EVALUATION OF SUMMER OIL SPRAY ON AMENITY PLANTS

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Abstract. Scattered but persistent questions concerning the pesticidal efficacy and potential phytotoxicity of horticultural oils applied to woody and herbaceous plants in verdant condition prompted a continuing evaluation of the superior oil product Sunspray 6E. Fifty-one species commonly grown as ornamentals were evaluated for foliar phytotoxicity and efficacy against a wide range of arthropod pests. Treatment with 3% oil proved to be highly effective against aphid, scale, mite and other pest infestations. Phytotoxicity was limited to certain species of deciduous nut trees.

In a previous paper (1) we noted the lack of phytotoxic effects of horticultural oil applied to woody plants in dormant condition. During the following field season we continued evaluating spray oil phytotoxicity on actively growing plant foliage, bark and buds. This portion of our work investigating the properties of Sunspray 6E as a summer oil was also designed to evaluate its efficacy against as wide a range of arthropod pests as became seasonally available to us from plantings on the grounds of Cornell University, Ithaca, New York.

For several years, the conventional wisdom has been simple and unambiguous: oil "burns" leaves; that opinion concerning both safety and efficacy of oil is still very much divided, was shown by the recent survey of the Green Industry by Johnson and Caldwell (4). This series of trials was undertaken to address some of these questions and concerns.

Materials and Methods

During the summer field season of 1987 (early May to mid-August in central New York State), we treated 44 trees and shrubs and 7 herbaceous species located on or near the Cornell campus with oil (Table 1). Of these, 44 were deciduous and 7 were evergreen varieties. Nineteen species were evaluated for foliar phytotoxicity while the remainder were selected for evaluating efficacy against a specific pest as well as phytotoxicity. Over the course of the summer we evaluated the effects of oil on 32 commonly occurring arthropod pests (Table 1). The majority of these belonged to the insect order Homoptera: 15 aphids, 6 scales, a mealybug and a whitefly. The order Hymenoptera was represented by 2 species of sawfly larvae and the order Lepidoptera by a webworm and a leafroller. Five species of mites represented the non-insect order Acarina.

The horticultural oil Sunspray 6E, a product of Sun Refining and Marketing Company, Philadelphia, PA, was used exclusively throughout this study. It is a highly refined, light, nearly colorless paraffinic distillate whose refining specifications have been published previously (3). Unless otherwise indicated, the oil was diluted with distilled water to a standard concentration of 3% by volume just prior to application.

Whenever pest populations and weather conditons permitted, pest efficacy studies were first carried out in a laboratory rearing room and subsequently replicated in the field. The rearing room was given 12 hours of light at a constant air temperature of 68-70°F. A gentle circulation of air was maintained while a small flask with evaporating wick in each container assured adequate humidity. A hand sprayer adjusted to deliver a uniform, fine mist was used to spray both sides of foliage to the point of drip. Control plants received a comparable spray of distilled water. Depending upon pest density, 1 leaf or 1 twig with several leaves was usually studied as a single population. Typically 10 or more populations were evaluated for any given plant host. A minimum of 10 leaves or leaflets were checked when evaluating phytotoxicity. Following oil treatment, pest populations were observed and evaluated for a week on a post-24-hour then every-other-day count schedule, while studies on possible foliar damage were checked weekly for a 1-3 month period. Pest populations in the field were examined with a 10X hand lens, the exception being mite infestations, which could only be accurately evaluated under higher magnification in the laboratory.

Results and Discussion

Although the pesticidal efficacy of horticultural spray oil has been subject to discussion for a considerable length of time, results of our evaluations, as presented in this report, suggest that Sunspray 6E is highly effective against a wide range of pests commonly encountered on ornamental plantings throughout the northeastern United States. The efficacy of Sunspray 6E on some pests is equal to that of the synthetic organic pesticides.

Efficacy against Aphids. Of the 24 formal and 9 informal spray oil trials conducted during the summer of 1987, 15 involved various species of aphid. Plantings of European euonymus often supported heavy populations of *Aphis fabae,* commonly averaging more than 100 individuals per leaf. Terminal portions of many mock orange shoots were frequently seen solidly encrusted with the same aphid species. Leaves of red oak trees often supported about 40 individuals of *Myzocallis granovski* on many upper surfaces. *Myzocallis* sp. aphids were also abundant, about 50 per leaf undersurface, on the foliage of witch hazel and were also found, at a population density of 30 per linear inch, on ornamental pear. It is in-

Table 1. Plants and plant pests treated with Sunspray 6E horticultural oil.

Trees and shrubs
Acer saccharinum (Silver Maple)
Acer saccharum (Sugar Maple)
Carya illinoinsis 'Major' (Northern Pecan)
Carya laciniosa 'Bixby' (Shellbark Hickory)
Carya ovata 'Burton' (Shagbark Hickory)
Castanea mollissima (Chinese Chestnut)
Castanea mollissima 'Kuling' (Kuling Chestnut)
Cercis canadensis (Redbud)
Cornus sericea (Red Osier Dogwood)
Euonymus europaea (Tree Euonymus)
Hamamelis virginiana (Witch Hazel)
Juglans ailanthifolia var. *cordiformis* (Japanese Walnut)
Juglans ailanthifolia var. *cordiformis* 'Mitchell'
Juglans cinerea 'Herrick' (Butternut)
Juglans cinerea 'Kenworthy' (Butternut)
Juglans nigra (Black walnut)
Juglans nigra 'McKiniston'
Juglans nigra 'Mintel'
Juglans nigra 'Sparrow'
Juniperus chinensis 'Pfitzerana' (Chinese Juniper)
Juniperus communis 'Blue Rug' (Blue Rug Juniper)
Ligustrum obstusifolium (Privet)
Liriodendron tulipifera (Tulip Tree)
Malus domestica 'Empire' (Apple)
Philadelphus coronarius (Mock Orange)
Picea pungens (Colorado Blue Spruce)
Pinus resinosa (Red Pine)
Pterocarya stenoptera (Chinese Wingnut)
Pyrus calleryana 'Bradford' (Pear)
Quercus rubra (Red Oak)
Rhus typhina (Staghorn Sumac)
Robinia hispida (Bristly Locust)
Rosa sp. (Rose)
Sorbus aucuparia (Mountain ash)
Spirea prunifolia (Bridal Wreath)
Taxus baccata (Yew)
Thuja occidentalis (Arborvitae)
Tilia cordata (Little Leaf Linden)
Tilia tomentosa (Silver Leaf Linden)
Tsuga canadensis (Hemlock)
Ulmus americana (American Elm)
Viburnum prunifolium (Black Haw)
Viburnum sargentii 'Onondaga' (Viburnum)

Herbaceous plants
Amaranthus sp. (Amaranthus)
Asparagus sprengeii (Asparagus Fern)
Aster novae-angliae (New England Aster)
Dahlia sp. (Dahlia)
Hibiscus rosa-sinensis (Hibiscus)
Papaver orientale (Oriental Poppy)
Phlox paniculata (Summer Phlox)

Pest species
Acarina (Mites)
Aculus ligustri (Privet rust mite)
Eotetranychus tiliarum (Linden spider mite)
Oligonychus aceris (Sugar maple mite)
Oligonychus bicolor (Red oak mite)
Oligonychus ununguis (Spruce Spider mite)

Homoptera
Amauronematus sp.
Aphis citricida
Aphis citricola
Aphis fabae
Aphis pomi (apple aphid)
Aphis sp. A
Aphis sp. E
Aphis sp. 17
Carulapsis juniperi (Juniper scale)
Chionapsis pinifoliae (Pine needle scale)
Dysmicoccus wistoriae (Taxus mealybug)
Eucallipteris sp. (poss. *E. tiliae)*
Eulachnus agilis (Spotted pine aphid)
Gossyparia spuria (European elm scale)
Lecanium corni (Lecanium scale)
Macrosiphum liriodendri (European elm scale)
Macrosiphum rosae (Rose aphid)
Myzocallis granovski
Myzocallis sp.
Myzocallis sp. A.
Pristiphora geniculata (Mountain ash sawfly larva)
Pulvinaria innumerabilis (Viburnum cottony scale)
Tetraneura sp.
Trialeurodes vaporariorum (Greenhouse whitefly)
Unaspis euonymi (Euonymus scale)

Lepidoptera
Archips sp.
Yponomeuta multipunctella (European webworm)

teresting to note that neither of these plants has been previously reported as a host for this specific aphid. Red pine, the sole conifer, supported a large (about 25 insects per needle) population of pine needle aphid *(Eulachnus agilis).* Aphid infestations were also evaluated on 3 other woody ornamentals: *Macrosiphum liriodendri* at 50 per upper leaf surface on tulip tree, *Eucallipterus* sp. (possibly *E. tiliae)* on little leaf linden at 40 per leaf, and a species of *Aphis* found solidly encrusting the terminal shoots of shrubby viburnum. Informally evaluated (not actually counted) were 4 additional heavy aphid populations on woody ornamentals: *Aphis citricida* on bridal wreath, *Macrosiphum rosae* on rose, *Aphis citricola* on a semi-dwarf 'Empire' apple tree, and what is probably *Sitomyzus rhois* on staghorn sumac. Infestations of *Aphis* sp. were also found on a pair of herbaceous plants, garden amaranthus and oriental poppy.

In all of these cases, complete elimination of the colonies was obtained within a 24-hour period. During both laboratory and field trials, through several replications, both winged and wingless forms were killed rapidly with a 3% oil spray. Seen through a microscope at higher magnifications, individual aphids still had their mouth parts embedded in host plant tissues, implying that the oil was not an irritant. In none of these evaluations was there any indication that oil had damaged the foliage in any way.

Efficacy against Scales. Six trials evaluated the effect of Sunspray 6E on scale insects. Since one of the primary objectives of this study was to evaluate the ovicidal potential of this spray oil, as well as its effect on adults and crawlers, an effort was made to identify test populations before a large number of eggs had hatched into first instar crawlers. Heavy infestations of armored scales on a pair of conifer species, pine needle scale *(Chionaspis pinifoliae)* on red pine and juniper scale *(Carulapsis juniperi)* on American arborvitae provided an opportunity to do this.

The juniper scale population was just starting to hatch out with only a few crawlers present at the time the 3% oil spray was applied. Within 24 hours all crawlers on treated needles appeared to be dead. At the end of the following week nearly all eggs on the control needles had hatched and crawlers were abundant, whereas no additional eggs on treated foliage had hatched and no crawlers remained alive. Spray oil seemed to be immediately and highly effective against the life stages of these two scales.

The population of pine needle scale, representing a mid-season (early to middle July) second annual generation, was located and treated well prior to the first emergence of the reddish crawlers. Of the 255 female scale insects examined on 10 "population" needles, 85% were found to contain reddish eggs beneath the scale covering. Needles brought back into the laboratory for examination at higher magnification following application of spray oil showed that the oil had rapidly and readily migrated under the scale covering, nearly all of which contained a large number of eggs. Two weeks after spraying, most of the eggs on the untreated control needles had hatched and essentially all now supported more than 100 crawlers per needle. The reduction in crawler population on the treated needles was dramatic, ranging from no individuals to a high of 20 and averaging fewer than 10 crawlers/needle, thus indicating a better than 90% reduction in egg hatch and suggesting that this spray oil has very good ovicidal activity against scale eggs of the second generation.

A heavy pre-emergence population of euonymus scale *Unapsis euonymi)* on tree eunoymus provided supportive evidence for the ovicidal effectiveness of Sunspray 6E. Two days after oil treatment, control twigs supported an abundant active crawler population averaging 26 per linear inch while the treated twigs had no living crawlers. In addition, eggs on treated twigs had enlarged, become transparent and easily ruptured if touched; the overwintering female adults had darkened and started to decompose.

Three other scale infestations were treated with oil at a point when egg hatch was well advanced and nymphs were abundant. Two of these were lecanium scales, the European elm scale *(Gossyparia spuria)* on American elm and redbud scale *(Lecanium corni)* on redbud. An additional population of cottony maple scale *(Pulvinaria innumerabilis)* on blackhaw viburnum was also treated. All populations were counted at more than 100 individuals and all showed nearly com-

plete control of crawlers within a 2-day period. No additional egg hatch on treated foliage was observed in the following 5 days. In none of these evaluations against scale populations was there any indication of oil-induced damage to foliage.

Efficacy against Mites. Of the 6 trials of spray oil in controlling mite infestations, 5 involved species of spider mite: spruce mite *(Oligonychus ununguis)* on hemlock, red oak mite *(O. bicolor)* on Chinese chestnut, maple mite *(O. aceris)* on sugar maple and linden mite *(Eotetranychus tiliarum)* on silver leaf linden. One eriophyid species, privet rust mite *(Aculus ligustri)* of privet was also investigated.

Conifers were represented by a pair of mature northern hemlocks found, by the middle of June, to be heavily infested with spruce spider mites. Ten needle populations on separate tagged branches were found to average 4 adults and 14 eggs each. A recount of these populations 24 hours after spraying with 3% oil showed no living adults, and a follow-up at 1 week showed that none of the eggs had hatched. Mite populations on control branches continued to thrive and expand.

Results from oil-treated spider mite populations typically exceeding 100 individuals per leaf on deciduous ornamentals followed a similar pattern. Within 24 hours after treatment no living mites could be found on treated foliage and at the end of a week post-treatment no additional eggs had hatched. Under higher magnification the normally smooth-skinned eggs had darkened, shrunken and become wrinkled and irregular in shape. Repeat population counts on oil-treated leaves confirmed the observation that there had been essentially no emigration of mites away from the leaves following treatment with oil. An additional informal trial suggested that 3% oil was also highly effective in controlling spider mites on a greenhouse specimen of large-flowered tuberous dahlia without phytotoxicity.

Mites of the family Eriophyidae were represented by a heavy mid-August infestation of pivet rust mites on a planting of border privet. Each leaf typically supported a population of considerably more than 100 individuals, probably several hundred, and much of the planting showed severe russeting of foliage. As in previous trials involving spider mites, a thorough spray of 3% oil gave nearly complete control of privet rust mites within a day or two. Pest populations were also treated with 1% and 2% oil sprays in a first attempt at evaluating the degree of control attainable using lower concentrations of oil. Although still preliminary, the results of these trials suggest that acceptable control may be obtainable at oil concentrations substantially less than 3%.

Efficacy against Other Pests. As the 1987 field season progressed, several other insect populations were located and treated with a 3% spray of Sunspray 6E. One of these was a heavy infestation of euonymus webworm *(Yponomeuta multipunctella),* the larva of an ermine moth, on tree euonymus. This is a species of ornamental typically free of most holometabolous insect pests that in this case had been nearly defoliated by the caterpillars. Due to some uncertainty as to how well the web would be penetrated by oil spray, this trial was run in both field and laboratory. In one instance webs were sprayed from the outside, while in a parallel study caterpillars were extracted from their webs, treated with oil on a raised wire screen, and returned to fresh, unsprayed euonymus leaves. Unlike many other pests, the treated caterpillars were not immediately inactivated by the oil, although within 24 hours they had become noticeably lethargic, had not resumed eating, and were webbing only weakly. At the end of a week after treatment, untreated caterpillars had produced well-developed webs containing abundant frass and all had spun elongate, dense cocoons. During this same period, roughly half of the treated population had died outright, while the remainder had spun thin, poorly developed cocoons. Lack of frass accumulation suggested that none of the treated caterpillars had resumed eating. During the following 2 weeks, essentially the entire control population emerged as small, white moths, while not a single webworm from the treated population emerged. Although considered preliminary, these findings suggest that in such lepidopteran larvae as euonymus webworm, horticultural oil may act as a physiological toxin and/or an anti-feedant. Similar results were obtained when spray oil was evaluated against another moth larval form, a

leafroller *(Archips* sp.) on red osier dogwood.

Sunspray 6E was also evaluated for efficacy against the larvae of two Hymenoptera (sawfly) species, *Amauronematus* sp. on bristly locust and *Pristiphora geniculata* on mountain ash. The oil appeared to act as a strong antifeedant on the locust sawfly larvae, but had essentially no effect on the sawfly infestations of mountain ash.

Horticultural oil has been suggested as an effective means of controlling mealybug infestations on evergreen species, and our trials of Sunspray 6E seem to bear this out. Several decorative yew plantings were found to support heavy populations (about 20 per linear foot of twig) of taxus mealybug *(Dysmicoccus wisteriae).* Within a day or two of applying 3% oil, 80-100% of the insects physically contacted by the spray had been killed. The treatment seemed to have been as effective against adults in their waxy coverings as against naked first instar crawlers. Efficacy of oil against mealybug eggs is unknown. Of the several yew branches treated, none showed any indication of having been damaged by the oil application.

A small but severe infestation of greenhouse whitefly *(Trialeurodes vaporariorum)* on some floriculture stock provided an informal opportunity to evaluate the efficacy of spray oil against this nearly universal pest. A single spray treatment of 3% oil was found to be a rapid and highly effective control measure for whitefly infestations on New England aster and summer phlox. On neither was there any indication of foliar phytotoxicity.

Evaluation of Phytotoxicity

Information concerning the phytotoxic risk of Sunspray 6E to foliage was gathered during the 33 trials of the product on pest infestations. Whenever an oil-treated population was being evaluated, phytotoxicity data were also recorded. As an example, the eriophyid mite work on privet continued for nearly a month with spray oil being applied in full sun at air temperature regularly around 90°F. In other cases, plant hosts had been severely stressed by extremely heavy pest infestations: aphid populations on viburnum encased the terminal 2 inches of most shoots in a solid, continuous black sleeve of insects. In neither of these extreme examples, nor in any of the other insect efficacy trials, was there ever any indication that spray oil had in any way damaged host plant tissues.

Several trials were specifically designed to evaluate possible phytotoxicity on species of woody ornamental previously reported as being sensitive to oil; several species of nut trees have been traditionally placed in this category. One study surveyed the effects of 3% oil on 15 nut tree species, including 9 varieties or cultivars of walnut, 2 cultivars of chestnut, 3 pecan cultivars 2 of which were grafts, and 1 specimen of Chinese wingnut. Symptoms of foliar phytotoxicity included overall chlorosis, evenly distributed brown stippling, browning of leaf tips, necrosis of leaf margins especially on "downhill" edge, and in the most severe cases actual abscission of the entire leaf. Air temperature at the time oil was applied was 82°F in full sun. Table 2 summarizes the results of these trials. It is interesting to note that while the foliage of standard black walnut was somewhat damaged by the oil, none of the 3 black walnut cultivars tested seemed to share the parental sensitivity to oil. These findings clearly suggest that considerable care should be taken in precise identification of nut tree cultivars prior to treating with any horticultural oil.

One frequently heard criticism of spray oil is that when used on ornamental junipers being grown for their foliage color, a permanent loss of the bluish tinge results. Our evaluation of Sunspray

Table 2. Degree of foliar phytotoxicity displayed by 15 nut tree species three weeks after spraying with 3% Sunspray 6E horticultural oil. Results are given as average percentage of leaflets damaged per compound leaf.

Plant species	*% Damage*
Juglans nigra (black walnut)	20
J. nigra 'Mintle'	0
J. nigra 'Sparrow'	0
J. nigra 'McKiniston'	0
J. ailanthifolia var. *cordiformis* (Japanese walnut)	50
J. ailanthifolia var. *cordiformis* 'Schubert'	100
J. ailanthifolia var. *cordiformis* 'Mitchell'	100
J. cinerea 'Herrick' (Butternut)	100
J. cinerea 'Kenworthy'	100
Castanea mollissima (Chinese chestnut)	0
C. mollissima 'Kuling'	0
Carya illinoinsis 'major' (northern pecan)	0
C. illinoinsis + *C. laciniosa* 'Bixby' (shellbark hickory)	0
C. illinoinsis + *C. ovata* 'Burton' (shagbark hickory)	0
Pterocarya stenoptera (Chinese wingnut)	0

6E on 'Blue Rug' juniper confirms this observation. Six healthy plants were sprayed to drip with 3% oil and almost immediately lost their bluish bloom, becoming a nearly emerald green, but remaining otherwise undamaged. Over the next month the foliage remained healthy although green. During this same period, considerable new growth of normal blue coloration appeared, nearly obscuring the foliage originally treated.

At the end of a month's observation, on a humid, hot (99°F) sunny day, 3 of the original 6 junipers were resprayed with 3% oil. As in the preceding trial, the oil seemed to act as a solvent for the bluish, waxy coating on the new leaves, turning them bright green. At the end of another month, neither these plants nor those sprayed 2 months before had regained any of their characteristic color. No physical damage to the foliage was ever observed, although the cosmetic changes caused by spray oil appear to be permanent. Parallel studies of Chinese juniper and Colorado blue spruce yielded similar results: apparent permanent loss of coloration but no actual structural damage to the foliage.

Industry-wide, silver maple is one of the most frequently cited example of shade trees sensitive to spray oil. In an effort to evaluate the effects of longer-than-average time of the oil emulsion on especially tender foliage, 20 silver maple saplings whose leaves were just starting to unfold were drench sprayed with 3% Sunspray 6E. The spray oil emulsion was visible as pools of milky liquid in the folds and pockets of the unfolding leaves for at least 2 full days. Regular inspection of the developing foliage showed no indication of damage. One month after treatment all maples were fully leafed out bearing normal-appearing leaves. At the end of the summer, 112 days after being sprayed with oil, the healthy young maples were set out into the nursery. Sunspray 6E used at 3% does not appear to be injurious to silver maple foliage, buds or bark in spring applications. Similar informal trials on bristly locust and a pair of herbaceous species, hibiscus and asparagus fern, yielded the same results.

Summary

The horticultural oil product Sunspray 6E proved to be highly effective in controlling a wide range of arthropod pests including 15 species of aphid, 6 species of scale, 5 species of mites and an assortment of other commonly occurring insects. Control that ranged from good to excellent was obtainable at a 3% dilution. Sunspray 6E was also found to be highly efficacious against several different pest life stages and to have good ovicidal activity. Oil has antifeedant properties that need further investigation, especially against certain lepidopteran and sawfly larvae. Additionally, this superior oil appears to be an extremely safe product whose phytotoxicity to the vast majority of plants tested in verdant condition seemed to be very low, although certain nut species are clearly sensitive to spray oil. Lethal contact of oil to target arthropods requires the utmost attention to spray coverage. Success is dependent on the oil striking and completely bathing the target. Anything less often results in unsatisfactory control. Additional work on evaluating the effects of oil applied in the dormant condition on species reported as sensitive will be discussed in a subsequent report.

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