Botrytis Bunch Rot

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The most important fungal plant pathogen responsible for bunch rot of grape berries is *Botrytis cinerea* (Persoon). This fungus has a wide host range of both native and cultivated plants. On grape it can grow on any plant material that is succulent (young shoots or flower parts), stressed (damaged or ripened fruit), or dead (yellow leaves or senescent flower parts). The chemical enzymes produced by the fungus can destroy the integrity of a grape berry within a few days. Botrytis bunch rot can severely affect tight-clustered, thin-skinned varieties, especially under heavy canopies or during wet growing seasons. In the production of late harvest wines a late infection of berries by *B. cinerea* is referred to as “Noble rot” and is highly desirable to produce a concentration of sugars and flavor components under the right environmental conditions.

Symptoms

Foliage

In the early spring, prolonged warm moist conditions caused by frequent rains *Botrytis* can infect young succulent shoots, flowers, or young leaves. Patches of soft brown tissue develop resulting in the death of the infected plant part. Very young shoots can be killed by this type of infection and can result in yield reduction due to the loss of flower clusters. Older shoot stems may be girdled at the site of infection and wilt or break off. Infection of young expanded leaves can produce areas of brown necrotic tissue. In almost all cases, infection occurs in the axils of leaf or inflorescence junctions with the main shoot. The infection results from pooling water in these “crotches” thus allowing water to remain for a longer duration of time.

Fruit

Bunch rot often begins when blossoms become infected during spring rainfall. The pathogen invades the flower parts and then becomes dormant until veraison. At this time individually infected berries within the cluster turn brown due to enzymes produced by the fungus and subsequent fungal invasion of the pulp. Often this stage is known as "slipskin", because the enzymes break down the cutin in the epidermis and it easily slips off the berry. If temperatures are moderate, moisture is high and wind speed is low, epidermal cracks will form in which fungal growth produces mycelium and spores, resulting in the characteristic gray, velvety appearance of infected berries.. The fungus can then spread from berry to berry causing a "nested" appearance of infected berries. If conditions remain favorable, the disease can result in a high percentage of berries being rotted and if disease is severe enough to reach the rachis then "raisining" of infected berries can occur.

Disease Cycle

Overwintering

Botrytis survives winter by forming dormant structures called sclerotia, either on the surface or within colonized plant tissue including rachises and berries. The two most common sources of sclerotia in vineyards is grape mummy clusters from the previous season, and canes that were infected in the fall of the year. Sclerotia are hard, black structures about 3 mm (1/8 inch) in diameter.

After rains or irrigation in spring, the sclerotia germinate and produce masses of spores (conidia), which are spread by air currents, workers, or rain splashing. The production of spores by *Botrytis cinerea* results in the characteristic gray, fluffy appearance of the fungus.

Germination

To germinate and grow, spores of *B. cinerea* require continuous free water and nutrients for certain durations of time given certain temperatures. For example, at temperatures of 18 to 24 ºC (65 to 75 ºF), only 2 hours of free water are needed for germination and infection to occur while at temperatures lower than 16 ºC (60 ºF) and higher than 27 ºC (80 ºF), more time is needed for infection to occur. The free water can be from dew, fog, irrigation, or rain. Periods as short as 15 minutes with no available water are sufficient to stop germination. However, even with water present, germination also requires nutrients that can come from many sources, even from the surface of a healthy grape berry. The main nutrient required is a simple sugar, such as fructose or glucose. The dependency of spore germination and infection for water can be a factor in disease control. After veraison Botrytis bunch rot can begin in a cluster where the berries have been damaged. Insects, birds, or mechanical damage can cause juice to be released, thereby providing the spores with the nutrients and free water they need for germination.

Ambient air temperatures also affect germination. Warmer temperatures usually hasten the drying of the berries and directly reduce spore germination. Under field conditions, both temperature and duration of free moisture are related to infection. At 32°C (90°F) and above the fungus does not grow, but it will grow slowly even at 1°C (34°F), which allows it to severely infect stored table grapes.

Infection

In early spring under moist conditions the spores can infect the grape flowers, succulent young stems or young leaves. These infections can later lead to increased spore production. During bloom time, floral tissue can become infected and later in the season as blossom debris it can be found to be 100% infected. This tissue then will give rise to spores when wet at any point in the season and result in cap stem, rachis, and berry infections. Latent or quiescent infections can also occur when flower tissue becomes infected during bloom, and the fungus lays dormant within the berry until the sugar concentration increases. The fungus then resumes growth and spread throughout the berry. After veraison the skins begin to soften, the berries themselves become more susceptible to infection. Rot can spread to adjoining berries within a cluster or new infections can occur by air borne spores. Late-season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures are in the 15° to 28°C (59° to 82°F) range.

The fungus can penetrate grape berries through wounds or directly penetrate undamaged berries. The berry skin is the main protection from infection by Botrytis. Any chemicals or cultural practices that alter the skin of the berry will change the susceptibility of the berry to infection. For example, if fruit is grown in shady canopies with high RH then the cuticle on the berry is generally significantly thinner thus affording reduced protection from *Botrytis* infection. On the other hand, if fruit are exposed early, they develop a heavier epicuticular wax layer and thus have more protection from infection.

In infected berries, cracks quickly appear in the skin. The spores develop first in the cracks and then spread over the entire berry. The infection of other berries by the rapidly growing fungus and airborne spores contribute to the extremely rapid increase in disease observed after rains late in the season. Under optimum conditions, *Botrytis* can infect a berry, destroy it, and begin to produce spores in only 3 days. After infection, the berry may dry up if high temperatures and low relative humidities prevail. However, the fungus is still alive and can continue to grow if favorable conditions for growth resume.

Management of the Disease

Control of Botrytis bunch rot is best achieved through integrated pest management. Success depends on overall management of the disease. For example, the efficacy of a fungicide depends on getting good coverage, and coverage is affected by the canopy and stage of growth. By employing cultural control methods and properly applying fungicides,, the disease can be managed.

Sanitation

Sanitation is the cornerstone for all effective disease control. Clusters left on vines or on the vineyard floor from the previous season can be a source of inoculum the following spring. The removal of clusters from vines at pruning and placement into the row middles where they can be incorporated into the soil can reduce inoculum. After the overwinter-ing sclerotia have produced spores, the subsequent infection and disease development on the berries can be managed by maintaining less than optimum conditions for germination and growth of the fungus within the canopy.

Dormant Applications of Fungicides

Lime sulfur has long been used for the product of choice for dormant applications on grapevines. It is generally a good cleanup product. Research has shown that applying lime sulfur at 10 gal/A in a high volume of water (at least 100 gal/A) during dormant or delayed dormant will reduce overwintering sclerotia of *Botrytis cinerea* by 70-75%. The product kills the sclerotia and thus significantly reduces inoculum.

Canopy management

Since *Botrytis* spores have rigid environmental requirements for germination and growth, control can be obtained by creating a canopy microclimate less conducive to disease development. The objective is to increase exposure of the grape clusters to increase wind speed and light so that drying occurs more quickly.

Canopy management can be directed to the canopy or to overall growth of the vine. Vineyard design decisions such as rootstock and scion selection, trellis type, training/pruning method, and plant density can affect canopy density. Row orientation can influence the fruit microclimatic parameters wind speed, humidity, and temperature which can alter the evaporative potential of the canopy and fruit. Careful planning to design a vineyard to the anticipated vigor of the site conditions will produce balanced canopies with moderate shoot vigor that optimizes leaf and cluster exposure. Vineyard design decisions generally have long term effects on vine canopies that are not easily changed for the life of the vineyard. Other growing practices such as irrigation and nutrition management strategies can be altered annually. These practices can influence canopy density by increasing or decreasing the rate and amount of shoot and lateral growth. In general, the more dense the canopy (that is, the more layers of leaves surrounding the clusters), the more optimum conditions will be for development of

Botrytis bunch rot. With careful management, it is often possible to reduce the density of the canopy, which in turn will help alleviate disease pressure.

Shoot thinning, shoot positioning, leaf removal, and hedging are all practices that can increase air and light penetration to the clusters when canopies are too dense. Shoot thinning is a common practice for table and wine grape production. It can reduce density temporarily; the lateral shoot growth promoted by this practice can often increase canopy density by bloom to a level similar to a non-shoot thinned vine. Hedging is often used in vineyards in California to maintain an upright pattern of shoot growth that will enhance air movement directly to the clusters. However, careful timing is needed to achieve satisfactory results. If hedging is used too early, lateral re-growth often makes the canopy denser than non-hedged vines. In some cases these hedged vines have more bunch rot at harvest. Also, severe hedging removes a very large portion of the most photosynthetically active leaf area on the vine. This can result in delays of fruit maturity up to 3 weeks, thus offsetting any advantages of the open canopy for *Botrytis* control.

Removal of leaves and laterals around the clusters creates a microclimate within the canopy that is less conducive to development of Botrytis bunch rot. In many cases, the level of disease control can be equal or superior to up to 3 fungicide applications. Conducted immediately after fruit set this practice can also can physically shake off some of the floral debris that can be infected with *Botrytis* and reduce this source of inoculum. Leaf removal should be done on the side of the canopy that receives morning sun (east or north side) to reduce the fruit damage from sunburn. In warmer areas do not remove excessive numbers of leaves. If leaves are removed in the period after fruit set to when berries are BB size, the berries acclimate readily to the sunlight and develop a thick cuticle that helps prevent sunburn as well as Botrytis infection.

The microclimatic conditions within the canopy that most affect development of *Botrytis* are those that affect the duration of free water on the berries. The evaporation rate of water is affected by the temperature, vapor pressure deficit, and wind speed of the ambient air. When leaves around the clusters are removed, the wind speed across the surface of the berries is increased, and berry surface temperatures are increased. These two factors contribute to drying the clusters after they have become wet. In addition it has been shown that even berries infected with *B. cinerea* cannot sporulate if wind speeds are 0.3 meters per second or more on the berry surface.

In an unusually wet year, the benefits of microclimate modifications are reduced because of the impact of the macroclimate, and it may be necessary to increase applications of fungicides. If fungicides are required, however, proper canopy management will continue to benefit the grower because more of the fungicides will be deposited on the more exposed clusters. For example, leaf removal on both sides of the canopy increased fungicide deposition by 200X in California trials.

In trials conducted in California, a 30% reduction in bunch rot was achieved simply by using a common leaf blower to dislodge blossom debris from within clusters before berry touch. Appropriate timing for this application is just after drying of blossoms.

Irrigation

Choosing the right type, timing, or level of irrigation can help control bunch rots. For example, overhead sprinkler irrigations near harvest can increase *Botrytis* levels. If this is the only type of irrigation available, then the time of day or length of application may be varied to speed drying of the clusters. For example, in cool coastal valley vineyards, many growers irrigate at night to take advantage of the warmer, drier, daytime conditions that aid drying. The length of time free moisture is on the clusters should not be greater than 15 hours, including the time it takes to dry the clusters completely.

Other types of irrigation should also be used judiciously. High levels of drip or furrow irrigation will encourage dense canopy growth and provide moist conditions through increased RH, favorable to sporulation. Growers should determine the optimum levels of irrigation at each vineyard site that will result in canopy development that produces desirable yields without excessive shoot or lateral growth.

Berry Damage

Feeding wounds caused by high late season populations of the tortricid moths, orange tortrix (*Argyrotaenia citrana)* and omnivorous leaf roller (*Platynota stultana)* can significantly increase the levels of bunch rot caused by *Botrytis* and other secondary fungal and bacterial pathogens. Berry scarring caused by powdery mildew infections of developing berries can result in cracking during later growth stages and result in increased levels of bunch rot. Careful monitoring and management of these insect and disease berry injuries is a key component in reducing bunch rot infections.

Chemicals

Several fungicide classes are available for control of Botrytis bunch rot. Alternating fungicides with different modes of action is essential to prevent pathogen populations from developing resistance to fungicides. Single site modes of action fungicides are more susceptible to the selection of resistant fungus biotypes. Resistance of *B. cinerea* to fungicides has been observed in vineyards. Refer to the UC grape pest management guidelines fand the UCIPM Efficacy and Timing of Fungicide Tables for the most current information on registered fungicides for Botrytis bunch rot control.

Spray programs may consist of sprays at bloom or multiple applications applied at bloom, cluster preclose, veraison, and preharvest. This should depend upon the history of Botrytis bunch rot in a particular vineyard and variety. Data collected over many years have shown a direct relationship between the number of fungicide applications and the level of Botrytis bunch rot control. The greater the number of spray applications, the higher the control level.

Studies to determine the optimum timing of a single application have yielded variable results. A single application at bloom has rarely proved to be significantly more effective than a single application at any other time during the season, the exception being at vineyard sites where there was rain during bloom. At these sites bloom-time fungicide applications were more effective than at other times.

Timing sprays according to the plant's growth stage is usually not effective; a better method is to apply sprays only when environmental conditions conducive to the growth of the fungus have been forecasted. Fungicide applications applied before rain are more effective in reducing Botrytis infections.

To obtain optimum coverage of pesticides, spray adjuvants (most commonly surfactants) are often added to the tank mix. The purpose of these surfactants is to reduce the surface tension of the water droplets, thus allowing better dispersion over the plant's surface. The nonwettability of a plant part is due mainly to the layer of wax on its surface. Some adjuvants actually alter the structure of plant waxes. Although specific situations may call for using spray adjuvants, one must consider that most chemicals already contain them in their formulation, and that adding more adjuvants can be justified only by data that positively demonstrate a significant increase in efficacy or if the company has recommended their use.