Annual use of tractor and the machine was considered as 1000 and 240 h, respectively.

#### IV. RESULTS AND DISCUSSION

##### *Laboratory Testing and Evaluation*

##### *Nozzle Discharge*

Spray volume of nozzle was collected in measuring cylinder for a period of 60 seconds. Total discharge of nozzle observed was 0.69 l/min.

##### *Spray Angle*

Spray angle was found 71° for 3 kg/cm<sup>2</sup> pressure. The recommended angle of hollow cone nozzle varies 65° to 110° (Khuram, 2004).

##### *Spray Distribution Pattern*

Spray distribution pattern of hollow cone nozzle was determined using patternator at constant pressure 3 kg/cm<sup>2</sup> for two-minute time period. Spray distribution pattern was determined by drawing a pattern graph shown in Fig 1. The graph showed that a maximum volume (335 ml) was recorded at the central tube of patternator and spray volume was decreased in both the directions from the central tube i.e., left and right side of tubes of patternator.

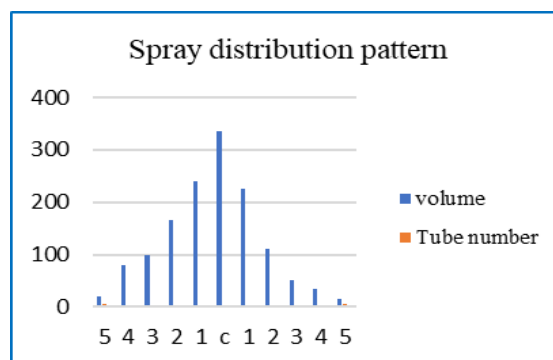


Fig. 1. Spray distribution pattern.

##### *Field Testing Evaluation*

Field testing was conducted at Farm of Soil and Water Conservation department at Junagadh Agricultural University. The developed sprayer cum weeder was tested in the field of chick pea crop sown at 50 cm row to row spacing. During its performance evaluation, its field capacity, weeding efficiency, plant damage, fuel consumption, speed of operation, spray application rate, cost of operation etc. were determined. The developed sprayer cum weeder mini tractor (15 kW) operated was tested and its performance was evaluated.

Table 1. Field Parameters.

| Sr. no | Particular       | Observation           |
|--------|------------------|-----------------------|
| 1      | Name of the crop | Chick pea             |
| 2      | Variety of crop  | Gujrat Gram 3 (GJG 3) |



| Sr. no | Particular  | Observation            |
|--------|---|------------------------|
| 3      | Type of soil  | Medium black soil      |
| 4      | Days of weeding and spraying after sowing                 | 40 days                |
| 5      | Moisture content  | 13.20 %                |
| 6      | Soil bulk density   | 1.26 g/cc              |
| 7      | Area of operation   | 96 m × 31 m            |
| 8      | Height of crop at time of weeding and spraying operations | 12 to 20 cm            |
| 9      | Depth of weeding  | 4 to 6 cm              |
| 10     | Length of strip   | 30 m                   |
| 11     | Blade angle   | 33.36°                 |
| 12     | Draft   | 91 kg                  |
| 13     | Height of boom  | 45 cm                  |
| 14     | Operating Pressure  | 3.5 kg/cm <sup>2</sup> |

### Soil Parameters

#### Soil Moisture (%)

The soil moisture content of the experimental field at the time of operation was determined and it was found as 13.20 % on dry basis.

#### Bulk Density

The bulk density of soil of experimental plot was determined and found as 1.26 g/cm<sup>3</sup>.

#### Spray Application Rate

The spray application rate was plotted against forward speed of machine as shown in Fig 2. The spray application rate decreased as forward speed increased. Spray application rate should be about 400 lit per hectare (Matthews, 1992). From the results it is clear that, the required spray application rate could be obtained at the forward of 1.5 km/h i.e., 395.35 l/ha which is very close application rate was found 329.21 l/ha at the maximum speed i.e., 2.5 km/h. Thus, this speed (1.5 km/h) may be considered as an appropriate speed for machine to get the better result.

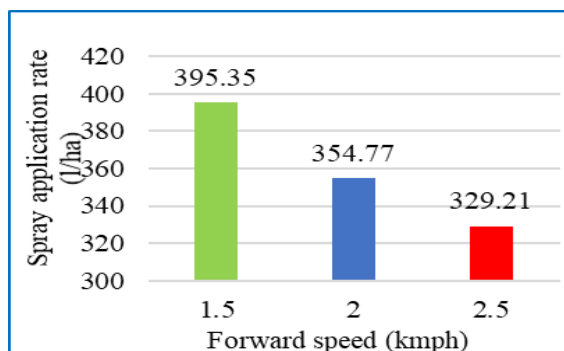


Fig. 2. Effect of forward speed on spray application rate.

### Weeding Parameters

#### Weeding Efficiency

The weeding efficiency decreased as forward speed increased. The weeding efficiency was plotted against forward speed of machine as shown in Fig 4. Weeding efficiency at 1.5, 2 and 2.5 km/h were found 88.94, 84.52 and 80.12 % respectively. From the result it is clear that the low speed of the machine was found an appropriate speed to get the higher weeding efficiency. At a higher speed, the blades may get slight jump and could not go deeper resulting poor weeding.

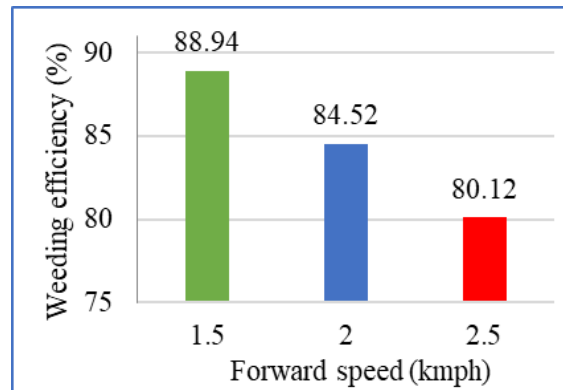


Fig. 3. Effect of forward speed on weeding efficiency.

#### Plant Damage

It is a negative factor of the machine. The plant damage was plotted against forward speed of machine as shown in Fig 3. Plant damage at 1.5, 2 and 2.5 km/h were found 3.00, 4.34, and 6.35% respectively. From the results it is clear that the low speed was appropriate speed of machine to get lower plant damage. At higher speed plant may come across on the way of weeding tool/blade due to high movement of soil and vibration and got fall down and crushed by the blade.

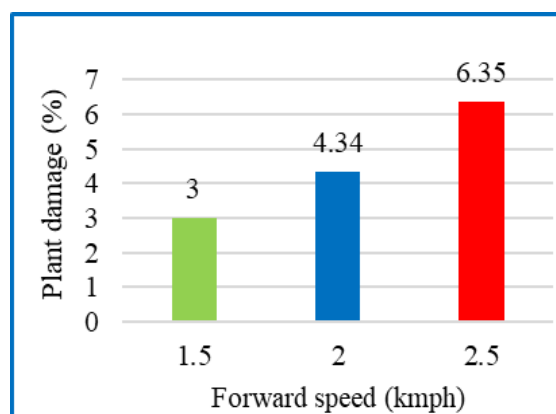


Fig. 4. Effect of forward speed on plant damage.

#### Depth and Width

The working depth of cut was found as 4 to 6 cm during the weeding operation. However, the maximum width of coverage by all the 5 weeding blade was observed as 200 cm in a single pass and for single row it was 50 cm.



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*Other Performance Parameters**Fuel Consumption*

Fuel consumed by the tractor during spraying and weeding operations simultaneously was measured and found 1.15, 1.68 and 2.24 l/h at 1.5, 2 and 2.5 km/h speeds respectively.

*Theoretical Field Capacity*

Theoretical field capacity of the developed sprayer cum weeder was determined and found 0.3, 0.4 and 0.5 ha/h at a speed of 1.5, 2 and 2.5 km/h respectively. The theoretical field capacity increased with the increased speed.

*Effective Field Capacity*

It is the actual rate of work done which includes the time lost in turning at the end of rows, making adjustments etc. Effective field capacity at speed of 1.5, 2 and 2.5 km/h were found 0.259, 0.334 and 0.405 ha/h respectively. The effective field capacity also increased with the increasing speed. It was due to more area was covered at higher speed of operation.

*Field Efficiency*

The field efficiency at the speed of 1.5, 2 and 2.5 km/h were found 86.27, 83.50 and 81.1 % respectively. Thus, the field efficiency decreased as forward speed increased. At higher speed not only the percentage of useful time as compared to lower speed decreased but the quality of work also reduced.

*Economics*

The operational cost was analysed for the developed mini tractor operated sprayer cum weeder. The depreciation cost was calculated on the basis of straight-line method. The operating cost of the developed system was found 244.73/h and ₹ 584.90/ha. The Benefit - Cost ratio of the machine was obtained as 3.68 and the payback period of machine was also found 2.71 years. Thus, the developed sprayer cum weeder was found economically well suitable for the spraying and weeding operation not only for the small farmers but also for all categories of farmers.

**V. CONCLUSIONS**

The working of the developed mini tractor operated sprayer cum weeder was found the most satisfactorily. It gave its best performance in the terms of the maximum weeding efficiency 88.94 %, the maximum field efficiency 86.27 % and the lowest plant damage 3.00 % at the minimum speed of 1.5 km/h. The best spray application rate of the developed system was found 395.35 l/ha as it is very near to the recommended rate (400 l/ha) at the speed of 1.5 km/h. The lowest fuel consumption i.e., 1.15 l/h was also observed at the operating speed of 1.5 km/h. Operational cost of developed machine/system was determined as ` 244.73 /h and ` 584.90 /ha.

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