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Development of Tractor Mounted Inter Row Shielded Herbicide Sprayer for Weed Control in Wide Row Crops

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ABSTRACT

A six-row tractor mounted inter row shielded herbicide sprayer was developed for weeds control in wide row crops. The different components of the developed sprayer were main frame, chemical tank, spray pump, pressure gauge, control assembly, boom, spray shields, hose pipes, nozzles and power transmission unit. The performance of developed shielded sprayer was evaluated in the field to study the effect of operating pressure (100, 200, 300 and 400 kPa) on volume median diameter (VMD), droplet density (DD) and uniformity coefficient (UC) at different forward speeds (2, 3 & 4 km/h) and different wind velocities (5, 6 and 7 km/h). From the results, it was found that operating pressure had significant effect on volume median diameter, droplet density and uniformity coefficient for all combination of wind velocities and forward speeds.

Key words : Volume median diameter, droplet density, uniformity coefficient.

INTRODUCTION

Weeds compete with crop for moisture, nutrients and sunlight and can have a detrimental impact on crop yields and quality, if uncontrolled. Weeds alone can cause a loss up to 37 per cent of total agricultural production in India (Gharde *et al.*, 2018). Herbicides are chemicals, designed to kill/control the weeds. Herbicide based weed control system may be both biologically efficacious and economically effective (Tewari *et al.,* 2018). For successful use of herbicides, their application must be accurate and uniform. Manually operated knapsack sprayer, knapsack power sprayer, solar powered knapsack sprayer, trolley power sprayer, tractor power sprayer and tractor mounted boom sprayer are used for application of herbicides (Tewari *et al.*, 2018). Tractor operated boom sprayer are commonly used for higher coverage and speedy operation, but they tend to leads a common problem known as "spray drift"spraying with boom sprayer for weed control has major issues such as drift, environmental pollution, health effect of operator and damage to the adjacent crops. Further application of this type sprayer is limited to the selective application of herbicide only. To tackle these issues a six-row tractor mounted inter row shielded herbicide sprayer was developed to control weeds in wide row crops. The performance of developed sprayer was evaluated in the field to study the effect of operating pressure at different combinations of forward speed and wind velocity on volume median diameter, droplet density and uniformity coefficient. The droplet size for effective application of herbicides is 250-350 μm for medium spray and 350-450 μm for coarse spray. The droplet densities for pre-emergence and post emergence herbicide application are 20-30 and 30-40 drops/cm^2, respectively (Anonymous, 2011).

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MATERIALS AND METHODS

A six-row tractor mounted inter row shielded herbicide sprayer was developed and fabricated at Agricultural Research and Development Foundation (ARDF) of M/s. American Spring and Pressing Works Private Limited (ASPEE), Thane District of Maharashtra State (Fig.1). The different components of the developed sprayer were main frame, chemical tank, spray pump, pressure gauge, control assembly, boom, spray shields, hose pipes, nozzles and power transmission unit. The brief specification of the different components used for fabrication of the developed sprayer is given in Table 1.

Table : 1 specification of components used for fabrication of the sprayer

S. N.	Sprayer parts	Specifications
1.	Main frame	Material: MS angles, Size: 75×45×5, 70×65×5, 80×70×5 mm, L×B: 1580×680 mm.
2.	Chemical tank	Material: Roto-mold plastic, Capacity: 400 l with agitator 20-40 l/min.
3.	Spray pump	Horizontal triplex pump (HTP), RPM: 950, Output: 50 l/min. Max. pressure: 28 kg/cm2, HP required:5.
4.	Pressure gauge	Make: ASPEE, Pressure range: 0-7 kg/cm2.
5.	Control assembly	Material: Brass, Seven on-off control valve (6 for shields & 1 for back flow) with pressure regulator and suck back valve.
6.	Boom	MS square pipe, Size: 50×50×3 mm, Length: 4500 mm.
7.	Spray shields	6 Nos. Material: 1 mm Aluminium sheet.
8.	Hose pipes	Make: ASPEE Duratek, Material: HDPE, Size: 10 mm ?, Working pressure: 50 kgf/cm2.
9.	Nozzles	6 Nos. Flat fan nozzle, Discharge 800 ml/min., Spray angle, 80°.
10.	Power transmission unit	PTO shaft (L:300, Dia.:30 mm), V belts (A30, 8 mm) & pulley (Two, 175 & 100?)

Development of six row tractor mounted inter row shielded herbicide sprayer

Main frame

Main frame was the part to which all other parts of the sprayer were attached. Main frame was fabricated to accommodate herbicide tank, boom, pump and other accessories of the sprayer. The overall length and width of the frame was 1580 mm and 698 mm, respectively. The height of the main frame was 1205 mm. The provision to mount the control panel and three-point hitches were also provided on the main frame.

Chemical tank

The roto-mould plastic chemical tank of ASPEE having tank capacity of 400 Ltr. was used to accommodate in the main frame of the sprayer. The tank was mounted on the main frame and bolted with two T type nut and bolts to the main frame. Usually, agitation flow should be 5 to 10 percent of the tank capacity (Sharma and Mukesh, 2013). Therefore, for 400 litre capacity of chemical tank the agitation flow was kept 20-40 litre/min.

Spray pump

The horizontal triplex pump (HTP) of discharge capacity of 50 lpm was used in the sprayer. The filter was also provided in between the outlet of chemical tank and inlet of pump to remove any foreign material in chemical with the help of transparent plastic pipe.

Control assembly

The control assembly consisted of seven on-off valves, pressure regulator and suck-back valve was fitted at front left-hand side of sprayer. It facilitated in spraying any section of the shield. Six on/off valves were provided for nozzles inside the shields and one for agitation assembly. Pressure regulator of the pressure range 0-7 kg/cm^2 was also provided for regulating the spray pressure of the sprayer.

Boom

The boom was fabricated from Mild Steel (MS) square pipe of size 50×50×3 mm. Spray shields were mounted on the boom with help of shield mounting assembly. The boom size in terms of length was established based on field capacity, speed and time using the expression given by Mathews (1992) thus;

$$L = \frac{A}{s \times t}$$

Where, A = Area to be covered, ha; S = Spraying speed, km/h; T = Time taken to cover an area, h; L = Length of boom

Spray shields

Spray shields (6 Nos.) were developed locally using 2 mm aluminum sheet (Fig. 1). Spray pattern of the nozzle was taken into consideration for developing the shield, so that edges of the shield do not touches the shield, so that edges of the shield do not touches and affects the spray pattern of nozzle (Nimkar, 2013). Rubber sheet of appropriate size was riveted to the shield so that shield should not damage with obstacles in the field.

Spray shields were mounted on shield assembly. Shield assembly consisted of clamps (2 for each shield) fabricated from 3 mm Mild Steel sheets, upper and lower pipes (one each for each shield), and shield brackets. The lower pipe was able to close fit inside the upper pipe and holes were made into both the pipes for height adjustment by nut and bolts.

Spray hoses

ASPEE Duratek high density polyethylene spray hoses of 10 mm Φ with working pressure of 50 kgf/cm^2 were used to carry spray chemical from control assembly to nozzles inside the shields.

Nozzle

The flat fan nozzle (one for each shield) was used as it is most commonly used nozzle for herbicide application (Bainer *et al.*, 1987). The position of the nozzle was kept in the center of the shield and care was taken so that the spray pattern of nozzle should not touch the edge of the shield. The material used for the nozzles was brass as it has less wear than plastic nozzles.

Power transmission

The power to operate the spray pump was taken from the power take off (PTO) shaft of the tractor. PTO shaft operated the pedestal pulley which further operated HTP pump through V belts and pulley arrangement (Gholap *et. al.*, 2014).

Fig. 1 View of the developed shielded sprayer

Experimental set up for field operation of the sprayer

The sprayer was mounted on the tractor and tank was filled with blue indigo dye mixed with the water (Gholap and Mathur, 2013). The sample glossy paper were placed in the field under each shield/nozzle for each experiment and collected for analysis in the laboratory. For analysis of VMD, DD and UC image analyzer with microscope (Fig. 2) was used. The sample glossy papers collected in different experiments were placed under the microscope. The microscope processed the glossy paper and directly gave Volume Median Diameter (VMD), Number Median Diameter (NMD) and Droplet Density (DD). Ratio of VMD and NMD gave uniformity coefficient (UC).

Fig. 2 Image analyzer for analysis of droplet spectrum

The operating pressure was adjusted through the control panel of the sprayer. The forward speed of sprayer was adjusted by changing the tractor travel speed through accerator pedal. A view of shielded sprayer in field operation for chilly crop is shown in Fig. 3.

Fig. 3 Field operation of devloped shielded sprayer for chilly Data analysis

The data obtained in different experiments were stored in microsoft (MS) excel and statistical analysis was carried out. The data were analyzed using CRD statistical software package (Gholap *et. al.*, 2012).

RESULTS AND DISCUSSION

Effect of spraying pressure on volume median diameter (VMD) at different wind velocities and forward speeds

The volume median diameter of sprayer varied from 139 µm to 445 µm. The smallest volume median diameter of 139 µm was found at operating pressure of 400 kPa, forward speed of 4 km/h and wind velocity of 7 km/h. The largest VMD of 445 µm was found at operating pressure of 100 kPa, forward speed of 2 km/h and wind velocity of 5 km/h. It is evident from Fig. 4 that volume median diameter decreased as spraying pressure increased for all combinations of wind velocities and forward speeds.

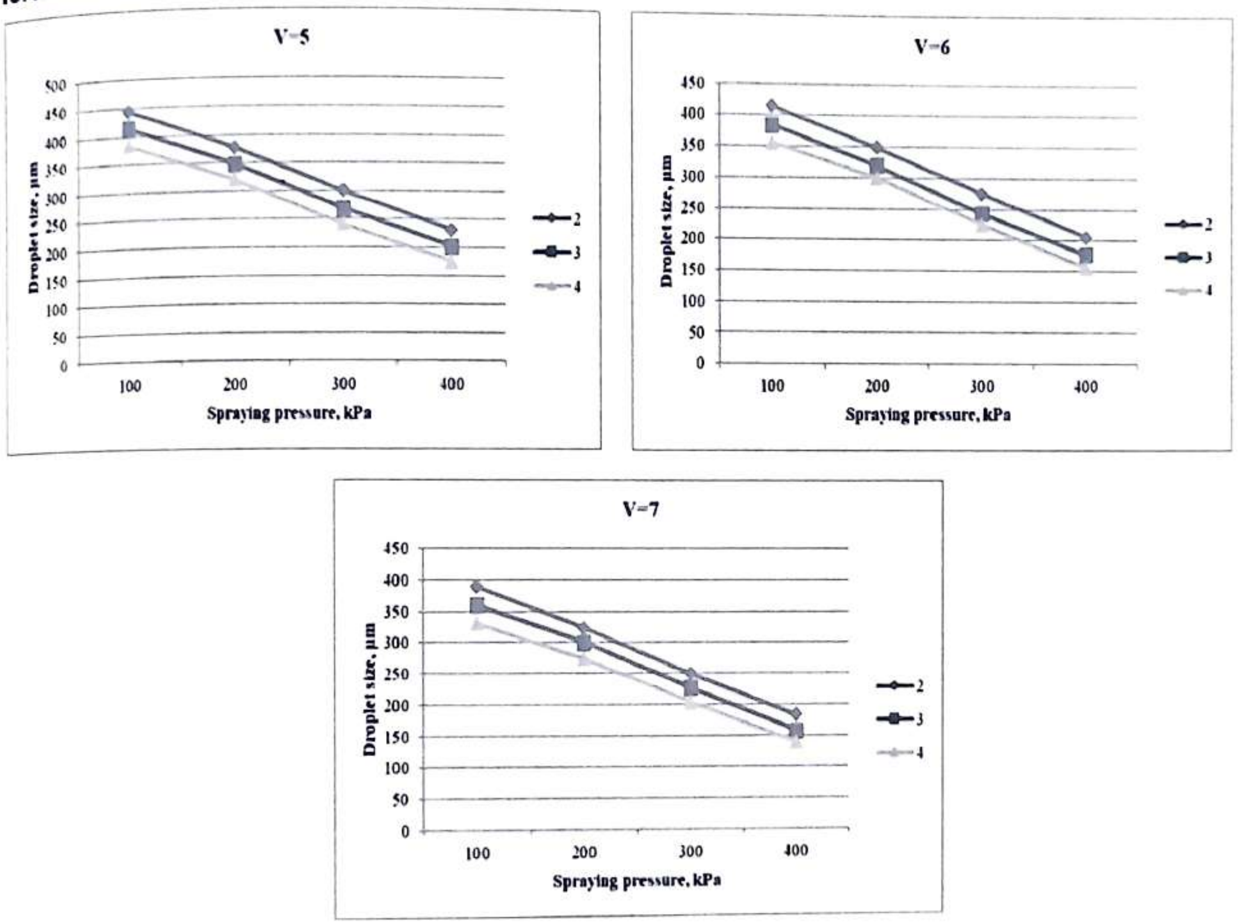


Fig. 4 Effect of spraying pressure on volume median diameter at different wind velocities and at different forward speeds

Effect of spraying pressure on droplet density (DD) at different wind velocities and forward speeds

The droplet density of sprayer varied from 32 to 42 No./cm^2. The smallest droplet density was found at operating pressure of 100 kPa, forward speed of 2 km/h and wind velocity of 5 km/h. The largest droplet density was found at operating pressure of 400 kPa, forward speed of 4 km/h and wind velocity of 7 km/h. It is evident from Fig. 5 that droplet density increased as spraying pressure increased for all combinations of wind velocities and forward speeds.

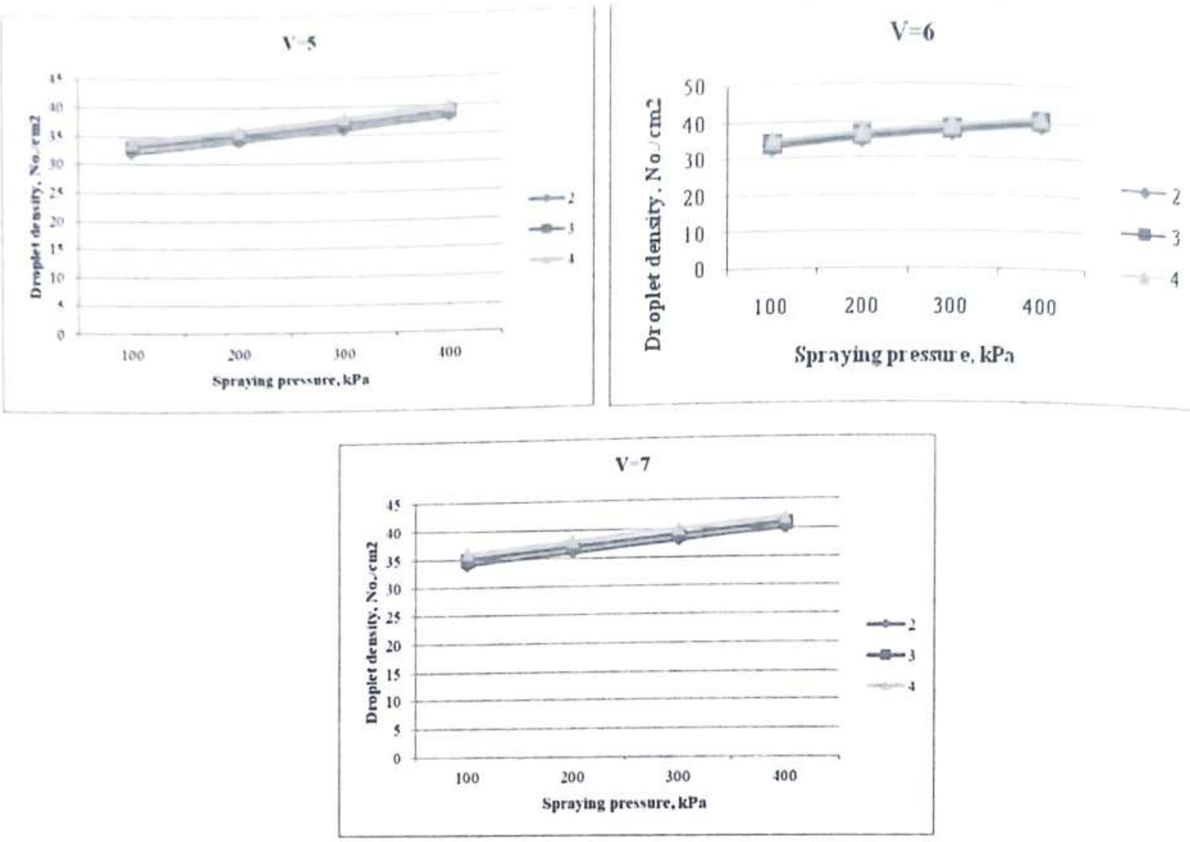
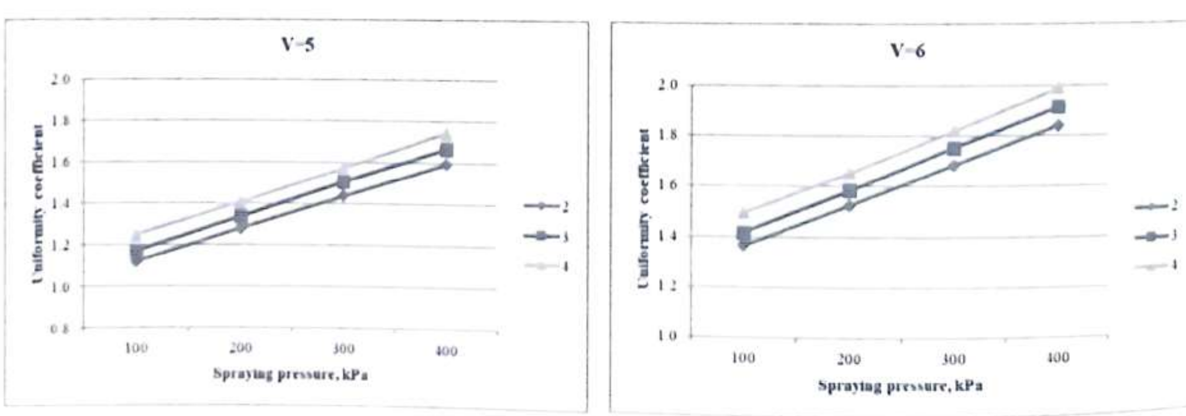


Fig. 5 Effect of spraying pressure on droplet density at different wind velocities and at different forward speeds

Effect of spraying pressure on uniformity coefficient (DD) at different wind velocities and forward speeds

The uniformity coefficient of sprayer varied from 0.95 to 1.15. The smallest uniformity coefficient was at operating pressure of 100 kPa and forward speed of 2 km/h. The largest uniformity coefficient was at operating pressure of 300 kPa and forward speed of 4 km/h. Fig. 6 slows that uniformity coefficient in-creased as spraying pressure in-creased for all combinations of wind velocities and forward speeds.



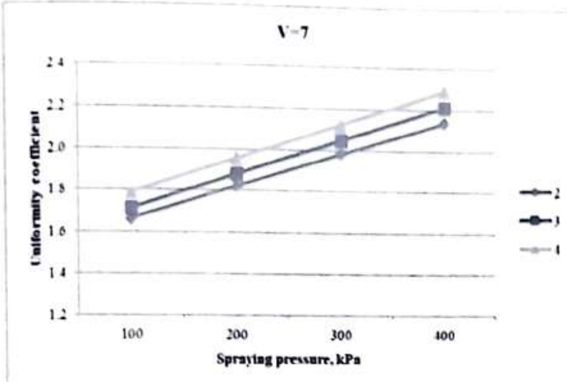


Fig. 6 Effect of spraying pressure on uniformity coefficient at different wind velocities and at different forward speeds

CONCLUSIONS

From the results, it was found that operating pressure had significant effect on volume median diameter, droplet density and uniformity coefficient for all combination of wind velocities and forward speeds. The volume median diameter, droplet density and uniformity coefficient of sprayer varied from 139 µm to 445 µm, 32 to 42 No./cm^2 and 0.95 to 1.15, respectively.

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