This is a section from the

2023/2024
New Jersey Commercial
Tree Fruit Production Guide

The recommendations are **NOT** for home gardener use.

The **full guide** can be found on the Rutgers New Jersey Agricultural Experiment Station (NJAES) website at: *https://njaes.rutgers.edu/pubs/publication.php?pid=e002*. The guide is revised biennially.

Cooperating Agencies: Rutgers, The State University of New Jersey, U.S. Department of Agriculture, and New Jersey Board of County Commissioners. Rutgers Cooperative Extension, a unit of the Rutgers New Jersey Agricultural Experiment Station, is an equal opportunity program provider and employer.

PESTICIDE USE DISCLAIMER

THE LABEL IS THE LAW

A pesticide applicator is legally bound by the labeling found on and with the pesticide container in their possession. Before using a pesticide, check and always follow the **labeling distributed with the product at the point of sale for legally enforceable rates and restrictions**.

In addition to the pesticide products listed in this Production Guide, other formulations or brands with the same active ingredient(s) may be commercially available.
ALWAYS CHECK THE LABELING ON THE PRODUCT CONTAINER ITSELF:
a) to ensure a pesticide is labeled for the same use,
b) to ensure the pesticide is labeled for the desired crop,
c) for differences in rates and percent active ingredient, and
d) additional restrictions.

Check the physical product label for the maximum amount of pesticide per application and the maximum number of applications per year.

IMPORTANT: DO NOT RELY ON ELECTRONIC LABELING (unless it is "web labeling" found directly on the product container)**.** *Online pesticide* labels may not be the same as the labeling distributed with the product. Some services include: Proagrica's CDMS *http://www.cdms.net/*; Agworld DBX powered by Greenbook *https://www.greenbook.net*; or Agrian *https://www.agrian.com/labelcenter/results.cfm.*

These electronic label services provide use disclaimers, and in some cases legally binding User Agreements assigning ALL liability to USER of service. For example, Agrian's webpages***** cite (in red): The *material and content contained in the Agrian Label Database is for general information only. Agrian Inc. does not provide any guarantee or assurance that the information obtained through this service is accurate, current, or correct, and is therefore not liable for any loss resulting, directly or indirectly, from reliance upon this service. This Label Database does not replace the official manufacturer issued label. Users of this database must read and follow the actual product label affixed to the container before use of the product. Use of the Label Database is subject to the Terms of Use and Privacy Policy* ***** [*date accessed: 12/23/2022*].

See a detailed regulatory discussion of this and other essential information on Pesticide Safety and the Pesticide Label in Chapter 1. Electronic labeling is discussed in section 1.3.1.

If you are having a medical emergency after using pesticides, always call 911 immediately.

POISON Help®
1-800-222-1222

In Case of an Accident

- **Remove the person from exposure**
- **Get away from the treated or contaminated area immediately**
- **Remove contaminated clothing**
- **Wash with soap and clean water**
- **Call a physician and/or the National Poison Control Center (1-800-222-1222). Your call will be routed to your State Poison Control Center.**
- **Have the pesticide label with you!**
- **Be prepared to give the EPA registration number to the responding center/agency**

2 Pesticide Calibration and Stability

2.1 Sprayer Calibration and the Tree Row Volume Method

Foliar pesticide spray applications in tree fruit orchards are made almost exclusively with airblast sprayers. The number and frequency of sprays needed each season represents nearly 20% of seasonal production costs. All aspects of the spraying operation need to be as cost-efficient as possible. Just because a treatment provides good pest control does not mean that it is also efficient. One reason for this inefficiency is that conventional guidelines for pesticide recommendations lack precision and are frequently misunderstood. **In this section we offer guidelines for defining spray volume and concentration requirements, and for sprayer calibrations to obtain maximum performance and consistent control.**

Tree Row Volume (TRV) and Determining Pesticide Dosage

The required dosage of any pesticide is the amount that must be applied per unit of target area that achieves the desired level of pest control. Determining when a pesticide dosage is too low is relatively easy since more pest damage is seen. It is more difficult to tell when the dosage level exceeds the required amount because there is often little or no difference in the level of pest damage. Using too little or too much pesticide is costly. Excessive rates mean increased costs, excessive worker exposure, unnecessary environmental contamination, and disruption of integrated control programs. Pesticide dosage is determined by two factors:
(1) the concentration of the pesticide in the spray tank (pounds of product per 100 gallons of water
(2) the spray volume applied per target unit (gallons per acre).

Target Definition

Defining the target area as "an acre" is too variable, and may lead to either too much or too little pesticide being applied. House painters determine the amount of paint required for a job by defining the house in more relevant terms. Thus, painting recommendations are never stated on a gallons-per-house basis, but on a gallons-per-1,000-square-foot basis. Fruit growers face a similar problem in determining how much pesticide is needed to treat an acre of orchard. The amount of target area within an orchard acre varies with tree size, planting density, and the degree of canopy development.

The "conventional acre" is a two-dimensional unit of area (43,560 square feet) and is accurate for pesticide dosage in orchards only when applying herbicide sprays to ground areas. For tree spraying, the **"orchard acre"** needs to be redefined in terms that are relevant to a three-dimensional target. This is done by using tree row volume (TRV) to estimate the volume of the target to be treated. Here, adjustments can be made for differences among orchards in tree size and planting density. TRV per acre is calculated by multiplying tree height (H) x foliar canopy width (W) x the row length (L) per acre, therefore:

H x W x L = cubic feet TRV per acre

The row length per acre (L) above is determined by dividing 43,560 square feet per acre by the distance between rows in feet as shown below for a 28 feet row spacing.

$$\frac{43{,}560\ \text{ft}^2\ \text{acre}}{28\ \text{feet between rows}} = 2{,}178\ \text{row feet per acre}$$

Determining High Volume Spray Requirements Based on TRV

The spray volume required for uniform coverage of an orchard depends on the total fruit and foliage surface area. One way good coverage can be obtained is to use high-volume (HV) dilute sprays of 200 to 400 gallons per acre (gpa) to thoroughly wet all target surfaces to a point where excess spray liquid drips to the ground. This is important where absolute coverage of all surfaces is required (for example, oil sprays for mite control and for certain plant growth regulators). Underdosing does not occur because all parts of the tree are thoroughly wetted. Overdosing does not occur because any excess material runs off. Obviously, if the spray volume used is excessive, then much is lost to the ground as drip. For trees with a full canopy of foliage, a dosage volume of about 0.7 gallon per 1,000 cubic feet TRV will usually reach the drip point. Early in the season however, sprayers should be calibrated to deliver between 0.25 and 0.35 gallon per 1,000 cubic feet TRV to avoid excessive runoff. (An apple tree at green tip has approximately one-fifth the surface area it will have at full leaf.) If applying sprays calibrated for dilute application and not reaching the drip point, the dosage will be less than adequate and control will be reduced. If the drip point is greatly exceeded, control will be adequate, but pesticide use will be excessive both in terms of cost and unnecessary environmental contamination.

Determining Concentrate and Low Volume Spray Requirements Based on TRV

Good coverage can also be obtained using low volume (LV) sprays of 25 to 60 gpa, with which a fine mist of spray droplets are uniformly deposited over all target surfaces without reaching the drip point. LV spraying is now the standard in the fruit industry because it requires less labor, time, and pesticide than HV sprays. However, without a visible gauge to determine when enough material has been applied, such as the drip point for HV sprays, dosage for LV sprays can be controlled only by adjusting the pesticide concentration in the spray tank. An LV rate of 0.09 gallon per 1,000 cubic feet TRV provides adequate coverage in most orchards under most conditions. Applying less than this amount may give less consistent results under variable orchard conditions because few airblast sprayers are designed for very low volumes. Applying more than this rate generally leads to excessive pesticide use and higher spray costs. See Table 2.1 for suggested spray volumes.

This dosage volume can be used to calibrate the sprayer to deliver a spray volume suitable for a three-dimensional orchard target defined by TRV. The conversion to gpa for sprayer calibration is made using the following formulas:

$$\frac{\text{ft}^3\ \text{TRV}}{1{,}000\ \text{ft}^3} \times 0.09\ \text{gallon} = \quad \text{gpa for } \textbf{LV} \text{ sprays}$$

$$\frac{\text{ft}^3\ \text{TRV}}{1{,}000\ \text{ft}^3} \times 0.70\ \text{gallon} = \quad \text{gpa for } \textbf{HV} \text{ sprays}$$

Regardless of the spray volume finally chosen, actual performance is still governed by coverage. This should be checked using water sensitive spray indicator cards, placed in the trees at the full-leaf stage of development. Proper adjustment of the sprayer manifold is paramount. The correct procedure for this is presented in Figure 2.1.

While it is a good idea to compute the TRV for each orchard block, adjusting the sprayer for each of many such blocks is impractical. Therefore, once the calculations are complete, select two or three spray delivery volumes that will be adequate for coverage in most blocks. A variance of plus or minus 20 percent of the calculated TRV spray volume generally affords adequate coverage without being excessive. If your sprayer has “flip over” nozzles, each side may be calibrated for an approximate tree size. If enough nozzles are present to shut off the “extra nozzles” for small trees, then those remaining nozzles used for small trees alone should be recalibrated for TRV.

Pesticide Concentration Factors

Adjusting the spray volume as described above improves the overall efficiency of the spraying operation. However, major reductions in pesticide use and cost savings are not realized until pesticide concentrations are also adjusted to control dosage. Recommendations for LV TRV spraying differ substantially from those provided on most pesticide labels, because many testing procedures do not use LV sprays, and very few use TRV calculations. Most recommendations are calculated based on estimates of HV dilute spraying requirements for trees in the full-leaf stage of canopy development. In addition, most labels state application rates on an amount per acre basis. On smaller trees, this can result in a dosage rate several times greater than actually necessary for control.

Research trials using airblast sprayers to apply LV treatments in mature orchards with a spray volume adequate for coverage clearly demonstrate that concentrating pesticides more than three to four times the normal dilute concentration (pounds of the product per 100 gallons), offers no significant improvement in the control of major tree fruit pests. This rule applies to all fungicides, insecticides, and miticides commonly used in commercial tree fruit production.

Going From Conventional Recommendations To TRV

HV Sprays. Mix the pesticide at the concentration per 100 gal as recommended on the label if stated. Total spray volume per acre should be calibrated based on 0.7 gallon per 1,000 cubic feet of TRV on trees with sufficient foliage, or 0.25 to 0.35 gallon per 1,000 cubic feet of TRV on trees with little or no foliage.

LV Sprays. Most conventional spray recommendations state that the rate should be applied on an amount per acre basis, and have been calculated based on the maximum dilute spray volume required for large trees at full leaf. Traditional LV spray recommendations require the same amount of chemical be applied per acre regardless of the spray volume. This means the spray volume per acre and concentration per 100 gallons for LV spraying must be adjusted proportionately, relative to HV spraying requirements. Thus, if the volume used for an LV spray is one half, one third, or one sixth that of the estimated dilute requirement of 300 gal/A, that is 150, 100, or 50 gal/A, respectively, then the pesticide is concentrated at 2, 3, or 6 times the usual dilute rate per 100 gallons.

By comparison, the defined dosage approach for LV sprays using TRV calibration calls for pesticides to be mixed at only three to four times the normal dilute concentration per 100 gallons and then applying a defined LV gallonage per acre that is adequate for coverage (for example, 0.09 gallon per 1,000 cubic feet TRV). Thus, this approach is similar to dilute spraying, in that a fixed concentration of pesticide is prepared and the spray volume used varies with coverage requirements.

Table 2.1 Approximate Spray Volume for Coverage at the Full-Leaf Stage of Canopy Development

Approximate spray volume needed in gal/A using High-Volume (HV) dilute or Low-Volume (LV) concentrate sprays made with airblast sprayers in orchards

Tree height x width (ft^2)	Type	Spray distance between tree rows (ft)									
		16	18	20	22	24	26	28	30	32	34
80	HV	152	136								
	LV	20[b]	17[b]								
100	HV	191	169								
	LV	25	22[b]	20[1]							
150	HV	256	254	229	208	191					
	LV	37	33	29	27	25					
200	HV			305	277	254	235	218			
	LV			39	36	33	30	28			
250	HV				346	317	293	272	254	238	
	LV				45	41	38	35	33	31	
300	HV				416	381	352	327	305	286	269
	LV				53	49	45	42	39	37	35
350	HV					445	411	381	356	334	314
	LV					57	53	49	46	43	40
400	HV						469	436	407	381	359
	LV						60	56	52	49	46
450	HV							490	457	429	404
	LV							63	59	55	52
500	HV								508	476	448
	LV								65	61	58
550	HV									524	493
	LV									67	63
600	HV										538
	LV										69

[1] LV applications of less than 25 gpa are not recommended because of equipment limitations. **Notes**: 1) gal/A: nearest whole gallon amounts, based on standard dosage volumes of 0.70 gal/1,000 ft^3 TRV for HV and 0.09 gal/1,000 ft^3 TRV for LV sprays. 2) Empty cells in the table: no data because the combination of this tree size on this planting density is unlikely. 3) For early season HV sprays, the 0.70 gallon rate may result in excessive drip. A calibration volume of 0.25 to 0.35 gallons is recommended. Check for drip to ensure coverage.

LV Concentration and LV Limits

Mix pesticides at not less than three and not more than four times the standard dilute concentration per 100 gallons of water, as stated on the product label. Apply this mixture at the rate of 0.09 gallon per 1,000 cubic feet TRV. In no case is a spray volume of less than 25 gallons per acre recommended. Do not use less on a per acre basis than the label recommended amount per 100 gallons.

Examples of Conventional and TRV Rates. Use Table 2.1 as a guide for spray volumes needed for various tree sizes and spacings. Consult actual labels for use rates per 100 gal. We use an orchard planting with trees that are 12.5 ft tall with a canopy diameter of 12 ft (tree ht x width = 150 ft^2). Tree spacing is 18 ft between rows, therefore 43,560 ft^2/18 ft = 2,420 row feet per acre; 150 ft^2 x 2,420 ft = 363,000 ft^3 (TRV); 363 x .09 = 32.7 (33) gal/A. This matches the 33 gal/A rate for this spacing, found in Table 2.1. Using a 4x concentration of the recommended per 100 gal rate, the resulting TRV per acre rates will be one third (33 gal/100 gal) of the 4x rate.

Comparison of Conventional vs. TRV Pesticide Rates

Chemical	Conventional Rate Amount/Acre	Conventional Rate Amount/100 gal	TRV Rate Amount/Acre
Imidan 70W	34 oz	0.75 lb	0.66 lb or 11 oz
Captan 50W	6 lb	1.5 lb	2 lb

Sprayer Calibration

The purpose of sprayer calibration is to control the pesticide dosage by delivering a known volume of spray liquid and therefore, a fixed amount of pesticide to a specified area of orchard. To do this, the sprayer travel speed in miles per hour (mph), pump discharge rate in gallons per minute (gpm), and area covered (swath = distance between tree rows in feet) must be held constant. Any change in these factors affects the application rate. The following procedures outline the basic steps for calibrating and adjusting airblast sprayers for maximum performance, and should be used in conjunction with the manufacturer's manual for your particular sprayer.

Calculate travel speed. Most tractor speedometers are geared to tachometers and are not accurate under field operating conditions. Use a stopwatch and a measured course to accurately determine the travel speed of your tractor and sprayer unit:

$$\frac{\text{feet traveled in 1 minute}}{\text{88 feet per minute}} = \text{mph}$$

Calculate pump discharge rate. Calculate the pump discharge rate (gpm) needed to deliver the correct number of gallons per acre (gpa) (based on your earlier calculation of TRV or Table 2.1) at a fixed travel speed (mph) and planting distance between rows (swath):

$$\frac{\text{gpa x swath x mph}}{495} = \text{gpm}$$

If the gpm is already known, then the gpa can be determined for various orchards and travel speeds by substituting these values in the following formula:

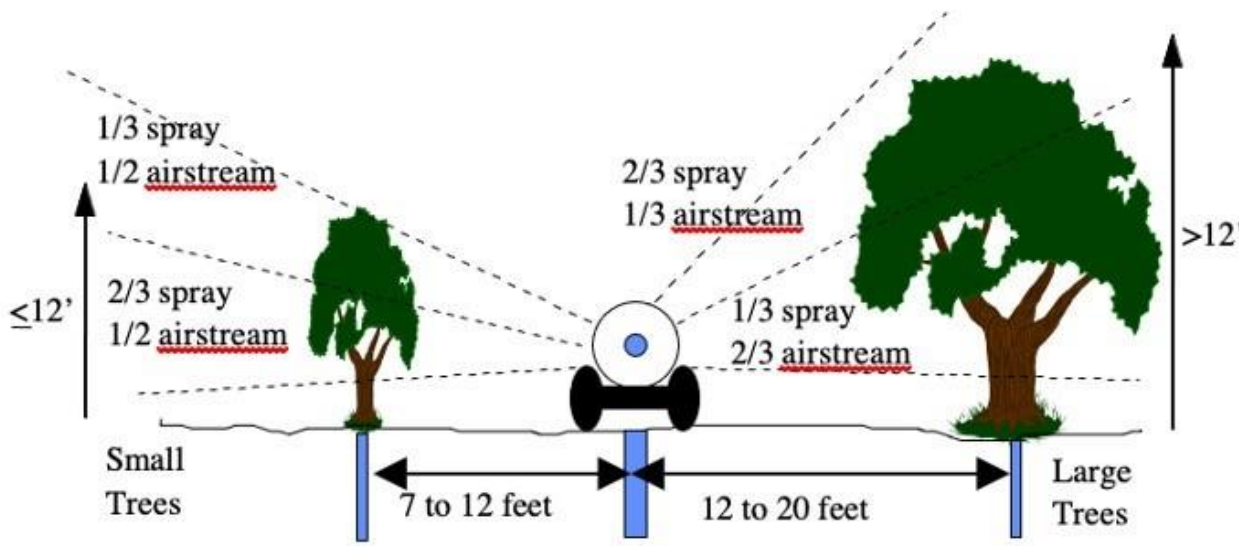
$$\frac{\text{gpm x 495}}{\text{swath x mph}} = \text{gpa}$$

Define the Effective Airblast. The effective airblast of a sprayer is that portion of the spray stream actually involved in covering the trees. It will vary with tree size and distance between the tree and the sprayer manifold (Figure 2.1). Place the machine at the normal spraying distance from a tree of typical size and shape for the orchard, and turn off all nozzles not actually used to cover the tree. The spray stream should just overshoot the top of the tree by a couple of feet.

Measure the Operating Pressure. The operating pressure for a sprayer, measured in pounds per square inch (psi), should be measured at the discharge manifold by replacing one nozzle with a reliable pressure gauge. This pressure value will be needed to select nozzles of the proper size and provide the right discharge rate.

Nozzle the Sprayer. Uniform coverage of large trees requires that two thirds of the spray volume be applied to the top one third of the tree. Figure 2.1 shows the proportions of liquid distribution for large and small trees. Note that for small trees that are less than 12 feet tall, one third of the spray volume is delivered to the top half of the tree. This arrangement is necessary to provide adequate coverage in the tops of trees without depositing excessive amounts on lower limbs. The worst possible arrangement uses the same size nozzle throughout the manifold. Refer to the sprayer manufacturer's tables on nozzle performance at various operating pressures and select the number and size of nozzles needed to obtain the right output at the selected operating pressure. When arranging the nozzles in the air stream, make sure that adjacent nozzle patterns merge before the spray stream reaches the nearest foliage of the tree canopies.

Figure 2.1 Proportional Distribution of Airblast Spray Required for Good Coverage



Test the Calibration Setup. Nozzle one side of the sprayer and determine the number of gallons delivered per minute by operating the machine for 3 to 5 minutes and then measuring the amount of water required to refill the tank to the starting level. For one side, this should be one-half the gpm discharge rate determined earlier. Differences between the desired rate and the measured rate may require only a slight pressure adjustment. Differences of more than 10 percent should be corrected by changing the size of the nozzles. Once you are satisfied with the performance of one side of the sprayer, nozzle the other side in a similar fashion and run a final check, operating the full system.

Check for Coverage. Where a major change in spraying practice is planned, conduct the calibration procedure in the late summer or fall when the setup can be tested on trees with a full complement of foliage that represents the most difficult target for coverage. Spray targets (cards, filmstrips, or water-sensitive papers) should be placed within the tree canopy to assess spray coverage. For a quick assessment of uniform spray distribution in the effective airblast and to see whether travel speed can be adjusted to improve this distribution, use water sensitive spray paper and clothespins. Clip papers to small branches in the lower, middle and top portions of the inside of the tree, then spray with water. Deposits on the paper should be reasonably uniform from top to bottom. If they are not, re-check the nozzle arrangement or the travel speed. Before putting the sprayer away, make a diagram of the sprayer manifold, noting the number, location, and size of all nozzles, and the operating pressure and travel speed used in the test. This written record will save valuable time during the spray season when the sprayer calibration may need adjustment.

Travel Speed Adjustments. The greater the distance between the sprayer and the spray target, the slower the travel speed should be. The same is true for the density of the foliar canopy. Thus, where a travel speed of 3 mph might be adequate for coverage during the prebloom period or when spraying from every row middle, operating at 2 to 2.5 mph will improve coverage when spraying from alternate row middles or when tree canopies become more dense. Spraying in the wind is not advisable but is sometimes necessary. Here again, a slower travel speed than usual is recommended to maintain coverage in the tops of trees. Under low humidity conditions, spray droplets evaporate quickly, reducing their mass and making it more difficult for them to be deposited in the tops of trees. Spraying in the early morning or late evening, when humidity levels are usually higher, can overcome this problem.

Alternate Row Middle (ARM) spraying. Complete sprays are applied to both sides of the tree as the sprayer travels each aisle in an orchard during a single spray application event with both sides of the sprayer on. Alternate row middle (ARM) sprays are applied from only one side of the tree row, or every other aisle, alternating between the odd- and even-numbered row middles with each successive spray treatment. The concentration of spray material in the tank and the sprayer delivery rate remain the same for both ARM and complete sprays. Thus, two ARM sprays equal one complete spray in terms of coverage and the amount of product used per acre. Carefully done, ARM sprays offer the advantages of reduced costs for labor, chemicals, and fuel and closer timing when conditions are critical.

ARM spraying should not be attempted in orchards where conventional spraying has not given consistent control of most pathogens and insect pests. The sprayer should be matched to the tree canopy, in that the sprayer should be able to cover 100% of the side being sprayed and about 75% of the side not being sprayed. Trees should be well pruned to allow spray droplets to penetrate into and through the tree canopy. Travel speeds should never exceed 3 mph, even under calm conditions. ARM spraying programs have been most successful when a conventional application (both sides) is made at the start of the season and then followed at regular intervals with ARM treatments. ARM spray intervals need to be shorter than where both sides of the tree are sprayed. Where conventional spraying recommendations call for sprays at 7-, 10-, or 14-day intervals, the intervals for ARM sprays should be reduced to 3-5, 7, or 10 days, respectively. Be prepared to shorten the spray interval or even to apply a complete spray (both sides) when using plant growth regulators, or when conditions are highly favorable for disease development, or when precise timing is essential. **Do not use ARM methods to apply streptomycin for fire blight control.**

2.2 Effect of pH on Pesticide Stability and Efficacy

Water pH can affect the performance of many pesticides. Some materials have a label cautioning against mixing the pesticide with alkaline materials. The reason for this caution statement is that some materials, in particular the organophosphate insecticides, undergo a chemical reaction known as alkaline hydrolysis. This reaction occurs when the pesticide is mixed with alkaline water, that is, water with a pH greater than 7. The more alkaline the water, the greater the breakdown. In addition to lime sulfur, several other materials provide alkaline conditions: caustic soda, caustic potash, soda ash, magnesia or dolomitic limestone and liquid ammonia.

Manufacturers may provide information on the rate at which their products hydrolyze. This rate is expressed as **half-life**, meaning the time it takes for 50 percent hydrolysis or breakdown to occur. Since a number of chemicals break down quickly under high pH and others under low pH, growers should have their water supply tested to determine its pH. If the pH is above 7, growers may wish to add a nutrient buffer to the spray tank. Trade names of commonly used buffers are: Buffer-X, Mix-Aid, Nutrient Buffer Spray, Spray-Aide, Sorba-Spray and Unite. However the water pH should not be adjusted in all cases. For example, fixed copper fungicides, coppers applied as a Bordeaux mixture, copper oxide, basic copper sulfate, and copper hydroxides should not be acidified. Table 2.2 lists the water pH sensitivity for a number of pesticides (adapted from Agri-Food Canada and the B.C. Ministry of Agriculture).

Table 2.2 Optimum pH and Half-Life at Different pH Values for Selected Pesticides

	Product	Optimum pH	Half Life (=time for 50% hydrolysis or breakdown) at different pH values
Insecticides	**Acramite**	<7	pH 9 (2 h), pH 7 (20 h), pH 5 (5.5 d)
	Actara	4	pH 4 (16 wk), pH 7 (5 wk)
	Admire	7.5	pH 5 to 9 (more than 31 d)
	Agri-Mek	6 - 7	pH 4 to 7.5 (stable)
	Apollo	6 - 7	pH 5 (10 d), pH 7 (34 h), pH 9.2 (4.8 h)
	Assail	5 - 6	below pH 4 and above pH 7 (unstable)
	Avaunt		pH 5 to 10 (stable for 3 d)
	Carzol	5	Not stable in alkaline water; use within 4 h of mixing.
	Dipel	6	pH above 8 (unstable)
	Entrust/Success	7	pH 6 to 9 (stable)
	Envidor	5 - 7	pH 4 (63 d), pH 7 (31 d), pH 9 (5 d)
	GF-120 NF	7	pH 6 to 9 (stable)
	Imidan	5	pH 8 (4 h), pH 7 (< 12 h), pH 5 (7 d)
	Lannate	6-7	pH 9.1 (loses 5 percent effectiveness in 6 h)
	Malathion	5	pH 9 (5 h), pH 8 (19 h), pH 8 (3 d), pH 6 (8 d)
	Nexter	-	pH 4 to 9 (stable)
	Rimon	5 - 7	pH 9 (100 d)
	Sevin XLR	7	pH 9 (24 h), pH 8 (2 to 3 d), pH 7 (24 d), pH 6 (100 d)
Fungicides	**Aliette**	4	pH 4.0 to 8.0 (stable)
	Bravo 500	6 - 7	Stable over a wide range of pH, pH 9 (38 d)
	Captan	5	pH 8 (10 min), pH 7 (8 h), pH 4 (32 h)
	Dithane	6	Most stable at pH 5.5 to 6
	Elevate	5.5 – 6.5	-
	Ridomil	5 - 7	pH 9 (88 d)
	Rovral		pH 7 (1 to 7 d), pH 9 (< 1 h)