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NSW DEPARTMENT OF
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# Using petroleum-based spray oils in citrus

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## OIL SPRAYS HAVE A NAME CHANGE

Following an international conference on Spray Oils in Sydney in 1999, new names were recommended to replace such terms as 'summer oils', 'superior oils', 'petroleum spray oils' and 'narrow-range and broad-range oils'.

The new classification is based on the degree of refinement of the oil. It recommends three new categories:

- mineral oil (MO)
- agricultural mineral oil (AMO)
- horticultural mineral oil (HMO)

HMOs and AMOs come from the lubricating fraction of petroleum oils. These high quality oils should be refined from virgin distillates and not from recycled products. Only HMOs and AMOs should be applied to plants in leaf. They are used to suffocate (that is, drown) or alter the behaviour of susceptible pests and to control some pathogens. Both types are suitable for use on citrus, but greater caution is required when using AMOs.

Oil sprays have been used for over a century to control insect pests. The use of petroleum products in Australia commenced with the use of kerosene in the late 1880s. During this time there have been significant changes in the way oils are formulated, in their quality and in the emulsifiers used.

Petroleum-based spray oils play an important role in the control of pests in citrus. They are important in integrated pest management (IPM) programs, but also as additives to other biocides.

Petroleum-based spray oils offer many benefits over broad spectrum pesticides:

- They are as effective or more effective than broad-spectrum synthetic pesticides for a wide range of pests and diseases.
- Many pests can be controlled simultaneously.
- They have less harmful effects on the natural enemies of citrus pests.
- They do not stimulate other pest outbreaks.
- Pests are not known to develop resistance to them.
- The oil deposits are broken down within weeks to form simple, harmless molecules.
- When using oils only minimum protective clothing needs to be worn.
- They are suitable, depending on the emulsifiers and additives used to formulate products, for use in organic farming.
- They are not toxic to humans or other animals.

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## PROPERTIES OF SPRAY OILS

Crude oils are basically composed of hydrogen and carbon atoms and are generally classified as paraffin, naphthene and aromatic. Because each oil is a complex of molecules of different molecular weights, they may be refined to produce a range of products with specific uses and characteristic properties.

Effectiveness as a pesticide and the risk of phytotoxicity both increase with increasing molecular weight. Four properties increase with increasing molecular weight: distillation temperature, *n*-paraffin carbon number, viscosity and pour point.

**Distillation temperature**

Oils may be separated into fractions with specific boiling or distillation temperatures. The 10, 50 and 90 per cent distillation temperatures and the range between the 10 and 90 per cent distillation temperatures are widely used to classify refined oils.

**Carbon number**

This property separates oil fractions according to the number of carbon atoms in their molecules. The property is used in a similar way to distillation temperature to denote the 10, 50 and 90 per cent distillation points. It was developed recently to standardise laboratory procedures and overcome problems associated with classification based on distillation temperatures.

**Viscosity**

Viscosity measures flow rate. Commonly 'heavy and thick' and 'light and thin' are used to describe high and low viscosity oils. It is a convenient, though no longer widely used, way to simply describe an oil.

**Pour point**

The pour point is the lowest temperature at which an oil will flow.

Two properties not related to molecular weight are unsulfonated residue and gravity° API.

**Unsulfonated residue (UR)**

UR gives a measure of the degree of refinement of spray oils. It is expressed as a percentage following determination of the extent to which the oil reacts with sulfuric acid under standard conditions. The minimum value for AMOs and HMOs is 92% UR.

**Gravity °API**

This is a measure of the density of spray oils. It is a function of molecular size and structure, and is indicative of paraffin content. A value of 37° is characteristic of very high paraffin content. Values greater than 32° are considered optimal.

## PESTICIDE EFFECTIVENESS

Paraffinic oils are used on citrus because they are more effective pesticides than naphthenic oils, which also tend to be more phytotoxic. Aromatic oils are not used because they are too phytotoxic.

When insects and mites are sprayed they suffocate. Death may take several days depending on size and stage of the insect or mite, oil type and formulation, spray concentration and volume, and spray coverage.

## FORMULATIONS

**Mayonnaise oils** are emulsions of about 85 per cent oil emulsified in about 15 per cent water with casein and ammonia. Undiluted emulsions resemble mayonnaise. They were common before 1980.

**Clear miscible spray oils** are emulsive formulations of oil and an emulsifier (surfactant or surface active agent). They form emulsions when added to water. They are now the most common type of product.

Concentration of emulsifiers in modern clear oils range from about 1 to 3 per cent. Increasing the concentration of emulsifiers can reduce effectiveness, but higher concentrations are required to mix oil with water as UR values increase. Products are formulated so that sprays break on impact to leave a film of oil after the water and emulsifier drain away.

When stored in hot situations over one or more summers, mayonnaise oils may deteriorate and the oil separate out. This may then be harmful to citrus. Most citrus spray oils are now formulated as clear oils. It is wise to use products within 2 years of purchase.

## STANDARDS FOR HMOs AND AMOs

There are a number of standards recommended for spray oils. Unfortunately this type of information is not usually on the registered label. You need to contact the manufacturer for these details.

- They must be virgin paraffinic oils (Cp ≥ 60%). This means that they must not be recycled oils and that more than 60% of the carbon-hydrogen molecules must be in chains rather than rings.
- The concentration of unsaturated molecules must be 8% or less. The unsaturated molecules can oxidise in sunlight (particularly in summer) and produce acids which can burn plant tissue.
- The unsulfonated residue (UR) must be 92% or higher. The higher the UR, the lower the risk of phytotoxicitity (damage).
- The *n*-paraffin carbon number (*n*C*y*) of HMOs are mostly *n*C21 and *n*C23 as well as *n*C24. The *n*-paraffin carbon number of AMOs are mostly *n*C24 or *n*C25. This number relates to the weight of the oil: the lower the carbon number, the lighter the oil. For example, a *n*C21 oil is lighter than a *n*C24 oil.

## PEST CONTROL USING OIL SPRAYS

Oil sprays control pests either by suffocation or by altering their behaviour (such as reducing feeding and egg-laying). Diagram 1 shows what happens to the oil droplet when it is applied to the plant.

Diagram 2 shows how insect pests are suffocated by oils. This mode of action has been known since early last century and was the principal mode of action recognised until the 1990s. Since 1990, research (most within NSW DPI and the University of Western Sydney) has shown that a wide range of pests including citrus leafminer, greenhouse thrips, bronze orange bug nymphs, citrus red mite and Queensland fruit fly are susceptible to significant impacts of spray deposits on their feeding and egg-laying behaviour. This mode of action may be more important than death from suffocation, as it has increased the range of pests for which oil sprays can be used effectively.

(These diagrams are based on Johnson, WT 1994, 'Oils as pesticides for ornamental plants', in AR Leslie (ed.), *Handbook of integrated pest management for turf and ornamentals*, Lewis Publishers, Boca Raton.)

**Things to know when using HMOs and AMOs:**

- You need to apply oils so that you achieve a thin even coating of oil over the plant or fruit surface.

**Diagram 1. Oil remains on the leaf surface or moves into the leaf and most water and emulsifier run off.**

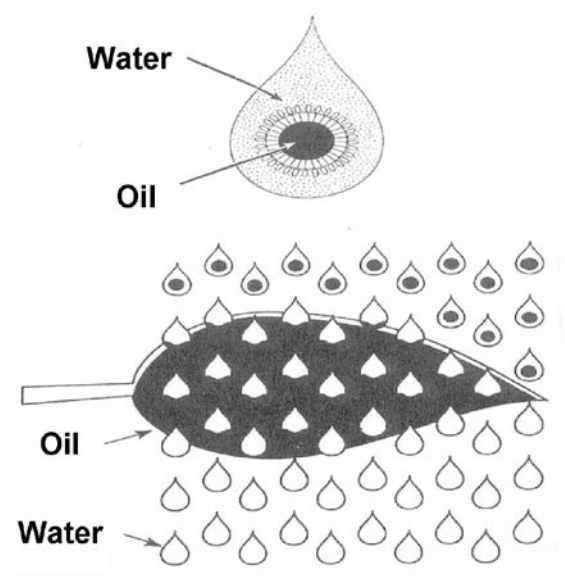
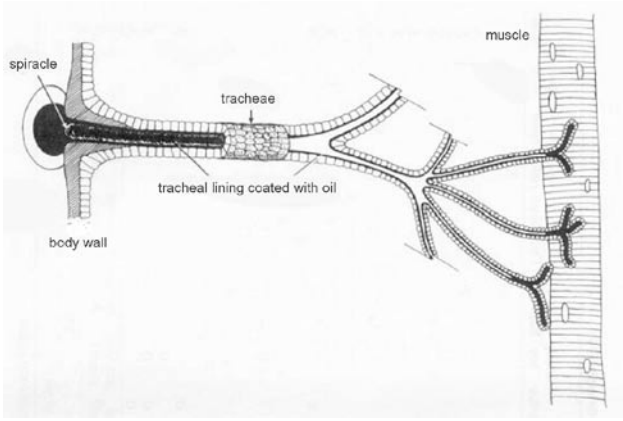



**Diagram 2. Anoxia (suffocation) from oil moving into the tracheae (breathing tube) of the pest.**




- It is better to apply a higher volume of spray mix than to use a higher concentration of oil in the mix.
- In situations in tropical, subtropical and temperate regions where you are using multiple low concentration (<0.5%) oil sprays annually for control of pests such as citrus leafminer, apply sprays just to the point of run-off (which is when the spray on leaves just starts to drip).
- In situations (subtropical and temperate regions) where only one or two applications of a higher concentration (1%) oil spray are used annually for control of pests such as scales, apply at volumes which exceed the point of run-off (which is when the spray on leaves is continuously dripping).
- Timing of oil sprays is critical. Apply them when the target pest numbers exceed

acceptable levels and they are at their most susceptible stage, or when susceptible new growth on trees starts to appear: for example, new summer and autumn growth in the Sydney region is attacked annually by citrus leafminer.

- For most pests you need to thoroughly coat all plant surfaces: the upper and lower leaf surfaces, fruit, twigs, branches, insides and outsides of trees.
- The residual activity of oils (how long they last) is less under hotter tropical conditions than in the cooler temperate climates. This is largely because the oil molecules evaporate and move within the plant more quickly in warmer climates.

### ⊙ Controlling soft scales and mealybugs

Soft scales and mealybugs can be more difficult to control than hard scales. White wax, pink wax and hard wax scales are the easiest of the soft scales to control. They have one annual generation in southern states and two generations in northern NSW and Queensland.

Control should be achieved with a 1% oil, as long as you apply the spray thoroughly to all infested plant surfaces. Timing of the oil spray is critical, and needs to coincide with the presence of the young, recently hatched stages (crawlers) which generally occur on the upper leaf surfaces.

The other soft scales such as black scale and soft brown scale are more difficult to control because they have overlapping generations.

To achieve the best control, time your oil spray to coincide with the greatest number of young stages. Spot spraying heavily infested trees rather than whole blocks is also an option for these scales.

**Ants** promote soft scale infestations and must also be controlled. In fact controlling soft scale infestations is pointless if you do not also control the ants.

There is an Open Use Permit for NSW (OP 70) for the use of chlorpyrifos to control ants in citrus orchards, and chlorpyrifos is registered for use in Queensland, South Australia and Victoria.

### ⊙ Controlling armoured (hard) scales

Light infestations of armoured scales such as red and purple scale are easily controlled using oil sprays. Moderate to heavy infestations are more difficult to control, largely as a result of the very large numbers of scale insects present.

A 1% oil spray applied at high volumes should be used. Good coverage of all the above-ground parts of the tree is necessary. Manipulate your sprayer to direct more spray into the tops of trees so that the spray drips down inside the canopy. Good coverage of the inside of trees is essential and high volume sprays are necessary.

### ⊙ Controlling mites

Mite infestations can be controlled using multiple low concentration (0.25–0.5%) oil sprays. The oils suffocate the mobile stages and the oil deposits on the plant surface can reduce feeding and egg-laying behaviour. Citrus red mite (only present in the Gosford and Sydney areas) is more susceptible to oil sprays than two-spotted mite.

### ⊙ Controlling citrus leafminer (CLM)

In most of southern and eastern Australia CLM infestations occur from mid-summer until mid-autumn. Adult moths lay eggs on immature leaves when they are less than 4 cm long. The peak egg-laying period occurs between mid-February and mid-March.

The oil sprays don't kill CLM but instead affect the behaviour of the female moth. The moth tends to lay fewer eggs on the oil-sprayed leaves and the oil deposits also affect the movement of moths between and within trees. This then results in reduced populations of CLM.

Control of CLM is usually only necessary in nursery situations and in young trees. Multiple (every 5–14 days, depending on the warmth of daily temperatures) low concentration (0.25–0.5%) oil sprays are applied to the susceptible new growth as soon as the summer flush commences in mid to late January. Good coverage of leaf surfaces is essential, and trees should be sprayed to the point where the spray just starts to drip off the leaves.

It is difficult for the moth to establish large populations if you commence spraying early in the summer flush cycle when the flush is first observed.

## SPRAY VOLUMES

HMOs and AMOs generally need to be applied at high volumes so that the oil forms an effective film over the plant or fruit surface. Thorough coverage to the tops and insides of trees is important, especially for control of armoured scales.

Oils are not poisons, and have limited residual activity, but the benefits of a single effective spray can last more than one season.

Some sprayers are better at applying high volumes of spray than others. The best high volume sprayer is the oscillating boom with a horizontal outrigger. If you are using an airblast sprayer, then a tower is recommended in trees higher than 2 m.

The volume of oil sprays needed depends on the type of pest; the level of infestation; tree height; canopy density; and planting density. The volumes recommended in Table 1 are for 4 m high orange trees. However, for young trees and lemons, which usually have a sparser canopy than oranges, the volumes may be reduced.

## PLANT DAMAGE FROM OIL SPRAYS

Oil sprays can sometimes damage plants – this is referred to as **phytotoxicity**. Instances of phytotoxicity are less common these days than in the past, largely due to the availability of better quality high grade products.

**Photo 1. Oil soaking on midrib of leaves is common.**

Discolouration of leaves may persist for months. Injury to fruit or wood seldom occurs. The rate of penetration, migration, oxidisation and evaporation of spray oils is generally rapid but slows with an increase in their molecular weights and decreasing air temperatures. The oils inhibit photosynthesis, respiration and transpiration.

Damage to plants can occur if the oil sprays are not applied correctly or under the right conditions. Damage can include leaf burning and oil soaking (of leaves and fruit), and in severe cases leaf drop and reduced yields.

Oil soaking (see Photo 1) may be evident on fruit surfaces and on leaves (typically along the leaf midrib) for several weeks after application (this is common).

The extent of soaking depends on the concentration of oil applied, spray volume, the frequency of application, the citrus variety

**Table 1. Spray volumes (L/ha) for 4 m high orange trees with dense canopies**

| Pest | Timing | Volumes (L/ha) | Concentration of oil |
|---|---|---|---|
| Red scale and other hard scales | Young stages | 10,000–14,000 | 1% |
| Mealy bugs | Young stages and before young fruits touch | 10,000–14,000 | 1% |
| Greenhouse thrips | Young stages and before fruits touch in mid to late January | 5000–8000 | 0.25–0.5% multiple low concentration sprays |
| Soft scales | Young stages | 8000–10,000 | 1% |
| Mites | Young stages | 5000–8000 | 0.7% single spray, or 0.25–0.5% multiple low concentration sprays |
| Citrus leafminer | As young new growth starts in summer/autumn, until most leaves produced are >4 cm long. | 4000 | 0.25–0.5% multiple low concentration sprays |

(Meyer lemon fruit appear more sensitive than Eureka lemon), and the climatic conditions. The oil soaking disappears over time, as the oil evaporates from the plant, and moves within the plant. The loss of oil from the plant is more rapid in tropical and subtropical climates than in temperate regions. This is largely related to daily temperatures: the higher the temperature, the more rapidly the oil disappears.

Leaf burn is largely caused by the acids, which are formed when unsaturated oil molecules in most but not all products are exposed to air and sunlight. This is why it is recommended that HMOs and AMOs have less than 8% unsaturated molecules, because it is these molecules which are responsible for the burning. Burning is more likely to occur in slow drying conditions, when trees are moisture stressed, in high temperatures, with high concentrations of oil, and with heavier oil products (oil with carbon values of *n*C24 and *n*C25).

Chronic phytotoxicity symptoms are twig dieback, reduced rind and juice quality (including total soluble solids), and reduced yield. (Excessive blemishing of fruit by windrub and scratches also results from the use of copper sprays and oils in pest and disease management programs.)

Reduced rind and juice quality only occur in fruit present at spraying. Reduced yield results from clogging of vascular tissue that leads to reduced blossoming in the spring following the application of sprays. It is related to flower initiation and bud development. Flowering is initiated by the onset of low air temperatures at night in summer and autumn and bud development proceeds through winter until flowering in spring. The timing of these events differs within NSW.

The risk of phytotoxicity is higher if oil sprays are applied

- at temperatures above 35°C, especially in hot dry winds,
- to trees in poor health,
- if soil moisture is low and trees are water-stressed,
- if trees are water-logged,
- to trees sprayed within one month after a sulfur spray,
- excessively, or
- during prolonged cold weather.

## APPLICATION GUIDELINES

HMOs and AMOs can be used safely to control citrus pests without risk of phytotoxicity, if the following conditions and precautions based on high volume spraying are followed. Generally speaking, a 'high volume spray' gives a thorough coverage of dilute spray applied to the point where excess spray runs off the tree. To ensure adequate wetting and canopy penetration, increase spray volume, rather than increasing the concentration of oil in the spray.

- To prepare an oil spray, fill the spray tank with two-thirds of the water, then add the oil whilst agitating the tank, then top up with the remaining water.
- Spray the oil mix immediately after preparation.
- Oil spray mixtures need to be continuously agitated. Never leave the spray mix to stand for longer than 10 minutes. If you do, then vigorously agitate or stir before recommencing application.
- Aim to have the oil spray dry on the plant within 1 to 2 hours of application.
- Some synthetic chemicals are more effective when mixed with low concentrations of oil.
- Don't apply oil sprays in temperatures higher than 35°C or when relative humidity exceeds 90%. (If high temperatures are forecast, spray in the early morning or late afternoon.)
- Don't apply oil sprays to moisture-stressed trees, that is, trees lacking water and water-logged trees.
- Do not add additional emulsifiers or surfactants to the oil spray.
- Do not mix oils with incompatible chemicals such as sulfur, captan, carbaryl, chlorothalonil, dinocap, folpet, binapacryl, oxythioquinox, propargite, dimethoate, and foliar fertilisers with high amounts of sulfur. If oils are mixed with incompatible chemicals, the risk of phytotoxicity is increased.
- Do not apply an oil spray within one month of a sulfur spray.
- Do not use more than a 0.5% concentration of oil with a copper spray.
- To reduce the likelihood of oil 'soaking' on fruit, do not apply oil sprays within eight weeks of harvest (especially in cool

conditions, when the oil takes longer to dissipate from and within the plant).

- Excessive use of oil sprays (high doses) can reduce yields by clogging up the water and food transport systems in the plant.
- Do not use more than an annual total of 3% in tropical and subtropical climates, and 2.5% in temperate climates.
- Take care when applying oil sprays when the ambient shade temperature is more than 32°C.

***Best practice guidelines***

- In most situations, the concentration of oils should not need to exceed 1%. Focus on increasing spray volumes rather than increasing the concentration of the oil.
- Oils need to be applied so that you get a good even coverage of all plant surfaces on which the target pest is located.
- Carefully follow all the application recommendations and precautions to avoid problems with phytotoxicity.
- Aim to apply oil sprays so that they dry within 1 to 2 hours after application.



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