Growing Grapes for White Wine Production: Do’s and Don’ts in the Vineyard

Markus Keller
Aroma, flavor: Volatiles for white wine

- **Norisoprenoids** (β-damascenone, β-ionone)
  - Mainly glycosides in skin (must be hydrolyzed to smell)
  - Accumulate during ripening (carotenoid breakdown)

- **Monoterpenes** (geraniol, linalool,…)
  - Mainly glycosides in skin, less in pulp
  - Accumulate mostly during ripening

- **Methoxypyrazines**
  - Volatiles in skin and seed, released upon crushing
  - Accumulate before veraison, then decline (mostly early)

- **Volatile thiols** (S-containing mercaptans)
  - Bound to glutathione or cysteine in skin, less in pulp
  - Accumulate during ripening (fatty acid breakdown)

- **C6 compounds** (hexenal, hexanal)
  - “Green-leaf” volatiles
  - Accumulate in crushed fruit/must (fatty acid breakdown)
Mouthfeel: Phenolics for white wine

- **Hydroxycinnamates → Volatile phenols**
  - Tartrate esters in pulp and skin
  - Accumulate early, then often decline
  - Astringent (tartrate esters) or bitter (ethanol esters)
  - Early and rapid oxidation (juice/must browning)

- **Flavonols**
  - Glycosides in skin (myricetin branch missing)
  - Accumulate throughout berry development
  - Bitter and/or astringent

- **Flavan-3-ols → Tannins**
  - Monomers in skin and seed
  - Accumulate through veraison
  - Bitter, late and slow oxidation

- **Tannins**
  - Oligo- and polymers in skin, seed, stem
  - Accumulate through veraison
  - May continue to polymerize during ripening
  - Astringent (bitter oligomers mostly in seeds)
• Water deficit before veraison → Small berries
• Berry size is determined early → It is difficult to manipulate after veraison
• Water deficit after veraison → Less sugar, berry shrinkage

Keller (2015)
Water deficit: It’s not just about berry size

- Water deficit $\rightarrow$ Small berries, low vigor
  - Open canopy, restricted shoot growth
  - High cluster sun-exposure
  - High light and high temperature
- Exposed berries are warm berries
Sun exposure: Light or heat?

- **Light** (>50% full sun) strongly increases flavonols, increases monoterpenes, hydroxycinnamates, and slightly skin tannins; reduces methoxypyrazines (early)

- **Temperature** below 68°F increases flavonols, above 95°F inhibits them (tissue temperature!)

- Temperature optimum for monoterpenes is 50-68°F, volatilization increases above 68°F

- High pre-veraison temperatures increase malate, tannins; reduce methoxypyrazines

- High post-veraison temperatures reduce malate, methoxypyrazines; increase K⁺ → pH!

Kolb et al. (2003)
Spayd et al. (2002)
Deficit irrigation for white wines

• Irrigation per se has little effect on white fruit composition, but water deficit leads to smaller, more open canopy, and smaller, warmer berries

• Sun-exposed white grapes have up to 8-fold higher flavonols and up to 4-fold higher flavan-3-ols (monomers, oligomers, polymers) than shaded berries

• More bitter and astringent phenolics → Wine quality?

• Mild water deficit increases β-damascenone, monoterpenes and volatile thiol precursors, reduces methoxypyrazines

• Moderate deficit reduces aroma potential

• Do: Impose mild water deficit

• Don’t: Impose severe water deficit
It depends…!

**Do:** Remove leaves early! Be careful on west/south side!
- Prebloom → Reduces cluster compactness, overcropping
- 2-4 weeks after fruit set → Enhances sun exposure

**Don’t:** Too much, too late (veraison or later) → Sunburn
Nitrogen (N): Moderation is a virtue

- More N → Higher yield, more lateral growth, denser canopy
- Growing shoot tips compete with fruit → Delayed ripening
- N increases malate and K⁺ → pH tends to increase
- N suppresses secondary metabolism → Lower phenolics
- N (and S) enhance aroma precursors (volatile thiols)

Keller et al. (2001, 2010)
High N increases disease susceptibility

<table>
<thead>
<tr>
<th>Soil N</th>
<th>Chardonnay</th>
<th>Cabernet S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 g/vine</td>
<td><img src="chart.png" alt="Bar chart" /></td>
<td><img src="chart.png" alt="Bar chart" /></td>
</tr>
<tr>
<td>3 g/vine</td>
<td><img src="chart.png" alt="Bar chart" /></td>
<td><img src="chart.png" alt="Bar chart" /></td>
</tr>
</tbody>
</table>

- **Do:** Apply moderate rates of N (<60 lbs/acre)
- **Don’t:** Allow N deficiency or excess
Potassium (K$^+$) and the pH conundrum

- K$^+$ may counter influence of organic acids (TA) by substituting for protons (H$^+$) in grapes → Juice pH
- Both TA and K$^+$ drive variation in juice pH
- Late harvest → TA (or if berries shrink), K$^+$ → pH
- Crop load → K$^+$ (phloem import) → pH
- Juice pH is not very responsive to soil K$^+$ (→ Malate)
- Ca$^{2+}$ and K$^+$ compete for root uptake: Soil pH, juice pH

![Graph showing relationships between solute concentrations and pH levels.](image)
Harvest time: Decisions, decisions

- Harvest date impacts wine style
- **Physiological maturity**: Seeds able to germinate
- **Water** increases then decreases → Concentration effect
- Natural **sugar** maximum at 23-25 °Brix
- **Tannins** polymerize but may bind to cell walls
- **Malate, methoxypyrazines** decline early, not much late
- **Terpenes** continue to accumulate late → Aroma potential
- …but so do some **volatile phenols** → Brett fodder?
- Some ‘fruity’ **ester** precursors decline → Fruit character?
- Danger: High **pH** → Microbial stability?

- **Do**: Ripen grapes to winery specifications (communication!)
Machine harvest: Bad for wine quality?

- Sensory differences to hand harvest are rare
- Quality effect depends on presence of MOG and time to processing, not harvest method
- “Pie and peas” (leafy, gamey, meaty flavors) from mix of green and overripe berries, leaves, shoots, sometimes insects (e.g. Asian ladybeetle)
- Machine (not hand) harvest + long-distance transport:
  → Continued metabolism → Flavor loss
  → Physical damage, maceration → Protein extraction
  → Juice protein concentration increases
  → Heat instability (haze formation) increases
  → Fining (bentonite) requirement increases
- Worse in warm temperatures
Summary: Vineyard practices for whites

**Do’s:**
- Apply mild water deficit (preveraison RDI)
- Remove leaves early, preferentially on east/north side
- Apply moderate rates of nitrogen
- Ripen (harvest) grapes according to winery specifications

**Don’ts:**
- Apply severe (or even moderate) water deficit
- Overexpose fruit, especially on west/south side
- Remove leaves late (veraison or later)
- Undercrop vines
- Apply very low or high rates of nitrogen
- Machine harvest and delay processing in warm weather