Factors affecting within orchard variability of nutrition, yield and quality of sweet cherry (Prunus avium L.)

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Financial Support

- Fluid Fertilizer Foundation
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- Okanagan-Kootenay Cherry Growers’ Association
- Agriculture and Agri-Food Canada Matching Investment Initiative (MII)
Summerland cherry cultivars

Sweetheart

Skeena

Cristalina

Staccato
BC production of sweet cherry

![Chart showing total value and price per kilogram over years]

- **Total value (K $1000)**: The value has increased significantly over time, with higher values in recent years.
- **Price per kilogram ($)**: The price has also increased, especially in recent years.

- **Year**: The data spans from 1900 to 2020.
Influence of weather on production

• production varies from year to year
• often due to weather in both pre-harvest and current year

Influence of weather on sweet cherry production

- **High production factors**
  - **Pre-harvest year**
    - Temp >19C Sept-early Oct
  - **Current year**
    - Temp >16C at bloom

- **Low production factors**
  - **Pre-harvest year**
    - High rainfall pre-harvest year (low temp. disease)
    - Low temp. -13 to -24C, Nov-Feb
  - **Current year**
    - Low temp. -2 to -5C at bloom
    - Precip. during fruit cell expansion and harvest
    - High temp. 33 to 37C during harvest

Risks associated with future crop water demand and supply

IPCC Fourth Assessment Report
Working Group II “Impacts, Adaptation and Vulnerability”
Chapter 3: Freshwater resources and their management

Box 3.1. Costs of climate change in Okanagan, Canada

High CO$_2$ Scenario

- High risk
- No risk

Lower CO$_2$ Scenario

- Water licence threshold
- Ecological supply threshold

Figure 3.7. Annual crop water demand and water supply for Trout Creek, Okanagan region, Canada, modelled for 1961 to 1990 (historic) and three 30-year time slices in the future. Each dot represents one year. Drought supply threshold is represented by the vertical line, maximum observed demand is shown as the horizontal line (Neilsen et al., 2004).

i-Button temperature sensor
(Dallas semi-conductor)
Kelowna Sweetheart Orchard
2006-2008

Kelowna, BC

30 Temperature Sensor
0.5m 2004 Ortho Photo

Scale 1 : 1 500
0 10 20 30 40 50 m
Biweekly (l,w,h) measurements (n=20)

May 4
May 20
May 31
June 16
June 29
July 13

Harvest - July 22
Harvest measurements (n=200, 2006-2008)

- Fruit N, P, Ca, Mg, K, B
- Mass, firmness, stem pull force, soluble solids content, TA, splits, color
2007-2008

- Trunk cross-sectional area (TCSA) 0.3m
- Yield estimate (2 limbs)
  - number of fruit/LCSA scaled to TCSA
Sap flow gauges track transpiration

Measures water movement up the xylem in response to
- Plant demand for C
- Atmospheric conditions
- Soil water availability
Monitoring set-up in orchard
Degree days above 5°C (DD5) at Summerland Weather Station (PARC), annually 1961-2008
Seasonal change in cherry volume, 2006, n=30.
Average seasonal change in cherry volume, 2006-2008
Seasonal variation in growing degree days above 5°C (GDD5), 2006-2008.
Spatial distribution of GDD5 along tree rows, 2006 & 2008

i-Button sensor location

GDD5
Within block variability

Coefficient of variation (CV) = (standard deviation/mean) x 100 as %

High (CV >25%)
- Tree yield, TCSA, % splits
- Leaf Zn, Mn

Medium (CV 5-25%)
- Most leaf and fruit nutrients

Low (CV <5%)
- Fruit firmness (durometer), SS
- GD5 accumulation at harvest, bloom
## Yield (kg/tree)

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean</th>
<th>Range</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>91a</td>
<td>(34-231)</td>
<td>52</td>
</tr>
<tr>
<td>2008</td>
<td>41b</td>
<td>(3-126)</td>
<td>75</td>
</tr>
</tbody>
</table>

unrelated to any measured parameter
Average minimum daily temperatures during the spring bloom period in 2008 relative to the 10% bud damage curve at Kelowna

![Graph showing average minimum daily temperatures during the spring bloom period in 2008 relative to the 10% bud damage curve at Kelowna.](image-url)
Comparison between development stage and day of the year in Kelowna orchard, 2007-2008
## TCSA (cm²)

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean</th>
<th>Range</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>113b</td>
<td>(60-166)</td>
<td>25</td>
</tr>
<tr>
<td>2008</td>
<td>141a</td>
<td>(68-221)</td>
<td>29</td>
</tr>
</tbody>
</table>
Relationship between TCSA and GDD5, 2008.

\[ R^2 = 0.32^{**} \]
Relationship between TCSA and Leaf K, 2008.

\[ R^2 = 0.56^{**} \]
## Leaf K (% dw)

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean</th>
<th>Range</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>2.11</td>
<td>(1.22-2.82)</td>
<td>16</td>
</tr>
<tr>
<td>2008</td>
<td>2.03</td>
<td>(1.53-2.92)</td>
<td>17</td>
</tr>
<tr>
<td>Recommended</td>
<td></td>
<td>(1.3-1.6)</td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{Leaf K (\% dw)} \]

\[ \text{Mehlich-3 extractable soil K (kg/ha)} \]

\[ R^2 = 0.03 \]
## Splits (%)

<table>
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<tr>
<th>Year</th>
<th>Mean</th>
<th>Range</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>7b</td>
<td>(1-17)</td>
<td>60</td>
</tr>
<tr>
<td>2007</td>
<td>36a</td>
<td>(8-72)</td>
<td>42</td>
</tr>
<tr>
<td>2008</td>
<td>4b</td>
<td>(0-16)</td>
<td>90</td>
</tr>
</tbody>
</table>

Correlated with Fruit K (20-30% variation)
Environmental factors and irrigation management affect transpiration and potentially growth, 2006

- Sap flow (transpiration) corresponds to PET early in the season
- Rainfall events reduce transpiration
- Day 182-199 stable ET – transpiration increased after irrigation

Sap flow (transpiration) matches PET early in season
Rainfall events reduce ET and sap flow
Just before harvest irrigation increases sap flow & potentially C accumulation
Summary (1)

- GDD5 varies among seasons
  - within block (year to year stability)

- Cherry size
  - smallest in warmest year immediately pre-harvest (*)
Summary (2)

- High orchard variability
  - Yield
    - no associated variable
    - spring frost (*)
  - TCSA
    - inversely with GDD5
    - positively with high leaf K
  - Splits
    - inversely with fruit K
Summary (3)

- Sapflow patterns
  - indicate irrigation limitations
  - suggest historical water stress

- Climate change?
  - >GDD5 >water stress on warmer sites, coarse soil
    - alter irrigation strategy (pulse irrigation)
Environmental limitations to sap flow (transpiration) in sweet cherry

- In well watered trees sap flow was reduced above 7mm/day calculated daily potential ET.
- Sap flow reduced above 35°C.
- High probability of water stress in cherries under these conditions regardless of irrigation strategy.
Thank you
Water management strategies (Sweetheart/Mazzard)

- Combined irrigation and precipitation met crop water demand (ET) 60% of the time in 2007 and about 90% in 2008.

- Large deficits occurred 4X during fruit cell expansion 2007, less so in 2008.

- Smaller, more frequent irrigation in 2008, probably resulted in lower drainage losses in this very coarse soil.