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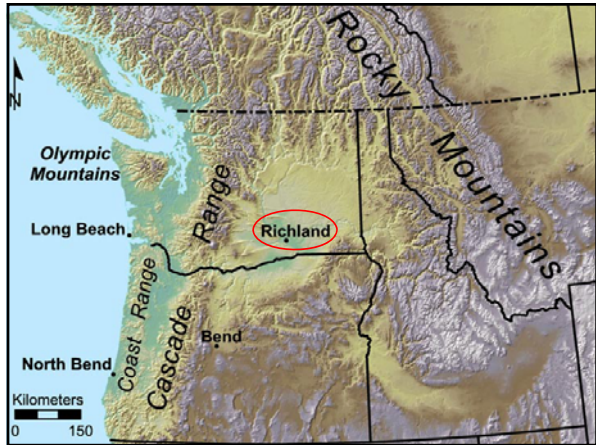
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### Washington AVA's

1. Yakima Valley - 1983
2. Walla Walla Valley - 1984
3. Columbia Valley - 1984
4. Puget Sound - 1995
5. Red Mountain - 2001
6. Columbia Gorge - 2004
7. Horse Heaven Hills - 2005
8. Wahluke Slope - 2006
9. Rattlesnake Hills - 2006
10. Snipes Mountain - 2009
11. Lake Chelan - 2009
12. Naches Height - 2011

Appellations and DOC's

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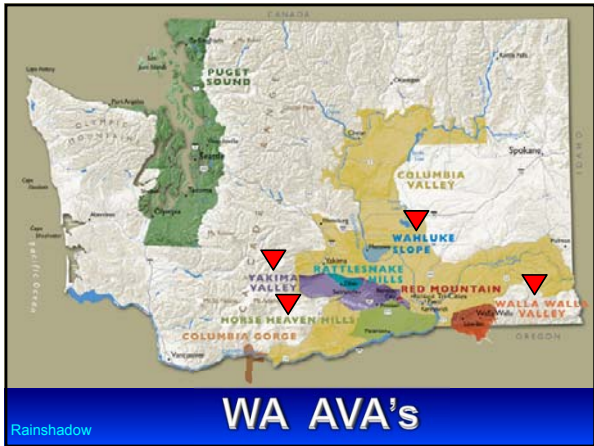
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### Washington Wine Facts

- National rank: **2<sup>nd</sup>**
- Number of Wineries: **740+**
- Annual cases produced: **12 million**
- Number of wine grape growers: **350+**
- Wine Grape Acreage: **> 40,000 acres**
- Total economic impact on WA state: **\$8.6 billion**
- Total economic impact on US economy: **\$14.9 b**

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### Most Important Grape Varieties

- **Red Varieties:** Merlot, Syrah, Cabernet Sauvignon, Cabernet Franc
- **White Varieties:** Viognier, Pinot Gris, Chardonnay, Riesling, Semillon, Sauvignon Blanc, Gewürztraminer

More than 30 different varieties are grown

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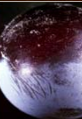

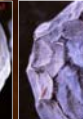
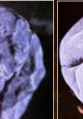

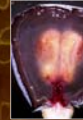

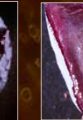
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### NOT ALL SHRIVELS ARE CREATED EQUAL

Healthy Sunburn Dehydration LBSN Berry Shrivel

Bondada and Keller 2012, American Journal of Plant Science 3: 1232-1240

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**Physico-chemical and morphological characteristics of different shrivels**

Shrivel type	Brix	Pedicle color	Berry shape
Sour shrivel	10	Green	Deflated ball
BSN (Water berry) (ESBN)	18	Brown	Shriveled (Raisin)
Dehydration	32	Green	Golf ball
Healthy	25	Green	Spherical

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### Fruit composition of berries afflicted with different ripening disorders

Table 2. Fruit composition of berries afflicted with different ripening disorders

	TSS (g/berry)	Glu + Fru (g/berry)	Tartaric acid (mg/berry)	Malic acid (mg/berry)	Ca (µg/berry)
H	0.28 c	0.25 c	4.63 c	0.91 bc	56.7 a
SB	0.20 b	0.18 b	3.08 b	0.46 a	53.1 a
PD	0.25 bc	0.22 c	3.09 b	0.97 c	100.9 b
LBSN	0.23 b	0.20 bc	1.21 a	0.56 ab	97.4 b
BS	0.05 a	0.04 a	4.60 c	0.44 a	51.8 a

H- Healthy, SB – Sunburn, PD- Prolonged Dehydration, and LBSN – Late-season Bunch Stem Necrosis berries.  
Means within a column followed by the same letter are not significantly different (P < 0.05).

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**SOUR Shrivel**

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**Ripening disorder**  
(initiates after veraison)

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**Flaccid Berries with poor sugar**

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**SOUR SHRIVEL?**

- SAD (Sugar Accumulation Disorder)  
(Mark Krasnow- Matthews Research Group, UC Davis)
- SOUR (Suppression of Uniform Ripening)  
(Bondada)

Italy ?  
Austria ?

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**Change in BS Nomenclature**

**SOUR Berry**

(Suppression of Uniform Ripening)

**BS = Sour taste**  
**Ripening disorder**

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**SOUR SHRIVEL –  
A GLOBAL CONCERN**

- USA
- BC
- Italy
- Austria
- Chile

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**CULTIVARS AFFECTED BY SOUR SHRIVEL**

**White varieties**

- Sauvignon Blanc
- Chardonnay
- Semillon
- Riesling

**Red varieties**

- Cabernet Sauvignon
- Merlot
- Petit Syrah
- Grenache
- Barbera

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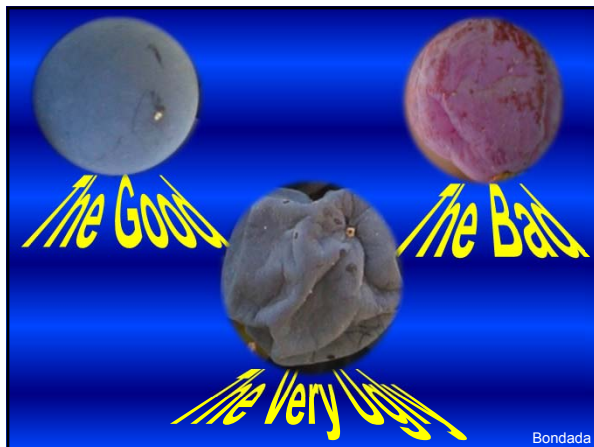
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**Table 1. Physical and compositional properties of berry shrivel and healthy 'Cabernet Sauvignon' grape berries.**

Berry type	Sugar content (mg/berry)	Berry fresh wt (g/fruit)	Berry vol (cm <sup>3</sup> )	Seed wt (mg/seed)
HB	269 c*	1.19 c	1.05 c	26 a
HAB	178 b	0.94 b	0.88 b	26 a
BS	53 a	0.41 a	0.39 a	25 a

\*Berry types include HB - Healthy berry from healthy cluster, HAB - Healthy appearing berry and BS - Berry shrivel berry from clusters afflicted with berry shrivel.  
 \*Means within a column followed by the same letter are not significantly different at P < 0.05.

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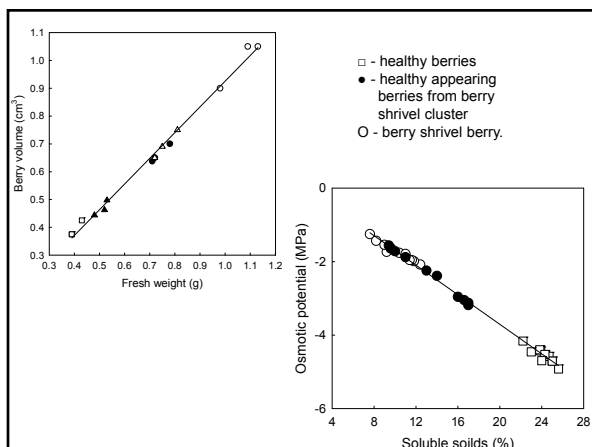
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**Fruit composition of berries afflicted with SOUR shrivel (Grenache)**

	Sugar (mg/berry)	Glu+Fru (mg/berry)	TA (g/L)	pH	K (mg/berry)
H	370 c	333 c	4.3 a	3.60 b	2.05 b
HBSS	310 b	279 b	4.8 b	3.54 b	1.98 b
SBSS	290 a	261 a	6.67 c	3.33 a	1.73 a

	Malic acid (mg / berry)	Tart Acid (mg / berry)	Tannins (mg / berry)	Total Anthocyanins (mg / berry)
H	1.32 c	8.81 b	0.49 b	0.94 b
HBSS	1.04 b	9.30 b	0.42 a	0.74 a
SBSS	0.24 a	12.9 a	0.55 c	0.69 a

H- Healthy, HBSS - Healthy berries of Sour Shrivel cluster, SS - Sour Shrivel berries  
 Means within a column followed by the same letter are not significantly different (P < 0.05).

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# Structural Analysis of SOUR Shrivel

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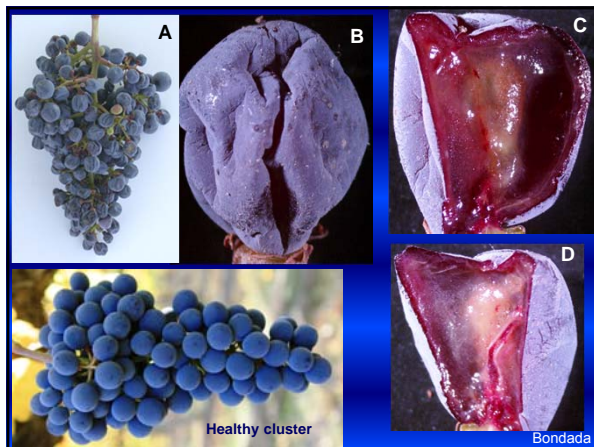
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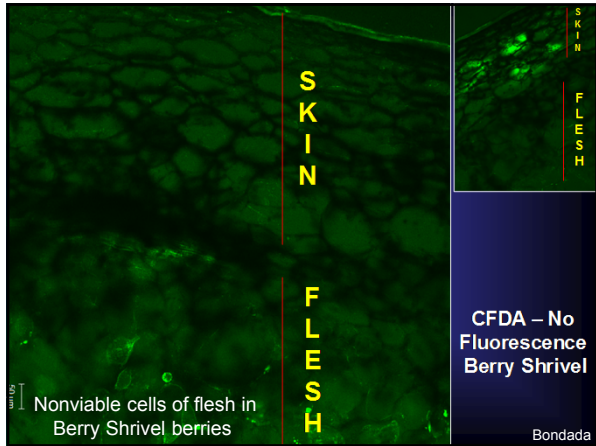
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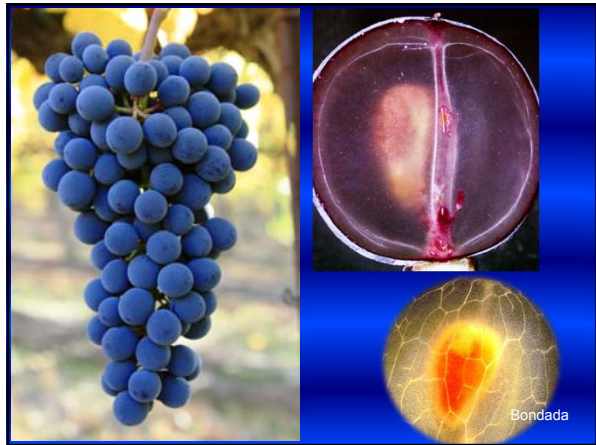
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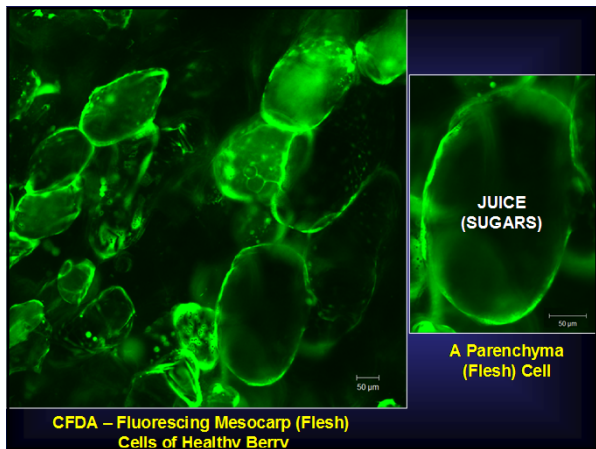
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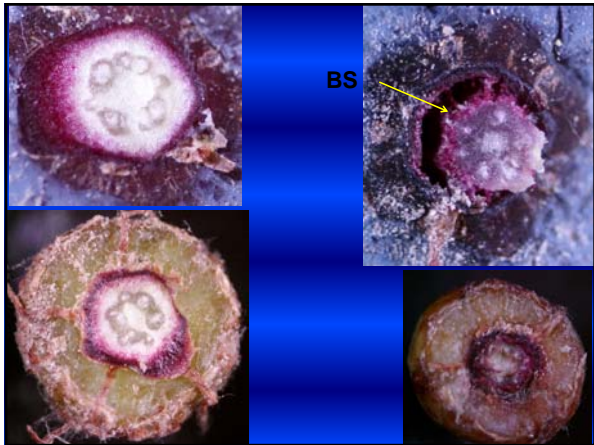
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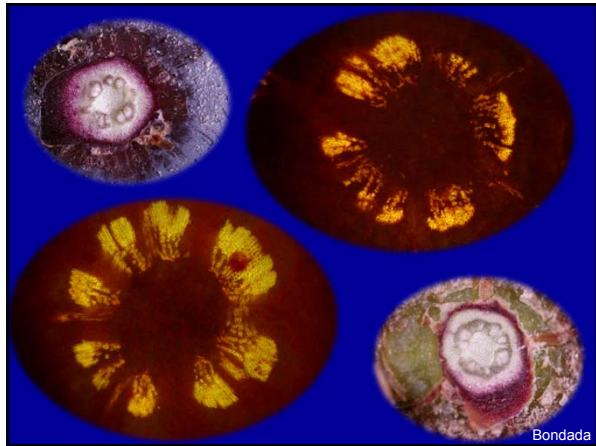
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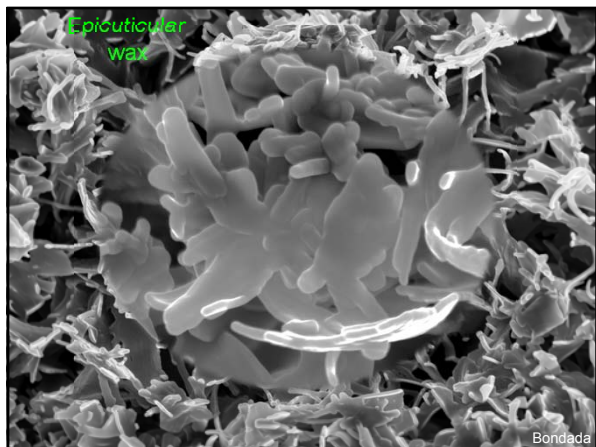
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### MORPHOLOGY OF SEED

Seeds of healthy berries from healthy cluster

Seeds of healthy berries from shriveled cluster

Seeds of shriveled berries

Germinating seed of shriveled berries

Raphe

Chalaza

Ventral view Dorsal view

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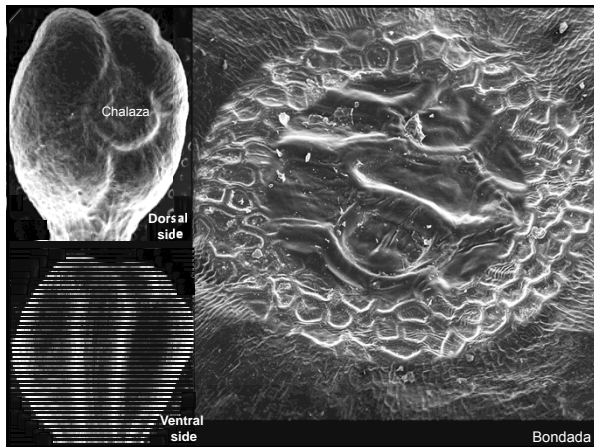
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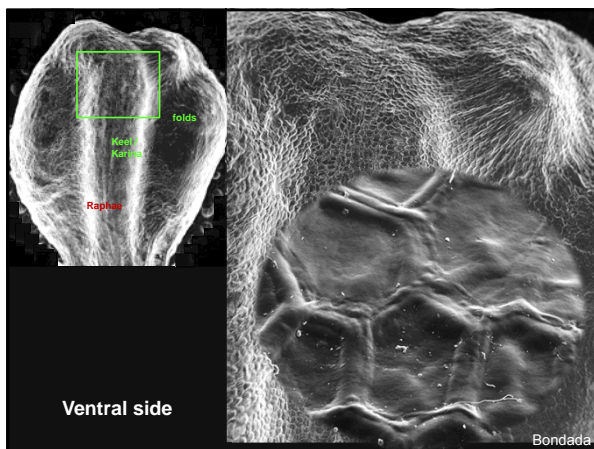
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# Differentiating SOUR Shrivel From BSN

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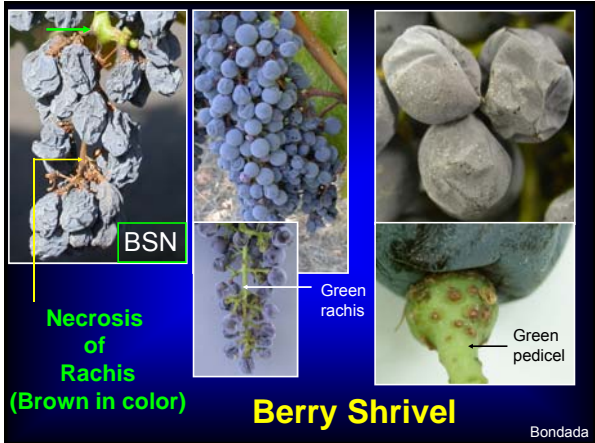
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## What are the causes of SOUR Shrivel?

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Pigmentation on the peduncle, rachis, and pedicel

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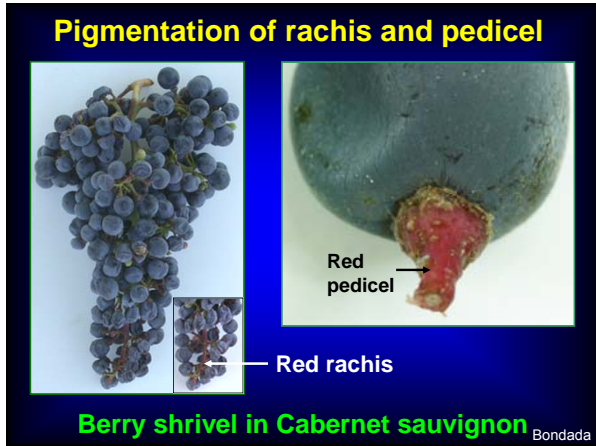
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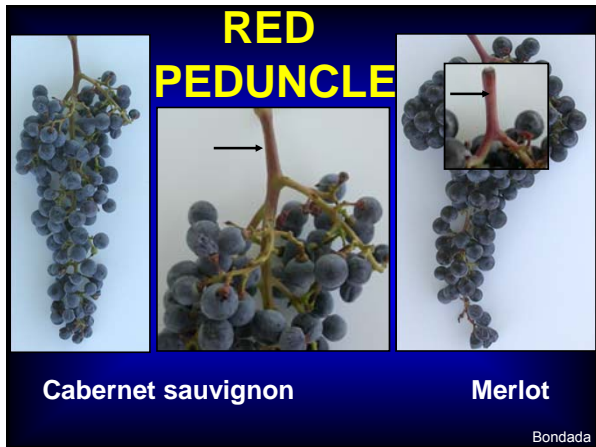
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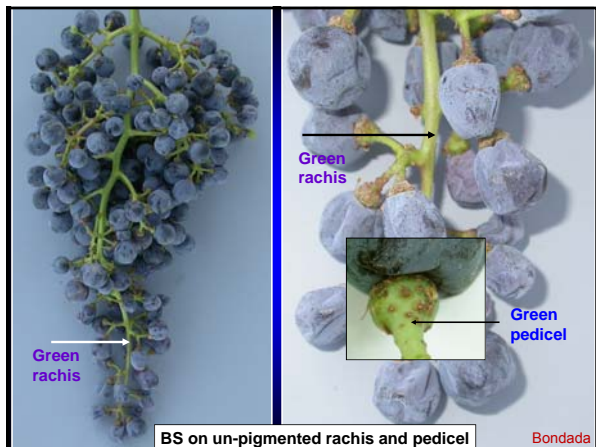
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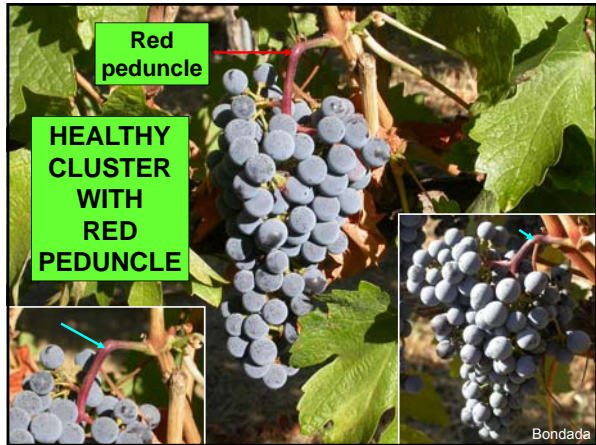
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**Pigmentation of rachis  
is not  
related to SOUR Shrivel**

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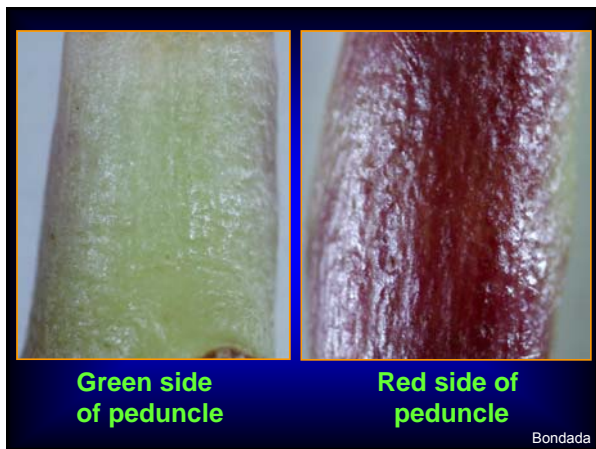
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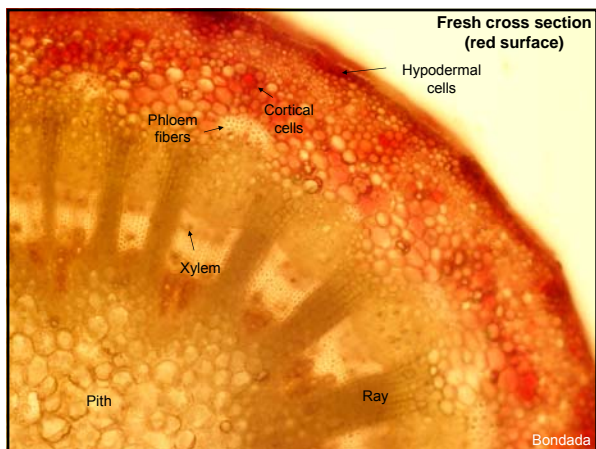
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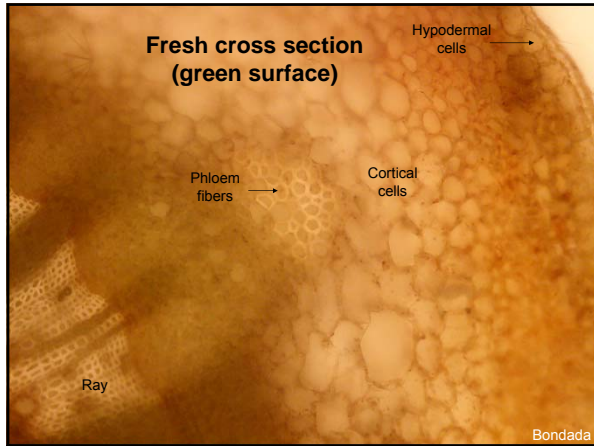
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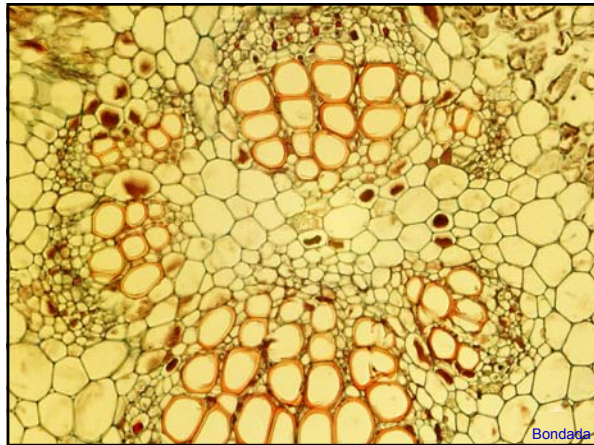
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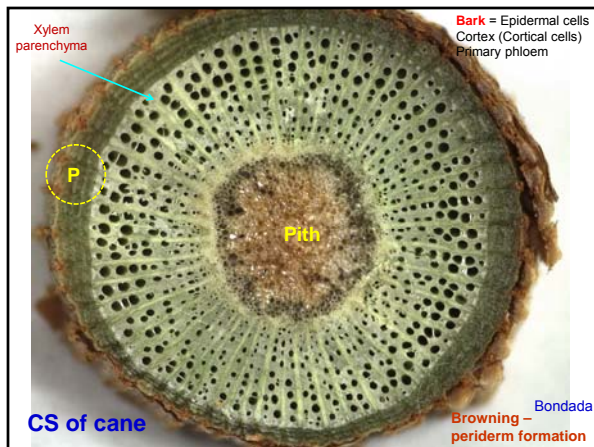
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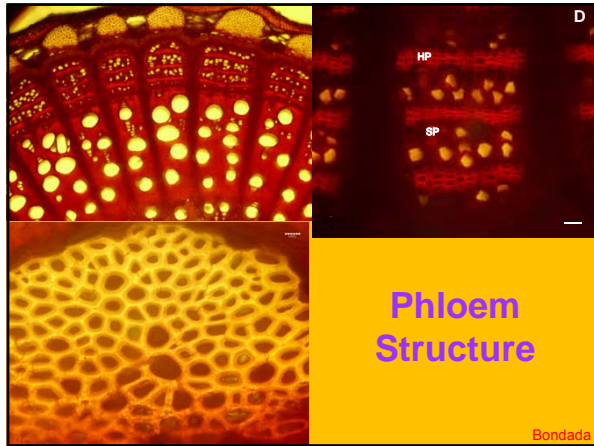
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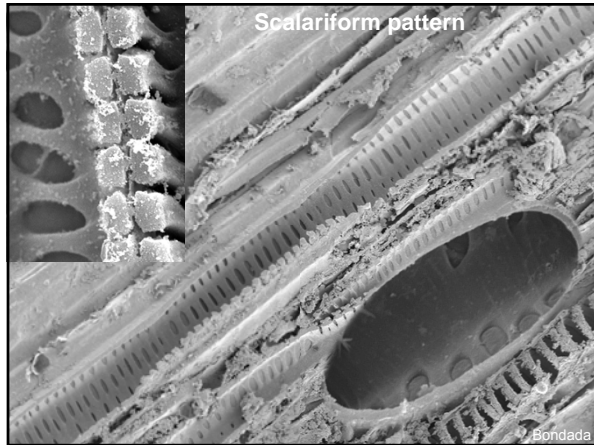
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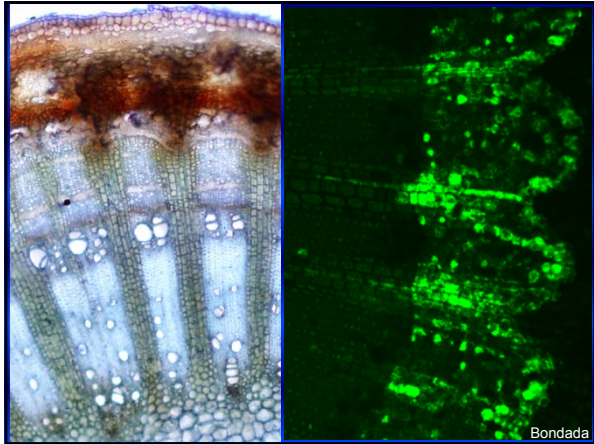
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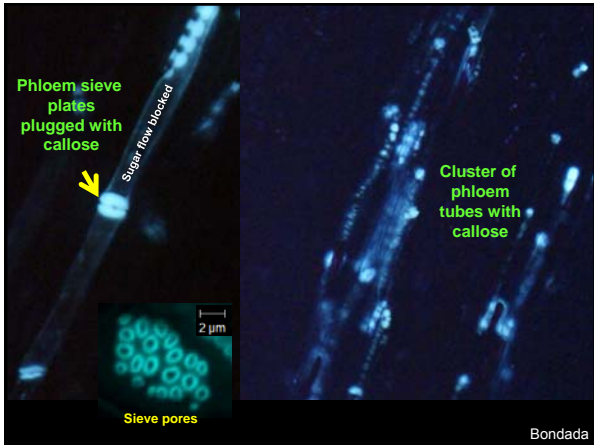
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### Proposed Causal Factors of SOUR Shivel

- Heavy crop load
- Water stress / Drought (Irrigation)
- Heat (Temperature)
- Soil potassium
- Vigor

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### Dealing with SOUR Shivel

The nebulous concepts about its causal factors make it difficult to formulate effective management strategies and deal with it.

One way to prevent the clusters with SOUR Shivel from reaching the wineries is to monitor clusters for symptoms of SOUR Shivel a few weeks before harvest in a vineyard that has a history of SOUR Shivel and discard affected clusters.

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