GRAPE DISEASE CONTROL, 2008

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It's that time again: the annual review of new developments, basic principles (a.k.a. the s.o.s.), forgotten factoids, proverbial reminders to look both ways when crossing the street, 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, Bob Seem); research technicians (Duane Riegel, Judy Burr); and graduate students and post-docs too numerous to mention. Rick Dunst and the crew at the Vineyard Lab in Fredonia also play a very significant role, particularly on projects related to native varieties. It is the combined research efforts of all of these people that serve as the basis for most of the following.

I'd also like to acknowledge the financial support of the coordinated public and private viticulture research funding bodies (the newly-resurrected USDA Viticulture Consortium-East program, the New York Wine and Grape Foundation, the Grape Production Research Fund, Lake Erie Regional Grape Program, Dyson Foundation, New York Wine Grape Growers, American Vineyard Foundation), not to mention that of Cornell's College of Agriculture and Life Sciences, that allows the various subdisciplines in viticulture and enology to keep moving forward. We're very fortunate to be associated with one of the most dynamic segments of agriculture today, and this doesn't happen all by itself.

FUNGICIDE CHANGES & NEWS

1. Nova is now Rally. Since its release nearly 20 years ago, the very same product has been labeled as Rally for use in the western states and Nova for use in the east (thereby allowing different price structures in the two regions). Now, however, "Nova" is history, and the product will be sold as Rally throughout the U.S. The only change from Nova is the name on the package (and one digit in the EPA registration number). Old product is fine to use according to its label directions.

2. New product, Adament. Adament is a new combination product containing virtually equal amounts of tebuconazole (the active ingredient in Elite) and triflozystrobin (the a.i. in Flint); 2 oz of Adament contains the same quantity of active ingredients as 1 oz of Elite + 1 oz of Flint. Thus, at the rate of 3 oz/A labeled for control of powdery mildew at 14-day spray intervals, Adament will provide the equivalent of 1.5 oz per acre of both Elite and Flint (or 2 oz of each component when used at the rate of 4 oz/A, as labeled for 21-day spray intervals).

Flint is an excellent PM fungicide when used alone at these rates <u>in vineyards where the strobilurins still work</u>, and the addition of tebuconazole (Elite) may help to slow the build-up of resistance in vineyards where it has not yet developed. However, resistance is already common throughout much of New York and is reported to be an increasing problem in the mid-Atlantic region. Unfortunately, the low rates of tebuconazole included in these rates of the Adament combination product (equivalent to 40-50% of the recommended rate of Elite) are unlikely to provide adequate control of the disease in vineyards where strobilurins are no longer doing the job, particularly in those with a long history of sterol inhibitor use. (Recall that prolonged use of the SI [or, DMI] fungicides "shifts" the sensitivity of the fungus population to a point where such fractional rates are no longer effective). In contrast, another combination product, Pristine, has been widely effective in such vineyards, because the non-strobilurin component is included at a rate sufficient to provide very good to excellent PM control by itself, even if the strobilurin component fails.

Adament is labeled at higher rates for control of black rot (4 to 7.2 oz/A) and Botrytis (6 to 7.2 oz/A). Flint has consistently provided very good to excellent control of Botrytis at a rate equivalent to 6 oz/A of Adament, although the Elite component won't do much, if anything, within the labeled rate range. However, both components are very effective against black rot and Adament should provide dynamite control of this disease, since the Flint component provides excellent activity in a "forward" (protective) manner and the Elite component is particularly active in a "backward" (post-infection) mode, especially at the higher end of the rate range (see data in the Black Rot section later on). Furthermore, the highest rate, providing the equivalent of 3.6 oz/A of Elite, should also do a reasonable job against PM in most vineyards where the strobies no longer work, although it's not yet clear how price-competitive this rate option will be. Remember that Flint has weak activity against downy mildew and Elite, like all sterol inhibitors, has absolutely none (unlike typical

fungi, the downy mildew organism doesn't produce sterols for its membranes, so fungicides that inhibit their production have no effect on it). Therefore, Adament is likely to provide control of this disease only during periods of drought.

3. Tebuconazole generics. The patent on tebuconazole (Elite) has expired, and other products containing this active ingredient are now coming onto the market. Such generic "knock offs" are often as effective as the original "name brand" product, but not always, as the formulation chemistry can have a major impact on a product's activity (the 55% "inert ingredients" in Elite 45DF are there for a reason). Of the generic tebuconazole products now labeled on grapes, the only one that we've tested is Orius; its activity has been comparable to that of Elite in several different trials that we've run.

4. New fungicide, Revus. This is a downy mildew-specific fungicide (no control of other grape diseases) that just recently received federal EPA registration; however, it is unlikely to be registered in NY in time for the 2008 season. It is unrelated to any other grape fungicide on the market, although it is in the same family as Acrobat, a material used on potatoes and some vegetable crops. There are virtually no U.S. data available to indicate the degree of its efficacy against grape downy mildew under our climatic conditions, although a number of trials are planned for the coming year.

5. New Pristine label, redux. Growers used to be required to possess a separate, supplemental label to allow them to use the higher Pristine rate registered for Botrytis control (18.5-23 oz/A, versus 8-12.5 oz/A for all other diseases). This should no longer be necessary for newly-purchased product, which now includes the Botrytis rate on the standard label (be aware, however, that older product must still be used according to the label that's on the package, so keep some new stuff around if you're going after Botrytis). This new label also clarifies that the re-entry interval is 12 hours for <u>all</u> rates used, unless workers are involved with cane tying, turning, or girdling (when it becomes 5 days). As noted in previous years, we've consistently obtained excellent Botrytis control at a rate of 19 oz/A, with significant but often reduced levels at lower rates. I'd consider 12.5 oz/A a minimum rate if I thought I was likely to need Botrytis control, and would recommend the higher rate range on susceptible varieties under any sort of pressure. It's quite possible that you might be able to drop down to 12.5 oz/A at bloom and save the higher rate for veraison or pre-harvest (the higher rate should also provide more help against secondary "sour rot" organisms), as we had some indication when first trying this approach last year; nevertheless, if I had $6,000/A of Pinot Noir on the vine and it was raining hard during bloom, I'm not sure how frugal I'd try to be.

6. Stylet Oil, protective activity. Although potassium salts (Nutrol, Armicarb, Kaligreen, etc.) provide no protective activity against new PM infections, JMS Stylet Oil has been reported to. We ran greenhouse tests to examine this, inoculating Riesling seedlings with PM spores either 1, 3, or 7 days after they had been sprayed with a 1.5% solution of the oil. One half of the sprayed plants were subjected to an artificial rain of 1 inch, 24 hr after the application (before challenge with the pathogen), the other half remained dry. Two weeks after inoculation, plants were evaluated for disease severity and for the number of new spores produced from the infected leaves. The test was run three times.

As shown in the figure below, the protective activity of Stylet Oil declined quickly with time and was strongly reduced when artificial rain was imposed after the spray application. <u>In the absence of rain</u>, control of disease severity declined from an average of 90% (relative to the unsprayed plants) when the oil was applied 1 day before inoculation, down to 38% when applied 7 days before; however, production of spores from these leaves was still reduced by 85% even when plants were inoculated a week after spraying. In contrast, the protective activity of Stylet Oil was minimal beyond 1 day after application when the treated plants were subjected to simulated rain,

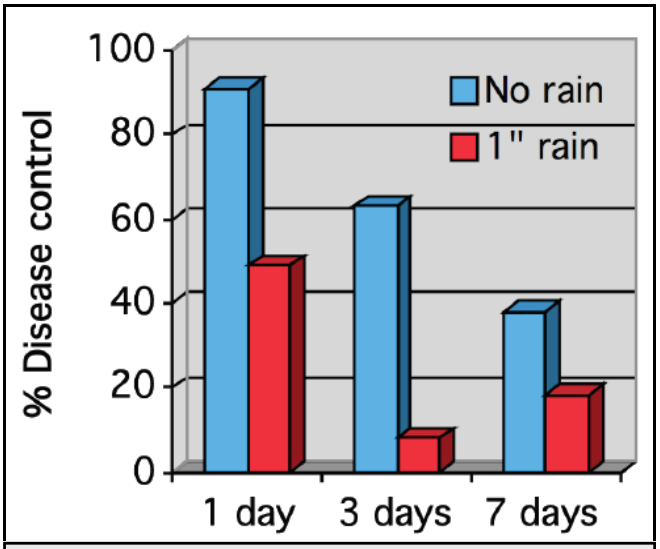

Fig. 1. Protective activity of JMS Stylet Oil (1.5% concentration) on Riesling foliage, with and without 1 inch of artificial rain (average of 3 trials).

and rain greatly reduced the antisporulant activity as well. It appears that Stylet Oil can provide moderate but significant residual (protective) activity, but that it is removed from treated tissues by rain, limiting this property when precipitation occurs.

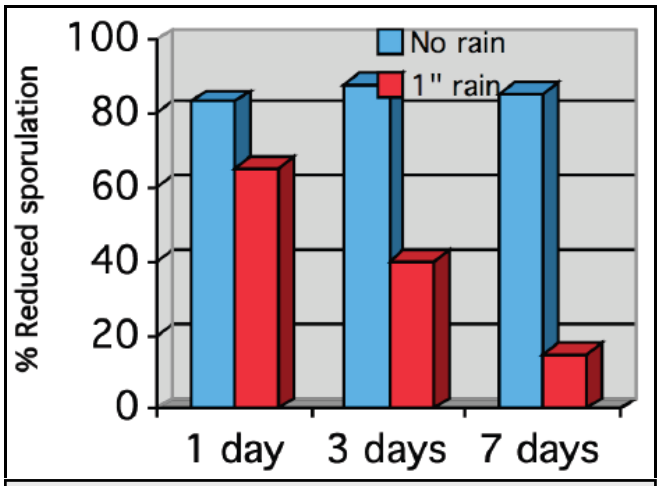

Fig. 2. Reduction in spore production when JMS Stylet Oil (1.5% concentration) was applied 1 to 7 days before infection, with and without imposition of 1 inch of artificial rain (average of 3 trials).

7. Strobilurin resistance, a reminder. Strobie resistance started causing a problem with PM control in the Finger Lakes and Long Island regions in 2002, and we all knew that it was just a matter of time until other areas had the opportunity to share in our "bounty". As mentioned in previous editions of this missive, Dr. Anton Baudoin at Virginia Tech began reporting resistance to both powdery and downy mildews in the mid-Atlantic region in 2005, and Dr. Turner Sutton at North Carolina State found DM resistance in nearly every production region of his state in 2006. Then, there were widespread DM control failures in Texas in 2007. The bottom line is, these things are toast with respect to DM control in many regions where disease pressure is high, and real caution is in order now when considering their utility against DM in New York and other more northerly areas where problems have not yet occurred. Conversely, 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 Dr. Baudoin's findings from select mid-Atlantic vineyards would suggest. Otherwise, the question regarding such an unfortunate occurrence becomes a matter of "when", not "if".

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 this progresses to the point of crop damage depends primarily on the number of selection events (spray applications) and the ability of the "selected" (resistant) individuals to multiply and spread. This latter factor is determined by (i) the weather (the number and intensity of infection periods); (ii) the relative ability of the disease-causing fungus to grow and reproduce on the host plant (varietal susceptibility); (iii) the inherent "reproductive capacity" of the fungus (the time between the start of an infection period and production of a new "crop" of spores, the relative number of spores then produced, and the extent to which these spores are dispersed over distance); and (iv) the extent to which reproduction is arrested (disease is controlled) by other farming practices, including both non-chemical means and applications of 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 the first PM problems were on Chardonnay (optimum pathogen reproduction); (iii) Why we haven't hit problems yet on Concords, 6 years after hitting them on *vinifera* (fewer sprays to select resistant individuals, less reproduction of them should a few be selected); (iv) Why the initial problems were so much less common in vineyards that had tank-mixed with sulfur (less reproduction of the resistant individuals); (v) Why nobody has yet encountered black rot resistance (BR has a much lower reproductive capacity than PM and DM—it takes a longer time for infections to produce spores [longer "generation" time], and most of those produced are dispersed only locally via splashing rain rather than being 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 (tank-mixing sulfur with Pristine is a good idea, too, to protect the non-strobie

component in vineyards where the strobie portion isn't doing much). As mentioned above, the non-strobie component of Adament is unlikely to provide adequate PM control by itself (if strobie-resistant individuals are selected and start to multiply) when used at the rates labeled for PM control. The higher rates recommended for other diseases might do a credible job, although cost is still an unknown (nevertheless, I have been able to determine that 6 oz/A will cost twice as much as 3 oz/A).

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 (phosphonate, mancozeb, captan, copper) to be safe in regions where DM resistance has begun to appear. The bottom line is, the strobies are no longer viable DM materials in much of the eastern U.S. (again, the worst problems have appeared in regions where generally warmer and wetter weather has sped the reproduction of resistant individuals). In more northerly regions such as New York, we have not yet seen widespread or documented control failures, probably because (i) DM pressure is somewhat less intense than further south, and (ii) strobie use has been consciously limited since PM resistance developed in 2002. Nevertheless, it's most likely only a matter of time until it happens here as well-- remember, 2007 was awfully dry and there was little DM, period, resistant or otherwise. The DM activity of Pristine, Abound, and even Sovran (on Concords and Niagaras) is part of what originally made them so attractive, and it still remains so in some regions. But use them for this purpose with caution.

POWDERY MILDEW (PM) NEWS AND REMINDERS

A 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. In New York, spores produced within these cleistothecia 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 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. (Cleistothecia beginning to develop from infections initiated in the very late summer/early autumn are unlikely to mature before frost kills the leaves and eliminates their food source).

Let's look at why this is so. Several years ago, we conducted an experiment in a Chardonnay vineyard where we either (a) sprayed through Labor Day, maintaining a clean canopy throughout the year; (b) quit spraying a month earlier, simulating a vineyard with moderate levels of PM by the end of the season; or (c) quit spraying in early July, simulating a vineyard where PM control got away from us. The next spring, the levels of cleistothecia (number per kilogram of bark) in these treatments were (a) 1,300; (b) 5,300; and (c) 28,700, respectively. Now, consider the case where 20% of the overwintering spores are 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, whereas in dirtier treatment (b) it's equal to the entire seasonal supply on the clean vines, and in treatment (c) it's four to five times the entire seasonal supply on the clean vines. Not surprisingly, this makes a difference. When we intentionally withheld a minimal spray program on these same vines until the immediate prebloom period the following spring, the resulting cluster disease severities were (a) 11%, (b) 22%, and (c) 48% cluster area infected, respectively, even though all were sprayed the same. Conclusion: Higher disease one year = More primary infections to start off the season next spring = Many more new ("secondary") spores by the time the fruit were susceptible to infection = Increasing 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 (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 during the bloom and early postbloom period provide ideal conditions for the fungus 24 hr a day, just when fruit are extremely susceptible to

infection. And things become even worse if warm weather is accompanied by extensive cloud cover, as discussed below.

(iii) Although not as important a factor as temperature, 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 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, and appears to be an important environmental variable distinguishing "easy" from "bad" 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. Your annual reminder.

(v) Failure to control even inconspicuous PM infections on the berries can increase the severity of berry rots (Botrytis and sour rot) at harvest, and can promote the growth of wine-spoilage microorganisms such as *Brettanomyces* on the fruit. Another annual reminder. Providing <u>excellent</u> 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 way to reduce the risk 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" materials (oils, bicarbonate and monopotassium phosphate salts, hydrogen peroxide, etc.) that have little 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 generally work in a post-infection/curative mode with little "forward" activity. This means that they need fairly frequent re-applications, or should be tank-mixed with something that provides good protective (forward) activity.

Effect of sunlight exposure

The general admonition to provide good sunlight exposure as part of a PM management program has been a staple of this treatise for the past few years, but in 2005 we began a project to examine the phenomenon in detail. Although it has "long been known" that PM is worse in shady portions of the vineyard, the deeper we get into it, the more I'm convinced that the impact of this factor on PM development, and how we should consider it in management programs, has been vastly underappreciated. (BTW, hats off to graduate student Craig Austin, who's done the lion's share of this work).

To illustrate: In a vineyard of cv. Chardonnay, we compared one group of vines in a portion of a row immediately east of a group of tall pine trees that provided morning shade until 11 AM, versus a second group located in the same row away from the trees. Within each group, we inoculated shoots (a) fully exposed to the sun on the outer edge of the canopy versus (b) others confined within the heavily-shaded canopy center. Thus, there were four treatments: (i) outer canopy, no tree shade (maximum exposure); (ii) outer canopy, with tree shade; (iii) inner canopy, no tree shade; and (iv) inner canopy plus tree shade (maximum shading). Average disease severities over multiple runs of the experiment during 2005 and 2006 are provided in Fig. 3 below.

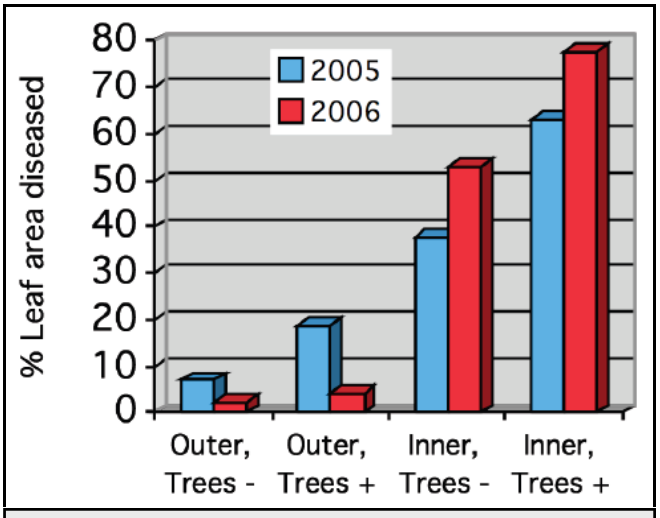

Figure 3. Disease severity on Chardonnay foliage subjected to various levels of natural shading in 2 different years (see text for treatment details).

In both years, transient morning shade provided by the pine trees increased disease severity relative to the comparable portion of the canopy away from the trees, but constant shading within the canopy had an even more pronounced effect relative to shoots receiving full sun exposure. And these effects were additive, with the most shaded leaves developing 9 times more disease than those with the best exposure in 2005, and 45 times more (!) in 2006.

In 2007, we conducted a new experiment in this vineyard, to examine whether exposing fruit clusters to sunlight via leaf pulling might reduce disease on the berries. Clusters on vines both near and away from the trees were inoculated with PM spores either at (i) bloom, or (ii) 2 weeks post-bloom, and variable leaf pulling treatments were imposed later. For the bloom inoculation, either (a) two leaves each above and below the cluster ('heavy'), or (b) a single leaf above and below the cluster ('light') were removed 5 weeks after infection. Following the second inoculation, these same 'heavy' and 'light' degrees of leaf pulling were imposed, either (i) 3 weeks later (i.e., 5 weeks post-bloom), or (ii) 7 weeks post-bloom.

Illustrative data are shown in Figure 4 below. For both inoculation dates, cluster disease was significantly more severe on vines subjected to the morning tree shading than on those away from the trees. Averaged across all leaf-pulling treatments, cluster disease severity resulting from the first inoculation was 28% for vines in the clearing versus 47% for those next to the trees, whereas following the second inoculation, these values were 31 and 48%, respectively. Leaf pulling following the first inoculation had little effect, probably because it was performed so long (5 and 7 weeks) after infection (*data not shown*). In contrast, both levels of leaf pulling performed 3 weeks after the second inoculation reduced disease severity by nearly 50% relative to the control treatment on vines away from the trees, whereas neither level had any effect when the operation was delayed until 5 weeks after this inoculation (Fig. 4). Near the trees, all four leaf pulling treatments provided only modest levels of disease reduction. Not surprisingly, it appears that leaf pulling can reduce PM severity on fruit clusters when sunlight is otherwise available to the vine, but is of much less benefit when sunlight is limited by other factors, such as nearby trees. Viewed interactively, cluster disease severity was reduced by two-thirds by the earlier leaf pulling treatments on vines in the clearing relative to the control vines near the trees.

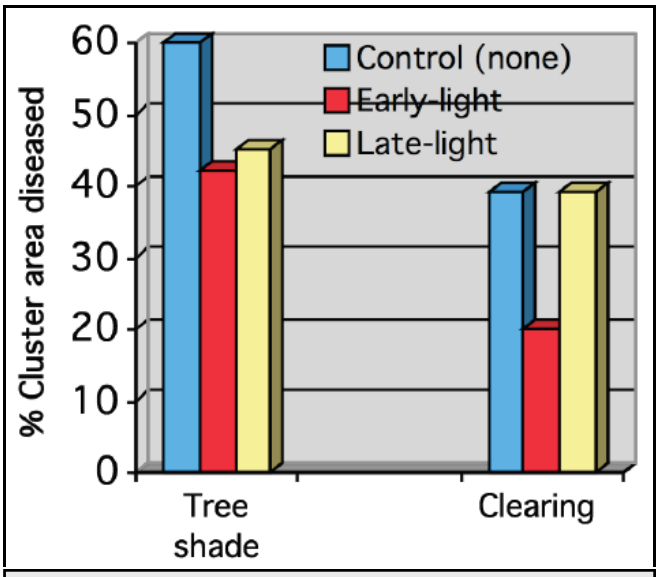

Figure 4. Effect of leaf pulling treatments on powdery mildew development on clusters of Chardonnay vines adjacent to or removed from nearby trees. Clusters were inoculated 2 wk post-bloom, then 'heavy' or 'light' leaf pulling operations were performed 3 wk ('Early') or 5 wk ('Late') afterwards. Disease severity values shown represent the means for 20 clusters per treatment; both levels of leaf pulling had similar effects, hence only the 'light' data are shown

Also, recognize that in order to discern the effects of the leaf-pulling treatments resulting from increased sunlight exposure, these clusters were covered with bags when fungicides were applied to the vineyard; in the real world, leaf pulling can also reduce PM development on clusters by improving fungicide spray coverage upon them. Furthermore, the leaf-pulling treatments were imposed rather late in this experiment. Many growers and viticulturists are now advocating that leaves be pulled shortly after fruit set, and both logic and the difference between our "Early" and "Late" treatments last year suggest that following this course of action might provide even better results than we obtained. We intend to explore this possibility during the coming season.

As we've discussed previously, it appears that sunlight helps to limit PM development in two ways: (1) Because the PM fungus is unpigmented and lives primarily on the <u>outside</u> of infected tissues, it is subject to "sunburn" from ultraviolet radiation; and (2) at mid-day, we've measured sun-exposed leaves and fruit to be anywhere from 2 to 23°F hotter than shaded tissues (depending on water status of the plant, wind speed, and cloudiness at the time of measurement), which are approximately the same temperature as the air. This can be detrimental or even lethal to the PM fungus during the summer. For example, on an 83° F afternoon, shaded tissues are at a temperature that is optimal for disease development,

whereas those in the sun are often 95 to 100°F, which can start to kill the PM colony after just a few hours.

To separate these effects, unsprayed Chancellor vines were subjected to three different treatments: (1) Some were protected from 80% of natural solar radiation by covering them with a meshed shade cloth, which filtered not only UV radiation but also the other sun rays that cause irradiated tissues to heat up; (2) Other vines were exposed to the sun but were protected from UV radiation by a clear filter above the canopy, thereby giving them the warming effects of the sun without UV (botanical 50F sun screen!); or (3) Still other vines were fully exposed to the sun, although fruit received some modest natural shading from the foliage of the well-pruned cordon training system. The data in Fig. 5 below shows that cluster disease severity was twice as high on bunches in the shaded versus exposed treatment, and was intermediate between these two extremes on those exposed to the sun (tissue heating) but protected from UV.

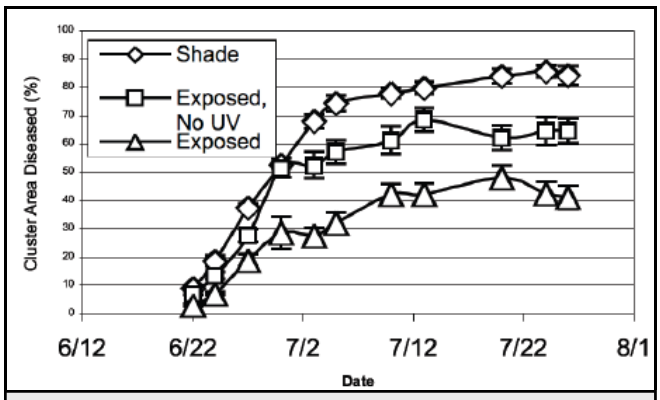

Figure 5. Disease severity on clusters of Chancellor vines, inoculated 1 week before bloom in 2006. Vines were either well exposed to the sun, exposed to the sun but filtered from UV radiation, or covered with woven shade cloth that removed 80% of all solar radiation. Values represent the means from 20 replicate clusters per treatment

Keep these concepts in mind, in terms of both (i) trying to limit PM by providing "optimal" levels of sun exposure through appropriate pruning and training systems, plus early leaf pulling on varieties where the economics support this practice; and (ii) recognizing that prolonged periods of rainy, cloudy weather are taking away the natural "fungicide" provided by sunlight and may require the spray program to be turned up a notch, especially if temperatures favor the disease.

A note to Concord growers: Remember that the value of mid-summer control on Concords depends on crop level, 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 (plenty of water and sunshine relative to crop size, few other stresses), research has shown that it can tolerate a lot of PM without significant negative consequences. However, this same research has shown that at high cropping levels, good PM control can be necessary to get the fruit to commercially-acceptable levels of ripeness.

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 the year, general vine vigor, fruit prices, etc. The basic two-spray program (pre-bloom, 10-14 days later) will keep the berries clean and is appears to be good enough in "average" vineyards in a "typical" year, but those with double-digit yields might benefit from (and be able to afford) one or two more in order to ripen the crop and bring it back strongly next year, depending on the season. We'd like to—but shouldn't—forget the 2003 season. You need leaves to ripen the fruit, and the more of it you have, and the less sun that there is, the more you'll need the leaves that you do have to be healthy and firing on all cylinders. Unfortunately, these are also the years where PM is the most difficult to control, and failing to do so can lead to disaster. The principles are simple, it's the choosing among a set of less-than-desirable options that can sometimes be hard.

Fungicides

Sulfur. A repeated summary of the major findings and conclusions from our recent studies on sulfur activities:

- <u>We were unable to demonstrate any negative effects of low temperatures on either the protective or post-infection activities of sulfur.</u> In a number of repeated tests, utilizing the equivalent of either 5 or 10 lb/A (6 or 12 g/L, sprayed to run-off), control was the same at 59°F as it was at 82°F. Workers from Australia have reported very similar results, i.e., they found a slight decrease in activity when a very low rate of 2 g/L [1.7 lb/A] was used at 59°F versus 68 or 86°F, but no difference among temperatures when the rate was increased to the equivalent of 5 lb/A. It appears that the potential detrimental effect of low temperature on sulfur efficacy has been significantly over-emphasized in our region, particularly in light of the fact that the PM fungus itself is not that active at cooler temperatures. Nevertheless, don't cheat on the rate or coverage if using it early, and don't forget that rains will wash some of it off.

- Sulfur provides very good protective activity on sprayed tissues, but this is limited by the tendency of shoots to "outgrow" the spray coverage as they expand. Sulfur can persist on sprayed tissues for quite some time (particularly in the absence of rain), but adequate redistribution to newly-developed, unsprayed foliage is questionable, even via the vapor phase. This may require more frequent application intervals during periods of rapid shoot growth.

- Sulfur provided consistent and extensive post-infection activity when applied through the time that young colonies emerged after inoculation with fungal spores (about 1 week after the start of an infection under summer temperatures, longer under cooler conditions). This activity was just as strong at 59°F as it was at 82°F.

- Post-infection sprays applied to heavily-diseased tissues were 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 Oxidate, a much more expensive alternative). And remember that once the leaf or berry cells beneath a well-established mildew colony have been killed, nothing's going to bring them back to life even if the mildew is eradicated. Successful eradication will, however, limit further spread of the disease.

A number of different field and greenhouse trials designed to clarify the effects of rainfall produced sometimes variable results. Nevertheless, the data suggest that:

- Rainfall of 1 to 2 inches decreases sulfur's protective activity.
- This effect is more pronounced with generic "wettable" formulations than with so-called "micronized" formulations (e.g., Microthiol), which have smaller particle sizes.
- The negative effects of rainfall can be somewhat compensated for by adding a "spreader-sticker" adjuvant to the spray solution and/or increasing the application rate.

In our experiments, doubling the application rate (from 5 to 10 lb/A or their equivalents) was even more effective than inclusion of the adjuvant. See Table 1 below for field data, standardized to reflect % disease control relative to the unsprayed check. Recall that 2005 was very dry during the period of berry susceptibility, hence no benefit of higher rate or surfactant on cluster disease control. And 2007 was dry, period.

***"Alternative"* materials.** As noted many times in previous years, there are numerous "alternative" materials labeled (and not) for PM control. In 2006, we compared seven products currently registered by the EPA and classified as "biopesticides", on Rosette vines in Geneva under two different scenarios: (a) season long, to determine the extent of their activities without any help; and (b) using Elite and Pristine 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" rotating Rubigan, Pristine, and Microthiol at 14-day intervals was also used for comparison. Specific data were provided in last year's treatise and will not be repeated here. But 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

Table 1. Powdery mildew control on Rosette (2004-06) and Chardonnay (2007) grapes as affected by sulfur rate and adjuvant (Finger Lakes, NY)

	Foliar Disease Control (%)				Cluster Disease Control (%)			
	2004	2005	2006	2007	2004	2005	2006	2007
Microthiol, 5 lb.	68	67	86	97	47	76	70	89
Microthiol, 5 lb. + Cohere 0.03% (vol)	84	80	89	97	64	73	79	90
Microthiol, 10 lb.	87	89	91	99	76	77	85	94

equivalent to the "standard. This is hardly surprising, since we all know that the prebloom through early post-bloom period is when you get (or don't get) most all of your control of berry infections. But it's a reminder that this is the time when you want to use the best materials available to you.

- There was a wide range in effectiveness for keeping foliar disease down. A few materials (Nutrol, Kaligreen, and Prev-Am) were nearly as efficacious as the standard program. These may have particular 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 is the fourth consecutive trial that we have run in which Nutrol and the bicarb products have provided almost exactly the same degree of control when used at recommended rates. Where they do differ is price: at labeled rates, the per-acre price for Nutrol is MUCH less than that of the bicarbs (on the order of 75% less, that is). But unlike the bicarbs, which are formulated with a surfactant, you'll need to add one with Nutrol. And 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 that 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, but they sure will if the disease is already established in the vineyard (control broke down and there are lots of new spores for spread), especially if it's warm and wet.

> *"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."*

Recall that in most vineyards, mummified berries are the main overwintering source of the BR fungus. Unless these are retained in the vine during pruning, spores from them are typically depleted by a week or two after bloom. (But also remember that they're liberated from the mummies during rains. If it doesn't rain from prebloom until 3 or 4 weeks later, as occasionally happens, they'll just sit tight and finish their coming out into viticultural society when the rains finally do arrive). So, 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 to infection, and additional sprays are not likely 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 Nova (or Elite) 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 read the fine print! Growers routinely get away with stopping their sprays before berries are fully resistant when there are few to no new infections and/or the weather is dry, but they routinely get nailed when they quit too early (e.g., 10-14 days post-bloom for minimal native grape programs), there are active infections capable of spreading the disease, and we get the rains to do so. Recognize when you can cut corners and when you can't.

2. 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 13-15 days later and that disease progress is typically completed within 21 days after the infection event. (Note that since the fungus is responding to growing degree days rather than the calendar, these periods are probably a bit shorter in significantly warmer climates). However, clusters infected near the end of their susceptible period do not develop symptoms until 3 to 5 weeks after infection. 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.

3. The SI fungicides are most effective in "reach-

back" activity, whereas the strobilurins are most effective in "forward" activity. We've been giving you this conclusion the past few years, here are some hard data on which it's based. They should provide one more reminder of this fact, and of why an SI + mancozeb combination gives such good BR control (forward protection from the mancozeb plus reach-back activity from the SI). Ditto for Adament (forward + backward activity).

Labeled rates of Nova (equivalent to Elite) and Abound (equivalent to the other strobies vs. BR) were applied to Concord vines, in the field, at various times before (protectant assay) or after (post-infection assay) inoculation with BR spores. (Unsprayed clusters were hammered, with over 80% of the berries rotted). Data are "standardized" to reflect percent disease control relative to the unsprayed check (of course, 100% is ideal).

Table 2. 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	Nova
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 indicated number of days before infection with black rot spores.
[b] Sprays were applied indicated number of days after infection with black rot spores.
[c] Percent control relative to the unsprayed check.

4. 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. 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.

5. Fungicides. Nova and Elite remain the "kings", in my opinion, although in many of our tests, the strobies have been right up there with them. Unfortunately, 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 the SI fungicides make them problematical at such a time in many vineyards. However, if BR is a greater concern than cluster PM (Niagaras, Concords after the 1st postbloom spray, some production regions well to the south of NY), this may not matter so much. All of the strobies provide very good to excellent control, equal to mancozeb and ziram under moderate pressure and superior under very wet conditions (they're more rainfast). Of course, this is when superior performance is most important. Mancozeb and ziram are old standards and provide very good control under most commercial conditions. Captan, Rubigan, and Procure are only fair, and are likely to be inadequate if there's any pressure. Copper is the most effective material available to organic growers but it has significant limitations in terms of both activity and sustainability. 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. That being said, towards the end of the wet 2006 season I visited an organic grower who had suffered some severe losses to BR in previous wet years, anticipating 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, but it controlled the disease.

Unfortunately, we don't know of any magic bullets for organic producers, although there are several products out there that claim to be. Bryan Hed at Penn State has been looking at a number of possibilities and we've followed up with a couple of the most promising, but right now it looks like nothing is as good as copper. Sanitation and cultural practices form the critical first (and second) line(s) of defense for growers who wish to produce grapes organically, and if this means you, you'll need to pay strict attention to limiting inoculum within the vineyard. Ideally, this would include removing or

burying (tillage, mulch) any mummies that you might encounter at the site. 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 (spores for disease spread are dispersed by rain primarily within the canopy, so should pose little risk of causing new infections if said clusters are simply dropped to the ground).

DOWNY MILDEW (DM) NEWS AND REMINDERS

Dry summers like 2007 are great. I like the wines and the weekends. And as I often tell growers who "sympathize" with me at the end of such seasons, I get paid the same amount whether disease is plentiful or scant, and you can use a break. But don't forget how devastating DM can be if the weather is right and the management wrong. It can happen fast.

Recall that the fungus persists in the soil as resting spores (oospores) that originate within infected leaves. Hence, the more infection last year, the more oospores this year. (Because the oospores can persist for more than 1 year, any vineyard with significant disease in the recent past should probably be considered a "high inoculum" vineyard). 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: A low percentage (the first ones mature) of a few overwintering spores is probably inconsequential, whereas a low percentage of a lot is still a lot.

These first "primary" infections, originating from overwintering spores in the soil, require a minimum rainfall of approximately 0.1 inch (to activate the infective spores and splash them into the canopy or onto nearby sucker growth) and a temperature of 52°F or higher. 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 are 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, many can survive for several days under cloudy conditions, 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 (humid nights, frequent showers, long periods of cloudy weather) and control programs are lacking. As we are periodically reminded.

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 let it get rolling if it's active. Keep an eye on the vineyard to see which of these possibilities is the current reality. 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

Downy mildew infection on a Chancellor cluster.
Photo: H. Walter-Peterson

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 about 2 weeks after the start of bloom, although losses due to berry stem infections can occur for at least 2 additional weeks after that. For many years, the standard fungicide test protocol on 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, on perhaps the worst possible variety, under abnormally high inoculum pressure. But remember that vines remain vulnerable to defoliation right into the fall if disease-conducive weather persists, even long after the fruit have lost their susceptibility.

Fungicides. Ridomil remains the best downy mildew fungicide ever developed for use on grapes, but its cost and lack of activity against other diseases have limited its general use. Although it's highly prone to resistance development, this has never been detected on grapes in the U.S., probably due to its limited use. (Remember that the PHI on Ridomil Copper has been reduced to 44 days, versus 66 days for Ridomil MZ). Abound has provided very good to excellent control every year since we began testing it in 1996, and Pristine has typically been even just a little bit better. Note, however, the discussion regarding DM resistance to these 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. Sovran is marginal, it seems to be OK under moderate pressure or on marginally-susceptible cultivars (e.g., Concord), but don't rely on it in a bad year or site. 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.

Which brings us to the phosphorous acid (also called phosphite and phosphonate) products. 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 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. These are very good fungicides against downy mildews (and closely related diseases, none of which are important on grapes). However, their general history (on other crops) of control of diseases beyond this narrow spectrum is erratic at best. If you're going after DM and get some activity against another disease, think of it as an unanticipated bonus. But I certainly wouldn't count on it.

Most of you know that products such as ProPhyt and Phostrol are labeled as fungicides for control of DM, whereas there are a number of "nutrient formulations" on the market that contain phosphonate but are not labeled for DM control. Which means that it's only legal to obtain disease control with these latter products if you do so unintentionally. Although this may seem somewhat less than fully rational, remember that the law requiring any material applied for a pesticidal purpose to be labeled for such generally benefits growers as well as the public at large. And you can still be cited for breaking a law that you consider to be "dumb".

Also recall that products claiming to be nutrient formulations must state the amount of P that they contain in terms of phosphor<u>ic</u> acid equivalents (this refers to phosphate, the nutrient form of P, which has no effect on DM), even if they contain only phosphor<u>ous</u> acid (phosphite or phosphonate, the DM material which, ironically, has no nutritive value). Also note that it can be difficult to tell just how much phosphonate is in some of these nutrient solutions, and that the rate very much matters when it comes to DM control.

A summary of the major results from 3 years of field experiments designed to determine the so-called "physical modes of action" of phosphonates in control of downy mildew follows below. Most tests were conducted with ProPhyt and/or Phostrol, applied at rates corresponding to the low and/or high rates on their labels.

- <u>Phosphonates generally provided good to excellent protective activity when applied 3 to 8 days before an infection period, depending on the rate used.</u> In some tests, activity declined significantly in the older leaves as the time between application and start of the infection period increased (phosphonates are "shipped" from older leaves to the growing points), particularly at the lower rate. These materials certainly have protective activity, but I wouldn't

consider it their strength. Sometimes you'll get a week, and sometimes you won't.

- Phosphonates provided excellent post-infection activity; again, there was some rate effect. 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 visible), lesions continued to expand but production of spores was reduced by 86 to 98% relative to the unsprayed check, depending on rate. Control of both lesion expansion and spore formation was improved moderately at the higher rate or when the initial application of the lower rate was repeated 5 days later.

- 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 should limit the potential for disease spread.

Two additional points:

- In simple "spray and count" trials using 14-day application intervals (too long under high pressure), we've seen significantly better control on clusters when post-bloom sprays of materials like ProPhyt and Phostrol were applied at rates in the high versus low end of their label range; similarly, we got relatively poor control when a nutrient solution containing phosphonate was applied at the equivalent of 60% of the low rate of the registered products' label range. This latter dosage is similar to some that I've heard rumored as applied for nutritional purposes in the Finger Lakes region. Once again: rate matters.

- Although sudden and total resistance to these materials (as we've seen with PM and the strobies in some vineyards) is not likely, experience on other crops suggests that they can lose some of their effectiveness over time after long and repeated use (similar to what we've seen with PM and the SI fungicides). Last season, a very good grower who has used these materials regularly for the past 5 years got far less control from them than I would have expected. Technical problems in our lab prevented us from determining whether or not "insensitivity" to them was responsible, so it remains an open question. Nevertheless, it drives home the point that these are useful materials, and we don't want to burn them 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.

BOTRYTIS NEWS AND REMINDERS

Although there are a number of fungi that can cause bunch rots (the "sour rot" complex; bitter rot and ripe rot in the warmer = southern viticultural regions; anthracnose on Vidal, especially where it's warmer), Botrytis is still "king" in our cooler or more "moderate" eastern climates. So let's review it first.

1. Biology. The Botrytis fungus is a "weak" pathogen that 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. The fungus thrives in high humidity and still air, hence the utility of cultural practices such as leaf pulling and canopy management to minimize these conditions within the fruit zone. Although the fungus does not grow well in berries until they start to ripen, it can gain entrance into young fruit through wilting blossom parts, old blossom "trash" sticking to berries, and scars left by the fallen caps. Such infections typically remain latent (dormant) all the way through harvest, but some may become active as the berries as start to ripen, causing them to rot. Should this occur, disease can spread rapidly through the rest of the cluster (or 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. High humidity during the preharvest period and high soil moisture after veraison appear to be 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. Ever had a year like that? 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 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 so 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 pay significant dividends if things turn wet before harvest. How good are you at predicting September and October weather in June?

- 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 loose clusters where some berries had been removed by hand so that they weren't so tightly compressed. Unfortunately, there are few practical ways of achieving such cluster architecture other than through clonal and varietal selection, although it has been and continues to be worked on by a number of investigators, since this represents the "holy grail" for Botrytis control. Note that this single diseased berry per cluster was meant to represent 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.

- Preharvest disease spread can be increased by increasing the N content of berries (foliar sprays of urea after veraison). This does NOT mean that such treatments should be avoided if one is trying to use them to ameliorate the atypical aging (ATA) phenomenon in white wines. However, it DOES mean that Botrytis management may be more critical if they're applied, or if N availability is high for any other reason.

- There is no single "correct" timing regimen for fungicide applications in a Botrytis management program. The standard "full" program used in fungicide trials 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 of the past decade; a summary of these data is presented in Figure 6. 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; in a majority of years, applying all four provided the best results. 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.).

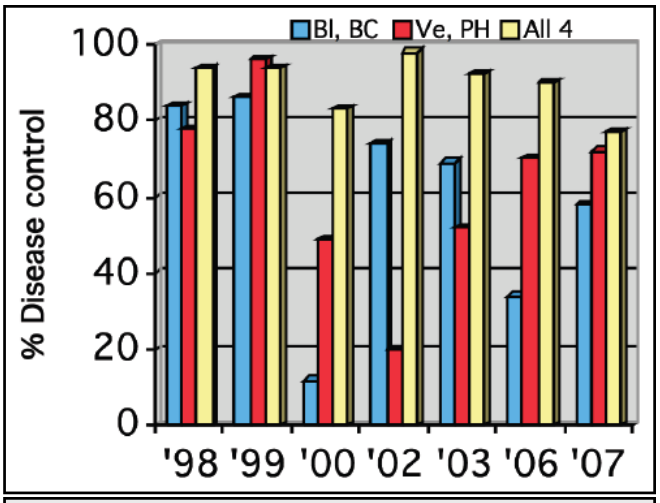

Figure 6. Influence of spray timing on control of Botrytis bunch rot in Geneva, NY (cv. Aurore, 1998-2000; cv. Vignoles, 2002-2007). Sprays we applied at (i) Bloom + bunch closure (Bl, BC); (ii) Veraison and 2-3 wk later (Ve, PH); or (iii) at all four of these stages. Data are expressed as percent control of disease severity relative to the check treatment (no Botrytis fungicides).

2a. Fungicides, physical modes of action. Over the past few years, we've been looking at some of the "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 summary 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 after mechanical damage such as 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, whereas 22% of the cluster area became diseased in the unsprayed treatment.

- 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 gave statistically comparable control, but did allow one or more latent infections to become active in approximately one-sixth and one-fourth of the treated clusters, respectively. When additional clusters were also treated a second time, 15 days after veraison, Scala, Vangard, and Elevate provided complete control (versus 37% infection in the untreated clusters). Rovral reduced infection by about three-fourths, whereas Flint, Pristine, and Endura provided 55-60% control.

"[R]emember 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.)."

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 has always been sold as a surface protectant. But this appears to have more to do with "market positioning" than science (colleagues in South Africa tell me that they've repeated some of these results with Elevate).

- 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 Fig. 6, 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 any curative effect from the later sprays doesn't completely 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 and, conversely, most good Botrytis fungicides (Rovral, Vangard, Scala, Elevate) provide relatively little control of fungi other than Botrytis (and a few close relatives that affect crops other than grapes).

The "new" Pristine label, its incorporation of the higher rates for Botrytis control, and my take on this use was discussed at the top of the treatise. Two additional notes: (i) 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 two-component makeup should help somewhat in lowering the resistance risk for Botrytis, but is probably even more appealing in terms of the increased spectrum of activity that it provides. (ii) Apropos of the preceding, an appeal for incorporating Pristine into a Botrytis program is its ability to also provide control not only of the obvious candidates (PM, BR, DM where it's not yet resistant) but also some of the "sour rot" complex that can plague us in wet years. Although we have not collected hard data,

I generally see less "other" rots in the Pristine treatments of our Vignoles trial block than in just about all other treatments. The label does not promise control of sour rot, but does say that the product "aids in [their] control". Every bit helps.

In fairness, I should point out that Flint also is a relatively broad-spectrum fungicide, and appears to control some of the secondary rots in addition to providing excellent Botrytis control at its higher (3 oz/A) rate. And growers in the more southerly states will know that both materials also control their more common rots (ripe rot, bitter rot).

"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. In truth, berries typically are colonized by a mix of various wound-invading fungi and bacteria and give off a strong smell of vinegar, the result of infection by a specific group of bacteria. Ethyl acetate (nail polish remover) is another nasty aroma produced by some of these microorganisms, and can be especially prominent in 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 is a particularly common point of entry for these secondary beasties, although rain cracks and bird or insect damage can do the trick as well.

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 relative broad activity spectra. However, any product that gives good Botrytis control will help greatly to limit sour rot.

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, we've found that applications during the early shoot growth period (as clusters first become visible) 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 common cause, of disease loss that I see on Concord and Niagara grapes. 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. A minimal Ph spray program should include at least one application during the period soon after clusters emerge.

NOTE: In a trial on Niagara grapes in 2006 (not an unusually wet season at its start), we documented a loss of over 3 tons/A, primarily due to rachis infections (and those that progressed into the berries), when early Ph sprays were withheld. I'm painfully aware of the current economic realities for Concord and Niagara producers, but fear that completely eliminating Ph sprays on these varieties is likely to lose more money than it saves, unless we're lucky enough to get another 2007.

Phomopsis lesions on shoot and rachis.
Photo: R. C. Pearson, "Compendium of Grape Diseases" (1988)

2. 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 that stuff out.

3. 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 in Michigan produced generally similar results. These data suggest that even though berries may remain susceptible throughout the season, as indicated by recent work from Ohio, the risk of infection is probably low once berries become pea-sized, since inoculum is scarce beyond that time.

4. Spray timing to control berry infections. In a trial conducted in a problem block of Niagaras--the poster child for Ph problems--we were surprised to find that sprays applied shortly after cluster emergence (i.e., the important sprays for controlling rachis infections) also provided significant control of berry infection. These results, and repeated observations in multiple vineyards, suggest that some berry infections probably result from the fungus growing into the fruit after it first becomes established in the cluster and berry stems. In our trial, control improved when we continued sprays through the immediate prebloom phase, and was almost complete when we continued until the 2nd postbloom spray. Nevertheless, these early sprays appear to be important for control of Ph fruit rot.

Note on berry infections: These are most problematical in very wet seasons, but are probably more common than some of us recognize (they look a lot like black rot, but don't show up until preharvest). We sometimes see significant Ph berry rot in our test block of Vignoles, and Dr. Schilder reports it on this variety in Michigan as well. Furthermore, Ph gets reported from time to time as part of the berry rot complex in warmer regions such as Missouri. I don't mean to overstate the threat, but don't assume that you don't have to worry about this form of berry rot if you don't grow Niagaras.

5. Fungicides. Mancozeb, captan, and ziram have all provided good control of basal shoot infections in our fungicide trials. Captan has been touted by some individuals as far superior to the others. This hasn't been my experience, although it did show a slight edge over mancozeb in one trial with extreme disease pressure. For those who aren't prohibited from using captan, I'd consider other issues (captan is better at conserving mite predators, mancozeb doesn't have the 3-day re-entry restriction) to be more important than any modest differences in biological activity between the two, especially in commercial vineyards that have maintained relatively good control over the years (low inoculum). 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.

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 was more variable. The benefits of alternate-row spraying are obvious and there's no reason to fix things if they ain't broke; however, if you've had trouble controlling Ph while using alternate-row spraying, the suggested remedy also is 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 over the past decade 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 tend to (understandably) preoccupy ourselves with the 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 do have canker diseases and they are slow but surreptitious (silent but deadly?) robbers of production and profit. And I believe that they will become increasingly visible and important as many of our newer and higher-value vineyards continue to age. Thus, it seems like 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.

In this regard, we are very fortunate that Dr. Philippe Rolshausen joined the staff at the University of Connecticut last spring. Dr. Rolshausen spent 10 years working on canker diseases in Doug Gubler's lab at UCD, and brings a wealth of experience in this field. Last summer, in cooperation with a number of

individuals in various eastern states, Philippe sampled cankered tissues from multiple vineyards, and determined the identities of the fungi associated with them. What he found was not surprising, but it is eye opening: we have a whole slew of fungi that appear to be causing canker diseases in our region in addition to Eutypa. Many of these are common in Europe and the west coast, including several known to be the cause of esca (or "black goo"), *Botryosphaeria* species, and others.

These organisms have most likely been here for a long time, they just weren't found until someone started looking for them (indeed, Dr. George Leavitt from California found a few of them in a couple of smaller exploratory surveys over the past decade). There's certainly no cause for panic, but we do need to be more aware of these diseases and do what we can to lessen their impact. I visited several "older" (20+ years) *V. vinifera* vineyards with Dr. Rolshausen last summer, where vines and arms killed or damaged by canker diseases were causing significant economic loss. With any luck, Philippe will be able to continue and expand his study, to include experiments on management techniques, and will be able to address this issue in some detail in the future. In the meanwhile, keep your eyes out for pruning-wound associated cankers and dieback. At the very least, we need to be thinking about getting dead trunks and arms out of our vineyards and put to the torch as convenient.

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. Here are some considerations. As always, just because it isn't listed here doesn't mean it's a bad idea. And remember, 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 training system or block history suggests high risk. Option A: Nothing. Option B: Captan or mancozeb.

3- to 5-INCH SHOOT GROWTH. A critical time to control **Ph** rachis infections if it's raining or likely to be soon. Early is better than late if it starts raining. Research indicates that this spray can provide significant benefit against fruit infections as well, since many of them appear to move into the berries from infected rachises and berry stems. Also an important time to control shoot infections, since this

Shoots on Noiret at 5-6" growth stage.
Photo: H. Walter-Peterson

is where the fungus will reside in 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 than in those that were "clean", although it may be beneficial even in relatively clean blocks of highly susceptible cultivars in cloudy, wet years if temperatures aren't 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. Still too early for **DM**. Option A: Nothing. Option B: Mancozeb (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. 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. Can eradicate incipient infections begun in the last week or so. Option E: Rally [Nova] or Elite (PM, BR). Use 3 oz/A for economy with so little foliage now, but remember that coverage becomes even more important when you're working with lower application rates (don't forget that the activity of these materials is very rate-dependent, particularly in vineyards with a long history of use, so partial coverage with a low rate is unlikely to cut it). Did somebody ask about problems with alternate row spraying? Option F: Rubigan (PM). At 2 fl oz/A (minimum labeled rate), cost is only about $4. Cheaper than Nova and Elite, especially if BR control

isn't an issue, and it usually isn't at this time. Same issue with the need for superior coverage at low rates. Vintage isn't labeled for use this early. Option G: JMS Stylet Oil (PM). Should eradicate young infections IF thorough coverage is provided, and can provide limited forward activity (unless it washes away in the 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. Nutrol is much cheaper than the other materials in this group, and has provided control equivalent to both Armicarb and Kaligreen in several of our head-to-head tests. Option I: Serenade or Sonata, if you want to experiment with these "biocontrol" products while disease pressure is low. Option J: One of the PM products plus mancozeb 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 this spray can be omitted under most commercial conditions in NY unless BR was a problem last year (inoculum levels are high) and weather is wet and warm. Don't wait any later than now to control **PM** on susceptible varieties. On Concord and other "moderately susceptible" cultivars, we generally recommend waiting until immediate prebloom. However, recall that in 2003 (wet, cloudy spring) we started seeing PM on Concords around the 10-in shoot growth stage, and uncontrolled early infections spread and really caused havoc. Get out in the vineyard and see what's happening. No need to spray before you need to, but if you already see PM, you need to. Now is one of the best times to use an SI, 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, 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 last year 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 a danger in wet years, particularly in blocks with some history of the disease. Option A: Mancozeb (BR, Ph, DM). A broad spectrum, 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. Option B: Captan (Ph, DM, some BR). An alternative to mancozeb if you're trying to avoid it due to mite concerns. 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 and temps should going up by now. Post-infection activity may be useful against new "primary" infections before they have a chance to spread. Option D: Rally [Nova] or Elite (PM, BR). Option E: Rubigan (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. Cheaper than Rally and Elite. Bump it up to the 3 fl oz/A rate by now. Still too early to use Vintage due to label oddity. Option F: 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. Recent research indicates some protectant activity as well, although much of that will disappear after a rain. Some other petroleum-based oils such as PureSpray Green should have similar effects, if you can find them, although the botanically-based oils are generally less effective. Option G: Quintec (PM). If trying to limit seasonal applications to two or three (as we recommend), probably more efficient and cost-effective to wait until prebloom, when cluster protection starts to become critical. Option I: Nutrol, Armicarb, Oxidate, Kaligreen. (PM). Should eradicate young infections IF thorough coverage is provided, but no forward activity. Option H: Serenade or Sonata, if you want to experiment with "biocontrol" 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! This and the first postbloom spray are the most critical sprays of the season--DON'T CHEAT ON MATERIALS, RATES, SPRAY INTERVALS, OR COVERAGE!** Option A: Quintec for PM control, plus mancozeb (for BR, DM, and Ph). Effective and no current resistance concerns, but let's keep it that way (avoid over-use). Option B. Pristine (PM, DM, BR). The 12.5-oz rate of Pristine will also provide significant protection against Botrytis, I wouldn't go to the higher "supplemental" rate this early unless Botrytis pressure was really high and/or I was really worried. On highly susceptible cultivars, where SI resistance is usually an issue to at least some extent and strobie resistance has occurred or is deemed risky, Quintec, Pristine, and/or sulfur would be the materials of choice, unless BR is more

of an issue than PM. Do not use Quintec or Pristine more than three times per season (considering the DM resistance potential, I'm more comfortable with a limit of two annual applications for all strobies, including Pristine), nor more than two times in a row. And if you do hit DM resistance to the strobies, you're less likely to risk fruit loss if you avoid sequential applications altogether (two in a row = 3 to 4 weeks of nothing effective on the clusters, more than enough time for trouble). I'd toss in some sulfur, especially in blocks where PM has already developed strobie resistance, just for additional protection. Option C: Abound or Sovran (plus sulfur, on cultivars where it can be used). (PM, BR, DM). Still an effective option in some vineyards, particularly native or certain hybrid varieties that have seen limited use over the years; if those are located well away from *vinifera* or hybrid blocks that have had resistance problems, so much the better (why? the answer is blowin' in the wind, just like the PM and DM spores from those blocks). Refer to the discussion on strobilurin resistance in the "Fungicide Changes and News" section at the beginning of this epistle. Option D: Flint plus sulfur (PM, BR, Botrytis at the 3-oz rate) plus mancozeb, captan, or phosphonate for DM. Consider substituting Adament for Flint if the price is right, especially if you need superior BR control. Option E: Either Rally [Nova], Elite, Rubigan, or Vintage PLUS mancozeb (PM, BR, Ph, DM). Add sulfur on *vinifera* and PM-susceptible hybrids (unless "sulfur shy"). Rally and Elite are excellent against BR, so might be the best choice if pressure is high and BR control is more important than PM; their postinfection activity against BR can make them valuable if significant unprotected infection periods occurred previously. Rubigan and Vintage are cheaper that Rally and Elite, but don't provide nearly the same BR control; however, the mancozeb part of the mix should be adequate if postinfection control isn't required and/or disease pressure is relatively low (little inoculum and/or dry weather the past week or two). 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). Cheap and effective, particularly if used at shorter spray intervals. Neither material is as rainfast as the strobies or SI fungicides, so frequency of reapplication can be both necessary and difficult in wet years. Potential mite problems.

BLOOM. Vangard, Scala, Elevate, Flint (3 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. The main problem is that for Botrytis-specific materials like the AP's and Elevate, 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 spray, reapply about now on highly susceptible *viniferas*, especially if it's been raining since then or will soon.

Concord flower cluster at bloom.
Photo: H. Walter-Peterson

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.** Shorten the spray interval and/or jack up the rate on PM-susceptible varieties if weather is warm and cloudy. 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 if necessary, or just go with Abound or Sovran for everything.

SECOND POSTBLOOM. **BR** control is still advisable under wet conditions and is strongly recommended if infections are evident on the vine, unless you're willing to bet that it's not going to rain within the next few weeks; however, BR sprays can often be skipped from here on out if the vineyard's clean, especially on native varieties. Fruit are less susceptible to **PM** now, but those of *vinifera* varieties (and susceptible hybrids?) still need PM protection, particularly to guard against later bunch rots and wine-spoilage microorganisms. New foliage remains highly susceptible to PM throughout the season,

although Concords can withstand a lot of foliar PM unless the crop is very large and/or ripening conditions are marginal. Try to avoid SI and, particularly, strobie fungicides if more than a little PM is easy to see (yes, clouds of spores kicked up by the pickup qualify as "more than a little"). **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 on susceptible cultivars the rest of the season, depending on the weather. Option A: Pristine, Abound, Sovran, or Flint (or Adament). See previous discussions. These provide good residual control of the listed diseases if used now, but limit their use to maintain viability. Pristine and Flint (or Adament) will provide Botrytis control when used at the appropriate rate as a pre-bunch closure spray. Option B: Quintec (PM) + 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) or a phosphonate are additional options. Quintec and Pristine shouldn't be applied in more than two consecutive sprays, but are an option if not used in both the prebloom and first postbloom application. Option C: Rally [Nova] or Elite (BR, PM) + the DM and Ph options presented in Option B. You can substitute Rubigan or Vintage as a PM material, but then will need mancozeb or ziram to pick up BR if that's required. Option D: Sulfur (PM) + the additional options just listed with Rubigan. In most years, lessening disease pressure makes this economical option increasingly practical as the season progresses. Option F: Copper + lime (DM, some PM). Adequate PM control for native varieties, generally not 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. Also **Botrytis** on susceptible cultivars, from veraison through pre-harvest. 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. SIs also are options, but only if they've been used minimally earlier (try to stick to a maximum of 3 applications per year) AND little disease is evident. So is an occasional application of Quintec or Pristine (or another strobie + sulfur), not exceeding the recommended maximum number sprays for each. All of these materials provide the advantage of longer residual activity than sulfur (especially Quintec or Pristine), particularly in wet weather, but limiting seasonal use for resistance management is important. Not to mention wallet management. 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 later on, 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 hesitant to recommend these products once the crop nears veraison, although a single application should be OK. For **DM**, phosphonate products have become economical and effective standards, but don't forget to rotate them with something else if you want to make sure they last; copper + lime and captan are tried and true options as well. Ridomil can be used in case of extreme pressure or emergency, remember that the PHI has been reduced to 42 days for the Ridomil Gold Copper formulation versus 66-days for the MZ formulation. Pristine and Abound have provided excellent activity in the past when they still fit into the program this late, but avoid using them if you've already sprayed a strobie product twice or have reason to suspect that resistance may be developing (or, if using Pristine for late-season Botrytis control, include something else for DM if you need to control this disease and have doubts about its efficacy). **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. Sprays for **Botrytis** may be advisable at veraison and/or preharvest, see previous discussion under that disease for details.