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DEVELOPMENT OF AIR ASSISTED SPRAYER FOR GREENHOUSE FLORICULTURE CROPS

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Abstract: Floriculture is one of the major sectors in Indian agriculture. Main threats to floriculture production are insects, pests and diseases. Therefore, a motor operated air assisted sprayer was developed for greenhouse floricultural crops. A tapered air sleeve was designed and made with fiber reinforced PVC material in order to get uniform air velocity at each outlet. The boom was developed to support air sleeve and nozzles. The centrifugal blower of capacity $0.40 \text{ m}^3 \cdot \text{s}^{-1}$ was used on the system to produce air stream in the sleeves. A horizontal triplex power pump of $16 \text{ l} \cdot \text{min}^{-1}$ capacity was used to create necessary pressure in the nozzles. Blower and pump were operated by 3.73 kW electric motor. The whole assembly of the sprayer was mounted on the trolley. The performance of developed sprayer was evaluated in the laboratory to study the effect of different air velocity ($9, 12, 16$ and $20 \text{ m} \cdot \text{s}^{-1}$) and pump discharge ($2.5, 4.5, 7$ and $9 \text{ l} \cdot \text{min}^{-1}$) levels on droplet size, droplet density and uniformity coefficient at six different positions of artificial plant canopy. The optimum results of droplet size ($100\text{-}150 \mu\text{m}$), droplet density ($25\text{-}35$ droplets per cm^2) and uniformity coefficient (near unity) at all plant positions were observed for air velocity of $20 \text{ m} \cdot \text{s}^{-1}$ and pump discharge of $2.5 \text{ l} \cdot \text{min}^{-1}$.

Key words: *greenhouse, floriculture, air assisted sprayer, droplet size, droplet density*

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INTRODUCTION

Floriculture in India is being viewed as a high growth Industry. Commercial floriculture is becoming important from the export angle. Indian floriculture industry has been shifting from traditional flowers to cut flowers for export purposes. According to a report of the Agricultural and Processed Food Products Export Development Authority (APEDA), Government of India, the total area under flower crops was estimated around 34,000 hectares, which included 24,000 hectares under traditional flowers such as marigold, jasmine, aster, rose, chrysanthemum, tuberose and 10,000 hectares under modern flowers like carnation, rose, gerbera, gladiolous, anthurium. Returns from floricultural products were estimated at Rs. 205 Crores, which included Rs. 105 Crores from traditional and Rs. 100 Crores from modern flowers [13].

Floricultural crops are more susceptible to pests and diseases during their flowering stages. Generally, chemical pesticides are used for controlling pests and diseases. Traditionally farmers use the knapsack sprayer for the application of pesticides. But, the manually operated knapsack sprayer has a number of limitations: it is labor intensive, have low application accuracy and require serious safety precautions. 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 [7]. 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 [3]. The air sleeve boom spraying technology is based on air assisted spraying. This system essentially consists of a blower, nozzles, pump and sleeve or duct. The sleeves, made of PVC material, are inflated with the air mass generated by blower. The sleeve has number of holes at bottom for delivering air. The spray droplets produced by nozzles are transported to a target through a stream of air coming out of sleeve orifices which results in better control over spray droplets and deposition [6].

Shahare *et al.* [8, 9] developed a tractor operated air sleeve boom sprayer for cotton crop for better deposition of pesticide throughout the canopy and evaluated its performance in the field for cotton crop with findings that higher air velocity improves the deposition of pesticide on whole canopy of cotton crop. Sirohi *et al.* [10] developed an air-assisted hydraulic sprayer for improved deposition of pesticides in different canopy structures of vegetable crops. Bauer and Raetano [1] evaluated the effects from air speed variation on spraying sleeve boom and conclude that the use of air assistance resulted in better deposit levels on the abaxial surface of the folioles positioned in the lower portion of the plants.

Therefore, efforts have been made to develop an air assisted sprayer for pesticide applications in floricultural crops and the performance of the sprayer was evaluated in the laboratory to study the effect of different air velocity and pump discharge levels on droplet size, droplet density and uniformity coefficient at different positions on plant.

MATERIAL AND METHODS

Development of air assisted sprayer

The basic principle of the system is the replacement of air within the canopy of plant with sprays laden air. The droplets must travel in and around plant canopy in order to cover as many leaves as possible. Efforts were made to develop an air delivery system considering the canopy structure of the greenhouse floriculture crops mainly rose and gerbera. 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 from the blower was conveyed and distributed through two sleeves with multiple orifices to achieve an airflow pattern covering the canopy. 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 details of different components of the sprayer are given below.

Blower

The centrifugal blower of existing mist blower having capacity of $0.40 \text{ m}^3 \cdot \text{s}^{-1}$ was used on the system to create air pressure in the sleeves attached on the either sides of the blower at its outlet. It consists of casing and impeller. Specifications of casing and impeller are given below.

Blower casing. It is fabricated from high density polyethylene plastic. Blower casing was connected to lance assembly to which sleeves were connected on its either sides. Lance assembly was made of PVC pipe. The specifications of the blower casing and lance assembly are shown in Fig. 1.

Blower impeller. Centrifugal impeller was used to provide high velocity air to transmit spray droplets to intended target effectively. The specifications of the impeller are given below.

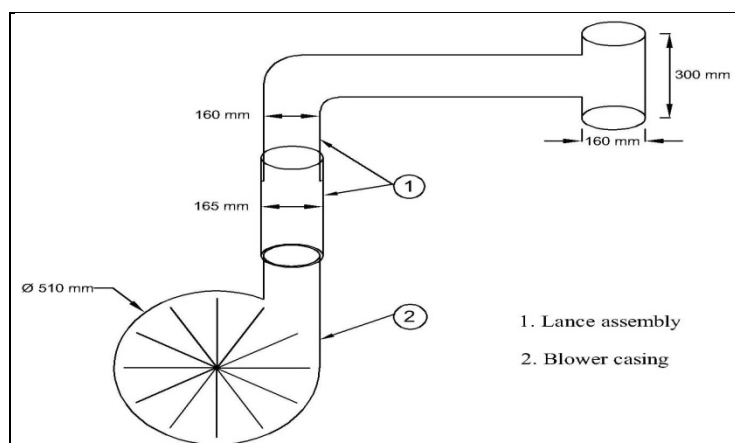


Figure 1. Blower casing with lance assembly

<i>Material</i>	: Stainless steel	<i>No. of blades</i>	: 48
<i>Type of blade</i>	: Forward curved	<i>Blade inlet angle</i>	: 16°
<i>Blade outlet angle</i>	: 160°	<i>Inner diameter</i>	: 220 mm
<i>Outer diameter</i>	: 300 mm	<i>Width of impeller</i>	: 140 mm

Air sleeve

A horizontal flexible air duct was designed to generate an air curtain with a uniform air velocity profile throughout the length of boom by tapering the duct (sleeve) towards the close end.

Let ' L ' be the length of sleeve equal to swath width and ' D_o ' its diameter at the inlet (at the exit of blower) whereas the other end of sleeve is closed. It has ' n ' number of orifices of uniform cross section throughout its length (Fig. 2). The air is blown into the duct from the blower and forced out through the orifices. As it is required to have uniform distribution of air along the duct, it was decided to taper the duct so that vertical air velocity will remain constant along its length [4]. Thus, to maintain uniform distribution of air along the length of the duct, the diameter of the duct at different cross sections (D_x) was determined as shown below. Let D_o , diameter of duct at $X = 0$ and $D_o = 0$ at $X = L_S$ (Fig. 2).

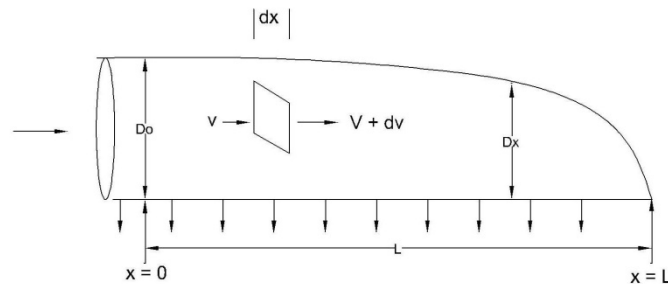


Figure 2. Tapered air duct

The air flow at the duct entrance can be calculated from continuity equation as:

$$Q = A \cdot V \quad (1)$$

where:

Q [$\text{m}^3 \cdot \text{s}^{-1}$] - air flow at the duct entrance,

A [m^2] - area of cross-section,

V [$\text{m} \cdot \text{s}^{-1}$] - air velocity.

The cross sectional area, at $X = 0$ and diameter D_o , can be found as

$$A = \frac{\pi}{4} \cdot D_o^2 \quad (2)$$

where:

π [-] - constant (3.14),

D_o [m] - diameter of duct at $x = 0$.

The total volume entering the duct is equal to the total discharge throughout its length. Therefore,

$$Q = Q_d \cdot L \quad (3)$$

where:

Q_d [$\text{m}^3 \cdot \text{s}^{-1}$] - total discharge from duct throughout the length of the duct,

L [m] - total length of the duct.

The quantity of air passing the section 'X' is calculated as:

$$Q_x = A_x \cdot V \quad (4)$$

where,

Q_x [$\text{m}^3 \cdot \text{s}^{-1}$] - total discharge through the section X,

A_x [m^2] - cross sectional area at section X.

The volume of air passing the section X is equal to the total discharge through the remaining length of duct. Therefore,

$$Q_x = Q_d \cdot (L - X) \quad (5)$$

Therefore, equations (1) and (5) can be written as:

$$Q_d \cdot L = V \cdot \pi / 4 \cdot D_o^2 \quad (6)$$

and:

$$Q_d \cdot (L - X) = V \cdot \pi / 4 \cdot D_x^2 \quad (7)$$

Thus, taking the ratio of the equations (5) and (6) we get:

$$\frac{Q_d \cdot L}{Q_d \cdot (L - X)} = \frac{V \cdot \pi / 4 \cdot D_o^2}{V \cdot \pi / 4 \cdot D_x^2}$$

which results into:

$$\frac{L}{L - X} = \frac{D_o^2}{D_x^2}$$

Therefore, the diameter of the duct at the section X can be found out as:

$$D_x^2 = D_o^2 \cdot \frac{L - X}{L} \Rightarrow D_x = D_o \cdot (1 - X / L)^{1/2} \quad (8)$$

where:

D_x [m] - diameter of duct at section X .

The above equation gives the relation between the length of the duct (air sleeve) and its diameter at different section tapering towards the close end. The diameter of sleeve obtained at different sections is shown in Fig. 3. By considering this two air sleeves of 160 mm in diameter at inlet matching to the outlet diameter of the blower and 2350 mm in length were sewed.

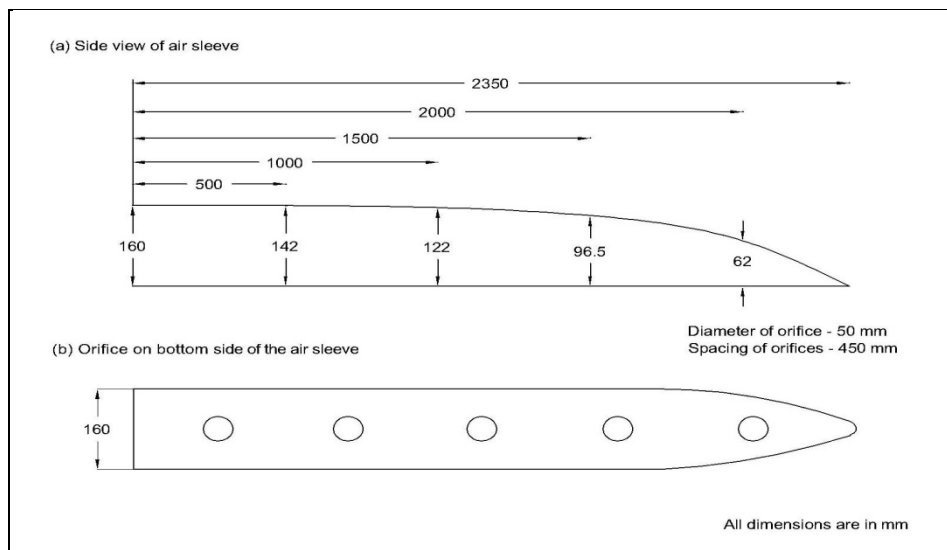


Figure 3. Diameter of sleeve obtained at different sections

Boom

The boom is the part of the sprayer which supports the air sleeve and nozzles. The boom is divided into two parts; center boom and side booms. Center boom was supported on M.S. angles fixed on the trolley and side booms were joined to center boom. It was decided to fabricate the boom from two circular M.S. pipes. One pipe on upper and another one on lower side joined each other with different slender member. The center boom was made up of 1.29 mm thick M.S. pipe of 20 mm outer diameter and side booms were made up of 1.29 mm thick M.S. pipe of 10 mm outer diameter. Six rings made up of M.S. rod of 10 mm diameter were provided on the boom to facilitate holding of flexible air duct. The total length of the boom was kept as 5 m. The nozzles were mounted on the boom along the length of horizontal air duct. A spring was provided at the joint of center boom and side booms to keep the boom straight during operation. The total boom assembly was rested on the M.S angles provided on trolley. The provision was made to facilitate the folding of boom along the length of trolley. The folding arrangement of boom is shown in Fig. 4.



Figure 4. Front view of the air assisted sprayer showing the folding arrangement of the boom

Trolley

The total assembly of the sprayer was supported on the trolley. Trolley was arbitrarily designed by considering row to row spacing of crops; it was decided to keep the width of trolley as 420 mm and its length as 1300 mm.

Trolley had four wheels of 200 mm diameter and one handle was provided at rear end for its operation. The trolley was fabricated from 38.1 mm \times 38.1 mm \times 5 mm section M.S. angle and it was provided with two M.S. angles at front side to support boom over it.

Power unit and nozzles

An electric motor of 5 HP was used as a power unit. It was used to drive the blower and pump. The power is transmitted to blower and pump through 'A' section of 'V' grooved belt and pulley (Fig. 5). Hollow cone plastic nozzles were selected for the study. In this study the spacing of nozzles was 450 mm as used in a conventional boom sprayer.

Accessories

A horizontal triplex power pump (HTP) was used to generate pressure on the spray fluid which worked in the oil bath and produced maximum discharge of 16 l \cdot min⁻¹ at the pressure of 2.75×10^5 Pa. The pump had two deliveries and one bypass hose, pressure gauge, agitator and a pressure control valve to stabilize pressure. A high density polyethylene (HDPE) tank of 25 liter capacity was used for pesticide (Fig. 5). The bypass hose from HTP pump was connected to the tank at the bottom of the tank. The pressurized liquid from pump was brought to the nozzles with the help of hoses. The diameter of hose was 8 mm and made of heavy duty plastic.



Figure 5. Side view of sprayer showing pesticide tank, blower, electric motor and pump

Performance evaluation of the air assisted sprayer

The laboratory experiments were conducted to study sprayer performance with different air velocities and pump discharges for droplet size, droplet density and uniformity coefficient at different plant positions. Air velocities of $9 \text{ m}\cdot\text{s}^{-1}$, $12 \text{ m}\cdot\text{s}^{-1}$, $16 \text{ m}\cdot\text{s}^{-1}$ and $20 \text{ m}\cdot\text{s}^{-1}$; and pump discharges of $2.5 \text{ l}\cdot\text{min}^{-1}$, $4.5 \text{ l}\cdot\text{min}^{-1}$, $7 \text{ l}\cdot\text{min}^{-1}$ and $9 \text{ l}\cdot\text{min}^{-1}$ were used. The different air velocities were obtained by changing the rotations per minute (RPM) of blower by using different combinations of driver and driven pulleys and pump discharge was obtained by using different nozzles having the discharge rates of 0.25 , 0.45 , 0.70 and $0.90 \text{ l}\cdot\text{min}^{-1}$. An artificial plant canopies were prepared with hibiscus plant spaced at recommended spacing of 300 mm . The spraying height was kept as 800 mm during the experiments. To facilitate the evaluation of spray penetration into the canopy of plant, glossy papers of size $44 \times 44 \text{ mm}$ were stapled onto the leaf in different plant locations, i.e. top position of plant canopy, upper leaf surface (TU); top position of plant canopy, lower leaf surface (TL); middle position of plant canopy, upper leaf surface (MU); middle position of plant canopy, lower leaf surface (ML); bottom position of plant canopy, upper leaf surface (BU) and bottom position of plant canopy, lower leaf surface (BL). The sprayer was operated at speed of 1 km/hr for spraying in laboratory. Royal blue indigo dye was mixed with water to prepare coloured spray solution. During the experiments impression of spray solution was collected on glossy papers and then the glossy papers were taken for further analysis using a droplet image analyzer. Droplet size and droplet density were measured by using Image-Pro software.

RESULTS AND DISCUSSION

The developed air assisted sprayer 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

Analysis of variance (Tab. 1, Tab. 2 and Tab. 3) showed that the air velocity had a significant effect on droplet size, droplet density and uniformity coefficient. The effect of air velocity on droplet size has been plotted in Fig. 6. 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 $9 \text{ m}\cdot\text{s}^{-1}$ and minimum droplet size was observed as an effect of air velocity of $20 \text{ m}\cdot\text{s}^{-1}$ at all plant positions. The values of droplet size observed as an effect of air velocity of $20 \text{ m}\cdot\text{s}^{-1}$ at top, middle and bottom position of plant and on upper and lower leaf surface was within the range of $100 \mu\text{m}$ to $150 \mu\text{m}$, which is very effective for control of pests in most of the crops [2, 5, 11, 12].

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 \times Pump discharge	9	597.809	66.4233	7.281**	0.712	2.620
Air velocity \times Canopy positions	15	995.294	66.3529	7.274**	0.872	3.208
Pump discharge \times Canopy positions	15	3156.09	210.406	23.065**	0.872	3.208
Air velocity \times Pump discharge \times Canopy positions	45	3834.11	85.2024	9.340**	1.744	6.417
Error	192	1751.52	9.12249			

** Significant at 1 % level
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 \times Pump discharge	9	422.625	46.9583	46.958**	0.236	0.867
Air velocity \times Canopy positions	15	41	2.73333	2.733**	0.289	1.062
Pump discharge \times Canopy positions	15	44	2.93333	2.933**	0.289	1.062
Air velocity \times Pump discharge \times Canopy positions	45	295.875	6.575	6.575**	0.577	2.124
Error	192	192	1			

** Significant at 1 % level
GM = 22.646 CV = 4.42

The effect of air velocity on droplet density is plotted in Fig. 7. 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 $20 \text{ m}\cdot\text{s}^{-1}$ air velocity and minimum mean droplet density was observed with air velocity of $9 \text{ m}\cdot\text{s}^{-1}$.

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 \times Pump discharge	9	0.715272	0.0794747	10.643**	0.020	0.075
Air velocity \times Canopy positions	15	0.664458	0.0442972	5.932**	0.025	0.092
Pump discharge \times Canopy positions	15	0.221771	0.0147848	1.980*	0.025	0.092
Air velocity \times Pump discharge \times Canopy positions	45	3.08083	0.0684629	9.169**	0.050	0.184
Error	192	1.43367	0.00746701			

*, ** Significant at 5 % and 1 % level respectively

GM = 1.449 CV = 5.96

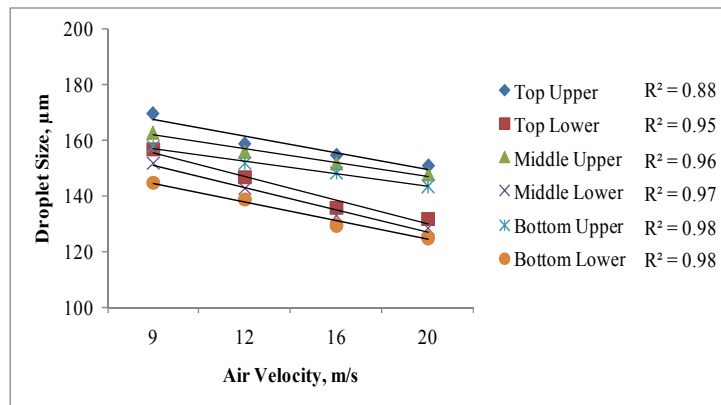


Figure 6. Effect of air velocity on droplet size at different plant positions

The trend of the curve (Fig. 8) showed that uniformity coefficient decreased with increase in air velocity from $9 \text{ m}\cdot\text{s}^{-1}$ to $20 \text{ m}\cdot\text{s}^{-1}$. Uniformity coefficient observed as an effect of air velocity of $20 \text{ m}\cdot\text{s}^{-1}$ 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.

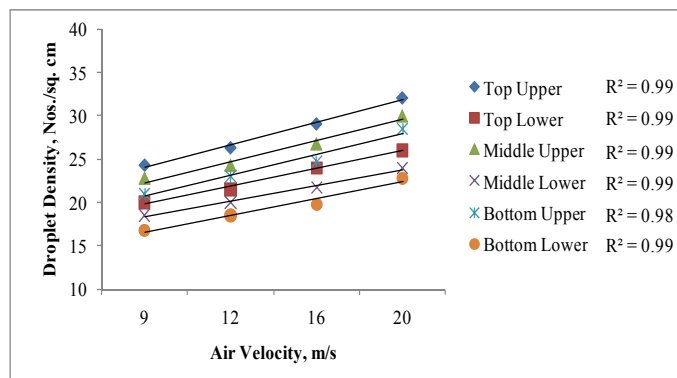


Figure 7. Effect of air velocity on droplet density at different plant positions

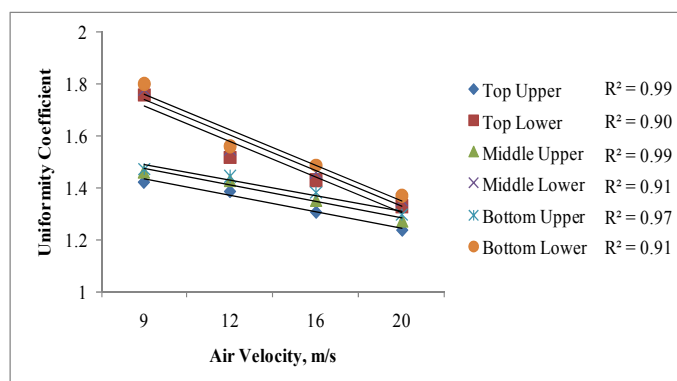


Figure 8. Effect of air velocity on uniformity coefficient at different plant positions

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

The pump discharge was set at 2.5 l·min⁻¹, 4.5 l·min⁻¹, 7 l·min⁻¹ and 9 l·min⁻¹ and the effect on deposition of droplets at six different plant positions was studied. Analysis of variance (Tab. 1, Tab. 2 and Tab. 3) showed that the pump discharge had a significant effect on droplet size, droplet density and uniformity coefficient. Fig. 9 shows that the droplet size observed as an effect of pump discharge of 2.5 l·min⁻¹ 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. Higher values of droplet size were observed at upper leaf surface than at lower leaf surface.

The effect of pump discharge on droplet density at different plant positions is shown in Fig. 10. 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⁻¹. It was also observed that droplet density decreased with increase in pump discharge from 2.5 l·min⁻¹ to 9 l·min⁻¹ at all plant positions. The maximum mean droplet density was observed with pump discharge of 2.5 l·min⁻¹.

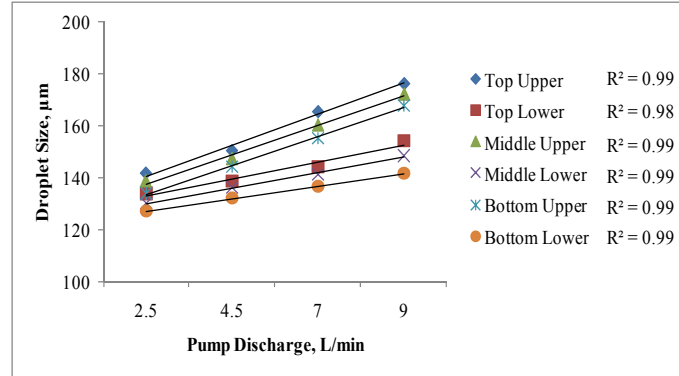


Figure 9. Effect of pump discharge on droplet size at different plant positions

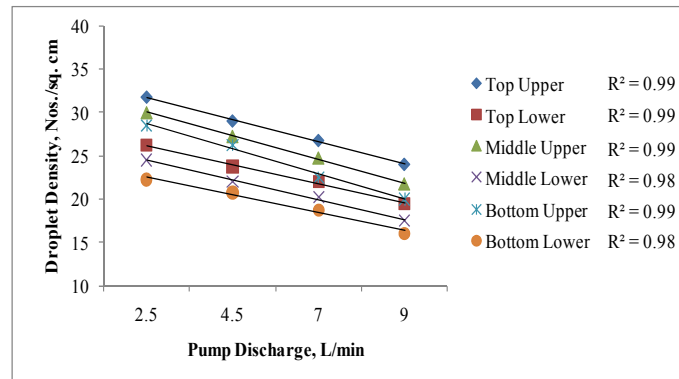


Figure 10. Effect of pump discharge on droplet density at different plant positions

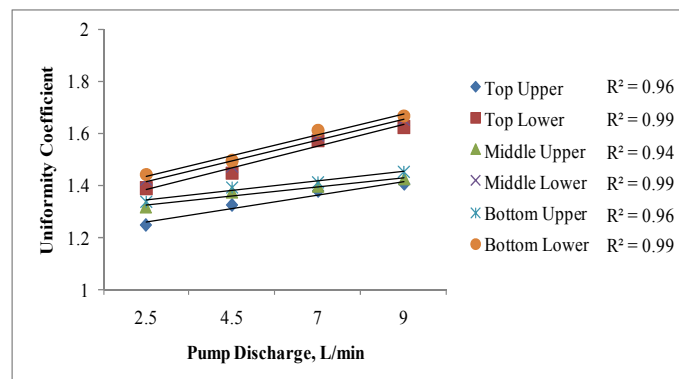


Figure 11. Effect of pump discharge on uniformity coefficient at different plant positions

The effect of pump discharge on uniformity coefficient is shown in Fig. 11. The trend of the curve showed that uniformity coefficient increased with increase in pump

discharge from 2.5 l·min⁻¹ to 9 l·min⁻¹. Uniformity coefficient observed as an effect of pump discharge of 2.5 l·min⁻¹ was within the recommended range.

The optimum droplet size, droplet density and uniformity coefficient were obtained at pump discharge of 2.5 l·min⁻¹.

Combined effect of air velocity and pump discharge on droplet size, droplet density and uniformity coefficient

Analysis of variance (Tab. 1, Tab. 2 and Tab. 3) showed that the combine effect of air velocity and pump discharge on droplet size, droplet density and uniformity coefficient was significant at 99 per cent level of confidence.

Multiple regression analysis was performed to develop a combined relationship among the air velocity, pump discharge and droplet size at all plant positions. The equation of following form was obtained:

$$S = a + b_1 \cdot V + b_2 \cdot Q + b_3 \cdot V \cdot Q \quad (9)$$

where:

- S [μm] - droplet size,
 V [m·s⁻¹] - air velocity,
 Q [l·min⁻¹] -pump discharge,
 a, b_1, b_2, b_3 - regression coefficients.

The regression coefficients for above equation are presented in Tab. 4.

Table 4. Regression coefficients for linear relationship of droplet size with air velocity and pump discharge

Plant Position		Regression Constant (a)	Regression Coefficient (b ₁)	Regression Coefficient (b ₂)	Regression Coefficient (b ₃)	R ²	Computed F
Top	Upper	163.208	-2.532	3.030	0.168	0.97	110.818**
	Lower	157.268	-2.247	3.161	0.011	0.95	67.362**
Middle	Upper	159.324	-2.424	2.397	0.192	0.98	216.577**
	Lower	159.477	-2.548	1.670	0.073	0.95	81.829**
Bottom	Upper	151.993	-2.193	2.728	0.167	0.99	374.028**
	Lower	158.119	-2.555	0.368	0.128	0.98	160.470**

** Significant at 1 % level

The equation shown below was obtained for the combined effect of air velocity and pump discharge at all plant positions on droplet density.

$$D = a + b_1 \cdot V + b_2 \cdot Q + b_3 \cdot V \cdot Q \quad (10)$$

where:

- D [Nos. per cm²] - droplet density.

The regression coefficients for above equation are presented in Tab. 5.

Table 5. Regression coefficients for linear relationship of droplet density with air velocity and pump discharge

Plant Position		Regression Constant (a)	Regression Coefficient (b ₁)	Regression Coefficient (b ₂)	Regression Coefficient (b ₃)	R ²	Computed F
Top	Upper	23.787	0.753	-1.033	-0.009	0.99	492.989**
	Lower	18.684	0.696	-0.645	-0.025	0.98	173.875**
Middle	Upper	24.513	0.598	-1.386	-0.011	0.99	309.773**
	Lower	18.734	0.578	-0.818	-0.015	0.97	136.328**
Bottom	Upper	21.763	0.717	-1.186	-0.010	0.99	274.980**
	Lower	15.387	0.664	-0.587	-0.025	0.97	145.275**

** Significant at 1 % level

Multiple regression analysis was also performed to study the combined effect of air velocity and pump discharge on uniformity coefficient at all plant positions. It gives following form of equation.

$$U = a + b_1 \cdot V + b_2 \cdot Q + b_3 \cdot V \cdot Q \quad (11)$$

where:

U [-] - uniformity coefficient,

The regression coefficients for above equation are presented in Tab. 6.

Table 6. Regression coefficients for linear relationship of uniformity coefficient with air velocity and pump discharge

Plant Position		Regression Constant (a)	Regression Coefficient (b ₁)	Regression Coefficient (b ₂)	Regression Coefficient (b ₃)	R ²	Computed F
Top	Upper	1.580	-0.026	0.001	0.002	0.97	113.848**
	Lower	1.796	-0.036	0.040	0.000	0.92	41.743**
Middle	Upper	1.685	-0.028	-0.011	0.002	0.96	93.519**
	Lower	1.805	-0.034	0.042	0.000	0.92	45.186**
Bottom	Upper	1.668	-0.025	-0.007	0.002	0.95	79.418**
	Lower	1.802	-0.032	0.046	0.000	0.92	43.717**

** Significant at 1 % level

CONCLUSIONS

On the basis of laboratory experiments following conclusions were drawn:

1. Droplet size and uniformity coefficient of developed air assisted sprayer was found to be decreased linearly with the increase in air velocity and decrease in pump discharge.
2. The droplet density was found to increase with increase in air velocity and decrease in pump discharge at all plant positions.
3. The recommended droplet size i.e. between 100 µm to 150 µm was obtained at air velocity of 20 m·s⁻¹ and pump discharge of 2.5 l·min⁻¹.
4. The developed air assisted sprayer exhibited better deposition efficiency with the air velocity of 20 m·s⁻¹ and pump discharge of 2.5 l·min⁻¹.

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**RAZVOJ VAZDUŠNOG RASPRSKIVAČA ZA ZAŠTITU CVEĆA U
ZAŠTIĆENOM PROSTORU**

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Sažetak: Cvečarstvo je jedna od glavnih oblasti indijske poljoprivrede. Ovu proizvodnju najviše ugrožavaju insekti, štetočine i bolesti. Zato je vazdušni rasprskivač na motorni pogon razvijen za zaštitu cvečarskih kultura u zaštićenom prostoru. Konusni usmerivač vazduha je konstruisan i napravljen od ojačanog PVC materijala kako bi dao

ujednačenu brzinu strujanja vazduha u svakom izlaznom otvoru. Nosač je razvijen kao oslonac za usmerivač vazduha i mlaznice. U sistem je ugrađen centrifugalni duvač kapaciteta $0.40 \text{ m}^3 \cdot \text{s}^{-1}$ koji stvara vazdušnu struju u usmerivačima. Horizontalna trostruka pogonska pumpa kapaciteta $16 \text{ l} \cdot \text{min}^{-1}$ je upotrebljena za obezbeđenje potrebnog pritiska u mlaznicama. Duvač i pumpa dobijaju pogon od elektromotora snage 3.73 kW . Ceo sklop rasprskivača postavljen je na kolica. Kod razvijenog rasprskivača u laboratoriji su ispitivani uticaji različitih brzina vazduha ($9, 12, 16$ i $20 \text{ m} \cdot \text{s}^{-1}$) i kapaciteta pumpe ($2.5, 4.5, 7$ i $9 \text{ l} \cdot \text{min}^{-1}$) na veličinu kapljica, gustinu kapljica i koeficijent ujednačenosti u šest različitih položaja veštačkog biljnog krova. Optimalni rezultati veličine kapljica ($100\text{-}150 \text{ }\mu\text{m}$), gustine kapljica ($25\text{-}35$ kapljica po cm^2) i koeficijenta ujednačenosti kod svih položaja biljke su dobijeni za brzinu vazduha od $20 \text{ m} \cdot \text{s}^{-1}$ i kapacitet pumpe od $2.5 \text{ l} \cdot \text{min}^{-1}$.

Ključne reči: zaštićeni prostor, cvečarstvo, vazdušni rasprskivač, veličina kapljice, gustina kapljica

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