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COMPARISON OF SEVERAL SLIDE SAMPLING TECHNIQUES USED FOR COLLECTING ULV DROPLETS[1]

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ABSTRACT. Droplets of 95% malathion from a ULV aerosol generator were collected on silicone coated slides, using the "slide pendulum" and 4 hand waving techniques. The droplet distribution was characterized by calculating 7 parameters. These parameters were analyzed to determine the most consistent droplet distribution among the slide waving techniques examined. The vertical swing and "slide pendulum" samples taken 4 ft. from the nozzle showed the most consistent droplet distribution patterns. The vertically waved slides, taken at 25 ft., and the diagonally waved slides, taken at 8 ft., showed the least consistent droplet distribution patterns. In addition, the aerosol cloud was sampled at 3 vertical levels. The data suggest a relatively homogeneous droplet distribution within the cloud, 4 ft. from the nozzle.

Field sampling methods for collecting droplets produced by ultra low volume (ULV) aerosol generators should be quick, simple to conduct, relatively inexpensive, give repeatable and comparable data, and minimize the exposure of the sampler to the insecticide. Hand waving of treated slides is the most common technique currently in use, principally because it is quick, simple, inexpensive and specified by insecticide labels. To determine whether a machine is atomizing the insecticide properly, the collected droplets are compared based on the calculated volume median diameter (VMD). Other droplet parameters which may be analyzed include: the average drop diameter, and the percent of droplets in the 1–6 μ range, 6–18 μ range, 1–24 μ range and 32–48 μ range. A variety of different hand waving techniques have been reported in the literature. Peterson et al. (1976) used a horizontal swing at 25, 20 and 15 ft. Anonymous (1977) directed that cythion droplets may be collected by waving the slide perpendicular to the movement of the aerosol, 25 ft. from the nozzle. G. A. Mount, U.S.D.A. (personal communication) utilized a swing at a distance of 8 ft. from the nozzle at approximately a 45 degree angle to the move-

[1] The opinions and assertions contained herein are those of the authors and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large. This paper reflects the results of research only. Mention of a pesticide or a commercial or proprietary product in this paper does not constitute a recommendation or an endorsement of this product by the U.S. Navy.

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ment of the aerosol, to collect impinged droplets. Beidler (1975) used a "slide pendulum" device to compare droplets collected at 1, 2, 3, 4 and 5 ft. distances from the nozzle.

This paper presents comparative data on these sampling techniques showing the level of consistency observed for several droplet distribution parameters. In addition, observations are outlined on the results of slide samples taken at 3 vertical locations, at a fixed distance from the nozzle, to evaluate the homogeneity of the insecticide cloud.

MATERIALS AND METHODS

A LECO ULV (Model HD) cold aerosol generator, atomizing 95% malathion, was set at an operating pressure of 4 psi with a flow rate of 4.3 oz./min. for all of the samples reported on in this paper. The relative humidity was 70%. Air temperature was 80°F, while the insecticide temperature was 77°F. The nozzle was 40 in. above the parallel to the ground, pointing downwind of a 6 mph (5.5 kt.) breeze. Droplets were collected consecutively, by utilizing a sampling apparatus described by Beidler (1975) and by hand wave methods previously described. All droplets were collected on standard microscope slides coated with a 10% solution of "Dri-Film" silicone compound in a diluent of acetone. The slides were secured by a spring-type paper clip to either the distal end of the arm of the sampling apparatus (Beidler 1975) or on the end of a 3½ ft. wooden wand. The collecting surface of the slide faced the nozzle. Three slides were taken at each of the following locations: 4 ft. from the nozzle using Beidler's method; 25 ft. from the nozzle using a vertical swing (Anonymous 1977); 25 ft. from the nozzle using a horizontal swing (Peterson et al. 1976); and 8 ft. from the nozzle utilizing a diagonal swing (Mount, personal communication).

In order to sample the top, center and bottom sections of the insecticide cloud, a cardboard mailing tube 39 in. long with a 2 in. internal diameter was utilized. The tube was open at either end. A spring type paper clip was attached to the end of a long pole and the pole, with slide attached, was inserted in the mailing tube. The pole was marked so that 1 in. protruded through the distal end of the mailing tube when the mark was lined up with the proximal end of the tube. Slide samples were taken by holding the distal end of the mailing tube in the section of the cloud to be sampled while sliding the pole through the mailing tube to the predetermined mark, and then returning the slide into the mailing tube with a smooth rapid motion. Three samples were taken at each of 3 locations in the cloud, top, center and bottom at 4 ft. from the nozzle.

The droplet distribution was characterized for all slides by calculating 6 parameters: VDM, average drop size, percent of droplets under 6 μ, percent of droplets in 6–18 μ range, percent of droplets under 24 μ, percent of droplets over 32 μ, and the number of droplets over 48 μ. A mean was calculated for each parameter by averaging the data obtained from the 3 slide samples taken for each technique being evaluated. The consistency of the data for these 3 slides was determined by computing the percent of variability between the data extremes for each parameter analyzed. This was accomplished by dividing the difference between the high and low values by the sum of the 3 values, then multiplying by 100.

RESULTS AND DISCUSSION

Volume median diameters (VMD's) were determined by the American Cyanamid method, Anonymous (1977). Spread factors were calculated as described by Yeomans (1949). The American Cyanamid Company, Anonymous (1977), states that ULV droplets of malathion should not exceed a VMD of 17 μ with no droplets exceeding 48 μ. Further, more than one-half of the total spray mass must be droplets within the 6–18 μ range with a minimum of two-thirds of the spray mass not to exceed droplets of 24 μ, and no more than 3% above 32 μ. Table 1 shows the data for these parameters computed for each of the 5 sampling techniques. Only the samples collected at the 25 ft. distance fall within these restricted limits. The average size drop was observed to be quite small, at 8 ft. (7.3 μ) using the diagonal swing, and at 25 ft. (8.3 μ) using the vertical swing, because of the large percentage of small drops under 6 μ obtained for these samples, 15.1 and 23.2 respectively. These 2 sampling techniques also impinged the fewest droplets over 32 μ. As sampling distance away from the nozzle increases, the velocity of the droplets decreases. For impingement to occur the slide must be accelerated through the spray cloud or the spray cloud must be accelerated by the slide. As a result, the diagonal or vertical swing used for sampling away from the nozzle resulted in the collection of a much greater number of smaller drops than the technique of sampling with a horizontal swing at a distance of 25 ft. from the nozzle. Peterson, et al. (1976) showed that of the sampling variables tested, machine pressure and sampling distance from the nozzle were the only 2 variables statistically significant in effecting droplet distribution. The VMD was observed to decrease as sampling distance increased.

Since the velocity of air being generated at the nozzle is different in each type of ULV machine (Rathburn and Boike 1977), and even in individual machines at different pressure settings, it follows that a different droplet spectrum would be seen in each case. However, if the slide sample is taken close to the nozzle, droplet velocity will be sufficient to cause impingement on a stationary or vertically waved slide in all of the popular ULV models.

Slide sampling data may or may not represent the true droplet spectrum being generated by a ULV machine; therefore, precise droplet measurement techniques are required to determine actual ULV droplet emissions. When droplets are impinged and precisely measured, at the same distance from the nozzle, comparisons between the droplets actually being produced and those observed on the slide can be made. Each type of machine must be evaluated in terms of its optimum operation for proper droplet distribution parameters. Once these parameters are known for a given machine, all machines of its type, in field use, may be adjusted to produce that optimum droplet spectrum by using a slide waving technique for droplet analysis.

The most important factor to be considered when choosing a sampling technique is the repeatability or consistency of the technique. Table 2 presents comparative data for 4 droplet distribution parameters in terms of the percent of variability observed between the 3 slides taken for each of the 5 techniques. The greatest variability is seen in the diagonal swing technique at 8 ft. and the vertical swing technique at 25 ft., with an average per-

Table 1. Droplet distribution parameters for 5 slide sampling techniques.

Technique	Distance from nozzle (ft.)	Means[a] VMD μ	average droplet μ	% 6–18μ	% under 24μ	% over 32μ	% under 6μ	Total drops over 48μ
Pendulum	4	16.4	14.2	43.8	74.4	2.2	6.9	0
Vertical swing	4	17.6	14.9	46.5	72.1	3.8	2.3	1
Diagonal swing	8	15.3	7.3	43.5	87.0	1.3	15.1	0
Horizontal swing	25	16.4	13.6	57.0	80.6	3.0	3.8	0
Vertical swing	25	10.7	8.3	51.2	85.8	1.2	23.2	0

[a] Three slides per technique.

Table 2. Percent of variability[a] for certain droplet distribution parameters of 5 sampling techniques.

Technique	Distance from nozzle (ft.)	Percents				
		VMD	Average droplet	% 6–18μ	% under 24μ	Overall[b] average
Pendulum	4	1.8	9.4	10.4	3.2	6.2
Vertical swing	4	2.5	2.2	4.9	3.0	3.2
Diagonal swing	8	10.0	31.5	12.7	4.1	14.6
Horizontal swing	25	7.7	5.9	11.8	6.1	7.9
Vertical swing	25	40.4	43.4	30.3	15.7	32.5

[a] Difference between the high and low values divided by the sum of the values of all 3 slides x 100.

[b] Sum of the percentages of variability for each parameter shown ÷ 4.

cent variability of 14.6 and 32.5 respectively. The most consistent results were obtained at the 4 ft. distance with the pendulum and vertical swing technique. These 2 techniques may be considered to be synonymous as every effort was made to duplicate as nearly as possible, by hand, the pendulum's action. These techniques showed an average percent of variability of 6.4 for the pendulum technique and 3.2 by hand. A high degree of variability for all techniques was observed by analysis of data obtained for percent of droplets over 32 μ and percent of droplets under 6 μ. For the percent of droplets over 32 μ the percent of variation ranged from a low of 25.4 for the horizontal swing technique at 25 ft. to 85.7 for the vertical swing technique at the same distance. For the percent of droplets under 6 μ the percent of variation ranged from 17.4 for the pendulum technique at 4 ft. to 54.6 for the diagonal method of 8 ft.

Table 3 shows the data for the slides taken 4 ft. from the nozzle utilizing the mailing tube to take samples at three vertical locations within the cloud. The data are fairly consistent for each parameter except the highly variable parameters of percent of droplets over 32 μ and the percent of droplets under 6 μ. Table 4 confirms the consistency of these samples by comparing the average percent of variability for 4 droplet distribution parameters, showing little variability between samples taken at the 3 cloud levels. The data indicate a homogeneity with respect to droplet distribution within the insecticide cloud at a distance of 4 ft. from the nozzle.

Before ULV aerosol generators can be adjusted to perform at peak efficiency a method must be found to measure accurately the true droplet spectrum being produced. These data can then be correlated with a slide sample method to

Table 3. Droplet data from impinged droplets collected from 3 vertical locations in insecticide cloud[a].

	Means[b]						
	VMD μ	Average droplet μ	% 6–18μ	% under 24μ	% over 32μ	% under 6μ	Total drops over 48μ
Top	18.6	13.5	44.9	71.4	5.0	2.5	1
Center	17.2	10.7	49.1	71.6	3.8	4.9	1
Bottom	16.1	13.8	48.7	82.5	1.0	2.0	1

[a] All samples taken 4 feet from nozzle.

[b] Three slides per location.

Table 4. Percent of variability[a] for certain droplet distribution parameters from slide samples collected from 3 vertical locations in the insecticide cloud.[b]

	Percents				
	VMD	Average droplet μ	% 6–18μ	% under 24μ	Overall average[c]
Top	5.9	3.0	9.4	10.2	7.1
Center	7.8	16.8	3.3	2.5	7.6
Bottom	4.1	4.8	9.6	2.7	5.3

[a] Difference between the high and low values divided by the sum of the values of all 3 slides × 100.
[b] All samples taken 4 ft. from nozzle.
[c] Sum of the percentages of variability for each parameter shown ÷ 4.

provide for the droplet analysis needs of the worker in the field. The data presented in this paper suggest that vertically swinging a slide at a distance of 25 ft. from the nozzle provides the least consistent results of all the sampling techniques tested. Further, the use of the parameters of percent of droplets over 32 μ and percent of the droplets under 6 μ for droplet analysis is probably too inconsistent to be valid. By sampling at the 4 ft. distance from the nozzle using a vertical pendulum or simulated pendulum method all the requirements of a satisfactory field sampling method can be met. These requirements include simplicity and speed of operation, low cost and the capability of providing repeatable data while presenting a minimum exposure of the sampler to the insecticides.

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