PNW 328 • September 1988 File Copy

Using horticultural spray oils to control orchard pests

M. Willett and P.H. Westigard

Petroleum oils have been used to suppress insect and mite pests for 100 years. Beginning in the 1880's, when kerosene was first used to control scale and aphids, to the present use of highly refined petroleum derivatives, these products have provided growers with a unique tool in their battle against the ravages of pest attack—unique because no target pest species has developed resistance to them.

Despite the broad-spectrum insect control that spray oils can provide, many growers have refused to use them, especially in the foliar period, because of concerns about possible plant damage and incompatibility with other chemicals. In addition, growers have tended to view all oils, diverse as they may be, as one product with a single set of chemical and physical attributes.

Our purpose in this publication is to outline the characteristics of spray oils and to discuss their uses and potential misuses. We will emphasize oils as they may be used on tree fruit grown in the Pacific Northwest.

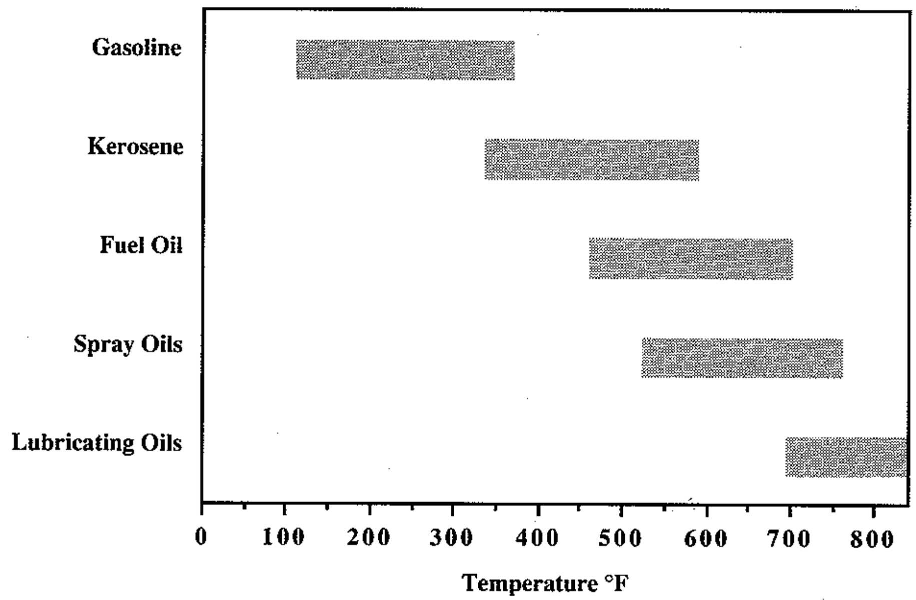

Figure 1.—Distillation temperature ranges of various crude oil components

Spray oil production

Oils suitable for use on fruit trees are produced by distilling and refining crude oils. In the first stage, crude oils are subjected to heat treatment in a fractionating tower, which separates components according to their differences in boiling point. Lighter components, such as those used for gasoline, are separated from heavier ones, such as those used for lubricating oils.

Figure 1 shows general boiling ranges of some petroleum products. You can see that the component destined for use as spray oils covers a 250°F range; however, this range may in fact be much wider, depending upon the type of crude and on the product desired.

This component, referred to as a *fraction,* needs further refinement to be considered a finished spray oil, such as treatment with hot sulfuric acid to remove phytotoxic properties (those poisonous to plants).

Other processes may be performed to improve efficacy. Dewaxing removes heavier compounds to raise the pour point; this allows the product to flow freely under orchard use temperatures (see "Pour point," page 5). Redistillation may be necessary if the manufacturer wishes to produce a "narrow cut" oil—that is, one with a narrow boiling range (see "Distillation range," page 4).

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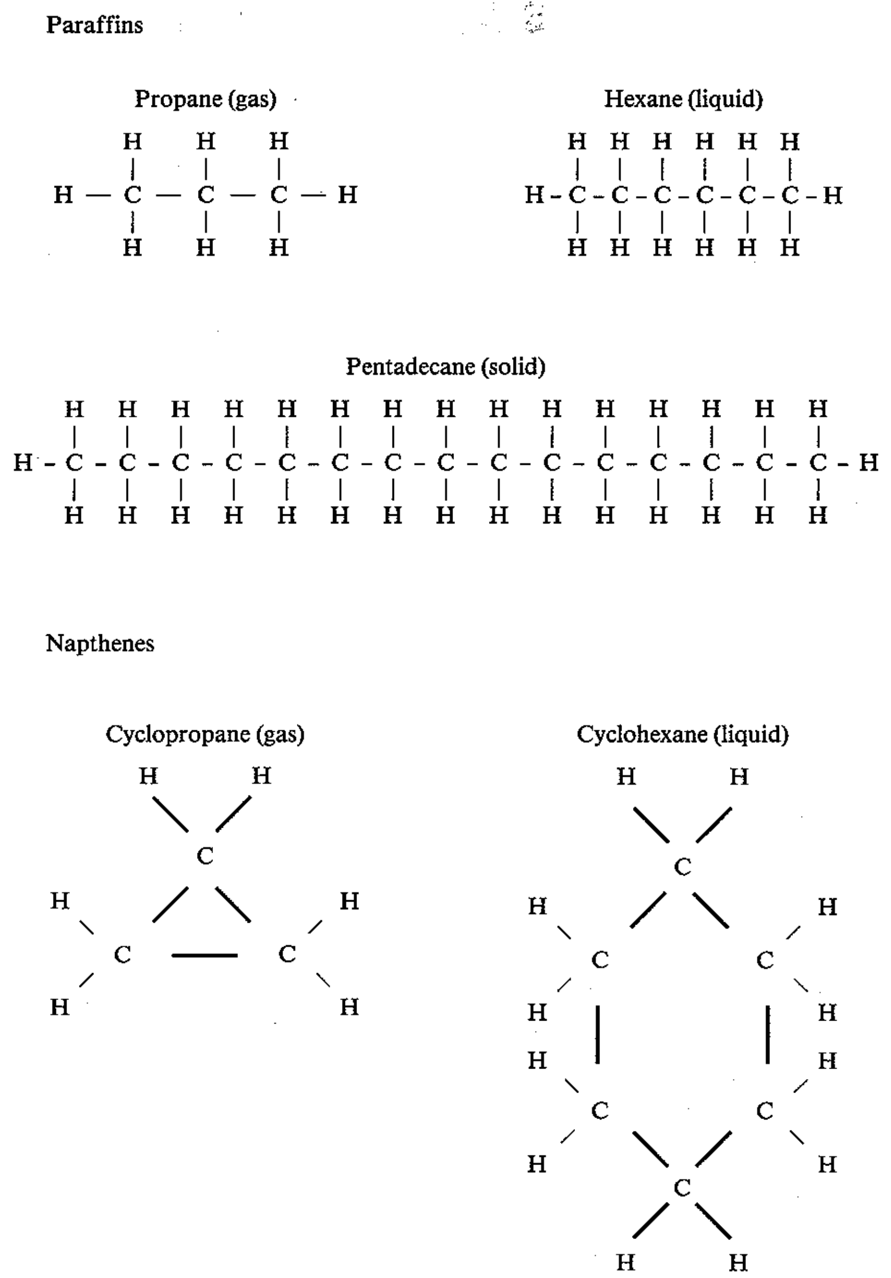

Figure 2.—Molecular structures of saturated hydrocarbons

How oil kills pests

Researchers believe oil affects target insects in three ways. First, oil essentially smothers insects. In the adult insect and its nymphal stages, oil plugs the insect's air-exchange apparatus. This causes suffocation by preventing oxygen intake.

Insect eggs are vulnerable to suffocation because they also require oxygen to live. A layer of oil on the surface of the eggs prevents air intake.

There are certain stages of egg development during which oil is more effective. When an overwintering egg is nearing hatch, its oxygen requirement increases, making even a slight interruption of oxygen fatal.

On the other hand, when the overwintering egg is deeply dormant, its oxygen requirement is low, and an interruption may not be critical. The oil film applied at this time may evaporate before the egg is damaged. (Usually, a higher concentration of oil is used to extend the effective residue.)

Second, there is speculation that oil kills by physically penetrating the insect's cuticle and interfering with nerve transmission. However, there are no data to support this speculation.

Third, oil acts as a repellant, in addition to its toxic effects. Applying oil before the start of pear psylla egg deposition will delay egg laying for up to 5 weeks. Others have reported an oil film may also prevent scale crawlers from settling.

Characteristics of spray oils

Even though most spray oils are distilled and refined, there may be tremendous variations among them because of the chemical differences in the original crude. A great amount of scientific research has been conducted over the past 50 years to examine various properties of oil as these relate to the production of safer products with greater power as insecticides.

Along with research to understand the nature of spray oil, considerable work has been done to standardize key properties, to avoid the marketing of ineffective and unsafe oils. The next five sections briefly describe characteristics of spray oils and the ways these relate to insect control or plant injury.

Paraffinicity performance

Oils pumped from the earth are called *base oils* or *crudes* before any treatment. These are a mixture of many types of hydrocarbons. In general, crude oils from fields in the Western States are *naphthenic base oils* because of the properties associated with ring structure in the molecules.

Crude oils from the Eastern U.S. (Pennsylvania, for example) and some from Texas have a greater proportion of straight-chain hydrocarbons and are called *paraffinic base oils.*

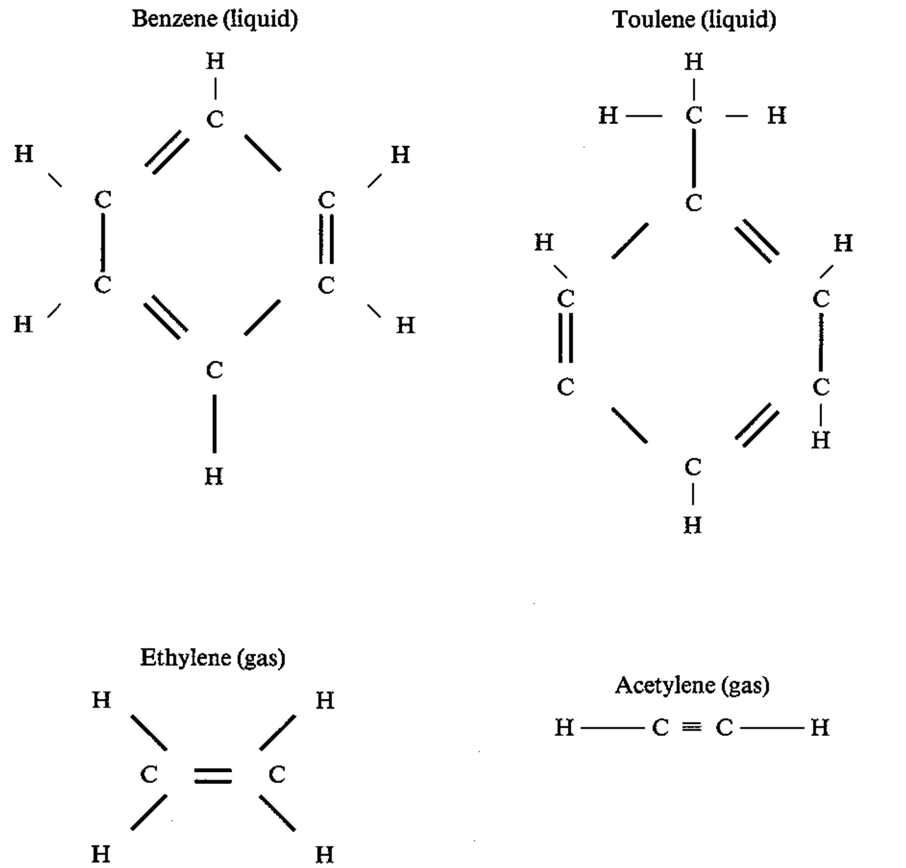

Figure 3.—Molecular structures of unsaturated hydrocarbons

Both the naphthenes and the paraffins are *saturated* compounds—that is, each carbon (C) atom is linked to four other atoms (figure 2). These saturated hydrocarbons are relatively unreactive and thus safer to use on plant tissue.

Studies have shown that control of insect and mite pests is directly related to the amount of paraffinic compounds in the oil. When oils of 50%, 75%, and 100% paraffinic compounds were compared, the spray oils with the highest paraffinic content produced the greatest mortality to eggs of the European red mite. Superior-type spray oils used in the West are generally produced from paraffinic crude sources.

Unsulfonated residues

In addition to a mixture of paraffinic and napthenic base compounds, crude oils also contain *unsaturated* hydrocarbon compounds (figure 3). These compounds possess double or triple bonds in their chemical structure; they're responsible for much of the plant damage reported in early years from foliar use of spray oils. These unsaturated compounds must be removed from any oil intended for use when leaf or flower bud tissue is exposed.

The method used to reduce (not eliminate) unsaturated compounds is to mix the oil with hot sulfuric acid, which reacts with them; then they can be removed. The percentage of finished product remaining that no longer reacts to additional sulfuric acid is called the *unsulfonated residue (U.R.)*. Thus, the higher the U.R. value, the fewer unsaturated hydrocarbons left in the oil—and the safer the oil.

Oils used on green tissue should have a minimum U.R. value of 92%. Many of the newer spray oils have U.R. ratings of 95 to 96%. When you select an oil for foliar use, read the label to make sure the U.R. level exceeds 92%.

An exception is dormant use on many deciduous fruit trees (for example, apple and pear), where the U.R. value may be as low as 80%. However, such oils will have higher percentages of unsaturated compounds, which have no value as insecticides and add nothing to the finished product.

Viscosity

Viscosity means resistance to flow and is used as a comparative term to indicate the "heaviness" of oils. Viscosity of spray oils is defined in terms of the time required for 60 ml of oil, heated to 100°F, to flow through a standard opening. Thus an oil may be referred to as a 60-second oil, 100-second oil, etc.

The higher the viscosity, the heavier the oil, providing the oils you compare are from similar crude oil sources. Paraffinic base oils flow faster (have a lower viscosity) than naphthenic base oils of similar molecular weight. Because of this variation, the paraffinic base oils have been recommended on a somewhat different basis than those of a naphthenic type.

In general, and within limits, spray oils with higher viscosities have been shown to be more active against pest species—but also more injurious to plant tissue.

Viscosity is important, but it can be misleading. For instance, if we mix a highly viscous oil (potentially phytotoxic) with an oil of low viscosity (noninsecticidal), we could produce an oil of intermediate viscosity.

If we didn't use any other standards, we might think this oil's viscosity was acceptable—but it would harm the plant, and it would not harm the pest. So it's important to balance viscosity against the other qualities of oils.

Distillation range

The first treatment of the crude product is distillation. The most volatile component (or cut) is boiled off and "collected" first, followed by the vaporization and collection of less and less volatile components.

When the process collects the component suitable for use in spray oils, the cut covers a wide temperature range. Depending on the type of oil to be produced, this cut can be further distilled to have a narrower boiling range temperature.

This more expensive procedure has been adopted for some of the newer oils, again to produce high insecticide qualities and low plant injury potential. These are called *narrow-cut oils.* Figure 4 shows the distillation properties for two hypothetical oils: *A* has a relatively narrow distillation range; *B* has a wide distillation range. They're narrow-cut and wide-cut oils, respectively.

California produced one of the first classifications of oils based on distillation range, primarily for use on citrus. This system identified five grades of spray oils. Table 1 shows the relationship of these grades to their differences in distillation.

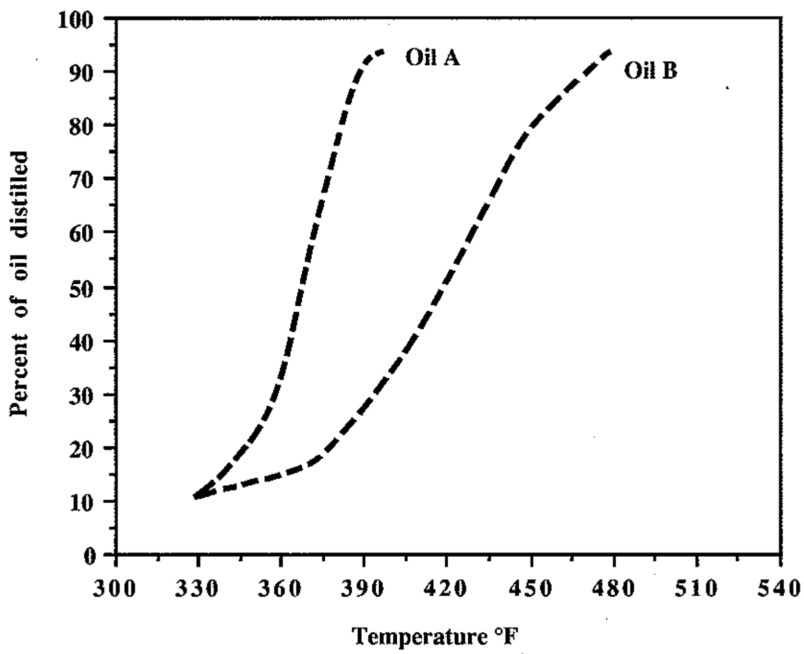

Figure 4.—Distillation properties for hypothetical oils *A* and *B*

Table 1.—Classification of oil grades in California based on their distillation properties[a]

Grade	Temp. (°F) for distillation of 5%	50%	90%	Percent of oil distilled at 636°F
Light	555	617	675	66.2
Light medium	571	628	703	55.4
Medium	582	643	715	43.2
Heavy medium	585	656	728	39.1
Heavy	612	671	727	18.0

[a] Reprinted from Walter Ebeling, *Subtropical Fruit Pests* (Berkeley, CA: University of California, Division of Agricultural Sciences, 1959).

Each oil grade had a somewhat different use: The lighter oils were used on more sensitive crops, and heavier oils were restricted to use against high-pest populations on oil-tolerant varieties.

The California system was developed for the naphthenic oils typical of the crude oils found in the West. The distillation range of a spray oil is important in classifying and standardizing these products, and it furnishes information about the relative amount of light (less insecticidal) and heavy (more phytotoxic) molecules found in a particular oil.

Figure 5 illustrates the importance of using spray oils with the proper distillation range to produce the best combination of desirable attributes. The tendency today is to produce spray oils with relatively narrow distillation ranges. However, some of the older, less refined oils can be obtained for a restricted number of uses.

Pour point

A final consideration in evaluating the performance of spray oils is the lowest temperature at which they will flow. As temperatures are lowered, oils flow more slowly; for use under field conditions, oils should still flow at relatively low temperatures. Most modern spray oils have pour points of 15 to 20°F—that is, they will still flow at these temperatures.

Judging safety and effectiveness

Using U.R., viscosity, distillation range, and paraffinicity as they were available, we examined five commercial spray oils (table 2). We didn't include pour point; we assumed it would be adequate to permit using these oils in the temperatures encountered in orchard situations.

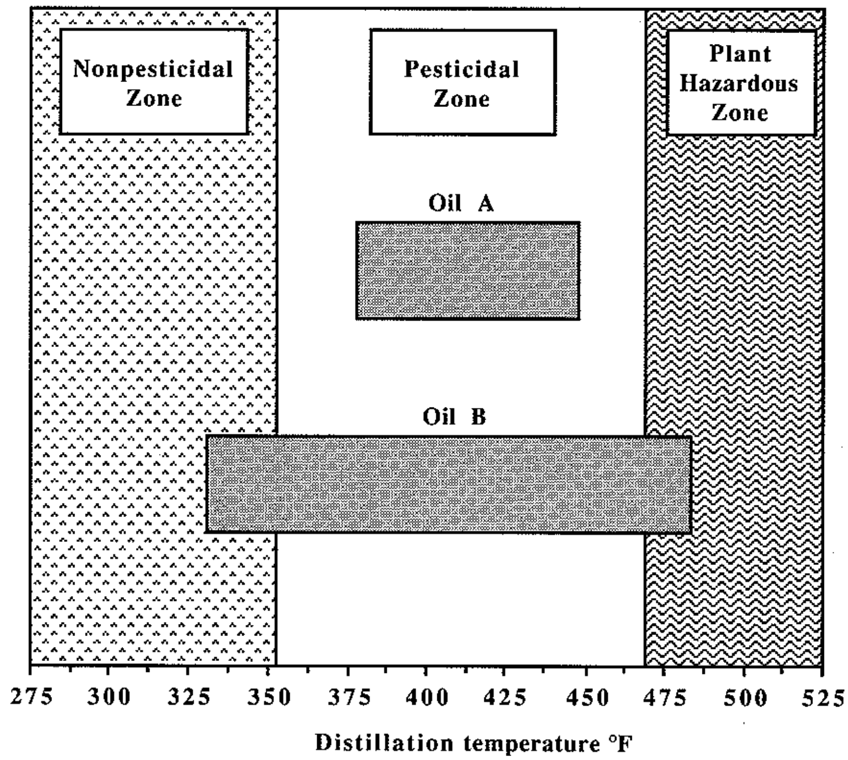

Figure 5.—The importance of proper distillation ranges for hypothetical oils *A* and *B* (adapted from P.J. Chapman, *Petroleum Oils for the Control of Orchard Pests,* New York Agricultural Experiment Station Bulletin 814, 1967)

Table 2.—A comparison of five spray oils based on some physical and chemical characteristics

	A	B	C	D	E
% Unsulfonated residues	92	96	94	94	70
Distillation (°F):					
Range 10-90%	110	70	50	125	80
Midboiling temperature	490	415	439	480	398
Viscosity (seconds)	140	73	90	137	90
% Carbon atoms in paraffinic structure	65	70	62	66	50

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS: Harmful if Swallowed. Do not Induce Vomiting. Call a Physician Immediately! Avoid breathing of spray mist.

Do not apply this product in such a manner as to directly or through drift expose workers or other persons. The area being treated must be vacated by unprotected persons.

ENVIRONMENTAL HAZARDS: Keep out of any body of water. Do not contaminate water by cleaning of equipment or disposal of wastes.

PHYSICAL OR CHEMICAL HAZARDS: To avoid injury to trees, fruit, or foliage the following precautions should be taken when using emulsifiable spray oils: Do not combine RED-TOP SUPERIOR SPRAY OIL N.W. with sulfur sprays on foliage or apply following a sulfur spray on foliage. Avoid applications of sulfur following sprays of RED-TOP SUPERIOR SPRAY OIL N.W. until sufficient time has elapsed for oil dissipation. For foliage applications, the spray tank should be free of sulfur residues. Do not combine with Captan, Phaltan, Sevin, Diclone, Kelthane, Karathane, and DDT as foliage or fruit injury may result. Do not use Captan and Phaltan after RED-TOP SUPERIOR SPRAY OIL N.W. has been applied to foliage.

Do not use if emulsion breaks. If the emulsion should break in the spray tank, free oil will float to the surface causing excessive oil deposits at the end of each tank. Severe injury to trees may result if used under these conditions.

No spray should be applied when temperatures are likely to fall below freezing before the spray has had a chance to dry. Do not apply RED-TOP SUPERIOR SPRAY OIL N.W. when temperatures are below 40 degrees F. or above 85 degrees F. Avoid use in sprayers having hydraulic agitation or those having insufficient agitation to form an emulsion with RED-TOP SUPERIOR SPRAY OIL N.W.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Do not enter treated areas without protective clothing until sprays have dried. Because certain states may require more restrictive re-entry intervals for various crops treated with this product, consult your State Department of Agriculture for further information.

Written or oral warnings must be given to workers who are expected to be in a treated area or in an area about to be treated with this product. Oral warnings should specify protective clothing areas or fields that cannot be entered without this clothing, period of time area is to be vacated, and statement of practical treatment (see above) in case of exposure. When oral warnings are given, warnings should be given in a language customarily understood by workers. Oral warnings must be given if there is a reason to believe that written warnings cannot be understood by workers. Warnings must include the following information. "Caution. Area treated with Spray Oil on (date of application). Do not enter without appropriate protective clothing until sprays have dried. (Insert here action to take in case of accidental exposure - see above.)"

EPNW-1

RED-TOP

SUPERIOR SPRAY OIL N.W.

ACTIVE INGREDIENT:	**By Wt,**
Mineral Oil	99.0%
INERT INGREDIENT	1.0%
	100.0%

Unsulfonated Residue (ASTM D-483) 93.0%
Petroleum Oil Classification: Unclassified

EPA Reg. No. 2935-405 **EPA Est. No. 2935-WA-1**

KEEP OUT OF REACH OF CHILDREN!

CAUTION:

—SEE PRECAUTIONARY STATEMENTS IN LEFT PANEL—

NET CONTENTS: 30 GAL.

DIRECTIONS FOR USE (Continued)

STORAGE AND DISPOSAL

1. **Prohibitions:** Do not contaminate water, food, or feed by storage or disposal.
2. **Pesticide Disposal:** Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.
3. **Container Disposal:** Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.
4. **Storage:** Store in original container only and keep sealed. Store in closed storage areas. Use caution when moving, opening, closing, or pouring.

MIXING DIRECTIONS: With agitator running, start filling spray tank with water. When combining with wettable powder or fungicide products, add these first when tank is 1/3 filled. Add RED-TOP SUPERIOR SPRAY OIL N.W. when tank is about 1/2 full and while there is sufficient agitation of the spray to insure complete emulsification.

APPLES: For the control of SAN JOSE SCALE, APHIDS, EUROPEAN RED and BROWN MITE EGGS apply in the delayed dormant stage of bud development at the rate of 1-1/2 to 2 gallons per 100 gallons of water as a dilute spray.

For concentrate sprays use 3 to 5 gallons per acre. On young trees and on oil susceptible varieties, use the lower rate. Be sure that agitation is adequate to keep the spray mixed uniformly while applying oils or oil-phosphate mixes at low volume or concentrate rates.

PEARS: For the control of SAN JOSE SCALE, APHIDS, EUROPEAN RED and BROWN MITE EGGS, and PEAR PSYLLA EGGS apply in the delayed dormant stage of bud development at the rate of 1-1/2 to 2 gallons per 100 gallons of water as a dilute spray.

For concentrate sprays use 3 to 5 gallons per acre. On young trees and on oil susceptible varieties, use the lower rate. Be sure that agitation is adequate to keep the spray mixed uniformly while applying oils or oil-phosphate mixes at low volume or concentrate rates.

APPLES, PEARS - SUMMER APPLICATION: For the control of ORCHARD MITES, use RED-TOP SUPERIOR SPRAY OIL N.W. at 3 to 4 quarts per 100 gallons of water as a dilute spray; summer forms of SAN JOSE SCALE use at 1 to 1-1/2 per 100 gallons of water as a dilute spray.

APRICOTS, CHERRIES, PEACHES, PLUMS, PRUNES: For the control of SAN JOSE SCALE, APHIDS, EUROPEAN RED and BROWN MITE EGGS apply at the rate of 1-1/2 to 2 gallons of water as a dilute spray in the dormant or delayed dormant stage of bud development.

For concentrate sprays use 3 to 5 gallons per acre. On young trees and on oil susceptible varieties, use the lower rate. Be sure that agitation is adequate to keep the spray mixed uniformly while applying oils or oil-phosphate mixes at low volume or concentrate rates.

GRAPES: For the control of MEALY BUG, apply at the rate of 1 gallon per 100 gallons of water. Use 300 gallons of this mixture per acre with thorough coverage of the vines at delayed dormant stage up to bud break. For concentrate applications, use 3 gallons per acre in 40 - 100 gallons of water.

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Figure 6.—A typical spray oil label

If we consider the amount of unsaturated hydrocarbons and relative safety to green tissue, only oil *E* would be dangerous to use; it has an unsulfonated residue (U.R.) value of 70. (Oil *A* has a low U.R. value, but it's at the minimum level suggested.) Oil *E* also has the lowest percentage of paraffinic compounds, and it should have the least value as an insecticide.

Oils *A* and *D* have higher viscosity, and they might be considered too heavy for use on some of the more sensitive plants. They have relatively wide distillation ranges; this indicates they may contain a greater percentage of molecules that are either noninsecticidal or more hazardous to green tissue of some plants. All the oils listed, however, would be safe to use in the fully dormant stage of most deciduous fruit trees.

Oil *B* has a rather narrow distillation range, moderate viscosity, high U.R. rating, and high paraffinic content. It appears to possess those properties that would result in good suppression.

Oil *C*, with a narrower distillation range but lower paraffinic content, should also give acceptable control with minimum plant injury.

While the four characteristics listed in table 2 are important, current spray oil labels are not required to list all these physical properties. Figure 6 shows a typical spray oil label. At first glance, it seems quite similar to common pesticide labels. The active ingredient is listed as mineral oil. Other spray oil labels might list petroleum oil or paraffinic oil as the active ingredient.

Just below the active ingredient statement, the unsulfonated residue (U.R.) is listed as 93%, and the oil is listed as *unclassified*—that is, outside the California oil classification system.

You'll find other important information in the "Precautionary Statements" and "Directions for Use," listed on a crop-by-crop basis. You can obtain information on viscosity, distillation range, and degree of paraffinicity from the manufacturer or its representative. Be sure to request this information if the oil you're concerned about has recently been introduced to the market.

Use pesticides safely!

- **Wear** protective clothing and safety devices as recommended on the label. **Bathe or shower** after each use.
- **Read** the pesticide label—even if you've used the pesticide before. **Follow closely** the instructions on the label (and any other directions you have).
- **Be cautious** when you apply pesticides. **Know** your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide use.

Plant damage from oils

Plant injury caused by oil applications is a complex issue. Many reports of oil damage involve foliar applications of older oils that have high molecular weights and low U.R. values. In addition, the deciduous fruit species grown in Northwest orchards are likely to have varying tolerances to oil application.

To examine this, we must consider how oils cause phytotoxicity. Trees "breathe" through openings on outer surfaces, lenticels in the bark and stomates in the leaves. Oils interfere with this air exchange. Damage severity varies, depending on the stage of plant growth and the drying conditions present.

Actively growing plants need greater air exchange, so they're more susceptible to damage caused by plugging the lenticels and stomates.

Trees that are "unthrifty" or suffer from drought (or both) are prime candidates for damage by oil applications. Trees under stress have lower tolerances to interruptions in air-exchange supply.

Phytotoxicity may also result under poor drying conditions, when oil remains on the leaves or woody parts to interfere with air exchange for a longer period of time. Concentration is also a factor, and greater damage results when increasingly greater oil concentrations are applied and take longer to evaporate.

The amount of damage will depend on the interaction of these three factors—stress, poor drying conditions, and concentration.

Oil can also directly penetrate bark and leaf tissue and interfere with internal processes. It is this property that is being exploited when oil is used as an herbicide, either alone or in combination with other materials.

Oil damage is often seen as dark green to purplish discoloration on leaf margins, water-soaking around leaf stomates or fruit lenticels, or swelling and corking of lenticels on woody tissue. Delay in budbreak has been noted. At higher than recommended concentrations, leaf drop and death of buds have also occurred on sensitive plants.

Plant injury can also be caused when certain pesticides are combined with oil or used within a certain period of time before or after oil use. It's impossible to generalize on the reasons why a specific pesticide, when used with oil, causes plant damage.

Most pesticides are tested in combination with oil to discover possible phytotoxicity problems. These warnings are printed on the product's label and/or in the spray guide published by your Cooperative Extension Service or Agricultural Experiment Station.

Pacific Northwest Insect Control Handbook

It's published annually—be sure to use the latest edition. Order from either of these sources:

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Use patterns in the Pacific Northwest

Oil used alone or in combination with other pesticides is recommended for dormant and/or delayed dormant use in nearly all tree fruit orchards. In recent years, the narrow-cut, paraffinic oils have generally replaced the older, less refined "dormant" oils.

You can find lists of pests controlled with these sprays, and recommended timings, in the current edition of the *Pacific Northwest Insect Control Handbook* (left).

Spray oil used during the foliar period is currently restricted to the more oil-tolerant tree fruit cultivars. No summer use of oil is recommended on stone fruits or on apples, but oil is widely used on some pear varieties, especially in southern Oregon.

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Published and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914, by the Oregon State University Extension Service, O.E. Smith, director; Washington State University Cooperative Extension, F.L. Poston, director; the University of Idaho Cooperative Extension Service, H.R. Guenthner, director; and the U.S. Department of Agriculture cooperating.