Residual and Antifeedant Activity of Landscape Insecticides Against Adult Japanese Beetles

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Nature of Work

The Japanese beetle (*Popilla japonica*) is the most widespread and destructive insect pest of turf, landscape, and nursery crops in the eastern United States (2). The adults feed on leaves, flowers, and fruit of more than 300 plant species (1), often severely defoliating lindens, Norway maples, sassafras, grapes, crabapples, certain *Prunus* species (e.g., purple-leaved plums), and other preferred hosts. They wreak havoc with blooms of roses, hibiscus, and other flowering plants and also are pests of grapes, berries, and other fruits. Japanese beetles are of major regulatory concern in Kentucky nurseries because quarantines restrict shipment of potentially grub-infested nursery crops with soil to states where the pest is not yet established.

Carbaryl (Sevin®), a broad-spectrum carbamate, has been both the industry and home landscape standard for controlling *P. japonica* for many years. Because carbaryl is highly toxic to bees and beneficial insects (predators and parasitoids) and generally provides only about one week residual, there is need for longer-lasting and reduced-risk alternatives. The purpose of this study was to examine residual and antifeedant activity of newer landscape insecticides including pyrethroids, botanicals, and reputed repellents using foliage of linden, a preferred plant, as a representative system.

Beetles were collected from the field from late June to early August using standard yellow funnel traps with floral lures. The females were then separated, held in bins with moist soil, and starved overnight prior to each assay. Males were discarded. All treatments were applied at labeled rates to separate intact, undamaged shoots of large littleleaf linden (*Tilia cordata*) trees, a preferred food plant for Japanese beetles. Foliage was thoroughly sprayed on both sides to ensure full residue coverage. Shoots were tagged according to treatment and left on the trees to weather until harvest.

Conventional Insecticides

Eight insecticides were chosen based on their active ingredients to evaluate and compare their relative effectiveness to one another and to untreated controls (Table 1). The sprays were applied at four separate timings: 19, 14, 7, and 2 d before shoot harvest. On day zero (July 15), the shoots were excised and brought into the lab. The sprayed shoots were exposed to varying amounts of rainfall while they weathered in the field: 19 and 14-d residues experienced 2.7 inches, 7-d residues experienced 0.3 inches, and 2-d residues experienced 0.24 total inches of rain. Maximum and minimum daily temperatures during the weathering period (June 26 to July 15, 2004) averaged 84º and 66ºF, respectively.

No-choice assays were used to compare the feeding damage between treatments of a given residue age as well as feeding on different residue ages within a treatment. Assays were done in 16 oz. clear plastic drink cups with lids. Each cup received a treated or control leaf and 10 beetles. Each combination of treatment and residue age was replicated five times. Beetles were exposed to the leaves for 6 h. All leaves were then replaced with untreated leaves overnight to evaluate the same beetles' capacity to feed after exposure to the residues.

Table 1. Insecticides and reputed repellent products that were evaluated.

Active Ingredient	Trade Name	Source
Conventional Insecticides		
Bifenthrin	TalstarOne	FMC
Bifenthrin	Onyx*	FMC
Carbaryl	Sevin SL**	Bayer
Cyfluthrin	Tempo SC Ultra	Bayer
cyfluthrin/imidacloprid	Bayer Advanced***	Bayer
Deltamethrin	Deltagard T&O 5 SC	Bayer
lambda-cyhalothrin	Scimitar GC	Syngenta
Permethrin	Astro	FMC
Homeowner Products		
Azadirachtin	Neem-Away	Gardens Alive!
Capsaicin	Hot Pepper Wax	Hot Pepper Wax
d-limonene	Orange Guard	Orange Guard
garlic juice and oil	Garlic Guard	Super-Natural Gardener
Kaolin	Surround WP	Engelhard
pyrethrins, canola oil	Pyola	Gardens Alive!
rotenone, pyrethrins	Liquid Rotenone-Pyrethrins	Bonide

* Onyx is formulated in a non-xylene solvent designed to penetrate leaves.
** Sevin SL was also used in the assays with homeowner products.
*** Bayer Advanced Rose & Flower Insect Killer Concentrate.

Homeowner Products

Six organic products reputed to be effective in deterring feeding by *P. japonica* were evaluated against carbaryl and an untreated control (Table 1). We included Surround WP, a kaolin-based particle film along with several botanical derivatives. Leaves were treated and left to thoroughly dry in the field for 4 h. No-choice assays were conducted as before. We also tested for repellence from the residues by placing five beetles in containers and providing them one treated and one untreated leaf, with six replicates per treatment. Leaves were removed for evaluation after 24 h. Three more choice assays were conducted in this manner. In the first, we treated the leaves as before, and after 4 h, we simulated rain on the residues with a watering can. For the remaining choice assays, we allowed the residues to weather naturally for 3 and 7 d.

To measure feeding damage, leaves were secured between two clear acrylic sheets and photocopied. The copies were then

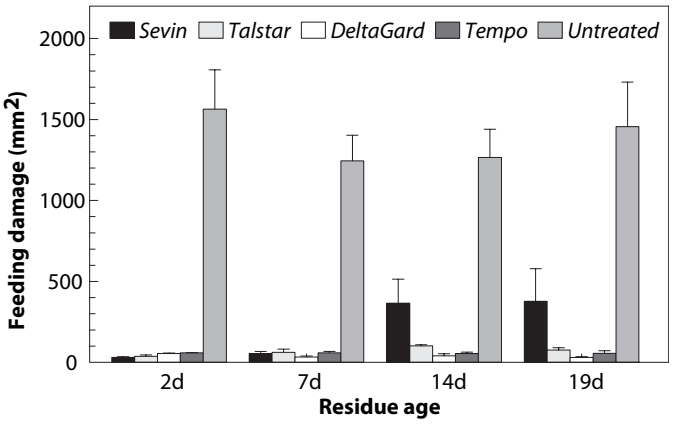
electronically scanned, and the eaten areas of the leaves were measured digitally using Adobe Photoshop 7.0. The areas were then recorded and converted from pixels to square millimeters.

Results and Discussion

Conventional Insecticides

- Weathered residues of TalstarOne, Onyx (data not shown), Tempo, Deltagard, and Scimitar provided 94 to100% protection of linden foliage for at least 19 days (Figure 1). Nearly all of the beetles were killed outright so there was little or no feeding damage when they were provided a second, untreated leaf.
- Sevin SL and Astro also provided significant protection (74 and 85% reduction in initial feeding, respectively, on 19-d-old residues). However, beetles exposed to older residues of those products generally recovered and fed when provided a second, untreated leaf.
- The Bayer Advanced product (cyfluthrin and imidacloprid) also reduced initial feeding by 73 to 84% for as long as 19 days, but most of the exposed beetles recovered and fed as much as the control group when provided a second, untreated leaf.

Figure 1. Japanese beetle feeding damage (mean ± SE) on linden leaves with different-aged residues of foliar insecticides (professional products). Shoots were pre-sprayed and residues were allowed to weather in the field. Treated leaves were then harvested and challenged with 10 female beetles for 6 h.



Homeowner Products

- In the no-choice test, 4-h-old, dry residues of Sevin, Pyola, and Neem-Away significantly reduced feeding (99, 97, and 68%, respectively) relative to untreated controls (Figure 2). Pepper wax and Surround did not reduce feeding.
- Sevin was the only homeowner product that killed the beetles, although they were noticeably intoxicated by Pyola. These treatments reduced subsequent feeding by 100 and 77%, respectively.
- Neem-Away provided short-term deterrence, but its effectiveness was reduced by simulated rain (Figures 3, 4).
- Garlic Guard and Orange Guard caused severe phytotoxicity.
- Pyola significantly deterred feeding for at least three days, but was no longer active after seven days. Simulated rain did not reduce its short-term effectiveness (Figures 3, 4).
- None of the other homeowner products (i.e., Hot Pepper Wax, Orange Guard, Garlic Guard, Surround, or Rotenone/pyrethins) protected linden leaves in choice tests.

Figure 2. Japanese beetle feeding damage (mean ± SE) on linden leaves with 4-h-old dry residues of selected homeowner products. Treated leaves were challenged with 10 female beetles for 6 h.

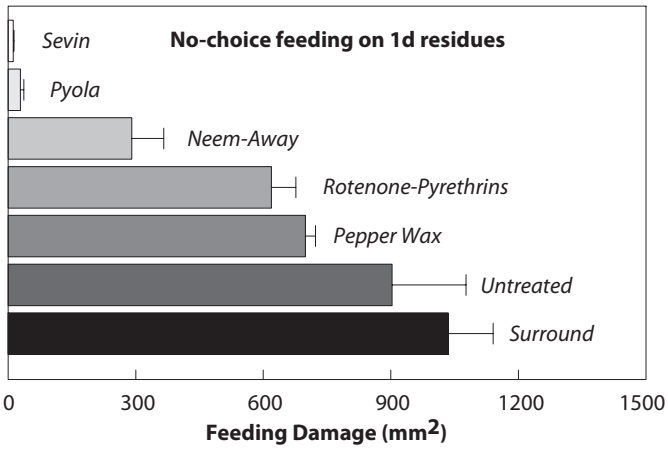


Figure 3. Feeding deterrence of different-aged residues of Pyola (pyrethrins and canola oil) and Neem-Away (azadirachtin) versus Japanese beetles in paired choice tests. To test for rainfastness, leaves with dry residues were drenched (2.54 cm of water) with a sprinkling can, then allowed to dry before the challenge.

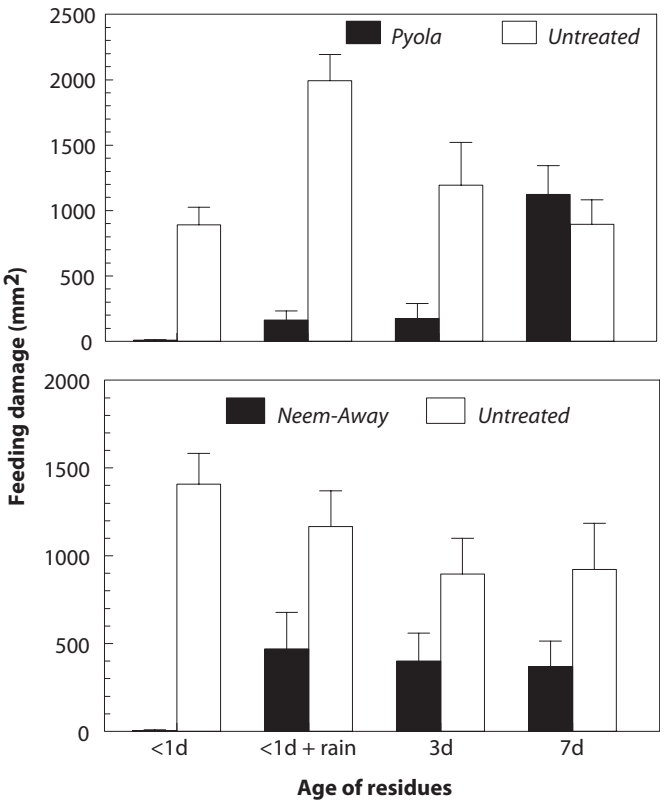


Figure 4. Typical silhouettes Neem-Away- or Pyola-treated linden leaves (left) versus untreated leaves (right) in choice tests. Residues of those products deterred Japanese beetles for several days (see also Figure 3).

Significance to the Industry

Field-weathered residues of Deltagard, TalstarOne (Talstar), Onyx, Scimitar, and Tempo provided 94 to 100% protection of linden foliage from Japanese beetles for at least 19 days (Figure 2). Those newer pyrethroids outperformed Sevin, which had been the industry standard for Japanese beetle control for many years. With the pyrethroids, beetles were knocked down quickly so there was little or no feeding damage before they were killed. The extended residual was obtained despite frequent and heavy rainfall on the sprayed shoots. Pyrethroids should allow arborists, landscape managers, nursery managers, and other professionals to manage Japanese beetle adult with fewer sprays and much less active ingredient than in the past. Homeowner formulations containing pyrethroids (i.e., products whose active ingredient ends in "-thrin") should also be effective.

Among the reputed repellents and "soft" pesticides marketed to home gardeners for Japanese beetle control, kaolin clay (Surround), capsaicin (Hot Pepper Wax), d-limonene (Orange Guard), garlic extract (Garlic Guard), and a rotenone/pyrethins combination were ineffective. Orange Guard and Garlic Guard caused severe phytotoxicity (drying out and burning) of linden leaves. Azadiractin or neem oil (Neem-Away) and a pyrethrins/canola oil mix (Pyola), both purchased online from Gardens Alive!, deterred Japanese beetles for about three days. Pyola resulted in knockdown and paralysis of beetles, as well as deterrence, whereas neem acts mainly as a feeding deterrent. Those products provide an option for homeowners seeking alternatives to chemical insecticides.

Literature Cited

1. Fleming, W.E. 1972. Biology of the Japanese beetle. U.S. Dep. Agric. Tech. Bull. 1383.
2. Potter, D.A., and D.W. Held. 2002. Biology and management of the Japanese beetle. Ann. Rev. Entomol. 47:175-205.

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