Bunch Rot
Botrytis cinerea

Joy Hilton, Department of Horticulture, and Dimitre Mollov, Plant Disease Clinic, Department of Plant Pathology, University of Minnesota

Botrytis bunch rot is known as both the vulgar rot and the noble rot when referring to its effect on wine. Both vulgar and noble rot are caused by *Botrytis cinerea*, and the type of rot is dictated by specific climatic changes. *Botrytis* bunch rot, or gray mold of grape, is responsible for an annual loss of approximately 20%, and costs to control *Botrytis* were 780 million dollars in 2002 (Genescope 2002). The greatest losses on grapes due to *Botrytis* are found in tight-clustered varieties of *Vitis vinifera* and French Hybrids (Ellis 2004). Fortunately for Minnesota vineyards, our hardy grapes and relatively dry fall climate have helped to minimize the impact of this pathogen in our area.

Botrytised wines are known under the names of Sauternes from Bordeaux, Tokaji from Hungary, and Rheingau from Germany (Jackish 1985). They require a skilled winemaker and many years to produce, but the effort is well worth it. Many wineries charge anywhere an average of $40-150 for a .75ltr bottle compared to charging $12-$40 for a normal white wine (La Cave 2007).

Symptoms

Some symptoms may be observed in early spring, but the most obvious are not seen until after veraison, the ripening of the berry, when it is too late to prevent.

Vegetative

Symptoms of *Botrytis* on leaves (photo courtesy of Jay W. Pscheidt, Oregon State Univ.)

The first symptoms of *Botrytis* may be observed in early spring on buds and young shoots. Infected shoots and buds may turn brown and dry out. Before bloom leaves may exhibit large, irregular, reddish brown, necrotic patches that are usually localized on the edge of the lamina (Pearson 1998). A gray mold may or may not be observed on the leaf. *Botrytis* can invade the inflorescences before bloom, which causes the bloom dry out and fall off the vine (Pearson 1998). This stage of infection can lead to high yield losses. The pathogen then moves to the end of stamens of aborted berries still attached to the clusters. From these infections *Botrytis* moves to the pedicel or rachis creating small patches that start out brown and turn black. By the end of the season, these infections can girdle the rachis causing any berries below the infection site to wither and drop off (Pscheidt 2007).

Botrytis on white grapes (Photo courtesy of Ed Hellman, Oregon State Univ.)

Fruit

Berry infection is the most common type of infection and can seriously reduce the quality and quantity of the crop (Ellis 2004). After veraison, grapes are infected through the epidermis or wounds. *Botrytis* will progressively invade the entire cluster. It will develop faster in tight clusters where

berries are compressed together. The infection tends to start in the center of a cluster and spread out to the entire bunch (Pearson 1998).

Infected berries will appear in late summer. The first sign may be small brown spots on maturing berries or the skin may slip off easily when rubbed (Pscheidt 2007). White grapes will start to turn brown while purple grapes turn reddish in color. If the weather is dry the grapes will dry out, but wet weather will cause them to burst and a gray mold will form on the surface (Pearson 1998). Rotted berries will eventually shrivel and drop off the vine as mummies, hard dead grape tissue (Ellis 2004).

Disease Cycle

Botrytis cinerea has a wide host range attacking both cultivated and wild plants (Agrios 2005). It can live as a saprophyte, attains food, on necrotic, senescent or dead tissue (Pearson 1998). This pathogen overwinters as sclerotia, hard resistant structures, on debris in the vineyard floor or on the vine (Agrios 2005). These sclerotia are resistant to harsh weather and will usually germinate in the spring.

In the spring, *Botrytis* sclerotia germinate and produce conidia, thought to be the primary source of inoculum for prebloom infection of leaves and clusters. The conidia are disseminated by both wind and rain to plant material and germinate when temperatures are between 34-86^{o}F (1-30^{o}C). If free water is present, germination is stimulated by nutrients from pollen or leaves, whereas if there is no free water germination occurs when the relative humidity is at least 90%. Under optimal temperatures and relative humidity, or free water, infection can occur within fifteen hours (Pearson 1998).

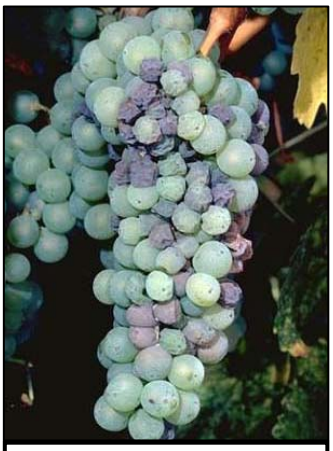
Later in the season hyphae will penetrate directly through the epidermis of healthy berries. Wounds caused by insects, powdery mildew, hail or birds help to facilitate infection (Agrios 2005). Swelling in tightly packed clusters can cause berries to rupture creating excellent infection sites for the pathogen. After infecting the berry, *Botrytis* may stay dormant until the fruit sugar content increases and the acid level decreases enough to support the pathogens growth (Ellis 2004).

Control Strategies

Proper site selection is the first step in controlling *Botrytis* bunch rot. Start with a site where vines are exposed to sun all day since this pathogen thrives in wet and humid conditions. Choosing resistant varieties, such as Frontenac and Frontenac Gris, is also important in reducing the impact of *Botrytis* bunch rot (Rombough 2002).

The most efficient way to control *Botrytis* bunch rot is the use of good cultural practices. Utilize pruning and training systems to improve air circulation which promotes rapid leaf drying. This will help reduce the high relative humidity the pathogen needs to infect the plant. Remove leaves around the grape cluster at shatter (Pscheidt, 2007). This will increase air circulation directly around the cluster. Avoid applying excessive nitrogen that will stimulate lush tender growth that is more susceptible to the pathogen (Rombough, 2002). In addition, clear crop debris from the ground after leaf drop or incorporate it into the soil at the beginning of the season. This will reduce the overwintering inoculum in the vineyard.

Noble Rot



Botrytis on a grape cluster
(Photo courtesy of William J. Moller, UC IPM Online)

Under specific climatic conditions *B. cinerea* is known as the noble rot. This type of infection is highly sought after in many regions of Europe, creating some of the world's best sweet white wines. In order for this pathogen to become the noble rot, the temperature needs to be between 68-77^{o}F (20-25^{o}C) and the relative humidity between 85-95% during the infection phase. Following infection, the relative humidity needs to decrease to 60%, which is the key factor in dehydration of the berries (Dharmadhikari 2007).

The best known botrytised wines, Sauternes, are produced naturally in France, Hungary and Germany. The natural conditions in the field make it possible to sporadically make these sought after wines. However, some vineyards in California are producing botrytised wines by artificially infecting grapes with *B. cinerea* and altering the growing conditions. They hold the humidity at the required level for up to fifteen hours then drop it back down. Other wineries in New York are infecting ripe harvested grapes with naturally occurring *B.* and holding them at specific temperatures and humidity for two weeks (Cornerstone Communications 2003). These techniques are new in the wine industry and come with some risk.

Botrytis cinerea creates many changes within the berry. The mycelium penetrates the grape skin allowing the berry to dry. This dehydration leads to a concentration of sugars. The osmotic pressure inside the berry causes the metabolic activity of the pathogen to decrease enabling vintners to create the sweet botrytised wine (Dharmadhikari 2007).

The pathogen causes significant changes in the composition of the grape, therefore special vinification techniques must be used by the vintners. Since the botrytised grape must has a higher sugar content than normal must, it ferments much slower. It is necessary to continually monitor the volatile acidity during and after fermentation to protect the wine from oxidation. The winemaker must also monitor to adjust the amount of alcohol, acid, and sugar to inhibit laccase, which causes browning (Jackisch 1985). The wine is usually fermented in oak and stored in oak casks. Unlike other wines, it is racked every three months for one year and then fined at the end of the first and second year (Jackisch, 1985). Botrytised wines are not ready to be bottled for three years, unlike normal wines, justifying the added expense to the consumer.

Depending on humidity, vintner knowledge and winemaker skill, *B. cinerea* can be a winery's best friend or worst enemy. If this pathogen infects the vineyard early in the season a significant yield loss can be expected. If it attacks grapes at the end of the season and the humidity stays high entire clusters will be lost or ruin the quality of the wine. This common and aggressive pathogen can sit out the harsh seasons, can live off dead tissue, and even wait for sugar levels to increase in the grape. Because of this, any growers producing susceptible grapes must follow a rigorous spray and cultural practice program. If a vintner is lucky and the grapes are infected but the humidity drops, then high quality and high priced botrytised wines may be created. Many growers do not take this risk and work hard to keep *B. cinerea* out of their vineyards.

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