



Phosphorous Acid Products for Controlling Downy Mildew of Grapes

Why Phosphorus Acid

Phosphorous acid products are used worldwide to prevent or control downy mildew (DM) of grapes. **ProPhyt, Rampart, Agri-Phos, Fungi-Phite, and Phostrol** are phosphorous acid products, and they work as a fungicide by interrupting the metabolic processes of downy mildew.

Studies have shown the efficacy of phosphorous acid fungicides for preventing DM when applied alone or when combined with other DM fungicides, such as Pristine, Abound, Sovran, or with Mancozeb, Captan, or Ziram.

Research shows that spraying phosphorous acid at 10- to 14-day intervals controls DM well; however, under high disease pressure, it was not as effective as strobilurin fungicides such as Pristine, Abound, and Sovran. **The current recommendation is to shorten phosphorous acid spray intervals to 7 to 10 days under high disease pressure.**

Studies also show that the incidence and severity of DM infection were significantly reduced by adding phosphorous acid to a standard control program of protectant fungicides (Captan, Mancozeb, Ziram) at 14-day intervals.

*Downy mildew is caused by the fungus-like organism **Plasmopara viticola** and is a significant disease of grapes in warm, damp climates.*



Downy Mildew spores on the underside of grape leaf.

Important Fact:

Phosphorous acid (H_3PO_3) is also known as phosphite or phosphonate and is **not** the same thing as phosphoric acid (H_3PO_4) or phosphate, which is a source of phosphorus fertilizer.

Phosphorous acid products are generally less expensive than other DM fungicides and when sprayed on the leaves it enters the plant tissue, then moves via the xylem and phloem into new areas of growth, such as vine shoot tips. This is called amphimobile systemic fungicidal activity, and it is advantageous in grapevines because the younger vine tissues are most susceptible to DM infection.

Advantages of Phosphorous Acid

- Less expensive
- Systemic activity
- Unique mode of action
- 0-day pre-harvest interval

The low toxicity of the active ingredients in most phosphorous acid products gives them a 0-day pre-harvest interval, so they can be used late in the season when other fungicides cannot.

Controlling Downy Mildew in Susceptible Vineyards

Frequent heavy rains during growing seasons in warm, damp climates can increase grape disease pressure. Mancozeb or Captan are the fungicides most widely used to prevent DM, but they are not systemic, and they are susceptible to wash-off by rainwater.

Strobilurin fungicides are absorbed primarily into the leaf or berry cuticle and move very short distances in that same organ (mesosystemic). These are used in preventative spray programs for DM and other diseases and have very good efficacy. However, DM and other pathogens can develop resistance to strobilurins, so growers apply these fungicides only two or three times per season, usually between bloom and veraison.

Strategic Uses of Phosphorous Acid

- Use in rotation or tank-mix to avoid pathogen resistance to strobilurins or protectant fungicides.
- Use during rainy periods when non-systemic fungicides wash off.
- Use close to harvest when other fungicides with long pre-harvest intervals cannot be used.

Metalaxyl and mefanoxam fungicides such as Ridomil Gold MZ, and Ridomil Gold Copper are also very effective against DM but have a long preharvest interval—42 days for Ridomil Gold Copper and 66 days for Ridomil Gold MZ.

Phosphorous acid can provide additional protection for DM during wet growing conditions if tank mixed or rotated with other DM fungicides.

Will Phosphorous Acid Burn Plants?

Research on 'Blanc Du Bois' and 'Lenoir wine grapes shows that phosphorous acid used alone at concentrations of 0.5 percent or less can be applied without causing leaf burn. Concentrations as high as 0.65 percent only rarely burn leaves, but concentrations of 1.0 percent will burn the leaves.

Leaf burn appears as necrotic islands on the corresponding upper and lower surfaces of the leaves or along leaf veins and margins. Necrosis of leaf margins is most severe on the edges nearest the ground indicating that phosphorous acid salts collect there during run-off.

Research has also shown that phosphorous acid can be effective when tank mixed with Mancozeb (Dithane F-45 Rainshield) or Captan (Captac 4L). In testing, a tank mix of 0.625 percent phosphorous acid with the 2 quart/acre rate of Dithane F-45 or Captac 4L did not cause leaf burn even in humid conditions at 90 to 93°F.



Phosphorous acid also effectively lowered the pH of the spray solution. The pH of the well water was 7.07. Additions of ProPhyt reduced the pH to 6.14 at 0.375 percent, 6.04 at 0.625 percent, and 6.00 at 1.0 percent.



Leaf toxicity symptoms on 'Blanc Du Bois' one week after spraying with 1.0% phosphorous acid solution.



Toxicity symptoms on leaf margins of 'Lenoir' one week after spraying with 1.0% phosphorous acid solution

Preventing Leaf Burn with Phosphorous Acid Products

The application rate for many protectant fungicides is expressed as the amount of product per acre. Application rates for phosphorous acid fungicides, on the other hand, are based on the concentration of phosphorous acid in the spray mixture. For these products, you must determine how much water per acre is needed to cover the vines fully and then add the amount of phosphorous acid to the tank mix to reach the desired concentration. Follow the label instructions to avoid salt concentrations that can cause leaf burn.

Trials in Texas showed that phosphorous acid can cause leaf burn at concentrations greater than 0.6 percent, but if you follow the labels of phosphorous acid products, the concentration should not exceed 0.5 percent.

For example, if you mix 4 pints of ProPhyt in 100 gallons of water, the total concentration will be 0.5 percent. Using any less than 100 gallons of water would increase the concentration of phosphorous acid and the risk of leaf burn.

Avoid tank mixing phosphorous acid with copper-based fungicides such as Kocide. In a Texas trial, 0.375 percent ProPhyt solution using well water decreased the solution's pH by nearly one unit. Acidic copper spray mixtures that have a low pH are known to cause leaf burn because copper becomes more available for plant uptake at low pH. Depending on the pH of the final spray solution, phosphorous acid mixed with copper should be tested on a small number of vines or avoided altogether.



When to Spray Phosphorous Acid

To get started, DM infection requires approximately 0.1 inches of rainfall and 52°F or higher. If conditions remain cloudy and damp, lesions can develop within 5 days of initial infection.

Most fungicides are sprayed to control DM before white spores appear on the undersides of leaves or on developing flowers. Once the leaves have lesions that produce and release spores, the disease cannot be controlled using protectant fungicides such as Mancozeb or Captan.

Studies have shown that both phosphorous acid and metalaxyl control DM effectively when applied before infection or within 3 to 4 days after plants are infected. For best results, phosphorous acid should be sprayed just before or just after an infection period, before spores of downy mildew are abundant.

Comparisons of Ridomil Gold Copper to ProPhyt (at 0.375 percent PA concentration) on 'Lenoir' wine grapes have shown that phosphorous acid suppresses the formation of DM spores, but is not as effective as metalaxyl (Ridomil Gold-Copper). As with all other fungicides, do not rely on phosphorous acid alone to eradicate DM.

Eradicating severe DM outbreaks with metalaxyl can be risky given that DM develops resistance to it readily. Spraying Ridomil or any fungicide on a large population of spores increases the chance that a population might become resistant; there is no guarantee that the same approach will work again if the pathogen becomes resistant. Spray programs must be designed to proactively prevent fungal diseases and fungicides with different modes of action should be rotated to discourage fungal resistance.



DM lesion 1 week after treatment with Ridomil Gold Copper.



1 Week after treatment with 0.375% phosphorous acid. Notice spores are still active in this photo.

Phosphorous Acid Rates for Various Tank Sizes

Not all phosphorous acid fungicides contain the same phosphorous acid equivalent. The label recommendations with a given amount of water should yield a solution between 0.4 and 0.6 percent phosphorous acid. Tables 1 and 2 illustrate the difference in mixing rates for two common phosphorous acid products*.

Table 1. Measuring table showing tank size and rates of phosphorous acid needed to produce low, high, and toxic rates of ProPhyt.

Tank size (gallons)	Pints of ProPhyt to produce:		
	Low rate 0.375%	High rate 0.500%	Toxic 1.000%
100	3	4	8
75	2.25	3	6
50	1.5	2	4
25	0.75	1	2

Table 2. Measuring table showing tank size and rates of phosphorous acid needed to produce low, high, and toxic rates of Rampart.

Tank Size (gallons)	Pints of Rampart to produce:		
	Low rate 0.375%	High rate 0.500%	Toxic 1.000%
100	3.23	4.31	8.62
75	2.43	3.23	6.46
50	1.62	2.15	4.31
25	0.81	1.08	2.15

*Rates are slightly higher for Rampart because it has 3.9 lbs/ gallon phosphorous acid equivalent. ProPhyt has 4.2 lbs/gallon phosphorous acid equivalent.

The Bottom Line

Phosphorous acid fungicides are a good option for controlling DM early in the growing season. They are especially useful later in the season when long preharvest intervals preclude using other DM products.

Rotating these products early in the season or tank mixing them with protectant fungicides can provide additional systemic control of DM before bloom. Using phosphorous acid mixed with strobilurins midseason may reduce resistance development by varying the modes of action.

During dry weather, DM prevention with Mancozeb or Captan is typically sufficient. Before or during rainy conditions, phosphorous acid products can be tank mixed with Mancozeb or Captan, or sprayed alone to control DM.

Mix phosphorous acid fungicides to appropriate concentrations to avoid burning grape plants and apply them just before or just after a DM infection period. Some phosphorous acid products are not compatible with surfactants, so read the label for proper mixing instructions.

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