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RESPONSE OF *DIAPREPES ABBREVIATUS* (COLEOPTERA: CURCULIONIDAE) TO APPLICATION CONCENTRATIONS OF A PARTICLE FILM

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Kaolin-based particle films were developed for horticultural applications as an environmentally benign method to deter arthropod pests and plant diseases (Glenn et al. 1999). Since the commercialization of a wettable powder formulation (Surround® WP, Engelhard Corp., Iselin, NJ), this product has been examined for applications against pests of temperate fruit trees (Puterka et al. 2000; Knight et al. 2000; Unruh et al. 2000); cotton (Showler 2002); whitefly (Liang & Liu 2002); thrips (Kerns & Wright 2000); and other pests. The value of the film includes deterrence of feeding and oviposition, and beneficial effects on carbon assimilation, leaf temperature, and fruit yield (Glenn et al. 2001). Particle film technology seems especially well suited for use in areas of low rainfall where leaf residues of the product can be maintained without frequent re-application. Use of particle films in the humid subtropical environment of Florida citrus groves may be limited by removal of residues by seasonally heavy rain (Lapointe 2000).

In addition to deterring pests (Puterka et al. 2000; Unruh et al. 2000; Knight et al. 2000; Lapointe 2000), particle films have been shown to increase fruit tree productivity in semiarid and sub-humid environments by reducing heat stress (Glenn et al. 2001). The humid subtropical environment experienced by citrus trees in Florida presents a different set of challenges for successful use of particle films. Periods of high rainfall are interspersed with dry periods accentuated by highly porous soils and intense solar radiation. Particle films, while effective in the laboratory (Lapointe 2000), may not adhere sufficiently to citrus leaves in the field in Florida to maintain deterrence to *Diaprepes* root weevils after heavy rains over the entire rainy season (May-October) when adults are active.

Prior to establishment of field trials (reported elsewhere), I investigated the feeding and oviposition response of *Diaprepes* root weevil to varying

concentrations of Surround WP. A hand-held sprayer was used to apply the product at three concentrations to bouquets of citrus leaves harvested from *Citrus macrophylla* Wester seedlings grown in a greenhouse. Methods were similar to those reported by Lapointe (2000). Foliage bouquets were sprayed to runoff with the manufacturer's recommended concentration ($x = 3\%$ wt/vol), $0.5x$, or $0.1x$, or with water alone. Foliage was allowed to dry and then placed in screened cages ($30 \times 30 \times 30$ cm) containing 5 male and 5 female *Diaprepes* root weevils. Weevils were obtained from a colony maintained at the U.S. Horticultural Laboratory, Ft. Pierce, FL (for rearing conditions, see Lapointe & Shapiro 1999). Each of the 4 treatments was replicated 3 times for a total of 12 cages and 120 weevils. Cages were randomly arranged on open shelves in a temperature-controlled greenhouse. Each cage was provided with wax paper strips as substrates for oviposition (Wolcott 1933). Bouquets and wax paper strips were removed every 2 days until 17 days and examined for egg masses. Leaf area consumed was assessed by tracing the leaf notches. Tracings were digitally scanned and the resulting files were imported into an image analysis computer program as described by Lapointe (2000). Leaf area consumed and total number of eggs oviposited were analyzed by ANOVA with the type III sum of squares for cage as the error term. Means were compared by the Tukey honestly significant differences (HSD) test (Abacus Concepts 1996). Linear regression was used to calculate the deposition of particle film required to achieve 50% reduction in leaf consumption and oviposition.

The deterrent effect of Surround against feeding and oviposition fell off quickly as coverage was reduced in a greenhouse trial. Adult weevils fed untreated citrus leaves over 17 d consumed approximately 3 times as much leaf area as weevils

TABLE 1. MEAN (\pm SEM, $n = 3$) LEAF AREA CONSUMED AND NUMBER OF EGGS PRODUCED OVER 17 DAYS BY *DIAPREPES* ROOT WEEVIL ADULTS FED CITRUS FOLIAGE SPRAYED WITH THE RECOMMENDED CONCENTRATION (1.0X) OF SURROUND® (3% WT/VOL), 0.5X, 0.1X, OR FOLIAGE SPRAYED WITH WATER (CONTROL).

	Leaf area consumed (cm ²)	% of control	Number of eggs laid	% of control
Control	236 \pm 30 a		4,575 \pm 255 a	
0.1x	207 \pm 10 a	88	2,792 \pm 168 ab	61
0.5x	145 \pm 44 ab	61	1,263 \pm 1,085 b	28
1.0x	83 \pm 13 b	35	823 \pm 288 b	18

Means within columns followed by the same letter do not differ ($\alpha = 0.05$, Tukey's HSD).

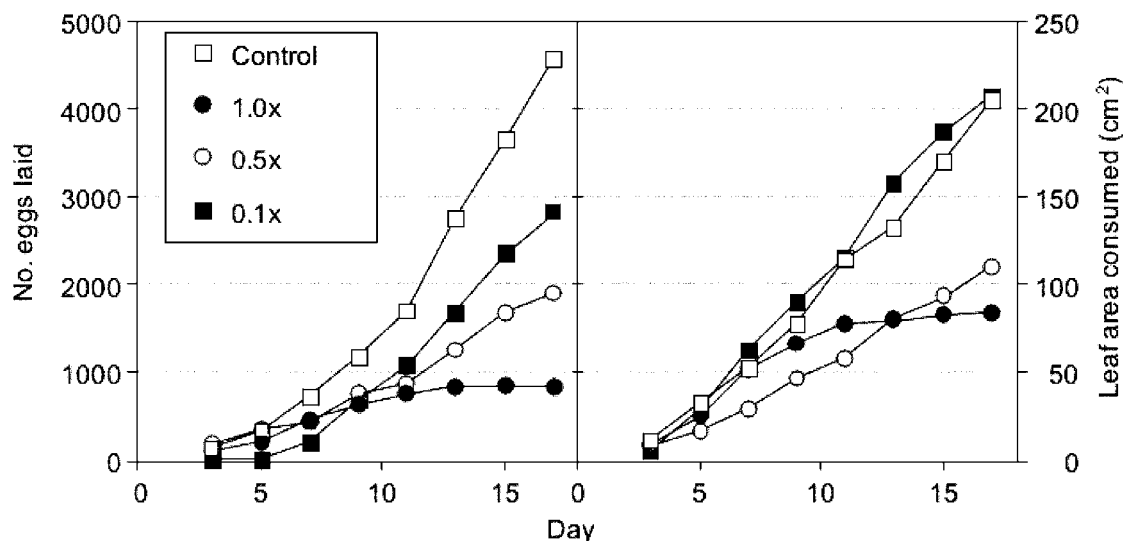


Fig. 1. Mean cumulative oviposition and leaf consumption by adult *Diaprepes* root weevils caged with untreated citrus leaves (control), or leaves treated with Surround® WP sprayed at one of three concentrations: 3% (1.0x), 1.5% (0.5x), or 0.3% (0.1x) wt/vol Surround/water.

fed citrus leaves treated with Surround at the recommended concentration (Table 1). By regressing percent reduction in leaf area consumed on concentration ($y = -0.016x + 1.505$), I determined that Surround deposition equivalent to 71% of the recommended concentration is required to obtain a 50% reduction in leaf consumption. Inhibition of oviposition by the particle film was stronger compared with inhibition of leaf consumption (Fig. 1). Weevils caged with untreated citrus leaves produced 5.6 times as many eggs as weevils in cages with leaves treated at the recommended concentration (Table 1). By regressing percent reduction in oviposition on concentration ($y = -0.011x + 0.962$), I determined that 50% reduction of oviposition would occur at Surround deposition equivalent to 41% of the recommended concentration. The roughly proportional decline in leaf consumption and oviposition with increasing particle film coverage suggests that significant repellency to root weevils during the rainy season in Florida would require multiple applications during the rainy season to maintain repellency.

The effect of Surround on oviposition may be attributed to a combination of two factors. First, oviposition may have been directly affected by a deterrent effect of the particle film on ovipositional behavioral (Lapointe 2000). Second, reduced feeding probably contributed to reduced fecundity, thereby decreasing the oviposition potential of females fed treated leaves, particularly after day 10 (Fig. 1). Oviposition was observed even at the highest concentration in the greenhouse under no-choice conditions, as has been reported previously (Lapointe 2000).

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SUMMARY

The deterrence of Surround® WP particle film to feeding and oviposition by the *Diaprepes* root weevil was proportional to the concentration of application to citrus leaves in a greenhouse trial. Reduced oviposition appeared to be due to the combined effect of reduced feeding and behavioral deterrence. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

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