Great Lakes Fruit, Vegetable & Farm Market EXPO
December 5-7, 2006
DeVos Place Convention Center, Grand Rapids, MI

Wine Grape

Wednesday morning 9:00 am

Where: Grand Gallery (lower level) Room D

Summary: This workshop will concentrate on vineyard factors affecting wine grape quality and what

Recertification credits: 1 (1C, Comm CORE, Priv CORE)

CCA Credits: PM(1.0) CM(1.0)

Moderator: David Miller, St Julian Wine Company, Paw Paw, MI

9:00 a.m. Development and Evaluation of Crown Gall-free (Agrobacterium Vitis) "White Riesling",

Tom Zabadal, SWMREC, MSU Extension

9:20 a.m. Systemic Insecticides for Selective and Targeted Insect Control in Michigan Vineyards

Rufus Isaacs, Entomology Dept., MSU

9:40 a.m. Strategic Grape-pest Chemical Screening Program for IR-4 Registration of Promising

John Wise, MSU Trevor Nichols Research Station

10:00 a.m. Improving Control of Phomopsis Fruit Rot in "Vignoles" Grapes

Annemiek Schilder, Plant Pathology Dept., MSU

10:20 a.m. Powdery Mildew Control in Wine Grapes

Wayne Wilcox, Cornell University, NY State Agr Expt Station, Geneva, NY

10:40 a.m. Controlling Bunch Rots in Wine Grapes

Wayne Wilcox, Cornell University, NY State Agr Expt Station, Geneva, NY

Development and Evaluation of Crown Gall-Free *(Agrobacterium vitis)* 'White Riesling', 'Chardonnay' and 'Cabernet franc' Grapevines

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Wine grape production in many of the viticultural regions of the eastern United States has steadily increased its focus on *Vitis vinifera* cultivars, which are notorious for winter injury. Therefore, winter injury to grapevine trunks of these cultivars is a common and increasing hazard. The development of crown gall on such winter-injured trunks is caused by the bacterial pathogen *Agrobacterium vitis*. The galling caused by this disease becomes a permanent genetic alteration of vine tissues, thus greatly increasing the impact of the original winter injury event. Frequently the initiation of such galling at the base of vines is an indication that as the galling expands it will ultimately cause the death of the vine. It is now known that the pathogen causing this problem is not ubiquitous in soils, but is widely distributed in the grapevine tissues of commercial vineyards. However, it is also known that it is possible to develop through tissue culture, vines free of this pathogen and there is an expectation that they will remain free of the pathogen as long as they do not come in contact with contaminated vine tissues. Therefore, grapevines of the three most commercially important *Vitis* vinifera cultivars in eastern U.S. viticulture and the principal rootstock in eastern U.S. viticulture were established through tissue culture to be free of *Agrobacterium vitis*. These vines were established in a mother vineyard and indexed. Tissues from these vines were utilized to create a population of vines that are currently being evaluated in several locations in New York, Pennsylvania, Ohio, Indiana and Michigan. Will these vines remain free of crown gall? Will these vines tolerate episodes of vine winter injury better than vines with crown gall? Research in progress will help to answer these questions.

Powdery Mildew Control in Wine Grapes

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Powdery mildew (PM) is the most consistently-important disease of *V. vinifera* grapes throughout the world, and is a serious problem on some hybrids with significant *vinifera* parentage. Following is a review of the basics and a summary of new research information on disease biology, PM fungicides, and disease control considerations.

(i) The fungus overwinters as minute fruiting bodies (cleistothecia) that form on leaves and clusters during late summer and autumn, then wash onto the bark of the trunk where they survive the winter. Spores produced within these cleistothecia are discharged between bud break and bloom (roughly) to initiate the disease, after which it can spread rapidly from the millions of new spores produced from these "primary" infections. Thus, the amount of fungus capable of starting disease this year is directly proportional to the amount of disease that developed last year. <u>An important consequence of this is that PM sprays during the first few weeks after bud break are likely to be far more important in blocks where PM was a problem last year than in blocks that remained relatively clean into September.</u>

A case study: in 2002 we conducted an experiment in a NY Chardonnay vineyard where we either (a) sprayed through Labor Day, maintaining a clean canopy throughout the year; (b) quit spraying a month earlier, simulating a vineyard with moderate levels of PM by the end of the season; or (c) quit spraying in early July, simulating a vineyard where PM control got away from us. The next spring, the levels of cleistothecia (number per kg of bark) in these respective treatments were (a) 1,300; (b) 5,300; and (c) 28,700. Now, consider the case where approximately 20% of the overwintering spores are discharged during the first couple of weeks after bud break. In the clean treatment (a), this number might be relatively inconsequential, whereas in dirtier treatment (b) it's equal to the entire seasonal supply on the clean vines, and in treatment (c) it's four to five times the whole seasonal supply on the clean vines. Thus, when we intentionally withheld a modest spray program on these same vines until the immediate prebloom period the following year, the resulting cluster area infected was (a) 11%, (b) 22%, and (c) 48%, respectively, even though all were sprayed the same. Higher disease in 2002 = More primary infections during the Spring of 2003 = More new ("secondary") spores once fruit were present and susceptible to infection = Higher disease pressure, “overwhelming” the minimal fungicide program.

(ii) Powdery mildew functions as a “compound interest” type of disease, that is, a few infections can “snowball” into many over a short period of time if conditions are favorable. The most important factor governing the rate of reproduction is temperature, with a new generation of the fungus produced every 5 to 7 days while temperatures remain between the mid-60's and mid-80's (Table 1). Thus, warm days and nights during the bloom and early post-bloom period, when fruit are highly susceptible to infection, provide ideal conditions for the fungus 24 hr a day. Spray programs may need to be intensified with respect to materials, rates, and intervals in years when this happens.

(iii) Although not as important a factor as temperature, high humidity also increases disease severity. The optimum relative humidity is about 80 - 85%, although the disease functions to some extent over the entire range of humidities that we experience. Nevertheless, vineyard sites (and canopies) subject to poor air circulation and higher humidities are at higher risk for PM development.

Table 1. Approximate generation time for powdery mildew at different average temperatures

Temp (°F)	Days	Temp (°F)	Days
44	32	63	7
48	25	74	6
52	16	79	5
54	18	86	6
59	11	90	--[a]

[a] Little or no disease development while temperatures remain above 90°.

(iv) Berries are extremely susceptible from the immediate pre-bloom period through fruit set. On Concord and similar cultivars, they become highly resistant to immune about 2 weeks later, but on all *V. vinifera* cultivars studied, berries maintain some susceptibility for about 4 weeks after bloom. Thus, the immediate prebloom through early postbloom period is the CRITICAL time to control this disease. Use your best materials and spray techniques then, and tighten spray intervals as appropriate for weather conditions and cultivar susceptibility. DON'T CHEAT!

(v) Failure to control inconspicuous PM infections on the berries can increase the severity of berry rots (Botrytis and sour rot) at harvest, and can promote the growth of wine-spoilage micro-organisms such as *Brettanomyces* on the fruit. This is just one more reason to strive for excellent PM control on susceptible wine grapes throughout the first month after bloom.

(vi) Powdery mildew is a unique disease in that the causal fungus lives almost entirely on the surface of infected tissues, sending little "sinkers" just one cell deep to feed. This subjects the non-pigmented fungus to the dangers of "sunburn" if it is well exposed to solar radiation. Observant growers have long noticed that PM is most severe in parts of the vineyard that are regularly shaded, e.g., near tree lines and in the centers of dense canopies.

Recently, we began looking at this phenomenon more closely. In one set of experiments, we covered selected vines with a layer of shade cloth, which allowed only 45% of the available sunlight to pass through and strike the vines, without affecting ambient temperature or humidity. This more than doubled the level of mildew that developed, and quadrupled the production of new mildew spores (agents of disease spread). When a different group of vines was covered with a double layer of shade cloth, which allowed only 20% of the available sunlight to pass through, disease severity increased more than four-fold, and the fungus produced nearly 10 times as many spores as on leaves in the full sun.

To look at the issue under more natural conditions, we took two groups of Chardonnay vines in a different vineyard. One group was at the edge of the vineyard, immediately west of a group of tall pine trees that provided morning shade; the second was in the same row, but in a cleared area not shaded by the trees. Within these two groups, we inoculated PM spores onto shoots that were either (a) on the outside of the canopy, fully exposed to the sun, or (b) trained into the centers of the canopies, subjected to natural shading. The results are summarized in Figure 1 below.

Note that both sources of shading increased disease development. Shade from the trees roughly doubled disease severity for both the outer and inner portions of the canopy. Similarly, severity on leaves within the canopy was three to five times greater than on those comprising the outer canopy edge, for both sets of vines. And these effects were cumulative, with fully 63% of the leaf area diseased on the inner shoots of vines shaded by the trees, versus only 9% on shoots that were provided optimal sunlight exposure.

Of course, excessive sun exposure can be detrimental to grape berries as well as to the PM fungus, so we need to avoid too much of a good thing where the fruit are concerned. But keep these concepts in mind, both in terms of trying to limit PM by providing "optimal" levels of sun exposure, and by recognizing that prolonged periods of cloudy weather are taking away this natural control agent. In NY, many of our worst years for PM have started with multiple rain events (promoting primary infections from the overwintering cleistothecia) and prolonged cloudy weather (allowing primary infections to flourish and multiply) during the weeks leading up to fruit set, providing lots and lots of inoculum to infect the clusters. Toss in warm, humid (cloudy) post-bloom weather, and you've got the potential for real losses if your spray programs has any holes in it.

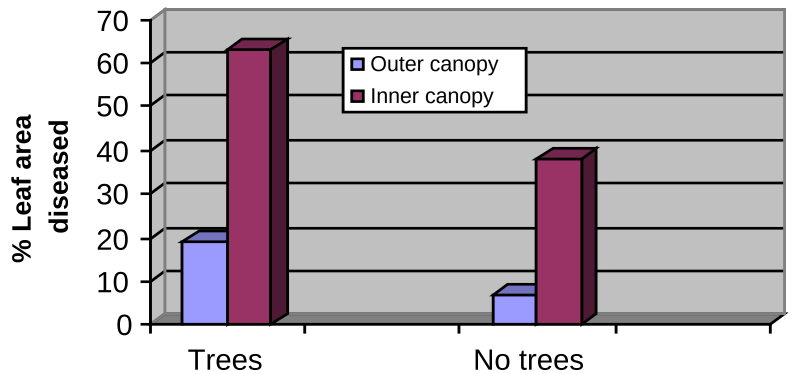

Fig. 1. Effect of two sources of shading on the development of powdery mildew. Evaluated leaves were from shoots on the outer (sun-exposed) or inner (shaded) portions of the vines, which were (a) adjacent to a group of tall trees (morning shade) or (b) away from the trees and exposed to available sunlight all day.

Fungicides. *Sulfur.* Has only three things going for it: (i) it's cheap; (ii) it's effective; and (iii) resistance hasn't developed after more than 150 years of intensive use throughout the world. Despite this long history, it's surprising to note that many properties of sulfur are based on "common knowledge" rather than actual data. Because of sulfur's importance, we decided to take a closer look at several issues regarding its use, yielding the following anticipated and unanticipated results:

- <u>We were unable to demonstrate any negative effects of low temperatures on either the protective or post-infection activities of sulfur.</u> In a number of repeated tests, utilizing the equivalent of either 5 or 10 lb/A, control was the same at 59°F as it was at 82°F. Workers from Australia have reported very similar results. It appears that the potential detrimental effect of low temperatures on sulfur efficacy has been significantly over-emphasized in our region.

- <u>Sulfur's protective activity is limited by the tendency of shoots to "outgrow" the spray coverage as shoots expand.</u> Sulfur can persist on sprayed tissues for quite some time (particularly in the absence of rain), but adequate redistribution to newly-developed, unsprayed foliage did not occur in our experiments. This suggests the need for shorter application intervals during periods of rapid shoot growth.

- <u>Sulfur provided consistent and extensive post-infection activity when applied up through the time that young colonies became visible following inoculation with fungal spores</u> (about 1 week after the start of an infection under summer temperatures, longer under cooler conditions). <u>However, sprays applied to heavily-diseased tissues provided only modest eradicative activity</u>.

- Rainfall effects:
    - Rainfall of 1 to 2 inches decreases sulfur's protective activity
    - This effect appears more pronounced with generic wettable formulations than with "micronized" formulations, which have smaller particle sizes (and higher price tags)
    - The negative effects of rainfall can be somewhat compensated for by adding a "spreader-sticker" adjuvant to the spray solution and/or increasing the application rate; in our field experiments, doubling the application rate (from 5 to 10 lb/A of Microthiol) was more effective than adding the adjuvant.

Sterol inhibitor (DMI) fungicides. In NY and many other regions, the DMI fungicides (Elite, Nova, Procure, Rubigan) have been used regularly for nearly 25 years. In many regions, including multiple NY vineyards, a "partial" form of resistance has developed over this time. Under such circumstances, these fungicides still provide significant control, but are not as strong as they once were. To address this "shift" towards reduced activity (either potential or already in progress), we recommend the following: (1) Limit the total number of DMI fungicide applications to a maximum of three per season. (2) Maintain full labeled rates and provide excellent spray coverage (this type of resistance is rate-dependent). (3) Tank-mix with sulfur whenever possible. (4) Avoid spraying these materials when significant levels of disease are present. Never try to use them to "burn out" active PM infections—this is not how they work, but it is a good way to speed resistance development.

Strobilurin fungicides. Abound, Flint, Pristine, and Sovran all provide very good to excellent control of PM in the absence of resistance, although resistance has been an increasing problem in commercial NY vineyards since 2002. Resistance was reported in commercial VA vineyards in 2005 as well. These are excellent products, but when problems have hit, they've been sudden and sometimes resulted in complete crop loss. I don't want to "cry wolf", but I do want to suggest caution. Following is a summary of our recommendations in NY:

(i) Apply a maximum of 2 times per season. In vineyards with a regular history of use (more than 15 or 20 applications in total over the years), it would be prudent to consider the resistance risk as high. If you're going to use these products on *vinifera* vines, tank mix with sulfur and/or use Pristine (the combination product that includes boscalid). Where significant resistance is already present, Pristine has provided better control than another strobie plus sulfur. If using Pristine in a vineyard with known or suspected strobie resistance, tank-mixing this product with sulfur is strongly recommended. The reason: boscalid is at risk for resistance development itself, and since the strobie component won't be providing dependable insurance in these vineyards, you'll need to get some from sulfur.

Native varieties are a different story, since they've generally seen fewer strobie sprays over the years and a sudden outbreak of resistance is likely to be less devastating. Abound remains a great choice to control PM, DM, black rot, and Phomopsis fruit rot on these cultivars immediately after bloom, when many growers are prohibited by their processors from using mancozeb or captan. Sovran is a little stronger on PM, equal on BR, but weaker on DM. And Pristine is not an option on Concord (injury).

As usual, hybrids occupy a large middle ground between *vinifera* and natives, which side of the middle depending on the particular cultivar. We've heard several reports of failures on Rougeon (very susceptible to PM, can't use sulfur), and straight strobies no longer work in my test block of Rosettes. As with *viniferas*, those using the strobies on susceptible hybrids should strictly limit the number of annual applications and tank-mix with sulfur (if they can) or choose Pristine. Rougeon remains a challenge.

(ii) Resistance to one strobie means resistance to all of them. And unlike the SI materials, we CANNOT compensate for resistance when we first detect it by increasing the rate or switching to another product with greater PM activity (e.g., Flint rather than Abound). Unfortunately, once they're done, they're done.

Quintec. Provides control of PM only. Good results in our trials and commercial experience in NY. A useful component in a rotational program on high-value, highly susceptible cultivars.

"Unconventional" PM fungicides. Because powdery mildew lives almost entirely on the surface of infected tissues, it is susceptible to control by a number of non-traditional materials (oils, bicarbonate and monopotassium phosphate salts, hydrogen peroxide, etc.) that have little or no significant effect on other disease-causing fungi, which live down inside the infected tissues where they can't be reached by such materials. However, there are two important limitations to the aforementioned group of products that need to be considered if you want to use them effectively: (a) they work entirely by contact, so can only be as effective as the spray coverage you provide; and (b) they generally work in a post-infection/curative mode with little "forward" activity. This means that they need fairly frequent re-applications, or should be tank-mixed with something that provides good protective (forward) activity.

Botrytis Control in Wine Grapes

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Although a number of microorganisms can rot grape berries, *Botrytis cinerea* (the gray mold fungus) is the most important in the cooler grape-growing regions of eastern North America, such as New York and Michigan. More than any of our other common diseases, Botrytis requires a true integration of cultural and chemical control practices in order to obtain adequate control on a consistent basis. Fungicide sprays aren't likely to do it by themselves on highly susceptible cultivars in a wet year.

Disease biology in a nutshell. The Botrytis fungus is a "weak" pathogen that primarily attacks highly succulent, dead, or injured tissues (e.g., by grape berry moth or powdery mildew), or those that are senescing (expiring), such as wilting blossom parts and ripening fruit. The fungus thrives in high humidity and still air, hence the utility of cultural practices such as leaf pulling and canopy management to minimize these conditions within the fruit zone. Although the fungus does not grow well in berries until they start to ripen, it can gain entrance into young fruit through senescing blossom parts, old blossom "trash" sticking to berries, and scars left by the fallen caps. Such infections initially remain latent (dormant), but given the "right" conditions, some of them can resume activity and rot the berries as they start to ripen. Once this occurs, the disease can spread from berry to berry within clusters (and, to a lesser extent, among clusters); again, the likelihood and magnitude of disease spread depends on conditions. Botrytis is a disease that is governed by a number of complex interactions between the vine, the weather, and the fungus itself, many of which are poorly understood.

Following are some relatively recent findings about the development of this disease and its control under NY conditions:

• Latent infections can be common following a wet bloom period, but the vast majority of them remain inactive through harvest, and the fruit stay healthy. Factors that determine whether latent infections become active (cause disease) or not are poorly understood. High humidity during the pre-harvest period and high soil moisture after veraison are two conditions that promote disease activation. Berries with elevated nitrogen levels (just how elevated, specifically, is still not clear) also are more prone to becoming diseased via the activation of latent infections. Recent work from Penn State Univ. has shown that certain mechanical injuries (wind, physical pressure from swelling berries within a tight cluster) can promote the activation of latent infections as well.

- Serious Botrytis losses result from disease spread during the post-veraison/ pre-harvest period, after berries begin to ripen and become highly susceptible to rot by the fungus. Thus, latent infections established at bloom can play a critical role in disease development if even a few of them become active and provide an initial "foot hold" from which substantial spread can occur thereafter given favorable pre-harvest conditions. Because so few of these early infections typically become active and turn into rot, controlling them at bloom provides only modest benefit if the post-veraison season is dry and doesn't support further disease spread. However, early season control can pay significant dividends if things turn wet before harvest. Want to guess what the weather will be like in September and October when deciding whether or not to spray in late June?

- “Everybody knows” that Botrytis development is far worse in varieties and clones with tight clusters than in those with looser clusters. It is now apparent that this pronounced impact of cluster compactness is largely due to its effect on berry-to-berry spread of the disease during the pre-harvest period. In one experiment that we conducted with a tight-clustered Pinot noir clone, we induced disease in just 1 berry per cluster approximately 2 weeks after veraison. The weather turned wet before harvest, and from this single berry, the disease spread to over 50 (!) berries per cluster by harvest, i.e., complete loss of the affected clusters. This single inoculated berry per cluster was meant to mimic the post-veraison activation of a small percentage of latent infections initiated at bloom, and vividly illustrates the particular importance of controlling early infections on tight-clustered cultivars and clones.

- Preharvest spread can be increased by increasing the N content of berries (we used foliar sprays of urea after veraison). However, sometimes there are good enological reasons to increase yeast-available N content in the must. Therefore, our results do NOT mean that nitrogen treatments should be avoided if one is using them in an attempt to ameliorate the atypical aging (ATA) phenomenon in white wines. However, it DOES mean that Botrytis management may need to be more intensive under such circumstances.

Control. As noted above, the Botrytis fungus thrives under conditions of high humidity and low air movement. Therefore, site selection, canopy management, and selective removal of leaves around the clusters can aid significantly in reducing disease pressure. However, fungicide sprays targeted specifically at this disease will often be necessary on susceptible cultivars and/or clones, particularly in wet year.

Traditionally, a “full” spray program for Botrytis control called for applications at late bloom, bunch closing, veraison, and 2 to 3 weeks before harvest. But is this always necessary? In the late 1970’s and 1980’s, a number of spray-timing trials were conducted in NY, the results of which suggested that the earlier two of these sprays were of marginal benefit so long as the veraison and pre-harvest sprays were applied, and focusing entirely on the later sprays became the standard recommendation. However, such a recommendation is contrary to experiences in many other parts of the world, and conflicts somewhat with what we now know about the biology of this disease. Therefore, in 1996 we began conducting a new set of annual timing trials, whose cumulative results suggest that there is no single “correct” timing regimen for fungicide applications in a Botrytis management program.

In some years of our trials, early sprays (bloom and bunch closing) have provided better control than late sprays (veraison and preharvest). In more years, the opposite has been true. In a few cases, two early sprays OR two late sprays provided the same control as all four. However, in a majority of years, all four applications provided the best results. Conceptually, think of early sprays in terms of limiting the initial establishment of the disease, and later sprays as limiting disease spread. Both <u>can</u> have a role, depending on circumstances. The relative benefits of early versus late applications, and the total number necessary, will vary among years according to rainfall patterns and, quite likely, individual vineyards as influenced by cultivar and clone. For example, in each of four different trials with Vignoles, we have seen a distinct benefit from the early sprays and assume that this reflects, at least in part, the tendency of the Botrytis fungus to spread extensively through these tightly packed clusters from just a few initial sources of infection.

Fungicides. Unfortunately, most fungicides that control other diseases are relatively ineffective against Botrytis, either providing no significant control or requiring substantially higher rates than for everything else. Similarly, most Botrytis-specific fungicides provide no significant control of other major diseases, although as with all "rules", there are important exceptions. Also be aware that all of the Botrytis fungicides are at moderate to high risk of resistance development. This makes it very important to rotate among groups of fungicides used to control this disease, even if you only spray them a couple of times a year. Don't use the same one year after year without substituting something else along the way.

Vangard, Scala. These represent two different fungicides in the same class of compounds (the so-called anilinopyrimidine or "AP" fungicides). They appear to have equivalent properties and provide the same general levels of control at labeled rates, but "rotating" between the two will provide no benefit in terms of resistance management (they're the same thing, for all practical purposes). These have been the most consistent performers in our trials over the years, and provide both protective and post-infection activity. They're absorbed by the fruit, so resist rainfall. The resistance risk is high, so use a maximum of two times per year, and never as the only Botrytis fungicide in a season or consecutive seasons. These products provide no significant control of any disease other than Botrytis.

Elevate. The other "work horse" over the past decade. Elevate is not related to any other fungicide on the market, so is an excellent rotational partner. When we've used it in rotation with an AP fungicide, we've seen no difference whether either one is used first or second in the rotation in terms of timing. Conventional wisdom has it that this is a protective fungicide, with no post-infection activity. Provides no significant control of any disease other than Botrytis. Resistance risk is moderate.

Pristine. The combination product of a strobilurin (pyraclostrobin) plus a compound representing new chemistry on grapes (boscsalid). Both components are active against Botrytis, which is good from a resistance-management perspective, but rate is important. When used at the rate of 8.5-10.5 oz/A that's labeled for other diseases, control is only fair under anything more than modest pressure, and there is no mention of Botrytis on the label (i.e., the company makes no claim concerning control of this disease). Pristine is labeled for "suppression" of Botrytis at a rate of 12.5 oz/A, and has provided good to very good results in a limited number of tests that we've conducted, although I'd consider this rate to be marginal under rainy conditions post-veraison. Finally, Pristine has a supplemental label for "control" of Botrytis at 18.5-23.5 oz/A. It has provided very good to excellent control on Vignoles grapes in our trials when used at a rate of 19 oz/A, even under very rainy conditions. It also has a much broader spectrum of activity against other fungi than do the Botrytis-specific materials mentioned above, so in addition to the mildews and black rot, it provided very good control of the numerous non-Botrytis rots that developed during a very wet September this past year. Be aware that the re-entry interval (without protective clothing) is 24 hr at rates up to 12.5 oz/A, but shoots up to 5 days at higher rates. The resistance risk is high, so we recommend a maximum of two applications per season (OK, maybe three if you're feeling lucky, considering the mixture of two unrelated ingredients).

Rovral. This was the only true Botrytis fungicide available for close to 20 years, so rotation just wasn't an option. As a consequence, resistance appears to be "not uncommon" (no data, observations only) in parts of the eastern U.S. where it was used regularly for many years. However, in locations where use has been much more limited, resistance is much less likely and the material often performs well. In the absence of resistance, Rovral is an excellent Botrytis fungicide, with both protective and post-infection activities. It should be a good rotational partner (keep to one application per season) where resistance is not a major concern, but should be used with caution otherwise. It provides no significant control of any disease other than Botrytis.