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THE USE OF HORTICULTURAL OILS AND INSECTICIDAL SOAPS FOR CONTROL OF INSECT PESTS OF AMENITY PLANTS

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Abstract. Major advantages associated with the use of horticultural oil and insecticidal soap sprays include enviornmental and applicator safety, compatibility with IPM programs and a wide range of pest control. Horticultural oils and insecticidal soaps are becoming major chemical pest control tools for the green industry. However, a complete working knowledge and proper application are essential in order for these materials to be effective and environmentally safe.
Key Words. *IPM, phytotoxicity.*

Résumé. Des avantages majeurs associés à l'utilisation des huiles horticoles et des savons insecticides incluent la sécurité environnementale et de l'applicateur, la compatibilité aux programmes de lutte intégrée aux insectes et pathogènes, et la grande étendue d'insectes contrôlés. Les huiles horticoles et les savons insecticides deviennent des outils chimiques majeurs de contrôle des insectes et pathogènes pour l'industrie horticole. Cependant, une bonne connaissance du fonctionnement de ces produits et des techniques d'application appropriées sont essentielles de manière à ce que ces produits soient efficaces et sécuritaires pour l'environnement.

A recent nationwide survey conducted by Johnson and Caldwell (7) revealed that 57% of arborists did not or have never used horticultural oils and of those, 1% were not aware that the product even existed. Of those that use oil, 54% routinely apply oils as a general purpose spray with 65% of the applications in the spring and only 8% of the applications applied in the summer months. Oils were used most commonly for control of scale insects and mites.

A major reason for the limited use of oil sprays is probably due to concerns and fears by members of the green industry because of the potential for phytotoxicity. Insecticidal soaps suffer from a similar situation due to their rather recent development and reluctance on the part of horticulturists to fully utilize their insecticidal properties. In addition, oils hold a rather unique position in the marketplace. Basic refiners do not advertize these products and do very little to promote their use. In most cases, horticultural oils are promoted by small agricultural chemical companies that have their own label and trade names. As a result, compared to the marketing exposure that synthetic pesticides receive, horticultural oils remain relatively obscure (7).

The purpose of this article is to inform members of the green industry on the properties, characteristics, benefits, and applicability of using spray oils and insecticidal soaps in the landscape as a major portion of the chemical component of an integrated pest management (IPM) program.

Horticulture Oils

History of Oil Sprays. Oils have been used since the late 1800's for control of various insect pests of fruit and shade trees. As early as 1880, 10% and 25% kerosene-soap emulsions were the first petroleum products to be used for control of aphids and other soft-bodied insects, and for more resistant scale species, respectively (5).

With the introduction in 1870 of San Jose scale, *Aspidiotus perniciosus,* into California from China, a new importance and initiative developed for examining the insecticidal properties of crude

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petroleum and its chemical fractions. Initial studies showed that the early kerosene and crude petroleum formulations were effective against the scale but often caused serious injuries to trees.

By 1905 oils became available, but received limited acceptance because liquid lime-sulfur was being used on a wide spread basis to control San Jose scale (5).

It was not until 1923, that Ackerman (1) reported the successful use of a 2% light lubricating oil against the San Jose scale. This discovery had particular significance because the oil provided satisfactory control in field test orchards where lime-sulfur had failed. As a result of this breakthrough, petroleum oils again became the primary dormant or semi-dormant treatment used in deciduous fruit orchards. This practice was further reinforced in the late 1920's and 1930's when the fruit tree leafroller, *Archips argyrosphila,* became a major pest. Oil sprays proved to be quite effective against the overwintering eggs of the leafroller whereas lime-sulfur sprays were ineffective.

Due to the development and widespread use of DDT during and shortly after World War II, oils were not fully utilized.

The greatest advances in spray oil technology and application occurred from 1945-1970 when oil companies and applied entomologists commenced working together to find new uses for the product and more effective insect pest control.

However, in spite of the satisfactory results obtained by using oil sprays and the advances in refining technology, there was still a reluctance on the part of horticulturists to use oils on a wide spread basis mainly due to the problems of phytotoxicity. Much of phytotoxicity originated from the large amounts of impurities found in the earlier oil products. Early research showed that non-woody plant tissues, such as leaves and buds, were injured mainly by the aromatics and other non-saturated fractions in the oil as compared to the non-volatile oil components (2). Further improvements in oil refining technology allowed for the removal of unsaturated hydrocarbons, acids, and highly volatile elements resulting in oils not only suitable for dormant sprays but also for use on green foliage as a summer oil (9).

Prior to 1892, oils were divided into two major groups: dormant oils and summer weight or superior oils. Dormant oils were characterized by a high viscosity (degree of oil heaviness or resistance to flow) and were to be applied during the dormant season. In contrast were the superior oils, which were more refined, were lighter, and could be applied to most plants during periods of active growth. Due to even better refinement techniques of today, most currently used oils are comparable to old summer or superior oils but are simply called superior horticultural or horticultural oils (2). Dr. W.T. Johnson of Cornell University defines a superior or horticultural oil as "a highly refined paraffinic petroleum product made solely for use on plants at specific dosages and acts as an insecticide" (2).

Type and Characteristics of Horticultural Oils. Spray oils come in basically two types: dormant and summer. In spite of their similarity, they do differ in their degree of refinement and time of application.

Pollet and Doughty (8) define dormant oils (heavier weight) as applied in spring prior to bud break or in the fall after leaf drop. Summer oils (lighter weight) are applied during the active growth stage when plant foliage is present.

There are three main characteristics to consider when evaluating an oil for pest control use: volatility, viscosity, and the unsulfonated residue (UR) rating (2).

Volatility is defined by the temperature at which the particular fraction or part of the crude oil is distilled (a process that consists of driving a gas or vapor from a liquid or solid by heating and condensation to a liquid product). The lower the volatility, the heavier the oil (dormant oil), and the more effective it is in pest control. The more volatile the oil, the lower the distillation value, and the lighter the oil (summer oil) (8). An oil with a low distillation value will evaporate more rapidly from the surface to which it is applied and the speed of evaporation is directly related to insecticide efficacy and phytotoxicity.

Viscosity, on the other hand, is the flow rate (resistance to flow) or thickness of the oil. The viscosity is measured by passing the material through a special measuring device and the rate is recorded in seconds. Most horticultural oils have viscosity readings in the range of 60-110 seconds (8, 9).

The purity or UR rating (unsulfonated residue) is an index of the quantity of oil free from unsaturated hydrocarbons. Most oils on the market today have UR indexes of at least 92% with some oils having UR undexes as high as 99%.

It is important to remember that the UR index and the volatility value are the most important characteristics when selecting an oil spray. Do not rely on the viscosity rating as it may be altered by blending with other oils during refinement and production (8).

Using Horticultural Oils. In the early days of oil sprays, most were strictly used in the dormant season, had distillation ranges of 430-480°F., and were used for control of various species of exposed insect eggs. Presently, distillation ranges of 412-475°F. are common. As a result, these oils have been more effective against insect eggs as well as a wide range of soft bodied insects such as aphids, scale crawlers, leafhoppers, and mealybugs. For additional information on uses and dosages of horticultural oils, see Table 1.

The problem of phytotoxicity is always a possibility when using oil sprays however, as with any chemical, there are certain guidelines that must be followed in order to insure effective pest control and prevent plant injury.

1. Do not apply oils when the temperature is below 40°F. or above 100°F. *Please note however, that in areas where the humidity is below 50%, oils are routinely applied at temperatures above 100°F.* If humidity conditions are not considered, phytotoxicity may result at temperatures below or above these points.
2. Do not apply oils if rain is a possibility or if plant tissues are wet. Leaves must be dry.
3. Avoid spray drift onto sensitive plants.
4. Apply the oil according to label rates. Do not overapply.
5. Do not spray when buds are fully opened and shoot elongation is occurring.
6. Do not spray plants when the humidity is expected to remain over 90% for a period of 36 to 48 hours.
7. Remember, leaf drop on deciduous plants is not reliable enough to determine dormancy. Therefore, do not spray if there is the possibility of mistaking plant dormancy in the fall.
8. Take into consideration plant genetic make-up and variability.
9. *Finally, and probably most important,* be aware and alert to plants that are sensitive to oil sprays. Be sure to read the label for specific plant species and varieties. *If in doubt, do not spray!* If you experiment on several plants, be sure to make notes on weather conditions, plant variety and/or species, and application rate. A partial listing of oil sensitive plants and plants with a tendency for sensitivity is shown in Table 2. For a more comprehensive listing of dormant and summer oils sprays, and their affect on woody plant material and insecticide efficacy refer to Baxendale and Johnson (3, 4).

Advantages of Horticultural Oils

1. Oils are very safe environmentally and are degradable by evaporation.

Table 1. Uses and dosages for horticultural oils.[1]

Distillation temperature	*Primary use*	*Dosage per 100 gallons*
412°F	Summer	2-3 gallons
435°F	Summer/Dormant	2 gallons for summer 4 gallons for dormant
438°F	Dormant	2-3 gallons

[1]Taken from Johnson (6).

Table 2. Plants sensitive to horticultural oils.[1]

Oil sensitive plants	
Maples	*Dormant*
Hickories	*Dormant*
Black walnut	*Anytime*
Cryptomeria	*Anytime*
Smoketree	*Summer*
Azaleas (limited)	*Summer*
Tendancy toward sensitivity	
Beech	Dormant
Japanese holly	Dormant/Summer
Redbud	Dormant
Savin junipers	Summer
Photinia sp.	Summer
Spruce	Dormant
Douglas-Fir	Dormant

[1]Taken from: Johnson (6).

2. Oils quickly dissipate by evaporation shortly after application with little pesticide residue left behind.
3. Oils are compatible with an integrated pest management (IPM) program and less harmful to nontarget organisms.
4. Oils are virtually nonpoisonous to the applicator.
5. Oils are noncorrosive to spray equipment.
6. Oils can provide a wide range of pest control without plant injury when applied correctly.
7. Oils may be mixed with the synthetic organic insecticides (ie. Ethion-oil).

Disadvantages of Horticultural Oils

1. Oils, if improperly applied, can cause phytoxicity and/or burning of the foliage. Light yellow foliage is the first symptom of injury. The yellow areas will darken, appear water soaked, and the leaves may later turn a dark purple and die. If an improper application is made during the dormant season, terminal and/or branch dieback may be apparent the following spring.

Horticultural Oils and Their Mode of Action. There are a variety of theories as to the mode of action of oils, however, only three are presented here. The first theory is that oils kill the pest through asphyxiation. Oils actually block the spiracles (external openings through which air enters the insect's body) of the pest. Due to the lack of oxygen, there is also a toxic buildup of carbon dioxide and other toxins. Theory two is that oils interact with the fatty acids within the insect's body, acting as a lethal poison, interfering with normal metabolism, and destroying membranes, particularly of immature insects. Some scientists (theory three) believe oils provide residual protection against certain sucking insect pests, such as aphids, leafhoppers, scale crawlers, and mites by disrupting their feeding habits and reducing the level of insect-transmitted pathogens.

Regardless of oil's mode of action, there are several points about oils that must be considered. First, there is a direct and precise relationship between oil dosage and insect mortality. During the dormant season, insect oxygen requirements decrease to extremely low levels. Because of the low oxygen requirement, an oil applied under dormant conditions may not be effective because the insect is very close to actually "holding its breath". The oil evaporates in time and the insect survives the exposure. Consequently, that is why dormant oils are applied at rates of 1.5 to 3 times the rate of summer oils. During the growing season, insects need a continuous supply of oxygen and thus the oil is usually sufficient for control. Second, check the oil before use to insure its effectiveness. When mixing, the oil and water should mix uniformly and have a milky-white appearance after shaking. If this does not occur, do not use the oil. Third, since oils are considered a contact material, effective pest control is dependent upon covering the insect's body with oil.

Insecticidal Soaps

History of Insecticidal Soaps. Both home gardeners and commercial horticulturists have long used soap as an insecticide. In the past, the origin of these soaps varied considerably and in some cases phytotoxicity resulted. In the 1970's, a major breakthrough occurred when scientists were able to unravel the insecticidal properties of certain naturally occurring plant oils and animal fats. These natural compounds are known as "fatty acids" (10).

Fatty acids play important roles as basic energy sources for living organisms as well as major building block components of cell membranes. The next step in utilizing the benefits of these fatty acids as a potential insecticide was to isolate those fatty acids from the hundreds found in nature. In the mid 1980's, this task was completed and now there are formulations available for pest control.

Characteristics and Chemical Makeup of Insecticidal Soaps. Insecticidal soaps are pure soaps which consist of approximately 49% potassium (K) salts of fatty acids and are formulated by treating selected acids with a potassium base. The inert ingredients are a combination of water and alcohol which aid in the mixing of the soap concentrate. Insecticidal soaps do not contain any organic solvents or dangerous inerts and are biodegradable (10).

Soaps are considered a contact insecticide, therefore the insect or mite pest must receive a direct application of the spray in order for it to be effective. Soaps are only effective in the liquid state with no insecticidal activity present once the material has dried on the plant surface.

Using Insecticidal Soaps. There are certain points that must be remembered when using soaps (10).

1. Insecticidal soaps differ from conventional insecticides in that the latter specify the amount of active ingredient per acre or 100 gallons of water. With insecticidal soaps, the relative concentration of the soap in the spray solution is important. Follow label directions for the desired concentration necessary to control the pest and apply enough of the spray to provide thorough coverage of the foliage.
2. Use soft water whenever possible to make the spray solution. Extremely hard water will reduce the insecticidal activity.
3. Use enough spray mixture to thoroughly cover foliage to the point of runoff.
4. Make applications when slow drying conditions prevail such as in the early morning, late afternoon or evening, or during periods when it is overcast. The longer the plant surface remains moist the longer the soap will keep its insecticidal properties.
5. Use the proper nozzle and pressure combination that will insure good spray coverage of infested foliage.
6. Insecticidal soaps should not be applied to tender, young foliage during periods of high temperatures (90°F) or when plants are under drought stress as phytotoxicity may result.
7. Insecticidal soaps may be tank mixed with natural pyrethrum, *Bacillus thuringiensis* (B.t.), pyrethroids, methoxychlor, and benomyl. Soaps should be tank mixed at a rate of one gallon per 100 gallons of water containing a reduced amount of the companion insecticide.
8. Insecticidal soaps may be toxic to certain plant species including horse chestnut, *Aesculus hippocastanum;* mountain ash, *Sorbus aucuparia;* Japanese maple, *Acer palmatum;* gardenia, *Gardenia* spp.; bleeding heart, *Dicentra formosa;* sweet pea, *Lathyrus odoratus;* maidenhair fern, *Adiantum pedatum;* crown of thorns, *Europhorbia milii;* corn plant, *Dracaena* spp.; nasturtium, *Tropaeolum majus;* and hawthorne, *Crataegus* spp.

Advantages of Insecticidal Soaps

1. According to product literature, soaps are specific to most pest insects and have a low toxicity rating for coccinellid beetles, parasitic wasps and bees, and honeybees.
2. Quite safe to the applicator and biodegradable in the environment.
3. Soaps are well suited for IPM programs.
4. Soaps are physically compatible with a wide variety of synthetic petrochemical and naturally occurring biorational pesticides.
5. Soaps may be used alone or may be tank mixed with conventional insecticides with no loss of efficacy.
6. Soaps may be used in rotation with other insecticides to help reduce the development of resistance.
7. Soaps are a natural spreader-sticker and tend to enhance many other products when tank mixed.

Disadvantages of Insecticidal Soaps

1. Soaps are only effective in the liquid form and leave no insecticidal residue behind on the application surface. Once they dry, no insecticidal properties exist.
2. Phytotoxicity may result on certain plant varieties and a "lens effect" may occur on plants with waxy horizontal leaves resulting in foliage discoloration.
3. Soaps are not compatible with concentrated mineral elements, lime sulfur, Bordeau mixture, copper sulfate, and rotenone.

Insecticidal Soaps and Their of Action. Insecticidal soaps penetrate the insect's body and disrupt the normal function of both cells and membranes. The overall effect of this process causes the loss of the cell contents and rapid death. This process affects the immature and adult stages of the target insect, but not the egg stage.

Summary

The growing concern over the use of toxic chemicals in the urban sector places an important emphasis on the development and use of less toxic materials and comprehensive IPM programs. The use of horticultural oils and insecticidal soaps for control of insect pests of woody ornamental landscape plants illustrates how "older" technologies can be modified or improved for effective use in the 21st century.

Horticultural oils and insecticidal soaps are becoming major chemical pest control tools for the green industry. However, a complete working knowledge of these products and proper application are essential in order for these materials to be effective and environmentally safe.

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Abstracts

FISHER, SUSAN W. 1989. **The evolution of insecticide resistance.** American Nurseryman 169(6):107-111.

Contrary to popular belief, resistance is not a new phenomenon. The evolution of resistance precisely parallels the use of pesticides. Following World War II, the modern age of insectides was inaugurated. Insecticide applications intensified, and the number of compounds available for use as insecticides increased dramatically. The evolution of resistance kept pace. Not only are more insects today exhibiting resistance to one or more insecticides, but they are displaying many degrees of resistance. Because it is not possible to measure resistance in an absolute sense, resistant individuals must be compared to normal, susceptible individuals. A resistance factor of 10 times is thought to make control efforts useless.

HECHT-POINAR, E.I., L.R. COSTELLO and J.R. PARMETER, JR. 1989. **Twig blight of oaks in California.** California Agriculture 43(1):15-16.

A recently recognized disease called "twig blight" has become a serious problem on oaks in California. Coast live oak appears to be the principal host. At least two fungi have been implicated in twig blight infections: *Cryptocline cinerescens* and *Discula quercina.* Twig blight of landscape oak trees was reduced to an acceptable level by pruning plus treatment with a fungicide.