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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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 California, reported on the distribution of the larvae within the soil of infested plantings but neither author specified the soil types of the orchard studied.

The purpose of the present study was to determine the distribution of larvae and pupae in 2 flatwoods soils common in the Indian River Area of Florida's east coast.

Materials and Methods

Research was conducted in groves planted on Oldsmar fine sand and Sunniland fine sand (1). Oldsmar is an imperfectly drained acid soil characterized by the presence of an organic hardpan within 35-76 cm of the surface. Sunniland is an imperfectly drained shallow soil overlaying clayey sediments. Soil was sampled beneath the tree canopy to within 60 cm of the trunk. Excavations closer to the trunk were impractical because of the presence of robust basal roots. When a site was sampled, the area was hand-weeded and 0.3 m^3 of soil carefully removed to obtain 4 distinct soil depths representing 0-7.6, 7.6-15.2, 15.2-22.9, and 22.9-30.5 cm levels. This was accomplished by using a 5 cm ID soil corer with an adjustable depth gauge. Cores were gently broken up by hand as they were 'pulled' to facilitate collection of any pupae or large larvae and sifted through a 7 mm mesh screen, pooled, and taken to the laboratory. The soil aggregate representing each depth was thoroughly hand-mixed, sampled for soil moisture and pH determination, and washed through mosquito screen to recover any larvae overlooked in the field.

Values for pH were determined by adding 50 ml distilled water to 25 g of air-dried, sifted, soil, permitting it to stand, and then vigorously re-stirring just prior to reading the pH on a calibrated Beckman Zeromatic II instrument. Percent soil moisture was obtained from 300 g samples oven-dried at 105°C for 24 hr, cooled, and reweighed.

Soil under six 13-year-old 'Duncan' grapefruit trees in Gwathmey grove (GG) in Indian River county was sampled during March and April of 1963. Twenty, 7, and 28 areas, respectively, under 13-year-old 'Valencia' orange trees in Varn (VG), 12-year-old 'Murcott' trees in Shawnee (SG), and 7-year-old 'Marsh' grapefruit trees in Hoeffner (HG) groves in St. Lucie county were sampled during Feb-Apr. 1964, Apr.-May 1967, and Mar.-Apr. 1968, respectively. Peak adult emergence occurs in mid-May (8), therefore soil sampling was conducted during the Feb.-May period when most larvae would be full-grown and easily seen.

Regression analyses were performed to determine if relationships between each soil parameter and number of each insect stage (larval and pupal) occurred. A split block experimental design was used with location as main plots and soil depth as split plots. Mean separation was performed using the Duncan's multiple range test, 5% level.

Results and Discussion

A total of 320 FRB larvae and pupae were unearthed. They were found in soils that had pH's ranging from 3.9 to 8.2 and soil moisture levels of 0.14 to 20.50%. Larvae and pupae were found in greater number within 7.62 cm of the soil surface than any of the deeper collections at GG, HG, and VG (Table 1). Only the Sunniland soil of Shawnee Grove (SG) harbored a significant number of immatures at the 7.63-15.25 cm depth. The absence of a hardpan in this soil may have had an unexplained influence on the distribution of immatures captured during Apr.-May excavations. Vertical distribution of larvae + pupae was not correlated with pH or soil moisture although Maskew (11) reported that the depths to which grubs penetrated the soil under strawberries appeared to be governed to a great extent by moisture: a 5 inch (12.7 cm) depth in dry soil, a 2 inch (5 cm) depth in moist irrigated soil.

Table 1. Distribution of Fuller rose beetle larvae + pupae in 4 groves planted on flatwoods soils of Florida's Indian River area.

Soil depth (cm)	Location[z] GG	HG	SG	VG
	$\bar{X}$ no. larvae + pupae			
0 - 7.6	2.6 a[y]	4.8 a	5.3 a	4.4 a
7.6 - 15.2	0.8 b	0.7 b	4.7 a	1.5 b
15.2 - 22.8	0.0 b	0.1 b	1.0 b	0.0 b
22.8 - 30.4	0.0 b	0.0 b	0.4 b	0.0 b

[z]GG = Gwathmey Grove; HG = Hoeffner Grove; SG = Shawnee Grove; VG = Varn Grove.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

Hely (7) found larvae mainly 15.2 to 20.3 cm deep in the root zone with some found at a depth of ca. 25.4 cm in an undescribed soil. The larvae in his study were concentrated in the zone beneath the spread of branches and, in one excavation that extended from dripline to trunk, tended to be more numerous nearer the tree trunk. Tarrant and McCoy (15) found that another weevil pest of citrus, the little leaf notcher, *Artipus floridanus* Horn, did not show this tendency but occurred in ca. equal numbers within 0-25 cm and 25-50 cm zones out from the trunk of 1-year-old 'Navel' orange trees planted in St. Lucie sand. Significantly greater numbers were recovered from a depth of 7.5-15.0 cm than from either 0-7.5 cm or 15.0-22.5 cm depths. The depth at which a majority of the immatures were found corresponded to the depth containing the greatest mass of roots. Ground traps placed by Kovach and Gorsuch (9) at the base of peach trees in a South

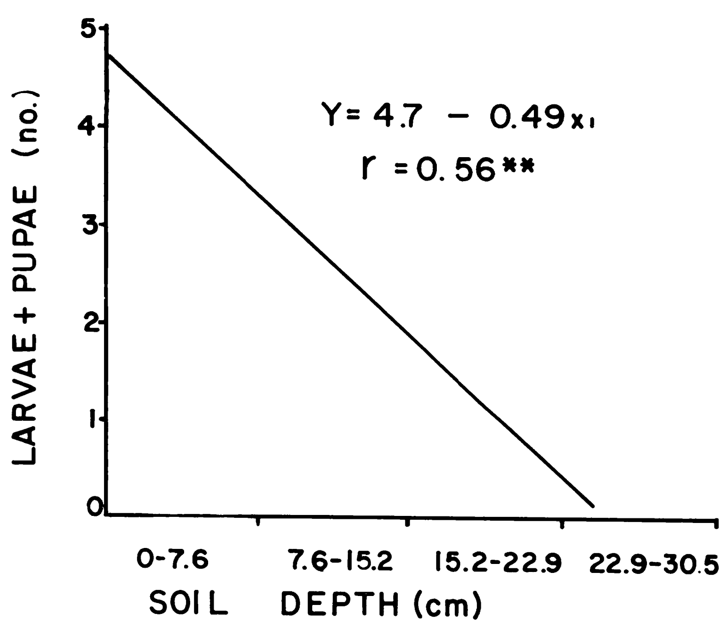

Fig. 1. Relationship of larvae + pupae population to soil depth.

Carolina orchard caught 70% of the adult FRB emerging from the soil whereas only 28% were trapped at the drip-line. This trend was not apparent in the current study because the extensive root system radiating out from the base of the tree prohibited digging close to the tree trunk. Dickson (4) reported larvae at depths from 7.62 cm to 60.96 cm in citrus groves, both between and beneath trees. Pupation occurred usually within 10 cm of the soil surface.

While influence of pH on distribution of several turf pests has been investigated (12, 13, 16, 17, 18), the presence of FRB larvae + pupae in soils with such a wide range of pH suggests that its management by adjusting acidity of flatwood soils with lime or sulfur applications might be ineffective.

The proximity of immature FRB to the soil surface from Feb. through May in the flatwoods soils of the Indian River area of Florida (Fig. 1) may make shallow digging in soil beneath the tree canopy a practical method of confirming the presence of active FRB infestations in groves where foliar feeding damage has been found.

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FERTILIZATION, NITROGEN LEACHING AND GROWTH OF YOUNG 'HAMLIN' ORANGE TREES ON TWO ROOTSTOCKS

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Abstract. **Five experiments were conducted with newly planted 'Hamlin' orange trees (*Citrus sinensis* [L] Obs.), 1 in 1987 and 2 in 1988 using sour orange rootstock (*C. aurantium* L.) and 2 in 1989 using Carrizo citrange rootstock (*C. sinensis* x *Poncirus trifoliata* [L.] Raf.) to determine optimum fertigation rate and application frequency, to compare fertigation with granular fertilizer, and to monitor N leaching in the soil. Experiments were conducted on a Ridge- or flatwoods-type soil. Irrigation was maintained at optimum levels (20% soil moisture depletion) and all treatments were irrigated equally. Soil samples were taken at 0-15, 16-46 and 47-76 cm depths the day before the third major fertilization date and thereafter at weekly intervals the day after each fertigation. No difference in growth occurred in 1987 or 1988 on sour orange rootstock in response to fertilizer type (granular vs. liquid) or application frequency (granular 3 and 5, or liquid 3, 5, 10 and 30 times/year). However, during 1989 'Hamlin'/Carrizo growth was greatest on the Ridge-type soil using the 30 time/year treatment. There was a positive linear correlation between fertilization rate and trunk diameter for both Ridge- and flatwoods-type soils in 1989, with maximum growth occurring at the 0.23 kg rate. Nitrate and ammonium concentrations fluctuated seasonally and increased significantly at the 15 and 46 cm depths after fertilization and rainfall. There was considerably more nitrate leaching at the 0.23 kg granular rate applied 5 times/year compared with the 10 or 30 time/year liquid treatments.**

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Since 1988 over 48,000 ha of citrus have been planted in Florida (7), most of which are irrigated using microirrigation systems. Consequently, fertigation is also becoming increasingly popular for newly planted groves (18). The increased use of fertigation has led to many questions concerning optimum fertilizer rate and frequency of application for liquid materials. Reuther et al.(16) found a positive correlation between growth of mature citrus trees and number of fertilizations in an 8-year study. Conversely, Rasmussen and Smith (15) found no effect of application