SECTION 4
FIELD PRODUCTION

Dr. Kris Braman
Section Editor and Moderator

Factors Influencing Residual Activity of Chlorpyrifos Against Imported Fire Ants (Hymenoptera: Formicidae) in Nursery Potting Media

Anne-Marie A. Callcott, Homer L. Collins and Timothy C. Lockley
Mississippi

Nature of Work: The imported fire ant (IFA) quarantine was invoked by the United States Department of Agriculture (USDA) May 6, 1958 in an effort to slow or prevent artificial spread of *Solenopsis invicta* Buren and *Solenopsis richteri* Forel. Movement of certain regulated articles, particularly nursery stock, outside the quarantine area is prohibited unless those articles are free of imported fire ant infestation. Chlorinated hydrocarbon insecticides such as aldrin, dieldrin, heptachlor and chlordane were utilized for treatment of nursery potting soil to render it fire ant free from inception of the quarantine until registration of chlordane was canceled December 31, 1979. Laboratory studies showed that Dursban®10 G (Dow Chemical Co., Midland, MI), incorporated at a rate of 1.0 lb/cu yd into a nursery potting media consisting of equal parts of Canadian sphagnum peat moss, coarse river sand and milled pine bark (IFA lab media), was highly effective against fragmented imported fire ant colonies for 39 mths (6). As a result of these studies, Dow registered FA-5, a 5% granular (G) formulation of chlorpyrifos in January 1980. However FA-5 was electively withdrawn from sale in late 1981 by the registrant. No granular insecticides were available for treatment of nursery potting media until Ford's Chemical Co. obtained registration of a 2.5 G chlorpyrifos formulation in July 1984. Enforcement of the quarantine was relegated to state plant regulatory agencies in 1987 by the USDA. This change increased the number of nursery site inspections and thus resulted in far more violations than previously detected. The increase in violations led growers to question the efficacy of chlorpyrifos in nursery potting media. In February 1993, granular chlorpyrifos was rejected by USDA as an acceptable quarantine treatment for incorporation into potting media and was subsequently deleted from the Imported Fire Ant Program Manual M301.81. Talstar T&O Granular® (bifenthrin, FMC Corp., Princeton, NJ) was registered by EPA in 1992 and approved by USDA for IFA quarantine use as a preplant incorporated treatment for containerized nursery stock in June 1992. Fireban® (tefluthrin, Uniroyal Chem. Co., Middlebury, CT) was accepted by USDA in September 1994. However, as shown in the cost estimates below, Fireban represents a 5 fold increase in cost per trade gallon pot over chlorpyrifos whereas Talstar is 6.5 times more expensive than chlorpyrifos.

Product	$/trade gal pot at 25 ppm	
	400 lb/ cu yd media	1000 lb/ cu yd media
chlorpyrifos[1]	.002	.005
Fireban[2]	.010	.026
Talstar[3]	.013	.032

[1] based on price of agricultural product produced by Prentiss Chem., 2.32% G - quote 1/95 from Coastal Farm Supply, Gulfport, MS

[2] based on personal communication from Laurie Treu, Uniroyal Chem. Co. - 1/95

[3] based on Talstar Granular Cost Comparison Break-out Sheet, FMC Corp - 6/93

Prior to the initiation of the studies reported here, a review of the literature (3) disclosed numerous other studies that explored a variety of factors, which alone or in combination with others, can influence the bioactivity and persistence of chlorpyrifos in soil. Factors include soil or media type, soil moisture, soil temperature, pH, chemical formulation and application, chemical volatility, chemical movement, and microbial activity. A number of these factors will be discussed in relation to our studies with nursery potting media.

We report here a lengthy series of studies which were conducted in an effort to understand why original laboratory studies indicated that chlorpyrifos was highly residual in nursery media, whereas later information indicated that little or no residual activity was associated with this product. In January 1989, we began a series of trials to examine a variety of factors whose interaction with chlorpyrifos could promote enhanced degradation of the chemical in potting media. Factors included geographical location of nurseries, media components, pesticide formulation, irrigation, pH of irrigation water, pesticide binding, leaching, enhanced microbial degradation, and percentage of organic matter in media.

In the interest of brevity, all the trials conducted from 1989 to 1993 will not be reported here, but rather representative studies of all factors involved in chlorpyrifos efficacy will be discussed. Results of some of these individual trials have been reported by Callcott (2,4). A brief description of each trial will precede the results as needed, since most trials encompass more than one possible degradation factor. Also, data tables for some trials have been omitted when a brief sentence would adequately address the results.

Chlorpyrifos formulations tested included Dursban®2.5 G and Dursban®10 G (Ford's Chemical and Specialty Co., Pasadena, TX), and Lorsban®15 G (Dow Chemical, Midland, MI; now DowElanco, Indianapolis, IN). Commercial potting media used included Strong-Lite® Potting Media (Strong-Lite Products Corp., Pine Bluff, AR; now Grace Sierra Horticultural Products Co., Milpitas, CA), Baccto® (Michigan Peat Co.,

Houston, TX), Tu-Co® (Tu-Co Peat Inc., Sebring, FL), Morris Majic® Mix (Morris Majic Soil, Hialeah, FL), Atlas®3000 (Boynton Beach, FL) and Sunshine® All Purpose Mix (Fison's Western Corp., Vancouver B.C., Canada). Media from several commercial nurseries was also used: Greenleaf Nursery, El Campo, TX; Flowerwood Nursery, Mobile, AL; and Windmill Nursery, Franklinton, LA. One in-house media mix was also used: a 1:1:1 mix of green milled pine bark, sphagnum peat moss (Les Tourbes Nirom Peat Moss Inc., Quebec, Canada) and river sand. Hereafter, this media will be referred to as the standard IFA lab media.

All trials followed the same basic protocol. Granular chlorpyrifos was incorporated into potting media at a pre-determined rate using a portable 2-cu ft electric cement mixer. Each batch of treated media was blended for 15 min to insure thorough incorporation of the pesticide. The treated media was then placed in standard 1 gallon plastic nursery pots and aged outdoors under simulated or actual nursery conditions. At monthly intervals, media from three pots of a treatment group was composited, and a 500 cc subsample removed and subjected to a standard IFA alate female bioassay, which is a slight modification of a procedure described by Banks et al. (1). Bioassay test chambers were 5 X 5 cm plastic nursery pots equipped with a Labstone® bottom (Patterson Dental Co., Jefferson, LA). The Labstone prevented escape through the drainage holes and also absorbed moisture from a underlying bed of damp peat moss to prevent desiccation of the ants. Approximately 50 cc of treated media was placed in each test chamber and five recently field collected alate females were introduced and confined to the pot. Each treatment was replicated four times (i.e. four test chambers per treatment). Percentage of mortality of the females was recorded after 7 d of continuous confinement to the treated media and the mean of the four replicates calculated. Where applicable, data were subjected to an ANOVA, and the means separated by Tukey's studentized range (HSD) test at the P=0.05 level (15). A pesticide is generally considered ineffective for quarantine use when the mortality rate falls below 90% regardless of statistical differences in treatment means.

Results and Discussion: CONFIRMATION OF LACK OF EFFICACY. A number of trials were initiated beginning in early 1989 to confirm efficacy of chlorpyrifos. Most examined such factors as geographical location, media type and application rate. The first trial, initiated in January 1989, compared the residual activity of Ford's Dursban 2.5 G incorporated into three media types and aged in different geographical locations. Dursban aged at sites other than Gulfport, MS achieved <4 mths of effective residual activity (Table 1). Of those media aged in Gulfport, MS, the Morris Mix showed decreased efficacy at 4 mths while the others were effective through 4 mths. The trial was terminated after 4 mths since we had confirmed that the residual activity of the Ford's chlorpyrifos formulation was far less than the 24 mth certification recognized under the Federal Quarantine Guidelines (PPQ Treatment Manual 301.81).

In a second trial initiated in May 1989, chlorpyrifos 2.5 G was incorporated into various potting media at rates of 20, 40, 60, 80 and 100 ppm and aged at test sites in FL and MS. Media from this trial was not only subjected to standard live IFA bioassay described above, but also was analyzed by gas liquid chromatography (GLC) to determine whether pesticide binding had occurred. These analyses were conducted by USDA,

Animal and Plant Health Inspection Service, National Monitoring and Residue Analysis Laboratory (NMRAL), Gulfport, MS. Bioassay results showed no residual activity after 2 mth of aging in FL (Table 2) and 1 mth in MS (Table 3). In general, within a given media type, increased initial dose rates did not significantly effect mortality over a given time period, indicating that increased application rates do not extend residual activity. Figure 1 shows the GLC analyses for the Strong-Lite treated media aged in Gulfport, MS. These results are representative of all other chemical analyses done over time, and conclusively show that chemical degradation rather than pesticide binding accounted for the loss of efficacy of chlorpyrifos.

An additional study was initiated in October 1989 to determine the residual activity of Lorsban 15 G incorporated into various types of media at two initial dose rates; a weight to weight rate of 40 ppm and a weight to volume rate of 11.3 g (AI)/cu yd. These treatments were aged in Gulfport, MS and bioassayed as above. Lorsban 15 G afforded <3 mths activity in either Baccto, Sunshine or Strong-Lite media, while a pure peat moss media, regardless of initial dose rate, remained active for 12 mths. These results showed that the apparent loss of efficacy was not due to the pesticide formulation.

DUPLICATION OF ORIGINAL EFFICACY TRIALS. The original efficacy trials conducted by this laboratory in the late 1970's (6) utilized Lorsban 10 G incorporated into the standard IFA lab media at a dose rate of 11.3 g (AI)/cu yd. A fragmented colony bioassay procedure was employed to determine residual activity. The bioassay procedure was as follows: field collected IFA colonies were first separated from the nest tumulus using a floatation technique (10) or through use of a desiccation tray (12). The fragmented colony (i.e. several thousand workers ants, immatures and alates, with queen status undetermined) was then introduced into a 1 gal pot of treated media and whole colony mortality assessed after 14 d. This procedure differed greatly from the current bioassay procedure which uses only alate female ants. In order to closely duplicate the original trials, Dursban 2.5 G and Lorsban 15 G were incorporated into IFA lab media at 11.3 g (AI)/cu yd (ca 20 ppm). This rate is equivalent to the original labelled rate of Dursban 2.5 G for use in the imported fire ant quarantine. After treatment, both the fragmented colony bioassay and the standard alate female bioassay were performed each month. Twelve mths of activity (the duration of the trial) was achieved regardless of formulation used or bioassay type. Therefore, bioassay technique was eliminated as a possible reason for discrepancies in results of original and current studies.

Another trial was initiated in which the individual media components of the IFA lab media (pine bark, peat moss and sand) and the complete media were treated with Lorsban 15 G at a rate of 11.3 g (AI)/cu yd. Treated media was aged in Gulfport MS and subjected to standard monthly bioassay. The sand component lost activity 7 mths after treatment and the pine bark after 22 mths. The peat moss and the mix of the three components (IFA lab media - 20 ppm) were effective for the 24 mth trial duration. Thus, the results of the original chlorpyrifos efficacy trials were substantiated: chlorpyrifos can provide 24 mths activity, but only in a certain type of media or in one with certain characteristics.

FORMULATION. A variety of granular chlorpyrifos formulations are available, ranging from agricultural formulations to home owner use products. These granular products are also formulated on several types of inert carriers, including montmorillonite clay, corn cob granules and pecan hulls. Three formulations of granular chlorpyrifos, one formulated on pecan hulls, one on cob granules and one on clay, were incorporated into Strong-Lite potting media at a rate of 11.3 g (AI)/cu yd. Other non-granular formulations including micro-encapsulated, controlled release (CR), emulsifiable concentrate (EC), dust and wettable powder (WP) formulations were also evaluated. Non-liquid formulations were incorporated into Strong-Lite potting media at 100 ppm. Liquid formulations were applied as drenches at a rate of 100 ppm. All treated media was then aged and subjected to standard bioassay as described above. Granular chlorpyrifos formulated on various inert carriers showed no effective activity 3 mths after incorporation regardless of carrier type. Other non-granular formulations of chlorpyrifos were generally not effective for more than 2 mth. However, Empire®20, a micro-encapsulated formula applied as a drench, was effective for 13 mths.

IRRIGATION. A number of trials investigating variables associated with irrigation were undertaken. Chlorpyrifos is known to be relatively unstable in alkaline substrates (7). Dursban 2.5 G was incorporated into Strong-Lite potting media at a rate of 11.3 g (AI)/ cu yd. The media was then placed into 10 cm square pots, divided into three groups, and maintained on greenhouse benches. One group was irrigated with plain tap water (Gulfport MS Municipal Water Dept., pH _ 7.8), while each of the other groups was irrigated with distilled water adjusted to pH 9 and 11, respectively, with a 50% solution of sodium hydroxide. All groups received 2.54 cm water each week. At monthly intervals, three pots from each treatment group were composited and a subsample subjected to standard alate female bioassay. Dursban 2.5 G incorporated into Strong-Lite potting media and subsequently irrigated weekly with water with a pH of 7.9 (tap water), 9.0, or 11.0, provided activity for _2 mths.

Pond, lake, well or city water may be used for nursery irrigation, all of which vary greatly in chemical and microbial content. In December 1989, a trial was initiated to study the effects of city water versus distilled water on degradation of chlorpyrifos. Dursban 2.5 G and Lorsban 10 G were incorporated into Strong-Lite potting media at a rate of 11.3 g (AI)/cu yd. Treated media was placed in standard 1 gal nursery pots and maintained in a greenhouse under ambient conditions. On a weekly basis, each pot received 5.08 cm of either city tap water or distilled water. Source of the city water was the Gulfport MS Municipal Water Dept. This water is heavily chlorinated, high in carbonates (146 mg/ liter), and has a relatively high pH (9.20). Standard bioassays were performed on a monthly basis using media from a composite of two pots from each treatment. Less than two mths residual activity was provided regardless of formulation or irrigation water (Table 4). Therefore, we concluded that the pH of tap water, and contaminants normally found in tap water, were not factors in persistence of chlorpyrifos.

LEACHING. Leachability of granular chlorpyrifos in nursery potting media was also studied; although chlorpyrifos has a very low solubility in water and therefore a low leaching capacity (7). Strong-Lite potting media and the IFA lab media were treated with Dursban 2.5 G at a rate of 65 ppm. One gal nursery pots were then filled with

treated media and each pot placed on a 22.9 cm dia aluminum pie pan with a hole cut in the center. Each pot and pan set was then placed on a rack with the hole in the pan centered over a 1000 ml beaker which was used to collect the leachate. This trial was conducted in a greenhouse at ambient temperature with irrigation applied at 2.54 cm/ wk. At monthly intervals, three pots from each treatment and their leachate (from the irrigation immediately prior to collection) were collected and bioassayed. Media was subjected to standard alate female bioassay described above. Leachate was bioassayed (four replicates per collection) by dipping a piece of filter paper (Whatman #1) in the leachate, placing the paper in a petri dish, and introducing five alate females. The paper was kept moist by adding 0.5 ml tap water per day. Percentage of mortality was recorded after 7 d continuous exposure to the paper.

The leachate from the IFA lab media was 98% effective at 24 hours after treatment probably due to physical removal of dust particles from the chemical (Table 5). Chlorpyrifos began losing efficacy after 2 mths in Strong-Lite media, versus 6 mths of excellent activity in the IFA lab media (Table 6). These results confirm that leaching is not the mechanism by which chlorpyrifos degrades rapidly in most media and concur with other studies on chlorpyrifos leaching in soil (17, 18, 11, 16).

ENHANCED MICROBIAL DEGRADATION. In order to study microbial degradation, Morris Magic Mix potting media was placed in 1 qt mason jars, sealed, and steam sterilized at 17 psi for 1 hr on two consecutive d (8). Dursban 2 EC was aseptically added to sterile and non-sterile media. Both treated and untreated media were then aged under greenhouse conditions in open and closed containers. Media was bioassayed monthly with alate females as above. If enhanced microbial degradation of chlorpyrifos was occurring, we would expect the treated sterile media to show extended residual activity, regardless of whether the container was opened or closed. We found that media in closed containers, both sterile and non-sterile, extended the residual activity of the chemical (Table 7). These results suggest that volatilization may play a role in chlorpyrifos degradation. However, since the treated sterile media aged in open containers did not extend residual activity, this suggest that enhanced microbial degradation is not a factor affecting the residual activity of chlorpyrifos in this trial.

Antibiotics such as bactericides and fungicides might also slow or prevent the degradation process. A trial was initiated in March 1991 to determine whether potting media rendered sterile by fumigation or by treatment with antibiotics and fungicides would extend the activity of the chlorpyrifos. Ten cu ft of Strong-Lite potting media was fumigated under 4 ml polyethylene sheeting with 1.0 lb of methyl bromide (Brom-O-Gas®, Great Lakes Chemical Corp., West Lafayette, IN). Sheeting remained in place for 72 hrs after the gas was introduced. Granular chlorpyrifos was incorporated into fumigated or non-fumigated potting media at the labelled rate of 1.0 lb/cu yd, providing an initial dose rate of 65 ppm. Granular chlorpyrifos was also incorporated into the IFA lab media at 65 ppm based on dry weight bulk density of the media. Benomyl (Benlate®, Du Pont Agricultural Chemicals, Wilmington, DE), a fungicide, and streptomycin (AgriStrep®, MSD Agvet/Div. of Merck & Co., Inc., Rahway, NJ), a bactericide, were incorporated into the media at 500 ppm. Various combinations of fumigant,

fungicide and bactericide were employed for this trial. Treated media was again placed in 1 gal trade nursery pots, aged under simulated nursery conditions and subjected to monthly alate female bioassay as described above. This more extensive trial, using various combinations of fumigants, fungicides and bactericides to sterilize media showed that, regardless of sterilization technique, _2 mths of activity was noted (Table 8). Again, excellent results were obtained with the IFA lab media. Evidence of microbial involvement in chlorpyrifos degradation was not apparent. These results agree with numerous other reports that show that enhanced microbial degradation does not occur with chlorpyrifos (9, 14, 8, 5).

ENHANCED RESIDUAL. Negative data produced in approximately 20 different trials (not all reported here) prompted us to hypothesize that enhanced residual activity of chlorpyrifos, rather than enhance degradation, was occurring. In 1991, this observation led to trials that examined the effect of sphagnum peat moss and pine bark on chlorpyrifos activity. Sphagnum peat moss and pine bark are the major components of the IFA lab media in which chlorpyrifos invariably provides 100% efficacy against imported fire ants for a minimum of 24 months at rates as low as 20 ppm.

Addition of sphagnum peat moss to enhance residual. In March 1991, a trial to explore the effects of the addition of sphagnum peat moss to Strong-Lite potting media in various volume to volume ratios (9:1, 3:1, 1:1 media:peat) was initiated. Dursban 2.5 G was incorporated into all media including peat only and Strong-Lite only at 65 ppm. Treated media was then potted, aged and bioassayed as above. The residual activity of chlorpyrifos was extended proportionally with the amount of peat added (Table 9). The greatest extension of activity occurred in the 1:1 combination providing 18 mths of residual activity versus 2 mths in the non-amended media. These results suggest that the inclusion of sphagnum peat moss enhances the residual activity of chlorpyrifos. Activity was also 18 mths in pure sphagnum peat.

Later, a trial similar to that described above was conducted with media from three large nurseries. Chlorpyrifos was incorporated into the IFA lab media at a rate of 18.4 ppm, which is the dose rate achieved with the labelled rate of 1.0 lb/cu yd. Chlorpyrifos was also incorporated at 18.4 ppm into media acquired from the nursery operations and various volume to volume mixes of these media with peat (5:1, 3:1, 1:1 media:peat). Treated media was potted, aged and bioassayed as above. Greenleaf Nursery (El Campo, TX), Flowerwood Nursery (Mobile, AL) and Windmill Nursery (Franklinton, LA) cooperated in this study. Physical and certain other characteristics of the media were determined by various laboratories: 1) percentage of organic matter by USDA, NMRAL, Gulfport, MS, 2) cation exchange capacity and pH by the Agronomy Dept., MS State Univ., Soil Testing Laboratory, Mississippi State, MS, and 3) bulk density by the Imported Fire Ant Station. Results from this trial indicate that slightly extended residual activity of chlorpyrifos is afforded through the addition of sphagnum peat in some media (Table 10). However, 24 mths of activity against IFA is not achieved unless chlorpyrifos is incorporated into the IFA lab media. Components and characteristics of the media used in this trial are shown in Table 11. The IFA lab media and the Greenleaf Nursery media have the lowest percentage of organic matter, 13.6% and 24.1% respectively.

Chlorpyrifos in these two media types and media:peat combinations provided longer residual than in the other media types; 24 mths in IFA lab media and 5-9 mths in the Greenleaf media:peat combinations.

Addition of pine bark to enhance residual. The effect of pine bark on the residual activity of chlorpyrifos was the subject of additional studies. Most commercial nursery operations use pine bark as a major component of their potting media. However, some growers use fresh green bark and others use composted bark which is in various stages of decomposition. The pine bark used in the IFA lab media was relatively fresh green bark. Lorsban 10 G was incorporated at 65 ppm into green bark, composted bark, and two IFA lab media, one using green bark and another using composted bark. Media was potted, aged and bioassayed as above. Chlorpyrifos incorporated into composted pine bark was bioactive for only 3 mths (Table 12). In IFA lab media using composted pine bark, chlorpyrifos was effective for 15 mths. However, in green pine bark alone or in IFA lab media using green pine bark as a component, chlorpyrifos was effective for 24 mths (trial duration), indicating that the age or the state of decomposition of the pine bark used has an effect on the degradation rate of chlorpyrifos.

Efforts were also made to determine whether solvent extractable compounds from the pine bark could be involved in enhanced chlorpyrifos residual. Alcohol and acetone are solvents commonly used for the extraction of 2-pinene, pine oil and pine tar (13). Green, freshly ground pine bark was solvent-extracted as follows: 1 cu ft of bark was placed in a 12 gal open container with 6 gal of isopropyl alcohol and acetone (1:1 by volume), and manually agitated for 30 min. The solvent was decanted, and excess solvent allowed to drain over a sieve for ca 15 min. A second extraction was then performed with fresh solvent solution described above. The bark-solvent mixture was again manually agitated for 30 min before decanting and then allowed to drain overnight. Next, the bark was spread in a 2.54 cm layer and allowed to air dry for 48 hrs before use. IFA lab media was prepared using either the solvent-extracted pine bark or non-extracted pine bark and Dursban 2.5 G incorporated at 18.5 ppm. Media was potted, aged and bioassayed as above. Solvent-extracted green pine bark used as a component in the IFA lab media did not affect the activity of chlorpyrifos. Twelve mths of activity was achieved with both extracted and non-extracted bark (duration of the trial). Thus, solvent-extractable compounds, such as 2-pinene, pine oil and pine tar, apparently are not involved in the enhancement of chlorpyrifos efficacy. However, other unknown compounds may leach out or degrade during composting. These unknowns may be reacting with chlorpyrifos or somehow preventing the normal routes of degradation for chlorpyrifos.

Use of sphagnum peat moss and pine bark as a carrier for chlorpyrifos. The use of sphagnum peat as an inert carrier in the pesticide formulation was investigated. A 5% formulation of chlorpyrifos on sphagnum peat pellets was submitted by a private laboratory (Formulogics Co., Princeton, NJ) for testing. Also, two 2.5% formulations were formulated by us; one with Dursban 4 EC and another with chlorpyrifos technical (99%, Dow Chemical Co., Midland, MI). For the in-house formulations, sphagnum peat moss was sifted through a Hubbard wire screen sieve (mesh size 6) to remove large

particles and to acquire a fairly uniform size. To prepare the EC formulation, 2.5 ml of Dursban 4 EC was mixed with 100 ml of water and used to thoroughly saturate 48.4 g of sphagnum peat. To achieve a 2.5% formulation using the technical material, 2.02 g of technical chlorpyrifos was mixed in 240 ml of analytical grade acetone. This solution was added to 80 g of sifted peat. Both
formulations were spread in a 2.54 cm layer in an open container and allowed to air dry for 48 hrs before incorporation into media as described above. The EC formulation was incorporated into Windmill nursery media (composted pine bark) at 100 ppm. All others were incorporated into Strong-Lite potting media at approximately 65 ppm. Media was potted, aged and bioassayed as above. All specialty formulations of chlorpyrifos using sphagnum peat moss as an inert carrier did not extend the residual activity of chlorpyrifos. Six mths or less of activity was produced in all trials regardless of media type or initial dose rate.

The final trial reported here, examined the potential of pine bark as a carrier to enhance residual activity of chlorpyrifos. Fresh, green pine bark was milled with a laboratory grinder (Quaker City Mill, Model 4-E, Philadelphia, PA) and sifted through a Hubbard wire screen sieve (mesh size 6) to remove large particles and to acquire a uniform size. To achieve a 2.5% formulation, 25.0 g of technical chlorpyrifos was added to 250 ml of analytical grade acetone. This solution was mixed with 1,000 g of pine bark in a 2-cu ft cement mixer for 15 min. The formulated bark was then spread in a 2.54 cm layer in an open container and allowed to air dry for 48 hr. This 2.5% bark formulation and the aforementioned 2.5% sphagnum peat formulation were incorporated into Grace Sierra potting media (formerly Strong-Lite potting media) at 83 ppm, which is the dose rate achieved with the original 2.5 G labelled rate of 1.0 lb/cu yd. Treated media was then aged at 3 sites: the Imported Fire Ant Station in Gulfport MS, the Alabama Agric. Exp. Station in Mobile AL, and the Univ. of Florida's Institute of Food and Agric. Sciences in Homestead FL. Bioassays were performed monthly as described above. Again, the specialty chlorpyrifos formulations did not extend the residual activity of the pesticide.

DISCUSSION. Original efficacy trials with chlorpyrifos treated IFA lab media were repeatable. However, numerous trials examining the factors of geographical location and media type conclusively show that chlorpyrifos incorporated into any potting media, except the IFA lab media, becomes inactive within 3-4 mths. Application rate was not a cause of decreased efficacy since a five-fold increase in initial dose rate (20-100 ppm) did not significantly extend residual activity past 1 mth. Pesticide binding to media particles was ruled out, because if binding had occurred, GLC analyses would indicate the presence of relatively large residues while bioassays would be negative. Traditional formulations and carrier types also produced the same poor results. The effects of irrigation, pH and possible contaminants in tap water, and leaching were eliminated as causal factors in decreased residual activity of chlorpyrifos. Finally, volatilization and enhanced microbial degradation were ruled out.

While these negative results were discouraging, they did compel us to focus our attention on enhanced residual activity rather than reduced residual activity. This enhanced activity may possibly be caused by one or more of the components of the IFA

lab media, either alone or in combination. While we found that the addition of sphagnum peat moss did extend the residual activity of chlorpyrifos, no more than 18 mths of activity was achieved, and that was only in one media type (Table 9). In most trials, activity was extended proportional with the amount of sphagnum peat added, but no more than 8 mths of activity was achieved.

In examining the pine bark component, the possibility that some compounds in pine bark, such as solvent-extractable 2-pinene, pine tar and pine oil, may affect the efficacy of chlorpyrifos was ruled out since IFA lab media using "extracted" pine bark afforded at least 12 mths of activity. When turning our attention to the age of the pine bark, we found that old composted pine bark alone did not extend the residual activity of chlorpyrifos, but when used as a component in the IFA mix was effective for 15 mths. More importantly, green pine bark alone or when used as a component in the IFA lab media has been extremely effective at enhancing chlorpyrifos bioactivity.

Using either sphagnum peat moss or green pine bark as an inert carrier for chlorpyrifos did not extend the activity of the pesticide against the imported fire ant.

Significance to Industry: While many factors have been ruled out, there appears to be some aspect of the IFA lab media that interacts with chlorpyrifos and causes the enhanced residual bioactivity. At this time, the green pine bark component of the IFA lab media appears to be the most likely candidate. More work will be required to understand the mechanism which is producing this effect. A better understanding of the mechanism whereby chlorpyrifos activity is extended in one particular media could lead to the reinstatement of a relatively inexpensive quarantine treatment.

Literature Cited

1. Banks, W.A., C.S. Lofgren & C.E. Stringer, Jr. 1964. Laboratory evaluation of certain chlorinated hydrocarbon insecticides against the imported fire ant. J. Econ. Entomol. 57:298-299.

2. Callcott, A.-M. 1989. Influence of soil type and other environmental factors on toxicity of chlorpyrifos to imported fire ants, pp. 143-160. *In* Proceedings, 1989 Fire Ant Research Conference, 18-19 April 1989. College of Veterinary Medicine, Univ. of Georgia, Athens, GA.

3. Callcott, A.-M. 1990. Influence of environmental factors on toxicity of chlorpyrifos to the imported fire ant. Down to Earth. 46: 5-9.

4. Callcott, A.-M. 1992. Factors influencing residual activity of chlorpyrifos in nursery potting media, pp. 59-76. *In* Proceedings, 1992 Imported Fire Ant Conference, 20-24 April 1992. Department of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico.

5. Chapman, R. A. 1982. Persistence of insecticides in water and soil with special reference to pH. *In* H.D. Niemczyk & B.F. Joyner, eds. Advances in Turfgrass Entomology. Chemlawn Corp., Columbus, Ohio. p. 65-69.

6. Collins, H. L., C. L. Mangum, J. G. Medley & A. W. Guenthner. 1980. Evaluation of soil insecticides for quarantine treatments against imported fire ants, 1976-1979. Insect. & Acaric. Tests. 5: 209.

7. Dow Chemical Co. Dursban® Insecticides Technical Information. Technical Data Sheet. Form No. 134-289-R585.

8. Getzin, L. W. 1981. Degradation of chlorpyrifos in soil: influence of autoclaving, soil moisture, and temperature. J. Econ. Entomol. 74: 158-162.

9. Hirakoso, S. 1969. Inactivating effects of micro-organisms on insecticidal activity of Dursban. Japan J. Exp. Med. 39: 17-20.

10. Jouvenaz, D. P., G. E. Allen, W. A. Banks & D. P. Wojcik. 1977. A survey for pathogens of fire ants, *Solenopsis* spp., in the southeastern United States. Fla. Entomol. 60: 275-279.

11. Kuhr, R. J. & H. Tashiro. 1978. Distribution and persistence of chlorpyrifos and diazinon applied to turf. Bull. Environ. Contam. Toxicol. 20: 652-656.

12. Markin, G. P. 1968. Handling techniques for large quantities of ants. J. Econ. Entomol. 61: 1744-1745.

13. The Merck Index. 1989. S. Budavari, M.J. O'Neil, A. Smith & P.E. Heckelman [eds.] Eleventh Edition. Merck & Co., Inc. Rahway, N.J.

14. Miles, J.R.W., C. M. Tu & C. R. Harris. 1979. Persistence of eight organophosphorus insecticides in sterile and non-sterile mineral and organic soils. Bull. Environ. Contam. Toxicol. 22: 312-318.

15. SAS Institute. 1988. SAS/STAT users guide. Release 6.03 edition. SAS Institute, Cary, NC.

16. Sharom, M. S., J.R.W. Miles, C. R. Harris & F. L. McEwen. 1980. Behavior of 12 insecticides in soil and aqueous suspensions of soil and sediment. Water Research. 14: 1095-1100.

17. Smith, G. N. 1966. Basic studies on Dursban insecticide. Down to Earth. 22: 3-7.

18. Whitney, W. K. 1967. Laboratory tests with Dursban and other insecticides in soil. J. Econ. Entomol. 60: 68-74.

Table 1. Residual activity of Dursban 2.5 G incorporated into various potting media and aged at various geographical locations - January 1989

Media	Location	Mortality of alate females at indicated mths post treatment(%) (0)	(1)	(2)	(3)	(4)
Strong-Lite	Gulfport MS	100a	100a	100a	100a	100a
	Gainesville FL	100a	100a	100a	100a	20b
	Winter Haven FL	100a	100a	20b	15b	40b
	Miami FL	100a	100a	20b	30b	20b
TuCo peat	Gulfport MS	100a	100a	100a	100a	100a
	Winter Haven FL	100a	100a	100a	100a	65a
Morris Mix	Gulfport MS	100a	100a	100a	100a	70b
	Miami FL	100a	10b	15b	10b	20b

Means within a row followed by the same letter are not significantly different according to Tukey's studentized range (HSD) test (SAS Institute 1988)

Table 2. Residual activity of Dursban 2.5 G incorporated into various media at various rates and aged in Miami FL - May 1989

Media	Initial Dose Rate (ppm)	Mortality of alate queens at indicated mths post treatment(%) (0)	(1)	(2)	(3)
Morris Mix	20	100a	0a	15a	0a
	40	100a	0a	25ab	5a
	60	100a	5a	60b	0a
	80	100a	20a	15a	10a
	100	100a	40a	0a	5a
Atlas 3000	20	100a	90a	10a	5a
	40	100a	50a	45a	0a
	60	100a	60a	100b	25a
	80	100a	40a	100b	35a
	100	100a	40a	100b	60a
Strong-Lite	20	100a	100a	100a	0a
	40	100a	100a	15b	0a
	60	100a	100a	35b	40ab
	80	100a	100a	100a	5a
	100	100a	100a	100a	65b

Within a media type, means within a column followed by the same letter are not significantly different according to Tukey's studentized range (HSD) test (SAS Institute 1988)

Table 3. Residual activity of Dursban 2.5 G incorporated into various media at various rates and aged in Gulfport MS - May 1989

Media	Initial Dose Rate (ppm)	Mortality of alate females at indicated mths post treatment(%) (0)	(1)	(2)	(3)
Morris Mix	20	100a	95a	10a	0a
	40	100a	85a	5a	5a
	60	100a	100a	15a	0a
	80	100a	100a	5a	15a
	100	100a	100a	0a	15a
Atlas 3000	20	100a	25a	15a	30a
	40	100a	75b	15a	20a
	60	100a	100b	10a	10a
	80	100a	100b	15a	10a
	100	100a	100b	60a	60a
Strong-Lite	20	100a	100a	20a	0a
	40	100a	100a	5a	0a
	60	100a	100a	10a	0a
	80	100a	100a	25a	35b
	100	100a	70a	5a	25b

Within a media type, means within a column followed by the same letter are not significantly different according to Tukey's studentized range (HSD) test (SAS Institute 1988)

Table 4. Effects of tap water vs. distilled water on residual activity of various chlorpyrifos formulations incorporated into Strong-Lite potting media - January 1990

Insecticide	Type Irrigation Water	Mortality of alate females at indicated mths posttreatment (%) (1)	(2)	(3)
Dursban 2.5 G	Tap	100	30	0
	Distilled	100	10	10
Lorsban 15 G	Tap	100	15	5
	Distilled	100	5	10
Check	Tap	0	15	5
	Distilled	10	0	0

Table 5. Activity of leaczhate from potting media treated with Dursban 2.5 G - August 1991

Media	Mortality of alate females at indicated mths posttreatment (%) (24 hr)	(1)	(2)	(3)	(4)	(5)	(6)
Strong-Lite	3.3	11.7	22.7	26.7	0	5	1.7
Untreated check	5	5	0	5	0	5	5
IFA lab media	98.3	5	31.7	10	1.7	13.3	10
Untreated check	5	5	5	20	0	20	0

Table 6. Residual activity of Dursban® 2.5 G in potting media - August 1991

Media	Mortality of alate females at indicated mths posttreatment (%) (24 hr)	(1)	(2)	(3)	(4)	(5)	(6)
Strong-Lite	100	100	68.3	100	65	6.7	8.3
Untreated check	5	15	0	10	0	10	0
IFA lab media	100	100	100	100	100	100	100
Untreated check	5	5	20	0	5	0	0

Table 7. Residual activity of Dursban 2 EC in sterile vs. natural media and open versus closed containers - December 1989

Treatment Media/Dursban/Container	Mortality of alate females at indicated mths posttreatment(%) (1)	(2)	(3)	(4)	(5)	(6)
Sterile/treated/open	100	5	45	100	5	35
Non-Sterile/treated/open	100	75	0	100	5	0
Sterile/treated/closed	100	100	100	100	100	100
Non-Sterile/treated/closed	80	100	100	100	100	0
Sterile/untreated/open	5	5	5	5	20	0
Non-Sterile/untreated/open	5	0	0	20	10	0
Sterile/untreated/closed	0	0	0	10	25	5
Non-Sterile/untreated/closed	10	0	0	5	5	50

Table 8. Residual activity of chlorpyrifos incorporated into potting media treated with various combinations of fungicides and bactericides - March 1991

Treatment	Mortality to alate females at indicated mths posttreatment (%)																	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Strong-Lite + methyl bromide + 500 ppm benomyl + 500 ppm streptomycin sulfate + 65 ppm Dursban	100	100	50	10	-[a]													
Strong-Lite + 500 ppm benomyl + 500 ppm streptomycin sulfate + 65 ppm Dursban	100	100	0	20	-[a]													
Strong-Lite + methyl bromide + 65 ppm Dursban	100	100	30	35	-[a]													
Strong-Lite + 65 ppm Dursban	100	100	65	35	-[a]													
IFA lab media + 65 ppm Dursban	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Strong-Lite check	40	10	25	30	5	5	5	5	0	0	5	10	30	5	60	15	35	25

[a]discontinued due to decreased efficacy

Table 9. Residual activity of Dursban 2.5 G incorporated into various volume to volume combinations of Strong-Lite potting media and sphagnum peat - March 1991

	Mortality of alate females at indicated mths posttreatment (%)																				
Media Mix	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Strong-Lite only	100	100	55	30	5	-[a]															
9:1 Strong-Lite:Peat	100	100	35	45	10	-[a]															
3:1 Strong-Lite:Peat	100	100	100	100	45	95	45	100	10	80	0	0	80	45	45	15	-[a]				
1:1 Strong-Lite:Peat	100	100	100	100	100	100	100	100	100	100	100	100	100	100	85	100	90	100	10	65	30
Peat only	100	100	100	100	100	100	100	100	65	100	20	75	100	100	100	100	100	100	0	70	90
Strong-Lite check	30	10	25	30	5	5	5	5	0	10	0	15	30	5	60	15	35	25	20	5	5

[a]discontinued due to decreased efficacy

Table 10. Residual activity of Dursban 2.5 G incorporated into various nursery potting media and media/peat combinations - July 1991

Media	Treatment	Mortality of alate females at indicated mths posttreatment (%)																							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Greenleaf	Dursban	100	100	35	35	0	10	30	0	25	[a]														
5:1	Dursban	100	100	100	100	100	40	100	5	0	[a]														
3:1	Dursban	100	100	100	100	100	0	25	5	5	[a]														
1:1	Dursban	100	100	100	100	100	50	50	100	100	40	90	5	25	10	[a]									
Greenleaf	Check	10	30	10	15	20	10	0	0	10	5	75	10	5	0	15	30	10	10	0	5	10	30	15	10
Flowerwood	Dursban	100	100	100	60	0	[a]																		
5:1	Dursban	100	20	10	15	5	[a]																		
3:1	Dursban	100	100	15	20	10	[a]																		
1:1	Dursban	100	100	100	80	85	[a]																		
Flowerwood	Check	65	35	60	20	15	5	0	15	15	0	15	0	30	20	10	25	15	15	5	0	15	5	0	5
Windmill	Dursban	70	85	10	30	40	[a]																		
5:1	Dursban	65	50	0	55	30	[a]																		
3:1	Dursban	95	100	20	25	45	[a]																		
1:1	Dursban	60	50	40	20	5	[a]																		
Windmill	Check	20	40	10	20	5	0	10	5	5	5	60	15	10	20	25	5	10	10	5	0	10	15	5	10
IFA media	Dursban	100	100	100	100	100	100	100	100	100	95	100	100	100	100	100	100	100	100	100	100	100	100	100	100
IFA media	Check	20	0	15	10	10	5	0	50	0	5	15	0	5	5	10	10	5	5	0	5	5	15	0	15
Peat	Check	20	10	20	0	10	5	5	0	10	10	10	0	5	15	0	0	0	5	5	0	0	10	0	5

[a]discontinued due to decreased efficacy

Table 11. Components and characteristics of various nursery media and various media to peat mixes

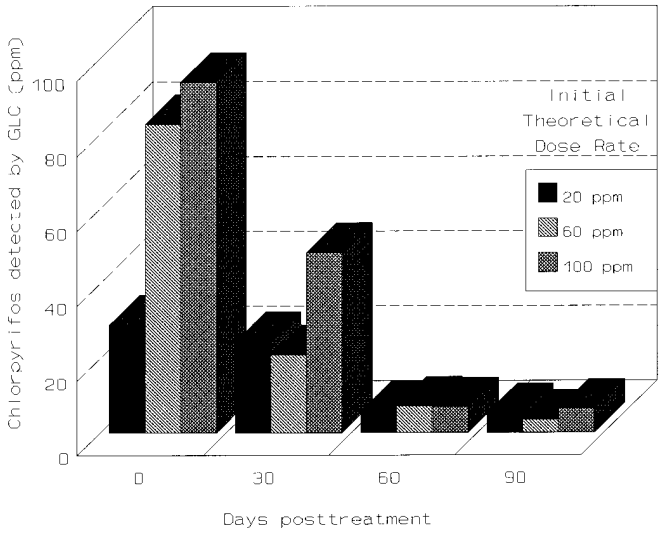
Media	Basic components	Organic matter (%)	Cation exchange capacity (milli equiv/100 g media)	pH	Bulk densit (lb/cu yd)
Greenleaf	5 parts pine bark, 2 parts sand and 1 part rice hulls	24.1	10.53	5.1	890
5:1 mix		47.8	14.24	4.9	895
3:1 mix		27.4	18.77	5.0	869
1:1 mix		29.8	13.23	5.2	561
Flowerwood	19 parts pine bark and 3 parts sand	39.9	9.35	5.6	920
5:1 mix		32.6	18.51	4.8	920
3:1 mix		27.2	13.73	5.2	867
1:1 mix		24.4	11.75	5.3	708
Windmill	all pine bark	57.5	13.54	6.7	481
5:1 mix		62.1	15.82	5.4	440
3:1 mix		61.1	15.43	6.2	507
1:1 mix		57.6	11.46	6.6	393
IFA Lab media	1 part pine bark, 1 part sphagnum peat and 1 part sand	13.6	11.13	5.0	1351
Sphagnum peat moss	all sphagnum peat	62.1	21.39	4.7	246

Table 12. Influence of pine bark age on residual activity of granular chlorpyrifos.

Media	Mortality of alate females at indicated mths posttreatment (%)																							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Composted pine bark	100	100	100	35	10	5	5	10	5	5	0	5	10	5	15	10	10	0	*					
IFA lab media	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	35	0	15	*					
with composted bark																								
Green pine bark	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	90	100	95	100	100	100	100	100
IFA lab media	100	100	100	100	100	100	100	100	100	100	90	100	100	100	100	100	100	100	100	100	100	100	100	100
with green bark																								
Check	5	0	5	10	10	0	10	10	10	10	0	15	0	5	0	5	5	0	0	5	0	15	5	0

* dropped due to decreased efficacy

Figure 1. Chlorpyrifos residues detected by GLC analysis in Strong-Lite potting media aged in Gulfport, MS.



Phytotoxicity of Fireban® 1.5G to Selected Cultivars of Foliage and Woody Ornamental Plants

Timothy C. Lockley, Adolphe J. Laiche, Jr. and James C. Stephenson, Jr.
Mississippi and Alabama

Nature of Work: Among the hundreds of toxicants evaluated for quarantine control of imported fire ants (IFA), only a few have the acceptable residual activity for use in nursery container plant production. Fireban 1.5G (tefluthrin, Uniroyal Corp.), a synthetic pyrethroid, has shown significant insecticidal activity for extended periods at varying rates when incorporated into media. Prior to its listing as a control toxicant under the imported fire ant quarantine in June 1993, tefluthrin was registered only as a preplant incorporated treatment for the control of wireworms in corn. No data was available on its potential phytotoxic effects on any other plants. As part of our ongoing evaluation of tefluthrin, tests were undertaken at the Mississippi Agricultural and Forestry Experiment Station at Poplarville, MS and at the Auburn University Ornamental Horticulture Substation at Mobile, AL to determine if tefluthrin has phytotoxic effects on containerized nursery plants. Five trials were conducted. Plants were selected on the basis of local availability, popularity among commercial growers and/or a previous history of phytotoxic responses to insecticides. All woody ornamental plants in Trials I, II and VII and all foliage plants were maintained in the greenhouse under normal horticultural practices. All woody ornamental plants in Trials III, IV, V and VI were grown outside, subjected to local climatic conditions and maintained under normal horticultural practices.

In each test, an experimental unit consisted of one containerized plant per plot with seven blocks per cultivar arranged in a randomized complete block design. As a check, an identical number of plants in each test were transplanted into pots containing untreated potting medium. Mean fresh shoot weights for all plants were subjected to analysis of variance and Duncan's new multiple range test at P = 0.05 level (1).

Trial I: On 23 March 1992, ten selected cultivars of foliage (n=5) and woody ornamental (n=5) plants were treated with two rates of Fireban 1.5G (tefluthrin). Cultivars were transplanted from liners to standard industry 1-gallon pots containing media into which Fireban 1.5G had been incorporated at 50 ppm (1X) and 150 ppm (3X). On 16 June 1992 (85 days post-planting), all plants were sacrificed. Fresh shoot weights were obtained by severing the plants at the growth medium surface. Shoots and roots were visually evaluated as follows:

Fresh Shoot Rating Scale

1. Plants healthy, not different from untreated check.
2. Slight yellowing, wilting, or other mild symptoms such as marginal chlorosis.
3. Symptoms more severe, leaf drop or necrosis.
4. Severe stunting, abnormal leaf drop or necrosis.
5. Dead.

Comparative Root Rating Scale
0. Roots Dead
1. Least developed.
2. Mean develpment.
3. Best developed.

Trial II: On 1 September 1992, seven varieties of plants (4 foliage and 3 woody ornamental) were treated with two rates of Fireban 1.5G (tefluthrin) incorporated into the media at rates of 50 ppm (1X) and 150 ppm (3X). Seven replicates/cultivar treatment were established in a randomized complete block design. Plants were sacrificed and evaluated as described in Trial I on 1 March 1993 (181 days post-planting).

Trial III: Twelve selected cultivars were transplanted from liners on 2 September, 1992 into pots containing media into which Fireban 1.5G (tefluthrin) had been incorporated at 50 ppm (1X) and 150 ppm (3X). Seven replicates/cultivar treatment were established in a randomized complete block design. Plants were sacrificed and evaluated as described above on 25 February 1993 (177 days post-planting).

Trial IV: In June 1993, tefluthrin was registered by the USDA as a quarantine treatment for IFA control in containerized nursery stock. Certification required that granular tefluthrin be incorporated at a rate of 25 ppm to potting media. Experimental rates were altered for subsequent trials to reflect quarantine requirements. On 18 August 1993, six foliage plants were transplanted into media containing tefluthrin incorporated at 25 ppm (1X) and 75 ppm (3X). Seven replicates/cultivar treatment were established in a randomized complete block design. Plants were sacrificed 110 days after planting on 6 December 1993. Evaluations were made as described previously.

Trial V: On 18 August 1993, eight woody ornamental cultivars were transferred from liners to industry standard 1-gallon pots containing Fireban at rates of 25 ppm (1X) and 75 ppm (3X). On 29 March 1994, all plants were transplanted to 2-gallon capacity containers containing Fireban at rates used in the 29 March 1994 planting. On 27 May 1994, three of the cultivars (river birch, Titi and wax myrtle) were pruned and the cuttings weighed. The same three cultivars plus *Gardenia* were pruned and weighed on 18 July 1994. On 6 October 1994 (414 days post-planting), all plants were sacrificed. Evaluations were made using the criteria described above. Top biomass data were combined for the cultivars previously subjected to pruning.

Trial VI: Nine woody ornamental cultivars were transplanted from liners into pots containing media into which Fireban 1.5G was incorporated at 25 ppm (1X) and 75 ppm (3X) on 13 September, 1993. Seven replicates/cultivar treatment were established in a randomized complete block design. Shoots and roots were evaluated on 19 October 1994 (402 days post-planting).

Trial VII: Fourteen foliage plants were transplanted from liners into pots containing media into which tefluthrin had been incorporated at 25 ppm (1X) and 75 ppm (3X) on 16 August 1994. Seven replicates/cultivar treatment were established in a randomized complete block design. All plants were sacrificed on 6 October 1994.

Results and Discussion: **Trial I**. A slight phytotoxic response was indicated among *Rhododendron* 'pink ruffle' at the 1X rate in total top biomass. However, root response at the 3X rate showed a positive response to the treatment. *Abelia grandiflora* showed a negative response in top biomass at both the 1X and 3X rates. Among the remainder of the woody ornamentals, no phytotoxic responses were noted. *Ilex crenata* showed enhanced growth at the 1X rate in top biomass and in the 1X and 3X rates in root growth. *Rhododendron* 'wakeibisu' displayed no significant differences in top biomass but did show superior root structure at the 1X rate (Table 1).

Trial II: No significant differencs were noted for either fresh shoot weight or of root systems among all cultivars evaluated (Table 2).

Trial III. No phytotoxic resonse was noted for the 12 cultivars evaluated (Table 3).

Trial IV. No significant differences were noted for either fresh shoot weights or root systems among all six foliage cultivars (Table 4).

Trial V: No significant differences were noted for top fresh weight or root structure for *Betula nigra*, *Ilex cornuta*, *Ligustrum sinense*, or *Myrica cerifera*. Higher total biomass was noted for *Cupressocyparis leylandis*, *Cyrilla racemiflora* and *Gardenia* at the 1X rate and for root structure at the 1X and 3X rates for *Quercus virginiana*. No phytotoxicity was indicated among any of the cultivars (Table 5).

Trial VI: No significant differences were noted within cultivars for either fresh shoot weight or root structure (Table 6).

Trial VII: Among the 14 foliage cultivars, no significant differences in root structure were noted. No phytotoxic response was observed among any of the cultivars. However, significant differences were observed at the 1X treatment level for *Antirrhinum majus, Celosia* sp., *Spathiphyllum* sp., *Syngonium podophyllum*, and *Viburnum tinus* and at the 3X level for *Allamanda cathartica*, *A. majus*, *Petunia* x *hybrida*, *Spathiphyllum* sp. and *V. tinus* (Table 7). Among the sixty-six cultivars tested, only *Rhododendron* 'pink ruffles' and *Abelia grandiflora* showed any phytotoxic response to media incorporated tefluthrin. Enhanced growth of top biomass was noted for the cultivars *Ilex crenata* 'compacta', *Allamanda cathartica*, *Petunia* x *hybrida*, *Cupressocyparis leylandis*, *Cyrilla racemiflora, Celosia* sp., *Antirrhinum majus, Spathiphyllum* sp., *Syngonium podophyllum*, and *Viburnum tinus*. Significant differences were also observed in enhanced root structure for *Rhododendron* 'wakeibisu', and *Quercus virginiana*.

Significance to Industry: The registration of Fireban (tefluthrin) has given growers another product for media incorporation to control the imported fire ant. Its long-term residual insecticidal activity and relatively low potential for phytotoxicity, makes this product a useful and valuable tool in the nursery industry's continuing battle against the transportation of the fire ant. The Imported Fire Ant Laboratory is continually seeking and evaluating new biocides to control the spread of these pest ants. Part of the evaluation process is the testing of potential candidates and newly registered products for potential phytotoxicity. Further testing of tefluthrin with other cultivars will continue.

Literature Cited

1. Duncan, D.B. 1955. Multiple Range and Multiple F Tests. Biometrics 11:1-42.

Table 1. Relative Phytotoxicity of Tefluthrin (Fireban 1.5G) Preplant Incorporated Into Media to Various Foliage and Woody Ornamental Containerized Plants, Trial I.

			Shoot Fresh Weight [g]			Roots
Cultivar	**check**	**1X**	**3X**	**check**	**1X**	**3X**
Woody Ornamentals						
Abelia grandiflora	154.4a	127.7b	131.0b	2.1a	2.7a	2.4a
Ilex 'San Jose'	22.3a	21.6a	20.1a	2.0a	2.1a	2.0a
I. crenata 'compacta'	46.3b	58.9a	52.7ab	1.9b	2.6a	3.0a
Rhododendron 'pink ruffle'	82.6a	65.9b	77.6ab	2.1b	1.7b	2.3a
Rhododendron 'Wakeibisu'	45.9a	46.6a	42.1a	2.0b	2.3a	2.1b
Foliage Plants						
Coleus	388.3b	457.3a	312.3b	1.7a	2.6b	1.9a
Lisianthus	58.1a	59.2a	57.3a	1.3b	2.3a	1.9ab
Salvia	222.4b	284.1a	208.7b	1.9b	3.0a	2.0b
Pothos	290.3b	327.0a	276.6b	2.1b	2.6a	2.6a
Portulaca	523.1a	606.4b	547.9a	1.7b	2.5a	2.0b

Means within cultivars followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 2. Relative Phytotoxicity of Tefluthrin (Fireban 1.5G) Preplant Incorporated Into Media to Various Foliage and Woody Ornamental Containerized Plants, Trial II.

	Fresh Shoot Weight [g]			Roots		
Cultivar	**check**	**1X**	**3X**	**check**	**1X**	**3X**
Woody Ornamentals						
Ilex meserveae 'blue girl'	55.9a	59.7a	53.1a	2.1a	2.2a	2.2a
Ilex 'ole spring'	28.7a	27.9a	28.3a	1.9a	2.3a	2.4a
Juniperus conferta						
'emerald sea'	44.6a	45.9a	44.6a	1.9a	1.9a	2.0a
Rhaphiolepus indica						
'Elizabeth'	62.0a	55.6a	54.3a	2.0a	2.0a	2.1a
Foliage Plants						
Antirrhinum majus						
'Tahiti yellow'	188.6a	160.0a	143.6a	2.0a	2.0a	2.0a
Petunia x *hybrida*	805.0a	771.4a	847.0a	2.1a	2.2a	2.3a
Syngonium podophyllum						
'butterfly'	277.6a	307.9a	272.0a	2.2a	2.4a	2.3a

Means within cultivars followed by the same letter are not significantly different using Duncan's multiple range test (P=0.05).

Table 3. Relative Phytotoxicity of Tefluthrin (Fireban 1.5G) Preplant Incorporated Into Media to Various Woody Ornamental Containerized Plants, Trial III.

	Fresh Shoot Weights [g]			Roots		
Cultivar	**check**	**1X**	**3X**	**check**	**1X**	**3X**
Abelia grandiflora						
'Edward Goucher'	36.9a	38.9a	44.0a	2.0a	2.0a	2.2a
Barberis thunbergii 'aurea'	4.0a	4.6a	3.7a	2.0a	2.5a	1.9a
Cotoneaster dammeri	46.0ab	40.9b	56.8a	2.0a	2.0a	2.6b
Cupressocyparis leylandis	62.9a	69.1a	71.4a	1.9a	2.1a	2.4a
Euonymus japonicus 'golden'	38.9a	36.0a	38.3a	2.0a	2.0a	2.1a
Ilex cornuta 'Carissa'	16.3a	14.6a	15.1a	1.9a	2.1a	2.0a
Ilex crenata 'Helleri'	36.9a	33.7a	37.1a	2.1a	2.0a	2.3a
Juniperus chinensis						
'green Sargent'	16.3ab	14.6b	21.1a	2.2a	2.0a	2.5a
Myrica cerifera	73.0a	62.6a	74.9a	2.0a	2.1a	2.2a
Rhaphiolepis indica						
'enchantress'	34.9ab	29.4b	35.7a	2.1a	2.0a	2.2a
Rhododendron 'pink gumbo'	27.4a	24.0a	25.1a	2.0a	2.0a	2.1a
Rhododendron 'Rene Michelle'	27.4a	24.0a	25.1a	2.1a	2.2a	2.3a

Means within cultivars followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 4. Relative Phytotoxicity of Tefluthrin (Fireban 1.5G) Preplant Incorporated Into Media to Various Containerized Bedding Plants,Trial IV.

	Fresh Shoot Weight [g]			Roots		
Cultivar	**check**	**1X**	**3X**	**check**	**1X**	**3X**
Chrysanthemum morifolium 'Megan'	226.1a	208.2a	237.0a	2.0a	2.0a	2.0a
Chrysanthemum morifolium 'Sandy'	171.5a	178.3a	191.0a	2.0a	1.9a	2.0a
Hibiscus 'single red'	135.4a	109.3a	121.6a	1.9a	2.0a	2.0a
Petroselium crispum	147.4a	140.6a	159.5a	1.9a	2.0a	2.0a
Plumbago auriculata	84.1a	67.9a	86.7a	2.0a	1.9a	2.1a
Trachelospermum asiaticum	24.9a	24.6a	26.7a	2.1a	2.1a	1.9a

Means within cultivars followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 5. Relative Phytotoxicity of Tefluthrin (Fireban 1.5G) Preplant Incorporated Into Media to Various Woody Ornamental Containerized Plants, Trial V.

	Fresh Shoot Weights [g]			Roots		
Cultivar	**check**	**1X**	**3X**	**check**	**1X**	**3X**
Betula nigra 'river birch'	938.0a	876.3a	901.1a	2.0a	2.1a	2.1a
Cupressocyparis leylandis 'Leyland cypress'	784.6a	839.0b	795.1a	2.0a	2.0a	2.0a
Cyrilla racemiflora 'Titi'	796.4b	999.8a	849.3b	2.0a	2.3a	2.1a
Ilex cornuta 'Anicet Delcambre'	251.2a	191.9a	231.9a	2.0a	2.0a	2.0a
Gardenia 'mystery'	1442.2b	1549.0a	1493.3ab	2.0a	2.0a	2.0a
Ligustrum sinense 'variegated'	164.4a	155.6a	179.3a	1.9a	2.0a	2.1a
Myrica cerifera 'wax myrtle'	2518.7a	2523.8a	2592.4a	2.0a	2.0a	2.0a
Quercus virginia 'live oak'	384.8a	376.5a	388.7a	1.7b	2.0a	2.1a

Means within cultivars followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 6. Relative Phytotoxicity of Tefluthrin (Fireban 1.5G) Preplant Incorporated Into Media to Various Woody Ornamental Containerized Plants, Trial VI.

	Fresh Shoot Weights [g]			Roots		
Cultivar	**check**	**1X**	**3X**	**check**	**1X**	**3X**
Abelia grandiflora						
'Sherwoodii'	121.1a	140.7a	138.9a	2.0a	2.1a	2.0a
Buxus sempervirens	36.0a	39.1a	38.9a	2.1a	2.1a	2.0a
Ilex cornuta 'fine line'	46.9a	41.4a	53.4a	2.0a	2.0a	2.0a
Ilex crenata 'bee hive'	138.6a	128.5a	134.3a	2.0a	2.0a	2.1a
Ilex crenata 'soft touch'	55.1a	53.1a	60.0a	1.9a	2.0a	2.0a
Ilex latifolia						
'Wirt L. Winn'	52.6a	45.1a	49.7a	2.0a	2.1a	2.0a
Ilex vomitoria 'Stokes dwarf'	80.9a	78.1a	76.8a	2.0a	2.0a	2.1a
Rhododendron 'copperman'	121.4a	115.1a	116.0a	1.9a	2.1a	2.1a
Rhododendron 'Hersheys red'	134.3a	147.4a	129.3a	2.0a	2.0a	2.0a

Means within cultivars followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 7. Relative Phytotoxicity of Tefluthrin (Fireban 1.5G) Preplant Incorporated Into Media to Various Containerized Bedding and FoliagePlants, Trial VII.

	Fresh Shoot Weights [g]			Roots		
Cultivars	**check**	**1X**	**3X**	**check**	**1X**	**3X**
Allamanda cathartica						
'cherry jubilee'	45.4b	56.4ab	63.3a	2.0a	2.0a	2.0a
Antirrhinum majus						
'snapdragon'	39.1b	50.0a	55.5a	2.0a	2.0a	2.0a
Celosia sp. 'kimono mix'	53.7b	59.9a	56.4ab	2.0a	2.1a	2.1a
Coleus sp. 'velvet wizard'	117.1a	119.2a	115.9a	2.0a	2.0a	2.1a
Lantana camara 'gold mound'	60.7a	61.9a	60.9a	1.9a	1.9a	2.0a
Melampodium paludosum						
'showstar'	176.6a	188.3a	192.3a	2.0a	1.9a	2.0a
Musa acuminata						
'Rajapura dwarf'	149.1a	138.8a	158.3a	2.0a	2.0a	2.1a
Nandina purpurea 'dwarf'	10.4a	10.7a	9.9a	2.0a	2.1a	2.1a
Petunia x *hybrida*						
(single) 'ultra burgundy'	110.0b	113.6b	125.9a	2.1a	2.2a	2.0a
Spathiphyllum sp. 'petite'	3.7c	6.9b	12.4a	2.0a	2.0a	2.1a
Syngonium podophyllum 'robusta'	8.3b	12.8a	7.3b	1.9a	2.1a	1.9a
Tagetes sp. (deep orange)						
'French Janie'	136.7a	143.4a	137.9a	2.0a	2.0a	2.0a
Viburnum tinus 'Laurustinus'	28.9b	39.1a	35.6a	1.9a	2.1a	2.0a
Viola wittrockiana						
'major giant'	46.4a	40.7a	42.6a	2.0a	2.0a	2.1a

Means within cultivars followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Oriental Beetle, Exomala orientalis (Waterhouse), as a New Nursery Pest in Maryland

K. Marc Teffeau, J. Lee Hellman and Mark J. Rothschild
Maryland

Nature of Work: The Oriental Beetle, Exomala orientalis (listed in American references as Anomala orientalis and Biltopertha orientalis in Japan) has been identified as a nursery, turf and landscape pest in Maryland. This insect is originally thought to be a native of the Philippines and was introduced into the continental U.S. in Connecticut in 1920 in balled nursery stock (2). It is currently found in Connecticut, Hawaii, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Rhode Island and has now moved into the southern states of Maryland, Virginia and North Carolina. In New Jersey and several New England states this species is replacing the Japanese Beetle as the key soil insect pest. In 1994, for the first time in Maryland, damage to container nursery stock by the c-shaped larvae (grubs) was found in two nursery operations on Maryland's Eastern Shore. Prior to 1994, this species was rarely detected because of its reclusive adult behavior and grub misidentification as other species. The larvae are nearly identical in size and shape to Japanese Beetle larvae and can only be distinguished from them by the rastrai pattern. Similar to Japanese Beetle adults in shape and size, the Oriental Beetle adults exhibit elytra pattern and color variations from straw-colored to black. Unlike Japanese Beetles, they are not considered serious foliage feeding pests and the major damage they do is in the grub stage, attacking the roots of turf grass and of ornamental shrubs.

In 1994 the Maryland Department of Agriculture and the University of Maryland Cooperative Extension Service instituted a joint trapping program to determine the extent of this pest in Maryland. The experimental pheromone was obtained from Japan through a cooperative effort with the University of Rhode Island and Cornell University. Industry cooperators detected this species in four Maryland counties in 1994. Prior to 1994 the extent of damage or species distribution in the State's nursery industry was unknown. In 1995, this trapping program was expanded to include 11 sites in 5 counties (two golf courses and 9 nursery operations) in the Eastern Shore and Central Maryland regions. Standard yellow and green plastic Japanese Beetle traps were used in the program. They were hung one foot above the ground on stakes or placed at ground level at the sites according to Cornell University recommendations (3). The traps were checked on a two to three day basis where populations were indicated to be high from the 1994 trapping program. Other traps were examined on a four to five dayor weekly basis to determine presence or absence of the beetle.

Results and Discussion: Adult beetles were trapped at all sites in Maryland. Traps were set out the week of June 4th with the first beetle caught on June 7th. Trapping continues through the month of August to determine the length of the adult beetle flight period. Two nursery sites in the Eastern Shore area of Maryland registered continuously high counts throughout the trapping program. Both of these operations had experienced crop damage from the larvae in the containers in 1994 and 1995. In the one central Eastern Shore site previously known to have the problem, five pheromone traps were set out; two in the interior of the nursery and three on the perimeters next to corn and soybean fields. Consistently higher beetle counts were noted in the three perimeter traps as compared to the two interior nursery sites. In addition, extensive Oriental Beetle presence was noted in an adjacent corn field with burrowing of adults into the soil observed.

Significance to Industry: With the expansion of this insect pest into container nursery stock in Maryland, there is a concern that quarantines may be warranted to contain this species in a few Northeastern states. Currently, container nursery growers are resorting to insecticidal sprays of the adults every few days during the flight period to control this pest. This control method is not effective or economically practical in the long run. An IPM approach needs to be developed to determine control recommendations for the MidAtlantic states. Preliminary work has been done with comparative trials of chemical and biological methods to determine levels of control in container nursery stock. (1) These efforts will be expanded in Maryland in 1995 and 1996 to additional comparative trials with both chemical insecticides and biological controls such as Bt strains.

Literature Cited

1. Clark, Scott, Dan Gilrein and Jennifer Jens. 1993. Control of Oriental Beetle Grubs in Container-Grown Azalea with Orthene 15G, Imidacloprid and Metarrhyzium. Cornell Cooperative Extension, Long Island Horticultural Research Laboratory.

2. Tashiro, Haruo. 1987. Turfgrass Insects of the United States and Canada. Cornell University Press, Ithaca, NY. (208-215).

3. Villiani, Mike and Steve Alm. May 15, 1995, Personal Correspondence, Department of Entomology, Geneva Campus, Cornell University, New York.

Reported Distribution of The Asian Ambrosia Beetle *Xylosandrus crassiusculus* (Motschulsky) in The Eastern United States and Associated Host Plants

Bill Ree, Leslie Hunter
Texas

Nature of Work: In 1974 the ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky), which is of Asian origin, was discovered infesting peach trees in Charleston and Dorchester counties of South Carolina (1). Since the initial detection, this insect has been reported as far north as Maryland and west into eastern Texas.

The intent of this study was to determine the current range of *X. crassiusculus* in the United States and associated host plants. This baseline distribution information will be used to monitor movement of this insect in the U.S.

During March and April 1995 questionnaires requesting information on *X. crassiusculus* were mailed to university entomologists in 26 eastern and southeastern states. States surveyed included: Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia and West Virginia. The survey requested information about distribution, reported host plants, time of infestations and educational information that was available to producers.

During May 1995 a separate survey was distributed to Texas wholesale nurseries through the Texas Association of Nurserymen, TAN. Questions in the TAN survey were directed toward economic losses, familiarity with the insect, sources of information and host plants.

Results and Discussion: Of the 26 states surveyed, 12 reported infestations or collections of adults. The states and year of first reported collection where available are: Alabama, Florida (1983), Georgia, Louisiana, Maryland (1993), Mississippi (1980), North Carolina (1979), Oklahoma (1994), South Carolina (1974), Tennessee (1993), Texas (1984) and Virginia (1995). The current reported distribution by state and county is shown in Figure 1.

When asked what months infestations were observed, most states reported infestations during February, March, April and May. However, Tennessee reported infestations during May, June and July; Georgia during March, September and October; and Alabama during the spring and September and October.

Infestations were reported on a wide range of host plants and sites. A list of reported host plants can be found in Table 1. Sites of infestations included wholesale and retail nurseries, fruit and nut orchards, city and state parks, professional landscapes, roadsides and private homes. Overall, *X. crassiusculus* was considered a serious pest only in Georgia, Mississippi, North Carolina, South Carolina, Tennessee, and Texas. Educational information for producers was available only from Florida, Entomology Circular 310, September 1988, and Texas, "Wanted" poster.

The Texas survey was sent through TAN to 350 wholesale nurseries with 69 (19.7%) surveys returned representing 34 counties. Of those returned, only 9 (13.04%) nurseries from 8 counties reported infestations. All infestations were observed between February and June. Of the nurseries reporting no infestations, 48% had no knowledge of the insect. Nurseries reporting no infestation of *X. crassiusculus* that indicated they were familiar with the pest obtained their information from industry trade publications and the Texas Agriculture Extension service. Other sources of information reported were the Texas Department of Agriculture, other nursery managers, consultants, college courses relatives and nursery organizations.

Significance to Industry: Although *X. crassiusculus* is considered only a nuisance pest in most states this insect has caused significant losses (in excess of $5,000 per nursery) in several nurseries across the southeast and Texas. In an industry with considerable inter and intrastate movement of host plants, this insect represents a serious threat. In Texas, 9 nurseries reporting infestations estimated losses during the spring of 1995 between $13,500 and $24,000.

Literature Cited

1. Anderson, D.M. 1974. First record of *Xyleborus semiopacus* in the continental United States (Coleoptera: Scolytidae). U.S. Dept. Agric. Coop. Econ. Insect Rept. 24:863-864.

Table 1. Reported host plants of the Asian ambrosia beetle, *Xylosandrus crassiusculus*.

Family	Genus	Species	Common Name	State(s)
Aceraceae	*Acer*	*palmatum*	Japanese maple	North Carolina
	Acer	*rubrum*	red maple	Florida
	Acer	spp.	maple	Georgia
Anacardiaceae	*Pistacia*	*chinensis*	Chinese pistache	Texas
Capparidaceae	*Koelreuteria*	*paniculata*	golden raintree	Texas
Cornaceae	*Cornus*	*florida*	flowering dogwood	Florida
	Cornus	*racemosa*	dogwood	Georgia
Cupressaceae	*Cupress*	spp.	cypress	Louisiana
			cedars	Louisiana
Ericaceae	*Rhododendron*	spp.	azalea	
Fagaceae	*Quercus*	spp.	oaks	Louisiana, Mississippi, Georgia
	Quercus	*macrocarpa*	bur oak	Texas
	Quercus	*muehlenbergii*	chinkapin oak	Texas
	Quercus	*nuttallii*	nuttall oak	Texas
	Quercus	*shumardii*	shumard oak	Texas
Juglandaceae	*Carya*	*llinoensis*	Pecan	Georgia, Louisiana, Mississippi, North Carolina, Texas
Leguminosae	*Ceris*	*canadensis*	redbud	Georgia, North Carolina, Texas
	Gleditsia	*triacanthos*	honeylocust	Oklahoma
Lythraceae	*Lagerstroemia*	*indica*	crape myrtle	Alabama, Georgia, North Carolina
Magnoliaceae	*Magnolia*	spp.	magnolia	Louisiana
Moraceae	*Ficus*	spp.	ficus	Georgia, Texas

Table 1. continued

Rosaceae	*Malus*	spp.	apple	North Carolina, Oklahoma
	Prunus	*persica*	peach	Louisiana, Mississippi, South Carolina, Texas
	Prunus	*serrulata*	Kwazan cherry	Alabama, Tennessee, Virginia
	Pyrus	*calleryana*	Bradford pear	Georgia, Texas
Saxifragaceae	*Hydrangea*	*macrophylla*	hydrangea	Alabama
Taxadiaceae	*Taxadium*	*distichum*	bald cypress	Texas
Ulmaceae	*Ulmus*	spp.	elm	Florida
Vitaceae	*Vitis*	spp.	muscadine	Mississippi

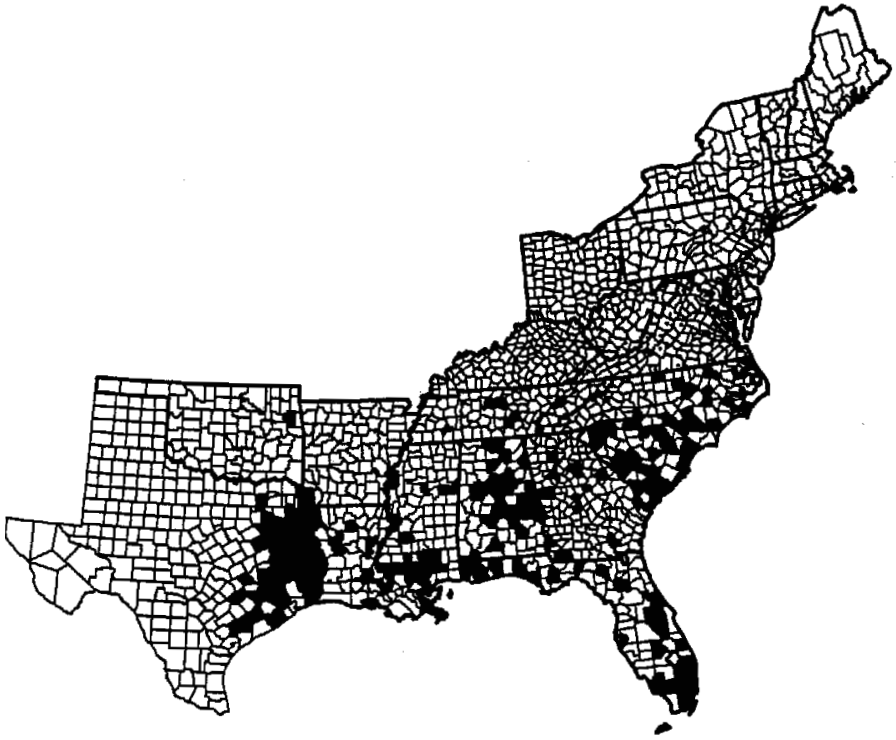


Figure 1. Reported distribution of *Xylosandrus Crassiusculus* (Motschulsky) in the Eastern United States as of May 1995.

Efficacy of Naturally Occurring Feeding Deterrents Endogenous to Rosaceous Trees on Japanese Beetle

Cynthia A. Patton, Thomas G. Ranney, James D. Burton and James F. Walgenbach
North Carolina

Nature of Work: The Rosaceae family contains many trees that are commercially important and commonly used in the landscape. It has been observed that different genera and species within this family vary considerably in their natural resistance to Japanese beetle attack (Hawley and Metzger, 1940). Recent studies have shown there to be a wide range of resistance among crabapple and cherry taxa to feeding of adult Japanese beetle (Ranney and Walgenbach, 1992). The nature of these mechanisms of resistance has not been determined. Natural resistance can be the result of many plant characteristics but defense chemicals or allelochemicals have been shown to be an integral part of natural control of many insect pests (Waiss et al., 1977; Reese, 1977). Identification of allelochemicals active in conferring resistance to insect attack in rosaceous trees would aid in the development of a base of knowledge concerning the biology of resistance.

Twenty three compounds known to be endogenous to rosaceous trees and having potential antifeedant qualities were evaluated for effects on the feeding of adult Japanese beetles during July 1994. Each compound was added to a standard artificial diet containing agar, cellulose and sucrose to yield molal concentrations of .001, .01 and .1. Each treatment (diet) concentration contained ten replications. Each replication consisted of a single female beetle placed into contact with a 1.5 x 1 cm plug of test media in a plastic petri dish. Beetles were starved for twenty four hours prior to the study and allowed to feed for twenty four hours during the study. A control media containing .1M sucrose was included during each test. Data was collected in the form of fecal dry weight.

Results and Discussion: Dose:feeding response curves were evaluated for each compound using linear and nonlinear regression analyses. The effective dose of a compound that reduced feeding by 25% (ED_{25}) was estimated from regression equations. Eight of the original twenty three compounds exhibited no antifeeding effects and in some cases imparted stimulatory effects on the feeding of adult Japanese beetles. These compounds include benzaldehyde, calcium oxylate, catechin, gallic acid, prunasin, quercetin, rutin and tannic acid. The remaining fifteen compounds all exhibited some degree of inhibitory influence on the feeding of adult Japanese beetle (Table 1). ED_{25} values for p-coumaric acid, eugenol and amygdalin were 1.8, 1.9 and 1.9 millimolar respectively. These values indicate that these three compounds were the most efficient at imparting antifeedant qualities when found at very low concentrations. Arbutin (ED_{25}=5.9 mM), phloretin (ED_{25}=6.8 mM), geraniol (ED_{25}=7.1 mM), phloridzin (ED_{25}=8.7 mM), naringenin (ED_{25}=9.8 mM), and o-coumaric acid (ED_{25}=14.6 mM) were effective in reducing feeding by twenty five percent at moderately low concentrations. The remaining six compounds had ED_{25} values that ranged from medium to medium high. Argenine had an ED_{25} of 41.2, benzoic acid 43.9, asparagine 53.1, chlorogenic acid 60.1, oxalic acid 62.8, and caffeic acid 77.9. These results indicate that a variety of compounds known to exist in rosaceous trees are effective feeding deterrents and may play an important role in host plant resistance.

Significance to Industry: As public concerns and limitations on the use of pesticides increase, plants with natural insect resistance will become an important tool in planning more sustainable landscapes. Long-term IPM programs which will guide the industry in the future dictate the use of pest resistant plants. The identification of effective endogenous allelochemicals is a step toward rapid screening methods for identification of resistant plants.

Literature Cited

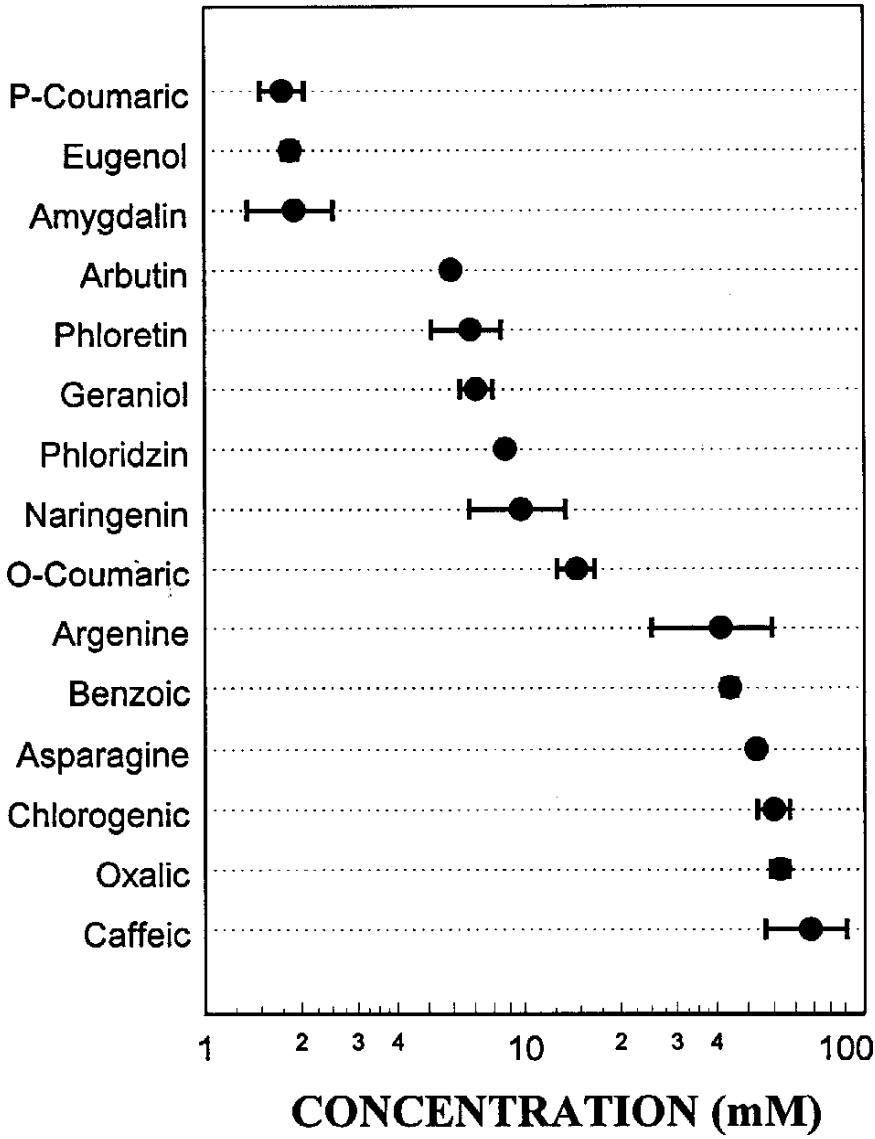
1. Hawley, J.M. and F.W. Metzger. 1940. Feeding habits of adult Japanese beetle. U.S. Dept. of Agr. Circ. 547.

2. Ranney, T.G. and J. Walgenbach. 1992. Feeding preference of Japanese beetles for taxa of birch, cherry and crabapple. J. Environ. Hort. 10:177-180.

3. Reese, J.C. 1977. The effects of plant biochemicals on insect growth and nutritional physiology. *In*: Host plant resistance to pests. P. Hedin ed., p. 129-152. ACS, Washington, D.C.

4. Waiss, A.C., Jr., B.G. Chan and C.A. Elliger. 1977. Host plant resistance to insects. *In*: Host plant resistance to pests. P. Hedin ed., p. 115-128. ACS, Washington, D.C.

Table 1. The effective dosage that reduced feeding of adult female Japanese beetle by twenty five percent (ED_{25}).



Susceptibility of Holly Species and Cultivars to Twolined Spittlebug

S. Kristine Braman and John Ruter
Georgia

Nature of Work: The twolined spittlebug (TLS), *Prosapia bicincta* (Say), is a North American species with a wide geographic distribution. It occurs from Maine to Florida and west to Iowa, Kansas, and Oklahoma. The TLS has been a sporadically severe pest of Coastal bermudagrass and other bermudagrass pastures in the souteast since the early 1950's. Recently damage to warm season grasses, especially centipedegrass, and to a wide variety of woody ornamentals, notably hollies, has focused attention on twolined spittlebug as a pest of ornamentals.

Two generations of the spittlebug have been shown to occur in Georgia and Florida, with a possible partial third generation present in some areas. Eggs overwinter in hollow stems of turfgrass, under leaf sheaths and in debris. Hatching nymphs feed on herbaceous plants. Nymphs have been recorded on over 40 different plants, predominantly grasses. Once the mouthparts are inserted, nymphs produce their characteristic protective spittlemass.

In Georgia adults of the first generation are active in June. Second-generation adult activity peaks in August and September. The adult stage causes injury to woody ornamental plants, including hollies. Damage associated with the second generation is usually most severe. Our objective was to determine the range in susceptibility to TLS among holly selections.

The *Ilex* collection (> 140 selections) at the Coastal Plain Experiment Station in Tifton, Georgia was screened for susceptibility to adult TLS infestation and damage. Levels of natural infestation and damage were assessed for the field-grown collection on three separate dates: August 19 and 26, 1994 and June 14, 1995. Sampling during 1994 corresponded with the occurrence of the second generation, while activity by the first generation was observed in 1995. Number of spittlebugs present per plant and number of damaged terminals per plant were recorded.

Cuttings from 23 accessions were taken during 1994 and used to confirm TLS preference under controlled laboratory conditions. Cuttings were arranged in a randomized complete block design with five replicates inside a large plastic arena on August 22, 1994. Twenty spittlebugs were released into the center of the arena and location of spittlebugs was noted at 2, 4, 9, 21, and 24 hours post-introduction. After the 24 h exposure period, three damage ratings per cutting were also taken using a scale of 0 (no damage) to 9 (severe damage).

Results and Discussion: Number of TLS on field grown plants observed on the three sampling dates ranged from 0 to 28 adult spittlebugs per plant. Number of damaged terminals ranged from 0 to 62. A susceptibility rating was assigned to each plant selection based on the average number of spittlebugs or damaged terminals observed as follows: None= 0 TLS and 0 damaged terminals, Slight= 0-2 TLS or 0-10 damaged terminals, Moderate= 2-8 spittlebugs or 10-30 damaged terminals, and High= 9-15 TLS or 30+ damaged terminals. Hollies in the collection ranged from highly susceptible to completely resistant (Table 1). In general *I. cassine* and *I. opaca* were susceptible to TLS. Crosses involving those species as parents were also very susceptible. Species with only slight or no susceptibility to the spittlebug included *I. cornuta, I. vomitoria, I. verticillata, I. glabra* and others.

Laboratory assays of 23 cultivars confirmed the susceptibility of cultivars with *I. cassine* or *I. opaca* parentage. Those exhibiting severe damage included 'Savannah', 'Carolina #2' 'Eagleston', 'East Palatka', Foster #2', and 'W. J. Bean', *I. cassine* (red fruit), *I. cassine* (yellow fruit), and an *I. integra x rugosa* cross. Cultivars in the laboratory assay exhibiting no damage included 'Shamrock', 'Winter Red', 'Burford', 'Wetumpka', 'Warrens Red', and 'Kathy Anne Batson'.

Significance to the Industry: Use of pest resistant plants in the landscape will reduce the need for insecticide use in our landscapes. Identifying pest resistant plant material provides an opportunity for incorporating pest resistant plants in plant breeding programs. Knowing the pest resistance status of available cultivars assists in recommendations concerning their proper placement in the landscape.

Table 1. Number of cultivars exhibiting various levels of susceptibility to twolined spittlebug.

Ilex spp. (no. cultivars)	None	Slight	Moderate	High
I. x attenuata (12) (*cassine x opaca)*		2	5	5
I. cassine (5)		1	3	1
I. integra x rugosa (1)			1	
I. opaca (10)		6	4	
I. aquifolium (2)		1	1	
I. x altaclarensis (3) *(aquifolium x perado)*		2	1	
I. aquifolium x cornuta		1		
I. (aquifolium x cornuta) x leucoclada (1)		1		
I. (aquifolium x ciliospinosa) x pernyi (1)		1		
I. x aquipernyi (1)			1	
I. colchica (1)		1		
I. x koehneana (4) *(aquifolium x latifolia)*		3	1	
I. latifolia x cornuta (1)			1	
I. x meserveae (4) *(aquifolium x rugosa)*		3	1	
I. rugosa x cornuta (2)		2		
I. spinicera (1)		1		

I. buergeri (2)	2	0	
I. cornuta (21)	16	5	
I. cornuta x ciliospinosa (1)	1		
I. cornuta x latifolia (3)	2	1	
I. cornuta x pernyi (2)	1	1	
I. (cornuta x pernyi) x latifolia (1)	1		
I. crenata (6)	4	2	
I. decidua (5)	2	2	1
I. glabra (5)	5		
I. integra (2)	1	1	
I. latifolia (3)	3		
I. perado (2)	2		
I. pernyi (1)	1		
I. purpurea (2)	2		
I. verticillata (5)	4	1	
I. verticillata x serrata (4)	4		
I. vomitoria (11)	8	3	

Timing and Control of *Proteoteras aesculana* (Lepidotera: Tortricidae) in Red Maple

F.A. Hale and M. Halcomb
Tennessee

Nature of Work: The destruction of the terminal bud or shoot of red maple, *Acer rubrum*, by a shoot boring caterpillar, *Proteoteras aesculana* Riley, produces a forked double leader. This damage is a major impediment to the production of high quality red maple in Tennessee.

P. aesculana have one generation per year. They are suspected to overwinter as early instar larvae by excavating terminal buds as does *Proeoteras moffatiana* Fernald (Simmons and Knight 1973). They may only leave the hibernation cell in the bud for a short time to feed on nearby buds before burrowing into the new shoot growth as does *Proteoteras willingana* (Kearfott) (Peterson 1958). Early season control is difficult because the larvae may only be in an exposed position on the outer surface of the small and expanding shoots and foliage for a short period of time. Since the new shoot quickly wilts after the initial entry of the borer, insecticide sprays need to control the exposed larvae before they can bore into the shoot. Previous studies (Hale and Halcomb 1994) have shown that the phenological stage of the red maple tree where the larvae enter the shoot is soon after the first two pair of leaves have emerged. Nine days after the two pair of leaves stage on April 29, 1994, larvae had already entered the shoots some of which were at the four pair of leaves stage, and wilting was visible.

A test was designed to see if control could be achieved by either applying a systemic insecticide prior to bud break or by applying a carefully timed spray in the early spring before the first signs of borer damage to new growth occur.

A block of 'Red Sunset' red maple at Pleasant Cove Nursery in Warren County, Tennessee was selected for the test. The trees had an average height of approximately 5.5 feet. This was the fourth growing season in the field. The systemic acephate insecticide, Pinpoint 15G (13.2 lbs./acre) was sidedressed in a shallow furrow to one side of the row which was then covered with soil on April 4, 1995. The tree phenology ranged from tight bud to green tip.

The other three insecticides applied as foliar sprays on April 21 were Orthene T & O 75 SP (1.33 lb/100 gal.), Merit 75WP (140 gm./100 gal.), and Talstar T & O 10WP (96 oz./ 100 gal.). The Merit 75WP rate of 140 gm./100 gal. was 10 times the label rate due to a error in calculating rates. The foliar sprays were applied at a 25 gal./acre rate using a CO_2 compression sprayer operating at 40 pounds per square inch, equipped with two TXVS-18 hollow cone nozzles. The treatments of 35 feet of row were replicated 4 times. The phenology of the trees on April 21 ranged from green tip to three pair of leaves. Low levels of damage was found in adjacent trees with up to four pair of leaves. A thorough complete tree inspection of all the trees in each treatment was made on May 3 for borer damage. The tree phenology was still quite variable with some trees having

terminal buds at green tip while most trees were in the three to five pair of leaves stage. Infested shoots were beginning to wilt and the leaves were turning dark brown. A small ball of insect fass and silk was usually found extruding from a small hole in the shoot. The damaged shoots were not dissected to reveal the presence or viability of the larvae.

Results and Discussion:

The percent of trees in each treatment that had at least one borer damaged shoot was 53.6% for the Control, 52% for Orthene, 40.2% for Merit, 33.1% for Pinpoint and 10.8% for Talstar. The average number of damaged shoots per tree was 1.7 for the control, 1.8 for Orthene, 1.6 for Merit, 0.8 for Pinpoint, and 0.2 for Talstar. One control tree had a high of twenty three borer damaged shoots.

Using the General Linear Model and the Duncans Mean Separation Procedure in SAS (SAS 1981), Talstar was significantly different from the Control, Orthene and Merit treatments (Table 1.). Merit and Pinpoint were not significantly different although it should be restated that Merit was inadvertently applied at 10 times the label rate. There was no significant difference between Pinpoint and Talstar.

The variability of plant phenology in the block of trees made the proper timing of the foliar applied insecticides difficult. A low level of damage may have occurred prior to April 21 when trees were sprayed. The soil applied systemic insecticide, Pinpoint 15G, has an advantage in this regard by being applied well before the first signs of damage. The variability in crop phenology and difficulty in timing are problems to be expected in actual nursery production. The use of a systemic insecticide followed by a carefully timed foliar spray needs to be evaluated in future studies.

Table 1. Mean number of red maple shoots damaged by *Proteoteras aesculana* Riley.

Insecticide	Rate/Acre	Mean number of damaged shoots
Control		58.50 a
Orthene T & O 75 SP	0.33 lb.	59.75 a
Merit 75WP	35 gm.	49.50 a b
Pinpoint 15G	13.2 lb.	25.75 b c
Talstar T & O 10WP	2.4 oz.	6.75 c

Treatment means followed by a different letter are significantly different ($P \leq 0.01$, GLM, Duncans {SAS Institute 1981}).

Literature Cited

1. Hale, F.A. and M. Halcomb. 1994. Shoot boring caterpillars, *Proteoteras* spp. (Lepidoptera: Tortricidae) Major pests of red maple in Tennessee nurseries Proc. Southern Nurserymen's Association Research Conference 39: 178-179.

2. Peterson, L.O.T. 1958. The boxeleder twig borer, *Proteoteras willingana* (Kearfott), (Lepidoptera: Olethreutidae). Can. Entomol.90: 639-646.

3. SAS Series in Statistical Applications. 1981. SAS Institute Inc. Cary, NC.

4. Simmons, G.A. and F.B. Knight. 1973. Deformity of sugar maple caused by bud feeding insects. Can. Entomol.105: 1559-1566.

Natural Resistance to Eastern Tent Caterpillar Among Rosaceous Trees

T.G. Ranney, J.F. Walgenbach, J.D. Burton, E.P. Maness, and D.M. Pharr
North Carolina

Nature of Work: Eastern tent caterpillar (*Malacosoma americana*)(ETC) is one of the most widespread defoliators of deciduous trees in the eastern United States (2). Many species of rosaceous trees, including cherries (*Prunus spp*.) and crabapples (*Malus spp.*), are preferred hosts of ETC (1) . Long-term control of this pest is complicated due to its wide distribution and diverse host range. Webs are highly visible and have been known to induce a primal fear among the generally entomophobic urban population resulting in a low "aesthetic threshold" of tolerance. The objective of this study was to evaluate a diverse collection of rosaceous trees for natural resistance to Eastern Tent Caterpillar.

A collection of 54 taxa of rosaceous trees were evaluated for natural resistance to Easter Tent Caterpillar. No-choice feeding trials were conducted in a laboratory to evaluate growth rates, developmental factors and survival of the of larvae fed leaves from the different taxa as a measure of antibiosis. Larvae were provided with leaves every other day collected from field grown trees every other day. Mean relative growth rate of the larvae was calculated as: (ln final weight - ln initial weight)/time, where ln is the natural log. Foliage samples were collected concurrently with feeding assays, freeze dried, and later analyzed for cyanide, nitrogen, total phenolics, and soluble carbohydrates including sucrose, glucose, fructose, and sorbitol.

Oviposition preference was evaluated as a measure of antixenosis. Pupae and larvae were randomly distributed throughout replicated (n=3) field plantings of flowering cherries and crabapples and egg masses were counted in the fall after leaf drop.

Results and Discussion: Relative growth rates varied considerably from a high of 213 $mg \bullet g^{-1} \bullet week^{-1}$ for insects fed leaves from *Malus* 'Madonna' to a low of 22 $mg \bullet g^{-1} \bullet week^{-1}$ for insects fed leaves from *Pyrus calleryana* 'Bradford' (Table 1). Pupa weights and survival showed similar trends (data not shown). Although none of the plants were completely resistant, many of these taxa demonstrated some antibiosis as indicated by reduced insect growth rates. Larvae fed *Pyrus calleryana* 'Bradford', *M. tschonskii*, *M.* 'Golden Raindrops', and *Prunus sargentii* had growth rates of less than 65% of maximum. Of the endogenous compounds that were analyzed, only total soluble carbohydrates were correlated with growth rate (r=0.68).

Variation in number of egg masses per tree was found to be a function of taxa and tree height. Trees smaller than 2.25 m were less likely to attract egg-laying females. For that reason, only trees _ 2.25 m were included in this analysis (Table 2). Seven taxa of *Malus* and 1 taxon of *Prunus* were found to strongly attract females and had means of 2.9, or more, egg masses per tree. Eighteen other taxa had no egg masses.

Significance to Industry: Of the 54 taxa of trees studied, only 4 (*Pyrus calleryana* 'Bradford', *M. tschonskii*, *M*. 'Golden Raindrops', *and Prunus sargentii*) were adequately resistant to reduce insect growth rates by more than 65%. These taxa might be considered for planting were ETC is prevalent. Seven taxa of *Malus* (M. *hupehensis*, *M*. Sugar Tyme, *M*. `Radiant', *M*. `Doubloons', *M.* `Sinai Fire', *M*. `Sentinel', and *M*. `Snowdrift') were found to strongly attract egg laying females and had means of 2.9, or more, egg masses per tree. These susceptible taxa should be avoided where Eastern Tent Caterpillar is a problem.

Literature Cited

1. Dethier, V.G. 1980. The world of the tent-makers. The University of Massachusetts Press, Boston, MA.

2. Johnson, W.T. and H.H. Lyon. 1976. Insects that feed on trees and shrubs. Cornell University Press. Ithaca, NY.

Table 1. Relative growth rates of Eastern Tent Caterpillar larvae reared on 56 different taxa of rosaceous tree species.

Taxa	mg g^{-1} $week^{-1}$
Malus 'Madonna'	213
Malus 'Baskatong'	207
Malus 'Dolgo'	202
Malus 'Harvest Gold'	201
Malus baccata 'Jackii'	201
Malus 'Snowdrift'	201
Malus 'Indian Summer'	200
Malus 'Radiant'	199
Malus 'Straw. Parfait'	197
Malus 'Red Splendor'	192
Malus 'Sinai Fire'	191
Malus 'Jewelberry'	191
Prunus 'Hilliers Spire'	190
Malus 'Louisa'	190
Malus 'Danald Wyman'	189
Malus 'Adams'	189
Malus 'Silver Drift'	187
Malus 'Doubloons'	186
Malus 'Calloway'	186
Malus 'Brandywine'	185
Malus Sugar Tyme	184
Malus 'Glen Mills'	182
Malus 'Sentinel'	182
Malus hupehensis	178
Malus 'Robinson'	177
Prunus 'Okame'	177
Prunus'Autumn. Rosea'	176
Malus 'Pink Satin'	176
Prunus serotina	174
Prunus 'Canada Red'	174
M. 'White Angel'	173
M. 'Ormiston Roy'	173
P. 'Snow Fountains'	170
M. 'Silver Moon'	168
M. 'Candy Mint'	167
P. 'Hally Jolivette'	166
M. 'Canary'	166
M. zumi 'Calocarpa'	166
M. *floribunda*	165
Malus 'Prairie Maid'	164
Prunus 'Afterglow'	161
Malus 'Molten Lava'	159
Malus 'Mary Potter'	159
Malus 'Pink Princess'	158
Malus 'Adirondack'	156
Prunus 'Kwanzan'	143
Prunus 'Snowgoose'	132
Pruns 'Akebono'	128
Amelanchier 'Aut. Bril.'	114
Malus 'Naragansett'	100
Prunus sargentii	73
Malus 'Golden Raind.'	72
Malus tschonskii	37
Pyrus 'Bradford'	22
$LSD_{0.05}$	52

Table 2. Oviposition preference of Eastern Tent Caterpillar for *Malus* and *Prunus* taxa.

Taxa	Egg masses/tree	Taxa	Egg masses/tree
Malus		*Prunus*	
M. hupehensis	8.3	*P.* 'Afterglow'	2.0
M. Sugar Tyme	7.0	*P.* 'Canada Red'	0.3
M. 'Radiant'	4.3	*P.* 'Autumn. Rosea'	0.0
M. 'Doubloons'	4.0	*P.* 'Hally Jollivete'	0.0
M. 'Sinai Fire'	3.3	*P.* 'Hillier Spire'	0.0
M. 'Sentinel'	3.0	*P.* 'Kwanzan'	0.0
M. 'Snowdrift'	3.0	*P.* 'Mt. Fuji'	0.0
M. 'Harvest Gold'	2.7	*P.* 'Okame'	0.0
M. 'Ormiston Roy'	2.7	*P. sargentii*	0.0
M. 'Donald Wyman'	2.5	*P.* 'Snow Goose'	0.0
M. 'Silver Moon'	2.3	*P.* 'Tai Haku'	0.0
M. baccata 'Jackii'	2.0		
M. 'Red Splendor'	1.7	$LSD_{0.05 =}$	2.9
M. 'Naragansett'	1.5		
M. 'Straw. Parfait'	1.3		
M. 'Radiant'	1.0		
M. *floribunda*	0.7		
M. 'Canary'	0.5		
M. 'White Angel'	0.5		
M. 'Callaway'	0.5		
M. 'Robinson'	0.3		
M. 'Madonna'	0.0		
M. 'Golden Raind.'	0.0		
M. 'Brandywine'	0.0		
M. zumi 'Calocarpa'	0.0		
M. 'Molton Lava'	0.0		
M. 'Adams'	0.0		
M. 'Baskaong'	0.0		
M. 'Indian Summer'	0.0		
M. 'Candy Mint'	0.0		

Implementation of Integrated Management of Whitefly and Two-Spotted Spider Mite

Mary A. Harris, Beverly Sparks, and Khristine Braman
Georgia

Nature of the Work: Insect pest control may seem like an endless battle that is never won. One control strategy that has been employed is that of applying chemical insecticides with prevention as the desired effect. For this tactic to be successful several criteria must be met: an insecticide must be registered for use on the crop, the insectide must be efficacious, and workers must be able to reenter the treated area within a period of time that allows the necessary activities associated with your production schedule. Growers are well aware of the difficulties meeting all three of these criteria. The numbers of insecticides registered for use on ornamentals is decreasing and the registration of a new insecticide is a rare event. Development of resistance to a number of pesticides has greatly reduced their efficacy (1). Furthermore, some of the registered insecticides have lenghty reentry restrictions that preclude their use on plants requiring worker contact such as that for pruning, spacing, and shipping.

Now, more than ever before, growers are seeking better control strategies than one of 'spraying and praying'. Integrated pest management, commonly referred to simply as IPM, is the approach most growers are taking. IPM programs are built on (1) information gained through monitoring and tracking pest population changes, (2) interpretation of this information using thresholds, and (3) decisions leading to a response to the interpreted information. However, neither monitoring methods nor thresholds have been developed for most ornamentals and most commercial nurseries produce many species of plants each with a different complex of associated pests (2). Growers can still rely on their own IPM programs despite these descrepancies in our knowledge. The purpose of this ongoing study is to demonstrate the IPM approach to insect control at a large commercial nursery.

McCorkle Nurseries produces over 700 species or cultivars for sale to 2,500 customers throughout the southeast. Three million containerized plants are produced over an area covering 150 acres near Thomson, Georgia. To initiate an IPM program we decided to concentrate on two of the most difficult and potentially costly pest problems: first, whiteflies on perennials and second, spider mites on *Euonymus japonica* particularly the cultivars 'Siver King' and 'Aureo-marginata' each of which drops leaves in response to mite damage. We initiated a weekly monitoring program that begain 15 March 1995. Yellow sticky cards were placed in perennial beds at a rate of approximately 1 card every 25 ft among the most susceptible whitefly plants such as lantana and verbena. The number of whiteflies was counted each week and recorded by crop and card location. In addition, the lower side of foliage was examined for whitefly reproduction. To sample spider mites on *Euonymous* two terminals of four leaves each were taken approximately every 25 ft along 4 ft wide beds. Numbers of mites were assessed along with lifestages; eggs, nymphs, adults.

Results and Discussion: The initiation in March of a monitoring program for two-spotted spider mites allowed early detection of this pest. By quickly responding to isolated infestations we were able to rely on a total of five localized acaricide applications between 3 April and 30 June. Weekly monitoring allowed us not only to locate infestations of spider mites, but also to assess the efficacy of treatments. Without such monitoring, nursery-wide miticide applications would have been initiated in mid-March and repeated everyother week. Early detection of and response to spider-mite infestations on these sensitive *Euonymous* cultivars prevented the leaf drop which the previous year destroyed over 20,000 containerized plants.

This spring with the use of imidachloprid (Marathon) early in crop growth along with weekly monitoring we have been able to reduce subsequent insecticide applications to control whiteflies on perennials. However, the remainder of this growing season will put our tactics to the test as the period from late June through August is a difficult time to control this pest.

Significance to Industry: The lack of established pest thresholds should not preclude growers from developing their own IPM programs. Devoting employee time to regular pest monitoring will allow growers to make decisions to treat and also, decisions not to treat. The elimination of calendar based sprays will 1) reduce the development of pesticide resistance thus maintaining the effectiveness of our registered chemicals and 2) reduce production costs as costs of chemicals, applicator time, and 'down time' in which treated plants cannot be handled are much greater than the employee costs associated with an IPM monitoring program.

Literature Cited

1. Smitley, D. 1995. Spider mites . . . rearing their resistant heads again. Feb. Greenhouse Grower, pp 20-26.

2. Johnson, W. T. and H. H. Lyon. 1991. Insects that feed on trees and shrubs. 2nd ed., revised. Cornell Univ. Press, Ithaca, NY.

Evaluation of Aphid Control in Multi-Plant Containers

P.B. Schultz
Virginia

Nature of Work: The oleander aphid, *Aphis nerii* Fonscolombe is primarily an urban pest. It occurs in large populations where its primary host plant, oleander, is found and feeds actively on growing terminals. The insect is bright yellow with black markings. It appears in early spring and colonizes the young shoots and buds. Huge colonies often develop and persists until high temperatures and predators contribute to their decline. The aphid produces honeydew in copious amounts, reducing the plants aesthetic appeal and causing the formation of sooty mold. The insect appeared in early spring on butterfly weed, *Asclepias tuberosa* L., grown in 1 gallon containers at the Hampton Roads AREC, Virginia Beach, Virginia.

A study was designed to evaluate the effects of multiple plants in containers on the efficacy of imidacloprid (Marathon 1G) in controlling the oleander aphid. Seeds were germinated February 9, 1995. Seedlings were transplanted into 1 gallon containers on April 25, 1995, and 9 gms of Osmocote 18-6-12 were applied to each container. Containers had 1, 2, or 3 plants and were treated with Marathon 1G at rates of 1.1 and 2.2 grams (=1/3 and 2/3 teaspoon) per container and an untreated check. There were 4 replications of each plant-treatment combination. Aphids were counted weekly beginning June 8, the day of pesticide application.

Results and Discussion: Both rates of Marathon 1G were effective within 7 days of application, and remained effective for the 6 weeks counts were taken (Table 1). There was no reduction in efficacy resulting from multiple plants per container. One of the plants in a container with 2 plants at the 2.2 gms rate had higher than expected numbers of aphids for 3 weeks after application, though still lower (approximately 10%) than the untreated plants.

Significance to Industry: The use of multiple plants in container production does not appear to reduce efficacy of granular insecticides such as Marathon. No adjustment in the rate or frequency of application would be needed.

Literature Cited

1. Johnson, W.T. and H.H. Lyon. 1988. Insects that feed on trees and shrubs. Comstock Publishing Assoc. Ithaca, New York.

Table 1. Control of oleander aphid with Marathon 1G, 1995.

Rate	6-8	6-14	6-21	6-27	7-6	7-13	7-19	7-27
2.2g	1366a	18a	13a	14a	3a	0a	0a	0a
1.1g	2397b	45a	2a	2a	1a	0a	0a	0a
Untrt.	1256a	1141b	681b	311b	469b	387b	341b	225b

The Influence of Foliage Coloration on Insect Diversity among Three Cultivars of Dogwood

D. Scott Neitch, Jerome F. Grant and Mark T. Windham
Tennessee

Nature of Work: Dogwood trees are recognized for their aesthetic value as well as for their role in the ecosystem (4). Aside from their beautiful appearance in the wild, they are also a valuable asset to any homeowner's property (1). Dogwoods are important economically to thousands of nurserymen. In the eastern United States, dogwood sales reach approximately $100 million annually, contributing $35-40 million to the nursery economy in Tennessee.

In the last decade, the flowering dogwood, *Cornus florida* Link, has become threatened by dogwood anthracnose, a fungal disease caused by *Discula destructiva* Redlin. Many commercial nurserymen and homeowners are concerned about the threat of losing such a beneficial and beautiful asset. The fungal disease is characterized by leaf spots, twig blights, and limb/trunk cankers (3). Since its discovery, dogwood anthracnose has caused extensive mortality in both woodland and ornamental dogwoods (5).

Little information about the transmission of the pathogen is available. Environmental factors, such as extremely damp weather, may predispose a tree to the spores of *Discula* sp. which are often dispersed by wind or rain (2). Mechanical injuries often aid in the entry of the pathogen. Researchers have suggested that insect species may play an important role in epidemiology of dogwood anthracnose. However, limited information exists on insect species that inhabit dogwoods. Thus, a two-year research project was initiated to compare insect taxa associated with different cultivars of flowering dogwood.

During 1993 and 1994, insects were collected bimonthly from April/May to October from individual dogwood trees at the Plateau Experiment Station, in Crossville, Tennessee. Two trees of three cultivars of flowering dogwood were selected based on foliage coloration: Cherokee Princess (green), Purple Glory (red/purple), and First Lady (yellow). On each sampling date, plastic tarps were placed underneath the tree canopy. A selected insecticide, Pyrenone® (a pyrethrin [botanical]), was then applied, in a ratio of 10ml/3.8 liter of water, to the canopy of the tree using a hand-held sprayer. After 2 to 4 hours, fallen insects were removed from the tarps using a modified Dustbuster®, placed in plastic containers, and taken to the laboratory for processing and identification. All insects were identified to species, where possible. Seasonal incidences of selected species were determined, and insect populations were compared among the three cultivars of flowering dogwood.

Results and Discussion: Approximately 4,300 insects were collected from dogwoods at the Plateau Experiment Station during 1993 and 1994. The four most common orders represented were Coleoptera, Diptera, Homoptera, and Hymenoptera (Fig. 1). About 800 more insects were collected in 1994 than in 1993. Although insect communities were similar, percent composition of insects varied among the three cultivars of dogwood (Fig. 2). Greater numbers of insects (about 2x) were collected from First Lady (cultivar Y) than Cherokee Princess (cultivar G) or Purple Glory (cultivar P). The predominately yellow foliage of First Lady (cultivar Y) may have served as an attractant which could account for this higher density. Seasonal abundance of insects was similar for each cultivar of dogwood throughout the season during 1993. Densities of insects on each cultivar peaked in late May and those on First Lady (cultivar Y) peaked again in late July. However, seasonal abundance of insects during 1994 peaked during April, when densities were 3 to 6x greater on First Lady (cultivar Y) than Cherokee Princess (cultivar G) or Purple Glory (cultivar P).

Significance to Industry: This research will provide a better understanding of insect taxa associated with different cultivars of flowering dogwood. Further research can better define influences of dogwood cultivar on insect populations. These data will be useful to growers in the development and implementation of management programs for insect pests of dogwood.

Literature Cited

1. Anonymous. 1991. Growing and maintaining healthy dogwoods. USDA Forestry Service Report R8-FR 14. March.

2. Brown, D.A., M.T. Windham, A.S. Windham, and E.T. Graham. 1991. Dogwood anthracnose: questions and answers. The University of Tennessee Agric. Exp. Sta. Report 91-06. March, 7 pp.

3. Hibben, C.R. and M.L. Daughtrey. 1988. Dogwood anthracnose in northeastern United States. Plant Disease 72: 199-203.

4. Redlin, S.C. 1991. Characteristics of the *Discula* sp. on *Cornus florida*. *IN* Proceedings of the 1991 Dogwood Anthracnose Working Group. January 9-11, Athens, GA.

5. Mielkle, M.E. and M.L. Daughtrey. 1990. How to control and identify dogwood anthracnose. USDA Forestry Service Report NA-GR-18.

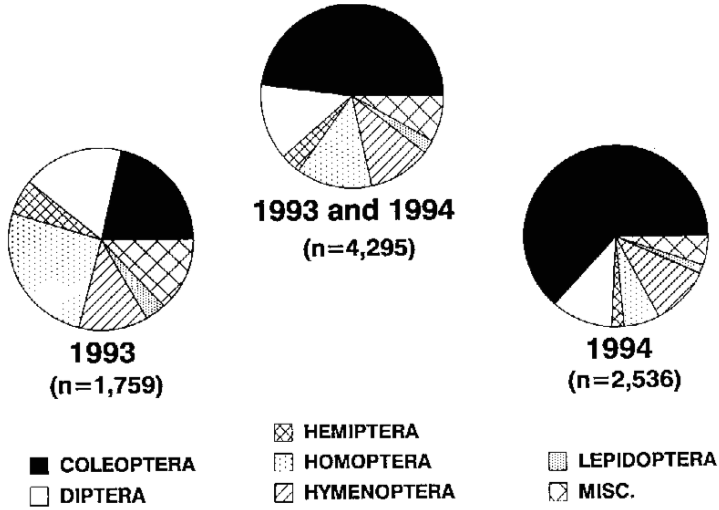


Fig. 1. Percent composition of insects collected from dogwood at the Plateau Experiment Station, Crossville, TN, during 1993 and 1994.

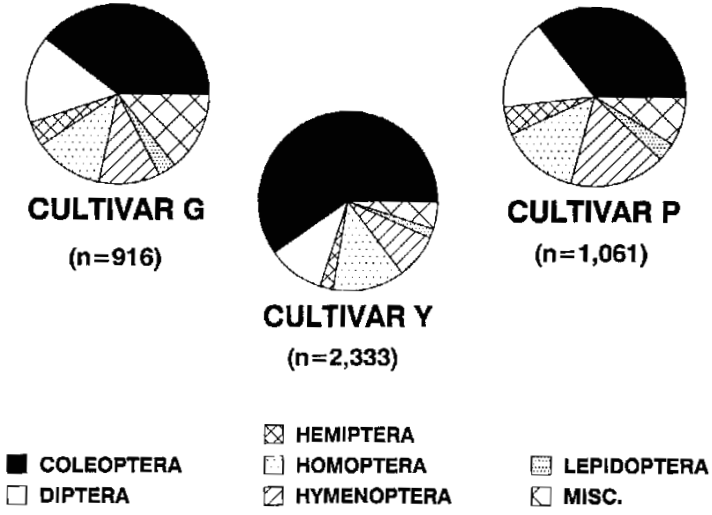


Fig. 2. Percent composition of insects collected from each cultivar of dogwood at the Plateau Experiment Station, Crossville, TN, during 1993 and 1994.