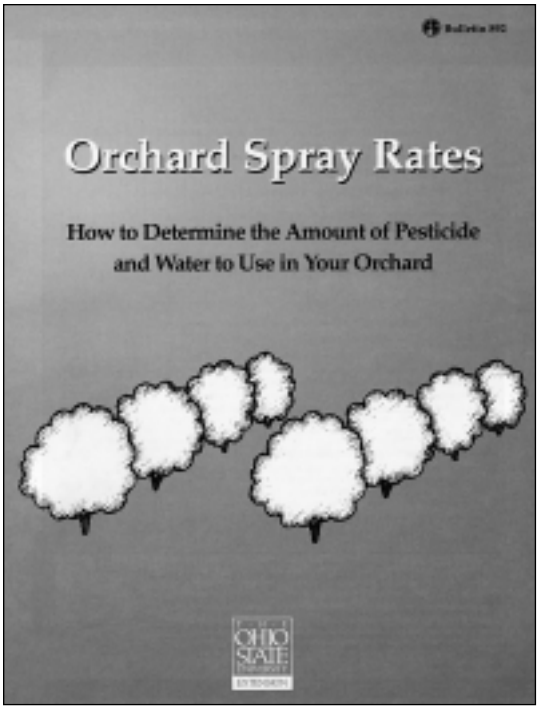
CHAPTER 4



SPRAYING FRUIT

How to choose the amount of pesticide and water to use

Adaptation of publication "Orchard Spray Rates — How to Determine the Amount of Pesticide and Water to Use in Your Orchard"

by Celeste Welty, Extension entomologist, The Ohio State University

BACKGROUND: TYPES OF ORCHARD PESTICIDE APPLICATIONS

Pesticide rates for fruit crops are listed in several different ways on labels for various pesticide products. These differences are sometimes confusing to novice fruit growers and even to experienced growers. How to decide which rate to use to determine appropriate amounts of pesticide and water to use for a specific orchard is explained in detail in this chapter.

Most reference books on fruit spraying show just one way of determining pesticide rates. This can leave the reader wondering if other methods are incorrect or just less preferred. In this chapter, several methods are presented that should include most of the variations in spray rate calculations that fruit growers normally hear about. The advantages and disadvantages of each method are presented along with recommendations for their use.

Orchards then and now

It helps us understand why rates are given in different ways if we consider the history of fruit growing and fruit spraying to see how pesticide rate recommendations have come about. In the early decades of the last century, apple trees were large and widely spaced within the orchard; horticulturalists still refer to large trees as *standard trees*. The old sprayers were hand-gun type sprayers that thoroughly covered the trees with the spray mix until drops began to drip from the leaves, which is what we call "to the point of runoff".

To treat large standard apple trees to the point of runoff, the general rule was to use 400 gallons of spray mix per acre. All of the older pesticide recommendations were given as a rate of product per 100 gallons of water, with the understanding that it would take 400 gallons of spray mix to treat 1 acre of apple trees or pear trees. For crops other than apple, the same principle applies but with different volumes. For peach, plum and cherry, 300 gallons per acre is the standard dilute volume. For strawberries, brambles, blueberries and grapes, 200 gallons per acre is the standard dilute volume.

Two major factors have changed since the old days. First, modern sprayers can adequately cover an acre of large trees with much less than 400 gallons per acre because coverage to the point of runoff is not needed for control of most insect pests and diseases. Second, few orchards now have large standard trees that take 400 gallons of spray mix per acre to treat to the point of runoff. Most commercial orchards now use dwarfing rootstocks. Dwarf or semidwarf trees are much smaller and more closely spaced than the old standard trees, and it takes less water to cover them.

Dilute applications

A pesticide rate per 100 gallons of water is the rate that should be used if the grower needs to make a *dilute* application with either an airblast sprayer or a handgun sprayer. When a tank of pesticide is mixed at the dilute rate, the applicator should apply it to the trees until all parts of the tree are wet. This is what we call spraying *to the point of runoff*—that is, until water begins to drip off of the leaves.

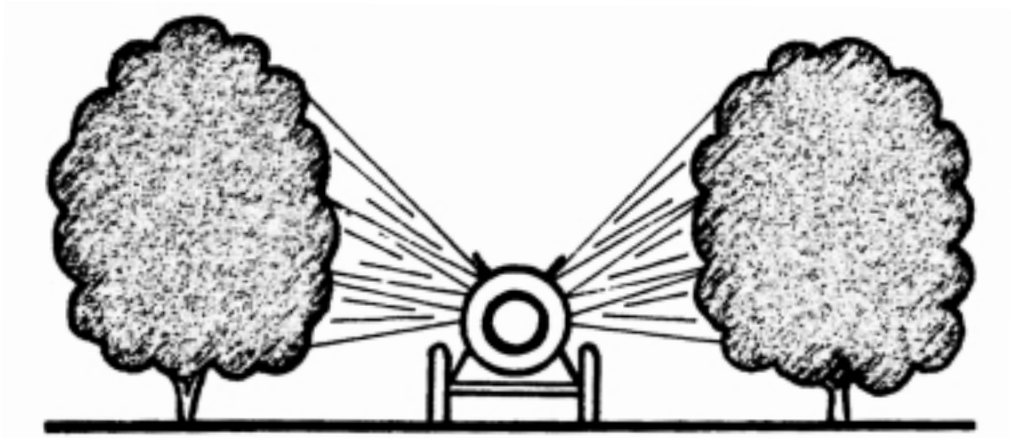
In many large commercial orchards, the only time that a dilute application is used is for sprays of superior oil in the delayed-dormant period in the spring, when the entire surface of the apple tree needs to be covered for good control of European red mite. In some smaller orchards, dilute applications are sometimes used throughout the growing season. Larger orchards usually are not treated with many dilute applications because they are more time-consuming.

Low-volume or concentrate applications

Modern airblast sprayers, which are also known as speed sprayers, can cover fruit trees with much less than 400 gallons of spray mix per acre. Airblast sprayers produce fine droplets that cover foliage very well without the large amount of water needed to reach the point of runoff. Low-volume applications made with airblast sprayers are most commonly in the range of 40 to 80 gallons per acre.

Low-volume applications are also called *concentrate applications* because as the volume of water is decreased, there is a proportional increase in the concentration of pesticide, in order to apply the needed amount of pesticide per acre. Low-volume orchard sprays are commonly concentrated to several times the dilute rate. If the fruit grower uses what is called a 3X concentration, the volume of water is reduced to one-third of the dilute volume and therefore the pesticide is increased by three times the dilute rate. **Note**: the pesticide is increased by three times the dilute rate, not three times the concentrate rate!

When a 5X concentration is used, the volume is reduced to one-fifth of the dilute volume and therefore the pesticide concentration is increased by five times the dilute rate. Orchard sprays in the range of 2X to 5X are common.



Airblast sprayer driving between the rows.

Tree-row volume

Because dwarf and semi-dwarf types of fruit trees are smaller at maturity than the large standard types of fruit trees, a system known as tree-row volume has been developed to determine how much spray mix is needed to cover them. Although tree-row volume might sound complicated to someone who has never used it, it is well worth the effort to learn about it because it should result in more accurate coverage and likely in less pesticide per acre compared to using the full rates of water and pesticide. Tree-row volume is used to determine both the dilute volume and the related concentrate rate of pesticide per acre.

CALCULATIONS FOR DILUTE APPLICATIONS

How much water *is needed for a dilute application?*

If you want to make a *standard* dilute application, then use 400 gallons of water per acre.

Because most orchards do not need as much as 400 gallons per acre, you can *customize* the spray to a volume that is best for your orchard. Even if you never make dilute applications, you need to determine what your dilute volume should be because it is the basis for calculating the amount of pesticide to use for concentrate applications.

Determining your dilute volume per acre means *determining how many gallons of water it should take to cover 1 acre of your trees to the point of runoff*, which is when water begins to drip off of the leaves. This number is your *dilute volume*; it is likely to be in the range of 100 to 200 gallons per acre for modern types of apple trees.

You can determine your dilute volume of water per acre by any of three ways:

Method 1. Experience:

Try different volumes of water per acre with your sprayer in your orchard, and observe which volume results in runoff.

Method 2. Use a tree-row volume chart:

Estimates of dilute volume of water per acre are shown in the chart at the end of the chapter. The chart is based on tree size and spacing. If tree size within an orchard block is variable, then choose the measurements for the average size of the larger trees. For any combination of tree size and spacing, the chart shows what the dilute

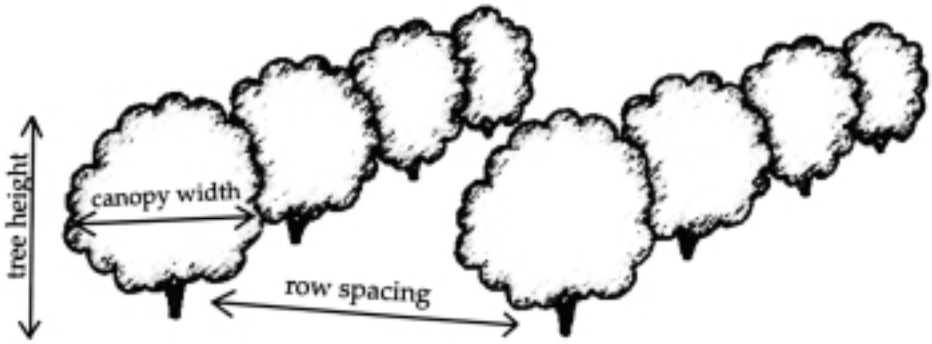
spray volume should be. The dilute spray volume is based on the rule that it takes 0.7 to 1.0 gallon to treat 1,000 cubic feet of tree canopy to the point of runoff. A canopy volume of 1,000 cubic feet is a section that is 10 feet wide by 10 feet tall by 10 feet deep. Most growers with well pruned trees can use the minimum dilute volume, which is 0.7 gallon per 1,000 cubic feet of tree canopy. The maximum dilute volume is 1.0 gallon per 1,000 cubic feet of tree canopy. The maximum dilute volume should be used in an unpruned orchard with a thick canopy.

For example, if your trees are about 12 feet wide and 10 feet tall in rows spaced 20 feet apart, the chart shows that you have a maximum of about 261,000 cubic feet of tree per acre. If these trees are relatively well pruned, then your dilute volume will be about 183 gallons of water per acre, as shown in the column for "maximum". If these trees are not pruned, then your dilute volume will be about 261 gallons of water per acre, as shown in the column for "maximum".

Method 3. Use tree-row volume equations:

If your tree size and spacing is not in the chart at the end of this chapter, then use the formulas below.

Tree-row volume is canopy width times tree height times row length per acre. Row length per acre is 43,560 square feet per acre divided by the distance between rows, in feet. This number can be considered the maximum volume of trees this size.



Orchard Measurements

Tree-row volume = (canopy width) x (tree height) x (row length per acre)

$$\text{Tree-row volume [cu.ft./acre]} = \left(\text{tree canopy diameter [feet]}\right) \times \left(\text{tree height [feet]}\right) \times \left(\frac{\text{43,560 square feet/acre}}{\text{distance between rows [feet]}}\right)$$

For example, for trees 10 feet wide and 8 feet tall in rows 18 feet apart:

$$\text{Tree volume} = 10 \text{ ft.} \times 8 \text{ ft.} \times \left(\frac{\text{(43,560 sq. ft./acre)}}{\text{18 ft.}}\right)$$

$$= 80 \times 2{,}420 = 193{,}600 \text{ cu. ft.}$$

Minimum dilute spray volume is your tree-row volume per acre times 0.7 gallon per 1,000 cubic feet. Use this as your dilute volume of water per acre, if your trees are well pruned.

$$\text{Minimum dilute volume [gal./acre]} = \left(\text{\textit{your} tree-row volume [cu.ft./acre]}\right) \times \left(\frac{0.7 \text{ gal.}}{1{,}000 \text{ cu.ft.}}\right)$$

Use this as your dilute volume of water per acre if your trees are well pruned.

Continuing the example just given:

$$\text{Minimum dilute volume} = \left(193{,}600 \text{ cu.ft.}\right) \times \left(\frac{0.7 \text{ gal.}}{1{,}000 \text{ cu.ft.}}\right) = 136 \text{ gal./acre}$$

Maximum dilute spray volume is your tree-row volume per acre times 1.0 gallon per 1,000 cubic feet. Use this as your dilute volume of water per acre if your trees are not well pruned.

$$\text{Maximum dilute spray volume [gal./acre]} = \left(\text{\textit{your} tree-row volume [cu.ft./acre]}\right) \times \left(\frac{1.0 \text{ gal.}}{1{,}000 \text{ cu.ft.}}\right)$$

Use this as your dilute volume of water per acre if your trees are not well pruned.

Continuing the example just given:

$$\text{Maximum dilute volume} = \left(193{,}600 \text{ cu.ft.}\right) \times \left(\frac{1.0 \text{ gal.}}{1{,}000 \text{ cu.ft.}}\right) = 194 \text{ gal./acre}$$

Optional Adjustments for Method 3

1. Canopy Thickness

Canopy thickness can be factored into tree-row volume calculations. You will need to choose a density factor between 0.7 and 1.0, depending on the relative canopy density or tree shape, rather than using either the minimum or maximum volume as described previously. However, many orchardists have found that such an adjustment does not make any difference, and in most commercial orchards 0.7 is a good choice. Only in a completely unpruned orchard would the full 1.0 density factor be needed.

2. Pesticide Type

Pesticide type can be factored into tree-row volume calculations. Multiply the dilute volume by certain percentages because some thinners require lower volume and some stop-drop materials require higher volume.

3. Lower Limit

Some applicators use a lower limit of 200 gallons per acre as the minimum dilute volume even when tree-row volume calculations show that a smaller volume should be adequate. Not all orchardists agree with this, but it could be considered in cases where a smaller number of gallons is used and control is not satisfactory.

How much pesticide is needed for a dilute application?

The amount of pesticide to use per acre is the *dilute rate times the dilute volume*. The dilute rate is the amount of pesticide per 100 gallons of water. The dilute volume is either the standard (maximum) of 400 gallons per acre or a customized amount that is likely to be much smaller (100 to 200 gallons per acre) as described earlier.

$$\text{Amount of product per acre} = \text{(dilute rate)} \times \text{(dilute volume)}$$

$$= \left(\frac{\text{amt. of pesticide}}{\text{100 gal.}}\right) \times \left(\frac{\text{gallons of water}}{\text{acre}}\right)$$

For example, two orchards of different sized trees need a dilute application of Guthion 50WP, which is used at a dilute rate of 0.75 pound per 100 gallons.

In the orchard of large standard trees that require 400 gallons to spray to the point of runoff, the amount of Guthion to use for a dilute spray is 0.75 pound Guthion per 100 gallons water, times 400 gallons water per acre, which equals 3.0 pounds Guthion per acre.

$$\left(\frac{\text{0.75 lb.}}{\text{100 gallons}}\right) \times \left(\frac{\text{400 gallons}}{\text{acre}}\right) = \left(\frac{\text{3.0 lb. Guthion}}{\text{acre}}\right)$$

In the orchard of small trees that require 120 gallons to spray to the point of runoff, the amount of Guthion to use for a dilute spray is 0.75 pound Guthion per 100 gallons water times 120 gallons water per acre, which equals 0.9 pound Guthion per acre.

$$\left(\frac{\text{0.75 lb. Guthion}}{\text{100 gallons water}}\right) \times \left(\frac{\text{120 gallons water}}{\text{acre}}\right) = \left(\frac{\text{0.9 lb. Guthion}}{\text{acre}}\right)$$

For another example with the same two orchards, how much superior oil per acre is needed at half-inch green if the dilute rate is 2 gallons of oil per 100 gallons of water?

For the large trees in this example:

$$\left(\frac{\text{2 gallons oil}}{\text{100 gallons water}}\right) \times \left(\frac{\text{400 gallons water}}{\text{acre}}\right) = \left(\frac{\text{8 gallons of oil}}{\text{acre}}\right)$$

For the small trees:

$$\left(\frac{\text{2 gallons oil}}{\text{100 gallons water}}\right) \times \left(\frac{\text{120 gallons water}}{\text{acre}}\right) = \left(\frac{\text{2.4 gallons of oil}}{\text{acre}}\right)$$

How much water is needed for a concentrate application?

No calculations are needed for this step. You simply need to know from experience, or from experimenting, how many gallons of water per acre your airblast sprayer uses to adequately treat your orchard for a low-volume application, for whatever speed, pressure and nozzle arrangement you prefer to use. This number of gallons of water per acre is your *concentrate volume*. It will probably be in the range of 40 to 80 gallons per acre.

A question sometimes asked is: what concentration should I use, 3X or 4X or 5X?

The answer: The exact concentration does not matter. If you want to calculate what your concentration is, you can do this without any knowledge of how much pesticide you will use. After you decide on the amount of water that is needed for dilute application and for concentrate application, then you can *calculate the concentration by taking your dilute volume of water per acre and dividing it by your concentrate volume of water per acre.*

$$\text{Concentration} = \frac{\text{dilute volume of water per acre}}{\text{concentrate volume of water per acre}}$$

For example, if you need 180 gallons to treat to the point of runoff but your airblast uses 60 gallons to make a low-volume application, then your concentration is 180 divided by 60, which equals 3; this is a 3X application.

$$\frac{180 \text{ gal. water/acre}}{60 \text{ gal. water/acre}} = 3 \quad \text{This is a 3X application}$$

How much pesticide is needed for a concentrate application?

The amount of pesticide to use per acre for concentrate applications can be determined for all orchards in general, as shown in Methods 1, 2 and 3, which are explained later in the text. The amount of pesticide to use per acre for concentrate applications can be customized to a specific orchard, as explained in Methods 4 and5.

Before describing these methods, an important general point is that in concentrate spraying in a specific orchard block, *the amount of pesticide per acre stays constant even if the amount of water changes.* The rate of pesticide per acre is completely independent of the concentration used. For example, if you have an old sprayer that applies 75 gallons per acre and a new sprayer that applies 50 gallons per acre, you will use the same amount of pesticide per acre in either sprayer, although the mix in the old sprayer with 75 gallons will be a weaker concentration than the mix in the new sprayer with 50 gallons.

Method 1: Use the "amount per acre" rate as given on the label.

The easiest decision about how much pesticide to use per acre is when a pesticide label states the rate *only* as an amount of product per acre, to be used regardless of whether the spray volume is high or low.

When the label states a *range* of rates of pesticide per acre, then grower experience with factors such as pest density and tree size can be considered in deciding whether the low end of the rate range can be used or if it is necessary to go to the high end or an intermediate rate.

Advantage of Method 1: It is easy because no calculations are needed.

Disadvantage of Method 1: The rate per acre is not given on the label of many pesticide products used on fruit crops, so this method is often not possible.

Recommendation: Use this method whenever possible. Note: this method is recommended only in cases where the rate on the label is stated only as a rate per acre. On many labels, the rate is given two ways: as the rate per 100 gallons and as a full (maximum) rate per acre based on the standard conversion (as explained in Method 2, below).

Method 2: Use the full rate per acre as calculated by the standard conversion from the dilute rate.

When a pesticide label states the rate as an amount of pesticide per 100 gallons of water but you want to make a concentrate application and you need to know the equivalent amount of pesticide per acre, then you can make the standard conversion to the full rate per acre. The full rate is sometimes referred to as the *concentrate rate*. This full rate per acre should be thought of as the *maximum* amount of pesticide to use per acre.

Make the standard conversion by *multiplying the amount of pesticide per 100 gallons by the standard dilute volume of water per acre*. In the case of apples, the standard dilute volume per acre is usually defined as 400 gallons per acre. The amount of pesticide per 100 gallons times 400 gallons per acre gives you the full amount of pesticide needed per acre of apples. This is based on the old assumption, as mentioned near the beginning of this chapter, that it takes 400 gallons of spray mix for a thorough dilute application to an acre of large apple trees.

$$\left(\frac{\text{Amount of pesticide}}{\text{100 gallons of water}}\right) \times \left(\frac{\text{standard dilute volume of water}}{\text{acre}}\right) = \text{the full rate of pesticide per acre}$$

For example, if the dilute rate for Captan 50WP on apples is 1.5 pounds per 100 gallons of water, then the full rate per acre is 1.5 pounds per 100 gallons times 400 gallons water per acre, which equals 6 pounds Captan per acre.

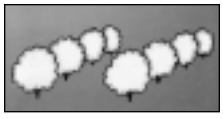
$$\left(\frac{\text{1.5 lb.}}{\text{100 gallons}}\right) \times \left(\frac{\text{400 gallons water}}{\text{acre}}\right) = \frac{\text{6 lbs. Captan}}{\text{acre}}$$

Summary of Full Rates

$$\text{full rate of pesticide per acre of } \textbf{apples} = \left(\frac{\text{amount of pesticide}}{\text{100 gal.}}\right) \times \left(\frac{\text{400 gal. water}}{\text{acre}}\right)$$

$$\text{full rate of pesticide per acre of } \textbf{peaches} = \left(\frac{\text{amount of pesticide}}{\text{100 gal.}}\right) \times \left(\frac{\text{300 gal. water}}{\text{acre}}\right)$$

$$\text{full rate of pesticide per acre of } \textbf{berries} = \left(\frac{\text{amount of pesticide}}{\text{100 gal.}}\right) \times \left(\frac{\text{200 gal. water}}{\text{acre}}\right)$$



Advantage of Method 2: It is relatively easy to calculate.

Disadvantage of Method 2: It can result in using higher than necessary rates, especially for small trees.

Recommendation: Do not use this method if you want the most economical rate; it is better to use Method 1 or 4 or 5.

Method 3: Use the full rate per acre less 20 or 25%.

Once concentrate spraying became a common practice several decades ago, experienced fruit growers and researchers noticed that effective insect and disease control was often obtained when using a lower rate than the full rate per acre. It became a common practice to use 20 or 25% less than the full rate per acre.

For example, for an application to apples of Imidan 70WP, which has a labelled rate of 1 pound per 100 gallons:

The full rate by the standard conversion =

(1 pound / 100 gallons)	x	(400 gallons / acre)	=	4 pounds per acre

To figure 20% less:

(4 pounds per acre)	x	(0.20)	=	0.8 pounds
(4 pounds per acre)	–	0.8 pounds	=	3.2 pounds per acre

A quicker way to get the same answer is to take 80% of the full rate:

(4 pounds per acre)	x	0.80	=	3.2 pounds per acre.

Advantage of Method 3: It means lower costs per acre for pesticides than if using the full rate per acre (as calculated in Method 2).

Disadvantage of Method 3: The 20% rule can work well for some products or some pest targets but not for others; research results are not available to determine exactly when this rule works and when it does not. It might mean that the rate being applied is below the rate stated on the label, thus the label directions are technically not being followed. If a below-label rate is used, the manufacturer can not be blamed if the product does not perform adequately.

Recommendation: Growers whose experience gives them confidence in using lower rates can certainly use this 20% reduction, but keep liability issues in mind if using lower than the label rate. It is better to use Method 1 or 4 or 5.

Introduction to Methods 4 and 5: Use a pesticide rate per acre customized to your fruit operation, based on tree-row volume.

When a label states the rate of pesticide per 100 gallons of water, then the rate of pesticide per acre can be customized for *your* sprayer and *your* orchard by following either of two methods based on tree-row volume. With either method, first you need to determine your dilute volume of water per acre, as described previously. Once you know your dilute volume, then you can determine your pesticide rate per acre either directly by tree-row volume (Method 4) or by the percentage-of-standard method (Method 5). Whether to use Method 4 or Method 5 is just a matter of personal preference; they are both based on the same principle.

Advantage of Methods 4 and 5: Spray costs are reduced by not applying more product than necessary.

Disadvantage of Methods 4 and 5: These are more complicated to calculate. However, most calculations can be done once per year; there is no need to recalculate for every spray.

Recommendation: Method 4 or 5 is best whenever the rate per acre is not provided on the label. In other words, these methods are best whenever Method 1 does not apply.

Method 4: Use a pesticide rate customized to your fruit operation based directly on the tree-row volume method.

Simply take *your dilute volume of water per acre* and multiply it by *the dilute rate of pesticide per 100 gallons of water*. This is a customized rate because your dilute volume is based on the size and spacing of your trees.

(the dilute rate of pesticide per 100 gallons of water)	x	(your dilute volume of water per acre)	=	your customized pesticide rate per acre

For example, for application of Imidan 70WP at a dilute rate of 1 pound per 100 gallons, in an orchard that needs 180 gallons per acre to treat to runoff: take 1 pound per 100 gallons times 180 gallons per acre, which equals 1.8 pounds. You thus need 1.8 pounds of Imidan 70WP for each acre. You can see that this is much less product than if you had used just the full rate, which is 4 pounds of Imidan per acre.

$$\left(\frac{\text{1 pound}}{\text{100 gal. water}}\right) \times \left(\frac{\text{180 gal. water}}{\text{acre}}\right) = \text{1.8 pounds Imidan per acre}$$

Method 5: Use a pesticide rate customized to your fruit operation by tree row volume method and the percentage-of-standard method.

First, *divide your dilute volume of water per acre by the standard dilute volume of water per acre*, which gives you the percentage of standard for your trees. How to determine your dilute volume per acre was detailed on page 27. The standard dilute volume for apples is 400 gal./A as defined on page 26.

Your dilute volume of water per acre / Standard dilute volume of water per acre	=	the percentage of standard for your trees

For example, if you determined that it takes 180 gallons per acre for a dilute application to your apple trees, then your percentage of standard = 180 gallons per acre divided by 400 gallons per acre = 45%. Your trees are 45% of standard.

$$\frac{\text{180 gal. water per acre}}{\text{400 gal. water per acre}} = \text{0.45 Your trees are 45\% of standard.}$$

An alternate way to get the percentage of standard is to use tree size and spacing in the chart at the end of the chapter. For example, for trees 12 feet wide and 10 feet tall at 20-foot row spacing, the trees are 46% of standard if well pruned, as found in the column for minimum dilute volume, or 65% of standard if unpruned, as found in the column for maximum dilute volume.

Second, determine the amount of pesticide to use by multiplying your percentage of standard by the full rate per acre. Remember that the full rate per acre = amount of pesticide per 100 gallons times 400 gallons water per acre of apples, as explained previously in Method 2.

(your percentage of standard)	x	(the full pesticide rate per acre)	=	the amount of pesticide to use per acre

For example, if your trees are 45% of standard and you need to apply Imidan 70WP, which has a dilute rate of 1 lb. per 100 gallons, then the full rate by the standard conversion is (1 lb. / 100 gallons) x (400 gallons / acre) = 4 lb. / acre. Take 45% of the full rate: 45% of 4 lb. / acre = 0.45 x 4 = 1.8 lb. / acre.

The full rate by the standard conversion:

$$\left(\frac{\text{1 pound}}{\text{100 gal. water}}\right) \times \left(\frac{\text{400 gal. water}}{\text{acre}}\right) = \text{4 pounds Imidan per acre}$$

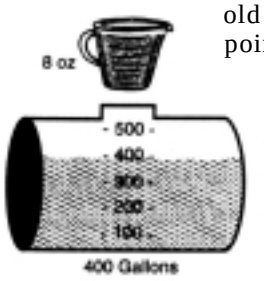
45% of the full rate:

45% of 4 pounds per acre = 0.45 x 4 = 1.8 pounds Imidan per acre

EXAMPLES FOR REVIEW

To help review the information presented in the last few pages, here are four sample calculations, all based on Provado 1.6F insecticide, which is labelled for application to apples for leafminer control at a dilute rate of 2 fluid ounces per 100 gallons. The Provado label does not state a rate per acre.

Example 1: How much Provado 1.6F should a grower use per acre for an orchard of big old apple trees, for a *dilute* application, if these trees require 400 gallons per acre to the point of runoff?

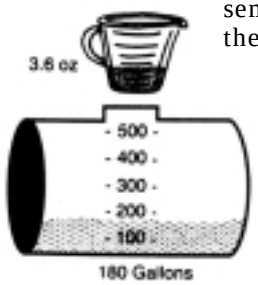


Example 1

(dilute rate) x (dilute volume) = (amount of product per acre)

$$\frac{\text{2 oz.}}{\text{100 gal. water}} \times \frac{\text{400 gal. water}}{\text{acre}} = \text{8 oz. per acre}$$

Example 2: How much Provado 1.6F should a grower use per acre for an orchard of semidwarf apple trees, for a *dilute* application, if these trees require 180 gallons per acre to the point of runoff?

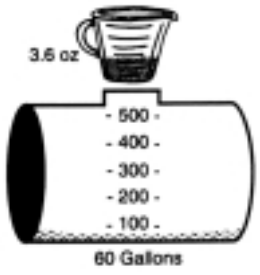


Example 2

(dilute rate) x (dilute volume) = (amount of product per acre)

$$\frac{\text{2 oz.}}{\text{100 gal. water}} \times \frac{\text{180 gal. water}}{\text{acre}} = \text{3.6 oz. per acre}$$

Example 3: How much Provado 1.6F should a grower use per acre for an orchard of semidwarf apple trees, for a *concentrate* application, if these trees require 180 gallons per acre to the point of runoff and his airblast sprayer uses 60 gallons per acre? And what concentration is this?



Example 3

(dilute rate) x (dilute volume) = (amount of product per acre)

$$\frac{\text{2 oz.}}{\text{100 gal. water}} \times \frac{\text{180 gal. water}}{\text{acre}} = \text{3.6 oz. per acre}$$

$$\frac{\text{dilute volume}}{\text{concentrate volume}} = \text{concentration}$$

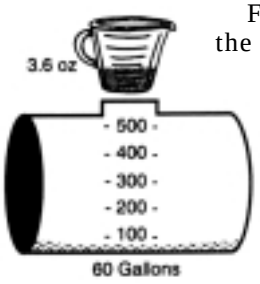
$$\frac{180}{60} = 3 \quad \text{This is a 3X concentration.}$$

You might have noticed that the block of semidwarf trees used in Examples 2 and 3 required the same amount of Provado per acre for either a dilute or a concentrate application, but the amount of *water* used per acre was different for the two types of applications.

Example 4: How much Provado 1.6F should a grower use per acre for an orchard of semidwarf apple trees, for a *concentrate* application, if these trees are in rows 18 feet apart, tree canopy width is 10 feet and tree height is 10 feet? And what spray concentration is used when an airblast sprayer applies 85 gallons per acre?

First, check the chart at the end of the chapter; for 18-foot rows and trees 10 feet wide and 10 feet tall, your dilute volume would be 169 gal./acre.

Dilute volume = 169 gal. per acre, based on the chart.



Example 4

For the final step, multiply the dilute rate by the grower's dilute volume to determine the amount of pesticide to use per acre.

(dilute rate) x (dilute volume) = (amount of product per acre)

$$\frac{\text{2 oz.}}{\text{100 gallons}} \times \frac{\text{169 gal.}}{\text{acre}} = \text{3.4 oz. per acre}$$

Another way to do the final step is to note in the tree-row volume chart that the trees are 42% of standard. Then take 42% of the full rate of Provado.

amount of pesticide per 100 gal. water	x	standard dilute volume of water per acre	=	full rate of pesticide per acre
(2 oz. per 100 gal. water)	x	(400 gal. water per acre)	=	8 oz. per acre (the full rate)

42% of the full rate: (8 oz. per acre) x (0.42) = 3.4 ounces per acre

The concentration is 169 gallons per acre divided by 85 gallons per acre, which equals approximately 2, so it is a 2X application.

$$\frac{\text{Dilute volume}}{\text{Concentrate volume}} = \text{concentration}$$

$$\frac{\text{169 gal. per acre}}{\text{85 gal. per acre}} = \text{approximately 2} \quad \text{This is a 2X concentration.}$$

SPRAYING IN DIFFERENT SEASONS AND IN DIFFERENT ORCHARDS

Managing different orchard blocks

Keep in mind that if you have several blocks of fruit trees that vary in tree size and spacing, then your dilute volume, your concentrate volume and your concentration factor probably vary from block to block. You might need to adjust your application accordingly from block to block. The calculations should also be redone periodically as trees grow from year to year.

Seasonal adjustments

During the growing season, the tree canopy changes from a relatively thin canopy during the dormant and delayed dormant periods in the spring, to a moderately thick canopy by petal-fall, to a maximum density after terminal shoots are fully developed by midsummer. Thorough coverage is more difficult to achieve when the canopy is thick. The dilute volume and concentrate volume required can be adjusted to allow for these canopy changes if the grower notices that one all-purpose volume is not always adequate.

Recommendation

Be sure to evaluate fruit quality on the packing line after harvest. If the grower's spray program is not adequately controlling all insect and disease problems, then spray rates and volumes are one factor that the grower should reevaluate for the following year.

SPRAYER CALIBRATION

The purpose of sprayer calibration is to ensure that your equipment delivers the correct amount of pesticide uniformly over the target area. Because virtually every sprayer is a unique combination of pumps, nozzles and other equipment, you should refer to the sprayer's owner manual for how best to calibrate your sprayer.

VARIABLES THAT DETERMINE SPRAY RATE

Two major variables affect the amount of spray mixture applied per acre (most commonly expressed in gallons per acre): the *nozzle flow rate* and the *ground speed* of the sprayer. You must understand the effect that each of these variables has on sprayer output to calibrate and operate your sprayer properly.

Nozzle Flow Rate

The flow rate through a nozzle varies with the nozzle pressure and the size of the nozzle tip. Increasing the pressure or using a nozzle tip with a larger opening will increase the flow rate (gallons per acre).

Increasing pressure will NOT give you a proportional increase in flow rate. For example, doubling the pressure will not double the flow rate — you must increase the pressure fourfold to double the flow rate.

Sprayer pressure (speed constant)	Sprayer output (gallons per acre)
10 psi	10
40 psi	20
160 psi	40

Pressure cannot be used to make major changes in spray rate, but it can be used to make minor changes. Keep in mind that operating pressure must be maintained within the recommended range for each nozzle type to obtain a uniform spray pattern and minimize drift.

The easiest and most effective way to make a large change in flow rate is to change the size of the nozzle tips. Depending on operating pressure, the speed of the sprayer and nozzle spacing, small changes in nozzle size can significantly change sprayer output per acre. Use nozzle manufacturers' catalogs to select the proper tip size.

Ground Speed of the Sprayer

Provided the same throttle setting is used, as speed increases, the amount of spray applied per unit area decreases at an equivalent rate. For example, doubling the ground speed of a sprayer will reduce the amount of spray applied by one-half.

Sprayer speed (under constant pressure)	**Sprayer output (gallons per acre)**
1 mph	40
2 mph	20
3 mph	13.3
4 mph	10

To determine the new output after changing speed:

$$\text{New output} = \frac{\text{old output x old speed}}{\text{new speed}}$$

Some low-pressure sprayers are equipped with control systems that maintain a constant application rate over a range of travel speeds, provided the same gear setting is used. Pressure is automatically changed to vary the nozzle flow rate in proportion to changes in ground speed. Even so, do your calibration at a set ground speed. In the field, travel speed must be kept within certain limits to keep the nozzle pressure within the recommended range.

Tree-row volume chart.

This chart shows the dilute volume of spray mixture per acre required to spray tree fruit of various tree sizes and spacings, and equivalent percentage of standard dilute volume; assumes that trees are mature enough to fill the rows.

Distance between rows (feet)	Tree canopy width (feet)	Tree height (feet)	**Tree-row volume** per acre (cubic feet, rounded to nearest 1,000)	**Your dilute volume** (gallons per acre)		Your dilute volume as a **percentage of standard** dilute volume			
						Pome fruit (base 400 g.p.a.)		Stone fruit (base 300 g.p.a.)	
				Minimum[1]	Maximum[2]	Minimum[1]	Maximum[2]	Minimum[1]	Maximum[2]
40	22	22	527,000	369	527	92%	132%	123%	176%
30	20	20	581,000	407	581	102%	145%	136%	194%
30	20	15	436,000	305	436	76%	109%	102%	145%
26	16	12	322,000	225	322	56%	80%	75%	107%
24	14	12	305,000	213	305	53%	76%	71%	102%
22	14	12	333,000	233	333	58%	83%	78%	111%
20	15	12	392,000	274	392	69%	98%	91%	131%
20	12	14	366,000	256	366	64%	92%	85%	122%
20	12	12	314,000	220	314	55%	78%	73%	105%
20	12	10	261,000	183	261	46%	65%	61%	87%
20	10	10	218,000	152	218	38%	54%	51%	73%
19	11	10	252,000	177	252	44%	63%	59%	84%
18	12	12	348,000	244	348	61%	87%	81%	116%
18	10	10	242,000	169	242	42%	60%	56%	81%
18	8	8	155,000	108	155	27%	39%	36%	52%
17	9	9	208,000	145	208	36%	52%	48%	69%
16	8	8	174,000	122	174	30%	44%	41%	58%
15	7	8	163,000	114	163	28%	41%	38%	54%
14	6	9	168,000	118	168	29%	42%	39%	56%
14	6	8	149,000	105	149	26%	37%	35%	50%
14	6	7	131,000	91	131	23%	33%	30%	44%
13	6	7	141,000	99	141	25%	35%	33%	47%
12	6	6	131,000	91	131	23%	33%	30%	44%
12	3	8	87,000	61	87	15%	22%	20%	29%

This chart shows the dilute volume of spray mixture per acre required to spray tree fruit of various tree sizes and spacings, and equivalent percentage of standard dilute volume; assuming that trees are mature enough to fill the rows.

[1] minimum: for most orchards that are regularly pruned (0.7 gal / 1000 ft^3).

[2] maximum: for unpruned orchards or unusually thick canopies (1.0 gal / 1000 ft^3).

Summary of how much water and pesticide to use for different types of spray applications to apple orchards.

Type of application	Amount of *water* per acre	Amount of *pesticide* per acre
Standard dilute application	Use 400 gallons per acre, which is enough to cover leaves of large trees to the point of runoff.	Use full rate of pesticide = (amount of pesticide per 100 gallons of water) x (400 gallons / acre).
Dilute application customized to smaller trees	Use enough to cover leaves to the point of runoff, as determined by experience and experimenting with your sprayer in your orchard.	Use (amount of pesticide per 100 gallons of water) x (your customized dilute volume of water per acre).
	OR Use amount estimated from the tree-row volume chart (see page 39).	
	OR Use amount determined by tree-row volume equations (pp. 28-29).	
Standard concentrate (low-volume) application	Use enough to provide adequate coverage of the canopy, based on experience and experimenting with your sprayer in your orchard; likely to be 40 to 80 gallons / acre.	Use amount of pesticide per acre as stated on pesticide product label.
		OR Use full rate of pesticide = (amount of pesticide per 100 gallons of water) x (400 gallons / acre).
		OR Use full rate less 20 or 25% if your experience shows that control is adequate with this adjustment.
Concentrate (low-volume) application customized to smaller trees	Use enough to provide adequate coverage of the canopy, based on experience and experimenting with your sprayer in your orchard; likely to be 40 to 80 gallons / acre.	Use the amount of pesticide per acre as stated on pesticide product label.
		OR Use amount based directly on tree-row volume = (dilute rate per 100 gallons) x (your dilute volume per acre).
		OR Use amount based on tree-row volume and percentage of standard = (full rate per acre) x (your dilute volume per acre) / (standard dilute volume per acre)

Glossary of terms

1. **'standard' trees**: fruit trees that are large (about 20 feet tall and 20 feet wide) and widely spaced (rows about 30 feet apart) within the orchard; it is the term used by horticulturalists for the type of apple trees that were grown for many years before dwarfing rootstocks became available.

2. **types of orchard pesticide applications**:

   dilute application: application of pesticide to fruit trees *to the point of runoff* — that is, until liquid begins to drip off of the leaves — by either an airblast sprayer or a handgun sprayer.

   concentrate application (also called *low-volume application*): application of pesticide to fruit trees by an airblast sprayer that produces fine droplets that cover foliage very well without the large volume needed to reach the point of runoff.

3. **spray volumes**:

   dilute volume: the number of gallons of water it takes to cover an acre of fruit trees to the point of runoff.

   standard dilute volume: the number of gallons of water it takes to cover an acre of standard (large) fruit trees to the point of runoff; for apple or pear trees, the standard dilute volume is 400 gallons of spray mix per acre. For peach, plum and cherry, 300 gallons per acre is the standard dilute volume. For strawberries, brambles, blueberries and grapes, 200 gallons per acre is the standard dilute volume.

   your customized dilute volume: the number of gallons of water it should take to cover 1 acre of your trees to the point of runoff; usually 100 to 200 gallons per acre for semi-dwarf or dwarf apple trees.

   your concentrate spray volume: the number of gallons of water per acre your airblast sprayer uses to adequately treat your orchard for a low-volume application, for whatever speed, pressure and nozzle arrangement you prefer to use; usually 40 to 80 gallons per acre.

   concentration (or concentrate factor): your dilute volume of water per acre divided by your concentrate volume of water per acre.

4. **rates of pesticide products**:

   dilute rate: the amount of pesticide that should be used to make a dilute application to the point of runoff with either a handgun sprayer or an airblast sprayer; usually expressed as an amount of pesticide to be mixed per 100 gallons of water.

   full rate: the maximum amount of pesticide to use per acre; calculated by multiplying the dilute rate (= the amount of pesticide per 100 gallons) by the standard dilute volume per acre (= 400 gallons per care for apples).

   concentrate rate: the amount of pesticide used per acre when making a concentrate (low-volume) application; this might be equal to or less than the full rate per acre.

5. **tree-row volume**: the amount of space occupied by fruit trees; calculated by tree height, tree width and tree spacing; used as the basis for determining the amount of water and pesticide needed to adequately cover the trees with spray.

CHAPTER 4

Review Questions

Chapter 4: Spraying Fruit. How to choose the amount of pesticide and water to use.

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. An insecticide is labeled to control aphids at a dilute rate of 5 fluid ounces per 100 gallons. How much insecticide will you need to spray a standard orchard at 400 gallons per acre?

   A. 5 fluid ounces.
   B. 10 fluid ounces.
   C. 20 fluid ounces.
   D. 50 fluid ounces.

2. Referring to question #1, how much insecticide per acre for a dilute application would you need if your orchard required 150 gallons per acre?

   A. 7.5 fluid ounces.
   B. 15 fluid ounces.
   C. 25 fluid ounces.
   D. 30 fluid ounces.

3. Referring to question #1, how much insecticide per acre would you use for a concentrate application if the trees required 150 gallons per acre and your air-blast sprayer uses 50 gallons per acre?

   A. 250 fluid ounces.
   B. 100 fluid ounces.
   C. 20 fluid ounces.
   D. 7.5 fluid ounces.

4. Referring to question #3, what is the concentration of insecticide application?

   A. 1X.
   B. 3X.
   C. 10X.
   D. 30X.

5. You should refer to the owner's manual to learn how to best calibrate your sprayer.

   A. True.
   B. False.