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Effect of air velocity and pump discharge on spray deposition

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ABSTRACT : An air sleeve boom which can be operated by 5 horse power electric motor was developed for greenhouse pesticide applications. The performance of developed air sleeve boom was evaluated for different air velocities, *viz.,* 9 m/s, 12 m/s, 16 m/s and 20 m/s in combination with different pump discharges, *viz.,* 2.5 l/min, 4.5 l/min, 7 l/min and 9 l/min in the laboratory to assess the effect on spray deposition. The droplet size decreased with increase in air velocity and decrease in pump discharge. Droplet density was found to increase with increase in air velocity and decrease in pump discharge. Droplet size, droplet density and uniformity coefficient had a linear relationship with air velocity and pump discharge. Optimum values of droplet size, droplet density and uniformity coefficient were obtained with 20 m/s air velocity and 2.5 l/min pump discharge. The statistical analysis of the data indicated that air velocity, pump discharge and their interaction had a significant effect on droplet size, droplet density and uniformity co-efficient.

KEY WORDS : Air sleeve boom, Air velocity, Pump discharge, Droplet size, Droplet density, Uniformity coefficient

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Some major challenges to greenhouse production and profitability are insects, diseases and weeds. Chemical control is the popular method adopted for controlling most insects and diseases (Mathews, 1985). Traditional methods of pesticide application have a number of limitations: they are labour intensive, have low application accuracy and require serious safety precautions, since they are highly hazardous for the operator who might be exposed to toxic chemicals by their use in an enclosed environment. Performance depends on skill of operator; manual application often results in an uneven distribution of the pesticide. Air assisted spraying is considered as one of the better pesticide application technique. The air assisted spraying system contributes towards: reduction in spray drift and loss on the ground, an increase in the agrochemical deposits levels and coverage rate of the abaxial surface leaves, improvement in the penetration of the spray droplets into the canopy as well as enabling a reduction in both dosage and in application volume (Raetano, 2005). Incorporation of air assistance in the spraying system improves the deposition uniformity in the entire plant canopy structure, spray deposition on the lower part of the plant leaves, where most pests harbor (Hadar, 1980). Sirohi *et al.* (2008) developed an air-assisted hydraulic sprayer and compared its performance with sprayer without air assistance. Result showed that the air-assisted hydraulic sprayer gave a superior performance in terms of effective spray in all canopies than the sprayer without air assistance. Shahare *et al.* (2010) developed and evaluated tractor mounted air sleeve boom sprayer at different air velocities and spray angles with findings that higher air velocity improves the deposition of pesticide on whole canopy of cotton crop.

In the view of this, an air sleeve boom was developed for greenhouse pesticide applications and its performance was evaluated to study the effect of different air velocity and pump discharge levels on spray deposition at different positions on plant.

METHODOLOGY

Air sleeve boom:

The major components of the sleeve boom spraying system were the blower, sleeve, spraying nozzles and pump. A trolley was fabricated to support whole assembly over it. The blower generated the required volume of air and directed the flow into the sleeve. Air form the blower was conveyed and distributed through two sleeves with multiple orifices to achieve an airflow pattern covering the canopy. The system was developed to obtain the required effective penetration of spray into the crop canopy with an air discharge velocity that would have the least air blast damage at the target. The centrifugal blower was used on the system. The sleeve was designed to produce an air curtain along the length of boom and to distribute air uniformly. The boom was made to support the air sleeve and hydraulic nozzles for a final delivery of air-pesticide mixture onto the target. The total assembly of sprayer was operated by 5 horse power electrical motor (Fig. A).

Fig. A : Front view of developed air sleeve boom

Test setup for laboratory test :

The laboratory experiments were conducted to study air sleeve boom performance with different air velocities and pump pressures for droplet size, droplet density and uniformity coefficient on different plant positions. Air velocities of 9 m/s, 12 m/s, 16 m/s and 20 m/s; and pump discharges of 2.5 l/min, 4.5 l/min, 7 l/min and 9 l/min were used. An artificial plant canopies were prepared with hibiscus plant spaced at recommended spacing of 300 mm. The spraying height was 800 mm. To facilitate the evaluation of spray penetration into the canopy of plant, glossy papers of size 44 × 44 mm were stapled onto the leaf in different plant locations, *i.e.* top position, upper leaf surface; top position, lower leaf surface; middle position, upper leaf surface; middle position, lower leaf surface; bottom position, upper leaf surface and bottom position, lower leaf surface. Royal blue indigo dye was mixed with water to prepare coloured spray solution. The sprayer was operated at speed of 1 km/hr for spraying in laboratory. The glossy papers were taken for further analysis using a droplet image analyzer.

RESULTS AND DISCUSSION

The developed air sleeve boom was operated at four air velocities and four pump discharges in the laboratory and its performance was studied for droplet size, droplet density and uniformity coefficient at various locations in artificial plant canopy.

Effect of air velocity on droplet size, droplet density and uniformity coefficient:

The air sleeve boom was evaluated at different air velocities (9, 12, 16 and 20 m/s). Its effect on droplet size, droplet density and uniformity coefficient was studied. Analysis of variance (Table 1, 2 and 3) showed that the air velocity had a significant effect on droplet size, droplet density and uniformity co-efficient.

The effect of air velocity on droplet size has been plotted in Fig. 1. It indicates that droplet size decreased with increase in air velocity at top, middle and bottom position of plant and on upper and lower leaf surface. The maximum droplet size was observed with air velocity of 9 m/s and minimum droplet

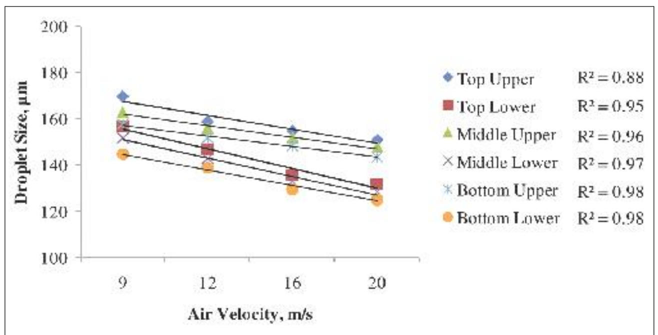

Fig. 1 : Effect of air velocity on droplet size at different plant positions

Table 1 : ANOVA showing the effect of air velocity and pump discharge on droplet size

Source	DF	Sum of squares	Mean square	F	SE	CD
Replications	95	68718.73	723.35506	79.294**	1.744	6.417
Air velocity	3	15336.4	5112.13	560.388**	0.356	1.310
Pump discharge	3	27119	9039.68	990.923**	0.356	1.310
Canopy positions	5	21082.3	4216.46	462.205**	0.436	1.604
Air velocity × Pump discharge	9	597.809	66.4233	7.281**	0.712	2.620
Air velocity × Canopy positions	15	995.294	66.3529	7.274**	0.872	3.208
Pump discharge × Canopy positions	15	3156.09	210.406	23.065**	0.872	3.208
Air velocity × Pump discharge × Canopy positions	45	3834.11	85.2024	9.340**	1.744	6.417
Error	192	1751.52	9.12249			

** indicates significance of value at P=0.01 GM = 146.400, CV = 2.06

Table 2 : ANOVA showing the effect of air velocity and pump discharge on droplet density

Source	DF	Sum of squares	Mean square	F	SE	CD
Replications	95	6412	67.494737	67.495**	0.577	2.124
Air velocity	3	1780.75	593.583	593.583**	0.118	0.434
Pump discharge	3	2178.25	726.083	726.083**	0.118	0.434
Canopy positions	5	2329.75	465.95	465.950**	0.144	0.531
Air velocity × Pump discharge	9	422.625	46.9583	46.958**	0.236	0.867
Air velocity × Canopy positions	15	41	2.73333	2.733**	0.289	1.062
Pump discharge × Canopy positions	15	44	2.93333	2.933**	0.289	1.062
Air velocity × Pump discharge × Canopy positions	45	295.875	6.575	6.575**	0.577	2.124
Error	192	192	1			

** indicates significance of value at P=0.01 GM = 22.646 CV = 4.42

Table 3 : ANOVA showing the effect of air velocity and pump discharge on uniformity coefficient

Source	DF	Sum of squares	Mean square	F	SE	CD
Replications	95	7.9546075	0.083732711	11.214**	0.050	0.184
Air velocity	3	3.61837	1.20612	161.527**	0.010	0.037
Pump discharge	3	1.25115	0.41705	55.852**	0.010	0.037
Canopy positions	5	2.07801	0.415601	55.658**	0.012	0.046
Air velocity × Pump discharge	9	0.715272	0.0794747	10.643**	0.020	0.075
Air velocity × Canopy positions	15	0.664458	0.0442972	5.932**	0.025	0.092
Pump discharge × Canopy positions	15	0.221771	0.0147848	1.980*	0.025	0.092
Air velocity × Pump discharge × Canopy positions	45	3.08083	0.0684629	9.169**	0.050	0.184
Error	192	1.43367	0.00746701			

* and ** indicate significance of values at P=0.05 and 0.01, respectively GM = 1.449 CV = 5.96

size was observed as an effect of air velocity of 20 m/s at all plant positions.

The effect of air velocity on droplet density is plotted in Fig. 2. The trend of the curve showed that the droplet density increased with increase in air velocity. This trend was found similar in almost all positions of the plant. The maximum droplet density obtained through the plant canopy on the upper leaf surface on target plant was at 20 m/s air velocity and minimum mean droplet density was observed with air velocity of 9 m/s.

The trend of the curve (Fig. 3) showed that uniformity coefficient decreased with increase in air velocity from 9 m/s to 20 m/s. Uniformity coefficient observed as an effect of air velocity of 20 m/s was within the recommended range. The reason behind this phenomenon was that the increased air velocity reduces the droplet size and increases droplet density throughout the plant canopy resulting in uniform distribution throughout the plant canopy.

The optimum results of droplet size, droplet density and

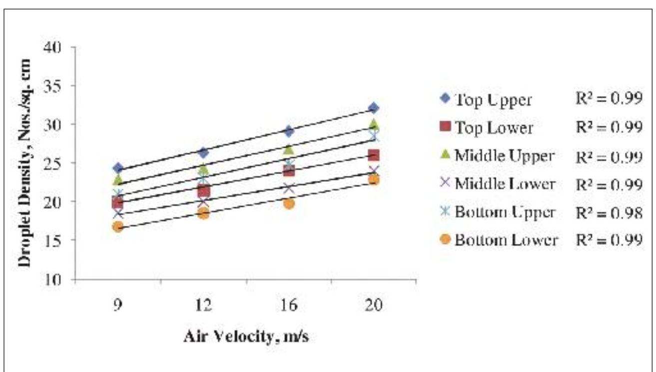

Fig. 2 : Effect of air velocity on droplet density at different plant positions

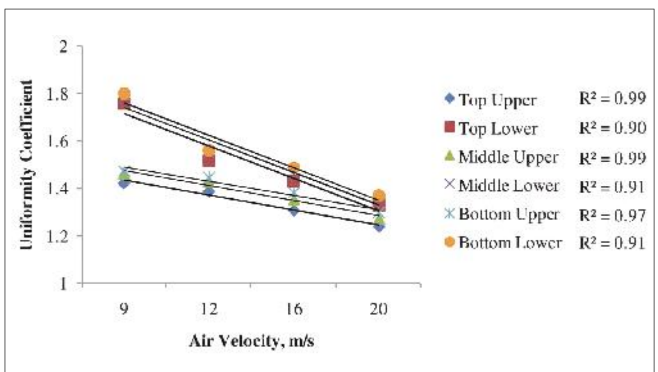

Fig. 3 : Effect of air velocity on uniformity coefficient at different plant positions

uniformity coefficient were obtained with air velocity of 20 m/s.

Effect of pump discharge on droplet size, droplet density and uniformity coefficient:

The pump discharge was set at 2.5 l/min, 4.5 l/min, 7 l/min and 9 l/min and the effect on deposition of droplets at six different plant positions was studied. Analysis of variance (Table 1, 2 and 3) showed that the pump discharge had a significant effect on droplet size, droplet density and uniformity coefficient. Fig. 4 shows that the droplet size observed as an effect of pump discharge of 2.5 l/min was within the recommended range. These values are significantly lower than the values of droplet size obtained as an effect of other pump discharge levels at all plant positions. The droplet size was found to decrease from top to bottom position of plant.

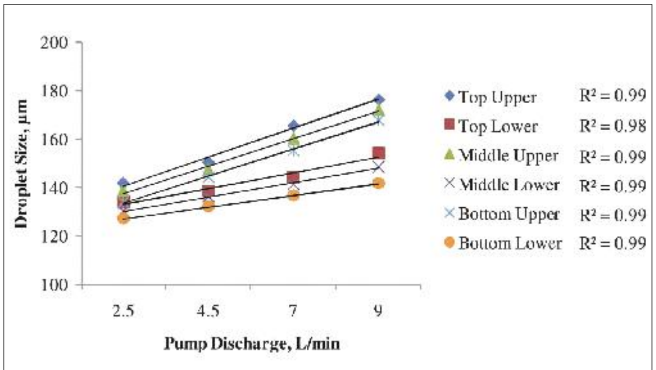

Fig. 4 : Effect of pump discharge on droplet size at different plant positions

The effect of pump discharge on droplet density at different plant positions is shown in Fig. 5. The maximum droplet density was deposited at top position of the plant and upper leaf surface as an effect of pump discharge of 2.5 l/min. It was also observed that droplet density decreased with increase in pump discharge from 2.5 l/min to 9 l/min at all plant positions. The maximum mean droplet density was observed with pump discharge of 2.5 l/min

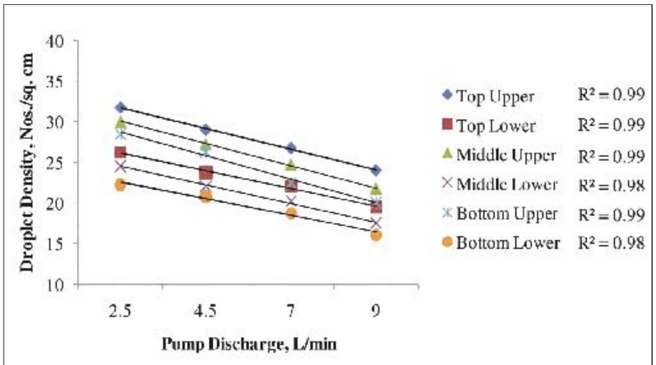

Fig. 5 : Effect of pump discharge on droplet density at different plant positions

The effect of pump discharge on uniformity coefficient is shown in Fig. 6. The trend of the curve showed that uniformity coefficient increased with increase in pump discharge from 2.5 l/min to 9 l/min. Uniformity coefficient observed as an effect of pump discharge of 2.5 l/min was within the recommended range. The optimum results of droplet size, droplet density and uniformity coefficient were obtained with pump discharge of 2.5 l/min

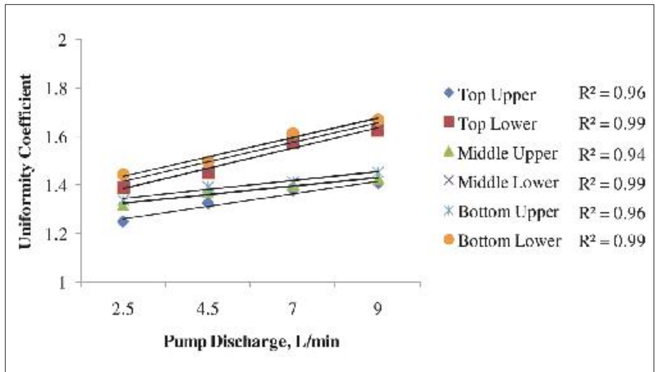

Fig. 6 : Effect of pump discharge on uniformity coefficient at different plant positions

Conclusion:

It can be concluded that droplet size of developed air sleeve boom decreased with increase in air velocity and decrease in pump discharge linearly. The droplet density was found to increase with increase in air velocity and decrease in pump discharge at all plant positions. The developed air sleeve boom exhibited better deposition efficiency with the air velocity of 20 m/s and pump discharge of 2.5 l/min.

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REFERENCES

Austerweil, M. and Grinstein, A. (1997). Automatic pesticide application in greenhouses. *Phytoparasitica* 25(Suppl.), 71S-80S.

Bauer, F.C. and Raetano, C.G. (2003). Air-assisted boom sprayer and spray deposition on bean plants. *Scientia Agricola Piracicaba*, **60**(2) : 211-215.

Darvishvand, M. and Brown, R.B. (1997). Performance of an air assisted forestry boom sprayer. *Canadian Agril. Engg*., **399**(4) : 281-287.

Hadar, E. (1980). Development criteria for air assisted ground crop sprayer. Degania sprayer, Degania Bet, 15230, Israel, pp. 23-26.

Hislop, E.C., Western, N.M. and Butler, R. (1995). Experimental air assisted spraying of a maturing cereal crop under controlled conditions. *Crop Prot.*, **14**(1) : 19-26.

Panneton, B., Philion, H., Theriault, R. and Khelifi, M. (2000). Spray chamber evaluation of Air assisted spraying on potato plants. *Trans. ASAE*, **43**(3) : 529-534.

Mathews, G.A. (1985). Air carrier sprayer. Pesticide application methods. Longmen group limited. ELBS Ed., pp. 162-171.

Shahare, P.U., Thakre, S.K., Mathur, S.M. and Bhatt, Y.C. (2010). Sleeve boom sprayer I: design and development of tractor mounted sleeve boom sprayer for cotton. Agril. *Mechanization in Asia, Africa & Latin America*, **41**(2) : 48-54.

Sirohi, N.P.S., Gupta, P. and Mani, I. (2008). Development of air-assisted hydraulic sprayer for vegetable crops. IE (I) J.-AG, 89.

■ WEBLIOGRAPHY

Raetano, C.G. (2005). Air assistance in sleeve boom sprayers. (Available at: <http://www.jacto.com/PDF/white_papers/Airassist_sleeve_boom_sprayers.pdf >).

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