UNDERSTANDING AND CONTROLLING BOTRYTIS

Wayne F. Wilcox
Department of Plant Pathology & Plant-Microbe Biology
Cornell University, NY State Agricultural Experiment Station
Geneva, NY 14456

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Botrytis is a chronic problem in New York, as it is in other humid growing regions of the world, and we have more experience with it than we'd like. Below is a recap of some old and new information concerning its biology and control.

Disease biology. Botrytis bunch rot (BBR) is an amazingly complex disease, being governed by multiple 3-way interactions between the grapevine, the environment, and the Botrytis fungus itself, many of which are poorly understood. This is fascinating to a research plant pathologist but frustrating to a vineyard manager, who needs to figure out when intensive disease control is necessary and when it's OK to let things slide. Such complexity notwithstanding, there are a several basic concepts that will go a long way in helping to get a handle on this disease and devise a strategy to manage it.

The Botrytis fungus is very widely dispersed, and can overwinter as resting structures on infected canes or, more commonly, in various vineyard debris. Old cluster stems appear to be a particularly common source of the organism between seasons. The fungus thrives in high humidity and still air, hence the well-known value of cultural practices such as leaf pulling and canopy management to minimize these conditions within the fruit zone.

Botrytis a "weak" pathogen that primarily attacks highly succulent, dead, or injured tissues, or those that are senescing. Berries damaged by insects, birds, powdery mildew, or splitting due to pre-harvest expansion within tight clusters and/or rain present injury sites commonly attacked by Botrytis. Withering blossom parts and ripening fruit are senescing tissues of particular importance to the development of this disease on grapes.

Although the fungus does not grow well in berries until they start to ripen, it can gain entrance into young fruit through senescing blossom parts, scars left by the fallen caps, and old blossom "trash" sticking to berries within the cluster. Such infections remain latent (dormant) while berries are green, but given favorable conditions, some of them can resume growth and rot the berries as they start to ripen. Once this occurs, the disease can spread rapidly from berry to berry within clusters and, to a lesser extent, among clusters; berry-to-berry spread is particularly likely in tight bunches with abundant surface contact among individual fruit. And of course, the probability and magnitude of disease spread depends on weather conditions and certain physiological factors within the vine.

Following are some recent findings concerning various details of this basic scenario, and the fungicides that are used to control the disease. Although this work was conducted in the Finger Lakes region of New York, the general principles should be applicable to California and other locations as well, although certain details will obviously differ among locations.

• Latent infections can be common following a wet bloom period, but the vast majority of them appear to remain inactive through harvest, meaning that the fruit stay healthy. For example, when we've inoculated Pinot noir clusters with Botrytis spores at bloom, we've been able to detect latent infections in up to 70% of the young berries that we've sampled later on, but we often end up with only 2 or 3% rotten berries at harvest, especially in a dry autumn or a clone with loose clusters. On the other hand, we've ended up with 25 to 40% rot in clones with tight bunches, particularly in wetter harvest periods. Which leads to the following point:

• Serious Botrytis losses result from disease spread during the pre-harvest period, after berries begin to ripen and become highly susceptible to rot by the fungus. Thus, latent infections established at bloom can play a critical role in disease development if even a few of them become active and provide an initial "foot hold" from which spread can occur under favorable pre-harvest conditions.

This point, and two vine factors that promote disease spread, are illustrated by the results of the following two field experiments. In the first, we inoculated either 1, 3 or 5 individual Pinot noir berries per cluster 10 days after veraison, by using a hypodermic needle to inject them with Botrytis spores. This produced initial "point sources" of the disease within clusters about a week later, which were meant to simulate occasional activations of latent infections before harvest. To determine the effect of cluster architecture on disease spread from these sources, we utilized clone 29 (very tight bunches) and thinned some of them by removing enough berries after fruit set so that they resembled the Mariafeld clone (loose clusters, generally less prone to bunch rot than other Pinot noir clones under commercial conditions).

As Fig. 1 shows, disease spread was minimal in the thinned, loose clusters. In contrast, Botrytis spread extensively throughout the tight, unthinned clusters, e.g., a single rotten berry that appeared 2.5 weeks after veraison was all it took to end up with 50 additional rotten berries at harvest (pre-harvest weather was wet that year).

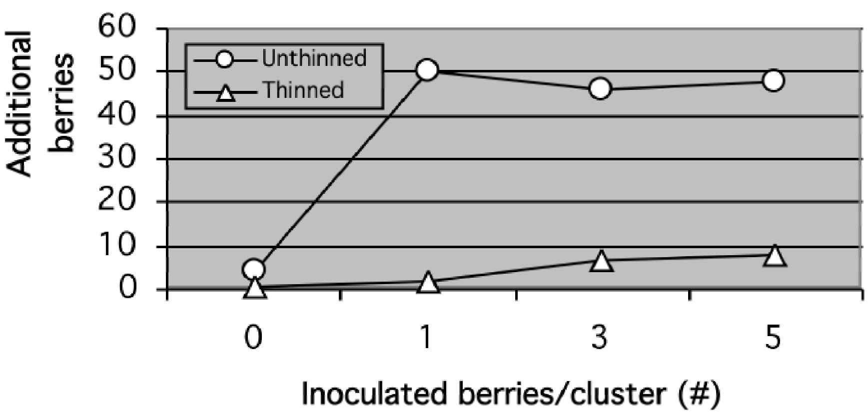

Fig. 1. Effect of cluster tightness on disease spread. Selected clusters on vines of Pinot noir clone 29 were hand-thinned after fruit set to approximate the looseness of those of the Mariafeld clone. Either 0, 1, 3, or 5 berries per cluster were inoculated at veraison and disease was present on those initial "point sources" 1 wk later. Data reflect the number of additional berries to which the disease had spread by harvest.

In a second experiment, clusters of a tight-bunched Chardonnay clone were similarly thinned and inoculated. Additionally, some vines received four weekly sprays of urea starting at veraison, to see if high berry N content would affect disease spread. This treatment increased YAN in the must (to 303 mg/L, versus 235 mg/L in the untreated) without increasing canopy growth.

As Fig. 2 shows, little disease spread occurred in the thinned clusters, regardless of nitrogen treatment. In contrast, elevated berry N double and tripled final disease levels in clusters with either 1 or 3 initial points of infection, respectively.

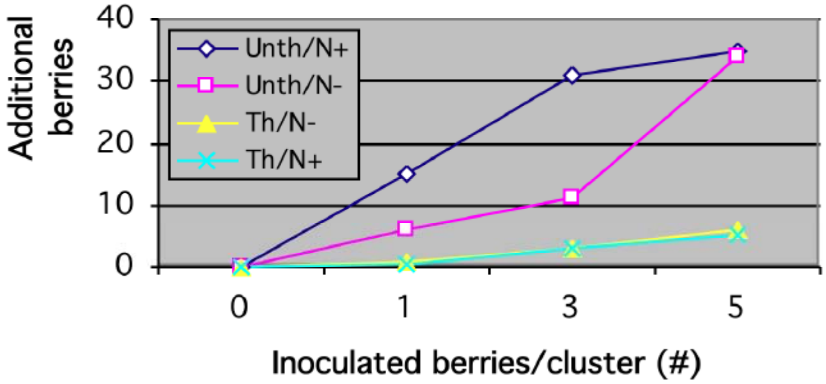

Fig. 2. Preharvest spread of Botrytis on Chardonnay berries as affected by the number of initial infection sites, cluster architecture, and berry nitrogen status. Vines designated as "N+" received four weekly foliar sprays of urea (8 lb/A) starting at veraison. Selected clusters on vines both with and without foliar N were hand-thinned after fruit set to approximate the looseness of those of the Mariafeld clone of Pinot noir. Either 0, 1, 3, or 5 berries per cluster were inoculated at veraison and disease was present on those berries 1 wk later. Data reflect the number of additional berries diseased after harvest.

• Factors that determine whether latent infections become active and cause disease or remain latent and symptomless are poorly understood, but appear related to the weather and vine physiology. Experience and controlled experiments both show that high atmospheric humidity during the pre-harvest period is one factor that promotes the activation of latent infections. To examine this, we inoculated clusters of potted Chardonnay vines at bloom to establish latent infections and kept the vines outdoors in a location protected from rain. Then, while all clusters were still symptomless, we moved the vines into a high humidity (92% RH) chamber for 0 to 9 days either at veraison or starting 10 days before harvest. As Fig. 3 below shows, the percentage of clusters with disease symptoms (due to activation of latent infections) increased in proportion to the duration of the high humidity treatment pre-harvest, but was not affected by high humidity at veraison.

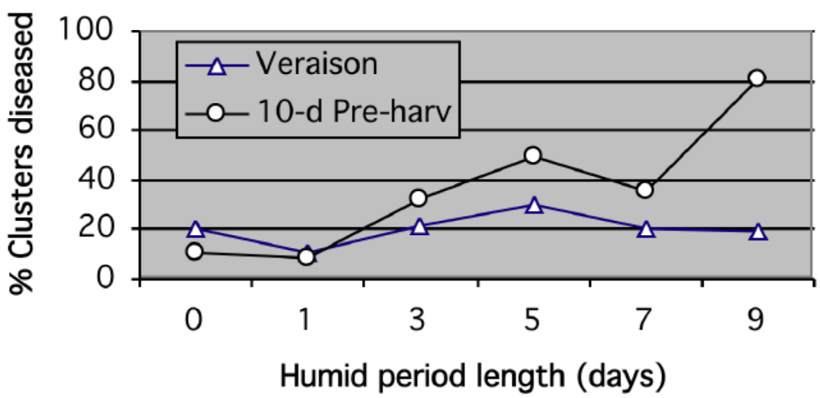

Fig. 3. Effect of relative humidity and humid period length on the activation of latent Botrytis infections. Clusters on potted Chardonnay vines were inoculated with Botrytis spores at bloom to establish latent infections in the berries, and protected from rain thereafter. Vines were moved to a chamber with RH > 92% for 0 to 9 days, beginning at veraison or 10 days before harvest. Data are expressed as the percentage of clusters showing any berries diseased with Botrytis.

In addition to high atmospheric humidity, high soil moisture (high vine water status) also can promote activation of latent infections. The influence of this factor is illustrated by the following experiment, in which potted Chardonnay vines were once again inoculated at bloom to establish latent infections and grown outside, where they were protected from rain and watered normally. At veraison, the vines were split into two groups, and either (a) watered heavily with a hose to keep the soil moisture levels constantly high (WET), while keeping the berries dry; or (b) watered similarly, but only when shoot tips began to wilt (DRY). At harvest, the percentage of clusters showing disease was more than three times greater in the WET versus DRY soil treatment (56% vs 18%, respectively), although the berries were subjected to the same protected environment. It is likely that many other factors can also promote latent infection activations, and there is evidence that high berry nitrogen and minor berry injuries (e.g., from wind or mechanical damage associated with pre-harvest cluster swell) are two other such factors.

As for most fungi, Botrytis spores require a film of water in which to germinate and initiate infections. Thus, rainy pre-harvest weather sets off a chain reaction, in which earlier latent infections are activated by high atmospheric humidity and high soil moisture, high humidity promotes spore production by the fungus, free water on the berry surfaces promote new infections by these spores, and rain cracks provide new points of entry for the fungus as the berry becomes highly susceptible to infection.

Control. Cultural practices such as canopy management and leaf pulling are well known and widely practiced. Removal or destruction of vineyard debris, particularly old cluster stems, is standard practice in top vineyards for a good reason. But fungicide sprays targeted specifically at BBR may be necessary on susceptible cultivars and/or clones, particularly in a wet year. The questions are, which materials and when?

Not surprisingly, the optimum timing for spray applications is heavily weather dependent, and probably accounts for the sometimes contradictory opinions and data regarding the relative importance of sprays early in the season near bloom versus later from veraison through pre-harvest. The early timing is designed to prevent the initial establishment of infections through susceptible blossom parts and the later sprays are designed to prevent both initial infections through injured berries and, especially, the spread of active infections through the ripening clusters. Thus, either, both, or neither of these ends of the seasonal spectrum can be important, depending on the infection pressure at that time. Fungicide labels and many recommendations also include a possible application at bunch closing, the concept being that this is the last opportunity to deposit residue on the entire surface of the berries, particularly those in the center of the cluster where the disease often starts.

Unfortunately, most fungicides that control other diseases are relatively ineffective against Botrytis, either providing no significant control or requiring substantially higher rates than required for other diseases. Similarly, many fungicides with good activity against Botrytis provide no significant control of other diseases. And when discussing Botrytis fungicides, it's important to remember that all of them are at moderate to high risk of resistance development, making it very important to rotate among groups of fungicides used to control this disease, even if you only spray them erratically. Don't use the same one year after year without substituting something else along the way. Following is a brief review regarding the fungicides available for Botrytis control.

Vangard, Scala. These represent two different fungicides in the same class of compounds (the so-called anilinopyrimidine or "AP" fungicides), so "rotating" between the two will provide no benefit in terms of resistance management. They appear to have equivalent properties and provide the same general levels of control at labeled rates, although Scala has been a bit weaker under high disease pressure in a couple of our NY trials. In general, these have been among the most consistent performers in our field trials over the years, and provide both protective and post-infection activity. In some tests where we've inoculated Chardonnay or Pinot noir clusters with Botrytis spores at bloom and then sprayed at veraison before the latent infections became active, both materials suppressed a significant number of the latent infections established almost 2 months earlier (note that these clusters were sprayed individually by hand, so coverage was absolutely thorough). The resistance risk for the AP fungicides is high, so rotation is important. These products provide no significant control of any disease other than Botrytis.

Switch. This product contains the active ingredient in Vangard (cyprodinil) plus another active ingredient (fludioxanil), which is unrelated to any other fungicide used on grapes. This second ingredient is included primarily to reduce the chance of resistance development but also provides some control of miscellaneous opportunistic fungi that can become problematic in very wet years. Fludioxanil is expensive to manufacture, which is reflected in the price of Switch. The labeled rate of 14 oz/A provides the same amount of cyprodinil as does 7 oz/A of Vangard (full label rate for Vangard is 10 oz/A).

Elevate. The other “work horse” against Botrytis over the past 10 or 15 years. Elevate is not related to any other fungicide on the market, so is an excellent rotational partner with anything else. Elevate has been marketed as a protective fungicide, with no post-infection activity, and (like other Botrytis fungicides) it is clearly most effective if used in a preventive program. However, it is now clear that that Elevate does have some post-infection activity, and that it can suppress or eradicate latent infections if applied before they start to become active. Elevate provides no significant control of any disease other than Botrytis. Resistance risk is moderate.

Pristine. The combination product of a strobilurin (pyraclostrobin) plus a compound (boscalid) that represents a new class of chemistry on grapes ("SDHI" fungicides) that's about to become increasingly important. Although the pyraclostrobin component has some activity against Botrytis, boscalid is the more active of the two. Rate is important. When used at the rate of 8.5-10.5 oz/A that’s labeled and usually effective against powdery mildew, control of BBR is only fair under anything more than modest pressure, and there is no mention of Botrytis on the label (i.e., the company makes no claim concerning activity against this disease). However, Pristine is labeled for “suppression” of Botrytis at a rate of 12.5 oz/A, and for “control” of this disease at 18.5-23.5 oz/A. Pristine provides protective and limited post-infection activity, although the post-infection activity has not been as great as that for the APs or Elevate in our tests. The resistance risk is high, so rotation is important, although the mixture of two unrelated ingredients should help. Our test results with Pristine have been a bit erratic: it has often been very good to excellent, but not always. Many of our growers use it at the 12.5 oz rate during the late bloom period, since it controls several fungal diseases active in our region then in addition to providing some insurance against blossom infections by Botrytis.

Luna Experience. Just received federal (EPA) registration. This is the first of several products representing the "next" generation of SDHI fungicides, of which bosclid (Pristine component) was the first modern one. These materials typically are highly active against both Botrytis and powdery mildew, and Luna Experience has provided excellent control of both diseases in several trials that we've conducted. Be aware that the SDHI group (FRAC Group 7 on the fungicide labels) is at moderate to high risk of resistance development, so they need to be rotated with other classes of chemistry, i.e., don't simply rotate Pristine and Luna Experience. (For the record, Luna Experience also provides a low rate of the DMI tebuconazole, the active ingredient in Elite; this won't provide any control of Botrytis, and it's activity is questionable in vineyards with any significant history of DMI use).

Flint. An excellent powdery mildew fungicide when used at 1.5-2.0 oz/A, it has typically provided very good to excellent control of Botrytis for us when used at the 3 oz/A rate labeled against this disease, although we have seen some slippage recently. Primarily a protective fungicide since little of it is absorbed into the berry. The resistance risk is high.

Rovral (and iprodione generics). In the absence of resistance (which is common in the East, where the product was used intensively for many years with no rotational alternative available), Rovral is an excellent Botrytis fungicide, with both protective and post-infection activities. It should be a good rotational partner where resistance is not a major concern, but should be used with caution otherwise. It provides no significant control of any disease other than Botrytis.

"Alternative" products. Although others have, we've never obtained **any** control of Botrytis with Stylet Oil or the various potassium bicarbonate products, and I would be very hesitant to rely on them for this purpose under any sort of disease pressure. We have sometimes obtained a measure of control with Serenade and Regalia, but these have never been as effective as the standard products discussed above.