Assessment of Blower Speed and Air Velocity in Relation with Combine Effect of Blade Angle and Speed of Operation of an Axial Flow Blower in air Assisted Orchard Sprayer

A. M. Gore[1], S. K. Thakare[2], M M Pakhare[3]

[1]Dr. A. M. Gore- Department of Agricultural Engineering, Maharashtra Institute of Technology, Aurangabad
[2]Dr. S. K. Thakare- Department of Farm Power and Machinery Dr PDKV Akola
[3]M.M.Pakhare College of Agriculture Khandala

---***---

Abstract: Laboratory evaluation of an axial flow blower with orchard sprayer was carried out to determine the changes in blower speed and air velocity at different speed and different blade angle. The minimum value 1539.5 rpm of blower speed was observed as a combine effect of blade angle 40˚ and speed of operation 2.5 km/h and maximum value 2172.6 rpm as a combine effect of blade angle 25˚ and speed of operation 3.5 km/h. The minimum value 18.5 m/s of air velocity on outer canopy was observed as a combine effect of blade angle 25˚ and speed of operation 2.5 km/h and maximum value 35.9 m/s as a combine effect of blade angle 40˚ and speed of operation 3.5 km/h. The minimum value of air velocity 0.567 m/s was obtained at inner canopy as a combine effect of blade angle 25˚ and speed of operation 2.5 km/h. The maximum value of air velocity 9.7 m/s was recorded when system was operated at blade angle 40˚ and speed of operation 3.5 km/h.

Keywords: blower, orchard sprayer, blade angle, speeds of operation.

Introduction: Air carrier sprayers are commonly used for spraying tree crops having large foliage. They use a stream of air to transport spray droplets towards the tree and penetrate the canopy. The air in and around the trees is thus replaced with a mixture of air and pesticide droplets. This method of application is considered superior as it increases the deposition. These sprayers are available in different shapes, sizes, fan types, nozzles and are operated with different volume rates and ground speeds. The working of an air-carrier sprayer system can be broadly divided into two modules. The first one comprises of the components that handle the delivery of liquid and is referred to as the liquid delivery system. The second module relates to the delivery of air and is called air delivery system. Air delivery system in air-carrier sprayers is responsible for producing high volume and velocity airflow to transport liquid droplets from the nozzles to the trees. The main components in the air delivery system include a fan, airflow straightened and air deflectors. Various types of fans that have been used in airblast sprayers are axial, centrifugal and tangential-flow fans. Axial flow fans are most popular for their large volume and low pressure applications. Air blast sprayers are a type of air carrier sprayers that use such fans. The fans consist of a series of radial blades attached to a rotating hub. This assembly of blades and hub is termed impeller or rotor. Air drawn by the rotor is discharged by the tangential component of velocity. This results in a swirling motion of the air, commonly known as slipstream rotation. The efficiency of the fan decreases with swirling as the air encounters more resistance. This swirl is removed by the stator or straightener placed downstream of the rotor. The dynamic pressure developed here is converted to static pressure rise. The air is then deflected towards the nozzles by a set of deflector surfaces (plates), sometimes, by about 90º to target trees lateral to the sprayer. The air stream created by the sprayer fan carries the spray mixture into the trees or vines and distributes it throughout the foliage. To reach all leaf surfaces and achieve adequate pesticide coverage, all the air around the foliage must be replaced by the spray-laden air stream. In some cases, air volume can be varied by increasing or decreasing the power take-off speed (PTO rpm), engine rpm or the fan gear. The air direction or angle of attack to the foliage is equally important, for that purpose blower calibration in laboratory is very much important to determine the blower speed and air velocity regarding changes in blade angles of fan blades and speed of operation.

Material and Methods:

The experiment was carried out at ASPEE, Agricultural Research Foundation, Tansa, Tal- Wada, Dist.- Palghar. Different variables selected for the study are described herewith as follows.

Independent variables:

Blade angle (25˚, 30˚, 35˚, 40˚)

Speed of Operation (2.5 km/h, 3km/h 3.5 km/h)

Dependent variables: 1) Blower speed, rpm

2) Air velocity, m/s

Blower speed:

The blower was provided with adjustable fan blades. In this experiment four blade angles (25˚. 30˚, 35˚, 40˚) were used. The blower rpm was recorded by using tachometer at each blade and different speed of operations (2.5 km/h, 3km/h 3.5 km/h). The experiment at all combination was repeated three times

Air velocity:

At each blade angle with different speed of operation the air velocity was recorded by using anemometer at two positions i.e. at outer canopy and inner canopy. The experiment at all combination was repeated three times.

Development of Blower:

For the said research work medium to high discharge and medium air pressure was required. In order to suit for the axial flow blower to be used for air assisted orchard type agricultural sprayer, aerofoil blade was selected for the development of blower. In case of aerofoil type of blade, the leading edge was rounded and thick whereas, the trailing edge was thin and sharp. That type of blades was fabricated with two different lengths (blade1- 160 mm and blade2- 190 mm) and material used was nylon. The performance of blower with these blades at different blade angles (25˚. 30˚, 35˚, 40˚) and at different speed of operation (2.5 km/h, 3km/h 3.5 km/h) was evaluated.

Procedure for changing the blade angle

1) The cover of the hub present on the impeller was taken off by dissembling the bolt assembly.
2) Hub of the impeller was marked with number in series as 1-2-3-4.
3) The bottom part of the blade was having a single mark.
4) The bolts of hub assembly were loosen which facilitated blade to rotate in required angle.
5) After making blade loose the marking on bottom part of blade was coincide with the required marking on hub.
6) After adjusting the required blade angle the bolts of hub was fastened.
7) Then hub was covered with the bolt assembly and ready for experiment.
8) The procedure was repeated to change the blade angle for the different experiments.

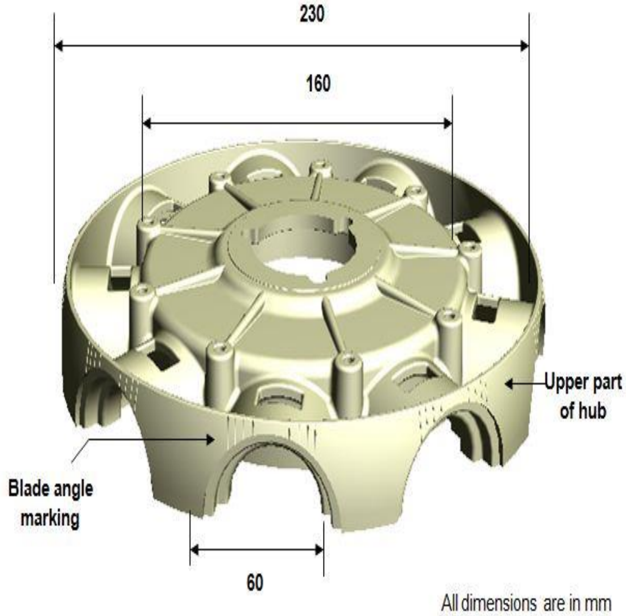

Plate 1: Upper part of hub showing angle setting

Plate 3: Measurement of blower RPM

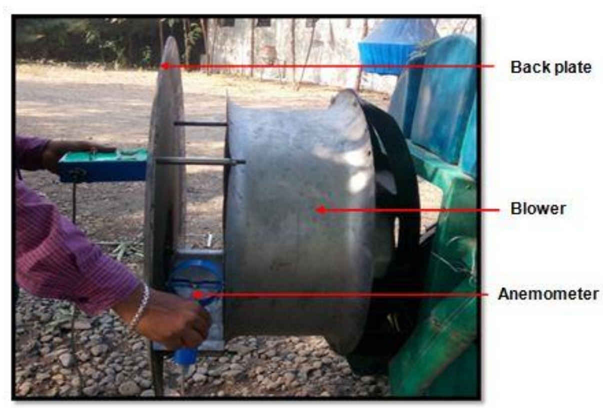

Plate 4: Measurement of blower Air Velocity

Results and Discussion

Combine effect of blade angle and speed of operation

a) Blower speed

Table 1 Combine effect of blade angle and speed of operation on blower speed

Sr. No.	Blade angle, degree	Blower speed, rpm			
		Speed of operation, km/h			Mean
		2.5	3.0	3.5	
1	25	1578.1	1851.0	2172.6	1867.2
2	30	1565.0	1832.1	2153.1	1850.1
3	35	1553.0	1823.0	2137.0	1837.6
4	40	1539.5	1814.5	1969.6	1821.5
	Mean	1558.1	1830.1	2108.1	
	F Test	Sig.			
	SE (m) ±	41.5			
	CD at 5%	118.2			

Table 1 revealed that the mean value of blower speed as an effect of different blade angles at speed of operation 2.5 km/h, 3.0 km/h, and 3.5 km/h. It was observed that at blade angle 25˚, the blower speed was recorded as 1867.2 rpm, whereas at blade angle 30˚, 35˚, and 40˚ the blower speed was recorded 1850.1 rpm, 1837.6 rpm and 1821.5 rpm respectively. The mean value of blower speed obtained as an effect of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h in combination of different blade angles 25˚, 30˚, 35˚, and 40˚ were recorded as 1558.1 rpm, 1830.1 rpm, and 2108.1 rpm respectively. The statistical analysis shows significant difference in the mean values of the blower speed as an effect of speed of operation and blade angle at 5 % level of significance. The minimum value 1539.5 rpm of blower speed was observed as a combine effect of blade angle 40˚ and speed of operation 2.5 km/h and maximum value 2172.6 rpm as a combine effect of blade angle 25˚ and speed of operation 3.5 km/h.

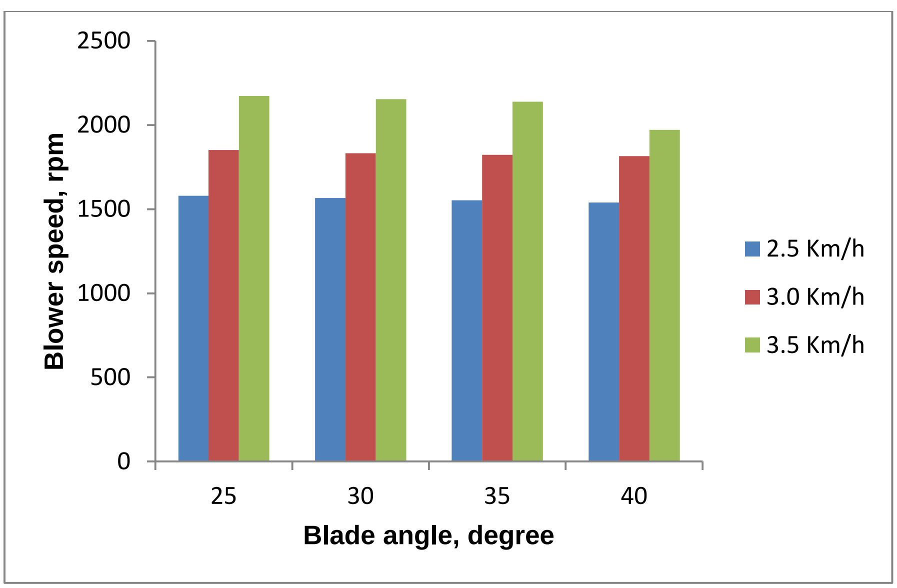

Fig.1 Combine effect of blade angle and speed of operation on blower speed

The fig. 1 shows the increasing trend for the values of blower speed with increase in speed of operation. At blade angle 25˚, the blower speed was increased by 17.30 % when the speed of operation was increased from 2.5 km/h to 3.0 km/h. It further increased by 17.34 % when the speed of operation was increased from 3.0 km/h to 3.5 km/h. Almost same value for increase in percent blower speed recorded at blade angle 30˚ and 35˚.However, there was a drastic reduction in percent increase of blower speed at blade angle 40˚ and it might be due to increase resistance of air at higher blade angle.

Table 2 Combine effect of blade angle and speed of operation on air velocity

Sr. No.	Blade angle,degree	Air velocity, m/s							
		Outer canopy				Inner canopy			
		Speed of operation, km/h							
		2.5	3.0	3.5	Mean	2.5	3.0	3.5	Mean
1	25	18.5	24.6	27.3	23.4	2.2	3.4	4.6	3.4
2	30	20.9	26.5	30.8	26.1	3.7	5.0	6.3	5.0
3	35	24.4	28.7	33.9	29.0	5.3	6.6	8.3	6.7
4	40	27.1	30.9	35.9	31.3	6.2	8.0	9.7	8.0
	Mean	22.7	27.6	32.0		4.3	5.7	7.2	
F Test		NS				Sig.			
SE (m) ±		0.4				0.1			
CD at 5%		-				0.3			

Table 2 revealed the mean value of air velocity on outer and inner canopy as an effect of different blade angles in combination of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h. It was observed that on outer canopy at blade angle 25˚, the air velocity was recorded as 23.4 m/s where as at blade angle 30˚, 35˚, and 40˚ the air velocity was measured 26.1 m/s, 29.0 m/s and 31.3 m/s respectively. The mean value of air velocity obtained as an effect of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h at different blade angles 25˚, 30˚, 35˚, & 40˚ were found to be 22.7 m/s, 27.6 m/s and 32.0 m/s respectively. However, statistical analysis shows no significant difference in the mean values of the air velocity. The minimum value 18.5 m/s of air velocity was observed as a combine effect of blade angle 25˚ and speed of operation 2.5 km/h and maximum value 35.9 m/s as a combine effect of blade angle 40˚ and speed of operation 3.5 km/h.

Table 2 shows that on inner canopy the mean value of air velocity were recorded 3.4 m/s 5.0 m/s, 6.7 m/s and 8.0 m/s as an effect of blade angle 25˚, 30˚, 35˚, and 40˚ in combination of speed of operation 2.5 km/h, 3.0 km/h, 3.5 km/h respectively. The mean value of air velocity at above mentioned speed of operation in combination of the blade angles of blower 25˚, 30˚, 35˚, & 40˚ were observed to be 4.3 m/s, 5.7 m/s and 2.2 m/s respectively. The minimum value of air velocity 0.567 m/s was obtained as a combine effect of blade angle 25˚ and speed of operation 2.5 km/h. The maximum value of air velocity 9.7 m/s was recorded when system was operated at blade angle 40˚ and speed of operation 3.5 km/h. The statistical analysis of data on inner canopy shows the significant difference in mean values of air velocity in combination of different blade angle and speed of operation.

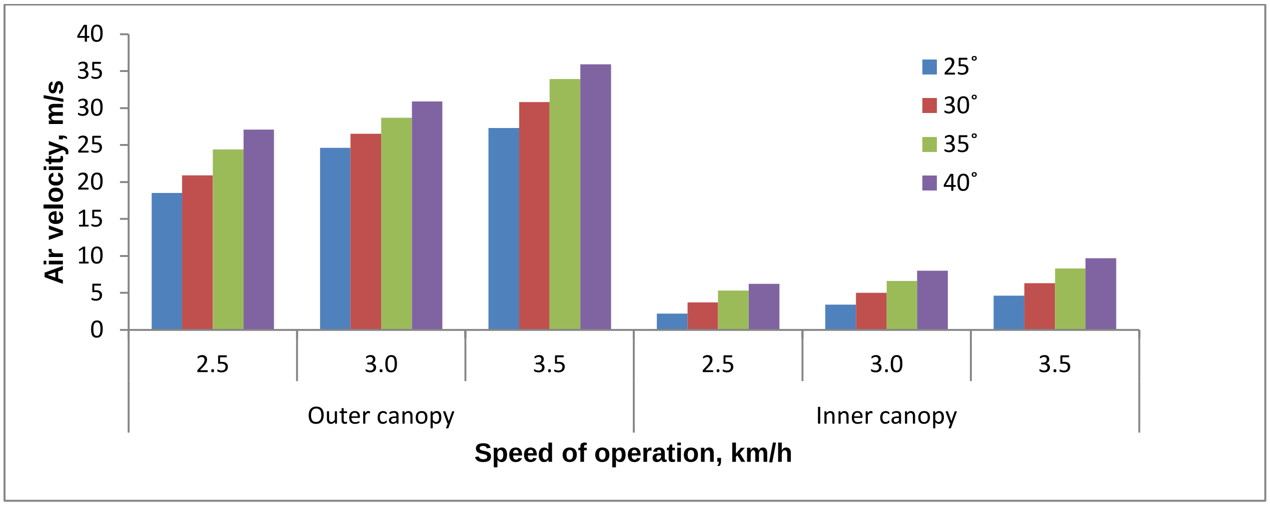

Fig.2 Combine effect of blade angle and speed of operation on air velocity

The fig. 2 shows the increasing trend for the values of air velocity with increase in speed of operation as well as increase in blade angle at both positions. On inner canopy at speed of operation 2.5 km/h, when the blade angle was increased to 30˚, 35˚ and 40˚ then the air velocity increased by 45.8 % 43.7 % and 16.7 % respectively. Whereas at speed of operation 3.0 km/h and 3.5 km/h the air velocity increased in the range from 16.5 % to 44 % for every change in blade angle 5˚ from 25˚ to 40˚.

Conclusions

1. The combine effect of blade angle and speed of operation shows significant difference in the values of blower speed and air velocity.
2. The combine effect of blade angle and speed of operation on blower speed shows that, the blower speed increases with increase in speed of operation and decreases with increase in blade angle. The maximum blower speed was recorded at the combination of blade angle 25˚ and speed of operation 3.5 km/h.
3. Air velocity increases on outer and inner canopy with increase in speed of operation as well as increase in blade angles. The maximum air velocity was measured on outer canopy as an effect of blade angle 40˚ and speed of operation 3.5 km/h.

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

1) 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.
2) Derksen, R.C. and R.L. Gray, 1994. Deposition and air speed patterns of air-carrier apple orchard sprayers. ASAE Paper No.93-1543.
3) Dhande, K. G. 1991. Design and performance evaluation of air carrier sprayer for Mango orchard. Unpublished Thesis, M. Tech. IIT, Kharagpur.
4) 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.
5) Mayande, V.M. 2000. Development and performance evaluation of air carrier orchard sprayer for mango orchards. Unpublished Ph.D thesis, IIT, Kharagpur.
6) 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.
7) Pezzi, F. and V. Randelli, 2000. The performance of air assisted sprayer operating in vines. J. Agricultural Engineering Research. 76:331-340

8) 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.
9) 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.
10) Wallis, R.A. 1983. Axial flow fans and ducts. John Wiley, Inter Science Pub. New York.

Biography

Dr Amol Mininath Gore have completed his B.Tech (Agricultural Engineering)from Mahatma Phule Krushi Vidyapeeth Rahuri Maharashtra in 2011. M.Tech and PhD in Farm Power and Machinery from Dr Panjabrao Deshmukh Krushi Vidyapeeth Akola, Maharashtra. He has received the INSPIRE Fellowship which is awarded by Department of Science and Technology Govt.of India. He is currently working as an Assistant Professor at Maharashtra Institute of Technology, Aurangabad. He has published 19 research articles, more than 20 popular articles and 4 books, also given 2 Radio talks. He is life member of several reputed professional societies.

Dr S K Thakare have completed his B.Tech (Agricultural Engineering) from Panjabrao Deshmukh Krushi Vidyapeeth Akola Maharashtra,PhD in Farm Power and Machinery from Balasaheb Sawant Kokan Krishi Vidyapeeth Dapoli, Maharashtra. He is currently working as an Assistant Professor at Dr Panjabrao Deshmukh Krushi Vidyapeeth Akola. He has published 30 research articles, more than 25 popular articles and 3 books. He is life member of several reputed professional societies.