

# A description of Currently Available Fungicides for Grape Disease Control

by Mike Ellis, Department of plant Pathology, The Ohio State University, OARDC/OSUE

## Fungicides for Controlling Black Rot

### Protectants

**Mancozeb**, **Ferbam**, and **Ziram** are all highly effective against black rot. Because these fungicides are strictly protectants, they must be applied before the fungus infects or enters the plant. They protect fruit and foliage by preventing spore germination. They will not arrest lesion development after infection has occurred.

**Mancozeb** provides an excellent foundation for a protectant spray program for grapes in the Midwest. It is a good protectant fungicide that will provide good to excellent control of downy mildew and Phomopsis cane and leaf spot in addition to black rot. The major problem with Mancozeb is a 66-day pre harvest interval (PHI) on grapes. It cannot be applied within 66 days of harvest. Mancozeb is available under many trade names and formulations. Some common trade names are Manzate 200, Manzate Prostick, Penncozeb, Dithane M45, Dithane F45, and Dithane Rainshield DF. There are many others

Some food processors may not accept Mancozeb-treated fruit or may have special restrictions on its use. This also applies to Captan. Growers need to know where they will sell their fruit and if the buyer has any restrictions on pesticide use prior to initiating a control program in the spring.

**Ziram** is similar in efficacy to Ferbam. It is highly effective against black rot and provides moderate control of downy mildew and Phomopsis cane and leaf spot.

Growers of processing grapes who cannot apply Mancozeb past the initiation of bloom could use Ziram during this period. Ziram can be applied up to 21 days before harvest.

**Ferbam** will provide excellent control of black rot but is not highly effective against the other grape diseases. In addition, there are restrictions on the number of applications that can be used. Always read and understand the label before using or purchasing a pesticide.

**Captan** and **copper fungicides** (fixed copper or Bordeaux mixture) are only slightly to moderately effective against black rot and will probably not provide adequate control under heavy disease pressure.

### Sterol Inhibiting (SI) Fungicides

The locally systemic fungicides, Nova (Rally), Mettle, and Revis Top are also highly effective against black rot and will provide some post-infection (curative) activity of the disease if applied at the higher labeled rates within 72 to 96 hours after the initiation of an infection period. Post-infection or curative control must be achieved prior to symptom development on leaves or fruit. Once the symptoms are present, these fungicides will not eradicate or burn out the fungus. Nova (Rally), Mettle and Revis Top also appear to

provide good protectant activity against black rot if applied at the lower labeled rates in a protectant program. These fungicides also have had excellent activity against powdery mildew as well.

**Note:** Revis Top is a package mix containing two fungicide (difenoconazole, which is an excellent sterol-inhibiting fungicide and Revis, which is for control of Downy mildew only). Revis Top will provide excellent control of Black rot, powdery mildew, downy mildew and anthracnose.

**Vintage** is another SI fungicide that is registered for use on grapes and will provide moderate control of black rot if applied in a protectant program. This fungicide is in the same general class of fungicides as Nova (Rally), Mettle and Revis Top; however, it does not provide adequate curative or post-infection control of black rot. Nova (Rally), Mettle and Revis Top are the preferred SI fungicides for black rot control.

### **Strobilurin Fungicides**

Abound, Sovran, Flint, and Pristine are locally systemic fungicides that are all highly effective for control of black rot. They do differ in their efficacy against some of the other important grape diseases.

**Note:** Flint or Pristine cannot be applied on Concord grapes or phytotoxicity (damage) could occur. Always read the fungicide label carefully.

## **Fungicides for Powdery Mildew**

### **Protectants**

**Sulfur** is highly effective against powdery mildew if used in a protectant program with a minimum of seven to 14 days between applications.

There are many formulations of sulfur (wetable powders, dusts, dry flowables, and flowables). The flowable formulations appear to be most effective and result in much less applicator exposure when preparing sprays.

**Note:** On sulfur-tolerant cultivars that are susceptible to powdery mildew, sulfur will probably be a major component of the fungicide program. On highly susceptible cultivars, spray intervals shorter than 14 days (7 to 10 days) will probably be required with sulfur. Although sulfur is highly effective for powdery mildew control, it has little or no effect on the other grape diseases. It is important to remember that sulfur will cause severe injury on some grape cultivars. Sulfur should only be used on cultivars known to be sulfur tolerant .

**Note:** Chancellor, Concord, DeChaunac, Foch, and Rougeon grapes are highly sensitive to sulfur. Sulfur injury may occur even on sulfur-tolerant cultivars when temperatures of 80 to 85°F or higher are experienced during or immediately after application.

**Copper fungicides** (fixed coppers or Bordeaux mixture) have been rated moderately effective against powdery mildew; however, care must be taken when using copper due to the danger of foliage injury (phytotoxicity). Grape cultivars differ in their sensitivity to copper fungicides. Under heavy disease pressure, copper fungicides may not provide adequate control. Copper is not the preferred fungicide for powdery mildew control. However, if copper is applied for downy mildew control, it will provide some protection

against powdery mildew. On less susceptible cultivars, such as Concord, copper fungicides may provide satisfactory control.

### **Sterol Inhibiting (SI) Fungicides**

**Nova (Rally), Vintage, Mettle and Revis top** are locally systemic and highly effective for control of powdery mildew. They will also provide good to excellent control of black rot, but they will not control downy mildew. All of these fungicides were highly effective against powdery mildew when they were first introduced; however, due to development of fungicide-resistant strains of the powdery mildew fungus, they are no longer recommended for powdery mildew control in vineyards where resistant strains of the powdery mildew fungus are present (see note on fungicide resistance development on page 11).

**Note:** Revis Top is a package mix containing two fungicides (difenoconazole, which is an excellent sterol-inhibiting fungicide and Revis, which is for control of Downy mildew only). Revis Top will provide excellent control of Black rot, powdery mildew, downy mildew and anthracnose.

### **Strobilurin Fungicides**

**Abound, Sovran, Flint, and Pristine** are locally systemic and all were good to excellent for control of powdery mildew when they were first introduced. Fungicide resistance development in powdery mildew has been observed in the strobilurin fungicides (see note on fungicide resistance development on page 6).

**Note:** Flint or Pristine cannot be applied on Concord grapes or phytotoxicity (damage) can occur. Always read the fungicide label carefully.

**Endura 70WG Fungicide** is new fungicide chemistry and is highly effective for control of powdery mildew and provides good control of Botrytis bunch rot. It is different chemistry from the sterol-inhibiting and strobilurin fungicides; therefore, it is an excellent material to use in rotation with these materials in a fungicide resistance management program.

**JMS Stylet-Oil** is a highly refined petroleum distillate that is registered for use on grapes in the United States. It has provided excellent powdery mildew control in fungicide tests in Ohio and New York and is currently being used rather extensively by California grape growers for powdery mildew control. It is registered for use at the rate of 1 to 2 gallons oil per 100 gallons water (1% to 2% concentration). The label states on grapes: "Make first application pre-bloom and continue sprays every two to three weeks depending on level of disease pressure. Use higher rates and shorter spray interval when disease conditions are severe."

**Note:** One potential problem with stylet oil is that it removes the "bloom" or waxy coating from the grape berry. This apparently has no effect on quality of wine or juice grapes, but it does affect the appearance of the berry and probably should not be used for fresh-market table grapes.

**Note:** DO NOT use CAPTAN or SULFUR within two weeks after applying JMS STYLET- OIL. Mixing Captan or Sulfur with oil could result in severe damage to the

vine. In addition, repeated use of oil during the growing season has been shown to be phytotoxic to vines.

### **Potassium Salts**

Armicard 100 (potassium bicarbonate) and Nutrol (manopotassium phosphate) have been reported to provide fair control of powdery mildew on grape but provide no control of the other grape diseases. It is assumed that they provide control through limited eradication and antispore activity. They do not provide protectant activity.

### **Quintec**

Quintec 2.08SC is new fungicide chemistry that is very effective for control of powdery mildew but has no activity against the other grape diseases. It is a protectant fungicide so it must be applied before infection occurs. It does not have curative activity. It is registered for use at the rate of 3 to 4 fluid ounces per acre on a seven- to 14-day schedule. Because it is new chemistry (not related to other fungicides), it will control strains of the powdery mildew fungus that are resistant to the strobilurin fungicides (Abound, Sovran, Flint, and Cabrio) and the sterol-inhibiting fungicides (Nova, Elite, Procure, and Rubigan). Quintec has a 12-hour re-entry interval and a 14-day preharvest interval.

**Torino 0.85 liquid (contains 0.85 % cyflufenamide per gallon)** is a new fungicide (registered in 2012) for control of powdery mildew **only** on grapes. It has been reported to be highly effective for control of powdery mildew. It is used at the rate of 3.4 fluid ounces per acre.

**Vivando 2.5 liquid** is a new fungicide (registered in 2011) for control of powdery mildew **only** on grapes. It has been reported to be highly effective for control of powdery mildew. It is used at the rate of 10.3 to 15.4 fluid ounces per acre.

## **Fungicides for**

### **Phomopsis Cane and Leaf Spot**

At present, **Mancozeb**, **Captan**, or **Ziram** are the fungicides recommended for control of this disease. They are ranked as moderately to highly effective.

Fungicide test results indicate that the sterol inhibitors are not effective and the strobilurins only provide moderate control. Copper and sulfur fungicides appear to be ineffective.

**Note:** Especially where Phomopsis is a problem or a concern, Mancozeb, Captan, or Ziram should be included in the early-season fungicide program.

The strobilurin fungicides (Abound) will provide some level of phomopsis control, but they are not as effective as the protectants discussed above and are more expensive.

## **Fungicides for Downy Mildew**

### **Protectant Fungicides**

**Mancozeb, Captan, and Copper fungicides** (fixed coppers and Bordeaux mixture) are highly effective for control of downy mildew. Ziram is moderately effective. All of these fungicides are effective only when used in a protectant spray program. They will not provide post-infection or curative activity and will not eradicate or burn out the fungus after symptoms appear.

Of the protectant fungicides currently available, **Mancozeb** is an excellent choice. Mancozeb is highly effective against downy mildew, black rot, and Phomopsis cane and leaf spot. One problem with Mancozeb is that it cannot be applied within 66 days of harvest. Even with this restriction, Mancozeb is an excellent protectant fungicide for early-season disease control and can also be used on later-maturing cultivars for post-bloom disease control (prior to 66 days of harvest).

**Captan** is also excellent for downy mildew and Phomopsis cane and leaf spot but is weak for controlling black rot. A good approach to using Mancozeb and Captan for downy mildew control is to use Mancozeb early in the season then switch to Captan within the 66-day preharvest interval for Mancozeb. Currently Captan does not have a preharvest interval for grapes.

**Note:** Although Captan has no preharvest interval on grapes, it does have a four-day reentry restriction. The following information is taken from the Captan label: “Do not allow persons to enter treated areas within four days following application unless a long-sleeved shirt and long pants or a coverall that covers all parts of the body except the head, hands, and feet, and chemically resistant gloves are worn. Conspicuously post reentry information at site of application.” Remember, always read the label.

**Ziram** is similar in efficacy to Ferbam. It provides only moderate control of downy mildew, and excellent control of black rot and Phomopsis cane and leaf spot. Under heavy disease pressure, Ziram may not provide adequate control of downy mildew.

### **Locally Systemic Fungicides with Curative Properties**

**Ridomil Gold MZ and Ridomil Gold/Copper** are by far the most efficacious fungicides available for control of downy mildew. Ridomil is locally systemic and has good post-infection or curative activity. If used in post-infection control programs, it should be applied as soon as possible, *but within* two to three days after the initiation of an infection period. Ridomil **should not be** applied after symptom development (sporulating lesions). Use of Ridomil in this manner (as an eradicant) will probably lead to a rapid buildup of Ridomil-resistant strains of the downy mildew fungus in your vineyard. If resistance develops in the vineyard, the use of Ridomil as a tool for downy mildew control is lost.

Ridomil also has excellent protectant activity against downy mildew. It should provide at least two weeks of protection, and in some tests in Ohio, it has provided up to three weeks of protection.

As mentioned previously, Ridomil Gold has a strong potential for fungicide resistance

development by the downy mildew fungus. For this reason, the manufacturer (Syngenta) has registered its use only as a **Package Mix** with a protectant fungicide. The two formulations available for use on grapes are Ridomil Gold MZ (4% Ridomil and 64% Mancozeb) and Ridomil Gold/Copper (5% Ridomil and 60% Copper hydroxide). The purpose of the package mix (at least in theory) is to delay the development of strains of the downy mildew fungus with resistance to Ridomil. Both formulations are equally effective for controlling downy mildew. The Ridomil Gold MZ formulation should be used on copper sensitive cultivars.

Although Ridomil is very effective, the current label use recommendations restrict the timing of its use on grapes. Ridomil Gold MZ cannot be applied within 66 days of harvest. Ridomil Gold Copper has a 42-day PHI (can be applied up to 42 days of harvest). Based on the 42 and 66-day preharvest interval, Ridomil will be of limited use for late season downy mildew control in the Midwest. In seasons when downy mildew is a problem and on highly susceptible cultivars, pre-bloom and post-bloom applications of Ridomil will aid greatly in disease control. However, additional fungicide protection may be required within the 42 and 66-day preharvest interval on late-harvested, highly susceptible cultivars. The alternative fungicides for use during this period are Captan, copper fungicides, phosphorus acid fungicides, or the strobilurin fungicides Abound or Pristine.

**Strobilurin fungicides** are also locally systemic, and some have had good to excellent activity against downy mildew (see note on fungicide resistance development on page 6). Whereas the strobilurins (Abound, Pristine, Sovran, and Flint) all have good to excellent activity against black rot and powdery mildew, they vary greatly in their efficacy against downy mildew. Abound and Pristine have excellent activity and are the most effective for downy mildew control. Sovran is moderately effective if used at the highest labeled rate, and Flint is registered for “suppression” of downy mildew, not control.

### **Phosphorous Acid**

**(Agri-Fos, ProPhyt, Phostrol, Rampart, Topas, Aliette , there are many others)**  
Several products containing phosphorous acid (PA, also called phosphite or phosphonate) are sold as nutritional supplements and plant conditioners. Recently several of these materials have been registered in the United States as fungicides for control of downy mildew on grape. In multiple New York trials, PA has provided excellent control of downy mildew but has not controlled any other grape disease. Australian experience suggests that PA provides most control on *foliage* when it is applied within a few days after the start of an infection period, providing only a few days of additional residual (protective) activity. Experience in New York suggests that spray timing is less critical for control of downy mildew on *fruit*, perhaps because this highly mobile chemical (which is exempt from residue tolerances) accumulates in these organs. When applied on a seven to 10-day protectant program, they appear to provide good to excellent control of downy mildew.

**Copper fungicides** are highly effective against downy mildew and are moderately effective against powdery mildew. Copper fungicides are weak for controlling black rot. A major concern with the use of copper fungicides is the potential they have for

phytotoxicity or vine damage. Grape cultivars differ in their sensitivity to copper fungicides.

**Note:** Certain food processors, such as the National Grape Cooperative, will not accept grapes treated with Mancozeb past the initiation of bloom, and the use of Captan is not permitted at any time. If growers cannot use Mancozeb or Captan, Ridomil Gold/Copper, copper fungicides, a phosphorus acid fungicide, or a strobilurin fungicide are the other alternatives for downy mildew control. Thus, copper may be an important fungicide for producers of processing grapes that have these fungicide use restrictions.

### **Four new fungicides were recently registered for control of downy Mildew. They are: Revus , Presidio, Ranman and Forum**

All of these fungicides have good to excellent activity against downy mildew and all have different modes of action against the downy mildew pathogen. This is an important point for fungicide resistance management. They can be used in alternating (two block) spray programs with each other and any of the previously mentioned fungicides that are at risk for resistance development in the downy mildew fungus.

Revus (mandipropamid) is used at the rate of 8 fl oz/A and has a PHI of 14 days, Presidio (fluopicolide) is used at the rate of 3 to 4 fl oz/A and has a PHI of 21 days, RANMAN (cyazofamid) is used at the rate of 2.1 to 2.75 fl oz/A and has a PHI of 30 days, and Forum (dimethamorph) is used at the rate of 6 oz/A and has a PHI of 28 days.. The 14 day PHI for Revus makes it an attractive option if downy mildew control is required close to harvest. It is very important to remember that these materials will need to be tank mixed with other fungicides because they will not provide adequate control of powdery mildew, black rot or any other grape diseases (Table 1).

#### **Revis Top**

**Note:** Revis Top is a package mix containing two fungicide (difenoconazole, which is an excellent sterol-inhibiting fungicide and Revis, which is for control of Downy mildew only). Revis Top will provide excellent control of Black rot, powdery mildew, downy mildew and anthracnose.

### **Fungicides For Anthracnose**

Fungicide recommendations for anthracnose control consist of a dormant application of Liquid Lime Sulfur in early spring, followed by applications of foliar fungicides during the growing season.

#### **Dormant application of liquid lime sulfur**

**Liquid lime sulfur (29% calcium polysulfide)** is applied at the rate of 10 gallons per

acre in sufficient water to obtain good coverage. **"I believe that this is the most important spray for controlling this disease"**. At this rate, lime sulfur will burn grape tissue so it should not be applied past bud swell. The dormant spray should be made in early spring just prior to bud swell. Remember that this high rate is intended to "burn out" over wintering inoculum on infected canes. If It Is applied to green tissue, it will burn it. In Ohio vineyards where the disease has become a problem, the dormant spray of lime sulfur has done a good job of getting it under control.

**Sulforix (27.5% calcium polysulfide)** is applied at the rate of one gallon per acre in sufficient water to obtain good coverage. Obviously, Sulforix is applied at one tenth the rate of liquid lime sulfur. The lower rate is supposed to be due to its formulation. The formulation of Sulforix is said to allow the material to "penetrate" plant tissues better; therefore it can be used at the much lower rate. The 10 gallon per acre rate of liquid lime sulfur has been the proven material for many years. I have not seen data that provide a direct comparison of 10 gallons per acre of liquid lime sulfur with one gallon per acre of Sulforix. However, it is apparently being used by some grape growers and on other crops such as blueberry as a dormant spray at the one gallon per acre rate and seems to be providing control. For small growers that are using a back pack or hand held sprayer, Sulforix is an attractive option because it can be purchased in a one gallon container. For large commercial growers liquid lime sulfur Is generally purchased in a 55 gallon drum. It can be purchased in a 5 gallon container, but is much more expensive.

## **Foliar fungicides**

Foliar fungicides applied during the growing season will provide additional control. Early season applications are important to keep the disease from getting established on new tissues. As leaves and canes get mature (fully expanded) they become resistant to infection; however, new leaves and succulent cane tips are susceptible throughout the season, and berries remain susceptible until *Véraison*. Although some susceptible tissue will be present later in the growing season, early season control is critical in managing the disease. Early season infections will produce additional spores (inoculum) that will spread the disease later in the growing season.

Data on the efficacy of foliar fungicides is generally lacking. I think this is largely due to the fact that the disease does not occur commonly in most vineyards on a year to year basis as do the other important grape diseases such as black rot, powdery and downy mildew. It is highly probable that the fungicide programs that Ohio growers are using to control the other major grape diseases (Phomopsis, black rot, powdery mildew and downy mildew) are also providing good control of anthracnose. Thus, we do not see the disease that often.

In fungicide trials conducted in Michigan, **mancozeb, captan, and ziram** provided a

significant level of disease control and are generally rated as moderately effective for anthracnose control. The **strobilurin fungicides, Pristine and Sovran** also provided a good level of control. In an Ohio fungicide trial in 2011, an experimental sterol-inhibiting fungicide provided excellent anthracnose control; therefore, the **sterol-inhibiting fungicides registered for use on grapes (Rally, Mettle, Revus Top and Vintage)** should provide a good level of anthracnose control.

At present, my foliar fungicide of choice for early season control of anthracnose would be mancozeb. In addition to providing some level of anthracnose control, it also provides excellent control of black rot, Phomopsis cane and leaf spot and downy mildew. It is important to remember that foliar fungicides will probably not provide satisfactory control unless they are used in conjunction with the dormant application of Liquid Lime Sulfur or Sulforix.

## **Botrytis Bunch Rot**

Vanguard, Elevate, Endura, Scala, Rovral, Pristine and Switch all have excellent activity against Botrytis bunch rot on grapes and are the fungicides of choice for control of Botrytis bunch rot. The strobilurins are moderately effective against Botrytis. Botrytis bunch rot is most commonly a problem on tight-clustered French hybrids and *Vitis vinifera* cultivars.

Proper timing and thorough spray coverage are essential for good control. Make at least two applications:

- When the disease is first observed or when the first berries reach 5°Brix (5% soluble solids/sugars), whichever comes first.
- Fourteen days after the first application. A third spray may be necessary on late cultivars, *e.g.*, White Riesling, if the interval between the second spray and harvest is greater than four weeks.

Field experience suggests that effectiveness of the fungicide is reduced following a heavy prolonged rainfall. If such conditions occur after the last intended spray has been made, an additional application may be necessary. If only one application can be made, wait until the crop average is 5°Brix. Direct the spray toward the fruit; use a minimum of 100 gallons of water/acre.

The importance of bloom sprays for control of Botrytis bunch rot is not clear; however, during seasons with wet conditions during bloom, fungicide application during bloom is probably beneficial. Research in New York has shown that the strobilurin fungicides have moderate to good efficacy for Botrytis control. The use of a strobilurin fungicide during the bloom period may be beneficial for Botrytis control, especially on highly susceptible cultivars. In addition, a strobilurin fungicide such as Abound or Pristine during bloom will provide excellent control of black rot, powdery mildew, and downy mildew as well.

**Note:** Growers in Europe and Canada have experienced loss of disease control due to the development of fungicide resistance when more than three sprays per year of Rovral were

applied over a period of three to five years. It is, therefore, strongly recommended that the use of Rovral, Endura, Vanguard, or Elevate be limited to a maximum of two to three applications per year to reduce the probability of developing strains of *Botrytis* that are resistant to this material. In addition, alternating these fungicides during the growing season or from season to season should be helpful in fungicide-resistance management.

**Note:** Removal of leaves around clusters on mid- or low-wire cordon-trained vines before bunch closing has been shown to reduce losses caused by *Botrytis* due to improved air circulation and improved spray penetration and coverage.

## **New Fungicide Combinations (Package Mixes) that Provide Control of Multiple Diseases**

**Inspire super- (Syngenta Crop Protection)** was recently registered on grape and is a package mix of difenoconazole ( a sterol inhibiting fungicide) and cyprodinil (Vanguard). It will provide excellent control of black rot and powdery mildew. See the note below on fungicide resistance.

**Revis Top- (Syngenta Crop Protection)** was recently registered on grape and is a package mix of Revis (mandipropamid) and difenoconazole (a sterol inhibitor). It will provide excellent control of black rot, powdery mildew and downy mildew. See note below on fungicide resistance.

### **Special comment on Revis Top**

Do not apply Revis Top to “Concord” grapes. In 2010, severe phytotoxicity (leaf burning) was observed on Concord grapes at several locations. Do not apply Revis Top to other American Type grapes (*labrusca*, *labrusca* hybrids, and other non *vinifera* hybrids) where sensitivity is unknown. Phytotoxicity appears to be worse when Revis Top is tank mixed with foliar fertilizers or adjuvant that increases the rapid uptake of chemicals by leaves. Thus far, *vinifera* grapes and French-American hybrids (Seyval, Vidal and others do not appear to be sensitive to Revis Top.

**Quadris Top- (Syngenta Crop Protection)** was recently introduced and is a combination of Quadris (Abound) and Revis. It should provide excellent control of black rot, powdery and downy mildew. It will only provide excellent control of powdery mildew and downy mildew where resistance to the strobilurins is not present. It will also provide some suppression of *Phomopsis* and *Botrytis*. See the note below on fungicide resistance.

**Switch-(Syngenta Crop protection)** has been registered on several small fruit crops for several years for control of *Botrytis* fruit rot and other diseases. It is a combination of Vanguard (cyprodinil) and fludioxonil. It should provide good to excellent control of *Botrytis* bunch rot, but will not control other grape diseases.

## **IMPORTANT NOTE on POWDERY and DOWNY MILDEW FUNGICIDE RESISTANCE**

### **Powdery Mildew**

In some locations the powdery mildew fungus has developed resistance or reduced sensitivity to the sterol-inhibiting fungicides (Nova (Rally), Rubigan, Elite, Mettle, and Inspire Super (difenoconazole) and the strobilurin fungicides ( Abound, Sovran and Flint). All of these materials were highly effective for control of powdery mildew when they were first introduced. In vineyards where these materials have been used for several years, reduced sensitivity or resistance may be present. In some vineyards, all of these materials may still be effective; however, at present there is no way to know the level of resistance that is in your vineyard. Having a control failure and crop loss due to fungicide resistance is a hard way to discover you have resistance. Reports from Virginia suggest that resistance may develop after as few as 10 applications of the material over the life of the vineyard. If these materials have been used in a vineyard on a regular basis for several years, growers should consider not using these materials alone for powdery mildew control. If resistance is a concern, they should be replaced or mixed with a sulfur fungicide, JMS Stylet Oil, Quintec, Endura, or potassium salts (table 1). Pristine is a combination of a strobilurin fungicide plus Endura; therefore, it should be safe to use alone for powdery mildew control. Sulfur fungicides are very effective for control of powdery mildew, relatively inexpensive, and are not at risk for resistance development. On sulfur tolerant varieties, the use of sulfur should be considered.

### **Downy Mildew**

The strobilurin fungicides (Abound, Sovran and Pristine) provided good to excellent control of downy mildew when they were first introduced. Several reports from various areas in Europe and, most recently from Virginia indicate that the downy mildew pathogen has developed resistance, or is at least less sensitive, to the strobilurin fungicides. Growers should consider not using strobilurin fungicides for downy mildew control. If these products are used to control other diseases and downy mildew control is required, they should be tank mixed with another fungicide with activity against downy mildew. Alternative downy mildew fungicides include: Mancozeb, Captan, Ridomil Gold MZ, Ridomil Gold Copper, Revis, Presidio, Forum, RANMAN, a copper fungicide or a phosphorous acid (phosphite) fungicide. Pristine still provides good control of powdery mildew when used alone and was the only material that would control almost all of our major disease when used alone. Unfortunately, it should now be combined with a downy mildew fungicide when downy mildew control is required.

### **To Aid in Resistance Management**

Do not apply more than two sequential sprays of any material that is at risk for resistance development, before alternating to a fungicide with a different mode of action. In addition, the less a specific fungicide or class of fungicide is used in a vineyard, the less likely for resistance to develop to it. Most of the fungicides that are at risk for resistance development have a limited number of applications that can be made per season. **Always read the label.**

Other grape diseases (fungi) and fungicides that are at high risk for fungicide resistance development include Botrytis bunch rot (Vanguard, Endura, Elevate, Rovral, Topsin, Scala and Switch).

**Table 1. Effectiveness of Fungicides for the Control of Grape Diseases**

<b>Fungicide</b>	<b>Phomopsis cane and leaf spot</b>	<b>Black rot</b>	<b>Downy mildew</b>	<b>Powdery mildew</b>	<b>Botrytis rot</b>	<b>Bitter rot</b>
Abound	+	+++	+++ (FRP)	+++ (FRP)	++ (FRP)	?
Adament	+	+++	+ (FRP)	+++ (FRP)	0	0
Bayleton	0	+++	0	+++ (FRP)	0	0
Captan	+++	+	+++	0	+	++
Elevate	0	0	0	0	+++ (FRP)	0
Elite	0	+++	0	+++ (FRP)	0	0
Endura	0	0	0	+++ (FRP)	++ (FRP)	0
Ferbam	+	+++	+	0	0	++
Fixed copper and Lime	+	+	+++	++	+	+
Flint	+	+++	+ (FRP)	+++ (FRP)	++ (FRP)	0
Forum	0	0	+++	0	0	0
Inspire Super	0	+++	0	+++ (FRP)	0	0
JMS Stylet Oil	0	0	0	+++	0	0
Mancozeb	+++	+++	+++	0	0	++
Mettle	0	+++	0	+++ (FRP)	0	0
Nova	0	+++	0	+++ (FRP)	0	0
Potassium salts	0	0	0	++	0	0
Phosphorous acid	0	0	+++	0	0	0
Presidio	0	0	+++ (FRP)	0	0	0
Pristine	++	+++	+++ (FRP)	+++	++	?
Procure	0	++	0	+++ (FRP)	0	0
Quadris Top	+	+++	+++ (FRP)	+++ (FRP)	+	++

Fungicide	Phomopsis cane and leaf spot	Black rot	Downy mildew	Powdery mildew	Botrytis rot	Bitter rot
Quintec	0	0	0	+++ (FRP)	0	0
RANMAN	0	0	+++	0	0	0
Revis	0	0	+++	0	0	0
Revis Top	0	+++	+++	+++ (FRP)	0	0
Ridomil Gold MZ	+	++	+++	0	0	++
Ridomil Gold Copper	+	+	+++	++	+	+
Rovral	0	0	0	0	+++	0
Rubigan	0	++	0	+++ (FRP)	0	0
Scala	0	0	0	0	+++ (FRP)	0
Sovran	+	+++	++ (FRP)	+++ (FRP)	++ (FRP)	0
Sulfur	+	0	0	+++	0	0
Switch					+++ (FRP)	
Topsin M <sup>1</sup>	++	+	0	+++ (FRP)	++ (FRP)	++
Torino	0	0	0	+++ (FRP)	0	0
Vangard	0	0	0	0	+++ (FRP)	0
Vivando	0	0	0	+++ (FRP)	0	0
Ziram	++	+++	++	0	0	0

Key to ratings: +++=highly effective; ++=moderately effective; +=slightly effective; 0=not effective;?=effectiveness unknown or not established;

FRP=Fungicide Resistance Possible, especially if the material has been used in the vineyard for several years. Generally, if they have not been used extensively, resistance may not be a problem.

<sup>1</sup>Where Topsin M-resistant strains of the powdery mildew and Botrytis fungi have been detected, Topsin M will be ineffective and should not be used.

