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AIRBLAST SPRAYER OSCILLATOR PERFORMANCE IN FLORIDA CITRUS

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Abstract. **A field experiment was conducted to evaluate the performance of airblast sprayer oscillators in Florida citrus. The sprayer was operated with and without oscillators at 1, 2, 3, and 4 mph ground speeds. A spray solution, containing 240 ppm of elemental copper as a deposition tracer, was applied to grapefruit and orange trees in a complete randomized block experiment. Deposition samples were taken from one quadrant of 6 target trees, at 2 heights and 3 radial locations. Tracer copper deposit on the samples was determined by colorimetry.**

Neither air oscillation nor ground speed had a significant effect on spray deposition and oscillator x speed interaction was not significant. However, on both types of trees and in most sample locations, there were numerically more deposits without oscillators than with the oscillators.

Spray applications of Florida citrus are carried out mainly by airblast sprayers. They may be operated by a tractor power-take-off (PTO-powered) or by their own engine (engine-driven). In either design, the sprayers are equipped with a fan that generates an air flow to transport the spray droplets from the nozzles to the tree canopies. The need for efficient transport of the droplets to the targets and increased penetration into the tree canopy has brought about many changes in the design of the sprayers.

Beasley et al. (1) believed that spray-laden air must replace the air inside and around the canopy to result in a thorough coverage. Matthews (5) stated that increased air volume generally improves spray distribution. However, the air should have sufficient velocity to move the leaves and allow droplets to penetrate inside the canopy and reach the top of the tree. Brann (2) reported that air velocity fell off rapidly as the distance from sprayer outlet increased. In the tops of mature apple trees, velocity was generally less than 20 mph.

As an attempt to increase spray penetration inside the tree canopy, some sprayers are designed to generate oscillating air and/or droplet streams. Oscillation may be accomplished by different mechanisms, depending on design features of the sprayers. Johnstone (4), using a small airblast sprayer (10,000 cfm), reported good penetration of spray droplets into citrus trees when the air stream was oscillated at 20-25 cycles/min. The oscillation was produced by oscillating flaps of contra-rotating twin centrifugal fans. Brooks et al. (3), using an airblast speed sprayer in Florida citrus, observed improved spray deposition with air oscillation as compared to without oscillation.

Regardless of design differences, air oscillators are employed to improve deposition of the sprayers. However, their usefulness in Florida citrus applications have been questioned by some sprayer users. Oscillators increase the purchase price of the sprayer and require considerable maintenance to prevent malfunctioning. Furthermore, it has been reported that some sprayer operators remove the mechanism and operate their sprayers without oscillators.

The objectives of this study were: a) to characterize spray deposition of an airblast sprayer within the citrus tree canopy with and without oscillators and b) to determine the effect of the ground speed on the effectiveness of the oscillators.

Materials and Methods

The sprayer used in the test was an engine-driven airblast sprayer (FMC 9100). It had an air flow rate of ca. 100,000 cfm with average air velocity of ca. 90 mph (measured at air outlet) and was equipped with air oscillators. The oscillators or wobble plates were made of steel discs (8-10 inch diameter) and mounted at 12-22° angles on 5 shafts on each side of the sprayer (Fig. 1). Rotation of the shafts produced an oscillating air stream at ca. 60 cycle/min./in. During the spray applications without oscillators, the power train of the shafts were disconnected and the discs were locked in a position that prevented them from interfering with the air flow. This arrangement did not cause a noticeable deflection to the air stream.

The sprayer was operated at ground speeds of 1, 2, 3, and 4 mph, with and without oscillators. It delivered 30.3 gal/min of the spray liquid at ca. 160 psi pressure to apply 500 gal/acre at the one mph ground speed. Ten ceramic disc-core nozzles were used on each side. They were selected so that 2/3 of the spray discharge was from the top

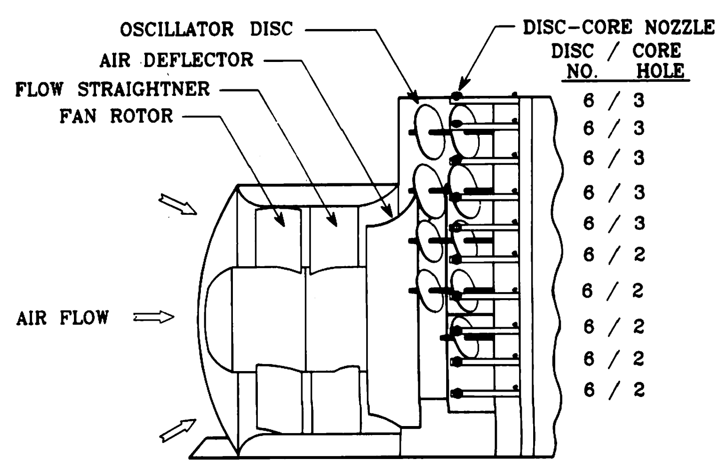

Fig. 1. Side view of the sprayer rear end, showing the locations of the nozzles and oscillators.

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5 nozzles and 1/3 from the bottom 5 (Fig. 1). Nozzle selection and sprayer output remained the same for all ground speeds; therefore, raw deposit data, corresponding to the speeds of 1, 2, 3, and 4 mph, were multiplied by speed factors of 1, 2, 3, and 4 to obtain comparable deposition data for all speeds.

The experiment was conducted in a commercial citrus grove near Lake Alfred, Florida, on 3 grapefruit and 3 orange trees. The grapefruit trees were in a 30 x 25 ft spacing, ca. 18 ft high, 24 ft wide and tree canopies touched in the rows. The orange trees were in a 30 x 20 ft spacing, ca. 15.5 ft high, 20 ft wide and canopies were freestanding. The orange trees had comparatively denser canopies than the grapefruit trees.

The trees were sprayed from both sides. The spray solution contained cupric hydroxide (50% copper) that provided 240 ppm elemental copper as a deposition tracer. Spray targets consisted of typical shoots, with 6-10 leaves, from the same grapefruit and orange trees. They were washed in a 0.05 N nitric acid solution, then in deionized water, and air dried. The clean shoots, free from residual copper deposits of previous applications, did not wilt or curl for several hours. Thus, they were considered to be very suitable targets for spray deposition assessment. They were placed at 6 locations inside each tree canopy (Fig. 2), at 2 heights (6 and 12 ft) and 3 radial locations (X, Y, and Z). Locations X and Y were 2-2.5 ft inside the canopy at 90° and 0° to the tree row line, and location Z was at the center of the tree (Fig. 2).

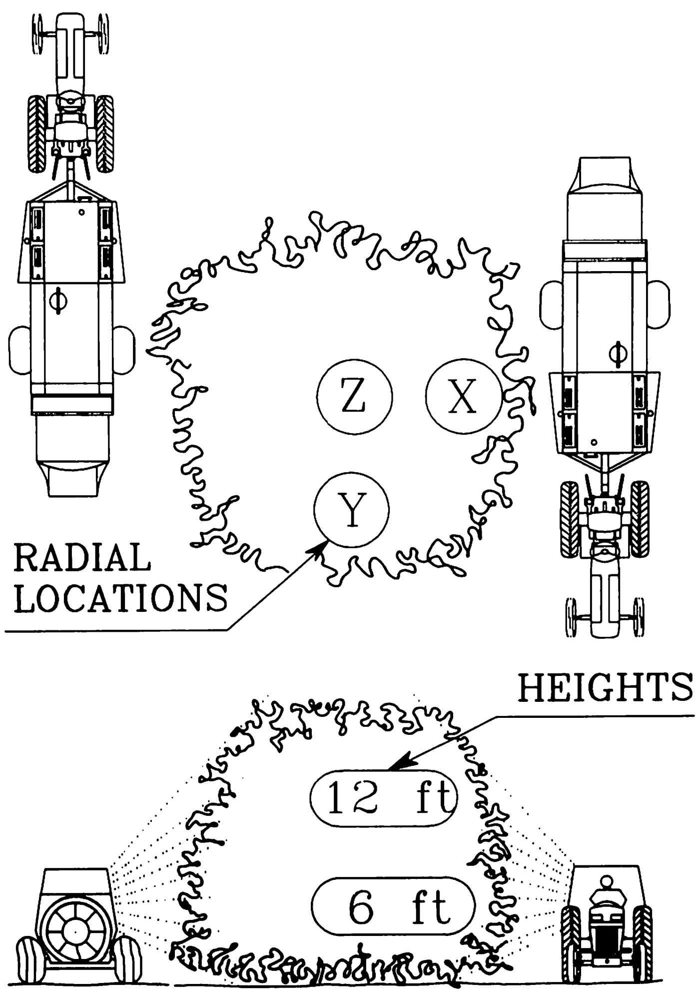

Fig. 2. Sample locations within the citrus tree canopies.

Table 1. Ranges of weather parameters during the test.[z]

Temperature (°F):	74.3 - 91.4	(at 10 ft)
	76.1 - 92.3	(at 20 ft)
Relative humidity (%):	35.0 - 65.0	(at 10 ft)
Wind velocity (mph):	3.5 - 5.5	(at 30 ft)
Wind direction (deg.)[y]	130 - 310	(at 30 ft)

[z]Recorded with a Campell Scientific CR-10 Weather Station.
[y]Measured clockwise with winds from the north = 0 °.

Following each round of spraying the 6 target trees, the shoots were retrieved from the trees. Three to 5 leaves of each shoot were placed in plastic bags and were taken to the laboratory for copper colorimetry (6). The amount of tracer copper deposit on the leaf samples was determined by a Hach DR-100 colorimeter and leaf surface area was measured with a Delta-T Type ABM area meter. Deposition data were calculated in oz/in^2 and variability of deposits among samples was expressed as the coefficient of variation (CV). The data were analyzed as a split-plot design, with oscillation and ground speed as main plot and sample locations as subplot effects, respectively.

Weather information was obtained with a Campbell Scientific CR-10 weather station. The ranges of temperature, relative humidity, wind velocity, and wind direction are shown in Table 1.

Results and Discussion

Statistical significance of results refers to F-values at 10% level. Oscillation did not have a significant effect on deposition. However, averaged over all speeds and canopy locations, spray deposition with the oscillators was 10.2% lower than that without (w/o) the oscillators. Overall, variability of deposition (CV) was slightly higher without the oscillators.

Sprayer ground speed (1-4 mph) did not have a significant effect on deposition and its interaction with oscillation was not significant (Fig. 3). Within each speed, spraying with the oscillators resulted in less deposits than without oscillators; however, the differences were not significant. In general, variability of deposition increased as ground speed increased.

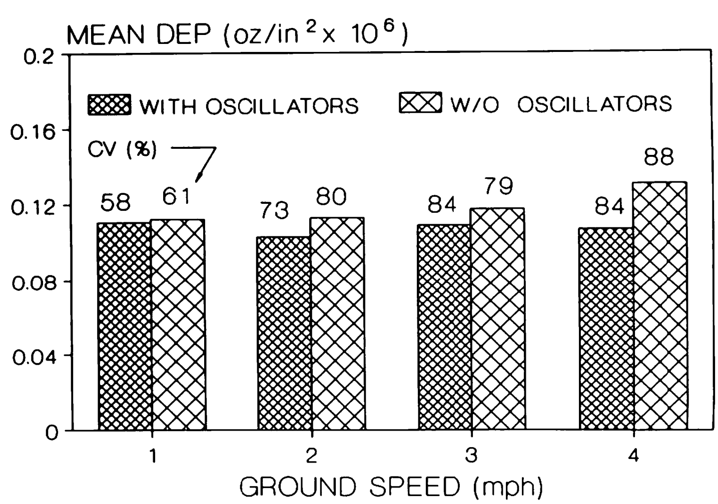

Fig. 3. Mean and variability of deposition at different speeds.

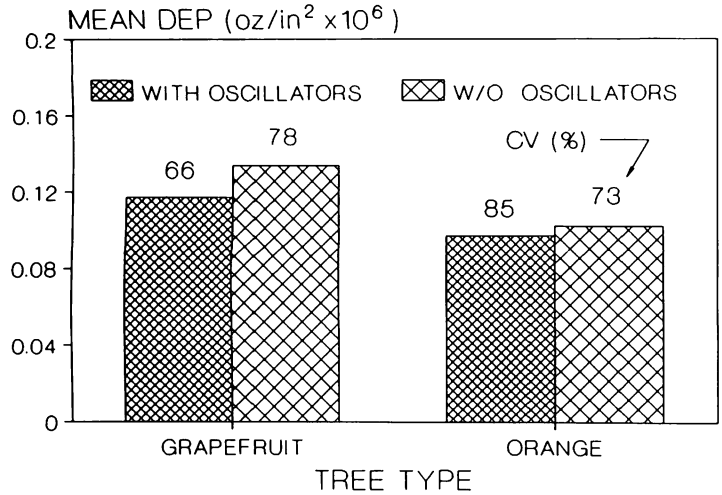

Fig. 4. Mean and variability of deposition on grapefruit and orange trees.

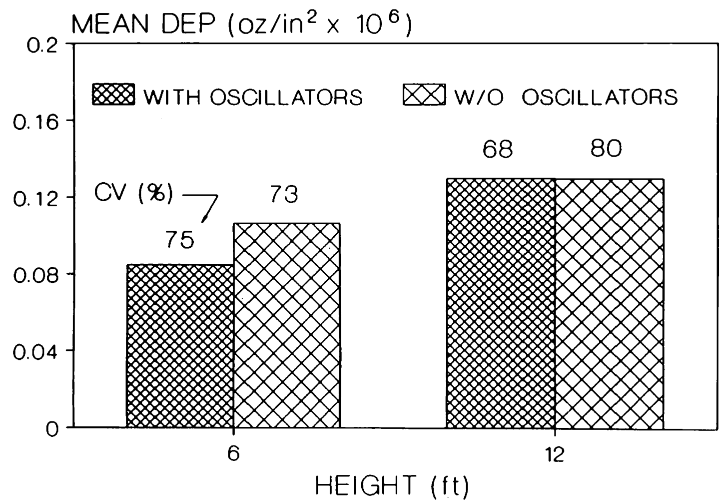

Fig. 5. Mean and variability of deposition at different sample heights.

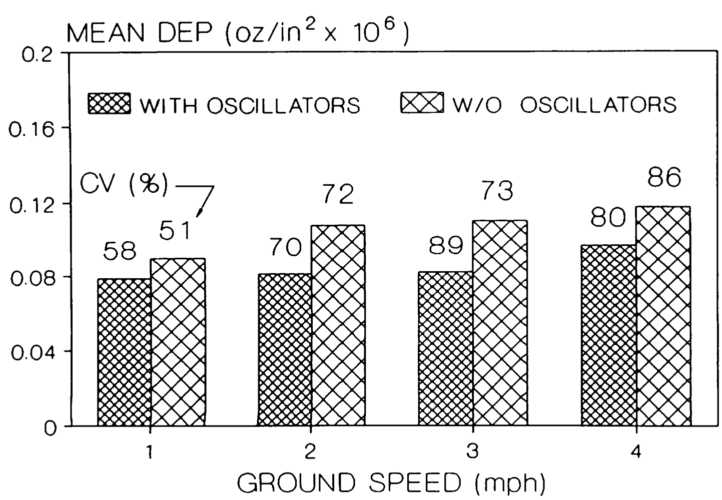

Fig. 6. Mean and variability of deposition at 6 ft height, for different ground speeds.

The orange trees, with relatively denser foliage, had less deposition than the grapefruit trees (Fig 4). On both types of trees, there were less deposits with the oscillators than without the oscillators; however, trends of the CV's, for the 2 tree types, were different.

The height and radial location of the samples had significant effects on deposition. The interaction of the sample height and oscillation was also significant (Fig. 5). While mean deposits at the 12 ft height were ca. the same with and without oscillators, they were significantly different at the 6 ft level. There was no interaction between ground speed and oscillation at 6 ft (Fig. 6) and mean deposits without oscillators were higher at all ground speeds. Overall, at the 6 ft level, spraying without oscillators resulted in 25.8% more deposit than with oscillators.

There was no significant interaction between oscillators and radial location (Fig. 7). In all radial locations, mean deposits were greater without oscillators; however, the differences were not significant. At location X (nearest to the sprayer), there were maximum mean deposits with minimum CV's. Location Y (on the tree row line), with high density foliage and increased distance from the sprayer, received minimum deposits with highest CV's. At location Z (tree center), mean deposits and CV's had intermediate values for both with and without oscillators.

While mean deposits at the radial location Y were ca. the same, with and without oscillators, there were different trends at Y (6 ft) and Y (12 ft) locations. In general, there were more deposits with oscillators than without oscillators at Y (12 ft) location (Fig. 8). This trend reversal may indicate that air oscillation may have been effective in transport of spray droplets to the higher and more difficult to reach canopy locations.

The overall lower deposits with oscillators suggests that air oscillation may have resulted in excessive shaking of the foliage at some canopy locations. Therefore, some portion of the impinged droplets may have been blown off from leaf surfaces. This may indicate that at the top of the tree, which is farthest from the sprayer and difficult to spray, air oscillation may become effective in increasing the deposition. The above argument may not be true at tree center where the air velocity is substantially less than that at X location.

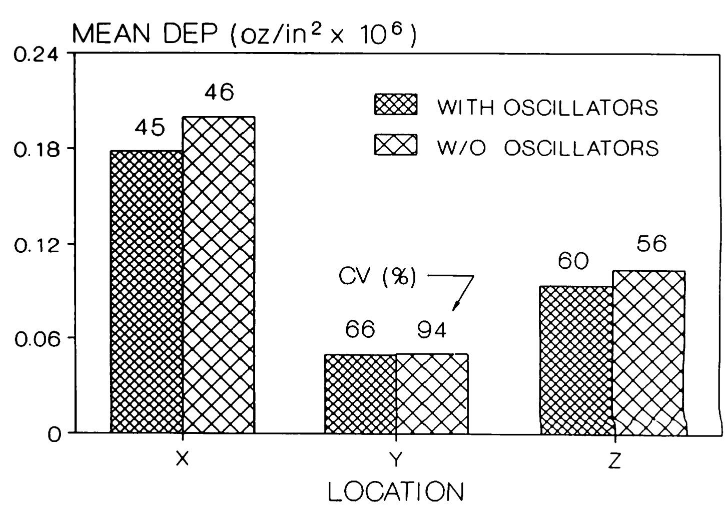

Fig. 7. Mean and variability of deposition on different radial locations.

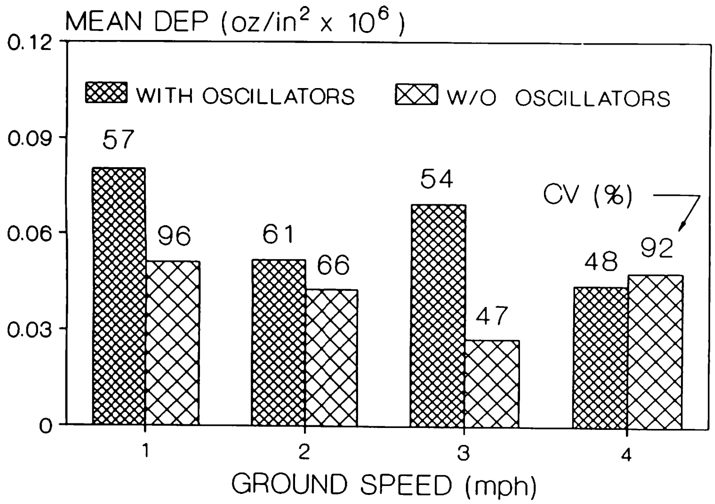

Fig. 8. Mean and variability of deposition at location Y (12 ft) for different ground speeds.

More detailed results of this test are given in Salyani and Whitney (7). These results do not agree with those of Brooks et al. (3) which showed significantly more deposition with oscillation. Brooks et al. (3) does not provide specific information about details of the sprayer and the test; however, we think that the difference in the results may be attributed to the differences in design of the sprayers and oscillators, type of the treated trees, spray application rates, weather conditions, and methodology of sampling and deposition assessment. It should be noted that this experiment was conducted with a relatively high air volume sprayer and with a certain design of the oscillators. Results could be different for lower air volume sprayers or different design of the oscillators. Therefore, the results should not be generalized for all kinds of sprayers.

Conclusions

Based on the results obtained with the above-mentioned sprayer, tree types, sampling locations, and deposition assessment technique, the following conclusions may be drawn from this experiment: a) air oscillation did not have a significant effect on spray deposition and b) sprayer ground speed of 1-4 mph did not interact significantly with oscillation.

Literature Cited

1. Beasley, E. O., J. Glover, and W. A. Skroch. 1976. Orchard spray equipment. North Carolina Agr. Ext. Service, Cir. AG-08, 34 p.
2. Brann, J. L., Jr. 1964. Factors affecting the thoroughness of spray application. Proc. New York State Hort. Soc. :185-195.
3. Brooks, R. F., W. L. Thompson, and P. T. Jutras. 1963. Evaluating spray equipment for Florida citrus. Proc. Fla. State Hort. Soc. 76:18-22.
4. Johnstone, D. R. 1970. High volume application of insecticide sprays in Cyprus citrus. PANS 16(1):146-161.
5. Matthews, G. A. 1982. Pesticide application methods. Longman Inc., New York.
6. Salyani, M. and J. D. Whitney. 1988. Evaluation of methodologies for field studies of spray deposition. Trans. of the ASAE 31(2):390-395
7. Salyani, M. and J. D. Whitney. 1990. Effect of airblast sprayer oscillators on deposition. ASAE Paper No. 90-1007.

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SPRAY PENETRATION CHARACTERISTICS OF THE AIR CURTAIN AND AIRBLAST SPRAYERS

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Abstract. **A copper-water spray was applied to one side of orange and grapefruit trees with a conventional (FMC Model 9100) airblast and an air curtain (AC) sprayer (CURTEC). Both sprayers were operated at 2.3 gal/min per side and 1.5 mph ground speed. Mean deposition of copper on the sampled leaves was greater for the conventional sprayer than that for the AC sprayer. The coefficients of variability of the deposits were 105 and 110% for the AC and conventionl sprayers, respectively.**

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In 1985, the Citrus Research and Education Center at Lake Alfred initiated pesticide application work in citrus after more than a decade of relatively little activity in this research area. Much of this work has been field experiments designed to provide performance data which should be helpful to the citrus grower and sprayer manufacturer in minimizing pesticide application costs. Whitney et al. (8) determined the horsepower requirements and measured the deposition characteristics of PTO airblast sprayers in 'Valencia' orange trees. Subsequently, airblast sprayer ground speeds from 1 to 2.5 mph and spray volumes from 125 to 500 gal/acre were reported by Whitney et al. (10) not to significantly affect spray deposition or greasy spot control in mature grapefruit trees. In addition, Salyani and Whitney (3) found that ground speeds varying from 1 to 4 mph with a large airblast sprayer did not have a significant effect on spray deposition in the citrus canopy; these tests were conducted at both a constant 250 gal/acre and a constant sprayer output which resulted in 500 gal/acre at 1 mph to 125 gal/acre at 4 mph. Using a large airblast sprayer with tower, Salyani et al. (4), Salyani and McCoy (2), and McCoy et al. (1) showed that spray deposition and rust mite control on orange trees were essentially the same for spray volumes from 25 to 500 gal/acre.