Sulfur Use for Disease Management in Vineyards and Potential for Residue at Harvest

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Sulfur Fungicide

- Elemental sulfur is one of the oldest fungicides and pesticides. "Dusting sulfur," elemental sulfur in powdered form, is a common fungicide for grapes, strawberry, many vegetables and several other crops. It has a good efficacy against a wide range of powdery mildew diseases as well as black spot.
- Dry flowable sulfur became a second standard in the 1980's
How does Sulfur kill Powdery Mildew

- The enzyme cytochrome c oxidase, or Complex IV, is a large transmembrane protein complex found in bacteria and the mitochondrion of fungi.
- It is the last enzyme in the respiratory electron transport chain of mitochondria.
- Sulfur binds to cytochrome c oxidase, thus competitively inhibiting the protein from functioning, which results in chemical asphyxiation of cells.
- It is thought that sulfur kills powdery mildew by the same mechanism (inhibition of the respiratory enzyme cytochrome c oxidase).

Why Sulfur?

- It was the first fungicide recognized
- It is still one of the best preventatives for powdery mildew control
- Dust applications give better coverage of entire vine – redistribution in the canopy
- No resistance detected to sulfur
- Combats resistance to synthetic fungicides
- Economical
- Relatively fast application
- It works!!
Sulfur Uses in Grape

- Powdery mildew
  - Preventive
  - Eradicant?
- Phomopsis
  - Preventive

History in California

- Used pretty much as a solo product for powdery mildew for over a hundred years
- In the 1970’s benzamidazole was introduced and the main product Benlate, had good activity against powdery mildew even though it was being used for Botrytis bunch rot (later product Topsis M)
- In 1982, the DMI fungicide Bayleton, was introduced into California for powdery mildew control in grapes
- In 1985, the indications of resistance to Bayleton
- In 1986, Full blown epidemic of powdery mildew and first documented detection of resistance
- Recommend sulfur be put back in control programs
History

- A few wine makers asked me to stop recommending sulfur
- No one had research data to say how much sulfur residue was on the berries vs how much it takes to cause higher H2S.
- One study used guessed residue but very levels were high
- Put a project together to look into this
  - Sulfur degradation trials
  - Fermentation trials

3 major questions for project

- What are typical and actual elemental sulfur residues on commercial grapes at harvest?
- How quickly does elemental sulfur degrade or volatilize during the growing season?
  - Can degradation be measured?
- At what residue levels does sulfur cause H2S in wine?
  - Are there interactions with yeast/nutrition?
Materials and Methods

- Cabernet Sauvignon and Pinot Noir
- Each site divided into 4 blocks
- Replications over vineyards
- All sites and blocks treated with Thiolute at 3.4-6 kg/ha at budbreak
- Cool wet weather resulted in 3 apps in 1990, 2 apps in 1989 til bloom
- DMI fungicides applied on an 18 day schedule
- Sulfur dust applied on a 7-10 day schedule at 10-15 lbs/a

M&M

- Sulfur residue was determined for 10 randomly selected grape clusters in each quadrant in 1989
- In 1990, clusters were collected from inner and outer regions at 3 points along the cordon
- Sulfur residue was determined the day after the final dust or df application and rated every two weeks until harvest
- Also in 1990, residues were determined in 16 additional vineyards to establish typical levels at harvest.
  - Each received alternating applications of Bayleton and sulfur dust
Changes in elemental sulfur residue on Pinot Noir berries, 1990, cut off date July 17

Changes in elemental sulfur residue on Pinot Noir berries, 1990, cut off date 7/13
The effect of canopy position on elemental sulfur residue, Cabernet Sauvignon

The effect of canopy position on elemental sulfur, Pinot Noir, 1990
Residues were determined in 16 additional vineyards to establish typical levels at harvest. Each received alternating applications of Bayleton and sulfur dust.

![Table 4. Summary of a 16 vineyard block survey of elemental sulfur residue measured at harvest.](image)

- Block number reflects the year of planting.
- All trellis systems were two-wire vertical unless otherwise stated.
- CS = Cabernet Sauvignon, CH = Chardonnay.
- Blocks harvested on 10-3 were on the valley floor, blocks harvested on 9-7 were on the hillside.
- *LSD = 0.6; p = 0.05.
Rutherford Cabernet Sauvignon
Sulfur Residue (ug S / g Berry)

Hand Leaf Removal 1.74
Machine Leaf Removal 1.71
No Leaf Removal 1.81

Sulfur Residue Survey Conclusions

- Residues were high only when wettable were used regularly late season (after June 10).
- Wettable used regularly before June 10 (Date 161) did not result in high residues.
- Wettable used once after June 10 did not result in high residues.
- Dust applied during the season did not result in high residues unless applied as COCS one month preharvest and two weeks following wettable application.
Manuscripts from Study


1992 Elemental Sulfur Experiments

Conclusions: Residue Threshold

1) 0 - 2 ug S / g Berry - No Significant H2S

2) 2 - 4 ug S / g Berry - Low H2S

3) > 4 ug S / g Berry - "Problem" H2S During Fermentation

Most Fermentations Were Not Problem Fermentations