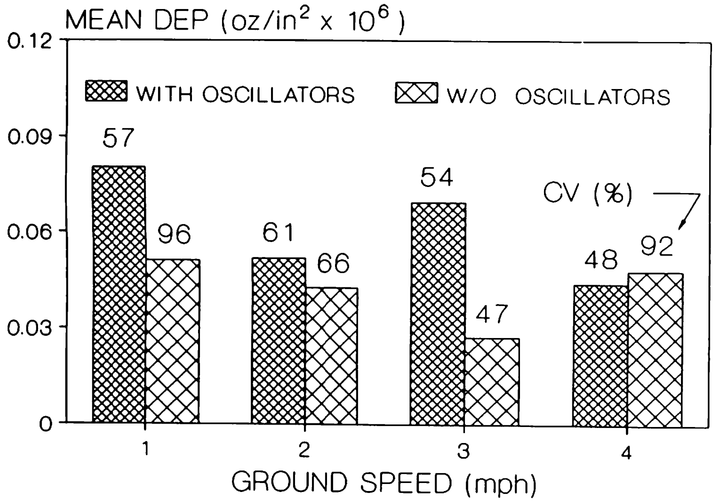

Fig. 8. Mean and variability of deposition at location Y (12 ft) for different ground speeds.

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.

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Proc. Fla. State Hort. Soc. 103:25-28. 1990.

SPRAY PENETRATION CHARACTERISTICS OF THE AIR CURTAIN AND AIRBLAST SPRAYERS

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Additional index words. Deposition, citrus trees, colorimetry.

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.**

Florida Agricultural Experiment Station Journal Series No. N-00300. Acknowledgements: The authors are grateful to Ralph Stalnaker and Haines City Citrus Growers Association for providing the grove to conduct this experiment and wish to acknowledge the valuable technical assistance of Joe Serdynski and Axel Santiago in conducting the tests and the preparation of this paper. Trade names and company names are used in this publication solely for the purpose of providing specific information and do not constitute a guarantee or warranty or an endorsement of the product by the University of Florida.

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.

Van Ee et al. (7) and Van Ee and Ledebuhr (6) researched and developed the "Air Curtain" sprayer in the U.S. during the 1980's. This sprayer uses rotary atomizers to produce spray droplets which are carried to the target in an air stream generated by cross-flow fans. The cross-flow fan principle had previously been used in Germany and later in England (5). With this system in tree crop spraying, the air and spray are generally delivered parallel to the ground on trees up to 20 ft in height. Van Ee et al. (7) stated that "the cross-flow or tangential fan produces a relatively non-turbulent 'straight stream' flow. In comparison, the axial, turbine, and centrifugal fans used in current sprayers produce high speed, turbulent outputs."

Van Ee et al. (7) and Van Ee and Ledebuhr (6) reported on field tests with the "Air Curtain" and a conventional (not specified) air carrier sprayer in mature Florida grapefruit trees. They reported that the "Air Curtain" sprayer provided uniform spray deposition on mylar targets located throughout the canopy even when spraying from only one side of the tree, while the conventional air carrier sprayer provided less uniform spray deposition even when spraying from both sides of the trees and at higher gal/acre rates. These results suggested that the "Air Curtain" sprayer, as compared with a conventional air carrier, achieved more uniform deposition at twice the field capacity (acres/hr) and lower gal/acre rates; and, thus, could apply chemicals more uniformly with a significant reduction in application costs.

In other Florida field tests (2, 3, 4, 8, 9, 10) with conventional airblast sprayers, spray deposition varied considerably in the citrus tree canopy and generally decreased with increasing distance from the sprayer. When spraying from both sides of the tree at ground speeds of 1 to 4 mph, spray deposits on leaves along the tree row centerline averaged 30 to 40% of the deposits at the outer tree canopy nearest the sprayer. When trees were sprayed from only one side at ground speeds of 1 to 4 mph, spray deposits on cotton ribbons at the tree row centerline and canopy side opposite the sprayer averaged 20% and 15%, respectively, of the deposits at the outer tree canopy nearest the sprayer.

After the "Air Curtain" sprayer was introduced into Florida, inquiries were received from several Florida citrus growers about its performance. Therefore, it was decided to make a comparative study of the performance of the "Air Curtain" sprayer and a conventional citrus air carrier sprayer when spraying from only one side of orange and grapefruit trees.

Materials and Methods

The field experiment was conducted in an orange and grapefruit grove near Lake Alfred in April, 1989. Tree rows were north-south with a between-row spacing of 30 ft for both orange and grapefruit trees. The in-row spacings, however, were 25 and 20 ft for grapefruit and orange trees, respectively. The grapefruit trees had developed natural individual canopies 18 ft high; near ground level, the canopies touched in-row and their cross-row diameters were 25 ft. In contrast, the orange tree canopies were 15 ft high and 20 ft in diameter near ground level and were standing as individual trees because of missing or very small adjacent trees in-row. In addition, the orange trees had developed relatively dense regrowth (foliage) in the center of the canopies as the result of considerable freeze damage to the outer canopy during the early to mid-1980's.

The 2 sprayers compared in this field experiment were a PTO-powered CURTEC (air curtain, hereafter called AC) and an engine-driven FMC Model 9100 (conventional air carrier). The AC sprayer was single-sided with 4 cross-flow fans and 1 rotary atomizer per fan, while the conventional sprayer was 2-sided with the 1 side used for spraying containing 7 FMC ceramic nozzles. Each sprayer was calibrated to discharge a copper-water mixture of 650 ppm elemental copper, at 2.3 gal/min per side at a ground speed of 1.5 mph, making the application 25 gal/acre spraying from one side. Trees were sprayed only from the east side with the sprayers moving in a southerly direction.

Three orange and 3 grapefruit trees with uniform canopies were selected for the tests. Eighteen target positions (6 locations at 3 heights, Fig. 1) were selected in each tree to characterize the deposition of the sprayers. The target heights for the orange and grapefruit trees were 4, 8, and 12 ft and 5, 10, and 15 ft, respectively. Locations 1 through 4 were in a line perpendicular to the tree row with location 1 being near the outside of the canopy nearest to the sprayer discharge, 2 and 4 were about 2 ft inside the canopy, and 3 was at the tree center. Locations 5 and 6 were in the tree row line about 2 ft inside the canopy on the leading and trailing edges of the canopy (with respect to the direction of sprayer travel). All 6 trees were sprayed once in the morning and again in the afternoon of the same day. In the morning, 2 orange trees and 1 grapefruit tree were sprayed with the conventional sprayer while 2 grapefruit trees and 1 orange tree were sprayed by the AC sprayer. In the afternoon, the spray order was reversed.

Shoots containing 5 to 10 leaves were clipped from other trees in the grove and taped to the 6 experiment trees as spray targets. Three to 5 leaves from each shoot was used to analyze the copper deposition (9).

In the morning, the winds averaged 5 mph from the SSE with dry bulb and dew point temperatures of 72 and 55°F, respectively. In the afternoon, the winds averaged 13 mph from the SSW with dry bulb and dew point temperatures of 73 and 57°F, respectively.

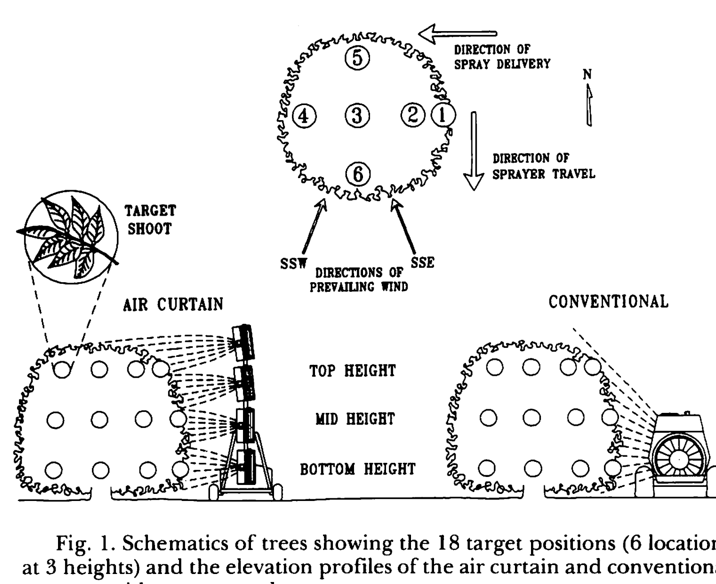

Fig. 1. Schematics of trees showing the 18 target positions (6 locations at 3 heights) and the elevation profiles of the air curtain and conventional sprayers with respect to the tree canopy.

Table 1. Means and coefficients of variability (CV) of copper deposits on leaves.

	Tree type		Time of day		Sprayer type		Height in tree			Location in tree					
	Orange	Grapefruit	AM	PM	AC[z]	Conv[y]	Bot	Middle	Top	1	2	3	4	5	6
Mean[x] (oz/inch^2 x 10^{10})	179	226	189	214	160	244	233	210	164	422	340	128	96	116	105
CV (%)	124	103	113	113	105	110	96	124	118	69	87	73	112	85	93

[z]"Air Curtain" CURTEC.
[y]"conventional" FMC Model 9100.
[x]Means in table must be multiplied by 10^{-10} to obtain oz/inch^2.

Results and Discussion

The analysis of variance was performed on the log of the copper deposit values to stabilize the variances (9). Statistical significances of results, where mentioned, refer to F values at the 5% level.

The arithmetic means and coefficients of variability (CV) of the several factors in the experiment are shown in Table 1. The "least-squares" means associated with tree type, sprayer type, height, and location are given in more detail in Table 2. The least-squares means were adjusted (see footnote in Table 2) relative to the arithmetic means to remove the time of day bias due to unequal replication of sprayers across tree types in the morning and afternoon.

Table 2. Deposit means[z] (oz/inch^2 x 10^{10}) of tree type, sprayer type, height, and location.

Tree type	Sprayer type	Location 1	2	3	4	5	6	Avg.
		Bottom height						
Orenge	AC[y]	255	130	128	16	96	96	121
	Conv[x]	606	408	132	50	128	114	239
Grapefruit	AC	422	358	203	178	153	84	233
	Conv	454	634	249	290	105	267	333
		Mid-height						
Orange	AC	130	100	71	27	46	43	68
	Conv	659	454	103	62	75	84	239
Grapefruit	AC	568	385	112	157	182	57	244
	Conv	378	846	148	66	130	141	285
		Top height						
Orange	AC	463	91	112	82	66	43	144
	Conv	686	385	132	78	87	130	249
Grapefruit	AC	260	125	66	68	264	71	144
	Conv	196	164	82	89	43	135	119
		All heights						
Orange	AC	283	107	103	41	68	62	112
	Conv	650	415	121	64	96	109	244
Grapefruit	AC	417	290	128	135	201	71	205
	Conv	342	549	160	148	93	180	246

[z]Deposit means were adjusted using the least-squares method of analysis. Arithmetic means can be obtained by subtracting a value of 5 from the above Conv x orange and AC x grapefruit least-squares deposit means; adding a value of 5 to the above Conv x grapefruit and AC x orange least-squares deposit means. To obtain oz/inch^2, means in table must multiplied by 10^{-10}.
[y]"Air Curtain" CURTEC.
[x]"Conventional" FMC Model 9100.

From Table 1, the overall mean copper deposition of the conventional sprayer was significantly higher than that of the AC sprayer. The effects of height and location in the tree were significant. Overall, deposits decreased with increased height. Deposits were markedly reduced with increasing distance from the sprayer discharge inside the canopy. The average deposit at location 4 (farthest from sprayer) decreased to 23% of the deposit at location 1 (nearest to sprayer) and were similar to those reported by Salyani and Whitney (3). The coefficients of variability (CV's, Table 1) for the various factors in the experiment ranged from 69 to 124% and were comparable to those measured in other field experiments (3, 10).

The sprayer type x tree type interaction was significant while the sprayer type x location interaction was not. The bottom of Table 2 shows the least-squares means associated with these interactions. The average deposits provided by conventional sprayer were similar for both tree types while those for the AC sprayer were considerably less in the orange than in the grapefruit trees. The mean deposit with the AC sprayer in the orange trees was significantly less than that with the conventional sprayer. In grapefruit trees, however, the deposits provided by the 2 sprayers were not significantly different. For all heights combined, the deposits with the conventional sprayer were numerically greater than those with the AC sprayer at locations 2, 3, 4, and 6 in the grapefruit trees and at all 6 locations in the orange trees.

Although the sprayer type x height interaction was not significant, the overall averages in Table 2 show differences in sprayers within tree type. In the grapefruit trees, deposit means decreased with increasing height for the conventional sprayer more so than for the AC sprayer. In the orange trees, however, deposit means for the conventional sprayer were about the same for all heights; whereas the deposit means of the AC sprayer at the mid-height was considerably less than at the other heights. For the conventional sprayer, the top height of the grapefruit trees were apparently more difficult to spray than that of the orange trees; this may have been due in part to the larger size of the grapefruit trees. For the AC sprayer, the lower deposition at the mid-height in the orange trees may have resulted from the dense inner canopies. Also, the low values at most locations (particularly location 1) at the mid-height (Table 2) suggest the spray from the rotary atomizers may not have completely merged to form a continuous, uniform pattern at the 8-ft height (Fig. 1).

As discussed earlier, the deposition of both sprayers generally decreased at greater distances into the canopy. One exception to this was the conventional sprayer in grapefruit trees at the 2 lower heights. The deposition at location 2 was substantially more than it was at location 1, near the sprayer discharge. This result may suggest that where the sprayer discharge was very near the canopy, the air volume and velocity of the conventional sprayer were too high to allow maximum deposition on outer canopy.

In contrast to previous reports (6, 7), the AC sprayer did not provide uniform deposition throughout the grapefruit tree canopy when spraying from only 1 side. Possible reasons for this may have been differenes in foliage density, wind conditions, ground speed, spray application rate, and deposition assessment methodology.

Although the prevailing wind speeds during this test were not abnormally high for spray applications in the citrus industry, they may have affected the deposition performance of each sprayer differently. The AC sprayer discharged spray at about 12 ft horizontal distance from the tree center, as compared to about 10 ft for the conventional sprayer. Because the AC sprayer discharge was farther from the tree canopy and had a smaller air volume flow rate and discharge velocity, wind could have disrupted its spray pattern more than with the conventional sprayer. The design of the AC sprayer used in this test allowed the fan discharges to be pointed at the tree canopy but did not allow the fan discharges to be configured near the profile of the tree canopy as was done with the model of the AC sprayer used in previous tests (7).

The lower overall deposition in the orange trees was probably due in part to their inner canopies being denser than the grapefruit trees. For locations 2 through 6 (inside the tree canopies), the mean deposition was 119×10^{-10} oz/inch^2 in the orange trees and 194×10^{-10} oz/inch^2 in the grapefruit trees.

For these tests, tree types, and weather conditions, the conventional sprayer deposited an average of 52% more copper than did the AC sprayer and was statistically significant. The mean deposit of the conventional sprayer was essentially the same in both tree types while the mean deposition of the AC sprayer in the orange trees was 55% of that in the grapefruit trees. Overall, the CV's of the deposits were 105% and 110% for the AC and conventional sprayer, respectively.

Conclusions

Based on the citrus tree and weather conditions of these tests with both sprayers discharging 2.3 gal/min per side at 1.5 mph ground speed, the following conclusions can be drawn:

1. The mean spray deposit of the AC (CURTEC air curtain) sprayer was significantly less than that of the conventional (FMC Model 9100) sprayer in orange trees, but not significantly less in grapefruit trees.
2. The overall coefficients of variability of spray deposits in both citrus tree types were similar for both sprayers.

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DISTRIBUTION OF FULLER ROSE BEETLE (COLEOPTERA: CURCULIONIDAE) IN FLORIDA FLATWOODS SOILS

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Additional index words. Pantomorus cervinus, edaphic factors.

Abstract. **Distribution of larvae and pupae of Fuller rose beetle, *Pantomorus cervinus* (Boheman), was not influenced by pH or % soil moisture during late winter and early spring in the citrus groves on Oldsmar and Sunniland fine sands in the flatwoods of Florida's east coast. Immatures were present in soils with moisture ranging from 0.14 to 20.50%. The range of pH's in which immatures were found, 3.9 to 8.2, suggests that management of populations by adjusting soil acidity would fail. Only soil depth affected distribution. Ninety-four percent of the larvae and pupae were within 15 cm of the soil surface during the February-May period.**

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The first published record of Fuller rose beetle (FRB), *Pantomorus cervinus* (Boheman), as a pest of citrus may have appeared in Comstock's Report of the Entomologist for 1879 (3). Chittenden (2) also cited reports of foliar feeding injury to citrus in Fullerton, CA, filed in 1892 and from National City, CA, in 1896.

While the root feeding habit of the larvae was known to be very destructive to foliage plants (5, 10, 14), the extent of injury to the root system of citrus was not appreciated until 1937 (6) when Hely reported it in an Australian orchard. Both Hely (7), and Dickson (4) in Califor-