Berry Shrivel Research Update – 2005 and 2006 investigations

Rhonda Smith
UC Cooperative Extension, Sonoma County

Note: This update includes a summary of research conducted by Mark Krasow, Post Doctoral Scholar at UC Davis, working with Principal Investigators Mark Matthews, Department of Viticulture and Enology, and Ken Shackel, Department of Plant Sciences. Funding was provided by the American Vineyard Foundation, the California Competitive Grants Program for Research in Viticulture and Enology and the North Coast Viticulture Research Group.

Background

Berry shrivel is a disorder of grapevines for which there is no known cause. It is more common in North Coast vineyards than in other areas of the state, however it was first described in seeded table grapes in the San Joaquin Valley over 50 years ago. Locally, berry shrivel (BS) has occurred in red and white varieties including Cabernet Sauvignon, Merlot, Pinot Noir, Chardonnay and Sauvignon Blanc. The onset of BS may occur anytime from just after veraison through harvest.

There are three prominent symptoms of BS regardless of variety. First, berries are flaccid and usually lighter in color than non-affected fruit. They remain flaccid for the remainder of the season with large depressions similar in appearance to those seen in a deflated volleyball. All berries on a cluster are affected, including those on the unexposed side of the bunch.

The second "symptom" of BS is actually a lack of symptoms on the rachis. The main bunch stem, lateral cluster stems and the pedicles (cap stems) are green and appear normal. Examining the rachis helps distinguish BS from other disorders.

The third symptom is the taste of the berries, which is always affected in BS clusters. Tastes range from incredibly objectionable to simply under ripe with high acid and low sugar.

Berry shrivel should not be confused with bunch stem necrosis, sometimes referred to in California as waterberry. Researchers here and abroad have evaluated and published articles on bunch stem necrosis (BSN) thus several names exist for this disorder in the literature. The most prominent BSN symptom is a necrotic rachis. Berries become flaccid but then continue to dehydrate until they are very dry and hard. Eventually, individual berries and entire clusters become so dry that they fall off the vine when disturbed. Unlike BS, berries taste sweet as they dehydrate, then pruney.

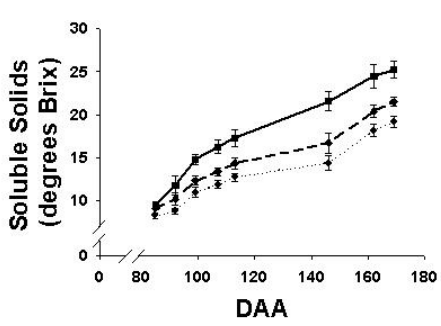
2005 and 2006 Research

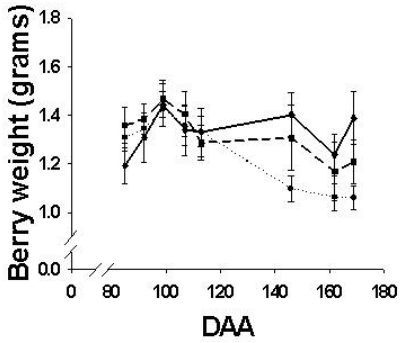
BS was evaluated at the Oakville Experimental Vineyard (OEV) and in an Alexander Valley vineyard each with a history of BS. At OEV, data were collected from vines with a consistent history of BS (since 1998) as well as from control vines. Berries were sampled weekly for compositional analysis starting prior to veraison. In the Sonoma County site, an irrigation trial was conducted to determine if an increase or absence of applied water would impact the incidence of BS. In 2006 cane girdling experiments were conducted at OEV and Davis on additional vines to analyze the affects of phloem disruption on berry composition as compared to the composition of berries with BS.

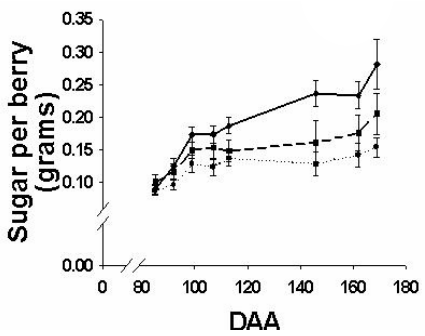
Oakville Experimental Vineyard, 2005 – Berry Composition

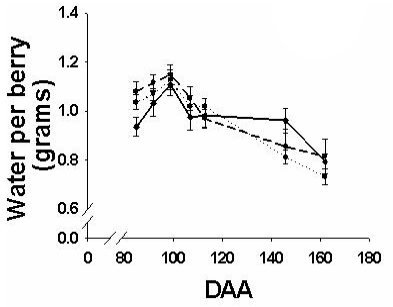
At OEV, investigations were conducted on vines selected for their history to have BS or to be non-symptomatic (control vines). Prior to veraison, 10 clusters on vines likely to develop BS and 5 clusters on control vines were flagged and two berries were removed from each cluster each week and frozen for later analyses. BS symptoms were first observed on 2 September 2005, 112 days after bloom (anthesis). At the end of the season, frozen berries were categorized into those from BS clusters; those from visually healthy clusters on BS vines - termed "likely to shrivel" clusters (LTS); and those from vines that did not have any BS (Control). Compositional analyses are presented below. The x axis in all figures, "DAA", is days after anthesis. BS fruit stopped sugar accumulation beginning about 2 weeks prior to visual symptoms and had less sugar, lower pH and reduced color. Visually non-symptomatic clusters on a vine with BS clusters (LTS fruit) have levels of some parameters that were intermediate between those in fruit on control vines and in BS fruit.

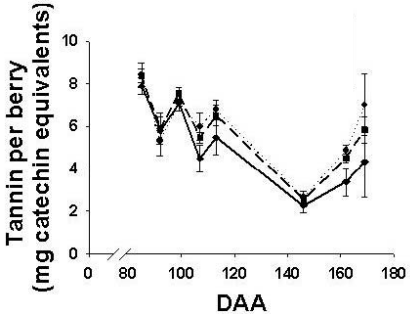
Legend for all graphs: ····•····**BS** ---▪---**LTS** —▲—**Control**

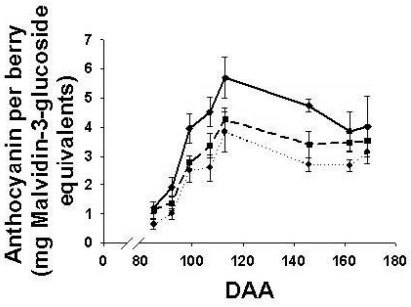


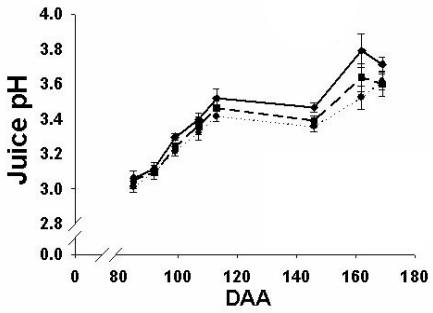


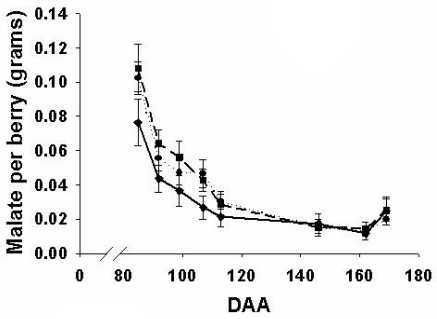


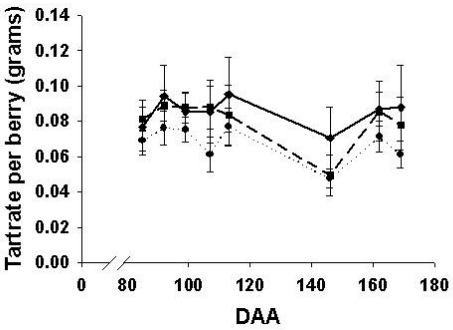












2006 was not a "BS year" at Oakville Experimental Vineyard

Data were collected in the same manner from the same vines in 2006, but "classic" BS symptoms did not appear. Several clusters on likely to shrivel vines were less turgid, yet the severity of symptoms was reduced. Cane girdling experiments (described below) indicated a difference in Brix between fruit on vines that had a history of BS and fruit from control vines. Remaining berry compositional analyses from 2006 of BS, LTS and Control fruit are in progress.

Alexander Valley site - Vine Water Status

To test the hypothesis that BS incidence is affected by vine water status, an irrigation trial was established in the Alexander Valley site in 2005. Extra emitters were added to selected vines to increase the application rate to 5 gph as compared to the grower standard rate of 0.5 gph. Leaf water potential was monitored weekly starting after veraison. Water was applied on 7 dates between 4 August and 15 September for either 6 or 8 hours. Vines selected to receive each irrigation treatment (standard or extra applied water volume) had BS or no BS (Control) the previous year resulting in 4 treatments: BS/standard volume; BS/extra volume; Control/standard volume; and Control/extra volume. Vine water status was significantly affected by the additional applied water, but there was no affect on incidence of BS or BSN in 2005.

In 2006, the trial was repeated on the same vines however the emitters in the standard water volume plots were removed and the holes plugged, thus the "standard" irrigation treatment became the "dry" treatment. Water was applied on 14 dates between 21 July and 30 September for 6 hours on 10 dates and 2, 4 or 8 hours on remaining dates. The irrigation treatments had a very small effect on vine water status and no statistically significant effect on the incidence of BS or BSN in 2006.

Xylem connection of berries to cluster

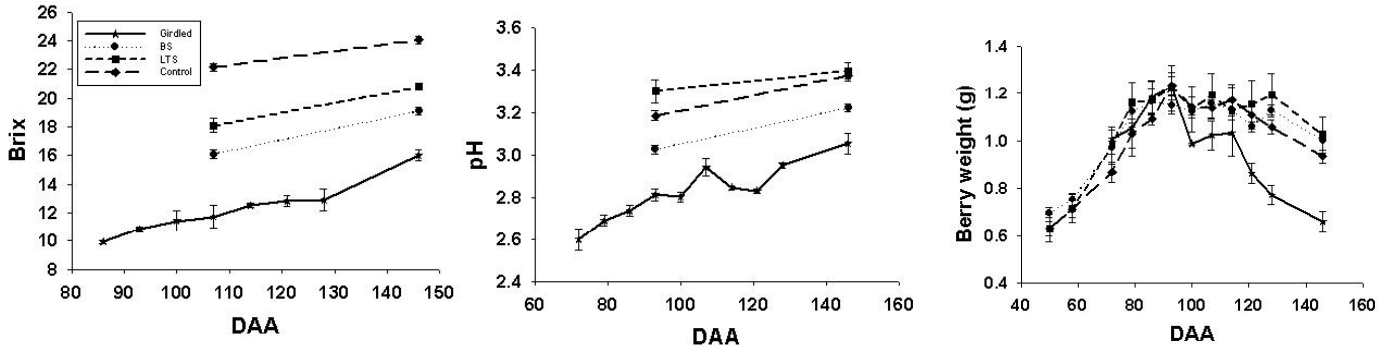
Under normal conditions, the xylem typically stops functioning at veraison and phloem becomes responsible for inflow into the berry. Because clusters with BS appear to lose water, dye uptake experiments were conducted in 2005 and 2006 to determine if the xylem in the pedicle between the berry and the rachis was different in BS berries as compared to berries on control vines. At veraison, single berries with pedicles attached were cut off the rachis of individual clusters on vines that were likely to shrivel and on vines that were not likely to shrivel. Pedicles were immersed in a dye for several hours, and then berries were cut longitudinally to determine if the dye had infiltrated the central vasculature. Results in each year were similar (Table 1). Dye uptake by the xylem was minimal or non-existent in both types of berries. This indicates that beginning at veraison, the xylem stops functioning in berries from BS vines as well as those from control vines, i.e. water is not exiting the berries through the pedicle.

Table 1. Uptake of dye at veraison into berries sampled from vines that have a history of BS and control vines; 2005, 2006.

Berry Source	**# of berries into dye**		**# berries that took up dye**	
	2005	2006	2005	2006
Likely to Shrivel vine	17	15	2	0
Control vine	22	15	0	0

Testing phloem transport into berries by cane girdling

The hypothesis that BS is essentially a loss of phloem transport was tested at OEV and Davis vineyards in 2006 by cane girdling above and below clusters. Individual berries were tested over time for their biochemical composition and compared to BS and control berries. The following figures are of berry compositional analyses from post veraison girdling that was done 91 DAA (1 September). All compositional analyses have been completed for berries sampled from girdled clusters, whereas analyses for remaining berries are not complete. Thus, results from only two sample dates are presented in the figures for BS clusters, likely to shrivel clusters and berries from control vines. Fruit in girdled clusters was similar to that of BS fruit in that Brix and pH did not increase to levels obtained in the control fruit.



Recent Developments - observations on vines propagated from BS vines

In 2003, Jason Benz, UC Staff Research Associate at the OEV, collected budwood from 5 vines that had a history of BS and from 5 control vines. From each source vine, he made 2 field-budded vines using 101-14 rootings for a total of 20 vines. In 2006, shoot length (measured 26 May) and weight of 40 berries and total berry number (both determined at harvest on 27 October) were found for each of the 20 vines. In all parameters, it appears that the two sets of vines were different, however only the 40-berry weights per vine were significantly different ($p<0.05$) with berries from BS-sourced vines weighing less (data not shown). Brix was measured on 3 dates in October prior to harvest and fruit from BS-sourced vines had significantly less soluble solids (Table 2).

Table 2. Soluble solids from juice of fruit sampled from each of 10 vines for each wood source, at 3 sample dates in 2006[a]

Wood Source	Brix - 6 October	Brix - 11 October	Brix - 27 October
Vines with history of BS	19.05 ± 0.61 a	20.09 ± 0.63 a	21.74 ± 0.66 a
Vines with no history of BS	24.52 ± 0.24 b	25.51 ± 0.30 b	27.83 ± 0.35 b

[a]Berries were sampled and analyzed separately from each vine, thus each value is the mean of 10 vines. Different lower case letters in the same column indicate significant differences at $p<0.05$.

Although these preliminary observations are quite interesting and suggest that BS is graft transmissible, that has yet to be proven. It is possible that more than one causal agent or condition can trigger or contribute to BS. Environmental conditions are still "on the table" as playing a role. It can be argued that if a biotic factor was solely responsible for causing the disorder, then there ought to be a more uniform occurrence of BS in the North Coast and elsewhere. Future investigations must tease apart the array of factors that could contribute to the occurrence of this disorder.

Some next steps as funding permits:

1. Conduct girdling experiments to investigate phloem dysfunction on berry composition. Analyzing compositional differences in berries brought about by girdling at different times and comparing them to composition of likely to shrivel berries from clusters that eventually have BS can help to determine when – or if – a phloem dysfunction occurs in BS fruit.
2. Further investigate the role of phloem in BS by thinning crop loads on likely to shrivel vines and monitor BS incidence and severity.
3. Conduct grafting experiments to determine if BS symptoms appear in previously non-symptomatic vines and conversely, if no symptoms appear in previous symptomatic vines.
4. Foundation Plant Services will test BS and control vines using ELISA, PCR and herbaceous testing methods to determine disease status.
5. Isolate and identify potential fungal pathogens in the vascular tissue and bud chips taken from BS and healthy vines.

Summary

- Sugar accumulation stops in BS fruit about 2 weeks prior to visual symptoms.
- By harvest BS fruit has lower pH and skin anthocyanin content and greater tannin per berry than fruit from vines that do not have BS.
- As the season progresses, BS berries lose weight faster than control berries, thus are smaller by harvest.
- It is likely that BS impacts the entire vine and not only just those clusters with BS.
- Altering plant water status does not affect the incidence of BS.
- Preliminary results from cane girdling investigations in 2006 indicate that reduced pH rise and no appreciable rise in Brix in berries from clusters on girdled canes reflect a similar ripening pattern in BS berries. Cane girdling may be the best method to mimic the effect of BS in clusters and thus provide an opportunity to study the effects of phloem dysfunction on this disorder.
- It was observed that vines propagated from bud wood taken from vines with a history of BS had reduced sugar accumulation and berry weight as compared to those propagated from control vines.