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Effect of Speed of Operation on Droplet Size, and Droplet Density of Axial Flow Blower in Air Assisted Orchard Sprayer

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Abstract: *Farmers and fruit growers of developed countries have been using air-assisted spraying system for many years. In India, although air-assisted spraying technique has been employed in some of the hand operated and boom sprayers, air-carrier sprayers capable of spraying vast orchard and tree crops are still aliens to Indian agriculture. As the name implies, an air-assisted sprayer utilizes an air stream to carry the spray droplets onto the target It employs a blower (which is basically a fan) to produce and deliver an air stream of sufficient discharge, velocity and pressure, and introduces the spray fluid into this air stream in the form of fine droplets at high pressures (from a reciprocating pump) at the air outlet. The study has been carried out on the parameter viz. speed of operation which was affecting the droplet size and droplet density of spray. For this study three speed of operation selected (2.5 km/h, 3 km/h, 3.5 km/h).The laboratory testing was carried out at the workshop of ASPEE Agriculture Research Foundation, Mumbai. The minimum value of droplet size at outer canopy (147.5 μm) and inner canopy (147.5 μm) was observed at top position at speed 3.5 km/h while the maximum value of droplet size at outer canopy (198.0 μm) and inner canopy (191.0 μm) was observed at bottom position at speed 2.5 km/h. The minimum value of droplet density at outer canopy (36.5) and inner canopy (40.9) was observed at bottom position at speed 2.5 km/h while the maximum value of droplet density at outer canopy (59.6) and inner canopy (65.1) was observed at top position at speed 3.5 km/h.*

Keywords: *Air assisted sprayer, axial flow blower, speed of operation, droplet size and droplet density.*

INTRODUCTION

Uniform distribution and deposition of chemical from top to bottom of plant canopy and on the undersides of leaves is of utmost importance for effective pest control. Incorporation of air assistance in spraying system improves the deposition uniformly in the entire tree canopy. Spray deposition on the lower portion of plant leaves, where most of pests harbour, also improves in the air assisted spray application (Sirohi *et. al.* 2008). The deposition of spray droplets, requirement of air volume in air assisted spraying system and pesticide application rates are mainly influenced by canopy characteristics like leaf area index and leaf area density. The higher leaf area density results in lower droplets density at the canopy (Bhargav, 2001). The tractor operated air-assisted sprayer in which high air velocity is generated through axial or centrifugal blower produces smaller size droplets by atomization. The air-assisted sprayer produces appropriate size droplets uniformly reducing losses of expensive chemical and environmental pollution. Considering the environmental hazards and non uniformity in spray deposition the fruit growers in developed countries use tractor operated air-carrier sprayer, which uses air stream to transport 250-400 ìm VMD spray particles (Norman *et. al.*; 1979) to the distant target. The fine droplets at high pressure during movement mix up thoroughly with air. The turbulent air stream along with fine spray particles causes ruffling action of foliage and effect impingement of spray droplets on both sides of

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Table 1
Effect of speed of operation on droplet size

		Droplet size, mm					
		Outer canopy			*Inner canopy*		
Sr. No.	*Speed of operation, km/h*	*Top*	*Middle*	*Bottom*	*Top*	*Middle*	*Bottom*
1.	2.5	178.6	186.3	198.0	171.0	177.1	191.0
2.	3	163.8	171.8	184.0	155.29	163.3	174.6
3.	3.5	147.5	154.8	168.4	139.1	147.4	160.0
	F Test	S	S	S	S	S	S
	SE(m)	0.257	0.26	0.28	0.32	0.29	0.33
	CD (5%)	0.731	0.739	0.80	0.93	0.83	0.95

leaves, including those in the innermost part in the canopy. It therefore, makes effective and economic spray deposition on tall and branched tree leaves (Mathews, 1992).

Technological advancement includes direct injection, on-board application system, handling and control systems, air-assisted sprayer, electrostatic spraying and nozzle development. In developed countries, air-assisted sprayer with efficient blowers producing large volume of air at high velocities, were developed for large fruits and nut trees, which are operated by high horsepower tractor. These technologies have allowed precise application of fertilizers and pesticides with minimal impact on environment (Fox *et. al*; 2008).

For droplet spectra, two types of median are often used to describe the range of droplet sizes. The volume median diameter (VMD) is the diameter such that half the total spray volume is in smaller droplets and half is in larger ones, and the number median diameter (NMD) is the diameter such that half the total number of droplets present has a smaller diameter and half of them have a larger diameter.

Droplet density is the number of droplets per centimeter square.

MATERIAL AND METHODS

With the help of study on existing blower a new blower was developed which is suitable for small hp tractor.

Components of blower:

1. Blower casing
2. Blower hub (boss)
3. Blade
4. Gear box
5. Back plate

Laboratory Testing of Newly Developed Blower

The developed blower was calibrated and tested with test set up as shown in plate 1 .In the trial, power source that was used as 18 hp tractor and blower fitted behind the tractor which was operated by tractor PTO. The speed of operation maintained by using tractor accelerator.

The droplet size and droplet density was measured at two different testing frames considering two different plant positions. First frame is outer canopy of the plant and second frame is the inner canopy. On that two positions three different heights marked as bottom (1-2 m), middle (2-3 m) and top (3-5 m). The glossy papers was fixed on that two frames with three different heights as mentioned earlier. These readings recorded at each treatment combinations and selective samples collected in the polythene bag for droplet size analysis. The collection of glossy paper sample for droplet size analysis is as shown in plate 1.Droplet size analyzer was used for droplet size analysis.

Following independent and dependent variables were used for the evaluation.

Table 2
Effect of speed of operation on droplet density

		Droplet size, mm					
		Outer canopy			*Inner canopy*		
Sr. No.	*Speed of operation, km/h*	*Top*	*Middle*	*Bottom*	*Top*	*Middle*	*Bottom*
1.	2.5	45.1	40.6	36.5	50.5	45.9	40.9
2	3	52.5	47.7	43.1	57.5	52.1	47.2
3	3.5	59.6	55.3	50.4	65.1	60.3	55.6
	F Test	S	S	S	S	S	S
	SE(m)	0.26	0.24	0.23	0.29	0.26	0.26
	CD (5%)	0.74	0.70	0.67	0.84	0.75	0.74

Independent Variable

1. Speed of operation (2.5 km/h, 3 km/h, 3.5 km/h)

Dependent Variable

1. Droplet size (μm)
2. Droplet density (No./cm^2)

RESULTS AND DISCUSSION

The results are explained as follows:

The table 1 shows that the effect of speed 2.5 km/h, 3 km/h, 3.5 km/h on droplet size was found significant. The minimum value of droplet size at outer and inner canopy was observed at top position at speed 3.5 km/h while the maximum value was observed at bottom position at speed 2.5 km/h.

The Figure 1 shows the decreasing trend for the values of droplet size at bottom, middle and top at each speed on outer and inner canopy. At outer canopy at top position the droplet size decreased by 8.4% when the speed was increased from 2.5 km/h to 3 km/h and it further decreased by 9.8% when the speed was increased from 3 km/h to 3.5 km/h. At middle position the droplet size decreased by 8.7% and 9.9% when the speed was increased from 2.5 km/h to 3 km/h and 3 km/h to 3.5 Km/h respectively. At bottom position when the speed was increased from 2.5 km/h to 3 km/h and 3 km/h to 3.5 km/h then the droplet size decreased by 7.07% and 8.6% respectively.

At inner canopy at top position the droplet size decreased by 9.3% and 10.3% when the speed was

Glossy paper sample after spraying

Plate 1: Measurement of droplet size and droplet density

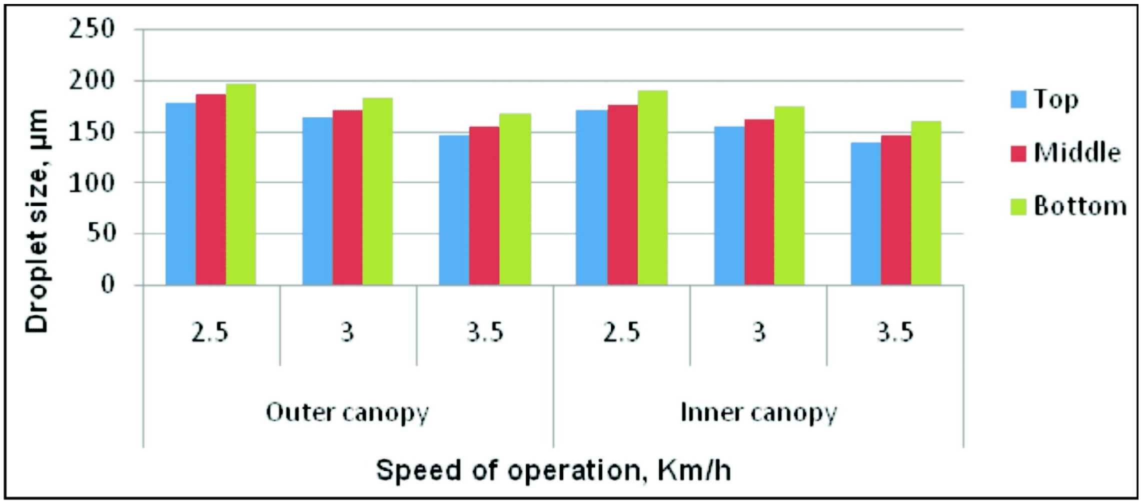

Figure 1: Effect of speed of operation on droplet Size

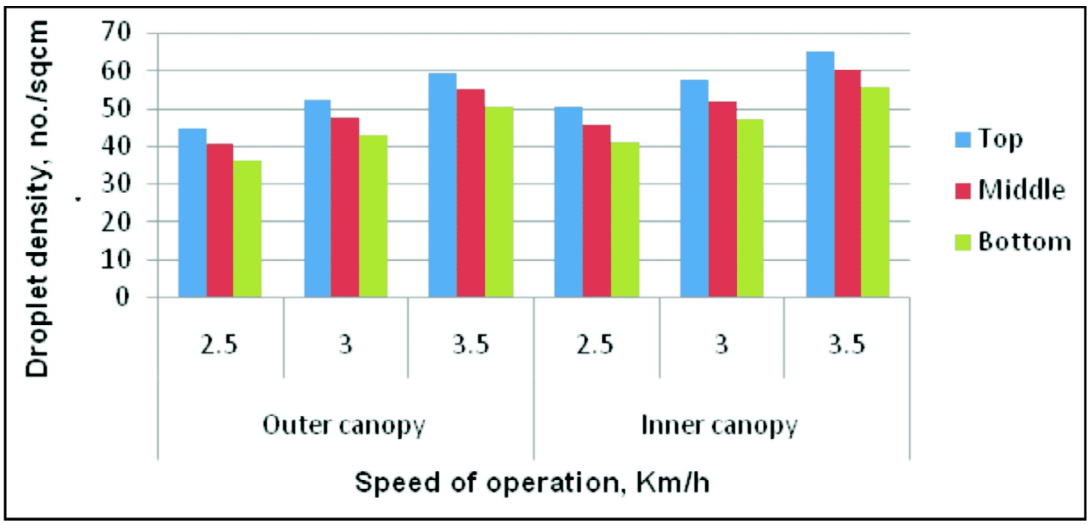

Figure 2: Effect of speed of operation on droplet density

increased from 2.5 km/h to 3 km/h and3 km/h to 3.5 km/h respectively. At middle position when the speed was increased from 2.5 km/h to 3 km/h and 3 km/h to 3.5 km/h then the droplet size decreased by 7.9% and 9.8% respectively. At bottom position the droplet size decreased by 8.9% when the speed was increased from 2.5 km/h to 3 Km/h. It further decreased by 8.04% when the speed was increased from 3 km/h to 3.5 km/h.

The table 2 revealed that the effect of speed of operation 2.5 km/h, 3 km/h, 3.5 km/h on droplet density. The minimum value of droplet density at outer and inner canopy was observed at bottom at speed 2.5 km/h while the maximum value was observed at top at speed 3.5 km/h. The statistical analysis shows that significant difference between mean values of droplet density at every speed of operation.

The Figure 2 shows the increasing trend for the values of droplet density at bottom, middle and top at each speed on outer and inner canopy. At outer canopy at top position the droplet density increased by 15.5 when the speed was increased from 2.5 km/h to 3 km/h and it further increased by 13.4% when the speed was increased from 3 km/h to 3.5 km/h. At middle position the droplet density increased by 17.5% and 17.02% when the speed was increased from 2.5 km/h to 3 km/h and 3 km/h to 3.5 km/h respectively. At bottom position when the speed was increased from 2.5 Km/h to 3 km/h, and 3 km/h to 3.5 km/h then the droplet density increased by 19.4% and 16.2% respectively.

At inner canopy at top position the droplet density increased by 14% and 14.3% when the speed was increased from 2.5 km/h to 3 km/h 3 km/h to 3.5 km/h respectively. At middle position when the speed was increased from 2.5 km/h to 3 km/h and 3 km/h to 3.5 km/h then the droplet density increased by 11.5% and 15.3% respectively. At bottom position the droplet density increased by 17.8% when the speed was increased from 2.5 km/h to 3 km/h. It further increased by 17.0% when the speed was increased from 3 km/h to 3.5 km/h.

CONCLUSION

According to the various treatments the following conclusion are resulted from the evaluation of axial flow blower.

1. Droplet size decreases as the speed of operation increased.
2. Droplet density increases as the speed of operation increased.
3. The minimum value of droplet size at outer canopy (147.5 mm) and inner canopy (147.5 mm) was observed at top position at speed 3.5 km/h while the maximum value of droplet size at outer canopy (198.0 mm) and inner canopy (191.0 mm) was observed at bottom position at speed 2.5 km/h.
4. The minimum value of droplet density at outer canopy (36.5) and inner canopy (40.9) was observed at bottom position at speed 2.5 km/h while the maximum value of droplet density at outer canopy (59.6) and inner canopy (65.1) was observed at top position at speed 3.5 km/h.
5. The statistical analysis shows that significant difference between mean values of droplet size and droplet density at every speed of operation.

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