RIPENING PERIOD
VINEYARD MANAGEMENT
OVERVIEW

- Background: the ripening process & the ripening period
- What can go wrong during ripening
- A preemptive ripening period management strategy
- Responsive management tactics for periods of high temperatures

THE RIPENING PROCESS & THE RIPENING PERIOD
WHAT IS RIPENING?

- The change of mature fruit from an unfavorable to favorable condition
  - Firmness
  - Texture
  - Color
  - Flavor
  - Aroma
- A senescence process under hormonal control
- Ripeness depends intended wine product

AND THE RIPENING PERIOD?

- The period between veraison & harvest
- When berries expand, soften, color, & become more palatable
- When berry damage susceptibility increases
- When stems become woody & winter hardy
- Lasts about 30 to 70 days depending on variety, weather, & intended wine product
RIPENING PERIOD EVENTS – BERRY WEIGHT

(Data from Coombe (1975) And figure from Hamilton and Coombe (1992)).

RIPENING PERIOD EVENTS – INCREASE IN SOLUTES

(Data from Coombe (1975) And figure from Hamilton and Coombe (1992)).
### RIPENING PERIOD EVENTS – SUGAR ACCUMULATION

- Light drives sugar accumulation
- There is an upper limit to light energy absorption; with too much light
  - The photosynthetic system is damaged
  - Toxic oxygen species inhibit repair
- Such damage, called *photosynthetic overload*, is a ripening period risk
- This risk is higher in California than in many other grape growing regions

(Data from Coombe (1975) and figure from Hamilton and Coombe (1992)).
Temperature also affects photosynthesis & sugar production
- Little photosynthesis occurs below 50°F
- Optimum ≈ 77°F to 86°F; variety dependent
- Sharply declines above 95°F
- In most of California, heat stress is ripening period reality & sometimes it is severe
- Also above 95°F, fruit quality is diminished
PHOTOSYNTHESIS
INHIBITING HEAT

Sunlit leaves may be 3.5 to 5.5° F warmer than shaded leaves

RIPENING PERIOD EVENTS – SUGAR ACCUMULATION

- Photosynthesis requires water to combine with CO₂ to produce sugars
- We purposely limit water availability using regulated deficit irrigation schedules
  - Providing many benefits, including increases water use efficiency for sugar production
- In addition, under drip irrigation the size of the soil water reservoir is limited
- There is water stress risk during ripening
Typical wetted soil volume of 4% to 13%, depending on drip emitter density
RIPENING PERIOD EVENTS – MINERAL NUTRIENT UPTAKE

- Potassium promotes sugar movement from leaves to fruit
- Under potassium deficiency
  - Sap flow is markedly reduced (even for well watered vines)
  - Sucrose becomes trapped in leaves
- With large crops, internal competition favors fruit, which may induce potassium deficiency
Vine water stress increases the risk of potassium deficiency
With high sunlight intensity, surplus electrons quickly induce leaf symptoms of deficiency
Maximum potassium demand in vines coincides with maximum evaporative demand
RIPENING PERIOD CONCERNS

- Normal grape ripening stresses
  - Crop stress – internal resource competition
  - Water stress – regulated deficit irrigation
- Common environmental stresses
  - Light
  - Heat

RIPENING PERIOD RISKS

- Risks begin at the molecular & organelle level in leaves & sometimes, berries
  - Protein denaturation & inactivation
  - Chlorophyll degradation – excess E, e\(^-\), O\(_2\)
  - Attachment of surplus electrons to oxygen
  - Membrane breakdown & containment loss
  - Reactive oxygen species toxicity
Subcellular risks become visibly manifest at the tissue level
- Premature senescence
- Discoloration
- Chlorosis
- Death

Risks have operational & economic consequences
- Impaired ripening & delayed harvest
- Diminished fruit quality
- Reduced fruit yields
- Decreased return on investment of time, water, nutrients, pesticides, labor, etc.

What follows is a more detailed look at the stresses associated with these risks
THE RIPENING PERIOD

WATER STRESS

SEVERE WATER STRESS – EARLY SIGNS
**LEAF COOLING**

- Grape leaf cooling mechanisms
  - Transpirational water vapor heat release
  - Reflection (i.e., re-radiation) of infrared
  - Convective cooling with moving air
  - Leaf lobing enhances convective cooling
- Transpiration alone is often sufficient to cool leaves to near air temperature

**WATER STRESS & LEAF TEMPERATURE**

- In response to water stress
  - Stoma begin to close
  - Transpiration decreases
  - Leaf temperatures rise above air temps
- Under severe water stress
  - Leaf tissue hydration is low
  - Leaf temperatures are high
  - Oxidative stress develops
  - Water stress symptoms become apparent
SEVERE WATER STRESS – PROLONGED

THE RIPENING PERIOD

HEAT STRESS
HEAT STRESS

- Clear skies, still air, & water stress increase the intensity of leaf heat
- At leaf temperatures near & above 104°F
  - Chlorophyll content markedly decreases
  - Photosynthesis abruptly declines
  - Especially a concern for sunlit leaves
- If leaf heat is not lost to the atmosphere
  - Harm to the photosynthetic apparatus escalates
  - Damage becomes significant & permanent
Even slow air can limit leaf heat damage
- Underscores the importance of careful vineyard design & canopy management
- Leaf lobing enhances heat transfer
SEVERE HEAT STRESS

- Vine responses to heat stress may lessen effects in surviving green tissues
  - Starch to sugar conversion
  - Calcium accumulation*
  - Amino acid production*
  - Protective protein synthesis
  - Volatile terpene emission
- Intact leaf tissues can recover within a few days of normal air temperatures

SEVERE HEAT STRESS

- Such responses redirect sugar away from ripening & towards leaves
  - Stem ripening may be more sensitive to heat than fruit ripening, but it appears to recover faster with normal temperatures
- Leaf tissue death cannot be overcome
Bad news:
- Berries have few stoma & low transpirational cooling capacities

Good news:
- Berries have a high temperature damage thresholds: $\geq 108^\circ F$
- Shaded berries temperatures are near ambient air temperatures

Sunlit berries may be $27^\circ F$ warmer than shaded berries
HEAT STRESS - BERRIES

- Vineyard design & canopy management can limit berry exposure & heat damage
- Cluster density also matters
  - Berries on dense, compact clusters heat more readily than those on loose clusters

HEAT STRESS - BERRIES

- Anthocyanin synthesis is inhibited at temperatures $\geq 95^\circ$ F
- At very high temperatures, anthocyanins are degrade due to oxidative stress
- Berry potassium normally increases with increasing temperature; pH may increase
HEAT STRESS - BERRIES

THE RIPENING PERIOD

THE SUNLIGHT FACTOR
WHAT ABOUT SUNLIGHT?

- UV radiation, in combination with high temperatures, damages leaves
  - Degrades chlorophyll
  - Discolors (purple, black, bronze) & kills tissues
- Damage symptoms are called *black leaf*
- They may or may not be associated with low potassium

LIGHT + HEAT DAMAGE
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- Leaf features that limit UV damage
  - Epicuticular wax reflects & scatters UV
  - Leaf hairs scatter & reduce UV adsorption
  - Phenolic compounds strongly adsorb UV & are strong antioxidants

LIGHT + HEAT DAMAGE

- More on phenolics
  - Their actions effectively filter out all UV, preventing transmission through leaves on canopy exteriors
  - Shoot tips & young leaf tissues have high phenolic concentrations
  - Phenolics are concentrated sun-exposed berry epidermal cells
  - Still, excess UV light + high temperatures will sunburn berries
LIGHT + HEAT DAMAGE

LIGHT + HEAT DAMAGE
As previously mentioned, ripening period potassium deficiency is common. Typical symptoms: faded chlorosis with small areas of dead tissues.
RIPENING PERIOD
POTASSIUM DEFICIENCY

RIPENING PERIOD
POTASSIUM DEFICIENCY
RIPENING PERIOD MANAGEMENT STRATEGY

Developing a preemptive approach

RIPENING PERIOD GOALS

- Promote fruit & stem ripening
- Encourage balanced mineral nutrition
- Control pests & diseases
- Avoid or at least, minimize stresses & tissue damage
RIPENING PERIOD CONCERNS

- Normal wine grape ripening stresses
  - Crop stress – internal resource competition
  - Water stress – regulated deficit irrigation
- Common environmental stresses
  - Heat
  - Light

RIPENING – SETTING THE STAGE

- Promote large, well aerated root zones
  - Deep cultivation, amending, fertilizing, & moisture management
- Enhance spring & autumn root flushes
  - Maximum uptake capacity & hormone production
  - Ensure ample phosphorus, calcium, boron
- Promptly develop complete canopies & protect them
RIPENING – MONITORING

- Visual vineyard monitoring - weekly
  - Follow an established protocol for observations & records

- Aerial vineyard monitoring - weekly
  - Target canopy NDVI $\geq 0.39$ (CVC scale)
  - Target canopy temperatures $\leq 95^\circ$ F
  - Water for changes in temperature & NDVI

![Image of vineyard monitoring results]
RIPENING – MONITORING

- Moisture monitoring
  - Soil moisture - daily
  - Vine water status - weekly
- Weather monitoring - daily
  - Watch for forecasts of maximum temperatures approaching 100° F

RIPENING – MOISTURE

- Maintain vines on the wetter side of moderate water stress
  - White varieties: -10 to -11 bars
  - Red varieties: -11 to -12 bars
- Maintain soil moisture within the range of moderate availability
  - 20 to 80 cbars
  - 18% to 50% available moisture
RIPENING – CANOPIES

- Promptly develop canopies
  - They ought to be complete near fruit set
  - 14 to 20 leaves per shoot with 2 clusters
- Thin shoots & position them, forming a single leaf layer veneer over fruit zones
  - Facilitating air movement
  - Limiting berry exposure to direct sunlight

RIPENING – CANOPIES

- Variety specific considerations
  - Those with entire leaves (i.e. no lobes) prone to over heating – Chardonnay & Malbec
  - Those with smooth leaves prone to UV damage – Grenache
- All varieties
  - Control leaf damaging pests
  - Avoid certain tissue penetrating adjuvants (e.g. MSO, COC, & others)
RIPENING – CROP

- Apply gibb to loosen compact, dense clusters & impede heat transfer
- Thin clusters to:
  - Minimize contact & heat transfer between adjacent clusters
  - Maximize cooling air flow around them

RIPENING – MINERAL NUTRIENTS

- Prior to veraison, promote adequate vine calcium essential for heat tolerance
- Collect & analyze leaf blades during veraison to check nutritional status at the onset of ripening
- Assure adequate P, K, Fe, Mn, Cu, & B required for ripening & antioxidants
- Apply low-rate K fertigations to promote photosynthesis under RDI
HEAT SPELL TACTICS - BEFORE

- Immediately before high temperatures, abandon regulated deficit irrigation (RDI)
  - Liberally apply water to hydrate vine tissues
  - Daily cycle through blocks (e.g. 3 8-hr sets/d) before & during heat spells
  - If appropriate, apply a soil surfactant to enhance water infiltration
HEAT SPELL TACTICS - BEFORE

- Stimulate antioxidant production & lessen stress
  - Focus on afternoon sun sides of canopies
  - Apply *Oxycom Calcium + diKap*
  - Apply amino acids*
  - Ensure adequate Ca, Fe, Mn, Zn, & B, perhaps applying as amino acid chelates

HEAT SPELL TACTICS - AFTER

- For a couple of days, irrigate to maintain soil & vine moisture before resuming RDI
- Also, apply CN-9 at low rates to:
  - Promote hormone production in roots & translocation to shoots
  - Delay senescence
  - Activate healthy leaf tissues
Next, apply available potassium to enhance sugar movement to the fruit
- KTS or 0-0-30
- K-Cellerate or Petrik K + FX + MoCob
Apply silicon (e.g. MainStay Calcium Si) to increase leaf uprightness & rigidity*

If needed, apply CN-9 at high rates to stimulate renewed shoot growth
RIPENING PERIOD VINEYARD MANAGEMENT

CONCLUSIONS

- Ripening period events affect
  - Fruit quality & yields
  - Return on management investments
- Elements of successful ripening management include:
  - Recognizing potential problems & formulating a strategy to address them
  - Monitoring for the onset stresses & quickly responding to them