Methods of Vineyard Frost Protection

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Cold/Freeze/Frost Injury

• Cold/winter injury: extreme winter temperatures cause injury to dormant vine buds, canes, cordons, trunks and/or roots.

• Freeze and frost injury: freeze or frost after budbreak causes injury to buds and/or young shoots
Acclimation and Deacclimation

Grapevines acclimate in response to decreasing day length and cooler temperatures:

- formation of outer bark (periderm) on shoots
- accumulation of carbohydrates in tissue
- leaf senescence
- tissue dehydration
Mitigating Cold Injury

- Cultivar selection
- Site selection
- Cultural practices
- Mounding soil
- Frost fans
- Heaters
Late Spring Freeze

- Partial to complete crop loss
- Reduction in fruit quality
## Frost Avoidance and Protection

<table>
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<th>Passive</th>
<th>Active</th>
</tr>
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<td>• Site selection</td>
<td>• Heaters</td>
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<td>• Cultivar selection</td>
<td>• Wind machines</td>
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<td>• Double/delayed pruning</td>
<td>• Helicopters</td>
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<td>• Floor management</td>
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<td>• Soil water management</td>
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<td>• Anti-transpirants</td>
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<tr>
<td>• Bactericides</td>
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<td>• Cryoprotectants</td>
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</table>
# Tissue Sensitivity to Cold

<table>
<thead>
<tr>
<th>Growth Stage</th>
<th>Critical Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swollen bud</td>
<td>&lt; 26°F</td>
</tr>
<tr>
<td>Budbreak</td>
<td>&lt; 30°F</td>
</tr>
<tr>
<td>&lt; 6” Shoots</td>
<td>&lt; 31°F</td>
</tr>
</tbody>
</table>
## Timing of Bud Break

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Time of Bud Burst (days)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chenin blanc, Chardonnay</td>
<td>0</td>
</tr>
<tr>
<td>Gewurztraminer, Viognier</td>
<td>1</td>
</tr>
<tr>
<td>Pinot gris, Pinot noir, Merlot</td>
<td>3</td>
</tr>
<tr>
<td>Petite Verdot, Tannat</td>
<td>5</td>
</tr>
<tr>
<td>Riesling, Cabernet Franc, Semillon</td>
<td>6</td>
</tr>
<tr>
<td>Grenache, Muscat Ottonel, Rousanne</td>
<td>7</td>
</tr>
<tr>
<td>Sauvignon blanc, Syrah, Tempranillo</td>
<td>8</td>
</tr>
<tr>
<td>Carignan, Marsanne</td>
<td>10</td>
</tr>
<tr>
<td>Cabernet Sauvignon, Mourvedre</td>
<td>14</td>
</tr>
</tbody>
</table>

*adopted and modified from ENTAV-INRA, 1995
Delayed/Double Pruning

Double pruning: rough prune to long spurs early and follow up after the danger of frost has passed or once basal buds begin to break.

- Larger vineyards may be limited by labor

5 - 10 bud spurs

2 bud spurs
Long Pruning

Rough pruning

Rough/Trash Pruning
Study #1 – Passive Freeze Protection

Impact of delayed pruning on fruitfulness

• Timing:
  – Bud break
  – 3 weeks post-bud break
Impact of Delayed Pruning on Fruitfulness

From: Labay, 2018
Inflorescence

Pea-sized cluster
Anti-transpirants

Dormant applications of vegetable and mineral oil have shown to delay budbreak (2 to 19 days) in some grape cultivars.

• Results varied by:
  – Cultivar
  – Application timing
  – Rate

8% v/v soybean oil + 1% v/v spreader sticker @ 100 gal/acre

(Dami 2007, Proceedings of Understanding and Preventing Freeze Damage in Vineyards Workshop)
Study #2 – Passive Freeze Protection

Ethephon sprays to delay bud break

- 2 rates
- 3 timings
  - November
  - January
  - February
- 3 locations
Impact of Ethephon on Bud break in ‘Sangiovese’
Impact of Ethephon on Bud break in ‘Sangiovese’

Bud break (Whole Vine)

Treatment

C  HD  HJ  HN  LD  LJ  LN

5  4  3  2  1  0
Cryoprotectants

Protect plants by lowering the freezing point of tissue or surface.

- Ethylene glycol
- Surfactants
- Potassium dextrolactate
  - ex. Glacier, Mega-Fol, Frost Guard

There is a general lack of compelling evidence of efficacy under field conditions.

Ice Nucleation Active Bacteria

• Certain species of bacteria initiate ice formation on the surface of plants.
  – Low populations observed on grapes compared to other crops. More likely to be present on ground cover.

• Copper sprays appear to be most effective in reducing INA bacteria populations.
## Floor & Soil Moisture Management

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Cooler</th>
<th>Warmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Texture</td>
<td>Sand</td>
<td>Loam</td>
</tr>
<tr>
<td>Soil Water</td>
<td>Dry</td>
<td>Moist</td>
</tr>
<tr>
<td>Row Middles</td>
<td>Tall vegetation</td>
<td>Low vegetation</td>
</tr>
<tr>
<td>Under Vine</td>
<td>Vegetation</td>
<td>Bare soil</td>
</tr>
</tbody>
</table>

- Moist soil retains heat better than dry soil.
- Tall vegetation insulates the soil from heat transfer and may reduce cold air drainage.
Advection Freeze

- Cold air mass moves into the region, low day and night temperatures
- Wind mixes air in lower layers of the atmosphere
Radiation Freeze

Heat

- 34°F
- 31°F
- 29°F
- 27°F
Sprinkler Frost Protection

- Limited by water availability
Sprinklers

As water freezes heat is released; heat is lost with evaporation. Need approximately 8 times as much freezing as evaporation to maintain positive heat balance.

• Must be turned on before critical temperature is reached and remain on until ambient temperatures are above critical
• Overhead vs under vine
Overhead Irrigation

- Application rate depends on sprinkler rotation rate, wind speed, and dew point.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>0 - 1.1 mph</th>
<th>2 - 3 mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>2,715</td>
<td>3,259</td>
</tr>
<tr>
<td>23</td>
<td>3,530</td>
<td>4,073</td>
</tr>
<tr>
<td>26</td>
<td>4,616</td>
<td>5,430</td>
</tr>
</tbody>
</table>

Adopted from: Synder 2000, Principles of Frost Protection

Pulsator microsprinklers – lower water volume (720–900 gph/acre)
Frost (Tower) Fan

- Blend warm air at 30 to 50’ with cooler air near ground
- Gain 25 to 50% of thermal inversion strength
- Coverage: up to 10 to 12 acres
- Cost: $25,000 to $40,000 installed
- Gas, diesel, electric, propane, PTO

- 38°F
- 35°F
- 32°F
- 30°F
Helicopters

- Typically cost $700 to $1600 per hour
- May protect 25 to 60 acres
- Slow passes at 5 to 10mph or hovering
- Only effective under inversion conditions
Cold air flows downhill.
Cold Air Displacement Systems

- Low spots
- Gas, electric, PTO
- Suggested coverage: 10 acres

Images from: frostsolutions.com
Study #3 – Active Freeze Protection

Ground based frost fans (Shur Farms Cold Air Drain®)

• 2 vineyard sites in North Texas
• 6 temperature data loggers per site
• 2 years
Ground Fan

Positioned in cold air pocket where it blows colder, denser air up to allow warmer air to flow from higher elevations.
Ground Based Fan

Site 2 March 20

Site 2 March 21

Temperature (°F)

Distance from fan:
- 10 m
- 20 m
- 30 m
- 40 m
- 50 m

Fan on
Burning Hay Bales or Brush

- How effective? How much to burn?
- Time and cost to set out and clean up
Propane Heaters

- Stationary or tractor mounted
- Circulate hot air and modify moisture
- Coverage: variable up to 25 acres
Study #4 – Active Freeze Protection

Propane heaters
• 30,000 BTU
• 42/acre
• 22 temperature loggers
• Infrared imaging
Average Temperature During Freeze Event

Heater 1

Temperature (°F)

Mean Control Temp

Closest to farthest from heater

Heater 2

Temperature (°F)

Mean Control Temp

Closest to farthest from heater
Cost of Propane Heater System

- Heaters: $1,000-$1,500/acre
- Hardware: $2,500/acre
- Propane: $11.92/hr/acre (wholesale); $33.52/hr/acre (residential)

Breakeven yield @ $2,000/ton and 12 hours run time:

1.82 tons/acre to 1.95 tons/acre
Summary

• Active frost protection methods are more expensive, but offer protection after bud break and may also be used to mitigate winter injury.