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Berry Shrivel

"Berry Shrivel" is a term used in the north coast that describes a specific condition of grape berries that may occur any time after veraison. "Waterberry" is a term used throughout California and in the literature that is also descriptive of the berry's condition; however it is commonly included in the list of terms used to describe a disorder of the rachis. These include Stiellahme (Germany), disseccamento del rachide (Italy), dessechement de la rafle (France), palo negro (Chile), shanking (New Zealand) and late season bunchstem necrosis, bunchstem necrosis or just "BSN" by the Australians.

In waterberry, the rachis disorder begins soon after veraison with small necrotic lesions first commonly appearing on the pedicels (cap stems) or rachis laterals and then progressing to other parts of the cluster stem framework. Portions of the cluster distal or below a lesion turn brown and dry. The lesions may elongate and coalesce. The rachis may be girdled at the lesion and the cluster part below it can fall off the vine or is easily pulled off the cane. Sometimes the entire cluster stem dries. As more of the rachis becomes involved, the fruit shows symptoms that reflect a lack of normal water and solute flow through the rachis. The fruit in a waterberry cluster lacks sugar and flavor; the berries become flaccid and wrinkle; they have a flabby, soft texture and they continue to shrivel. Sometimes they completely raisin. Berry color is affected early in the progression of symptoms.

Throughout the grape regions of the world, the first sign of waterberry, BSN, etc. is always on the rachis. Waterberry occurs in the North Coast; however it is not nearly as common as it is in the San Joaquin Valley. The symptoms are identical to those described in the literature. Bottom line: with waterberry, the rachis shows the first signs of the disorder, followed by the berries.

In the North Coast, growers have experienced similar fruit symptoms as occur in waterberry, but without the apparent rachis symptoms, thus the term 'berry shrivel' is used locally. The same term has also been used among table grape researchers when describing waterberry symptoms in seeded table varieties – most notably Emperor and Calmeria – two varieties that at one time were extensively planted. The most commonly affected winegrape varieties in the North Coast are Cabernet Sauvignon and Merlot, although Chardonnay has also been involved.

Symptoms and timing of berry shrivel

Berry shrivel is observed anytime during the fruit ripening stage, that is, from just after veraison through harvest. The fruit takes on the same appearance as berries affected by waterberry. Berry color is dramatically affected if the onset of symptoms occurs just after veraison is complete. Fruit in red varieties does not completely color. On the other hand, if onset is late, the berries of red varieties may appear darker than normal. Most people notice flaccid berries and off-color fruit as the first sign of berry shrivel.

At the onset of berry symptoms, all parts of the rachis, including the pedicels of affected berries, appear to be normal, and there is no apparent necrosis of the bunch stem tissue. Depending on the timing of berry symptom onset, the rachis may or may not remain symptomless. When berry shrivel occurs just prior to harvest, the rachis has no observable signs of discoloration or dryness. When berry shrivel occurs early or mid-season post veraison, the pedicels will turn brown, dry and become very thin after an undetermined length of time. In addition, the cluster laterals and the main cluster stem will become tan colored. Desiccation or necrosis follows shortly after. If the cluster is first noticed at this stage, it appears to be classic waterberry.

Growers observed berry shrivel in their vineyards a short time after veraison was complete in 1996. The following year, some growers noted that the onset of symptoms occurred within a few weeks of normal harvest dates. In 2002, the onset of symptoms in one Alexander Valley vineyard in Sonoma County was mid August whereas the onset of symptoms in a specific Rutherford area vineyard as well as at the UC Oakville Experimental Vineyard was just prior to harvest.

In a vineyard that is prone to berry shrivel, the number of vines with symptomatic clusters in that vineyard is extremely variable from year to year. In other words, a vine that has a high incidence of berry shrivel one year may not be affected the next.

The severity of berry shrivel within a cluster ranges from a few berries to - most commonly - the total involvement of all berries in a cluster. The number of symptomatic clusters present on a vine at harvest can range from zero to 90% of the bunches per vine (unpublished data).

Selected Areas of Research from the Literature

There have been several decades of wide experimentation on the cause and control of the cluster stem disorders. Unfortunately there is still no definitive cause or cure. The information presented in this section only touches on a few areas of interest. Although it is not certain that berry shrivel is caused by the same factors that cause waterberry, BSN, etc., that literature can be taken as a model.

Water relations

There has been local discussion on the effects of vine water status as well as temperature fluctuations during veraison on berry shrivel. In 1999 results from a UCCE irrigation research trial conducted in Lodi indicated that the incidence of berry shrivel was not related to vine water status (Terry Prichard, personal communication).

Since berry shrivel occurs post veraison, hot spells during that time are often thought to be the cause or at least make the problem worse. While temperature seems a likely culprit, it is important to remember that high temperature is not the most important driving force behind high evaporative demand. Evaporative demand is more closely tied to clear skies and low relative humidity. However, that being said, berries lose water during the day just as leaves do. Greenspan et al. (1996) found that berry transpiration rate was greater pre-veraison then post veraison – regardless of whether vines were under water stress. Therefore, while berries lose water both pre and post veraison via transpiration, their daily size fluctuation is greater pre-veraison when xylem is responsible for most of the berry in-flow. As a result, perhaps we ought to be concerned with excessive evaporative demand prior to veraison as well as after it.

After veraison, the phloem is responsible for the vast majority of the in-flow into berries (Greenspan et al. 1994). If the phloem is blocked, then there is no in-flow into the berry, yet transpiration continues resulting in berry shrivel (B. Coombe, personal communication).

In the Alexander Valley, it is common to see a vineyard with apparently no symptomatic vines adjacent to one that is prone to berry shrivel. Also, a vineyard that is prone to berry shrivel commonly has areas that seldom have this problem. The weather conditions experienced by all vineyards or blocks in a small region are nearly the same, yet there is annual variability of expression within that region and incidence of berry shrivel is not consistent. This means that differences in cultural practices play a role in this disorder and that environmental conditions may only affect the severity of berry shrivel.

Nutrition

This is by far the biggest area of research. Many people have explored localized nutrient deficiencies, toxicities or impaired metabolism. The following is <u>not</u> a complete discussion.

<u>Calcium, Magnesium and Potassium</u>
European researchers have reported nutritional imbalances of calcium, magnesium and/or potassium with rachis disorders. They associated a high ratio of K/(Ca+Mg) with BSN and some have shown that foliar applications of Ca and Mg reduced the disorder.

California researchers have not shown these effects. Nutritional studies in two table grape varieties using Ca and Mg fertilizers failed to reduce fruit symptoms (Christensen et al. 1974, 1975). In 1980, petioles collected from areas of low and high incidence of waterberry in 13 commercial vineyards did not show differences in P, K, Ca or Mg (Christensen and Boggero, 1985). Calcium and Mg levels in symptomed cluster rachises collected in the same vineyards were not significantly different when compared to normal cluster rachises from either high or low areas of waterberry. However K levels were lower in symptomed rachises than in normal rachises. As a result, the ratio of K/(Ca+Mg) in symptomed rachises was significantly lower than in normal clusters. This is opposite to what the Europeans found in which lower Ca and Mg levels increased the value of the ratio and this was associated with increased BSN.

<u>Nitrogen</u>
Nitrogen fertilizer trials have also shown apparently contradicting impacts of BSN incidence. Christensen and Bogerro (1985) conducted fertilizer trials in 3 locations over 3 years in Thompson Seedless. They reported that waterberry was significantly increased in the N and the N+P treatments at two locations in one out of 3 years. In the 1980 survey of 13 vineyards that were all prone to waterberry, (see previous discussion) they found higher total N and ammonium-N in cluster rachises from high waterberry incidence areas. In addition, the petioles from the high incidence areas were significantly higher in both total N and nitrate-N.

Holzapfel and Coombe (1998) found they could induce BSN by perfusing ammonium sulfate or agmatine into cluster peduncles. Both treatments raised tissue free ammonium levels. However, other treatments induced BSN without raising ammonium levels, thus they surmised that free ammonium was not responsible for the BSN caused by agmatine. The metabolism of agmatine can result in the production of the polyamine putrescine and Christensen et al. (1991) indicated that putrescine may induce waterberry.

Capps and Wolf (2000) showed significant reduction of BSN when nitrogen was applied to a commercial vineyard in 3 out of 4 years. Fertilizer applications in a second vineyard did not produce the same reduction of BSN, but there were very low levels of BSN (an average of 1% in the controls) at the site over two of the 4 years. In addition to nitrogen, treatments included magnesium and calcium applications. Petiole tissue levels of Mg and Ca were the lowest in the year with the least BSN incidence in the controls (average of 7%). Thus, BSN incidence decreased with an increasing ratio of K/Ca+Mg. This is opposite of the European studies.

North Coast investigation – 2002

Three Cabernet Sauvignon vineyards were monitored for berry shrivel last year. Locations were Rutherford, Napa County and Healdsburg, Sonoma County as well as at the University of California Oakville Experimental Vineyard (OEV). At each site, a minimum of 50 vines were sampled at 2 week intervals beginning at veraison and continuing through harvest. A sample consisted of one basal cluster per vine. After the onset of symptoms one symptomatic cluster and one non-symptomatic cluster was removed from each affected vine. For each sampled cluster, all of the berries were removed and the rachis was rinsed, then dried.

At the end of the season, tissue samples were submitted for analysis from each site from specific vines that eventually had berry shrivel as well as from specific vines that remained normal. Individual rachises from non-symptom and symptomed clusters collected over time from symptomed vines were submitted along with rachises collected on the same dates from vines that remained non-symptomatic. Thus, clusters from first 2 then 3 symptom categories were collected over the season (i.e., clusters from non-symptomed vines; non-symptomed clusters from vines that became symptomatic, and finally, symptomed clusters.

In Oakville and Rutherford, symptoms were not seen until the final sample date just prior to harvest. In Alexander Valley, symptoms began to appear within two weeks of veraison. In that location, ten vines were "mapped" as to the location of the symptomed clusters on the vine. The percent of berry shrivel clusters in the mapped vines ranged from 63%-84%.

The nutrients analyzed in the individual rachises were ammonium, total N, nitrate-N, potassium, phosphorus, boron, calcium and magnesium. Ammonium and total N were not consistent across the three sites. In Alexander Valley, there was no difference among the three symptom cluster categories for either compound. In Oakville, ammonium was higher in non-symptomed clusters from symptomed vines while in Rutherford, ammonium was not different among the cluster categories. In Rutherford, total-N was greater in non-symptomed clusters from symptomed vines. There was no significant difference in potassium in cluster categories at any site.

In both Oakville and Alexander Valley, calcium levels were significantly greater in non-symptomed clusters from symptomed vines. Calcium levels were not different among cluster categories in Rutherford. In all three vineyards, magnesium levels among cluster categories was significantly different but not in the same manner. In the two Napa County sites, Mg levels were slightly lower in non-symptomed clusters from symptomed vines. In the Alexander Valley site, Mg levels were greatest in those clusters. In that location and in Oakville, the ratio of K/(Ca +Mg) was significantly greater in clusters sampled from vines that did not show berry shrivel during the season.