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FOLIAR AND GROWTH EFFECTS OF REPETITIVE SUMMER HORTICULTURAL OIL SPRAYS ON TREES AND SHRUBS UNDER DROUGHT STRESS

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Abstract. A 2% Spray of Sunspray 6E Plus horticultural oil was applied, 2, 3 or 4 times to 52 species and cultivars of nursery trees and shrubs during the droughty summer of 1988. Phytotoxicity was rated monthly and found to be negligible. Growth effects were evaluated in October. Nine species showed significant differences in growth between treated and untreated plants. All treated plants averaged 1.7 cm more growth than untreated plants.

Résumé. Une vaporisation de 2% de Sunspray 6E Plus a été appliquée 2, 3 ou 4 fois à 52 espèces et cultivars d'arbres et arbustes de pépinière durant l'été sec de 1988. La phytotoxicité était estimée mensuellement et s'est avérée négligeable. Les effets sur la croissance ont été évalués en octobre. Neuf espèces ont montré des différences significatives dans la croissance entre les plants traités et ceux non-traités. Tous les plants traités ont en moyenne cru de 1,7 cm de plus que les plants non-traités.

Nielsen (12) recently reviewed the history of integrated pest management (IPM) in arboriculture and stated "IPM has moved from theory to practice." This statement is true to a point. Unfortunately, the level of IPM currently practiced by most arborists is rudimentary. Where insect and mite pests are concerned, it is mostly a single control tactic, spraying, that is used compared to the multitactic IPM programs for food and fiber crops which may utilize spraying, biological, cultural, and mechanical controls. These agricultural programs are the result of some 30 years of research supported by high levels of funding. A significant financial commitment will be needed before a similar research base for IPM programs can be developed for the protection of landscape plants by the production and maintenance industries. In the meantime, arborists can make one immediate change to improve the quality of their IPM programs. Where pesticides are available, and label recommendations permit, they can change from residual to nonresidual materials to control many insect and mite pests.

Thus far demonstration landscape (9, 13, 15) and nursery (4, 5, 6, 7, 8) IPM programs attribute most of their success to one control tactic—spot spraying; i.e. spraying only infested plants, not cover spraying an entire planting. This tactic has two beneficial results: 1) a dramatic reduction in pesticide use compared to cover or calendar based sprays, and 2) the conservation of beneficial predators and parasites which should, under some conditions, lead to reduced pest population levels. The first result is obvious, and we have demonstrated significant pesticide use reductions in several pilot IPM programs in Maryland (14). The second result also seems obvious, but to our knowledge it has yet to be demonstrated by researchers for IPM programs protecting landscape plants.

If a residual pesticide is defined as a chemical with pest killing powers that lasts several days, then many arborists are using residual, broad spectrum, contact pesticides in much of their spot spray work. For example in 1988 and 89 we gave intensive landscape plant IPM short courses to 48 participants, mostly arborists, who were developing IPM programs for their companies. A survey showed they used 23 different insecticides and miticides. The majority of these have residual ac-

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tivity periods as contact pesticides from several days, to 3 weeks or more.

Most sucking pests like aphids and scale insects are sedentary except during periods of dispersal, which are usually in the spring and fall. As long as their host plant provides life's necessities, these pests move little, feed much, and reproduce abundantly. Unless residual contact sprays hit them, or land close by, they are unlikely to be affected. On the other hand, many parasites and predators move rapidly among plants and plant parts seeking suitable prey. Even poorly applied pesticides often eliminate these beneficials from plants because in the course of their searching patterns they are likely to encounter spray deposits. We suggest that the more residual a pesticide is, the more likely it will adversely affect mobile predators and parasites thereby limiting the use of biological control as a tactic. We believe this practice works against the theory and implementation of multitactic IPM programs.

From the considerations above, it appears that to be useful in IPM programs the pesticide of choice should have the following traits: 1) kill the pests it hits, and 2) break down rapidly and not be present when predators and parasites hunt in the treated area. Two commonly available, broadly labeled (for many pest groups and plants) materials exhibiting these desirable characteristics are insecticidal soap and horticultural spray oil. This article discusses the safety and utility of a newly developed horticultural spray oil, Sunspray 6E PLUS, as a summer foliar spray.

The ability of dormant season oil sprays to kill overwintering pest stages, has long been known (16). Recent work (1) has shown Sunspray 6E PLUS in the dormant season is safe even to plants supposedly sensitive to oil. In our experience most arborists believe in, and use, dormant oil sprays as needed. Summer oil sprays do not yet enjoy this acceptance despite their ability to effectively control sucking pests such as hemlock woolly adelgid (11), and aphids, spider mites and scale insects (3). Apparently, arborists are reluctant to spray oil in hot weather for fear of causing phytotoxicity. For example, of 527 companies surveyed (10) about 65% made spring, 16% fall, and 11% winter oil applications, while only 8% used summer oil sprays.

Current studies should allay these fears. Baxendale and Johnson (2) evaluated 44 species of trees and shrubs in central New York State for phytotoxic effects following mostly single, summer oil sprays of Sunspray 6E PLUS. They found only certain *Juglans* species to be adversely affected. The work reported here was done to determine the effects of monthly foliar applications of Sunspray 6E PLUS on the growth and phytotoxicity of common landscape trees and shrubs. This product is now available from Safer Inc. under the name SunSpray^{R} ULTRA-FINE SPRAY OIL.

Materials and Methods

During the summer of 1988 we treated blocks of 50 different species, or cultivars, of trees and shrubs in 3 nurseries located in central Maryland within 20 miles of Baltimore-Washington International Airport (BWI) (Table I). A few Colorado blue spruce and blue Atlas cedar also were sprayed. Thirty seven test plants were deciduous and 15 were evergreen. Plant names used are from Hortus Third. As the numbers in brackets indicate, most were sprayed 4 times; once each month May - August, with the labelled rate of 2% Sunspray 6E Plus. Plants that showed wilting symptoms at the scheduled time of application were not sprayed. Therefore, some were sprayed only 2 or 3 times. The averages for air temperature, relative humidity in %, and wind speed were derived from 5 readings taken at 3 hour intervals between 10 AM and 10 PM on each spray date. This information was supplied by the weather station at BWI Airport for each spray date.

All plants were evaluated for phytotoxicity symptoms monthly. Growth effects were evaluated post treatment in early October before the onset of senescence. Growth effects were obtained by comparing incremental new growth on shoots of 10 trees treated with oil, to those on 10 untreated trees. Incremental growth measurements were taken in cm from the 4 ordinal points of all plants in the study. Phytotoxicity was evaluated using a 5 point visual rating system where 1 = no visible symptom, 2 = slight yellow-

Table 1. Trees and shrubs treated with repetitive summer sprays of 2% Sunspray 6E PLUS horticultural spray oil during a droughty summer. Code numbers associated with cultivar names match codes on Figure 1.

Code	Cultivar	Number of Sprays	Rating[a]
1.	*Acer griseum* (Paperbark Maple)	[4]	(1)
2.	*Acer palmatum* (Japanese Maple)	[4]	(1)
3.	*Acer platanoides* 'Crimson King' (Norway Maple)	[4]	(1)
4.	*Acer platanoides* 'Debbie' (Norway Maple)	[4]	(1)
5.	*Acer rubrum* 'Embers' (Red Maple)	[4]	(1)
6.	*Acer rubrum* 'October Glory' (Red Maple)*	[4]	(3)
7.	*Acer saccharum* 'Green Mountain' (Sugar Maple)	[4]	(3)
8.	*Betula pendula* (Weeping Birch)	[4]	(1)
9.	*Cedrus atlantica* 'Glauca' (blue Atlas Cedar) (not in Fig. 1)	[3]	(1)
10.	*Cornus florida* pink (Flowering Dogwood)	[4]	(1)
11.	*Cornus florida* white (Flowering Dogwood)	[4]	(1)
12.	*Cryptomeria japonica* (Japanese Cedar)	[3]	(1)
13.	*Euonymus alata* 'Compacta' (Winged Spindle Tree)	[2]	(1)
14.	*Fraxinus pennsylvanica* 'Marshal Seedless' (Green Ash)	[4]	(1)
15.	*Fraxinus pennsylvanica* 'Autumn Applause' (Green Ash)	[4]	(1)
16.	*Ginkgo biloba* 'Prince Century' (Maidenhair Tree)	[2]	(1)
17.	*Gleditsia triacanthos* Var. *inermis* 'Shademaster' (Honey Locust)	[4]	(1)
18.	*Ilex x attenuata* 'Fosteri'*	[4]	(1)
19.	*Ilex crenata* 'Convexa' (Japanese Holly)	[4]	(1)
20.	*Ilex opaca* (American Holly)	[4]	(1)
21.	*Juniperus chinesis* 'Pfitzerana Glauca' (Blue Pfitzer Juniper)	[3]	(1)
22.	*Juniperus chinensis* blue 'Sky Rocket' (Chinese Juniper)	[3]	(3)
23.	*Juniperus communis* var. *depressa* (Prostrate Juniper)	[4]	(2)
24.	*Laburnum anagyroides* (Golden-Chain)*	[2]	(1)
25.	*Magnolia quinquepeta* 'Betty' (Lily Magnolia)	[4]	(2)
26.	*Magnolia stellata* (Star Magnolia)	[2]	(1)
27.	*Malus* 'Indian Summer' (Crab Apple)	[4]	(1)
28.	*Oxydendrum arboreum* (Sourwood)	[4]	(1)
29.	*Picea pungens* (Colorado Blue Spruce) (not in Fig. 1)	[2]	(3)
30.	*Picea abies* (Norway Spruce)	[4]	(2)
31.	*Platanus x acerifolia* 'Blood Good' (London Plane)	[4]	(1)
32.	*Prunus laurocerasus* (Cherry Laurel)	[4]	(1)
33.	*Prunus serrulata* 'Kwanzan' (Japanese Flowering Cherry)*	[4]	(1)
34.	*Prunus serrulata* 'Tibetica' (Japanese Flowering Cherry)*	[4]	(1)
35.	*Prunus yedoensis* 'Yoshino' (Japanese Flowering Cherry)	[4]	(1)
36.	*Prunus subhirtella* 'Pendula' (Higan Cherry)	[4]	(1)
37.	*Pyrus calleryana* 'Aristocrat' (Ornamental Pear)*	[4]	(1)
38.	*Pyrus calleryana* 'Bradford' (Ornamental Pear)	[4]	(1)
39.	*Pyrus calleryana* 'Red Spire' (Ornamental Pear)	[4]	(1)
40.	*Quercus rubra* (Red Oak)	[4]	(3)
41.	*Quercus palustris* (Pin Oak)	[4]	(1)
42.	*Syringa vulgaris* (Common Lilac)	[2]	(1)
43.	*Syringa x chinensis* 'Expansa' (Chinese Lilac)	[2]	(1)
44.	*Taxus x media* 'Hicksii' (Hicks'Yew)	[4]	(1)
45.	*Taxus cuspidata* 'Intermedia' (Japanese Yew)	[4]	(1)
46.	*Thuja occidentalis* (Arborvitae)*	[4]	(4)
47.	*Tilia cordata* 'Green Spire' (Linden)	[4]	(1)
48.	*Tsuga canadensis* 'Sargentii' (Canada Hemlock)	[2]	(2)
49.	*Tsuga canadensis* (Canada Hemlock)	[4]	(1)
50.	*X Cupressocyparis leylandii* (Leyland Cypress)	[3]	(1)
51.	*Zelkova serrata* 'Green Vase'	[4]	(1)
52.	*Zelkova serrata* 'Village Green'	[4]	(1)

a. Ratings marked with an * indicate greater growth in treated than untreated and ratings marked with ** indicate greater growth in untreated than treated.

ing on some leaves, 3 = moderate yellowing on most leaves but no burn, 4 = burn but no dieback, and 5 = dieback. A rating of 3 or more was easily noticed and objectionable. It should be noted that the blue color was removed from Colorado blue spruce, and blue 'Sky Rocket' juniper, and they were given a 3 rating (objectionable) even though this is not a symptom of phytotoxicity.

Results and Discussion

1. *Climatic Conditions.* The nurseries involved depended on rainfall to supply plant water. In 1988 Maryland experienced a drought for the third consecutive year. According to the State Climatologist's summary of weather data for the summer of 1988 in North-Central Maryland, the average temperature for June, July and August was 3.4°F above normal. A heat wave occurred from the last days of July through the middle of August. A record 21 days of consecutive maximum temperature of 90°F or above was set in Baltimore, where the highest temperature reached 105°F on August 5. Summer rainfall in the Baltimore area averaged 2.5 inches below the 13 inch normal. This shortfall was accentuated by a

long period without significant rainfall from the end of May through mid July. June was a record breaking low month with only 0.22 of an inch in central Maryland. July rainfall was above normal, but August was again below normal. One of our test nurseries appeared to receive no summer rainfall. These climatological conditions resulted in an excellent opportunity to test the effects of monthly foliage applications of horticultural spray oil (Sunspray 6E PLUS) under the severe stress factors of high temperatures and low rainfall. On each spray date the average temperature in °F, %RH and wind speed were respectively :5/9, 62.8°F, 56%RH, 11.6WS; 6/1, 83.8°F, 50.6%RH, 14.6WS; 7/6, 89°F, 45%RH, 7WS; 8/3, 85.4°F, 52.2%RH, 5WS. It is important to point out that relative humidities were unusually low for Maryland during this period which means these sprays dried quickly. It is believed that foliar oil sprays should dry quickly to lessen the possibility of phytotoxicity.

2. *Phytotoxicity*. Table 1 lists the plants sprayed in alphabetical order followed by the number of monthly sprays each received in [ ], followed by the phytotoxicity rating in ( ). Of 39 species treatment blocks that received 4 monthly oil sprays 32 rated 1; no phytotoxic symptoms, 3 rated 2, 3 rated 3, 1 rated 4 and 0 rated 5. One unusual situation needs clarification. *Picea abies* (Norway spruce) received a 2 rating by averaging the ratings for 10 trees. Seven trees received a 1 rating, 1 received a 3 rating and 2 received ratings of 5. This it the only case where symptoms were not evenly distributed across a treatment block and reasons for this are not clear. We were near the end of the tank in the last application when spraying these spruce, and perhaps we over-sprayed to use up the material.

Of 4 species receiving 3 sprays only 'Sky Rocket' juniper showed objectionable symptoms with a 3 rating because the blue color was removed. We noted that the new fall growth came in blue and this began to mask the older green foliage. Of 8 species receiving 2 sprays only Colorado Blue Spruce rated 3, again because the oil removed the blue coloration.

3. *Growth Effects*. Growth measurements were included in this study because we feared repetitive foliar oil sprays would reduce growth. The opposite proved true. Nine of 52 plants showed significant differences in growth between treated and untreated plants based on Student's t -tests at the $p = 0.05$ level (see cultivars in Table I, and corresponding numbers in Fig. 1, with asterisk (s)). Eight of these showed greater growth when treated with oil (*). One of 9 showed greater growth when not treated (**). When all plants are considered, a slight but signficant growth effect was observed (t - test, $p < 0.05$). Treated plants averaged 1.7cm, 0.7 (s.e.) more growth than untreated plants. We have no idea why this occurred. Pressure from obvious pest populations seemed relatively low on untreated plants. Perhaps there is a physiological basis for this affect.

When this work began we could not foretell a severe drought would occur. Since we saw few signs of ill effects early on we continued to spray

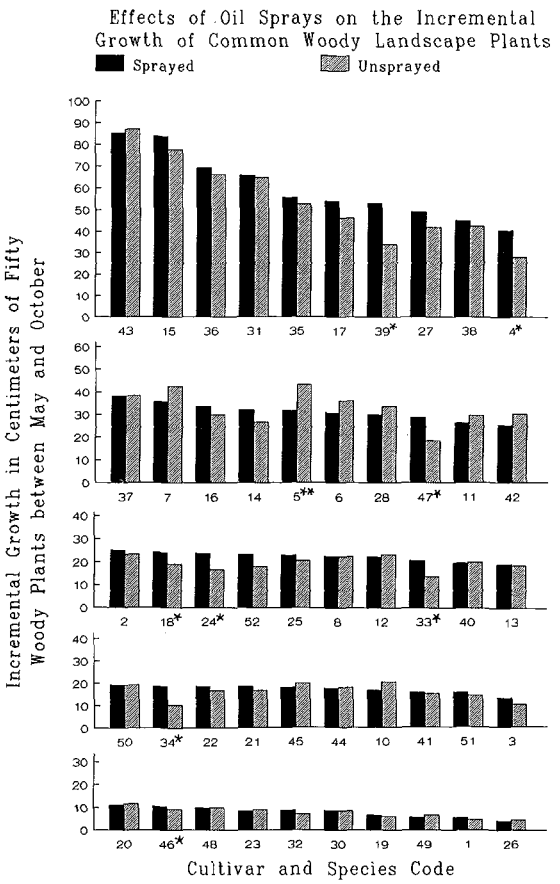

Figure 1. Effects of horticultural oil sprays on the growth of fifty cultivars of woody landscape plants.

most plants through the summer. However, the Sunspray 6E PLUS label clearly states "do not spray oil on plants in a drought." Therefore, this test was done under "misuse" conditions. The results clearly show this material has a tremendous plant safety margin for summer spray work, and may even have some beneficial effects not yet understood.

These findings, in conjunction with those of Baxendale and Johnson (2), lend further support for the use of horticultural spray oils during the growing season in IPM programs conducted by commercial arborists. However, it should be noted that objectionable levels of discoloration occurred on 6 cultivars. They were *A. rubrum* 'October Glory', *A. saccharum* 'Green Mountain', *J. chinensis* 'Sky Rocket', *P. pungens* 'Colorado Blue Spruce', *Q. rubra,* and *T. occidentalis.* Caution should be exercised in the repetitive use of oils on these cultivars and species under severe conditions of heat.

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