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After a 1-yr hiatus, it's that time again: the (almost) annual review of new developments, basic principles, forgotten factoids, nagging reminders of the obvious, and various options for fungal disease control. As always, I'd like to acknowledge the outstanding team of grape pathologists here in Geneva, including faculty colleagues (David Gadoury and Bob Seem in the fungal jungle; Marc Fuchs with viruses; Tom Burr with bacteria); research technicians (Duane Riegel, Judy Burr); and graduate students and post-docs too numerous to mention. It truly is the combined research efforts of all of these people that serve as the basis for most of the following.

SPECIAL NOTE: Duane Riegel, who has been the lead research technician in the grape pathology program for three decades, retired at the end of 2010. It's been said that the role of people like Duane is to hit home runs while the faculty run around the bases. It's not only true, but Duane has been a real Hank Aaron in this respect (not a Barry Bonds, Duane did it the old fashioned way). Although he'll continue to work with us for a while on a part-time basis, this is a great opportunity to tip a collective hat to an individual who has contributed far more to this program and the industry that it serves than almost anyone except those of us who work with him probably realizes.

I'd also like to acknowledge the financial support of the coordinated public and private viticulture research funding bodies that pool their limited budgets to allow bigger things to happen. These include the apparently-defunct USDA Viticulture Consortium-East program--which, over the past decade has by far been the largest financial contributor to practical viticulture research conducted east of the Rockies, and whose demise will be a MAJOR blow to addressing the applied day to day problems of real growers--the New York Wine and Grape Foundation, the Grape Production Research Fund, Lake Erie Regional Grape Program, the Dyson Foundation, and the New York Wine Grape Growers. We should also continue to recognize the tremendous support that Cornell's College of Agriculture and Life Sciences has devoted to multiple aspects of the viticulture and enology program during a period of intense competition for shrinking resources within that institution.

And finally, I'd especially like to thank the grape growers, wineries/processors, and industry support personnel--extension educators, processor field reps, agrichemical industry personnel, private consultants, etc.--who are so helpful in identifying problems that require attention, sharing their experiences and observations (and opinions!), and letting us know when we get things right and when we don't. This really is a great industry to be associated with.

FUNGICIDE CHANGES & NEWS

1. New products. There have been several since the last version of this tome:

a. The difenoconazole products. Difenoconazole (DFZ) is an important "new" (to the US) sterol inhibitor/DMI fungicide, registered for use on grapes--even in NY!--under three different trade names. This confusion is because DFZ is sold only in pre-packaged mixture with another fungicide in the parent company's stable, and there's a different name for each mixture, depending on the "partner" fungicide employed. Not surprisingly, these different products have different attributes and per-acre costs. In addition to recognizing these differences, it also will behoove you to pay attention to the amount of active ingredient of both components in each mixture, as will be shown below.

In the six trials where we've looked at it (two each over the past 3 seasons), DFZ has provided excellent to outstanding powdery mildew control, far superior to that provided by our traditional DMI materials such as Rally/Nova, Vintage/Rubigan, and Elite/tebuconazole generics. As many are aware, performance of the standard DMI products has been "slipping" in a number of locations over the years, and in a 2010 Chardonnay trial that we ran, a seasonal program applying Rally at its maximum label rate of 5 oz/A provided virtually ZERO control of the disease on clusters, i.e., they were completely destroyed. In stark contrast, two different DFZ products (Revus Top, Inspire Super) provided almost complete control (Table 1).

So what gives? Recall that resistance to the DMI fungicides is a "shades of gray" phenomenon. Huh? Resistance/ susceptibility to some fungicides, such as the strobies, is an "all or nothing" affair. That is, an individual fungal colony is either very susceptible to the material or it is virtually immune. Black and white, all or nothing. Immunity involves one single fungal gene, which confers immunity against all related compounds, regardless of the dosage (rate) involved. The only way to control these buggers is to hit them with something else.

In contrast, resistance/susceptibility to the DMI fungicides involves multiple genes and does depend on the rate being used, hence the shades of gray terminology. That is, as these materials are first introduced, the portion of the fungus population that is controlled by lower rates fails to reproduce, leaving behind only those individuals controlled by higher rates. As time goes on (remember, we're approaching the 30-yr mark since Bayleton was introduced), the population becomes increasingly composed of those controlled only by a higher dose. At first, you can address this by increasing the rate of the fungicide within legal and financial limits, but at some point you max out. For example, the rate for Rally is 3 to 5 oz/A, but what happens when 5 oz/A is no longer working well enough?

Answer: Use a material with greater "intrinsic" activity, i.e., one that is many times stronger than your other material. Lab studies we've conducted show that this is exactly what's happening with DFZ: the dose of myclobutanil (the active ingredient in Rally) required to provide a given level of control of the powdery mildew fungus is many times greater than the dose of DFZ necessary to give the same control, yet they are sprayed at comparable rates (of active ingredient). In other words, against this specific disease, applying the label rate of a DFZ product is like putting on many times the label rate of Rally. Each fungal colony is different, but on average, you need about 29 milligrams (or ounces or tons, etc.) of Rally to get the same level of fungal inhibition as you do with 1 milligram (or ounce or ton, etc.) of DFZ. No wonder these latter products work better.

DFZ also has given excellent control of black rot in trials conducted in other states. Labels claim control of a couple of additional minor/sporadic diseases including anthracnose, but I have no experience or knowledge related to these claims.

Now, for the specific players:

• *Revus Top*. This one's easy. Revus Top is a mixture of DFZ and the new downy mildew-specific fungicide, mandipropamid (the latter is sold alone as Revus) and is labeled at just one rate, 7 fl oz/A. For the following discussion, it will be considered to provide the "full" rate of DFZ. In several of our trials, Revus Top (or the appropriate components) has given excellent control of both downy and powdery mildews under very high pressure. AND it's very reasonably priced. This should be a very attractive product for many growers, but it cannot be used on Concords and is risky on a few other natives and hybrids (see below).

• *Inspire Super*. This is a combination of DFZ and cyprodinil (the active ingredient in the standard Botrytis fungicide, Vangard), labeled at a use rate of 16 to 20 fl oz/A. At the top 20-fl oz rate, it provides the same dose of DFZ as the labeled rate of Revus Top and the same dose of cyprodinil as 7 oz of Vangard (recall, the label rate for Vangard is 10 oz/A, or 5 to 10 oz if mixed with another Botrytis fungicide; note that the DFZ component of Inspire Super has no meaningful activity against Botrytis at labeled rates). My guess is that this might be a high enough rate of cyprodinil in the early part of the Botrytis season, but I'd hate to count on it from veraison onwards under pressure. For additional control, spike with another 3 oz/A of Vangard.

• *Quadris Top*. This is a combination of DFZ and azoxystrobin, the active ingredient in Abound, labeled at a use rate of 10 to 14 fl oz/A. At the highest rate of 14 fl oz/A, it provides the same dose of DFZ as the labeled rate of Revus Top and the same dose of azoxystrobin as 11 fl oz/A of Abound (recall that the labeled use rate for Abound is 11 to 15.4 fl oz/A).

Be especially conscious of resistance management considerations when using any of these products, e.g., remember that applying Inspire Super is the same thing as applying Vangard with respect to resistance management issues for the AP fungicides (Vangard, Scala; Group 9) and that applying Quadris Top is the same thing as applying Abound with respect to strobie resistance issues, discussed below. Similarly, do not apply any combination of these or other DMI (Group 3)-containing fungicides more than 3 times per year. And of course, there are legal restrictions on the amount of any active ingredient that can be applied each growing season, regardless of the product name under which it's sold. For example, the annual legal maximum for cyprodinil is 1.4 lb/A, equivalent to 30 oz of Vangard. So, if you applied two shots of Inspire Super in June/July and the full 10-oz rate of Vangard at veraison and preharvest, you'd not only be irresponsible from a resistance-management standpoint, you'd be illegal. Such scenarios should not be a common problem, but do be aware.

As noted previously, DFZ can cause injury to Concord and a handful of other native cultivars and hybrids. The whole story is not in yet, but field observations made by Cornell and Penn State Cooperative Extension, Syngenta personnel, and various consultants and nurserymen during the 2010 season identified the following varieties as having incurred **SOME INJURY** in the Finger Lakes and Lake Erie regions of NY: **Brianna, Canadice, Concord, Concord Seedless, Frontenac (minor), Glenora, Noiret (minor), Skujinsh 675** [interspecific hybrid containing *V. vinifera, V. amurensis, V. labrusca,* and *V. riparia*]**, St. Croix (minor), Thomcord** (Thompson seedless x Concord). The following showed **NO INJURY**: ALL *V. vinifera* cultivars observed, Aurora, Backus, Baco Noir, Catawba, Cayuga White, Chambourcin, Chancellor, Chelois, Colobel , Corot Noir, deChaunac, Delaware, Diamond, Elvira, Foch, Fredonia, Interlaken, Leon Millot, Niagara, Rougeon, Seyval Blanc, Steuben, Traminette, Vidal Blanc, Vignoles.

It also is worth noting that in follow-up experiments and anecdotal observations, injury was much more severe when the product was applied with a standard rate of a nonionic surfactant (NIS) than it was if no surfactant was used, and it was even more severe when applied with a surfactant that combined an NIS with an organosilicate material. These varying levels of injury correspond to the relative degree and/or rate of fungicide absorption that you'd expect with and without these additives.

b. Vivando is a brand new product that received its first EPA registration just before Christmas. It's a fungicide that controls powdery mildew only, but has shown outstanding activity against this disease in our trials. For example, last year it provided 100% control on Chardonnay clusters subjected to extreme disease pressure: high carryover inoculum from the year before, no sprays whatsoever before bloom, untreated vines and those with various ineffective treatments scattered elsewhere throughout the block, 14-day spray intervals (Table 1). CAUTION: Do not try this at home--if you do things likely to burn out a material, that will probably happen! However, these results do illustrate the strength of the product. Vivando represents a new class of chemistry, so there are no cross-resistance issues and it should be a very useful addition to rotational programs with other materials. This is likely to become one of our "big guns" for powdery mildew control, especially if it's priced competitively.

VIVANDO IS NOT YET REGISTERED IN NY (all other states are OK). We are working with the DEC in hopes that registration might come through by the time we'll really need it this season (pre-bloom onwards), but NY distributors cannot stock it, and it cannot be kept or applied in NY, unless and until that happens.

Table 1. Control of powdery mildew on Chardonnay grapes; Geneva, NY 2010

Treatment, rate/A*	Leaf infection		Cluster infection	
	% Leaves	% Lf area	% Clusters	% Clstr area
None	100	70.2	100	99.5
Revus Top, 7 fl oz	64	1.7	27	3.2
Inspire Super, 16 fl oz	67	2.1	16	2.0
Inspire Super, 20 fl oz**	39	1.1	6	0.2
Vangard, 7 oz	100	27.4	100	91.4
Rally (Nova), 5 oz	100	33.2	100	96.7
Vivando, 10 fl oz	12	0.3	12	0.4
Vivando, 15 fl oz	6	0.1	0	0.0

* Seven sprays applied at 14-day intervals.

** Contains same dose of difenoconazole as Revus Top treatment, same cyprodinil dose as Vangard treatment.

c. Downy mildew-specific fungicides. Why so many of them? Two reasons:

(i) The downy mildew (DM) organism belongs to a group of critters (oomycetes) that are so biologically different from "true" fungi that they are no longer even considered fungi by those who make such classifications. Although there are a lot of similarities and relationships between the two groups, one practical consequence of their biological differences is that they don't always respond similarly to the same toxicants. Hence, some chemicals that poison oomycetes don't do much to true fungi, whereas others that control true fungi don't touch oomycetes (the sterol inhibitor fungicides fall into this latter category).

(ii) DM is Public Enemy #1 throughout a couple of million acres of European viticulture, with growers in many locations spraying a dozen or more times per year to control it. Hence, it's a very attractive market for fungicide development even if a material doesn't control other grape diseases, and many of the final products make their way to us. A few of the DM-specific materials that have hit here recently, in alphabetical order:

• *Forum (dimethomorph; Group 40 for resistance management purposes)*--Same active ingredient as Acrobat, registered for many years in the U.S. on vegetable crops. Not much experience with it here on grapes as a solo product. It will be combined with a new active ingredient to form another product (Zampro), whose registration is currently pending at the EPA.

• *Presidio (fluopicolide, Group 43)*--Unrelated to any other grape product on the market. It has had EPA registration for a couple of years, but was just registered in New York this winter. It has locally systemic properties, hence some post-infection activity, although this is not well characterized. It has consistently provided excellent control in our trials.

• *Ranman (cyazofamid, Group 21)*--Also unrelated to any other grape product. Primarily a protectant fungicide, it has provided good to very good control in our trials when used alone, very good to excellent control when tank-mixed with a phosphorous acid product to add post-infection activity.

• *Reason (fenamidone, Group 11)*--Different from, but same biochemical mode of action as, the strobies. Hence, it is classified with them as a Group 11 material for resistance management purposes (i.e., you can't rotate among the same group, resistance to one is resistance to all). However, one important difference from the strobie products in that it has a much narrower spectrum of activity, i.e., it only controls DM. Reason was outstanding in the one trial that we've run so far, provided 100% control of downy mildew. And it's cheap. There's just that small matter of resistance/rotation for these "Group 11" fungicides, discussed below.

d. Switch. While we've been using Vangard (cyprodinil) to control Botrytis since the end of the previous millenium (!), most of the international viticultural world has been using Switch, a mixture of cyprodinil + a second active ingredient called fludioxanil, which has a wide spectrum of activity that includes Botrytis and a number of other fungi. The upside of this mixture is that it not only helps limit the potential for developing resistance to cyprodinil (Vangard), but it also provides some activity against the grab bag of fungi in the "sour rot" complex. The down side is that fludioxanil is expensive to manufacture, so the per-acre cost of Switch is noticeably more expensive than that for Vangard.

Switch is labeled at a per-acre rate of 11 to 14 oz, which provides the same amount of cyprodinil as 5.5 to 6.8 oz of Vangard (recall, the Vangard label rate is 10 oz/A). In a limited number of trials over the years, Switch at 14 oz/A has provided control comparable Vangard at 10 oz/A. I have no data or observations concerning the degree of control against sour rot. I'd expect "some", but don't know if it's enough to warrant the extra cost. In a bad year, other Botrytis fungicides that provide some activity against sour rot (e.g., Pristine, Flint) do manage to reduce it from a level of ghastly down to just real bad. This isn't a disease that you'll spray your way out of, although you can sometimes get a little help with the right product. Again, it comes down to a question of economics, and, unfortunately, we don't have the answer.

2. Strobilurin ("Group 11") fungicide resistance, reminder and update. Strobie resistance started causing a problem with powdery mildew control in the Finger Lakes and Long Island regions in 2002. For several years now, Dr. Anton Baudoin at Virginia Tech has also reported PM resistance from select mid-Atlantic vineyards, and downy mildew resistance has become so widespread in many mid-Atlantic and southern regions that these materials are no longer relied upon there for DM control. We have received anecdotal reports of poor DM control from several parts of NY, and had a failure after multiple Pristine applications in one of our trials at Geneva in the very wet 2009 season. Thus, real caution is in order when considering potential strobie utility against DM in New York and other more northerly areas where problems have not yet become apparent or only occur erratically. Similarly, other regions that have not yet had problems with powdery mildew would be well advised to learn the same lessons that we have when it comes to guarding against “surprise” failures to control this disease. As we often point out, the question regarding the development of resistance to these materials is one of “when”, not “if”. How you use them will determine whether the answer is “when I’m old(er) and gray(er)” or “any day now”.

Recall that control failures due to strobie resistance typically occur suddenly and without warning in an affected vineyard. As discussed many times before, the development of fungicide resistance is a simple but classical illustration of the principles of evolution (natural selection), a “survival of the fittest” for individuals within a fungal population that’s treated with the material. How quickly these individuals come to dominate the population to a point that the stuff no longer works well when used properly (i.e., not because you screwed up or pushed the envelope too far) depends primarily on (a) the number of selection events (spray applications) imposed on the population, and (b) the ability of the “selected” (resistant) individuals to multiply and spread. This multiplication and spread is determined by a number of factors, including (i) the number and intensity of potential infection events (the weather); (ii) the relative ability of the disease-causing fungus to grow and reproduce on the particular vine (varietal susceptibility); (iii) the inherent “reproductive capacity” of the fungus (the time between initiation of infection and production of a new generation of spores, and the relative number of spores then produced); (iv) the extent to which these spores are dispersed over distance, to start their dirty work elsewhere; and (v) the degree to which reproduction is arrested (disease is limited) by other farming practices, including non-chemical means and applications of effective, unrelated fungicides in rotation and/or tank mixture.

These somewhat self-evident principles explain a lot about our recent history with strobie resistance, where we're likely to go with it in the future, and the options that we have at our disposal to address it. For example: (i) Why we got PM resistance in New York more quickly than DM resistance (a run of dry years shortly after introduction of the strobies—1998, 1999, 2001, 2002—that favored reproduction of PM but not DM); (ii) Why resistance to DM rather than PM is a greater problem further south (warmer temperatures are more favorable to DM reproduction and spread; also, we started aggressively limiting strobie use in PM land earlier in the game, due to the 2002 PM resistance wake-up); (iii) Why the first PM problems were on Chardonnay (optimum pathogen reproduction); (iv) Why the initial problems were so much less common in vineyards that had tank-mixed with sulfur (less reproduction of the strobie-resistant individuals that were selected); and (v) Why nobody has yet encountered black rot resistance (BR has a much lower reproductive capacity than PM and DM—it takes two- to four times longer for infections to produce new spores [hence, fewer generations per year]--and these new BR spores are dispersed only a matter of feet by splashing raindrops, versus new PM and DM spores that are spread far and wide by wind currents).

Remember, it is imperative to limit the use of these products if you want them to last—no more than two sprays per season is our recommendation. If using a strobie product to control PM, growers should either use Pristine or tank-mix with sulfur if using one of the other strobie materials (Concord growers don't have this combination of efficacy and price for a mixing partner; a modest rate of Stylet Oil or Nutrol would be the closest). Tank-mixing sulfur with Pristine is a good idea, too, in vineyards where the strobie portion is or might be compromised, in order to protect the non-strobie component. As noted in previous missives, the non-strobie (tebuconazole) component of Adament is unlikely to provide adequate control of strobie-resistant PM colonies when used at the PM rates on this product's label.

The non-strobie component of Pristine does not provide any appreciable control of downy mildew, so even this product must be tank-mixed with an effective DM fungicide to be safe in regions where DM resistance has begun to appear--a recommendation that's a lot easier to make if it's not your own money being used to buy the second material. Nevertheless, the bottom line is, the strobies are no longer viable DM materials in significant portions of the eastern U.S. The DM activity of Pristine and Abound is part of what originally made them so attractive, and it still remains so in some regions. And in the absence of resistance, Reason looks like an excellent product at a cheap price (<u>around</u> $9 per acre in some places, depending on all sorts of things). But use these materials for DM control with caution and be ready to change horses on the fly if it looks like they're no longer working for this purpose.

POWDERY MILDEW (PM) NEWS AND REMINDERS

Your annual quick review of PM biology with respect to management 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 are produced within them, and in New York, those of any consequence are discharged between bud break and bloom (more or less) to initiate the disease, after which it can spread rapidly via the millions of new spores produced from each of 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. An important consequence of this is that <u>disease pressure will be higher, and PM sprays during the first few weeks of shoot growth are likely to be far more important, in blocks where PM control lapsed last year than in blocks that remained "clean" into September.</u> (In much of the Northeast, cleistothecia initiating from infections that occur after Labor Day are unlikely to mature before temperatures become limiting and/or frost kills the leaves and eliminates their food source.)

The annual illustration of what this means: Several years ago, we conducted an experiment in a Chardonnay vineyard where we either (a) sprayed up through Labor Day, maintaining a clean canopy the entire season; (b) quit spraying other vines a month earlier, to represent a planting with moderate levels of foliar PM by the end of the season; or (c) quit spraying in early July, to represent a planting where PM control broke down for one reason or another. The next spring, the levels of cleistothecia (number per kilogram of bark) in these treatments were (a) 1,300; (b) 5,300; and (c) 28,700, respectively. Now, consider a hypothetical case where 20% of the overwintering spore load is discharged during the first couple of weeks after bud break (a reasonable approximation, based on published studies). But 20% of what? In the clean treatment (a), this number might be relatively inconsequential; 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 greater than the entire seasonal supply on the clean vines. Not surprisingly, this makes a difference, i.e., the degree of control provided in one season can affect the success of the control program in the following one. When we intentionally waited until the immediate prebloom period to apply a minimal spray program to these same vines the year after inducing our variable foliar disease levels, the resulting cluster disease severities were (a) 11%, (b) 22%, and (c) 48% cluster area infected, respectively, even though all were sprayed exactly the same during the second season. Conclusion: Higher disease in Year 1 = More primary infections to start off Year 2 = Many more new ("secondary") spores by the time the fruit were formed and highly susceptible to infection = Much heavier disease pressure to “overwhelm” the fungicide spray program.

(ii) Powdery mildew functions as a “compound interest” type of disease, that is, a few infections can “snowball” and build up to many in a short period of time if conditions are favorable for reproduction of the fungus. The most important factor that governs the rate of reproduction is temperature, with a new generation produced every 5 to 7 days at constant temps between the mid-60's and mid-80's Fahrenheit (more details are provided in the NY and PA Pest Management Guidelines for Grapes, and in an on-line fact sheet). Thus, days in the 80's and nights in the 60's and 70's provide ideal conditions for the fungus 24 hr a day. Conversely, a cold night or two can seriously set the fungus back, as discussed a little farther below.

(iii) High humidity also increases disease severity, with an optimum of about 85% RH. Although PM develops to some extent over the entire range of humidities that we experience, research has shown that disease severity is twice as great at a relative humidity of 80% versus an RH of 40%. Vineyard sites (and canopies) subject to poor air circulation and increased microclimate humidity, and seasons with frequent rainfalls, provide a significantly greater risk for PM development than their drier counterparts. Thick canopies and frequent rainfall are also associated with limited sunlight exposure, which greatly increases the risk of disease development in its own right. Collectively these appear to be important environmental variables that distinguish “easy” from “challenging” PM years (see below).

(iv) Berries are extremely susceptible to infections initiated between the immediate prebloom period and fruit set, then become highly resistant to immune about 2 weeks (Concord) to 4 weeks (*V. vinifera*) later. This is when you use the good stuff and don't cut corners in terms of spray frequency and application technique. Your annual reminder.

(v) Failure to control even inconspicuous PM infections on the berries can increase the severity of Botrytis and sour rot at harvest, and can promote the growth of wine-spoilage microorganisms such as *Brettanomyces* on the fruit. Another annual reminder. Providing excellent PM control on susceptible wine grapes from pre-bloom right through bunch closing does not guarantee control of bunch rots and spoilage beasties, but it’s a relatively easy method to eliminate one way of getting them.

(vi) Powdery mildew is a unique disease in that the causal fungus lives almost entirely on the surface of infected tissues, sending little "sinkers" (haustoria) just one cell deep to feed. This makes it subject to control by any number of "alternative" spray materials (oils, bicarbonate and monopotassium phosphate salts, hydrogen peroxide, etc.) that have little to no effect on other disease-causing fungi, which live down inside the infected tissues. Recall that there are two primary limitations to the aforementioned group of products, which need to be considered if you want to use them effectively: (a) they work by contact, so can only be as effective as the coverage you provide; and (b) they work primarily in a post-infection/curative mode by killing the fungus right after they hit it, with little (JMS Stylet Oil) to no (potassium salts) residual activity to protect against new infections after they've been put on. This means that they need fairly frequent re-application, or should be tank-mixed with something that provides good protective (forward) activity in order to lengthen effective spray intervals.

New research I: Effect of sunlight exposure

As noted in previous missives, "it has long been known" that PM is most severe in shaded regions of the vineyard (canopy centers, near trees, etc.), but until recently there was very little work done to determine either the magnitude or cause(s) of this effect. However, graduate student Craig Austin recently completed a thorough study of the phenomenon, and the results were quite striking. The following is a "final report" of his findings.

One of the first experiments in this study was conducted in a Chardonnay vineyard near the Finger Lakes village of Dresden, NY where a small portion of the easternmost row was bordered by a group of 50-foot tall pine trees. In previous years, we had seen PM completely destroy the clusters on the three panels of vines immediately next to the trees, despite a spray program that controlled the disease adequately on all other vines in the block. These panels were shaded during the morning and it wasn't until the sun crested over the treetops just before noon each day that the vines received their first direct exposure to sunlight. So, we initiated a trial in which we inoculated leaves on either (a) the outer (exposed) or (b) inner (shaded) portions of vines, which were located either (i) immediately next to or (ii) 200 feet away from these trees, thereby providing a total of four levels of natural shade. The resulting disease severity increased substantially with each increasing level of shade, becoming 8 to 40 times more severe on the most heavily shaded leaves (interior of vines next to the trees) compared to the unshaded leaves, i.e., those on the exterior of vines away from the trees (Fig 1)

Although shading could potentially change air temperature or relative humidity within the vine canopy, our measurements did not show this. However, they did show that UV radiation levels and leaf temperatures were dramatically different among the different treatments. Within the shaded regions, UV levels were (as one would expect) a mere fraction of those in the sun, and temperatures of leaves in the sun were as much as 10° to even 30°F higher than those of leaves in the shade. As we later found out, both elevated leaf temperature and UV radiation are responsible for the inhibitory effects of sunlight on PM development.

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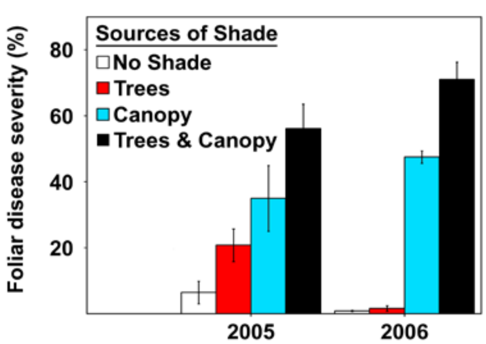

Figure 1. Percent leaf area diseased on Chardonnay leaves receiving (i) full solar radiation, on the outer canopy edge of vines away from trees (No Shade); (ii) morning shade from an adjacent grouping of pine trees but otherwise exposed to the sun, i.e., leaves on the outer canopy edge of these vines (Trees); (iii) shade provided by the vine itself, i.e., located within the center of the canopy of vines away from the trees (Canopy); or both tree and the internal canopy shading (Tree & Canopy).

Sunlight characteristics influencing powdery mildew development. UV radiation from the sun can damage the cellular structure of virtually all forms of life. However, powdery mildew is uniquely vulnerable to such damage: the PM fungus lives primarily on the outside of infected tissues, whereas nearly all other pathogens live and grow within infected organs where they are protected from UV. On top of that, the PM fungus is white--it has no pigment in its "skin" to protect against this radiation.

As noted above, direct sunlight heats up exposed leaf surfaces, as it does anything else for that matter--as we all know from the difference between standing in the sun or taking two steps away into the shade. This additional heat can suppress or even kill PM colonies on sun-exposed leaves and berries. Recall that powdery mildew grows best at temperatures near 80°F, but stops growing at temperatures above 90°F and will start to die at temperatures above 95°F, depending on how hot it is and for how long. On a hypothetical summer day in the 80's, temperatures of shaded leaves and clusters will remain near that of the air--i.e., at or near optimal for PM development. However, nearby vines or portions thereof that are exposed to sunlight can often have temperatures elevated to a point where PM growth will stop or even "go backwards".

Surface Temperature and UV: Field Experiments. In order to separate these two specific sunlight components, we suspended a Plexiglas "roof" over Chancellor and Chardonnay vines in Geneva, NY and Chardonnay vines in a vineyard at Washington State University's Irrigated Agriculture Research and Extension Center in Prosser, WA (grateful acknowledgement to Dr. Gary Grove and staff for their contributions to this trial). Plexiglas blocks UV radiation but permits passage of the sunlight wavelengths that elevate surface temperature. At the Chancellor vineyard in Geneva, we also suspended shade cloth over other vines to shield them not only from UV radiation but also from the heating effect of direct sunlight. Clusters were inoculated with PM spores at 75% capfall. As shown in Figure 2, we found that removing UV radiation (Plexiglas filter) increased disease severity on fruit by 50% to fivefold, for both varieties and locations. The Chancellor shade cloth treatment, which eliminated both the increase in surface temperature *and* UV radiation, further increased disease severity in one of the two experiments.

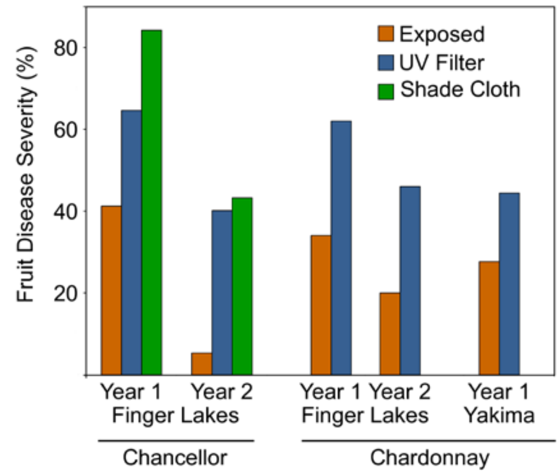

Figure 2. Percent disease severity on cv. 'Chancellor' and cv. 'Chardonnay' vines receiving: full solar radiation (Exposed), sunlight from which 95% of the UV radiation had been filtered (UV Filter), or sunlight reduced to 20% of ambient via neutral density shade cloths suspended over vines (Shade Cloth). Vineyards were located in Geneva, NY (Finger Lakes) or Prosser, WA (Yakima)

Sunlight Manipulation in the Vineyard. Given that UV radiation and sun exposure reduce PM, how can we use this information to better manage the disease? We examined this question in a young Chardonnay vineyard in Geneva, NY by comparing two training systems, Vertical Shoot Positioning (VSP) and Umbrella-Kniffen (UK), and removing basal leaves around clusters to provide different levels of light exposure in the fruiting zone. UK provided more shoots per linear foot of row than VSP, hence more potential for canopy shading in the fruit zone. Within each training system, we removed basal leaves at two dates: 2 weeks post-bloom (fruit set) and 5 weeks post-bloom. We inoculated clusters with PM spores at bloom and rated disease severity in each treatment.

We found that both factors affected PM severity (Figure 3). First, powdery mildew severity was lower in the VSP than in the UK training system, regardless of leaf pulling treatment. Second, leaf removal at fruit set significantly reduced the amount of disease in both training systems, but leaf removal 5 weeks after bloom had no effect. The benefits of the early (versus late) leaf removal once again illustrates the critical nature of those first few weeks following the start of bloom--this is when you want to hit the fungus with not only your best spray program but also the cultural control tools you have available, rather than wait until significant infection has occurred before you employ them. *Bottom line: simply by utilizing a VSP training system and basal leaf removal at fruit set, we were able to reduce fruit disease severity by 35% relative to UK-trained vines with no leaf removal.* It should be noted that in 2009, a summer during which it sometimes seemed that there was no direct sunlight reaching the state of NY, we did not see the same effect of training system in this vineyard but did see the same effect of early leaf pulling.

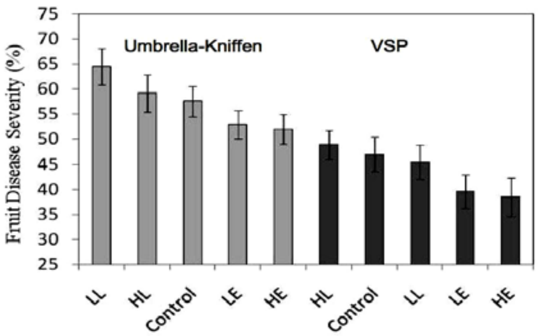

Figure 3. Powdery mildew severity on Chardonnay clusters subjected to five different leaf-removal treatments in each of two vine-training systems. Leaf-removal code: **First letter** is leaf removal severity, H = heavy, L = light (either two leaves or one leaf above and below each cluster, respectively); **Second letter** is leaf removal timing, E = early, L = late (2 and 5 wk post-bloom, respectively). Each data bar represents the mean for 30 clusters per treatment.

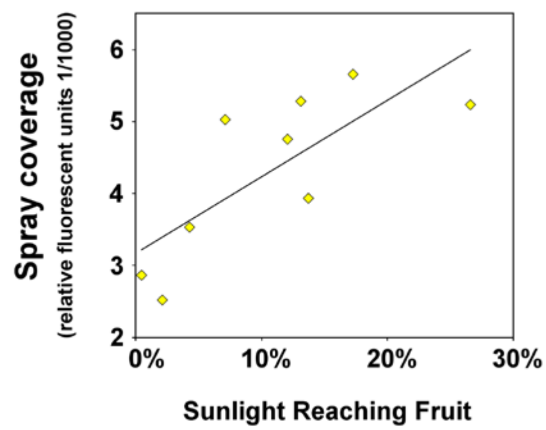

Figure 4. Effect of canopy density on deposition of sprays onto clusters of ‘Chardonnay’ vines treated in mid-July with a conventional airblast sprayer.

Exposure of fruit to sunlight and pesticides. It's common sense that canopy management practices that increase sunlight penetration into the fruiting zone should also increase the penetration of sprays applied to control pests and diseases. With the assistance of Dr. Andrew Landers, we were able to quantify the effect that canopy density can have on spray coverage. Vines in our ‘Chardonnay’ planting subjected to the above canopy manipulations were sprayed with a conventional air blast unit and deposition on clusters from each vine was assessed in the lab. As expected, we found a direct relationship between the quantity of spray deposited on each cluster and the sunlight exposure level (Figure 4), with well-exposed clusters receiving approximately twice the deposition as those with poor exposure.

Management Implications. In all vineyards, in all seasons, for all experiments at all locations, increasing sunlight exposure on leaves or fruit reduced the severity of powdery mildew on those tissues – independent of spray coverage. And when improved spray coverage is factored in, the benefit of canopy management for PM control is not only compounded but extends to other diseases as well. However, a central concept associated with quality viticulture is “balance". Zero sunlight exposure might lead to diseased berries, but absolute maximum exposure can lead to sunburned berries instead. It's all about balance.

New research II: What's a bad PM year?

Cornell graduate student Michelle Moyer, working in the lab of Drs. David Gadoury and Bob Seem, also has recently completed her thesis research examining some other aspects of powdery mildew biology. Michelle focused on trying to define just what makes a "bad" PM year while it is occurring, so that growers might take action to prevent damage rather than conduct a post-mortem after it's too late.

A few highlights:

• Severe fruit infection is much more likely if the disease become well established on the foliage pre-bloom, providing abundant new spores to infect the adjacent fruit while they're highly susceptible. This is logical, but she demonstrated it very convincingly.

• Relatedly, after analyzing over 25 years worth of climate and disease severity data, Michelle showed a significant association between severe disease one season and accumulated degree days the previous autumn. This goes back to the earlier discussion concerning formation and maturation of the overwintering fruiting bodies of the PM fungus (cleistothecia) during late summer and autumn of one growing season and disease pressure the following. That is, a long, warm autumn allows late-season infections more opportunity to form mature cleistothecia (i.e., containing viable overwintering spores) than in shorter/cooler falls.

• We know that PM is favored by warm temperatures, cloudy weather, and high humidity, but is there an easy way to integrate these factors for measurement purposes? Yes. Michelle found a strong relationship between PM severity in any given year and the "pan evaporation" measurements during the critical prebloom through fruit set period that year. Pan evaporation is a figure reported by some weather stations that measures--surprise!--the depth of water that evaporates from an exposed pan (don't you love high-tech gadgetry!) over a given period of time. It's main purpose is to help schedule irrigations but, conveniently, it also integrates the three major environmental variables that govern PM development--temperature, relative humidity, and solar radiation. A simple decision tree has been suggested for assessing PM severity risk, based upon a combination of post-veraison degree-day accumulation the previous year and pan evaporation data during the critical part of the current growing season. We hope to start evaluating it this year.

• Another interesting fact: cold nights (below 40°F) throw PM for a loop. After as little as 2 hr at 36°F, portions of existing colonies are killed, new infections take longer to form colonies with the secondary spores that spread the disease, and the colonies that do form are reduced in size (hence, fewer new spores in addition to later). Thus, cold nights during the period between early shoot growth and bloom have the potential to restrict the ability of the PM fungus to produce new spores capable of infecting the young, highly susceptible berries. Or seen another way, lack of such nights can give the disease a running start relative to a "normal" year. Note that prolonged cloudy conditions that otherwise favor PM by increasing humidity and limiting exposure to direct sunlight also keep us from getting those really chilly spring evenings. Something to keep in mind should such conditions come to pass.

A note to Concord growers: Remember that the value of mid-summer control on Concords is strongly influenced by the combination of crop level and ripening conditions (heat, sunlight), and that foliar PM is one more limitation on the vine's ability to photosynthesize and ripen the crop. When its capacity to do so is not being pushed (moderate crop size, plenty of water and sunshine, few other stresses), research has shown that it can tolerate a lot of foliar PM without significant negative consequences. However, this same research also has shown that at high cropping levels, good PM control can be necessary to get the fruit to commercial levels of ripeness. And in cloudy, rainy years--those that give you a double whammy, lousy for ripening and ideal for mildew development--even more moderate crops can be affected. Unfortunately, there is no simple formula to tell you how much control is cost effective, and every case is likely to be different, depending on disease pressure, growing conditions, vine vigor, fruit prices, etc. But keep the general concept in mind.

The minimal two-spray Concord PM program of pre-bloom and 10-14 days later will keep the berries clean and often appears to be good enough in “average” vineyards in a "typical" year, but it certainly is minimal. A second or even third post-bloom shot may be warranted as yields start going up (you thought you got all of that extra fruit for free?) and it's worth scouting to make sure you can't see mildew colonies a couple of weeks prebloom before deciding outright that you don't need to spray for it yet. We’d like to—but shouldn’t—forget the 2003 season, which started out with visible PM established around the 10-inch growth stage and just went downhill from there. The worst doesn't usually happen, but it can. And it work out a whole lot better if you see it coming then take defensive action before it's too late. But you won't see it coming if you're not looking.

Fungicides

***Sulfur*.** Another summary of the major findings and conclusions from our studies on sulfur activities a few years back:

• We were unable to demonstrate any negative effects of low temperatures on either the protective or post-infection activities of sulfur. In a number of repeated tests, control was the same at 59°F as it was at 82°F when we sprayed with the equivalent of 5 lb/A of Microthiol. Workers from Australia also reported no differences in control at 59°, 68°, or 86°F when used at this rate, although there was a slight decrease in activity at 59°F when the rate was reduced down to 1.7 lb/A equivalent. It appears that the potential detrimental effect of low temperature on sulfur efficacy has been over-emphasized in our region, particularly in light of the fact that the PM fungus itself is not all that active at cooler temperatures. Nevertheless, don’t cheat on rate or coverage if using it early, and don’t forget that spring rains will wash some of it off.

• Sulfur provides very good protective activity on sprayed tissues, but not on new leaves that emerge after the last application. No kidding.

• Sulfur provides excellent post-infection control when applied up through the time that young colonies start to become obvious. Although it does have some eradicant activity against raging infections (see below), it's significantly stronger against the younger ones. Practically speaking, this means that when a PM spore lands on a new, unprotected leaf produced since the last application (see above), there's still time to hit it with the next spray in a post-infection mode if that's applied early enough. Which is up to about 1 week after infection is initiated should temps remain in the 70's and 80's, longer if there are significant cooler periods mixed in.

• Post-infection sprays applied to heavily-diseased tissues are much less effective than those applied to incubating or very young colonies. Sulfur is not the material of choice as an eradicant if you reach the “Omigod!” stage. That would be Stylet Oil or the similar PureSpray Green (or perhaps Oxidate, at a much higher cost). And remember that once the leaf or berry cells beneath a well-established mildew colony have been sucked dry by the fungus, nothing’s going to bring them back to life even if the mildew is eradicated. The best that an eradicant spray can do is to keep things from getting much worse, it can't raise the dead. And for the one thousandth time, the results you get will only be as good as the spray coverage you can provide.

A number of different field and greenhouse trials designed to clarify the effects of rainfall produced occasionally variable, but generally consistent results. To wit:

• Rainfall of 1 to 2 inches decreases sulfur’s protective activity significantly.

• This effect is more pronounced with generic “wettable” formulations than with so-called “micronized” formulations (e.g., Microthiol), which have smaller particle sizes so adhere better to tissue surfaces. These latter formulations cost more for a reason.

• 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 (from 5 to 10 lb/A in our field experiments, or their equivalents in the greenhouse). Both increased rate and adjuvant have an effect, and these effects appear to be additive. See Table 2 below for field data, standardized across years to reflect % disease control relative to the unsprayed check vines in the relevant experiment.

Table 2. Powdery mildew control on Rosette (2004-06) and Chardonnay (2007-10) grapes as affected by sulfur rate and adjuvant (Geneva, NY)

	Foliar disease control, severity (%)*							Cluster disease control, severity (%)*						
Treatment, rate/A	2004	'05	'06	'07	'08	'09	'10	2004	'05	'06	'07	'08	'09	'10
Microthiol, 5 lb……….	68	67	86	97	76	70	61	47	76	70	89	90	4	16
Microthiol, 5 lb + Cohere, 0.03% (vol)…	84	80	89	97	83	73	64	64	73	79	90	96	4	37
Microthiol, 10 lb………	87	89	91	99	91	83	77	76	77	85	94	---	6	41
Microthiol, 10 lb + Cohere, 0.03% (vol)...	---	---	---	---	95	86	86	---	---	---	---	98	9	65

* % reduction of the diseased area on leaves and clusters, relative to the unsprayed check treatment.

***"Alternative"* materials.** As noted many times in previous years, there are numerous "alternative" materials labeled (and not) for PM control. A few years back, we compared seven products registered by the EPA and classified as "biopesticides" for control of PM on Rosette vines under two different scenarios: (a) season long, to determine the extent of their activities without any help; and (b) using "standard" materials (Elite and Pristine at that time) to provide control into the early postbloom period, then switching to the alternative products to maintain disease control on the leaves and cluster stems after the berries had become relatively resistant to infection. Generally, sprays were applied at 10-day intervals, and a "commercial standard" at the time (rotating Rubigan, Pristine, and Microthiol at 14-day intervals) was also used for comparison. The bottom lines were:

• When applied throughout the season at 10-day intervals, none of these products (Elexa, Kaligreen, Nutrol, Oxidate, Prev-Am, Serenade, Sonata) were as effective as the Rubigan/Pristine/Microthiol program at 14-day intervals. However, using Elite/Pristine through 10 days postbloom followed by the alternatives provided control of berry infections equivalent to the "standard". This is hardly surprising, since the prebloom through early post-bloom period is when you get (or don't get) most all of your control of berry infections. Yet another reminder that this is the time when you want to use the best materials available to you.

• There was a wide range in the performance of these materials for keeping foliar disease down in the summer. A few materials (Nutrol, Kaligreen, and Prev-Am) were nearly as efficacious as the standard program, which relied on sulfur to finish the season (albeit at 14- rather than 10-day intervals). These may have interest for growers who are trying to avoid sulfur in late-season sprays.

• Kaligreen is a potassium bicarbonate product, as are several other similar, labeled products not examined here (e.g., Milstop, Armicarb). Nutrol is monopotassium (or, "dihydrogen potassium") phosphate. This was the fourth consecutive trial that we ran in which Nutrol and the bicarb products provided almost exactly the same degree of control when used at recommended rates. Prices among these materials have sometimes differed dramatically, even though their activities are basically the same. Be aware that unlike the bicarbs, which are formulated with a surfactant, you'll need to add one with Nutrol to get optimal coverage of the entire surface of the leaves and berries. Also, Nutrol is not certified "organic", if that's important to you philosophically or commercially.

BLACK ROT (BR) NEWS AND REMINDERS

1. As fruit mature, they become increasingly resistant to infection. Another annual reminder. Remember that under NY conditions, berries are highly susceptible to black rot from cap fall until 3-4 weeks (Concord) or 4-5 weeks (Riesling, Chardonnay) later. Then, they begin to lose susceptibility, finally becoming highly resistant to immune after an additional 2 weeks. Note this means that Concords can become infected up to 6 weeks after the last cap has fallen, and *V. vinifera* varieties up through 7 weeks post-bloom. In the mythical "average" year, most growers won't need to be too concerned towards the end of these susceptible periods, since the overwintering spore load is long gone by then and the leaves and berries on the vine are presumably clean. However, protection will need to continue throughout the entire period of susceptibility if active infections are present in the vineyard unless you either know or want to gamble that the weather won't be suitable for disease spread before the fruit become fully resistant.

Recall that in most vineyards, mummified berries are the main (oftentimes, only) overwintering source of the BR fungus. Spores from mummies on the ground--which is where they should be unless somebody screwed up and didn't prune them off the vine during the dormant season (see below)--are typically depleted by a week or two after bloom. (Now for the CYA fine print: remember that these spores are liberated from the mummies during rains. So, if it doesn't rain from bloom until 3 or 4 weeks later, as occasionally happens, the last shot of them will just sit and wait until the rains finally do arrive). Thus, if the disease has been very well controlled by the time the overwintering spores are depleted, there should be no source for new infections even though fruit may still remain susceptible, and additional sprays are not likely to be necessary. In contrast, if new black rot infections are established (and producing spores right within the clusters), protection will need to continue so long as fruit retain any susceptibility.

As often noted, we've regularly obtained excellent control with sprays applied at the start of bloom plus 2 and 4 weeks later. Such a program provides protection throughout the period of peak susceptibility and during most or all of the time remaining before berries become highly resistant. But as noted above, you get away with stopping sprays before berries are fully resistant when there are few to no active infections present and/or the weather is dry, but growers routinely get nailed when they quit too early when there are active infections present. Also, waiting until the immediate prebloom period is a lot safer in a vineyard that was clean last year than in one with more than a touch of disease and the consequent overwintering spore load. Recognize when you can cut corners and when you can't.

2. Mummies retained in the canopy provide significantly more pressure for BR development than those dropped to the ground. Mummies in the canopy produce many more spores than those on the ground and continue to produce them throughout the period of berry susceptibility, whereas spores from ground mummies are finished shortly after bloom. Furthermore, spores from mummies in the canopy are much more likely to land on and infect susceptible berries than are those produced from mummies on the ground, since they are released right next to the new clusters. As often noted, when I go into a vineyard and find a BR "hot spot", the first thing I do is look for last year's mummies still hanging in the trellis near the current zone of activity. I almost always find them.

3. The incubation period for the disease can be very long. Under upstate NY conditions, we've found that clusters infected during the first few weeks after bloom show symptoms about 2 weeks later and that all diseased berries are apparent within 21 days after the infection event. However, clusters infected near the end of their susceptible period do not develop symptoms until 3 to 5 weeks after infection. (Note that since the fungus is responding to accumulated heat units rather than repeats of the sun rising and setting, these periods will be a tad shorter in significantly warmer climates). In New York vineyards, black rot that begins to show up in mid- to late August is probably the result of infections that occurred in mid- to late July, depending on the cultivar. This fact should be considered when trying to determine "what went wrong" should such disease occur.

4. The SI [DMI] fungicides are most effective in "reach-back" activity, whereas the strobilurins are most effective in "forward" activity. Just a reminder of how these materials work (along with supporting data), and why mixing a DMI + protectant fungicide (mancozeb, ziram, strobie) gives such good BR control--reach-back activity from the DMI plus forward activity from the protectant.

Table 3. Protective and post-infection activities of a strobilurin (Abound) and sterol inhibitor (Nova = Rally) fungicide in control of black rot under field conditions

	% Disease control[c]	
Protective (days)[a]	Abound	Rally
5	90	65
8	93	39
11	66	0
Post-infection (days)[b]		
3	39	95
7	42	87
10	15	39

[a] Sprays were applied at label rates to Concord vines in the field at indicated number of days before infection with black rot spores.

[b] Sprays were applied at label rates to Concord vines in the field at indicated number of days after infection with black rot spores.

[c] Percent reduction in the number of diseased berries relative to unsprayed clusters.

5. Fungicides. Nova/Rally and Elite were always the kings in our trials, which haven't been run since we lost our BR test vineyards a few years back. Elite is no longer marketed as such, although I'd assume that the generic tebuconazole products do the same thing if used at an equivalent rate to supply 1.8 oz/A of active ingredient. Trials run by colleagues in Ohio and PA show that Mettle (still not labeled in NY) and the difenoconazole products have similar levels of activity (note that all four of the abovementioned fungicides belong to the same chemical family within the DMIs, the triazoles). In many of our trials, the strobies were right up there at a similar level. Of course, the most important time to control black rot (bloom and early postbloom) is also the critical time for controlling PM on the clusters, and diminishing levels of PM control with most DMI fungicides make them potentially problematical at this critical part of the season in many vineyards. However, if BR is a greater concern than cluster PM (which could be true of many native and hybrid cultivars, and all cultivars in some production regions well to the south of NY), this may not matter so much. And it may be even less of a factor given the superiority of PM control provided by the difenoconazole products, although I'd still use them gingerly on *V. vinifera* cultivars during this period.

All of the strobies appear to be equivalent to one another and provide very good to excellent control, equal to mancozeb and ziram under moderate pressure and superior under very wet conditions, since they're more rainfast. Of course, rainy conditions are when superior performance against BR is most necessary. (FYI, the non-strobie component of Pristine provides virtually no control of black rot). Mancozeb and ziram are old standards and provide very good control under most commercial conditions. Captan, Rubigan/Vintage, and Procure are only fair, and are likely to be inadequate if there's any pressure. Copper is discussed below. Sulfur is poor.

6. Special considerations for "organic" growers. Black rot is probably the "Achilles heel" for organic grape production in the East. In the only good trial that we've run with copper, it provided 40% disease control when applied at 2-week intervals, versus essentially 100% control with Nova. (I recently found an old report from a trial that Roger Pearson ran in the mid-1980's, where he got about this level of control with a copper product). That being said, towards the end of the wet 2006 season I visited an organic grower who had suffered severe losses to BR in several previous wet seasons, anticipating that I'd see more of the same. But I had to search to find a black rot berry. What had he done?

Implemented a rigorous program to remove mummies during pruning, and sprayed copper once a week throughout much of the growing season. This was hard on some of the hybrid vines and runs counter to the thinking of many with a "sustainable" orientation (after all, copper is a metallic element that by definition doesn't break down into anything else, so it stays in the soil forever), but it did control the disease in a manner that conforms to the letter of the organic law.

Unfortunately, we don't know of any magic bullets for organic producers to spray, although there are several products out there that claim to be. Bryan Hed at Penn State has looked at a number of possibilities and we've followed up with a couple of the most promising, but the typical scenario is that things look good in the greenhouse and not so good in the field (most likely, they wash off, among other things). Right now, it looks like nothing is as good as copper.

Therefore, the simple fact remains that sanitation and cultural practices form the absolutely critical first (and second and third....) line(s) of defense against BR for growers who wish to produce grapes organically. So if this means you, you'll need to pay strict, bordering on religious, attention to limiting inoculum within the vineyard. Ideally, this would include removing or burying (tillage, mulch) all mummies that you might encounter at the site; next best is do this to as many as you can. At the very least, it is imperative that all mummified clusters be removed from the trellis during pruning. And if you're able to patrol the vineyard from 2 to 6 weeks after cap fall and prune out any affected clusters before they allow the disease to spread, all the better. Note that spores for disease spread during the current season are dispersed by rain primarily within the canopy, so they should pose little risk of causing new infections if said clusters are simply dropped to the ground. (And if dropped this early, they should decompose before next season rolls around).

DOWNY MILDEW (DM) NEWS AND REMINDERS

Recall that the DM organism persists in the soil as resting spores (oospores) that originate within infected leaves and berries. Hence, the more infection last year, the more oospores this year. (Because the oospores can persist for more than 1 year, vineyards with significant disease in 2009 might still be considered "high inoculum" as well). And as with PM, high overwintering inoculum levels mean that early sprays are more important than they would be in a vineyard that has remained clean in the past. This is particularly true in years when the weather favors infection during the 2- to 3-week period before bloom, when the first oospores become mature and ready to cause infection. It's the same old story: Only a low percentage of the seasonal "crop" of oospores matures early, and a low percentage of just a few is probably inconsequential; in contrast, a low percentage of a lot is still a lot.

The first "primary" infections, originating from overwintering oospores in the soil, require a minimum rainfall of approximately 0.1 inch and a temperature of 52°F or higher to "activate" them and splash their infectious progeny into the canopy or onto nearby sucker growth. Of course, heavier rainfall and warmer temperatures will increase the probability and severity of primary infection.

Once primary infections occur, new "secondary" spores (sporangia) form in the white downy growth visible on infected clusters and, particularly, the underside of infected leaves. Several different weather factors must come together for sporangia to form and spread the disease, but this can occur rapidly when they do. Basically, what's required is warm, humid nights (to form the sporangia) with rain following soon thereafter (to allow germination and infection). Without rain, most of the ungerminated sporangia will die the next day if exposed to bright sunshine; however, they can survive for several days between rainfalls if conditions remain cloudy, which helps to keep the epidemic running.

Spread is most rapid with night and morning temps of 65-77°F, although it can occur down into the 50's. With an incubation period (generation time) of only 4 to 5 days under ideal conditions, disease levels can increase from negligible to overwhelming in very short order if the weather remains favorable for long stretches of time--repeated humid nights, frequent showers, and extended periods of cloudy weather. See: Summers of 2008 and 2009.

The erratic development of DM coupled with its explosive and potentially devastating nature make it an ideal candidate for scouting, especially after fruit have become resistant and the consequences of incomplete control are diminished. No need to spray for it when it isn't there, but you don't want to allow it to get rolling if it's active. Keep an eye on the vineyard to see which of these possibilities you might be able to avoid. For additional guidance, my colleagues, Bob Seem and David Gadoury, have developed a computer model (DMCAST) that integrates a number of weather and crop development factors to advise when infections are likely to occur. This model can be accessed via the NYS IPM Program website (www.nysipm.cornell.edu/newa/).

Fruit susceptibility. Clusters of some varieties—including all *V. vinifera* cultivars--are highly susceptible to infection as soon as the fungus becomes active during the prebloom period. Recent research indicates that berries become highly resistant to direct infection within 2 weeks after the start of bloom, although losses due to berry stem infections can occur under some poorly-defined conditions for at least 2 additional weeks after that.

When berry stem infections occur, the DM organism follows that pipeline into the fruit and causes the aptly-termed "leather berry" symptom (hard and dry berry, no DM spores produced upon it). There was a bit of that around in 2008 and 2009, likely due to inadequate protection as people prematurely let their guard down several weeks after bloom. Last year made it easy to forget how these things can happen. But don't.

For many years, the standard fungicide test protocol on hyper-susceptible Chancellor vines at Geneva has been to start spraying about 2+ weeks prebloom and continue through approximately 4 weeks postbloom. The best materials consistently provide virtually complete control of fruit and cluster stem infections using this schedule, even in bad years and on perhaps the worst possible variety for cluster infections (leaves are relatively resistant), under abnormally high inoculum pressure. But remember that vines with susceptible foliage remain vulnerable to defoliation from DM right into the fall if disease-conducive weather persists, even long after the fruit have lost their susceptibility. Which is something you'd rather avoid.

Fungicides. Ridomil remains the best downy mildew fungicide ever developed, but cost and lack of activity against other diseases have limited its use. Although it's highly prone to resistance development, this has never been detected on grapes in the U.S., probably due in large part to its relative lack of use. But if you get to the point that you're ready to call in the big guns, this is the Howitzer. Remember that the PHI on Ridomil Gold Copper was reduced to 42 days several years ago, versus 66 days for Ridomil Gold MZ.

Note the discussion regarding DM resistance to the strobie and related materials at the beginning of this tome: use them with caution in regions where resistance has not yet become a problem, and think of use in regions where it has developed as a disease-management form of Russian roulette. Within this context and without resistance, Abound is very good, Pristine is even better, and last year, the new product, Reason, gave perfect control in our trial; Sovran is marginal; and Flint is poor. Copper, mancozeb, and captan are old standards because they work, but are prone to wash-off under heavy rains and may need to be reapplied more frequently in wet years. Ziram is much better than nothing, but it wouldn't be your first choice if good materials were an option. In addition to Reason, several other new DM fungicides (Presidio, Revus, Ranman) are discussed under the New fungicides section at the very beginning.

Which brings us to the phosphorous acid (also called phosphite and phosphonate) products once again. We've discussed these *ad nauseum* for the past few years, so will only review the main points this time around. Recall that these are excellent materials for anyone consciously seeking a "least toxic" or "sustainable" approach to growing grapes, due to their low toxicity (4 hr REI, exempt from US-EPA residue tolerances) and minimal environmental impact. They're also very good for anybody who wants a DM fungicide that's easy to use, price-competitive, and effective. Although there are occasional reports and testimonials alluding to the ability of these materials to control other grape diseases, I have not found this to be so in several different trials that we've run. In general, these are very good and reliable fungicides against downy mildews on a variety of crops and some other closely related diseases (DM is the only one that's important on grapes), but control of anything else is erratic at best. If you do get control of another disease, think of it as an unanticipated bonus. I certainly wouldn't encourage you to even hope for it.

You know by now that there are several phosphonate products labeled for control of DM, and a number of other "nutrient formulations" on the market that contain phosphonate but are not labeled for DM control. Which means that it's legal to obtain disease control with these latter products if you do so on purpose. Whether this seems fully rational or not, remember that the law requires any material applied for a pesticidal purpose to be labeled for such, and you can still be cited for breaking a law regardless of what you think about it.

From 2003-05, we ran a series of field experiments designed to determine the so-called "physical modes of action" of phosphonates in control of downy mildew. These results and conclusions have been reported in detail in previous years, but a quick review the major points:

• Phosphonates generally provided good but limited (3 to 8 days) protective activity, <u>depending on the rate used.</u> Protective activity in the older leaves sometimes declined significantly after 3 days, particularly at lower label rates, as phosphonates are "shipped" out of them.

• Phosphonates provided excellent "kick-back" activity against new infections. When applied 3 or 4 days after infection, few lesions developed at either rate and spore production was greatly to totally inhibited. When applied 6 days after infection (small lesions just starting to become visible), lesions continued to expand but production of spores was greatly inhibited. Control was better at the higher label rates, and when an initial application was repeated 5 days later (7 would probably be OK). If you truly need some significant kick-back activity, don't go cheap and do keep an eye on things; if it looks like you didn't get it all the first time, hit it again.

• Phosphonates did not eradicate well-established infections, but when applied to actively sporulating lesions, they limited further spore production by approximately 80%. Limiting the production of these spores will obviously limit the potential for disease spread.

• **<u>CAUTION</u>**: The phosphonate products have become very popular, for the good reasons cited above. But they're not miracle drugs, and some people like to push them past their limits in terms of both spray intervals and rates. Furthermore, there can be a subconscious tendency to think that these aren't "real" fungicides, for various reasons having to do more with marketing than with science. However, they <u>are</u> real fungicides when it comes to the DM organism, i.e., they're toxic to it. And just as with other real fungicides, this organisms can develop resistance to these materials if given a chance.

Although sudden and total resistance to the phosphonates is not likely to occur, there is evidence that they can lose some of their effectiveness over time, similar to what we've seen with the DMI fungicides and control of powdery mildew. <u>Don't</u> burn these materials out by relying on them exclusively throughout the summer. Rotate them with something else, like you would any other fungicide with the potential for resistance development, to make sure that you can keep using them into the future.

BOTRYTIS NEWS AND REMINDERS

Although there are a number of fungi that can cause bunch rots, especially in warmer regions, Botrytis is still king in the cooler or more moderate summer climates of the East. A review of what makes it tick.

1. Biology. The Botrytis 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. It's a "weak" pathogen inasmuch as it primarily attacks highly succulent, dead, injured (e.g., grape berry moth, powdery mildew), or senescing (expiring) tissues such as wilting blossom parts and ripening fruit. Although the fungus does not grow well in berries until they start to ripen, it can gain initial entrance into young fruit through wilting blossom parts, old blossom "trash" sticking to berries, and scars left by the fallen caps. Such infections typically remain latent, but some may become active as the berries start to ripen (senesce), causing them to rot. Should this occur, disease can spread rapidly through the rest of the cluster or to others nearby, reducing both marketable yield and quality. Some recently-determined details re the above:

• Latent infections can be common following a wet bloom period, but the vast majority remain inactive through harvest and never rot the fruit. Factors that cause latent infections to activate (cause disease) are incompletely understood, but high humidity and high soil moisture are two environmental factors that promote this process. Note that for the preceding reasons, a wet bloom period (to establish latent infections) followed by a wet pre-harvest period (to activate them and provide conditions for further spread) is a perfect "recipe" for Botrytis. Berries with high nitrogen levels or subject to various mechanical injuries (nice work by Bryan Hed from Penn State on that last one) also are more prone to becoming diseased via the activation of latent infections.

• Serious Botrytis losses result from rampant 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 be important if only a few of them become active and provide the initial "foot hold" from which subsequent spread can occur during ripening.

Because relatively few of these early infections typically do 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, it can be critical in a year with a wet pre-harvest period (especially if the mid-summer was wet as well), which favors both the increased activation of latent infections and their rapid spread. So in one sense, bloom sprays are an insurance policy against the future unknown. Sometimes they pay huge dividends, sometimes not (data below). What's your risk (and tolerance of it) of not being insured?

• The pronounced impact that cluster compaction has on Botrytis development appears to be due largely to its effect on berry-to-berry spread. In one experiment with a tight-clustered Pinot Noir clone, a single diseased berry first showing symptoms 2.5 weeks after veraison spread the disease to over 50 (!) berries per cluster by harvest. In contrast, spread was reduced by 90% (!) in the same group of vines where clusters had been loosened by removing some berries by hand right after set. Note that this single diseased berry per cluster (produced by inoculation) was meant to simulate the post-veraison activation of a few latent infections initiated at bloom, and vividly illustrates the particular importance of controlling blossom infections on tight-clustered cultivars and clones.

Loosening clusters by hand thinning was possible on a small scale to demonstrate the principle, but unfortunately, there are few practical, foolproof ways of achieving the same effect on a commercial scale other than through clonal and varietal selection. The watchword here is foolproof. Over the years, several workers have experimented with prebloom sprays of gibberellic acid for this purpose, with some success. (Most recently, Bryan Hed and colleagues at Penn State have published an in-depth paper on their positive results with Chardonnay and Vignoles). And there are now some GA formulations (e.g., ProGibb 4%, which is even OMNI approved) that are labeled for use on wine grapes.

These labels contain warnings about possible yield reductions during the current and/or following years and a range of rates specific to different varieties. Nevertheless, some growers and investigators have been able to get the benefit of such treatments without noting negative effects. IMHO, loosening cluster compactness represents the "holy grail" for Botrytis management. And GA treatments just may have their place. But this technology is not foolproof, we do not have all the answers yet, and there are risks involved. I would caution anyone interested to still view it as experimental, to do their own experiments on a small scale, and to keep their eyes and ears open with respect to the experiences of others.

• There is no single "correct" timing regimen for fungicide applications in a Botrytis management program. The standard "full" program used in fungicide trials, on many fungicide labels, and by some growers of highly susceptible and valuable cultivars consists of four sprays: at bloom, bunch closure, veraison, and 2-3 weeks pre-harvest. We have looked at the relative contributions of the two early sprays, the two late sprays, or all four in most years over the past decade and a half; a summary of these data is presented in Figure 5. Note that in some years, the two early sprays provided better control than the later sprays. In an equivalent number of seasons, the opposite was true. In some years, two early sprays OR two late sprays provided the same control as all four; but in most (especially 2008!), applying all four provided the best results.

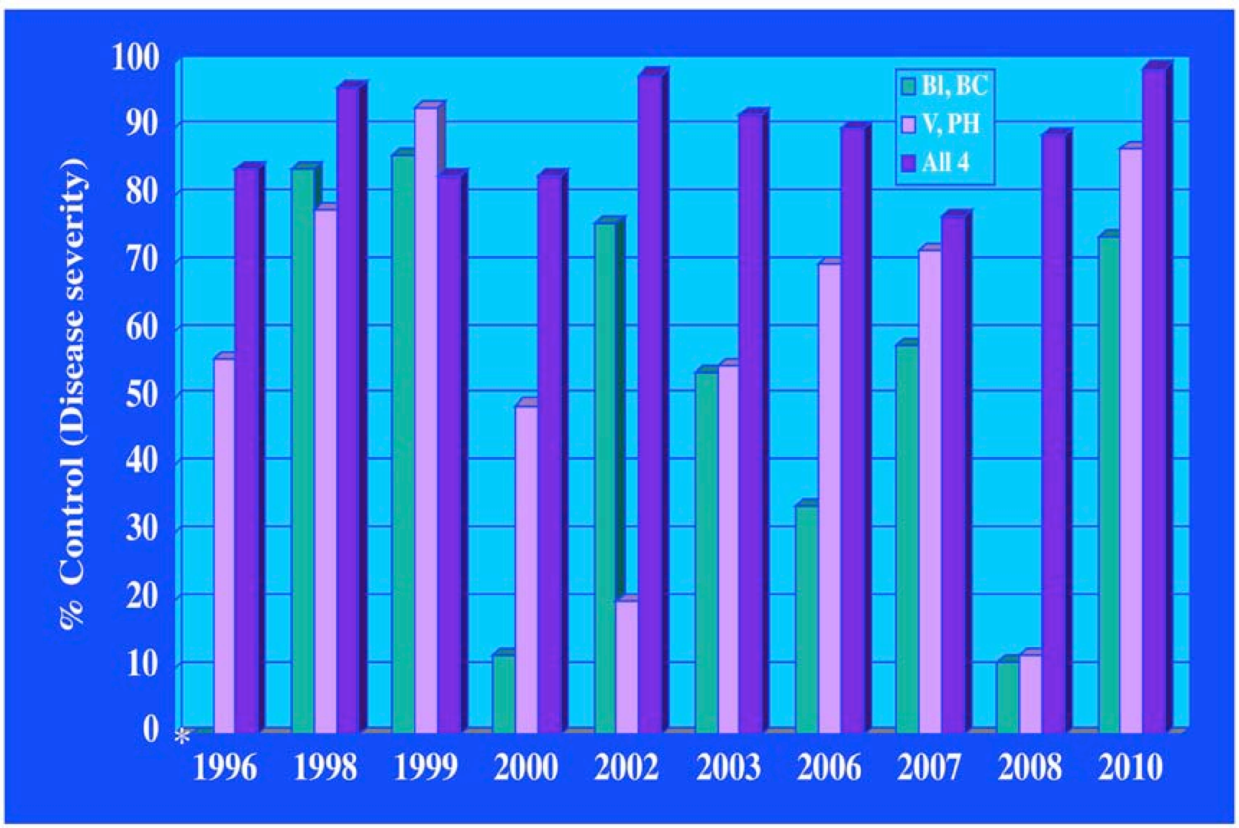

Figure 5. Influence of spray timing on the control of Botrytis bunch rot in Geneva, NY (cv. Aurore, 1996-2000; cv. Vignoles, 2002-2010). Sprays we applied at (i) Bloom + bunch closure (Bl, BC); (ii) Veraison and 2-3 wk later (Ve, PH); or (iii) at all four of these stages. Data are expressed as percent reduction of diseased berries relative to vines receiving no Botrytis fungicides.

The relative benefits of early versus late applications, and the total number necessary, will vary among years according to rainfall patterns and, quite likely, differences between cultivars and clones (e.g., cluster tightness). Think in general terms of early sprays as limiting the establishment of primary infections, and later sprays as limiting disease spread. But remember that Botrytis is not a disease that you can just "spray your way out of". These materials help, but they won't do the job by themselves in a tough block and tough year if you don't give them a hand with cultural practices (canopy management, leaf pulling, etc.).

2a. Fungicides, physical modes of action. Over several years, we looked at the various "physical modes of action" of the available Botrytis fungicides, to get a better idea of some of their specific characteristics and differences. Following is a repeat of previous summaries of the major findings and conclusions for this project:

• In one set of tests, we examined the ability of the fungicides to protect the **internal** berry tissue against infection from spores that might be deposited inside them following mechanical damage, such as that from rain cracking, berry moth feeding, etc. Chardonnay clusters were sprayed at pea-sized berries, bunch closure and veraison, then a hypodermic needle was used to inject berries with Botrytis spores 2 weeks after the last spray. Scala, Vangard, and Elevate provided excellent control, and Rovral was close. Pristine (19 oz/A) was comparable in preventing rot, but was less effective in limiting spore production from the limited number of berries that did develop symptoms. Flint and Endura provided the least protection of the internal berry tissues. However, all fungicides completely prevented spread to the neighboring berries when inoculated berries became diseased; in contrast, such spread occurred in two-thirds of the unsprayed clusters.

• In a more direct test for residual protective activity on the berry surface, clusters on a second set of Chardonnay vines were sprayed on the same dates as above and Botrytis spores were applied to the surface of the unwounded berries 2 weeks after the final application. As we would hope, all fungicides provided virtually complete control.

• In another test, Pinot Noir clusters were inoculated with Botrytis spores at late bloom but weren't sprayed with Botrytis fungicides until veraison. The purpose of this test was to see whether the fungicides could eradicate or suppress latent (dormant) infections long after their initiation, so long as the materials were applied before such infections became active. (Recall that preharvest activation of bloom-initiated latent infections is often the kick-start to a Botrytis outbreak). Under the conditions of this test (individual clusters sprayed by hand, complete spray coverage to an extent not likely in commercial production), a single application of Scala or Vangard at veraison provided almost complete control of latent infections established at bloom, 60 days earlier. Elevate and Rovral were almost as good. When additional clusters re-treated a second time, 15 days after veraison, Scala, Vangard, and Elevate provided complete control. Rovral reduced infection by about three-fourths, whereas Flint, Pristine, and Endura provided 55-60% control.

• Take home-messages and cautions:

- All of the current "standard" fungicides registered for Botrytis control provided excellent protective activity on the surface of the berries. That's why they got developed and marketed in the first place.
- The so-called AP fungicides (Vangard and Scala) and Elevate also provided very good protective activity within the berries. This was anticipated for the AP's, since such fungicides are known to be absorbed by plant tissues, but Elevate was long sold as a surface protectant. However, this appears to have more to do with the company's marketing strategy than with science.
- Similarly, the same three materials provided very good curative activity against latent infections initiated at bloom, even when applied 2 months after infection. Nevertheless, as shown in Figure 5, we often get better control in our field trials when these fungicides are sprayed at bloom and bunch closure

in addition to veraison and 2 weeks later. This suggests that the level of curative effect from the later sprays doesn't replace the need for earlier applications when conditions favor infection at bloom, although it probably contributes to the overall level of control obtained.

2b. Fungicides, Pristine and Flint. For biological reasons, most common fungicides provide relatively little control of Botrytis at the rates used for other diseases and, conversely, most good Botrytis fungicides provide relatively little control of fungi other than Botrytis and a few close relatives affecting crops other than grapes (Rovral, Vangard, Scala, and Elevate fall into this category). Two striking exceptions to this general rule are Pristine and Flint.

Recall that both components of Pristine provide control of Botrytis, although the non-strobie ingredient is the more active of the two (and, fortunately, reputed to be somewhat less prone than strobies to resistance development). This non-strobie component is not very active against any grape diseases other than Botrytis and PM, but the strobie part picks up the erratic "summer rot" diseases and helps a bit with the "sour rot" complex in addition to PM, DM, and BR. This same broad spectrum of activity also applies to Flint (minus the DM), which has consistently provided excellent Botrytis control at its higher (3 oz/A) rate in my trials.

"OTHER" ROTS

SOUR ROT is a catch-all term often used to describe the "snork" that takes over injured clusters during the pre-harvest period if the weather becomes good and wet. Such berries typically are colonized by a mix of various wound-invading fungi and bacteria and can, but don't always, give off a strong smell of vinegar (hence the name) if part of the microbial complex includes a specific group of bacteria. Ethyl acetate (nail polish remover) is another nasty aroma produced by some of these microorganisms, and can transfer into wines made from such fruit (yuck). Diseased berries drip juice and spores or cells of the sour rot microorganisms onto nearby healthy berries, which in turn become infected through any wounds that might be available. Damage from Botrytis, rain cracks, and bird or insect punctures are common points of entry for these beasties.

Although it is almost impossible, under wet conditions, to stop sour rot once it has become established, controlling the aforementioned causes of injury will greatly reduce the probability of it getting started in the first place. Excellent control of powdery mildew and, especially, Botrytis are two measures that will significantly minimize sour rot development. And as mentioned above, there is some indication that Pristine and Flint used for Botrytis control may provide *some* additional control of the wound-invading sour rot fungi due to their relatively broad activity spectra, although they certainly won't prevent this disease by any stretch of the imagination. Nevertheless, any product that gives good Botrytis control will help to limit sour rot. And one of the best things you can do is to focus on the standard cultural practices for minimizing various injuries, opening up the canopy to promote drying of the fruit, etc.

SUMMER ROTS is a term sometimes used for two similar diseases (ripe rot and bitter rot) common in more southern, humid (and quite warm) production regions. Those beneath the Mason-Dixon line and in the lower Midwest deal with these diseases on a regular basis and they occur sporadically to the north. Bitter rot, in particular, seems to pop up with some regularity on Long Island, particularly on Chardonnay. Those of us to the north should probably start being more aware of these diseases, especially in very wet years. It's not a threat to be over-emphasized in our region, but neither is it one to be flat out ignored. Particularly if our summers do continue to heat up.

Bitter rot appears to be the more likely threat in our "marginal" northern areas, as it doesn't have quite the need for heat that ripe rot does. Usually, symptoms first occur after veraison, as the bitter rot fungus moves into the berry from the berry stem and turns the diseased portion brown (on white varieties) or a dull purple. Once the berry is completely rotted, it becomes absolutely <u>covered</u> with <u>numerous</u> prominent, raised black pustules (the fungal fruiting bodies). You can't miss 'em. More details on the appearance of symptoms and how to distinguish them from Phomopsis and BR symptoms can be found in the 2011 Pest Management Guildeline (hard copy and on-line).

Ripe rot tends to predominate as you keep moving south, although it has been documented as far north as New England. Symptoms do not develop until after veraison and become increasingly prevalent the closer you get to harvest (who'da thunk it with a name like that?). Infected fruit initially develop circular, reddish brown lesions on their skin, which eventually expand to affect the entire berry. Under humid conditions, small "dots" of slimy, salmon-colored spores may develop across the rotten berry as the lesions become depressed, and serve to spread the disease to healthy fruit if rains continue. Infected fruit shrivel and mummify, and may either remain attached or fall to the ground. No foliar symptoms are produced.

Both diseases are favored by abundant, warm rains (77° to 86°F is optimum) between fruit set and harvest. Infections occurring before veraison typically remain "dormant" until fruit begin to ripen. Captan and the strobilurin fungicides are the go-to materials for control of these diseases in regions where they occur regularly (as is mancozeb, within its PHI restriction).

Cultural practices, such as pruning out dead spurs, removing overwintered mummies, and removing weak or dead cordons, are important to help reduce the inoculum in the vineyard. Turner Sutton at NC State, who has done more work with these diseases than anyone, has demonstrated this nicely by showing that they even tend to be worse in spur-pruned blocks, where some old (previous) fruiting wood is always retained. Both diseases are frequently controlled in the early- to mid-summer by sprays containing mancozeb, captan, or a strobie product directed against other diseases. However, with the exception of Flint and Pristine, fungicides used for Botrytis management (Elevate, Scala, Rovral, Vangard) provide very little control of bitter rot or ripe rot, and their exclusive use during wet preharvest seasons can lead to outbreaks of these diseases in regions where they are not routine and, therefore, are not consciously managed.

Sprays targeted against bitter rot and/or ripe rot may be needed in the late season if the weather is warm and wet, especially if the diseases are observed in the vineyard or have occurred there in the past. In southerly regions where they are consistent problems, it is typically necessary to apply protectant fungicides on a 2-week schedule from bloom until harvest, except during periods of drought. Because fruit are especially vulnerable in their final stages of ripening, pre-harvest sprays can be particularly useful when these diseases are active, to avoid rapid secondary spread. This potential utility must be balanced against wine makers' concerns about the effects of such sprays on fermentation (of course, they also love fruit with bitter rot, another aptly named disease). That legal preharvest restrictions on fungicide labels <u>must</u> be followed is a given.

PHOMOPSIS (Ph) NEWS AND REMINDERS

1. Early sprays are the most important for control of rachis infections. Your annual reminder that in multiple spray-timing trials over a number of years, we found that applications during the early shoot growth period (as clusters first become visible, about 3 inches of shoot growth or so) are the most important for controlling disease on the rachises. Rachis infection by the Phomopsis fungus is among the most common causes, if not *the* most consistent cause, of economic disease loss that I see on Concord grapes, and is even worse on Niagaras since it seems to move more readily into the fruit of this cultivar (not to say that DM can't kick Niagaras pretty hard in some years as well). Note that early sprays also provide the greatest control of shoot infections, which serve as sources of Ph spores in subsequent years if retained as infected canes, spurs, or pruning stubs.

2. Early sprays also provide significant control of berry infections. In a trial conducted several years ago in a problem block of Niagaras, we were surprised to find that sprays applied before and just after cluster emergence (the important sprays for controlling rachis infections) also provided nearly 70% control of berry infection. In retrospect, this shouldn't have been too surprising, since it's common to see rachis infections expand into the berry stem and then into the berry itself, especially on this variety. But it was an eye opener nevertheless.

In a subsequent trial in a different high-inoculum Niagara vineyard, we documented a gain of over 2 tons/A in two particularly bad Phomopsis years, simply as a result of applying a single mancozeb spray during the early "3- to 5-inch" shoot growth stage. The quotes are to stress that this timing is approximate; the point is to get something on the young clusters soon after they emerge.

Thus, a minimal Ph spray program should include at least one application during this period. Research has repeatedly shown that waiting until the immediate prebloom spray is far too late if there is any significant disease pressure going on (inoculum in the vineyard + rain). Commercial experience has consistently shown the same thing.

PHOMOPSIS: EFFECT OF EARLY CONTROL ON YIELD (cv. Niagara; Fredonia, NY)

Phomopsis program	Yield (tons/A) 2006	2008
None…………………….…...	7.7	13.2
Mancozeb, 1x…………….…...	10.0	15.5
Mancozeb, 3x…………….…...	10.8	16.4

Mancozeb at 1- to 3-in shoots; + 2 wk; + 2k

Table 4. Effect of a single well-timed Phomopsis spray on yield. In both years, the single spray ("1x") was applied 2 weeks after the first spray (1- to 3-in shoots) in a comparison treatment that received three applications in total ("3x").

3. Dead wood and canes may be particularly important sources of Ph spores. The Ph fungus is especially prolific in dead tissues, including dead wood. The obvious practical implication of this observation is that removing dead wood during pruning operations is an important component of a Ph management program. This includes not only obvious sources such as dead canes and arms, but also less-obvious ones such as old pruning stubs. The Ph fungus can remain active in such wood for at least several years, so a “dirty” block is going to stay that way until you prune the stuff out.

4. Little fungal inoculum, if any, is available by mid-summer. We monitored the release of Ph spores in several Lake Erie and Finger Lakes sites over 3 consecutive years. And in each year, we detected few if any infectious spores beyond early- to mid-July, with the vast majority released between bud break and bloom. A similar study conducted by Annemiek Schilder at Michigan State University produced generally similar results. These data suggest that even though berries may remain susceptible throughout the season, as shown by work from Mike Ellis and students at Ohio State, the risk of infection is probably very low once berries become pea-sized, since inoculum is scarce beyond that time.

5. Fungicides. Mancozeb, captan, and ziram have all provided very good to excellent control of basal shoot and rachis infections in our fungicide trials. Experience with the strobies has been mixed. Fortunately, they’ve looked better against fruit (and maybe rachis) infections than they have against basal shoot infections. We’ve seen no difference between the efficacy of Abound versus Ziram for controlling fruit infections when mancozeb was used prebloom and these materials were compared in subsequent postbloom sprays. In a trial on Niagaras a couple of years ago, four sprays of Pristine were as effective as four of mancozeb, with some indication that the non-strobie component of the product was making a significant contribution. Sulfur, although touted as a Ph material in California (where it doesn’t rain during most of the growing season) did practically nothing in this same trial.

6. Spray application technique. Many growers like to spray alternate rows in the early season when it’s the critical time for controlling Ph, assuming that sufficient spray will blow through the target row and impact on vines in the “middle” row. For 3 consecutive years, Andrew Landers helped us examine this issue in a commercial Niagara vineyard. Consistently, vines in the middle row received less spray than vines subjected to every-row spraying, and perhaps more importantly, the coverage on them was much more variable. I recognize that the benefits of alternate-row spraying are obvious and am a firm believer that there's no reason to fix things if they ain’t broke. However, I'm also a firm believer in seeing things how they are rather than how you want them to be, so if you've had trouble controlling Ph while using alternate-row spraying, the suggested remedy is just as obvious.

WOOD CANKERS

Eutypa dieback has been on the radar of eastern grape growers for many years; in fact, it is standard practice to cut through a piece of cankered trunk or cordon, see a wedge-shaped area of dead tissue, and diagnose it as Eutypa. However, work conducted for more than a decade now at the University of California, primarily in the lab of Dr. Doug Gubler at UC Davis, has shown that there are a number of different fungi that cause canker diseases in the west, each with its own specific biology and, potentially, appropriate management program. In the east, we (understandably) tend to preoccupy ourselves with the whole panoply of fruit and foliar diseases found in humid climates, which can destroy a crop in a single season if not adequately controlled. Nevertheless, we also have canker diseases, and although less flamboyant than our usual rots and mildews, they are "silent but deadly" robbers of production and profit in the east as well. We continue to see signs that they will become increasingly visible and important as our newer and higher-value vineyards continue to age. Thus, it seems time to start paying more attention to these diseases, and a good place to start would be to determine just which organisms are responsible in our region.

We were very fortunate to have Dr. Philippe Rolshausen--a 10-year veteran of Doug Gubler's lab at UCD, with a wealth of experience in this field--working on the problem at the University of Connecticut while he was there on a temporary appointment, and to continue working in our region from his base at UC Riverside after returning there. Philippe has sampled cankered tissues from multiple eastern vineyards, determined the identities of the fungi associated with them, and done field trials with them in a Chardonnay vineyard at Geneva and a Concord vineyard in Portland, NY. I hope to be able to give some final results from the study in this space next year.

In the meanwhile, suffice it to say that Philippe's results to date confirm that canker diseases are a larger problem in the East than is commonly acknowledged. Many of the organisms that he found are well-known causes of disease in California and Europe (including those responsible for esca and "black goo" syndrome). Although management options are limited, at the very least it appears that we need to do a better job of getting dead wood out of the vineyard and putting it to the torch before the fungi within make spores and attack new pruning wounds, thereby spreading the disease. There may also be options for chemical control, where appropriate.

PUTTING IT ALL TOGETHER

As I preface this section every year, we all know that there are as many good disease control programs as there are good growers and advisors. The following are <u>some</u> considerations among the many possible. As always, just because it isn't listed here doesn't mean it's a bad idea. And don't make this any harder than you need to.

1-INCH SHOOT GROWTH. A **Ph** spray may be warranted if wet weather is forecast, particularly if the pruning/training system (significant inoculum retention) or block history suggests high risk. <u>Option A</u>: Nothing. <u>Option B</u>: Captan, mancozeb, or ziram. The best one is whichever is cheapest and most convenient.

3- to 5-INCH SHOOT GROWTH. A critical time to control **Ph** rachis infections if it's raining or likely to be soon, especially in blocks with any history of the disease. Early is better than late if it looks like some rain is setting in. Late is much better than nothing if those are the only two options. This spray can provide significant benefit against fruit infections as well, since many of them originate from movement into the berries from infected rachises and berry stems. Also an important time to control basal shoot infections, since this is where the fungus will establish itself for the future if infected tissue is retained in canes, spurs, or pruning stubs.

Now is the time to start thinking about control of **PM** on *vinifera* varieties if temperatures remain above 50°F for long stretches of the day. This spray is much more likely to be important in vineyards that had significant PM last year (we're talking late season foliar disease more than fruit infections here) than in those that were "clean" into the fall; however, it may be beneficial even in relatively clean blocks of highly susceptible cultivars, particularly in cloudy, wet years when temperatures aren't severely limiting. And if you're already spraying for Ph, why not include something for PM on highly susceptible (and valuable) varieties while you're at it.

In NY, spending extra money for **BR** control is almost never justified this early unless you're trying to clean up a severe problem block AND weather is wet and reasonably warm. In general, the farther south you go, the more important early sprays can become. Still too early for **DM**.

Option A: Nothing. Option B: Mancozeb or ziram (BR, Ph). Option C: Captan (Ph, some BR). Easier on predator mites than mancozeb or ziram, probably good enough against BR this early, but 3-day REI issue. Option D: Sulfur (PM). As discussed above, historical pronouncements concerning reduced activity of sulfur at temps below 65°F appear to have been significantly exaggerated. It should be good enough, and is a cheap insurance option. With thorough coverage, sulfur sprays can eradicate incipient infections initiated during the previous week or 10 days (depending on temps since then). Option E: Rally, tebuconazole generics, Mettle [except NY] (PM, BR). In theory, one of the difenoconazole (DFZ) products (Revus Top, Inspire Super, Quadris Top) should fit here, too, since they should all give PM control superior to that from the preceding materials and are equivalent against BR. The problem with any of the DFZ products so early in the season comes down to resistance management issues: We're trying to limit the use of all DMIs (combined) to a total of three applications per season. And all of the DFZ products are mixed with something that we'd rather not apply now because pressure from the target organism for the mixing partner doesn't justify its use yet and we're trying to limit the number of applications of these materials. (This is especially critical for Quadris Top, since it contains a strobie). Did I already mention the critical nature of dosage with the DMI products, how dosage is a function of spray coverage in addition to the amount of product in the tank, and the coverage problems with alternate row spraying? Option F: Rubigan/Vintage (PM). An economical option, especially if BR control isn't an issue, and it usually isn't at this time. But the same issue with the need for limiting DMI applications and superior coverage at the low rates used early in the season. Option G: JMS Stylet Oil (PM). Should eradicate young infections that have already occurred IF thorough coverage is provided, and can provide a few days of limited forward activity, although much of this protective capability washes away with less than ½-inch of rain. Can use with mancozeb or ziram, but not with or near captan or sulfur (plant injury). Option H: Nutrol, Armicarb, Oxidate, Kaligreen. (PM). Should eradicate young infections IF thorough coverage is provided, but no forward activity. If choosing this option so early in the year, go with the low end of the label rate and use the cheapest one. Option I: Serenade or Sonata, if you want to experiment with these "biocontrol" products while disease pressure is low (PM; maybe BR if there's a spore or two flying around). Option J: One of the PM products plus mancozeb, ziram, or captan for Ph.

10-INCH SHOOT GROWTH. We once recommend not waiting any later than this to control **BR**. Continued experience tells us that we can get way with withholding a BR spray at this time under most commercial conditions in NY unless this disease was a problem last year (inoculum levels are high) and weather is wet and warm. DO NOT wait any later than now to control **PM** on susceptible varieties. On Concord and other "moderately susceptible" cultivars, we normally recommend waiting until immediate prebloom. However, there have been seasons where we started seeing PM on Concords around the 10-in shoot growth stage, and uncontrolled early infections spread to the clusters and really caused havoc. And I've had excellent Concord growers tell me that when they wait until prebloom, they see a little PM already established, which puts them behind the 8-ball right from the start. So, get out in the vineyard and see what's happening. No need to spray before you need to, but if you already see PM, or you have experience with early disease development and weather conditions are forecast to favor PM, it might be a good idea. Remember, as crop load goes up, so does the need for good PM control and the ability to pay for it. Now is one of the best times to use a DMI, and a possible time to experiment with "alternative" materials if you're so inclined. It's also one of the best times to use an oil or other eradicant material against young "primary" infections that might just be getting started, particularly if the PM program up until now has been marginal or absent. **DM** control should be provided on highly susceptible varieties, especially if disease was prevalent the last year or two and rains of at least 0.1 inches at temps >52°F are anticipated or have occurred recently. Rachis and fruit infections by **Ph** are still a danger in wet years, particularly in blocks with some history of the disease.

Option A: Mancozeb (BR, Ph, DM). A broad spectrum, reasonably economical choice for everything except PM; tank mix with a PM material to complete the picture if necessary. Excessive use can lead to mite problems by suppressing their predators. You can substitute ziram if necessary or desired but will give up some DM control for in the process, although that might not be too significant this early. Option B: Captan (Ph, DM, some BR). An alternative to mancozeb if you're trying or are forced to avoid it. The limited BR activity should still be sufficient if the disease was controlled well last year (limited inoculum) and good BR materials will be used in the next three sprays. Toss in something for PM where needed. Option C: Sulfur (PM). Historical concern about reduced activity during cool weather is going down as we look at experimental data and temps should going up now as we look at the calendar going forward. Post-infection activity may be useful against new "primary" infections before they have a chance to form new spores and spread to developing clusters. Option D: Revus_Top (PM, BR, DM). Superior PM control relative to anything else recommended at this stage of the season other than Quintec or Vivando [no Vivando in NY yet]. BR and DM control, and all at a highly competitive price. A combination that's pretty hard to beat if that's what you're looking for. Except on Concord and a few other cultivars (likely to cause injury). Option E: Quintec or Vivando [Vivando still not registered in NY at the time of writing] (PM). Both are Cadillac PM material that should be limited to two applications per season each (they are unrelated to one another) for resistance management purposes. You'll get even more bang for your buck with a Cadillac PM material in another week or two, but if you feel that you need or want to start throwing the kitchen sink at it now, these are viable options. Option F: Rally, tebuconazole generics, Mettle [outside NY] (PM, BR). Option G: Rubigan/Vintage (PM). Limited BR activity usually is not a problem if effective materials are applied in the next three sprays, and is a non-issue if tank-mixing with mancozeb or ziram. Cost may be attractive, but higher 4-oz rate might be necessary where DMIs are starting to poop out. Option H: JMS Stylet Oil (PM). If (and only *IF*) coverage is thorough, this spray should eradicate early PM colonies that may have started, should previous PM sprays have been omitted or incompletely applied. But don't waste your money if you can't cover thoroughly. Also may help with mites. Will provide a few days protectant activity going forward in addition to the eradicant action, although much of that residual activity will disappear after a rain. Mix with something offering forward protective activity if your next spray won't be for much more than a week from now. The petroleum-based PureSpray Green should have similar effects if you can find it, whereas the botanically-based oils are generally less effective. Option I: Nutrol, Armicarb, Oxidate, Kaligreen. (PM). Should eradicate young infections IF thorough coverage is provided, but no forward activity. Option J: Serenade or Sonata, if you want to experiment with OMRI-certified "biological" products before entering the critical period for disease control.

IMMEDIATE PREBLOOM TO EARLY BLOOM. **A critical time to control PM, BR, DM, and Ph on the fruit! Just starting to enter Botrytis season, too. This and the first postbloom spray are the most critical sprays of the entire season--DON'T CHEAT ON MATERIALS, RATES, SPRAY INTERVALS, OR COVERAGE!!** Option A: Quintec or Vivando [Vivando still not registered in NY at the time of writing] for PM control, plus mancozeb (for BR, DM, and Ph). Effective and no current resistance concerns in the real world, but let's keep it that way by avoiding over-use (no more than 2 applications per year of each one). Option B. Pristine (PM, DM, BR, some Bot and Ph). We'd like to keep this one down to 2 applications per season, too, especially with the increasing risk of DM resistance the longer that we keep using it. The 12.5-oz rate of Pristine will also provide significant protection against Botrytis, I wouldn't spend the extra money on the higher "Botrytis control" rate (18.5-23 oz/A) this early unless Botrytis pressure was really high and/or I was really worried. On highly susceptible cultivars, where DMI resistance is usually an issue to at least some extent and strobie resistance has occurred or is deemed risky, Quintec, Vivando (check NY status), or Pristine (plus sulfur) would be the materials of choice for PM, but don't forget about DM and BR. With Pristine especially, I'd toss in some sulfur, particularly in blocks where PM has already developed strobie resistance, just for additional insurance at this critical time. Option C: Revus Top (PM, BR, DM), Inspire Super (PM, BR, Bot), or Quadris Top (PM, BR, DM). Discussed in detail under "New fungicides" at the beginning of this tome. Worth reviewing, especially if you're considering use at this time. If using Inspire Super, you'll need to add something for DM. I can't overemphasize the fact that the outstanding PM control we've seen with difenoconazole is due to the high "intrinsic" activity of this material, but that it's rate dependent and you'll start losing this activity--especially on the clusters!--if you get spotty spray coverage (i.e., only put a partial rate on your spray target). Option D: Abound or Sovran [plus sulfur, on cultivars where it can be used] (PM, BR, DM [only moderate DM for Sovran]). Still an effective option in some plantings, particularly on native and certain hybrid cultivars that have seen limited use over the years, although the scuttlebutt is that they're slipping in some of these vineyards, too. As with most rumors, recognize this one for what it is and then apply your own experience in determining how much credence to give it. Refer to the discussion on strobilurin resistance in the "Fungicide Changes and News" section at the beginning of this epistle. Option E: Flint plus sulfur (PM, BR, Botrytis at the 3-oz rate) plus one of the many options for DM. Substituting Adament for Flint is an option if the price is right. At the 6 oz/A rate labeled for Botrytis (equivalent to 3 oz of Flint + 3 oz of the former Elite or some tebuconazole generics), the tebuconazole should provide significant additional BR activity in a kick-back mode and some additional PM activity, although the latter will be limited in vineyards where DMIs have started to fade to any extent. It also adds one DMI application to the seasonal "cup", which shouldn't contain more than three applications for all DMI products. Option F: Rally, tebuconazole generics, Vintage/Rubigan, or Mettle [no Mettle in NY] (PM, BR [except Vintage/Rubigan]) PLUS mancozeb (DM, BR, Ph) or captan (DM, Ph). One of the new DM-specific fungicides could also be used for this purpose, but they may give more bang for the buck after bloom unless there's heavy DM pressure early (clusters are highly susceptible now, after all). Add sulfur on *vinifera* and PM-susceptible hybrids (unless "sulfur shy"). Like the difenoconazole products, Rally, the tebuconazoles, and Mettle provide excellent postinfection activity against BR, which can make them especially valuable if significant unprotected infection periods occurred over the last week or 10 days. If wet, mancozeb (or captan) should be included for control of Ph fruit infections in blocks where this has been a historical problem (note some processor restrictions and poor BR control with captan). Option D: Mancozeb + sulfur (PM, BR, Ph, DM). Used to be cheap and effective, particularly if used at shorter spray intervals; it's no less effective than before. Neither material is as rainfast as the strobies or SI fungicides, so shorter spray intervals can be both necessary and difficult in wet years. Of course, this is precisely when their activity is needed the most. Potential mite problems, as this mixture is hard on mite predators.

BLOOM. Vangard (or Inspire Super), Scala, Elevate, Flint/Adament (3/6 oz rate), Endura, or Pristine for Botrytis control will probably be beneficial sometime around now on susceptible varieties, particularly in wet years. It's certainly easier to use or include one of these materials for Botrytis purposes in the "immediate prebloom/early bloom" or "first postbloom" spray, and from what we know of these materials' activities, they should be effective when applied then, although we've never directly compared these timings (results would likely be different from year to year anyway, depending on if and when rains fall through the pre- to post-bloom period). One problem with tank-mixing Botrytis-specific materials like the AP's and Elevate is that you'll be distributing them throughout the entire canopy, whereas the only place they're effective is on the clusters. Also, if sulfur was the only PM material in the previous (immediate pre-bloom) spray, reapply about now on highly susceptible *viniferas*, especially if it's been raining since then or will soon.

FIRST POSTBLOOM (10-14 days after immediate prebloom/early bloom spray). **Still in the critical period for controlling PM, BR, DM, and Ph on the fruit. And we're well into the start of Bot season. This and the immediate prebloom/early bloom spray are the most critical applications of the entire season--DON'T CHEAT ON MATERIALS, RATES, SPRAY INTERVALS, OR COVERAGE!!** Shorten the spray interval and/or jack up the rate or PM material quality on PM-susceptible varieties if weather is warm and cloudy. For Botrytis-sensitive cultivars/blocks/seasons, make sure that this application has some Bot activity if you haven't used anything at for it yet. Same considerations and options as detailed under IMMEDIATE PREBLOOM. Juice grape growers can substitute Ziram (very good BR and Ph, only fair DM) for mancozeb or captan if necessary, or just go with Abound or Sovran for everything if they're still working. Captan, mancozeb, or the strobies will protect against bitter rot and ripe rot, if/where those are concerns.

SECOND POSTBLOOM. **BR** control is still advisable under wet conditions and is should be considered critical if infections are evident on the vine, unless you're willing to bet part of your crop that it's not going to rain within the next few weeks; however, BR sprays can often be skipped from here on out on natives and hybrids if the vineyard's clean. Fruit are less susceptible to **PM** now, but those of *vinifera* varieties (and susceptible hybrids?) still need good PM protection, particularly to guard against later bunch rots and colonization by wine-spoilage microorganisms. Of course, new foliage remains highly susceptible to PM throughout the season, and it behooves you to keep it clean for purposes of leaf function in addition to reducing primary inoculum for next year. Concords can withstand a lot of foliar PM unless the crop is very large and/or ripening conditions are marginal. Minimal programs can stop now on this cultivar if the preceding crop/ripening conditions don't apply, although one more PM spray now is often justified. Try to avoid DMI and, particularly, strobie fungicides if PM is easy to see without trying. **Ph** danger is basically over unless very wet and a problem block. Clusters are still susceptible to **DM** and should be protected on susceptible varieties if weather is wet, especially if disease already is established (take a look and see). Foliar DM will remain a potential threat throughout the rest of the season, depending on the weather, and can quickly turn into an epidemic on susceptible cultivars if we get into a prolonged set of summer rains or thundershowers. Option A: Pristine, Abound, Sovran, or Flint (or Adament). See previous discussions on all of these. They provide good residual control of the listed diseases if used now, but strictly limit their use to maintain viability. And if you think they might not be working against DM, don't wait for somebody from the university to confirm that before you switch to something else. Pristine and Flint (or Adament) will provide good Botrytis control when used at the appropriate rate as a pre-bunch closure spray. Option B: Quintec or Vivando [Vivando still not registered in NY at the time of writing] for PM control + captan (DM, Ph) or mancozeb (BR, DM, PH, but 66-day preharvest restriction and mite issues) as needed for these other diseases. If DM is the only other issue, Ridomil (in a bad year), a phosponate, copper, or one of the new DM-specific materials (see Chapter 1 of this book) are additional options. Quintec, Vivando, and Pristine shouldn't be applied in more than two consecutive sprays. You may want to save one of your two Pristine shots for veraison or later, to pick up Botrytis and other rots. Option C: Revus Top (PM, BR, DM), Inspire Super (PM, BR, Bot), or Quadris Top (PM, BR, DM). Remember, these are discussed in detail under "New fungicides" at the beginning of this tome. Inspire Super will provide Bot control when applied pre-bunch closure, the low cyprodinil (Vangard) rate that it provides might or might not be adequate, depending on pressure. If using this, you'll need to add something for DM on susceptible cultivars. Option D: Rally, tebuconazole generics, Vintage/Rubigan, or Mettle [no Mettle in NY] (PM, BR [except Vintage/Rubigan]) PLUS mancozeb if still within the 66-day PHI limit (DM, BR) or one of the many DM options (captan, phosphites, new DM-specific materials discussed previously). Like the difenoconazole products, all of the DMI products except Vintage/Rubigan provide excellent postinfection activity against BR. Option E: Sulfur (PM) + the options listed above for BR and DM. In most years, lessening PM pressure makes this economical option increasingly practical as the season progresses. Option F: Copper + lime (DM, some PM). A good PM option at this time for Concord and other native varieties needing one (reasonable efficacy, no resistance issues, significant residual activity if this is the last spray), generally not good enough for *vinifera* and susceptible hybrid cultivars.

ADDITIONAL SUMMER SPRAYS. Check the vineyard regularly to see what's needed, the main issues will be **PM** and **DM** on the foliage (remember, you'd like to keep foliage clean of PM into September). Also **Botrytis** on susceptible cultivars, from veraison through pre-harvest. And the **"summer rot"** diseases (bitter rot, ripe rot) are potential threats in wet years, particularly in blocks or regions where they've occurred before.

On *vinifera* and other cultivars requiring continued **PM** control, use sulfur as an economical choice. However, this can be a problem as you approach veraison, as some wineries are setting fairly long withholding intervals. DMIs, particularly the difenoconazole products, also are options; Revus Top is particularly attractive for the combined reasons of PM/BR/DM efficacy and cost (except on Concords, of course). But pay attention to previously-discussed maximum number of applications for all of these materials. Quintec or Vivando (not yet in NY, etc.) will certainly provide outstanding control if you need/want it and haven't used up your seasonal allotment yet. Ditto for Pristine (save for later against Bot and other rots?). All of these materials provide the advantage of longer residual activity than sulfur. Copper + lime can be used on Concords, but mid-summer sprays for PM on this variety are probably worth the expense only under high crop and/or poor ripening conditions. Alternative materials such as Nutrol, Kaligreen, Armicarb, Oxidate, Serenade, and Sonata can have their place during this period, especially if you're trying to avoid sulfur, although they generally need to be sprayed more frequently and most of them are not cheap. The well-documented ability of oils to decrease photosynthesis and consequently decrease Brix accumulation makes me wary of recommending these products once the crop nears veraison, although a single application should be OK. For **DM**, there's the whole raft of products discussed previously. **Summer rots** are controlled with mancozeb, captan, and strobies; the peak period of susceptibility appears to be near veraison. Strongly consider an "insurance" application against **Botrytis** at or soon after veraison (depending on the weather), then determine the need for a subsequent pre-harvest spray based on weather and the need to limit spread of the disease, should it be revealed by scouting. **BR** should not be an issue after the second postbloom spray, except in very unusual circumstances (disease is established in the clusters of *vinifera* varieties, wet weather is forecast, and it's possible to direct sprays onto the clusters). **Ph** should not be an issue, period.