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Field Evaluation of Air Assisted Sleeve Boom Sprayer

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Effective pest control can be achieved, if pesticides are properly applied at correct rate, at right time and on the target by appropriate equipment. The spray with conventional sprayer does not reach the bottom of the plant canopy and also the upper and lower side of leaves in required quantity. In view of this a new air sleeve boom sprayer was designed, developed and its performance was evaluated in the laboratory and field trials. The working principle of the sprayer was totally based on the replacement of air within the canopy with spray laden air. A laboratory set up was developed and tested on actual plant canopy of cotton crop at four experimental variables *viz*, air velocity (12, 20 and 26 m/s), air sleeve angle (-15^0, 0^0, 15^0 and 30^0), nozzle angle (25^0, 35^0 and 45^0) and height of boom (50 cm and 70 cm). In the study, special emphasis was given to determine the effective droplet density and droplet size for the control of pests. The deposition of droplet was made at top, middle and bottom position of the plant and on upper and lower leaf surfaces. The results indicated that the recommended levels of droplet density and size were obtained at an air velocity of 26 m/s, air sleeve angle 30^0, nozzle angle 35^0 and height of boom 70 cm during lab experiment. The deposition indices during field trials were also calculated at these selected levels of variables. The value of regression coefficient was calculated in laboratory experiments to determine the effect of air velocity, air sleeve angle, nozzle angle and height of boom and to confirm field experiments.

Key words: Deposition Index, Droplet density, Droplet size, Sleeve boom.

World community is aware of serious food shortages over the past 50 years and in recent decades the food shortage has become critical. Furthermore, world population continues to increase. The most important problem faced around the globe is that of feeding hungry million people in developing countries. It is predicted that the production of world's basic food crops must be doubled by the early 2030's to feed the increasing population (Godki, 2003).

In agricultural pursuits, from time immemorial man has contended with the weather, plant pests, diseases and weeds. The extent to which the food supply can be maintained depends upon the ability to manipulate those factors over which he has control. One of these factors is protection against ravages of pests. Thus, attention has been made to spray pesticides to eliminate or minimize the debilitation of food crops by various pests. In this context a new type of spraying system *i.e.* air sleeve boom sprayer was developed and evaluated in laboratory as well as in field.

Byass *et.al* (1960) and Randall (1971) described importance of air stream in the context of droplet spectrum and deposition on canopy. Fleming (1962) first deduced the relationship between air volume, air velocity and efficiency of sprayer. He stated that for a given air energy, larger the droplet the greater would be the air velocity required to keep it air borne for a given distance. Harrell *et.al* (1970) developed a dual, air assisted sprayer for applying chemicals to cotton foliage with pneumatic nozzle in an air duct outlet (8.9 m/s air velocity) placed 150 mm above each row which showed unsatisfactory spray pattern to obtain complete coverage.

Quanguin *et.al (*1989) used a Hardi twin air assisted sprayer with an air speed set at 30 m/s to investigate the spray deposition on potato plant foliage. They reported that the coverage increased with air assistance and was even better with a spray angle set at 30^0 backward.

Materials and Methods

A horizontal flexible air duct was developed to generate an air curtain with an uniform air velocity profile throughout the length of the boom. This was achieved by keeping the air exit per unit length of the duct constant and by decreasing its cross section from blower outlet to dead end of the duct (Fig.1). It helped in maintaining the static pressure and air exit velocity in the system constant. For the laboratory evaluation, the duct was constructed based on the parameters obtained to satisfy the design consideration. The tapering air duct system, 0.25 m in diameter at inlet and 2.5 m in length converging to zero diameter towards the dead end was made of fiber- reinforced PVC. It was sewed to distribute air over the full length of the boom. The length of the

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duct was determined based on the available air flow from the blower. At the bottom of the duct, the orifices of 40 mm diameter spaced at a distance of 90 mm were made continuously throughout its length. The newly developed air duct (air sleeve) was mounted on the boom with the help of circular rings. The laboratory experiment was planned (Fig. 3) to evaluate the effect of different independent variables on spray coverage at different position on the cotton plant. The variables were air velocity at 12, 20, and 26 (m/s); air sleeve angle at -15, 0, 15, and 30 (degree); nozzle angle at 25, 35, and 45 (degree); height of boom at 50 and 70 (cm) and the effect was observed on dependent variables like droplet density (no/sq. cm) and droplet size (VMD).

The targeted field crop selected was cotton, which consume almost 40 per cent of the total pesticides used. A new type of air delivery system was conceived considering the canopy structure. Air from the blower was conveyed and distributed through a duct with multiple outlets (orifices) to achieve airflow pattern converging on the canopy. Cotton seeds were sown in plastic bags to raise the seedlings. Extra large bags with full mature plants were arranged in the laboratory to get recommended spacing of plants to simulate the field conditions. Rest of the seedlings raised in small bags were transplanted in the field after 15 days of sowing covering 1.5 acres of land. A spacing of 90 × 90 cm was maintained during transplantation with randomized block (RBD) was followed for field trials with nine different sub plots treatments. To facilitate the evaluation of spray penetration into the canopy, both in laboratory and field trials the plant was divided in to six different parts depending upon the location where the effect of independent variable on spray coverage was to be evaluated. These parts include 1. Top of the plant and upper side of the leaf, 2. Top of the plant and under surface of the leaf 3. Middle part of the plant and upper side of the leaf, 4. Middle part of the plant and under surface of the leaf, 5. Bottom part of the plant and upper side of the leaf, 6. Bottom part of the plant and under surface of the leaf.

Before commencement of experiment in laboratory, it was ensured that the tractor was set at selected gear and throttle position for a particular air velocity. The air velocity was measured 10 cm below the orifice in the static position of the test set-up. A digital type vane anemometer was used to measure the air velocity. Three glossy papers were stapled on the leaves at each position to observe the deposition of the droplets. After making all adjustments, the experimental set up was run ideally for 30 min before actually starting the observation.

The deposition characteristics inside the canopy were determined in terms of droplet density and droplet size. One of the most used field base droplet collection technique involves the use of dyed spray and glossy photographic paper (Maksymiuk, 1964; Matthew and Hislop; 1993). The sleeve boom along with the whole set up was trailed behind the tractor in the laboratory at a constant forward speed of 2 km/h above the plant canopy. In order to achieve uniform exposure time, the setup was operated 3 m before the reach of canopy and stopped immediately after passing the canopy. The spray deposition was collected on the sample cards (62 mm × 44 mm) of glossy paper. Royal blue indigo dye was mixed with water to prepare a coloured spray solution which was allowed to fall on the sample glossy photographic paper. After the experiment, the sample cards were removed carefully and analyzed in a digital image analyze to determine stain diameter and droplet size after 24 h of application to ensure that droplets had stopped spreading.

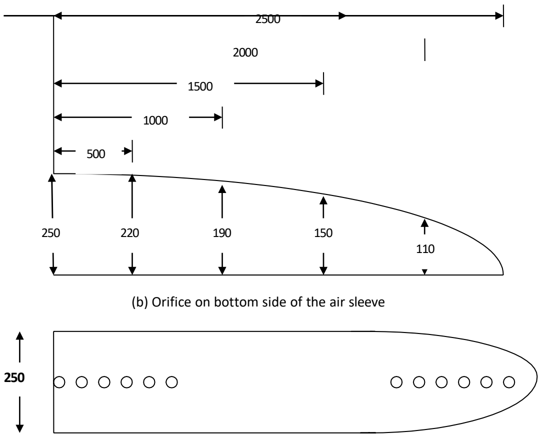
The field experiment was conducted at ASPEE farm, Tansa at Mumbai with NH-44 cotton variety shown in Fig. 4 at the optimum combination of independent variables as in laboratory experiment. The relative humidity and wind velocity during the experiment ranged from 32 to 46 per cent and 3.2 to 4.4 km/h, respectively. The statistical analysis was carried out to determine the significance of dependent variable on the independent variables in terms of droplet density and Volume Mean Diameter(VMD).

Results and Discussion

A prototype of the air assisted sleeve boom sprayer was developed for laboratory and field evaluation in cotton crop. During the laboratory evaluation, the optimum combination obtained were a) air velocity, 26 m/s b) air sleeve angle, 30°c) nozzle angle, 35° and d) height of boom, 70 cm above the plant canopy. The average height and width of the crop during field evaluation was 105 and 90 cm, respectively. The field evaluation of air sleeve boom for tractor mounted sprayer was conducted at predetermined optimum variables. The results obtained on droplet density, droplet size and deposition of volume are presented in Table 1.The analysis of data indicated that the droplet density was in the range (20 to 25 droplets/sq.cm) at top, middle and bottom position of the plant at upper leaf surface. However, at lower leaf surface and at top of the plant, the droplet density was within the

Table 1. Date on field evaluation of air assisted sleeve boom sprayer

Position	Surface	Droplet		Volume ml/cm^2	Deposition Index
		Density no/cm^2	Size VMD		
Top	Upper	26.4	119.8	2.3×10^{-5}	1.82
	Lower	23	122.2	2.2×10^{-5}	1.68
Middle	Upper	21.2	107	1.3×10^{-5}	1.04
	Lower	12.6	75.9	2.5×10^{-6}	0.19
Bottom	Upper	21	113	1.5×10^{-5}	1.21
	Lower	14.2	90.8	5.5×10^{-6}	0.42



* all measures in mm

Fig.1 Air sleeve for laboratory experiment

range whereas; at middle and bottom position of the plant, the droplet density deposited was almost 40 per cent below the required limit.

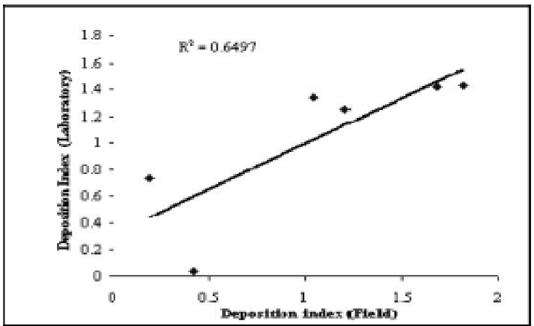
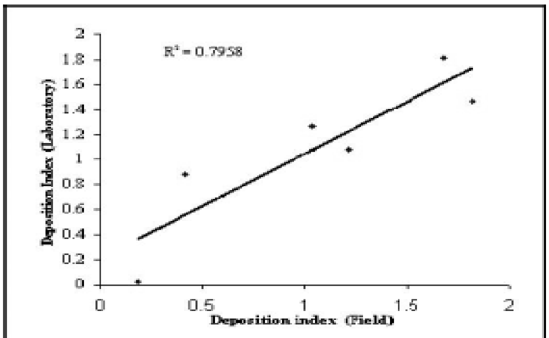


Fig. 1 Regression between laboratory and field deposition index at air velocity 26 m/s

a)



b) egression between laboratory and field deposition index at air sleeve angle 30 deg

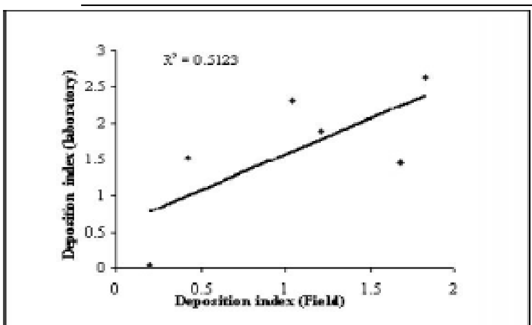


Fig. 3 Regression between laboratory and field deposition index at nozzle angle 35 deg

c)

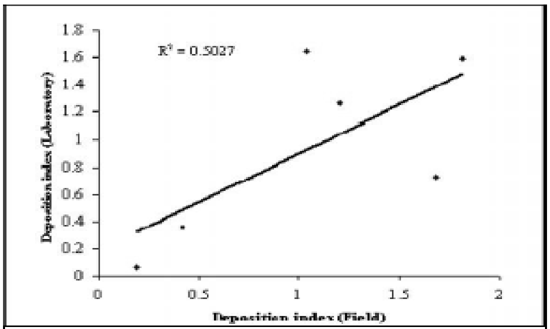


Fig. 4 Regression between laboratory and field deposition index at air velocity 26 m/s

d)

Fig.2 Regression between laboratory and field deposition index

The maximum VMD was observed on the top position of the plant and upper leaf surface during the field evaluation. The VMD values observed on upper leaf surface at top, middle and bottom position of the plant as well as on lower leaf surface at top position of the plant were well within the recommended zone (150 to 200 VMD). However, the VMD observed at middle and bottom position of the plant at lower leaf surface was below the limit.

The maximum value of deposition index (1.82) was recorded at top position of the plant and on upper leaf surface. However, the deposition index at almost all position of the target plant was slightly higher than one except at middle and bottom position of the plant and lower leaf surface.

Fig.3. Laboratory experiment of air sleeve boom sprayer

Comparison of deposition index between laboratory and field results

The deposition index observed at optimum levels of air velocity, air sleeve angle, nozzle angle and height of boom in the laboratory experiment was compared to that observed during field evaluation Fig.2. The value of regression coefficient was observed as 0.64, 0.79, 0.51 and 0.50 for air velocity, air sleeve angle, nozzle angle and height of boom, respectively. The value of regression coefficient indicated that the results of field experiment confirmed the results of laboratory experiment (Fig. 2). The R^2 value indicated that the effect of air velocity and air sleeve angle are more comparable than the results obtained with effect of nozzle angle and height of boom.

Fig. 4. Field testing of air assisted sleeve boom sprayer

The deposition index *i.e.,* R^2 was found to be close to one as the effect of air velocity at 26 m/s, air sleeve angle of 30^0, nozzle angle of 35^0 and height of boom of 70 cm. In field evaluation, the droplet density and droplet size was as per the requirement at top, middle and bottom position of the plant and on upper leaf surface. Similar results were observed on top position of the plant and lower leaf surface. The deposition index at different position of the target plant was close to the one except at middle and bottom position of the plant and on the lower surface of the leaf. At this position of the plant, it was below the value of one.

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