The Effects of Pre-bloom, Fruit Set and Veraison Leaf Removal on Yield, Composition and Wine Quality in the Okanagan Valley

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Canopy Management

- Trellis design
- Canopy structure
- Pruning
- Shoot thinning
- Shoot positioning
- Shoot tipping
- Leaf removal
- Fruit removal
- Fruit positioning
Shade Effect On Fruit Quality

Reduced:
- Phenolics (tannins, anthocyanins, etc…)
- Fruity/floral flavour and aroma (eg. monoterpenes)
- Sugar

Increased:
- Malic acid
- Disease incidence
- Herbaceous flavour and aroma
Benefits of Leaf Removal and Open Canopies

- Opens the fruiting zone
- Changes light quality and quantity
- Changes fruit temperature
- Increases air circulation reducing humidity
- Better spray penetration
- Quicker hand harvest
- Useful for leaf hopper control
- Changes fruit composition and quality
How Much Fruit Exposure

- Depends on goals and methods of exposure
- Open canopies provide dappled light
- Dappled light in fruiting zone promotes phenolic and some flavour development
- Optimum exposure levels and timing may be different for white and red grapes
1. Compositional Evaluation of Okanagan Pinot Noir and Chardonnay Grapes

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2) Okanagan University College, Kelowna, B.C., Canada
Study Design

- Chardonnay clone 76 - 40 vineyards
- Pinot noir clone 115 - 40 vineyards
- Two plots within each vineyard
- 5 vines (one panel) per plot
- Three consecutive years
Vine, Canopy and Fruit Environment

Vine size, canopy density and fruit environment
- cane / cordon
- circumference
- trunk circumference
- canopy height and width
- canopy volume
- hedging
- leaf removal
- cluster exposure
- canopy openness
- canopy surface area

Leaf quality
- leaf area
- leaf dry weight
- petiole dry weight
- leaf greenness
- leaf nitrogen content

Fruit and yield components
- crop load
- yield per vine
- clusters per vine
- average cluster weight
- berry fresh weight
- skin fresh weight
- skin dry : fresh ratio
Fruit Composition

Basic composition

- Soluble solids
- Titratable acidity
- pH

Aroma

- Aroma Volatiles (norisoprenoids (NIP))
- Glycosyl glucose (flavour potential)

Nitrogen

- Total nitrogen
- Yeast assimilable nitrogen content (YANC)
- Free Amino Nitrogen (FAN)
- Ammonium

Ions

- Inorganic ions (Potassium, Phosphate, Sodium, Calcium, etc…)
- Organic acids (tartrate, malate, citrate, isocitrate)
Yearly Differences in Total Norisoprenoid

Optimal temperature for NIP biosynthesis is 10 – 20 °C

Average Daily Temperature
Total Norisoprenoids vs Row Direction and Slope Aspect

- N/S: 100 ug/L (Eastern aspect) 80 ug/L (Western aspect)
- E/W: 60 ug/L (Eastern aspect) 60 ug/L (Western aspect)
- NE/SW: 40 ug/L (Eastern aspect) 40 ug/L (Western aspect)
- SE/NW: 30 ug/L (Eastern aspect) 30 ug/L (Western aspect)

Row direction:
- N/S
- E/W
- NE/SW
- SE/NW
Cluster Exposure Affects Norisoprenes

Cluster Exposure (%)

Leaf Removal

Leaf Removal

NIP (μg/L)

- Loliolide
- Damascenone
- Vomifoliol

Leaf Removal
Intense late-afternoon exposure. Clusters heat but ambient temperatures drop soon after the exposure ends.

Low-intensity late-morning exposure. Clusters stay cool until afternoon.
Low-intensity early-afternoon exposure. Helps keep clusters warm under high ambient temperatures.

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Experimental Design

2 Varieties
1) Cabernet Sauvignon
2) Merlot

4 Treatments X 4 Blocks
1) Sprawl and early tipping (early July)
2) Sprawl and late tipping (late July)
3) VSP and early tipping
4) VSP and late tipping

4 Sampling dates
1) Pre-veraison
2) Post-veraison
3) Commercial maturity
4) Extended maturation
Vine Measurements

• **Canopy dimensions:**
  - Height
  - Width
  - Shoot length
  - Shoot number
  - Lateral number
  - Lateral length

• **Crop:**
  - Clusters per vine
  - Cluster weight
  - Berry weight
  - Skin weight
  - Seed weight
  - Seed number

**Fruit zone light penetration:**
- Direct radiation
- Indirect radiation
- Canopy gaps
- Canopy area
Fruit Composition

- **Basic:**
  - Sugar
  - Total acidity
  - pH

- **Volatile:**
  - Pyrazines

- **Phenolics:**
  - Total phenolics
  - Flavanols
  - Tannins
  - Anthocyanins
% Open space in canopy and direct sun flecks in fruiting zone in Cabernet Sauvignon
Seed Tannin (% dry weight)
- Seed tannin was higher in sprawl canopies
- No difference between tipping treatments

Skin Tannin (% dry weight)
- Skin tannin was higher in merlot sprawl canopies
- No difference between tipping treatments
Cabernet Sauvignon IBMP content

![Graph showing IBMP concentration over sample dates for different treatments.](image-url)
Merlot IBMP Development

IBMP (Early - Late Tip)

<table>
<thead>
<tr>
<th>Harvest Date</th>
<th>Early Tip</th>
<th>Late Tip</th>
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</thead>
<tbody>
<tr>
<td>Sept 2/2008</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>Oct 07/2008</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>Oct 30/2008</td>
<td>15</td>
<td>10</td>
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</tbody>
</table>
3. The Economics and Quality Impacts of Leaf Removal, Cluster Positioning and Shoot Positioning

K. Usher, T. Lowery, P. Bowen, C. Bogdanoff, D. Gregory, J. Drover

Investigate fruiting zone canopy management and its impact on fruit quality/maturity and evaluate the economics of leaf removal in commercial vineyards.

1) Survey the industry to evaluate the current leaf removal practices including timing, level of exposure and the goal(s) that growers expect to achieve.

2) Determine the economics of early season leaf removal using cost/benefit analysis.

3) Investigate the impacts of leaf removal timing and severity on grape production for improved quality.

4) Use non destructive cluster positioning and shoot positioning to alter fruit exposure level and determine the effects on quality and physical characteristics of the fruit.
Timing of Leaf Removal

**Pre bloom** (physical and chemical changes)
- Reduces Yield – lighter and looser clusters, smaller berries
- Increases sugar, phenolics, colour
- Increased quercetin (copigmentation)
- Lower seed mass and number

**Fruit set** (mainly chemical changes)
- Advanced ripening
- Acclimatize to sun exposure – sunburn
- Quercitin levels increase up to 10x (copigmentation)
- Tannin precursors decreased
- Reduce bunch rot and powdery mildew
- Reduce malate, TA and K⁺

**Veraison** (chemical but Less known)
- Little known
- Risk sunburn
Leaf Removal in the Okanagan

Level of exposure

• How much leaf removal?
• Cooler side of vine or both sides?
• Do site conditions, row direction and canopy structure matter?

Timing

• How does timing affect Okanagan grapes?
• Do the results match the goals?

Concerns

• Sunburn
• Hail damage after early season removal
• Economics – does it pay off?
  o Quality
  o Pesticide efficiency and disease reduction
  o Quicker harvesting
1) Survey the industry to evaluate the current leaf removal practices including timing, level of exposure and the goal(s) that growers expect to achieve.

**Survey Design**

- 53 growers participated, 51/53 did leaf removal.
- 10 questions about leaf removal: how, when, why, how much does it cost, etc....
- Survey followed up with a site visit to measure when and how leaf removal was done
Survey Summary

- 53 vineyard owners/managers surveyed
- 96% do leaf removal
- 87% hand, 13% mechanical,
- 33% do LR more than once in the season
- Estimated cost $160/acre (average for hand removal)

Reasons for doing leaf removal: RED WHITE
  Advance ripening 20% 23%
  Wine Quality 43% 35%
  Pest/disease control 37% 42%

How is LR applied:
  1 side only 47% 39%
  2 sides 53% 61%

Timing of LR:
  Bloom 6% 14%
  Fruit set 65% 61%
  Veraison 29% 25%
Impacts of leaf removal timing and severity on Syrah

Treatments
- No defoliation
- 4 Leaf pre-bloom
- 6 Leaf pre-bloom
- Fruit set leaf removal

Vineyard Measurements
- Temperature/humidity
- Light penetration to the fruiting zone
- Vigor assessments
- Return fruitfulness/winter hardiness
- Yield components

Basic Winemaking - Stopped after secondary fermentation, no oak or adjustments

Chemistry - Phenolics, fruit composition

Sensory - Judges selected from the industry winemakers
• 6 basal leaves removed pre-bloom

• 6 basal leaves pre-bloom, picture taken at fruit set
50% leaf removal at fruit set
No leaf removal (Control)
Prebloom Leaf removal reduces yield by reducing berries per cluster and cluster weight

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Year</th>
<th>Clusters per Vine</th>
<th>Cluster Weight (g)</th>
<th>Berries Per Cluster</th>
<th>Berry Weight (g)</th>
<th>Yield (kg/vine)</th>
<th>Yield (Tonnes/Acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Defoliation</td>
<td>2012</td>
<td>23.7 a</td>
<td>218.9 c</td>
<td>124.5 b</td>
<td>1.92 a</td>
<td>3.62 b</td>
<td>5.73 b</td>
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<tr>
<td>4 leaf PB</td>
<td>2012</td>
<td>24.0 a</td>
<td>186.3 ab</td>
<td>122.1 ab</td>
<td>1.77 a</td>
<td>3.52 b</td>
<td>5.52 b</td>
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<tr>
<td>6 leaf PB</td>
<td>2012</td>
<td>22.6 a</td>
<td>170.4 a</td>
<td>108.5 a</td>
<td>1.74 a</td>
<td>2.90 a</td>
<td><strong>4.40 a</strong></td>
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<tr>
<td>Fruit Set</td>
<td>2012</td>
<td>23.9 a</td>
<td>207.7 bc</td>
<td>115.4 ab</td>
<td>1.87 a</td>
<td>3.79 b</td>
<td>5.55 b</td>
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<tr>
<td>No Defoliation</td>
<td>2013</td>
<td>20.5 a</td>
<td>144.7 b</td>
<td>170.8 b</td>
<td>1.28 b</td>
<td>2.86 c</td>
<td>4.38 c</td>
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<tr>
<td>4 leaf PB</td>
<td>2013</td>
<td>19.4 a</td>
<td>111.7 a</td>
<td>95.5 a</td>
<td>1.14 ab</td>
<td>2.38 b</td>
<td><strong>3.47 b</strong></td>
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<tr>
<td>6 leaf PB</td>
<td>2013</td>
<td>19.9 a</td>
<td>86.0 a</td>
<td>87.0 a</td>
<td>0.93 a</td>
<td>1.92 a</td>
<td>2.76 a</td>
</tr>
<tr>
<td>Fruit Set</td>
<td>2013</td>
<td>18.8 a</td>
<td>131.1 b</td>
<td>146.5 b</td>
<td>1.29 b</td>
<td>2.79 c</td>
<td>3.96 c</td>
</tr>
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</table>

% Decrease

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2012</th>
<th>2013</th>
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</thead>
<tbody>
<tr>
<td>6 leaf PB</td>
<td>33%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>13%</td>
<td>49%</td>
</tr>
<tr>
<td></td>
<td>9%</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>23%</td>
<td>37%</td>
</tr>
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</table>
Syrah Skin Anthocyanin Content

Treatments
- No defoliation
- 4 Leaf pre-bloom
- 6 Leaf pre-bloom
- Fruit set leaf removal

mg/g dry skin

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Glucosides (Acylated)</th>
<th>Cinnamoyl derivatives</th>
<th>Glucosides (Non-acylated)</th>
<th>Total Anthocyanins</th>
</tr>
</thead>
<tbody>
<tr>
<td>No defoliation</td>
<td>2</td>
<td>5</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>4 Leaf pre-bloom</td>
<td>3</td>
<td>7</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>6 Leaf pre-bloom</td>
<td>4</td>
<td>8</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>Fruit set leaf removal</td>
<td>1</td>
<td>3</td>
<td>12</td>
<td>16</td>
</tr>
</tbody>
</table>
Syrah Wine Phenolics

A twofold increase in condensed tannins with the 6 leaf removal pre-bloom
Syrah Skin Quercetin

**Quercetin-3-galactoside**

**Quercetin-3-glucoside**

**Quercetin-3-glucuronide**

**Quercetin-3-galactoside**

**Quercetin-3-glucoside**

**Quercetin-3-glucuronide**
Quercetin Content

- **Quercetin-3-glucuronide**
- **Quercetin-3-glucoside**

**Graph 1:**
- No defoliation
- 4 leaf PB
- 6 leaf PB
- Fruit Set

**Graph 2:**
- No defoliation
- 4 leaf PB
- 6 leaf PB
- Fruit Set

mg/g dry skin

mg/kg berries
Timing of Leaf Removal

**Pre bloom** (physical and chemical changes)
- Reduces Yield – lighter and looser clusters, smaller berries
- Increases **phenolics**, **colour**
- Increased quercetin - stabilizes wine color
- Lower seed mass and number

**Fruit set** (mainly chemical changes)
- Advanced ripening
- Acclimatize to sun exposure – sunburn
- **Quercitin levels increase up to 10x** – polymeric pigment stability
- Tannin precursors decreased
- Reduce bunch rot and powdery mildew
- Reduce malate, TA and K⁺
- Reduced IBMP
- Increases aromatics (free and bound) e.g. terpenes

**Veraison** (chemical but Less known)
- Very little known – reduce veggie aroma and change aroma profile
- Risk sunburn
PARC Wine Grape Research Team

Tom Lowery
Entomology

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Plant Physiology

Dan O’Gorman
Plant Pathology

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Plant Pathology

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Phytochemistry

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Pest Pathology

Scott Smith
Soil Resources

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Nematology

Margaret Cliff
Sensory Analysis
Acknowledgements

- BC Wine Grape Council & AAFC
- Collaborating wineries and vineyards
- David Gregory, John Drover, Tom Kopp
3. Light management – Effects of Row Direction and Cluster Exposure in Merlot
Goals of Canopy Management

1. Advance maturity
2. Produce high quality fruit

What is the optimum light exposure pattern to achieve the highest quality: mature and desirable?

Row direction affects the timing of cluster and canopy exposure – does it affect maturation and quality?

**ROW DIRECTION X CLUSTER EXPOSURE**

We can’t do this with our resources!

Gain some insights by comparing treatment effects in blocks with contrasting row directions.
Light Management = Canopy Management

Goals:
- produce mature, high-quality fruit
- reduce/eliminate sunburn

- Fruit quality is affected by sun exposure
- Are effects consistent by row direction?

Compare exposure effects in contrasting row directions
Cluster Exposure Experiments

Variety – Merlot 346 on Riparia Gloire

2 experiments - contrasting row directions

Treatments:
- shaded clusters, each side of vines
- exposed clusters, each side of vines
  via shoot, cluster and leaf positioning

Wines – 3 treatments:
- exposed, each side of vines
- shaded
Mid-August Temperatures

Morning Sun

Ambient:
mean – 25°
min – 15°
max – 33°

Air
25°

NE
24°

Air
25°

NW
25°

Air
26°

SW
25°

Air
25°

Air
25°

SE
25°
Mid-September Temperatures

Ambient:
mean – 18
min – 6
max – 27
Yield, Pruning Mass and Fruit Maturation

Morning sun

- Afternoon: SW
- Morning: NE
- Air: 17°

Yield: 3.7 Kg/vine
Pruning mass: 430 g
September 10: 20.5 Brix
October 19: 25.3 Brix

Afternoon sun

- Afternoon: SE
- Morning: NW
- Air: 27°

Yield: 3.5 Kg/vine
Pruning mass: 450 g
September 10: 20.2 Brix
October 5: 25.5 Brix
Wine Quality

Morning sun

Afternoon sun

Morning:
- Most body
- Highest phenolics
- Highest anthocyanin
- Highest colour
- Least vegetative
- Lowest must TA
- Most fruity

Afternoon:
- Lowest phenolics
- Lowest anthocyanin
- Least vegetative
- Lowest must TA
- Low colour

Shaded:
- Most vegetative
- Lowest colour
- Least fruity

Shaded:
- More vegetative
- Low colour
- Least body