EFFICACY OF SUMMER OIL SPRAY ON THIRTEEN COMMONLY OCCURRING INSECT PESTS

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Abstract. The limited investigations of the past have shown that, when applied at low concentrations to woody ornamentals in verdant condition, horticultural oil provides a safe and effective means of controlling a wide variety of arthropod pests. This report provides data showing that the superior oil product Sunspray 6E Plus is highly effective against the woolly larch adelgid, cottony maple scale, calico scale, golden oak scale, boxwood psyllid, honeylocust plant bug, sycamore lace bug, European pine sawfly, and the euonymus webworm. Poor to no effect is reported here against adults of the sycamore plant bug, adults and larvae of the imported willow leaf beetle, and Japanese beetle. Phytotoxicity data are also included.

Résumé. *Les quelques recherches dans le passé ont montré qu'appliquée à de faibles concentrations à des végétaux ligneux en feuilles, l'huile dormante procure un moyen de contrôle sécuritaire et efficace contre une grande variété d'arthropodes. Ce rapport fournit des données montrant que le produit Sunspray 6E Plus est hautement efficace contre le puceron lanigère du mélèze, la cochenille floconneuse de l'érable, la cochenille calico, la cochenille dorée du chêne. le psylle du buis, l'insecte di chèvrefeuille, la punaise réticulée du platane, la tenthrède du pin d'Ecosse el la tisseuse du fusain. Peu ou pas d'effets ont été rapportés ici contre les adultes de l'insecte du platane, le calligraphe du saule et le scarabée japonais. Des données sur la phytotoxicité sont aussi incluses dans cet article.*

Studies at Cornell University over the past two years (1, 2, 3) have provided strong support for the statement made by Johnson in 1980 that "Oil continues to be the best available pesticide to control scales, mites, plant bugs, psyllids and certain moths in the dormant or semi-dormant season, and are competitors of the synthetic organic insecticides for use on trees in the verdant condition" (4). Recent work has also shown that for the vast majority of commonly grown woody ornamentals, the risk of serious phytotoxicity is probably very low, although a few species must clearly be classified as marginally to seriously oil-sensitive.

This portion of our experimental series evaluating the horticultural oil Sunspray 6E as applied to plants in the verdant condition was designed to expand the list of pest species for which summer oil efficacy data would be available, while at the same time continuing to monitor the product for indications of plant-specific phytotoxicity. Data from trials of this spray oil when applied to stressed, *dormant* woody ornamentals described in the literature as oil-sensitive will be presented in a subsequent report.

Materials and Methods

Over the course of the 1988 summer field season, approximately May through August in central New York State, we applied superior oil to 10 trees and shrubs that had been found to support populations of 13 insect pest species (Table 1). Located on or near the campus of Cornell University, the host plants included two evergreen and eight deciduous species, all of which were systematically evaluated over the course of the summer for any indication of foliar phytotoxicity. Of the 13 common insect pests we studied, most belonged to the order Homoptera; these included three scale insects, a psyllid, a leafhopper, and a "woolly aphid." The true bugs, order Hemiptera, were represented by three species of plant bugs, while the larvae of a sawfly represented the order Hymenoptera. A webworm, order Lepidoptera, and a pair of beetle species, order Coleoptera, completed the pest list.

The spray material used exclusively throughout the course of this study was the Sun Marketing and Refining Company's product Sunspray 6E. This horticultural oil is a light paraffinic distillate, nearly colorless and odorless, whose refining specifications clearly separate it from other similar products currently available on the market (5). The oil was diluted with distilled water to working concentrations of 2% or 3% by volume immediately prior to application.

A hand sprayer adjusted to deliver a fine, uniform mist was used to treat both sides of foliage to the point of drip; check plants were given a comparable treatment using distilled water alone. As determined by density of pest populations, one leaf or one twig bearing several leaves was usually considered a single, discrete population, and typically 5-10 populations were evaluated for each plant host. Following treatment, populations were evaluated for 7-10 days on a post-24-hour then alternate-day count schedule. Longer-term observations on possible phytotoxicity of Sunspray 6E were made weekly and continued for a one- to three-month period.

As permitted by pest population levels and weather conditions, those trials designed to evaluate pesticidal efficacy were initially conducted in the laboratory and subsequently replicated in the field. Our insect rearing room was placed on a 12-hour light cycle at a constant air temperature of 78°F. Humidity levels within individual rearing boxes were maintained through the use of small flasks supplied with cotton evaporator wicks. Gentle circulation of room air was maintained.

A specialized technique for collecting boxwood psyllid nymphs was developed during the course of these studies. Adapting a standard technique used to recover and concentrate microfossils from the rock matrix, short boxwood branches were repeatedly dunked and swirled in a 4-liter beaker half full of tepid, ¼ strength Micro (International Products Corp., Trenton, N.J.) laboratory cleaning solution. The resulting mixture of insects and fragmentary plant parts was then decanted through a 50 mesh sieve and the residue washed with running water until all detergent had been removed. The cleaned residue was transferred to a glass evaporating dish and resuspended in water. Under low magnification, the floating bright green psyllids, still somewhat waxy and hydrophobic, were readily hand picked using a small brush. Micro cleaning solution at this concentration appeared to harm neither the psyllids nor the boxwood leaves, which were still healthy when rechecked for missed insects two weeks following the washing. No insects were found, suggesting that this procedure is highly effective in removing psyllid nymphs from their characteristically cupped leaves.

Results and Discussion

Over the past few years information has continued to accumulate that modern formulation superior spray oils are a safe and effective means of controlling a wide range of arthropod pests known to damage many varieties of woody ornamental host plants. Despite long-standing biases to the contrary, it has been suggested recently that when properly used, horticultural oils have no equal in their degree of safety to man and the environment (5). An expanded list of pest control problems for which spray oil can be recommended is suggested by the following experimental results.

Sunspray 6E has continued to prove a highly effective means of controlling several pest species belonging to the order Homoptera; one of these is the woolly larch adelgid (= "woolly aphid" *Adelges laricis)* of European larch *(Larix decidua).* At the time of treatment with 2% oil, pest populations were already heavy, giving the foliage its characteristic appearance of having been dusted with fresh snow. Exact population counts were difficult to obtain, but 10 randomly selected whorls of leaves, averaging about 50 needles per whorl, supported about 250 of the black early instars without wax and 75 adults covered in individual fluff, white waxy filaments; most of these masses still contained three to six unhatched cream-colored eggs each. One hundred whorls were treated. Within a few hours, all nymphal stages were apparently dead, with the spray oil seeming to dissolve the mass of waxy threads that enclosed each insect. By the end of a week the unhatched eggs had shrunk and turned a dark chestnut brown. These findings suggest that Sunspray 6E has good ovicidal activity against this species of adelgid eggs. One- and two-month post treatment checks for phytotoxicity showed no indication of oil damage to either bark or foliage, although longer-term effects have not been fully evaluated.

Good, broad-spectrum ovicidal action has been a well-known property of horticultural oils for many years, and the trials reported here continue to support that highly desirable characteristic. Three different scale species were identified and their host plants tagged before the first crawlers started to emerge. The three scale species involved were cottony maple scale *(Pulvinaria innumerabilis)* on flowering dogwood *(Cornus florida),* calico scale *(Eulecanium cerasorum)* on Japanese pagoda tree *(Sophora japonica),* and golden oak scale *(Asterolecanium variolosum)* on

English oak *(Quercus robur).*

The cottony maple scale population had not yet started to hatch early in May when the 2% oil was applied, although white egg sacs containing large numbers of eggs were developing on the overwintering female scales. Fifty typical scales were treated with oil. By early July nearly all eggs in the control populations had hatched, and large numbers of crawlers, averaging 100 per leaf, had migrated to the dogwood foliage where many had already inserted their mouthparts and begun to feed. Leaves on branches that had been sprayed with oil a month earlier showed a large decrease in crawler population, averaging slightly fewer than 30 per leaf. This suggests that a major reduction in egg hatch had been achieved by the pre-eclosion oil treatment. Subsequent direct spray application of Sunspray 6E to the crawlers appeared to give complete control in a 24-hour period with no indication of phytotoxicity observed.

Treatment of two other scale species yielded results similar to those obtained for the cottony maple scale. Heavy golden oak scale populations, averaging around 20 "pits" per linear inch of oak twig, were treated with oil well before the expected date of living young production by the overwintering female scales. Approximately a month following oil treatment, crawler populations on control branches averaged 106 per linear inch, while previously treated branches averaged only 21 crawlers, providing an oil treatment reduction in crawler production of nearly 80%. Data obtained from treating prepartum calico scales on Japanese pagoda tree, whose populations ranged from seven to nine adult females per 6-inch branch segment, suggest a comparable degree of reduction. In both scale species, application of 2% oil directly to the crawlers results in essentially complete control within a one-day period.

The compound leaves of the Japanese pagoda tree appeared to have been slightly mottled and curled by the oil application. Although these symptoms were transitory, permanent foliar damage might well have occurred under conditions of water stress. Consequently, this tree should probably be considered marginally sensitive to spray oil. No indication of phytotoxicity to oak leaves was observed.

It was noted that in every scale population studied a high level of parasitism was observed. Cottony maple scale, one of the least affected by parasites, still showed a 50% reduction in immature scale stages, and not a single unparasitized individual could be found in several populations of redbud lecanium *(Lecanium corni)* and magnolia scale *(Neolecanium cornuparvum).* Although further work will be required to evaluate the effect of spray oil on specific beneficial parasites, some research has suggested that certain species at least seem not to be harmed (7).

Damage caused by the boxwood psyllid *(Psylla buxi)* is very common and highly conspicuous on ornamental boxwood *(Buxus sempervirens)* plantings over much of the northeastern United States. Boxwood psyllid eggs are laid under vegetative bud scales where they overwinter. Late in April of an abnormally cold spring, 10 leafy boxwood twigs, each about 18 inches long, were clipped from the parent plant and sprayed to point of drip with 3% Sunspray 6E. The lower parts of clipped stems were placed in flasks containing water in the rearing room for forcing plant growth and to observe egg development. At that time no eggs had hatched. After eight days at 78°F most of the shrub's overwintering buds had produced 1-1½ inches of new terminal growth. At this point all branches were washed (as described previously) to recover any newly emerged psyllid nymphs. Ninety-two insects were recovered from the control branches as compared to four insects from oil-treated foliage. To evaluate a delayed hatching possibility, the same washing procedure was repeated one week later on the same foliage, yielding 14 more nymphs from the controls and one additional nymph from the treated foliage. When combined, these population counts indicate a dramatic decrease in psyllid egg viability of around 95%. As a check on the washing method for collecting nymphs, all branches were rewashed a third time at the end of the following week. No additional nymphs were recovered, suggesting that probably no individuals had been missed by clinging to the foliage. Results of these trials suggest that this spray oil has very good ovicidal action against psyllid eggs when applied in the spring. No phytotoxicity to the evergreen boxwood leaves, buds, or shoots was observed at the standard dormant concentration of 3% oil used in this trial.

Plant bugs (Hemiptera) and leafhoppers (Homoptera) seem to be nearly always found together as mixed populations on the foliage of honeylocust *(Gleditsia triacanthos)* where they cause characteristic discoloration and deformation of the new leaves and shoots. Such a population of adult and nymph honeylocust plant bugs *(Diaphanocoris chlorionis)* and leafhoppers *(Macropsis fumipennis)* was located and treated with 2% spray oil. Pest density was high, with a typical 20-inch segment of leafy branch supporting a population of at least 100 individuals in the ratio of about three plant bugs to one leafhopper. Within 24 hours of treatment the vast majority of insects had apparently been killed, and after 48 hours no individuals could be found alive. Spray oil used at a concentration of 2% thus appears to provide good control for these two pests of honeylocust.

Two other hemipteran pests were also evaluated for sensitivity to Sunspray 6E. One of these was the sycamore plant bug *(Plagiognathus albatus)* found in abundance on the leaves of several large American plane trees *(Platanus occidentalis)* growing on the Cornell University campus. Population densities of 30 or more adult insects on a small six-leaf branch were not uncommon, and most of the leaves showed the ragged, chlorotic, shot-full-of-holes appearance typical of severe plant bug damage. A drenching spray application of 2% oil to these pests appeared to have no immediate effect, and at the end of a week population levels remained essentially unchanged. It would seem from these results that while no phytotoxicity was observed, even to damaged tissues, Sunspray 6E when used alone would probably be ineffective in controlling sycamore plant bug adults.

Sycamore lacebugs *(Corythuca ciliata)*, another hemipteran, were commonly found sharing American plane tree leaves with the sycamore plant bug. Lacebug populations were somewhat smaller than plant bug, usually three to six individuals per leaf, typically concentrated near the veins on the under (abaxial) surface on the leaf. Lacebugs sprayed with a 2% oil became very active for two to three minutes, although none actually left the leaves, and then resettled; control lacebugs sprayed with distilled water exhibited no such temporary increase in activity. Of the oil-sprayed lacebugs, 50-70% appeared to have been killed within the first 24-hour period after treatment, with the remainder of the population succumbing in the following eight days. These results suggest that control of sycamore lacebugs may be obtainable using Sunspray 6E, and that a mode of action other than respiratory interference may be involved.

This horticultural oil was also evaluated for efficacy against the larval stage of the European pine sawfly *(Neodiprion sertifer)*. Of the large number of sawfly species that cause economic

Table 1. Host plants, their pests, and efficacy of Sunspray 6E.

Plant host	*Pest species*	*Degree of control*
Buxus sempervirens (English Boxwood)	*Psylla buxi* (Boxwood psyllid)	Excellent
Cornus florida (Flowering Dogwood)	*Pulvinaria innumerabilis* (Cottony maple scale)	Excellent
Euonymus europaea (Tree Euonymus)	*Yponomeuta multipunctella* (Euonymus webworm)	Excellent
Gleditsia triacanthos (Honey Locust)	*Diaphanocoris chlorionis* (Honeylocust plantbug)	Excellent
	Macropsis fumipennis (Leafhopper)	Excellent
Larix decidua (Larch)	*Adelges laricis* (Wooly larch adelgid)	Excellent
Pinus mugo (Mugo Pine)	*Neodiprion sertifer* (European pine sawfly)	Excellent
Platanus occidentalis (American Plane Tree)	*Corythucha ciliata* (Sycamore lacebug)	Excellent
	Plagiognathus albatus (Sycamore plantbug)*	None
Quercus robur (English oak)	*Asterolecanium variolosum* (Golden oak scale)	Excellent
Salix babylonica (Weeping Willow)	*Plagiodera versicolora (Imported willow leaf beetle)*	*Poor*
Sophora japonica (Japanese Pagodatree)	*Eulecanium cerasorum* (Calico scale)	Excellent

*adults only

damage in the United States, perhaps 100 are believed to restrict their feeding to the foliage of conifers (6). Mugo pine *(Pinus mugo)*, a common constituent in decorative plantings, is a host plant favored by pine sawfly; it is not uncommon to find an infested branch supporting a population of 50 or more larvae. In the lab, such a population of 50 was sprayed with 3% oil, and within 10 minutes of treatment 20% of the larvae had fallen inactive to the floor of the rearing cage; none of these individuals later recovered. By the end of the following 24 hours, nearly 75% had fallen moribund to the cage floor. Three days after treatment both control and experimental populations were transferred to shallow pans of moist soil, a procedure designed to provide the remaining larvae a suitable environment in which to overwinter for spring emergence.

Two weeks after having been transferred to the rearing room, all 38 control group larvae had burrowed into the soil. Forty-four of the 50 larvae initially treated with oil had been killed outright within the 14-day time period, while the six larvae that had survived the treatment had migrated into the soil to form prepupae. Ability to form viable pupae and thus complete the life cycle was evaluated in the spring of 1989. The control group produced 12 females that successfully laid eggs on mugo pine foliage, while the oil-treated group produced no adults. This suggests that oil on the surviving larvae may have interrupted a vital process and prevented successful pupation.

Larvae of the ermine moth *(Yponomeuta multipunctella)*, the euonymous webworm, are commonly reported as severe defoliators of tree euonymus *(Euonymus europaea)*. Previous work (2) has shown that when the caterpillars were sprayed with horticultural oil and placed on fresh, unsprayed foliage, they did not resume feeding, and none successfully completed their life cycle by pupating and emerging from cocoons as adult moths. It was suggested at that time that the efficacy of the oil could be due to anti-feedant properties, physiological toxicity, or both.

A follow-up trial designed to address these questions was made where *untreated* caterpillars could be transferred to previously oil-treated euonymus foliage and their behavior monitored. Within an hour both treated and control populations had migrated into centralized areas on their respective branches and begun constructing webs.

Initially, webworms in the experimental populations fed more slowly on oil-treated leaves, produced less frass, and were generally less active than their counterparts in the control group, but after a few days these differences had nearly disappeared, and within a week both groups were starting to form cocoons. A month after the start of the trial, 90% of the cocoons from the control populations and 87% of those cocoons produced by larvae that had been supplied oil-treated leaves as their food source had successfully emerged into adult ermine moths. These results would seem to indicate a contact-controlled mode of action; this finding adds support to the contention that effective use of horticultural oils is strongly dependent on the oil spray striking and completely bathing the target.

Two trials were conducted to evaluate the efficacy of Sunspray 6E against members of the beetle order Coleoptera. One of these was the imported willow leaf beetle *(Plagiodera versicolora)*, an important pest of willows and poplars over much of the United States. Near the middle of June several large specimens of weeping willow *(Salix babylonica)* were found to be suffering major leaf damage from a heavy population of imported willow leaf beetle. Forty larvae were transferred to washed willow leaves in the laboratory rearing room. Half of the leaves were sprayed to drip with 2% oil, and half were similarly sprayed with distilled water to act as controls. Although a few larvae appeared to have been injured by the oil treatment, about 80% successfully completed the transformation from larva to pupa to adult beetle within the period of a week. Subsequent treatment of adult beetles with 2% oil appeared to have essentially no effect.

Similar results were obtained when adult Japanese beetles *(Popillia japonica)* feeding on the leaves of American plane tree *(Platanus occidentalis)* were drench sprayed with both 2% and 3% horticultural oil. Although several beetles attempted to leave the treated foliage, none appeared to have been harmed in any way by the oil at either concentration. These results suggest that Sunspray 6E used alone would probably not provide adequate control of these two common beetle pests.

Summary

As experimental results accumulate, horticultural oils conforming to modern formulation and refining specifications are seen as an increasingly attractive alternative method of woody ornamental pest management. These trials continuing the evaluation of Sunspray 6E have found it to be a safe and effective means of controlling 10 additional species of phytophagous insects when physically bathed by the oil spray. The product was least effective against beetle (adult) defoliators. Phytotoxic side effects continue to be rare, although there is some indication that under conditions of severe water stress, certain species might be damaged by spray oil application.

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ABSTRACT

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Plants are "cold blooded"; that is, they assume the temperature of their environment. Temperature is a major uncontrollable climatic factor, and can dramatically affect the health and growth of most plants. Research is now being conducted on developing inheritable characteristics for temperature stress resistance. How does injury occur when plants or plant parts freeze? First, water in the leaves and stems supercools. Ice forms outside the cells first, because the water there contains less solutes. Then, since there is no contact of ice with water inside the cells, a vapor pressure gradient is formed from inside the cell to the outside, and water evaporates out of the cells to the point where the cells dehydrate and die. When freezing injury of roots and stems occurs, many physiological processes are affected. Uptake of water and elements is decreased; tissues dry out; leaves on evergreens turn red-brown; and flower and leaf buds die. Don't be too quick to pull out the pruners and saws. Sometimes the symptoms are worse than the injury. It's virtually impossible to second-guess the tree as to which stems will live and support the tree, and which will die. Timely, professional pest control can encourage recovery from freeze injury and conserve the tree's energy system. Sometimes the "cure" for freeze injuries is worse than the "disease".