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Research Paper :

Field evaluation of three outlet type air assisted sprayer

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ABSTRACT

Conventional method of spraying pesticides on row crops employs high volume hydraulic sprayers. This method consumes large amount of water, labour and time, almost 50 per cent of the applied spray fluid drips down to ground as a loss. With a view to evolve an alternate spraying system to replace the inefficient conventional method, three outlet type sprayer was developed. Field performance was evaluated for brinjal crop at ASPEE research field. Three nozzles were selected *i.e.* HCN/PA, BCN, NMD/S. Sprayer was operated at 2 km/h tractor travel speed and at 1450 rpm blower speed. The air assisted sprayer performed better with HCN/PA nozzle within the limit of tractor power (35 HP) Most of the droplets were in the range of 0 - 151µm. The droplet diameter with BCN nozzles were found to be better. Volume deposition was more when HCN/PA nozzle set was used.The better parameters *viz.* droplet density, uniformity coefficient was obtained with NMD/S nozzle and HNC/PA , respectively. The three outlet type sprayer could cover a swath width of 7.5m in brinjal field and actual field capacity was found to be 1.13 ha/h at 2 km/h travel speed. The field efficiency of the sprayer was found to be 75.4 per cent.

Key words : Air assisted sprayer, Air discharge rate, Air velocity, Total pressure, Droplet size, Volume deposition.

Among all methods of pest control chemical method is most commonly used, the use of pesticides constitutes probably the most important method in spite of their limitation and adverse effect on the environment. The consumption of pesticides increased considerably to the level of 7500 tonnes by the end of 7th plan from a level of 2350 tonnes at the beginning of the planning era. (Rajak, 1992). During the year 2000 global pesticide expenditure was 9500 US $, whereas Indian expenditure was 3200 crores and overall Indian pesticide industry size was 3382 crores. Major consumption *i.e.* 52 per cent for cotton, 14 per cent for rice 7.1 per cent for vegetables and 5.1 per cent for tea crop (Patel, 2001).

Chemicals used for pest control need to be applied in such a manner that they come into contact with pest, distributed evenly over the surface of the plants to form an uniformly persistent deposit to secure a protective covering with minimum wastage of the liquid and minimum expenditures in terms of active ingredients and cost involved. Presently used hydraulic sprayers are inefficient at delivering pesticide to its target but farmers use it with some success by employing doses vastly greater than those theoretically required. In these sprayers, large volume of water is required and frequent filling of tank is quite time consuming. The speed of operation is low and reliability of operator can make spraying a success or failure such sprayers are subjected to heavy loss of pesticides as more than 50 per cent of spray volume drips down to the ground, making pesticide application a hazardous task besides spoiling the soil.

In the dynamic and fast changing agricultural scenario of the country, particularly diversification in cropping pattern and commercialization of agriculture, more efficient and sophisticated equipment are required. The tractor operated air assisted sprayers with three outlet is developed by ASPEE, Mumbai for orchards as well as for row crops which improves coverage, boosts chemical effectiveness and makes spraying job easier and faster. Those parts of the plant that could not be reached by conventional spraying received a much better covering, when spraying with air assisted sprayer.

Panneton *et al.* (2000) studied the effect of air speed, air flow rate, and air jet orientation in isolated spray chamber. A carriage supporting a standard spray boom was moved at 6 km/h over micro plots of green house grown potatoes. Results showed that air speed had larger impact on leaf coverage. Higher air speeds increase the coverage on the underside of the leaves within crop canopy. Jadhav (1998) found that air-carrier sprayer could cover a swath of 8.22 m in the cotton field and actual field capacity was found to be 0.81 ha /h at 1.5 km/h travel speed. Plans and Pons (1991) stated that the effect of fan speed was directly responsible for the higher deposition. The flow from the fan at 540 rev./min and forward speed upto 4 km/h was too high for the structure of the trees and incurred large losses as drift and

evaporation. Hollow cone hydraulic nozzles are extensively used in presently available sprayer. Traditionally, large orifice hydraulic hollow cone nozzles were used, producing drops of large average size (VMD 200 - 300 μm.). In order to achieve smaller droplet sizes, small orifice type are widely used (Wiedenhoff, 1991).In order to get the desired performance by air assisted sprayer the droplet size, droplet density nozzle type, nozzle discharge are essential parameters to study. Air assisted sprayer with three outlets is new concept. Therefore, work was undertaken to test its field performance using different nozzles.

METHODOLOGY

Three-outlet type sprayer was an air-assisted sprayer. Centrifugal double-sided, forward curved bladed impeller was provided to generate high-pressure air blast. A volute type casing was provided to accommodate the impeller. Three outlets were provided one over other to cover the entire height of the fruit tree. Upper outlet was so designed that it could cover 50 per cent of swath width, second one 37.5 per cent of swath width and third one 12.5 per cent of total swath width. The diameters of outlets were 21, 16, and 11 cm, respectively. High-speed gearbox was provided to maintain the required speed, a Horizontal Triplex Pump (HTP) is provided to generate required hydraulic pressure and is operated by tractor PTO (Fig.1). This sprayer uses volute type of casing to produce air current without developing eddies. The control panel assembly is provided to control flow of liquid to nozzles and maintain system pressure third control simply discharges the part of the liquid back into the pesticide tank, thus providing the hydraulic agitation. The pressurized liquid from control panel was brought to the nozzle with the help of hoses. The nozzles used in this blower were BCN, NMD/S and HCN/PA. As there are three outlets, three nozzles of different discharge were mounted on respective outlets depending upon the area covered by the outlets. Three-outlet type sprayer consists of blower casing and centrifugal impeller, frame for mounting blower, hydraulic pump, control panel assembly, hoses and nozzles, pesticide tank, strainers and power transmission unit. The specifications of three outlet blower used for the study is given in Table 1.

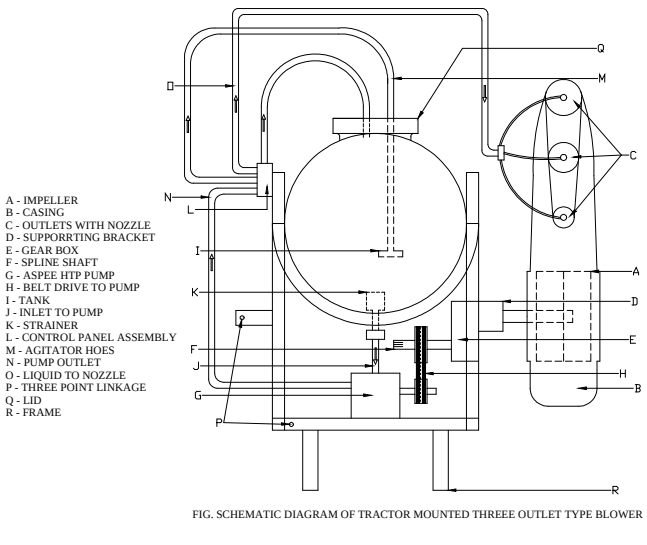

Fig. 1 : Schematic diagram of tractor mounted three outlet sprayer

Table 1 : Specifications of the three outlet type sprayer

Sr. No.	Details	Specification
1.	Impeller	
	1. Impeller type	Double sided
	2. Outer diameter, cm	52
	3. Inlet diameter, cm	44
	4. Impeller width, cm	24.5
	Blades	
	1. Number of blades	48
	2. Blade type	Forward curved
	3. Inlet blade angle, degrees	16
	4. Outlet blade angle, degrees	160
	5. Blade material	Stainless steel
2.	Casing	
	1. Type	Volute
	2. Number of outlets	3
	3. No of inlets	2
	3. Inlet diameter, cm	53
	4. Outlet diameter, cm	
	Upper outlet	21
	Middle outlet	16
	Lower outlet	11
	5. Width of casing, cm	27

Field experiment:

Field trials were carried out for the evaluation of droplet sizes, droplet density, uniformity coefficient and spray volume deposition. Various biological observations were carried out regarding experimental plot. Three replications of the sub plot treatments were used. In each replication, random assignments of the sub plot treatments were made within each plot. Travel speed and system pressure of the sprayer was constant. The tractor mounted three outlet type air carrier sprayer was tested in 160 days old brinjal crop of Mukatakeshi hybrid variety at the blower speed 1450 rpm and with three different sets of nozzle. Tractor was operated at 2 km/h speed and system pressure was kept constant to 300 kN/m^2. Various

biological observations were carried out such as average height of plant, number of leaves on plant, average width of plant, leaf area, row spacing, plant to plant spacing, volume of the plant. Based on the laboratory performance in terms of power consumption of the sprayer (14.27 kW), power required to run the pump 2.25 kW and tractor of 35 HP, the rotational speed of the blower was considered to be 1400 rpm. The spray volume required to cover one plant was calculated considering maximum leaf area of fully grown leaf and plant of maximum leaves the Volume of the spray requirement was worked out considering droplet density, diameter and found to be 6.388 ml per plant. The spray volume rate required for 2 km/h tractor speed was worked out to be 2.358 lit/min.

For field study nozzle selection was done on the basis of requirement that the nozzle at upper outlet, middle and lower outlet should deliver 50 per cent, 37.5 per cent and 12.5 per cent of total calculated discharge rate, respectively. On this basis selected nozzle includes, BCN which is hollow cone nozzle, HCN/PA is hollow cone mist nozzle and NMD/S is duro mist spray nozzle. These nozzles were tested on three-outlet type sprayer.

It is a proven fact that pest incidence mostly occurs on leaves. As such, it was decided to find out the droplet deposition on the leaves of brinjal. To achieve this, use of glossy paper was made. The coloured liquid was sprayed through sprayer. The coloured spots are easier to detect and examine under microscope for droplet spectrum analysis. The glossy paper of size 62 x 44 mm were placed on upper and lower side of leaves at the top, middle and bottom position of the plant height. The methyl violet was used as tracer at the rate of 5 gm per liters of water. Sampling cards were retrieved and analyzed in the laboratory with particle size analyzer and microscope to find out sprayer volume deposition and droplet size distribution.

RESULTS AND DISCUSSION

The results obtained from the present investigation are presented below :

Study of air velocity trajectory:

A study of the distribution of air velocities at a speed of 1450 rpm at distances of 3m, 6m, 7.5m and 9 m from the middle outlet of the three outlet type blower were studied. The main aim of the study was to find out effective swath width of blower. The air velocity values were obtained as 18.19, 9.73, 8.40 and 7.40 m/s at 3 m, 6 m, 7.5 m and 9 m distance from the blower outlet. The air velocity of the blower was found to be within the limit. According to Myers effective swath was limited to that point in the air jet where air velocity was not lower than 6.7-7.6 m/s.

Volume median diameter (VMD):

The data revealed (Table 2) that the volume median diameter for the BCN nozzle was found to be in the range of 55.33mm to 172.09mm. For NMD/S nozzle it was 43.16mm to 117.82mm while for the HCN/PA it was found to be in the range of 38.90mm to 152.66mm. For air assisted sprayer these values are in the satisfactory range. At various positions in the plant *i.e.* top, middle and bottom side and leaf position *i.e.* over side and underside the VMD with BCN nozzles (Table 3) were found in the satisfactory range. This nozzle has resulted better droplet size on lower side of the leaves and the purpose of the air assisted sprayers is solved.

Number median diameter (NMD):

The Table 2 clearly indicate that number median diameter for BCN nozzle at 1425 rpm blower speed was found to be in the range of 14.19mm to 66.18mm. The number median diameter for NMD/S nozzle was found to 26.78mm to 63.06mm. while, in case of HCN nozzle at 1425 rpm blower speed, number median diameter range was found to 26.13mm to 58.78mm. The BCN type nozzle performed better.

Table 2 : The range of VDM, NMD and UC

Parameters	Nozzle types		
	BCN	NMD/S	HCN/PA
VMD,µm	55.33-172.0	43.16-117.8	38.9- 152.66
NMD,µm	14.19-66.18	26.78-63.06	26.13- 58.78
Uniformity Coefficient	1.11- 4.37	0.77 - 2.89	0.76 - 3.74

Droplet density:

Data revealed that there was not definite trend of droplet density. However, the droplet density values were obtained in the range of 8.75 to 15.50 Nos/cm^2 . The deposition at the lower side of leaf was found better for all the nozzle tested. It can be concluded that due to the mixed throw of all three outlet there was nearly uniform coverage at top, middle bottom position of plant height and upper side and underside of leaves (Table 3).

Uniformity coefficient :

Uniformity coefficient, ratio of volume median diameter to number median diameter ranged from 1.11 to 4.37 at 1450 rpm blower speed for BCN nozzle. Uniformity coefficient for NMD/S nozzle ranged in between 0.77 to 2.89 where as, in case of HCN/PA nozzle

Table 3 : The average VMD, NMD UC and volume deposited on the plant at various positions

Nozzle type	Droplets parameter	Plant position and leaf position					
		Top		Middle		Bottom	
		Over side	Under side	Over side	Under side	Over side	Under side
BCN	VMD, µm	106.96	87.52	110.32	74.26	114.84	69.26
NMD/S	VMD, µm	93.08	47.09	92.31	49.58	88.32	61.98
HCN/PA	VMD, µm	96.24	62.5	6.4.9	46.58	82.1	48.68
BCN	NMD, µm	45.99	50.14	49.6725	46.15	49.6425	27.83
NMD/S	NMD, µm	52.35	49.57	44.38	47.12	47.58	33.49
HCN/PA	NMD, µm	54.15	46.91	39.61	35.34	47.71	47.24
BCN	U.C.	2.45	1.765	2.24	1.61	2.38	3.04
NMD/S	U.C.	1.77	0.96	2.2	1.13	1.95	1.99
HCN/PA	U.C.	1.79	1.36	1.85	1.38	1.84	1.02
BCN	Droplet density No/cm^2	15.25	11.75	13.25	12.75	14.5	13
NMD/S	Droplet density No/cm^2	14.75	14.5	13.5	14.75	13	15.5
HCN/PA	Droplet density No/cm^2	12.75	8.75	12.25	10	13.75	13.75
BCN	Volume ml/cm^2	1.19E-02	4.13E-03	0.008761	4.00E-03	0.01581	2.53E-03
NMD/S	Volume ml/cm^2	7.04E-03	2.29E-03	5.66E-03	9.48E-04	5.12E-03	2.33E-03
HCN/PA	Volume ml/cm^2	7.89E-03	1.22E-03	2.34E-03	1.13E-03	0.006312	2.45E-03

uniformity coefficient varied from 0.76 to 3.74 (Table 2). Table 3 indicated that the higher values are obtained with BCN nozzle. HCN/PA nozzle performed better.

Droplet spectrum analysis :

Droplet spectrum analysis was done with the help of computer analyzer. All the glossy papers retrieved from the plants were analyzed by 'image pro' analyzer which gave number of droplets of various diameters in one centimeter square area of glossy paper. The data of percentage of droplet sizes were grouped into eleven groups. The 54.80 % droplets were in the range of 0 - 50ìm size whereas 30.81 % were in the range of 51 - 100ìm size. There was very less per cent of droplets observed in the range of 151 to 200 ìm rage and found to be 1.61 % 1450 rpm, y. Droplets in the range of 201 to 500 ìm were found absent.

Volume deposited on the leaves:

It is revealed that (Table 4) volume deposition on upper side of leaves was more than that of lower side.

Table 4 : Percentage of volume deposited at under side of leaves by different nozzle

Nozzle type	Per cent deposition at under side at different position on plants		
	Top	Middle	Bottom
BCN	59.69	39.66	24.48
NMD/S	13.65	22.52	41.45
HCN/PA	46.84	48.58	51.81

The HCN/PA nozzle set has given comparatively more deposition on under side and it ranged from 46.84 to 51.81 per cent of upper side. The Fig. 2, 3 and 4 also show that at top side the deposition was more as compared to lower side of the plant. HCN/PA nozzle resulted in to comparatively better deposition at lower side of the leaves which is the need of spraying. Same result was claimed by May (1991). He reported that there was an increase in spray deposition of fluorescent tracer on the beet leaves when blower exit velocity was increased from 12 m/s to 23 m/s. But the deposition trend was not uniform. It might be due to high velocity exit air and less dense brinjal crop.

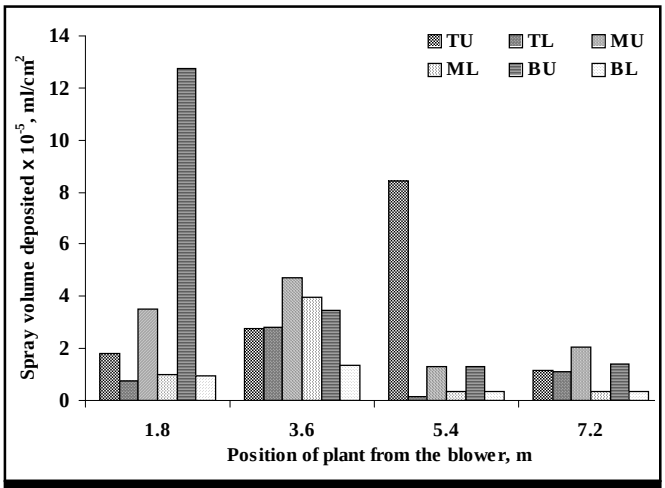

Fig. 2 : Spray deposition along the plant height at 1450rpm blower speed and BCN nozzle set

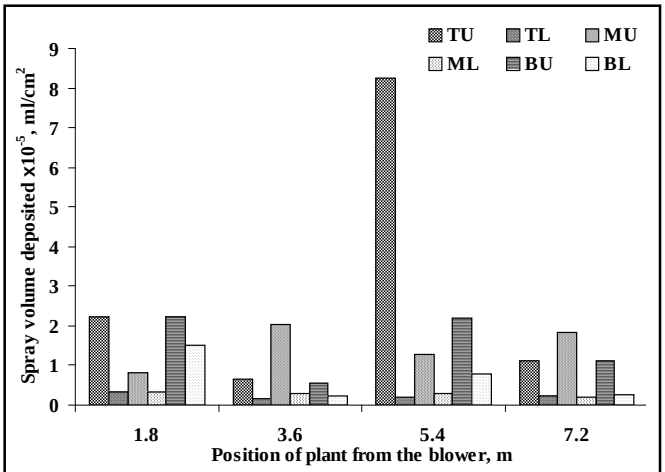

Fig. 3 : Spray deposition along the plant height at 1450rpm blower speed and NMD/S nozzle

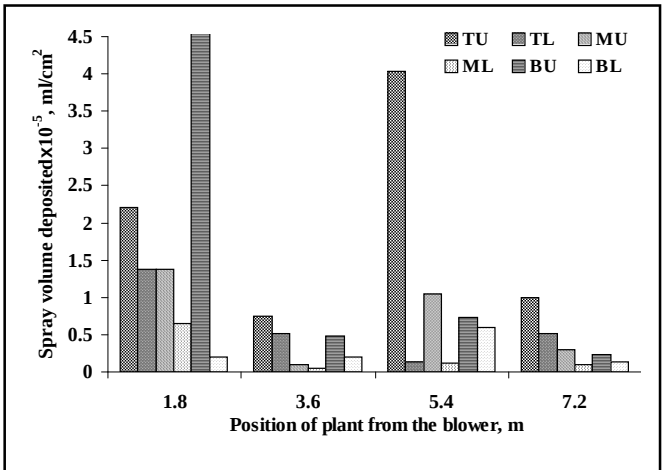

Fig. 4 : Spray deposition along the plant height at 1450rpm blower speed and HCN/PA nozzle

Field efficiency and fuel consumption and operating cost of a sprayer:

Field efficiency of the sprayer is the ratio of its actual field capacity and theoretical field capacity and was found to be 75.4 per cent. The fuel consumption of the tractor for the field operation was worked out during the field testing and it was found to be 4.00 lit/h and 3.55 lit/ha at 2 km/h tractor travel speed. The cost of spraying operation has been worked out to be Rs 214.00/ha at 2 km/h tractor travel speed.

Conclusions:

Most of the droplets were in the range of 0 - 151µm. It was found that 54.80 per cent droplets were in the range of 0 - 50 µm whereas 30.81 per cent were in the range of 51 – 100.

The droplet diameter with BCN nozzles were found to be better.

Spray volume deposition was obtained more on the upper leaf surface than on the lower leaf surface and volume deposition was more when HCN/PA nozzle set was used.

The better parameters *viz.*, droplet density, uniformity coefficient were obtained with NMD/S nozzle and HNC/PA, respectively.

The volume deposition along the swath was nearly uniform at 1450 rpm blower speed when HCN/PA nozzle set was used.

The three outlet type sprayer could cover a swath width of 7.5m in brinjal field and actual field capacity was found to be 1.13 ha/h at 2 km/h travel speed. The field efficiency of the sprayer was found to be 75.4 per cent.

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