Madras Agric. J., 85(5,6): 212 - 214 May, June 1998
https://doi.org/10.29321/MAJ.10.A00720

DEVELOPMENT AND TESTING OF DC MOTOR OPERATED KNAPSACK SPRAYERS

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ABSTRACT

Three types of knapsack direct-current motor operated sprayers working on the principles of hydraulic, pneumatic and centrifugal atomization respectively were developed and a study was carried out to compare the performance of the three sprayers in terms of spray distribution pattern and atomization characteristics. Among the three sprayers evaluated, centrifugal sprayer performed better with more uniform spray distribution and minimum energy expenditure over the other two sprayers.

KEY WORDS : DC motor operated sprayers, spinning disc sprayer, spray distribution pattern, atomization characteristics, battery service time per cycle.

Manually operated sprayers have the disadvantages of more water requirement, wide variation in droplet sizes and run-off losses of chemicals on plants (Attique and Shakeel, 1983 ; Chaudhury, 1984; Nyirendra, 1988, 1991 ; Bayat *et al.*, 1994). Annual expenditure of our nation in future on fuel to operate the power sprayers would be in the order of Rs. 2700 crores. This expenditure can be brought down by using DC motor operated sprayers. Therefore, three types of knapsack direct-current (DC) motor operated sprayers working on the principles of hydraulic, pneumatic and centrifugal atomization respectively were developed and tested to compare the spray distribution pattern and atomization characteristics of the sprayers.

MATERIALS AND METHODS

The knapsack DC motor operated hydraulic sprayer is operated by a 12 V, 17 W DC motor which drives a mini gear pump. The gear pump inlet was connected to a spray gun through a 5 kgf/cm^2 capacity pressure gauge. The spray gun was fitted with a hollow cone nozzle which is mostly used for spraying insecticides. In the knapsack DC motor operated pneumatic sprayer, a 24 V, 25 W motor coupled with centrifugal blower was used. An air outlet pipe was made of 1 mm thick galvanised iron (GI) sheet 475 mm long, 35 mm outer diameter (OD) at the inlet end and 10 mm OD at the outlet end. A 25 mm long nozzle with 1 mm bore was made of gun metal and fixed at the end of the air outlet pipe. The nozzle was connected to the 10 litre container by a 6 mm size plastic hose.

The knapsack DC motor operated centrifugal sprayer (spinning disc sprayer) consisted of a 98 mm OD spinning disc operated by a 12 V DC motor fixed at the end of an aluminum handle. Spray liquid was taken from a 10 litre container to the spinning disc through a plastic hose.

These sprayers were operated under no load and load at different voltages of a regulated DC power supply. The speed of DC motor was measured using a non-contact digital tachometer at each voltage level. The spray volume distribution pattern of each sprayer was determined using a spray patternator (Tajuddin, 1995) at different voltages and different liquid discharge rates. Spray volume collected in each measuring glass tube of the spray patternator was noted. Coefficient of variation (CV) was determined using the following expression (Ozkan *et al.*, 1992).

$$CV\ (\%) = \frac{\sqrt{\dfrac{(x_i - \bar{x})^2}{n-1}}}{\bar{x}}$$

where

x_i = spray liquid collected in ith channel of spray patternator, ml

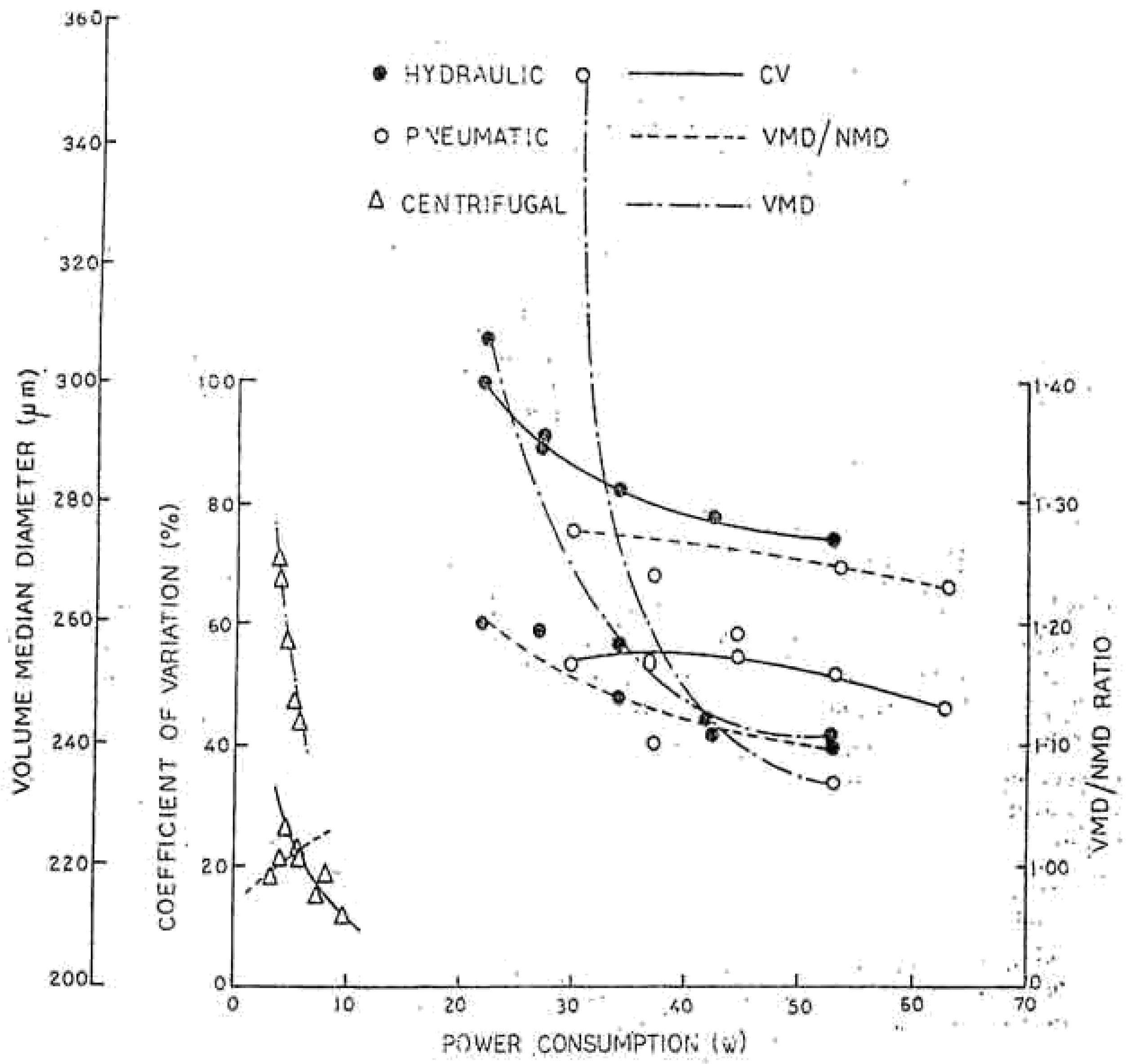

Fig.1. Comparision of CV, VMD and VMD/NMD ratio for DC Motor Opeated Sprayers

x = mean of spray liquid collected across the spray swath, ml

and n = number of channels on which the spray liquid was deposited.

A suitable water based dye (methylene blue) was added to water at 0.75 per cent weight by weight (Matthews, 1979). Spray droplets were captured on glazed bromide papers (Cunnigham *et al.*, 1962 ; Bindra and Singh, 1977 ; Pawar, 1988) of 40 x 40 mm size. After allowing 24 h for complete spreading of stains on the bromide papers, the stain diameters were measured in a biological microscope. Spray droplet diameters were found using a spread factor of 0.645 (Tajuddin, 1995). Volume median diameter (VMD) and numerical median diameter (NMD) of spray spectra emitted by the sprayers were computed.

The sprayers were operated continuously with fully charged battery until an apparent reduction in the rotational speed of DC motor was noticed. Battery voltage and motor speed were measured at regular time intervals

RESULTS AND DISCUSSION

The power consumed by the knapsack DC motor operated hydraulic sprayer varied from 22 to 53 W when the CV ranged from 74 to 99 per cent, power consumed by the pneumatic sprayer varied from 30 to 61W when the CV ranged from 46 to 55 percent and that by the by the centrifugal sprayer varied from 5 to 10 W when the CV ranged from 11 to 25 per cent (Fig. 1). Higher the CV, greater is the variation in the spray volume distribution (Azimi *et al.*, 1985). Comparison of the trends of the curves for hydraulic and pneumatic sprayers reveal that there is scope to reduce the CV for pneumatic sprayer rather than hydraulic sprayer.

The three types of sprayers were compared in terms of VMD and VMD/NMD ratio. The VMD ranged from 242 to 307 μm for hydraulic sprayer, from 234 to 350 μm for pneumatic sprayer and from 244 to 270 μm for centrifugal sprayer. The range of VMD was closer in the case of centrifugal sprayer. Optimum diameter of spray droplets for agricultural operations should be in the range of 200 to 300 μm (Himel, 1969). There is no advantage in VMD higher than 280 μm from drift control point of view. Centrifugal sprayer alone met the above requirements.

The VMD / NMD ratio of spray spectra of centrifugal sprayer was more closer to unity when compared to other sprayers. The more closer the VMD / NMD ratio to unity, more is the uniformity of spray droplet size distribution and narrower is the range of droplet size (Bode *et al.*, 1983). Though VMD obtained with hydraulic sprayer and centrifugal sprayer were close to each other, effective service time of battery per charge was only 1/2 h for hydraulic sprayer as compared to 8 h for centrifugal sprayer. The highest power consumption of hydraulic sprayer might be due to the mechanical losses in the gear pump.

Therefore, among the three types of sprayers tested the knapsack DC motor operated centrifugal (spinning disc) sprayer performed better in terms of minimum energy expenditure, more uniformity of spray distribution and maximum service time of battery per charge.

ACKNOWLEDGEMENT

The author records his gratitude to Dr.M.Balasubramanian, Dean, College of Agricultural Engineering, Kumulur for his help rendered during the study.

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(Received : March 1997 Revised : May 1998)