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Horticultural Oils[1]

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Abstract

Horticultural oils are among the safest of pesticides. Lack of product identification through the label makes it difficult for the field user to know what product was actually used in experimental studies. A minimum standard for product identification is suggested. Phytotoxicity, while relatively uncommon, continues to cause fears on the part of nurserymen and spray contractors. Factors that must be taken into account before spraying oil include dosage, timing with regard to plant phenological development and climatic conditions, and an awareness of sensitive plant species. A list of sensitive plants is given. A new expression of pesticide resistance through the thickening of the test of certain armored scales was observed.

Index words: phytotoxicity, superior oil, distillation temperature, pesticide resistance, oil-sensitive plants

Introduction

Petroleum oil has been used as a pesticide for more than 100 years. While much progress has been made in the refining of specialty oils, there remain problems and uncertainties, particularly about efficacy in controlling arthropods and phytotoxicity.

The resolution of these uncertainties and the promotion of oil as an insecticide was given a low priority during the DDT era. A number of good insecticides were set aside during that period.

Why should insecticidal oils be resurrected? While oil, *per se,* is an old product, its current refining specifications reflect more modern uses and applications. Nonetheless, the only justifiable reason for its promotion in the 1980's is its innate environmental safety. It degrades quickly after application by evaporation, is safe on mammals and people, and fits neatly into the concept of Integrated Pest Management. Horticultural oil is the same basic type as that used for skin lotions and both external and internal pharmaceuticals. Pharmaceutical grade "mineral" oil has long been used as "baby oil" and for purgatives. However, horticultural oil does not have a clean bill of health; it can kill fish by coating their gills, thus preventing respiration.

The word oil has different meanings to different people. When some people hear the word oil, they think of motor oil, heating oil, fuel oil, vegetable oil; hopefully horticulturists will think of *Superior* or *Horticultural* oil. My definition of a horticultural oil is "a highly refined paraffinic petroleum product made solely for use on plants at specific dosages and acts as an insecticide and miticide."

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Product Description

Sun, Exxon and Chevron oil-refining companies make horticultural oil following specifications from agricultural experiment stations in New York, Florida, Texas, and California. Many agricultural chemical companies have developed their own labels, but purchase their horticultural oil from one of the basic refiners listed above. Trade names include Scalecide (Pratt), Spray Oil 6E (Agway), and Volck (Chevron). However, none of the labels provide the user with enough information to know which of the several oils are actually in the container.

When one talks about horticultural oils with "oil men," their identifying terminology must be used. They describe these oils as narrow distillation range (400 to 480°F) paraffinic oil. Paraffinic oil means that it is a lubricating oil containing few aromatic or naphthenic compounds. (Aromatic and naphthenic oils are used as motor fuels and solvents and are highly toxic to plants.) The most precise identification is by distillation temperature or boiling point. Horticultural oils for East Coast distribution are available at 3 distillation temperatures—412, 435, and 468°F. Agricultural chemical companies can purchase any of these oils and sell them for any purpose for which their original label was approved, but you as a user will not know which one is in the container. Table 1 shows the primary use for the 3 distillation temperature oils. The designated number (temperature) also provides information about the relative speed of evaporation when applied to a plant. The lower the number, the more rapid the evaporation. The speed of evaporation is the key to efficacy and to phytotoxicity and is adjustable by increasing or decreasing dosage. No horticultural oil label to date provides enough information to properly identify the substance in the container. What is needed is the complete five-point refining specifications (Table 2), which you should demand before making a horticultural oil purchase. The minimum information necessary is the U.R. (unsulfonated residue) rating and distillation temperature. *Do not* depend upon the viscosity rating. Viscosity may be adjusted at the refinery by blending with other oils.

Use/Efficacy—Mode of Action

Use and efficacy data date back about three to four decades when the products available were in the 430 to 480°F distillation range. At that time, oils were strictly for dormant or semi-dormant use and used primarily against arthropod eggs. They were effective against naked and exposed eggs, but they were not as effective against eggs in masses covered with scales, hairs and spume-like substances. Likewise they were less effective against eggs deposited *in* plant tissues or covered by tight-fitting plant parts, i.e., under bud scales.

The most recent innovation in oil use has been the production of a 412 oil that performs best in summer use. It is effective against summer eggs and against a wide range of immature forms, if spray particles strike the insect's body, i.e., scale crawlers, mealybugs, aphids, leafhoppers, sawfly larvae, naked caterpillars and beetle larvae.

What does the label say about use and efficacy? The horticultural oil label is an enigma. EPA does not require proper identification of the oil and has allowed many use inconsistencies. Some labels may list usage against many insect groups but provide directions for use (the how and when) against only 2 or 3 specific insects of concern to arborists and nurserymen. This is a case of the inconsistent label begging for use in an "inconsistent manner."

In New York, we have chosen to deal with the label inconsistencies by recommending only the 412 oil for both summer (2-3 gal/100 gal) and dormant (3-4 gal/100 gal) applications, and for use against any insect mentioned anywhere on the label.

Table 1. Uses and Dosages for Horticultural Oils.

Designation/°F	Primary Use	Dosage/100 gal
412	Summer	2-3 gal
435	Summer/Dormant	2 gal/S; 4 gal/D
438	Dormant	2-3 gal

Table 2. Refining specifications for the trade name product Sunspray 6E.

Sun 6—Typical Specifications	
UR	92% min.
Viscosity SSU @ 100°F range	62-80
Gravity API @ 60°F	30 min.
Flash point °F	345 min.
Distillation range @ 10 mm Hg.	
50% °F	412 ± 8
10-90%	80 max.

Horticultural oil has three modes of action against arthropods. It 1) interferes with respiration, 2) interferes with membrane function, and 3) has a residual action against certain sucking, viruliferous insects. When oil coats the egg or covers the spiracles of an insect, it prevents the exchange of gases, a vital process in metabolic activity. An insect can "hold its breath" only for a short time before it self-destructs from the poisons of its own metabolism. Insects have both external and internal membranes that allow or disallow the penetration of certain liquids and gases into tissues and cells. The very thin membranes of immature arthropods cannot prevent the movement of horticultural oil through them; thus it penetrates cells, causing their death. When large numbers of cells die, the arthropod dies. With the development of a product called "Stylet Oil," which contains about 97% horticultural oil, it was found that certain virus vectoring insects, i.e., aphids and leafhoppers, were unable to feed because of the oil residue. From this work there is evidence that oil has a residual, although fleeting, effect against certain stylet bearing or "sucking" insects. To prevent their feeding, low concentration treatments must be made weekly.

Phytotoxicity

No one questions the fact that oil, improperly used, may injure plants. However, the subject of phytotoxicity has been difficult to monitor and is without adequate quantitative data. The plants listed in Table 3 have been tested numerous times by several investigators and under various sets of circumstances, but quantitative data are lacking. There are plantsmen throughout the U.S. who use oil during all seasons and under many phenological and humidity/temperature conditions and have never had a phytotoxicity problem. For example, Monrovia Nurseries in southern California routinely uses 1 gal of oil/100 gal of water as a spray on most of its field-grown plants. A Texas arborist has used oil throughout his arboricultural career at 2-3 gal/100 gal and has never experienced damage even when spraying at 100°F.

Dr. Paul Kelsey, University of Delaware, worked in the 1960's with a 70 second viscosity oil at Longwood Gardens, Delaware using summer applications to 139 species of woody ornamental plants. Of these, only Smoketree (*Cotinus coggygria*) and Azalea (*Rhododendron* sp.) cultivar Roselight, exhibited oil injury to foliage.

Dr. John Davidson, at the University of Maryland, sprayed 412 oil at 4-6% in summer on a wide range of woody ornamental plants and found no toxicity.

During the past 15 years we in New York have worked to produce phytotoxicity symptoms in summer treatments and have done so only when breaking the most basic rules, e.g., overdose, moisture-stressed plants, and very young foliage.

There are, of course, valid data from those who work with tree fruits that give us examples of conditions that bring about phytotoxicity. In the tree fruit industry it is accepted that dormant sprays of oil cause twig injury to the 'Delicious' apple. Interpolated data from tree fruits are not adequate for oil use recommendations to woody ornamentals. These data do provide leads, insights, and some techniques for researchers. Scientifically controlled experiments must be done with the currently available horticultural oil under a variety of environmental conditions to determine their safety range in terms of plant material and climatic conditions. We need to learn why some plants are sensitive to horticultural oil. Oils can penetrate the cuticle and other membranes of some plant species. This is particularly true for young, newly forming leaves and elongating shoots. It may also be true for the nonsuberized bark of twigs. If the "defensive chemicals" to oil have not formed or hardened on the leaf or bark surface, oil will penetrate and kill cells. If oil clogs lenticals and prevents respiration, especially when leaves have dropped or when somata are not functioning and the temperature remains warm enough for metabolic activity, twig dieback may occur.

From my studies and analysis of phytotoxicity by oil, I have developed some conclusions that almost always point to the user doing something wrong. I call these conclusions "Factors that cause phytotoxicity." They are as follows:

1) Overdose
2) Wrong timing of spray
   a. no spraying when buds have fully opened and shoot elongation is occurring.
   b. no spraying when there is an obvious moisture deficit observed in leaves
   c. no spraying to sensitive plants when the relative humidity is expected to remain over 90 for a period of 48 hours.
3) Mistaken dormancy (fall);
4) Genetic variability

Should phytotoxicity occur, the user failed to account for one or more of these factors. The extent to which genetic variability occurs is not known.

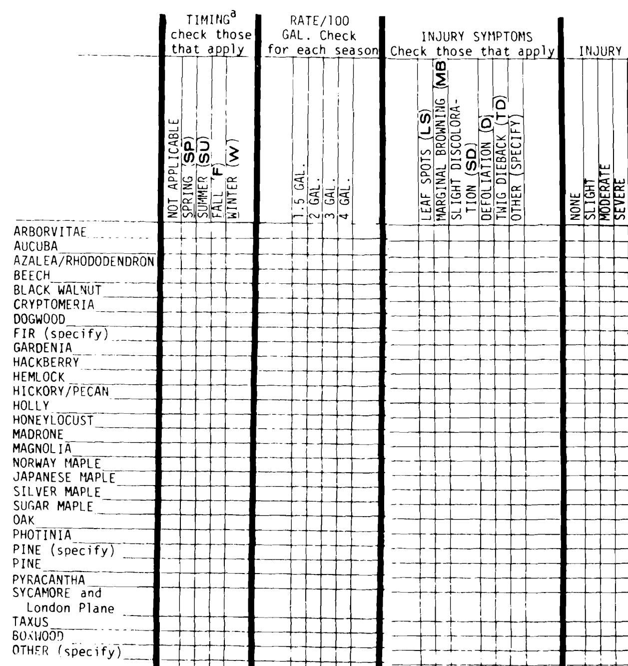
Preview of the oil use survey

In 1983 a questionnaire was selectively sent to 3,500 members of the Green Industry. There was a 35% response, of which 25% were arborists, 30% were landscapers, 37% were nurserymen and 7% were golf course superintendents and people associated with botanical gardens, zoos, parks, etc. Responses were received from people representing 45 states, the District of Columbia, and 5 Canadian provinces.

In the questionnaire, there were 1,135 potential responses. Fifty-seven percent of the respondents did not use horticultural oil. A few respondents were unfamiliar with the product.

To the question, Do you use oil as a routine, general-purpose spray?, 54% of the respondents said yes. One respondent in Oregon uses 2% oil to improve the effectiveness of other insecticides during all seasons; 54% said they had better pest control if they combined oil with another pesticide. The most commonly used additives in order of frequency were Ethion, Diazinon, Malathion, and Trithion. Industry experimenters were using Orthene, Dursban, Dimethoate, Pentac, Kelthane and Thiodan with oil. An arborist gave us his special mix of 2½ gal oil, 2 lb fertilizer, and 1½ lb of Ferbam, all in 100 gallons of water.

Most respondents used oil in the dormant season (early spring, fall and winter); only 8% used oil during the summer. Their source of oil use information came from Cooperative Extension (33%), Label (32%), and Supplier (13%), with 20% obtaining information from a wide variety of sources.



	TIMING[a] check those that apply					RATE/100 GAL. Check for each season				INJURY SYMPTOMS Check those that apply						INJURY			
	NOT APPLICABLE	SPRING (SP)	SUMMER (SU)	FALL (F)	WINTER (W)	1.5 GAL.	2 GAL.	3 GAL.	4 GAL.	LEAF SPOTS (LS)	MARGINAL BROWNING (MB)	SLIGHT DISCOLORATION (SD)	DEFOLIATION (D)	TWIG DIEBACK (TD)	OTHER (SPECIFY)	NONE	SLIGHT	MODERATE	SEVERE
ARBORVITAE																			
AUCUBA																			
AZALEA/RHODODENDRON																			
BEECH																			
BLACK WALNUT																			
CRYPTOMERIA																			
DOGWOOD																			
FIR (specify)																			
GARDENIA																			
HACKBERRY																			
HEMLOCK																			
HICKORY/PECAN																			
HOLLY																			
HONEYLOCUST																			
MADRONE																			
MAGNOLIA																			
NORWAY MAPLE																			
JAPANESE MAPLE																			
SILVER MAPLE																			
SUGAR MAPLE																			
OAK																			
PHOTINIA																			
PINE (specify)																			
PINE																			
PYRACANTHA																			
SYCAMORE and London Plane																			
TAXUS																			
BOXWOOD																			
OTHER (specify)																			

Fig. 1. Portion of the "Oil Use Questionnaire" requesting specific data about the effects of oil on some common woody ornamental plants.

Table 3. Two classes of trees and shrubs sensitive to oil when applied under seasonal conditions.

Oil-Sensitive Plants		Tendency Toward Sensitivity	
Maples	Dormant	Beech	Dormant
Hickories	Dormant	Holly (Japanese)	Summer/Dormant
Black Walnut	Dormant	Redbud	Dormant
Cryptomeria	Anytime	Savin Junipers	Summer
Smoketree	Summer	*Photinia* sp.	Summer
Azalea (limited)	Summer	Spruce	Dormant
		Douglas-Fir	Dormant

Table 4. Annual foliage and flowering plants tolerant to 4%, 412 oil applied in July on Long Island, NY.

Oil-tolerant annuals
Begonia semperflorens
Chrysanthemum morifolium
Coleus blumei
Dianthus barbatus
Impatiens wallerana
Pelargonium hortum
Salvia splendens
Tagetes patula
Viola tricolor

We estimate that the Green Industry uses about 750,000 gallons of oil per year. Oil was used most frequently for scale insect control followed by mite control. Eighty-two percent of the respondents had never experienced phytotoxicity from oil treatments made to the plant species listed in Fig. 1. However, with the exception of London plane and madrone, one or more of the respondents had seen some oil injury to all listed plants. The most frequently damaged plants were: Cryptomeria, Hickory/Pecan, Holly (Japanese), and Maple (Japanese, silver, and sugar). The most frequently observed injury symptoms were marginal leaf burn in spring and summer and twig dieback from dormant sprays.

Greater detail about this survey will appear in both arborist and nurserymen's journals after the analysis is complete.

New Studies

We have believed that arthropods could not become resistant to horticultural oil, and, in the traditional sense of pesticide resistance, this may be true. The following account will illustrate how another type of resistance may be developing among armored scale insects.

In a Christmas tree plantation of Scots pine where oil had been used repeatedly in spring dormancy sprays for about 10 years against the pine needle scale, *Chionaspis pinifoliae,* it was found that the scale was not being controlled even when the dosage was increased to 6%. Upon close examination we found that scale covers (tests) were much thicker than those in non-sprayed plantations. The eggs under the thick scale covers were free of oil with no evidence of oil anywhere except the outer surface of the test.

From this we have made some assumptions that through natural selection the pine needle scale is developing a resistance to oil via a stronger, thicker and more weather-resistant test. This same phenomenon may explain reports from the Midwest that oil is failing to control oystershell scale.

A second study showed that the 412 emulsified oil did not remain suspended when water temperature reached 110°F if there is no agitation. This temperature is significant when one considers summer operating temperatures. If spray crews take a lunch break and the tank and hose remains in full sun, the temperature of the tank mix can easily reach 125°F and much higher in the hose lines. When agitation is resumed, the spray material in the tank will again become suspended, but that which remains in the hose will have formed large globules. Such globules sprayed on even oil-resistant foliage may cause large necrotic spots.

One additional point of concern is the matter of increased hazard to the man holding the spray gun when a synthetic organic insecticide is added to oil sprays. Since horticultural oils have been likened to the oils used in hand lotions, it is important that the user be aware that an oil spray containing an organophosphorus insecticide may create a hazard for increased exposure through skin absorption. Because of this hazard the sprayer should wear gloves, a spray coat and a face shield.

Significance to the Nursery Industry

Oil is an effective and safe insecticide that fits well with the philosophy of integrated pest management. To successfully use oil requires more attention to climatological detail, and a plantsman who understands the basics of plant physiology. Confusion about oil as a pesticide will not be overcome until the product is properly labeled. Such a label will provide information about paraffinic purity (unsulfonated residue), distillation temperature, and greater detail about how, when and where the product should be used. The researcher can quote the refining specifications of the oil he/she has used, but if the field person cannot tell that the product purchased is the same that was used in experiments, confidence will be lost in both the researcher and the product.

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