

Combine Effect of Blade Type of Blower and Speed of Operation on Droplet Size in Air Assisted Orchard Sprayer

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Abstract

Droplet size analysis of orchard sprayer having axial flow blower was carried out to determine the changes in droplet size at different blade types and speed of operation. Droplet size analysis was carried out at two different positions (Outer and Inner) of crop canopy and at three different heights (Top, Middle, Bottom) of each crop canopy. On outer canopy, at top position, at speed of operation 2.5 km/h, 3.0 km/h and 3.5 km/h the droplet size decreased by 6.5 %, 7.6 % and 10.3 % respectively when the blade was changes from blade type 1 to blade type 2. When the blade was changes from blade type 1 to blade type 2 in combination of speed of operation 2.5 km/h, 3 km/h and 3.5 km/h the droplet size decreased by 6.2 %, 7.3 % and 8.6 % and 5.4 %, 6.8 % and 9.0 % for middle and bottom position. On inner canopy, at top position, when the blade type was changes from blade type 1 to blade type 2 at speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h, then the droplet size decreased by 7.3 %, 9.2 % and 10.2 % respectively. Whereas at middle position the droplet size decreased by 7.1 %, 7.6 % and 9.0 % respectively. Similar trend was observed in bottom position and decrease in values of droplet size was 5.6 %, 7.1 % and 8.9 % observed respectively.

Keywords: Droplet Size, orchard sprayer, axial flow blower, crop canopy.

Introduction:

In recent decades there is a clear tendency to reduce the use of pesticides in agriculture. For new designed field and orchard sprayers, precisely consumption of pesticide is essential for both. With this view, controlling the air volume and quantity of pesticide with technologies is milestone of the designs for air blast orchard sprayers. The efficiently usage of an axial fan can reduce tractor fuel consumption and offers more economical and environmental friendly pesticide application. To do this, the parameters that affected the air flow must be regulated. In air assisted orchard sprayers, the spray droplets produced by the nozzles are carried to the tree crown by the air flow that provided by fans. During the pest application of orchard, the airflow is needed to atomize the droplet, to carry the droplets to the target and to get better penetration.

The amount and the distribution of the pesticides on the tree crown varies depending on the characteristics of the air jet. The air volume flow rate of the orchard sprayer and penetration of the air flow must be set to be sufficient to different tree crowns. Beside this, the airflow need of orchard depends on the crown geometry of the tree, tractor speed, and vegetative development of the tree, foliage density, and wind velocity. Canopy geometry, foliage density and vegetative development of a tree affect the pesticide penetration and deposition of droplets on the tree. The economically produced sufficient airflow is one of the main mission of the pest application of a orchard also for spray deposit. The fans are used in different areas and for each blade angle of the fan, the performance and volumetric flow rate of the fan differs. The airflow that produced with axial fans can be controlled by changing the fan blade angles and fan rotation speed.

Material and Methods

Determination of Droplet size

The artificial target was developed for estimation of the droplet size of the sprayer (Plate 1). The laboratory set up of axial flow blower had different components such as small hp tractor (18.5 hp), artificial target having two frames for fixing glossy paper at different heights, tachometer, anemometer etc. for determining droplet size and droplet density of air assisted sprayer. The average height of the Sapota tree was recorded as 5 m and the average canopy width was recorded 6 m. Hence from this data the dimensions of frame were fixed 5 m x 3 m which was sufficient for recording the required information. Two testing frame was developed having dimensions of 5 m x 3 m. The frames was spaced at a distance of 3 m because, the spraying was done to the half of the crop canopy from one side of blower in the single run of sprayer. Two frames considered as two positions 1) Circumference of plant canopy i.e. outer canopy and 2) Centre of the plant i.e. inner canopy. The glossy papers were fixed on both the frames at three different heights, Top (4-5 m), Middle (2-4 m) and Bottom (1-2 m). The distance between two glossy papers horizontally and vertically kept as 20 cm. Droplet size of spray measured at different heights i.e. top, middle and bottom on both positions. The trials were repeated for different treatments selected for the study. To find out the combine effect of blade angle and speed of operation on droplet size readings were taken at each blade angle and in combination of selected speed of operation. The coloured water was prepared by mixing colour dye in 5 gram per liter of water. The coloured spray solution was filled in the tank. The air carrier sprayer was ready to spray. The sprayer was operated at different blade angles of blower blade. The spray from the sprayer was targeted and allowed to deposit on the glossy papers. These glossy papers were removed from the frame. The glossy papers were grouped in different sets as per their zone on the frame. The traces of coloured spray solution were retained on glossy papers in the form of droplets. The droplets size and other parameter were calculated using droplet analysis software. These glossy papers were analyzed on image analysis system to determine droplet size and droplet. The experiment was carried out at ASPEE, Agricultural Research Foundation, Tansa, Tal- Wada, Dist.- Palghar. Different variables were used for droplet size analysis, described herewith as follows.

Independent variables:

- 1) Blade type (Blade 1 and Blade 2)
- 2) Speed of operation (2.5 km/h, 3 km/h, 3.5km/h))

Dependent variable:

Droplet size, μm

The laboratory experimental data recorded and it was analyzed by Analysis of variance technique by using CRD.

Power transmission assembly

An 18.5 hp tractor was used as a power source of blower. The power was transferred from the tractor PTO shaft to the pump shaft by primary cardan shaft. The pump transferred the power to the blower assembly by the secondary cardan shaft. The blower was coupled with gear box (The ratio of gear box is 1: 4.5) which increases the rpm of blower.

Instrumentations

Following instruments were used for measuring various parameters during the laboratory testing of the blower.

1. Stopwatch
2. Measuring tape
3. Measuring cylinder
4. Droplet size analyzer

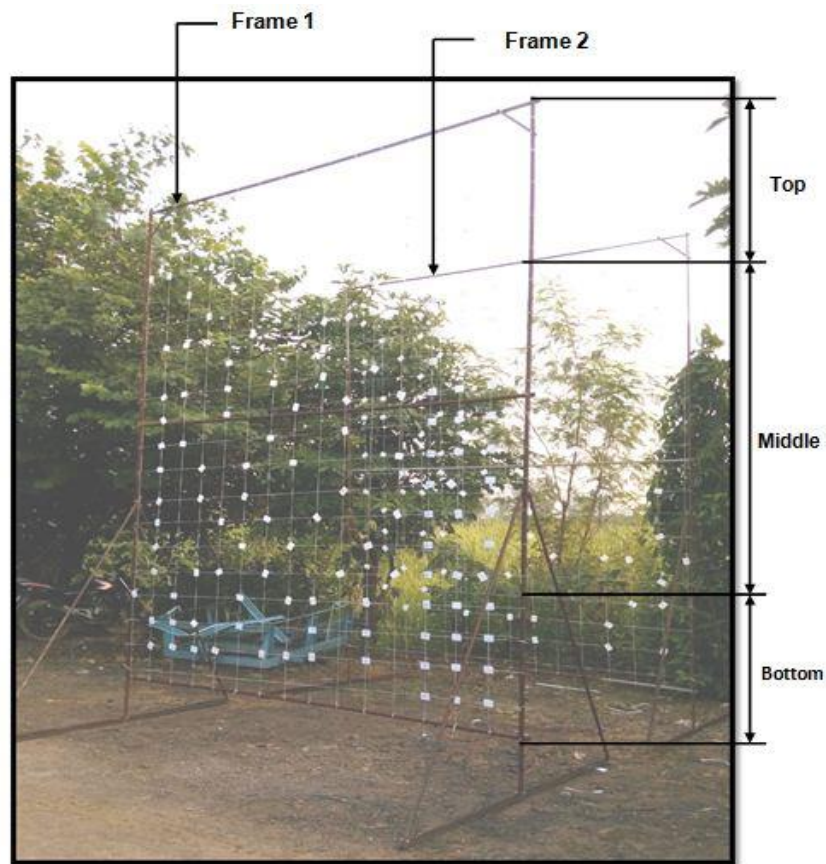


Plate 1 Developed Artificial Tree Target

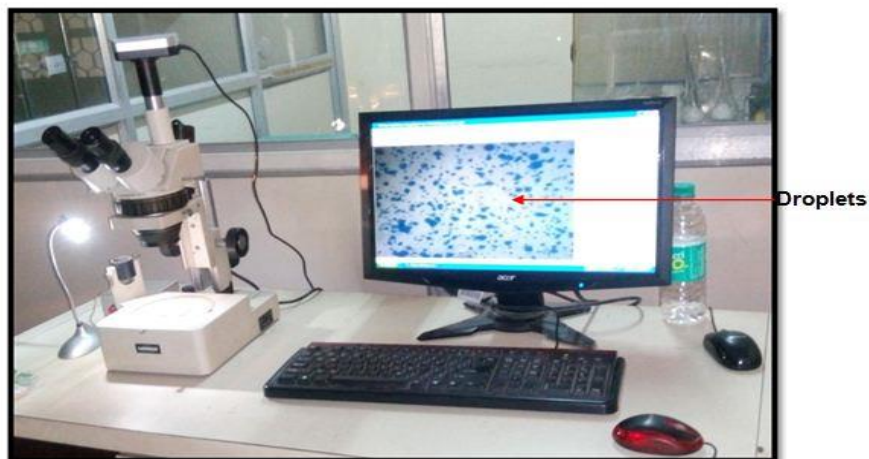


Plate 2 Droplet Size Analysis

Results and Discussion

Droplet size

Table 1 revealed the effect of blade type and speed of operation on droplet size. The mean value of droplet size on outer canopy at top position as an effect of blade type 1 and blade type 2 in combination of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h was recorded as 170.2 μm and 156.4 μm respectively. The mean value of droplet size obtained as an effect of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h with blade type 1 and blade type 2 were recorded as 178.6 μm , 163.8 and 147.5 μm respectively. The statistical analysis shows significant difference in the mean values of droplet size. The minimum value of droplet size 139.8 μm was observed as a combine effect of blade type 2 and speed of operation 3.5 km/h and maximum value 184.9 μm as a combine effect of blade type 1 and speed of operation 2.5 km/h.

Table 1 also revealed the droplet size 177.4 μm and 164.4 μm on outer canopy at middle position as an effect of blade type 1 and blade type 2 respectively in combination of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h. The mean value of droplet size obtained as a effect of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h at different blade types 1 and 2 were observed as 186.3 μm , 171.8 and 154.8 μm respectively. The statistical analysis shows there was a significant difference in the mean values of droplet size. The minimum value 147.8 μm of droplet size was observed as a combine effect of blade type 2 and speed of operation 3.5 km/h and maximum value 192.2 μm as a combine effect of blade type 1 and speed of operation 2.5 km/h.

The droplet size of sprayer on outer canopy at bottom position with blade type 1 and blade type 2 in combination of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h was recorded as 190.0 μm and 176.9 μm . The mean value of droplet size obtained as a effect of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h at different blade types 1 and 2 were recorded as 198.0 μm , 184.0 and 168.4 μm respectively. The statistical analysis shows significant difference in the mean values of droplet size. The minimum value of droplet size 168.4 μm was observed as a combine effect of blade type 2 and speed of

Table 1 Combine effect of blade type and speed on droplet size on outer canopy

Sr. No.	Blade type	Droplet size, μm											
		Top				Middle				Bottom			
		Speed of operation, km/h											
		2.5	3.0	3.5	Mean	2.5	3.0	3.5	Mean	2.5	3.0	3.5	Mean
1	1	184.9	170.3	155.3	170.2	192.2	178.4	161.8	177.4	203.6	190.3	176.2	190.0
2	2	172.4	157.2	139.8	156.4	180.4	165.1	147.8	164.4	192.4	177.7	160.6	176.9
	Mean	178.6	163.8	147.5		186.3	171.8	154.8		198.0	184.0	168.4	
F Test		Sig.				Sig.				Sig.			
SE (m) ±		0.5				0.3				0.4			
CD at 5%		1.4				1.0				1.1			

operation 3.5 km/h and maximum value 203.6 μm as a combine effect of blade type 1 and speed of operation 2.5 km/h.

The fig. 1 shows the decreasing trend for the values of droplet size with change in blade type and increases with increase in speed of operation at top, middle, and bottom position. On outer canopy, at top position, at speed of operation 2.5 km/h, 3.0 km/h and 3.5 km/h the droplet size decreased by 6.5 %, 7.6 % and 10.3 % respectively when the blade was changes from blade type 1 to blade type 2.

When the blade was changes from blade type 1 to blade type 2 in combination of speed of operation 2.5 km/h, 3 km/h and 3.5 km/h the droplet size decreased by 6.2 %, 7.3 % and 8.6 % and 5.4 %, 6.8 % and 9.0 % for middle and bottom position.

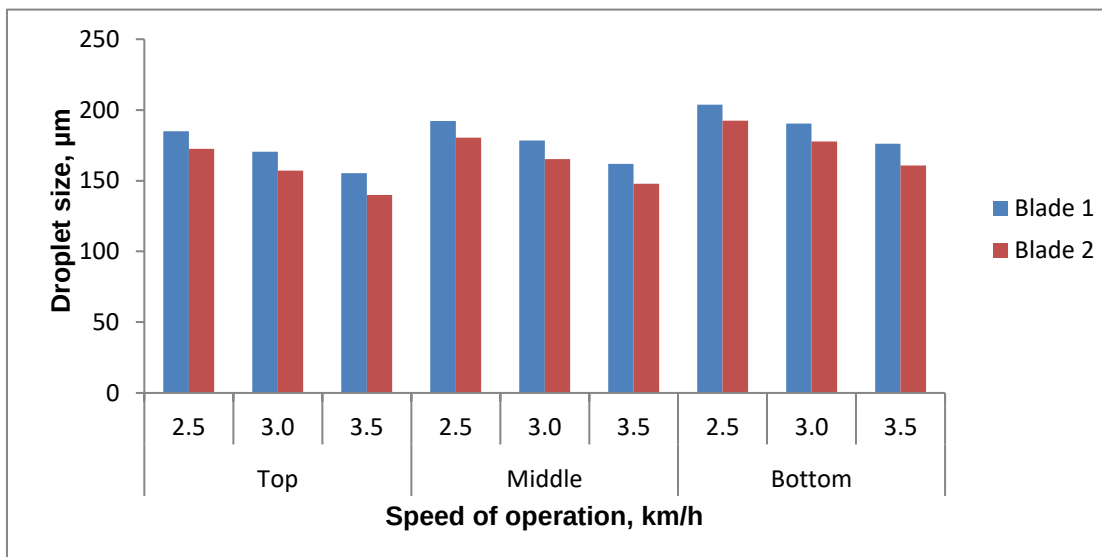


Fig.1 Combine effect of blade type and speed of operation on droplet size on outer canopy

Table 2 revealed the mean value 162.3 μm and 148.0 μm of droplet size on inner canopy at top position as an effect of blade type 1 and blade type 2 in combination of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h. The mean value of droplet size obtained as an effect of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h due to effect of blade type 1 and blade type 2 were recorded as 171.0 μm , 155.2 and 139.1 μm respectively. Statistical analysis of data shows significant difference in the mean values of droplet size. The minimum value 131.6 μm of droplet size was observed as a combine effect of blade type 2 and speed of operation 3.5 km/h and maximum value 177.3 μm as a combine effect of blade type 1 and speed of operation 2.5 km/h.

Table 2 revealed the droplet size 169.2 μm and 156.0 μm on inner canopy at middle position was observed as an effect of blade type 1 and blade type 2 respectively at speed of operation 2.5

km/h, 3.0 km/h, 3.5 km/h. The mean value of droplet size obtained as a effect of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h at different blade type 1 and blade type 2 were observed as 177.1 μm , 163.3 and 147.4 μm respectively. The statistical analysis shows there was no significant difference in the mean values of droplet size. The minimum value 140.6 μm of droplet size was observed as a combine effect of blade type 2 and speed of operation 3.5 km/h and maximum value 183.7 μm as a combine effect of blade type 1 and speed of operation 2.5 km/h.

Table 2 revealed the droplet size at inner canopy at bottom position with blade type 1 and blade type 2 and due to speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h was recorded as 181.7 μm and 168.7 μm . The mean value of droplet size obtained as a effect of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h at different blade types 1 and 2 were observed as 191.0 μm , 174.6 and 160.0 μm respectively. The statistical analysis shows significant difference in the mean values of droplet size. The minimum value 152.5 μm of droplet size was observed as a combine effect of blade type 2 and speed of operation 3.5 km/h and maximum value 196.7 μm as a combine effect of blade type 1 and speed of operation 2.5 km/h.

The fig. 2 shows the decreasing trend for the values of droplet size with change in blade type 1 to blade type 2 with increase in speed of operation at top, middle, and bottom position. On inner canopy, at top position, when the blade type was changes from blade type 1 to blade type 2 at speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h, then the droplet size decreased by 7.3 %, 9.2 % and 10.2 % respectively. Whereas at middle position the droplet size decreased by 7.1 %, 7.6 % and 9.0 % respectively. Similar trend was observed in bottom position and decrease in values of droplet size was 5.6 %, 7.1 % and 8.9 % observed respectively.

Table 2 Combine effect of blade type and speed of operation on droplet size on inner canopy

Sr. No.	Blade type	Droplet size, μm											
		Top				Middle				Bottom			
		Speed of operation, km/h											
		2.5	3.0	3.5	Mean	2.5	3.0	3.5	Mean	2.5	3.0	3.5	Mean
1	1	177.3	162.7	146.7	162.7	183.7	169.8	154.2	169.2	196.7	180.9	167.6	181.7
2	2	164.6	147.7	131.6	148.0	170.4	156.8	140.6	156.0	185.3	168.3	152.5	168.7
	Mean	171.0	155.2	139.1		177.1	163.3	147.4		191.0	174.6	160.0	
F Test		Sig.				NS				Sig.			
SE (m) ±		0.4				0.4				0.4			
CD at 5%		1.3				-				1.3			

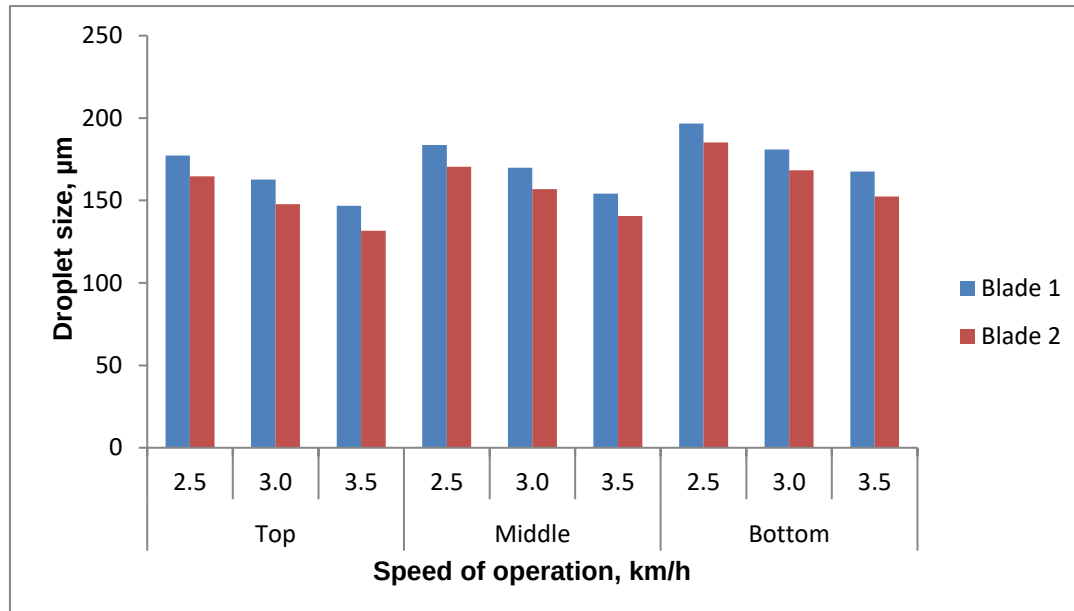


Fig. 2 Combine effect of blade type and speed of operation on droplet size on inner canopy

Conclusion

The effect of combination of two variables i.e. blade type and speed of operation shows non significant difference in the values of blower speed. The effect of combination of these two variables shows significant difference in the values of air velocity at outer canopy while non significant difference at inner canopy. The combine effect of these two variables shows significant difference in the values of droplet size and droplet density on outer and inner canopy at all positions excluding droplet size at middle position at inner canopy

ACKNOWLEDGMENT

The authors would like to express their appreciation to Inspire Foundation, Deptt. of Science and Technology, Govt. of India for providing the financial assistance and ASPEE group of companies, Mumbai for the guidance and facilities.

References

Bhargav, V. K. 2001. Design, development and evaluation of air-assisted boom sprayer for orchard application. Unpublished Ph.D thesis. I.A.R.I., New Delhi.

- Derksen, R.C. and R.L. Gray, 1994. Deposition and air speed patterns of air-carrier apple orchard sprayers. ASAE Paper No.93-1543.
- Dhande, K. G. 1991. Design and performance evaluation of air carrier sprayer for Mango orchard. Unpublished Thesis, M. Tech. IIT, Kharagpur.
- Gore A M and Thakare S K, 2017 Effect of blade angle and blade type on droplet size and droplet density of axial flow blower in air assisted orchard sprayer Green Farming 8 (5):1219-1222
- Gu, J., H. Zhu and W. Ding, 2012. Unimpeded air velocity profile of an air-assisted five-port sprayer. Trans. of ASABE. 55(5): 1659-1666.
- Mayande, V.M. 2000. Development and performance evaluation of air carrier orchard sprayer for mango orchards. Unpublished Ph.D thesis, IIT, Kharagpur.
- Marucco, P., M. Tamagnone and P. Balsari, 2008. Study of air velocity adjustment to maximize spray deposition in Peach orchards. Agric. Engg. International: The CICR e-journal. Manuscript ALNARP 08 009. Vol. X.
- Pezzi, F. and V. Randelli, 2000. The performance of air assisted sprayer operating in vines. J. Agricultural Engineering Research. 76:331-340
- Singh, S.K., S. Singh and V. Sharda, 2007. Effect of Air assistance on spray deposition under laboratory conditions. IE(I) Journal-AG. 88: 3-8.
- Sirohi, N.P.S., P. Gupta and I. Mani, 2008. Development of Air-assisted sprayer for vegetable crops. IE(I) Journal-AG. 89:18-23.
- Wallis, R.A. 1983. Axial flow fans and ducts. John Wiley, Inter Science Pub. New York.