Evaluating Cultural Practices for Recovery from Cold Damage in Grapevines

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Outline

• Cold hardiness classes of grapevines
• Overview of freeze damage in Ohio
• Goal and objectives
• Study 1 : Cane quality for trunk renewal and recovery
• Study 2 : Training systems for trunk renewal and recovery
• Conclusions and recommendations
Cold Hardiness of Grape Genotypes

<table>
<thead>
<tr>
<th>Cold hardness class</th>
<th>Range of critical temp (LT50)</th>
<th>Species</th>
<th>Examples of varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very tender</td>
<td>5 to -5</td>
<td>Most V. vinifera</td>
<td>Merlot, Semillon, Syrah, Sauv. Blanc</td>
</tr>
<tr>
<td>Tender</td>
<td>0 to -8</td>
<td>V. vinifera</td>
<td>Chardonnay, Cab Sauv, Gewurztraminer, Pinot gris, Pinot noir</td>
</tr>
<tr>
<td>Moderately tender</td>
<td>-5 to -10</td>
<td>Some V. vinifera, some hybrids</td>
<td>Riesling, Cab. Franc, Lemberger, Chambourcin</td>
</tr>
<tr>
<td>Moderately hardy</td>
<td>-10 to -15</td>
<td>Most hybrids</td>
<td>Chardonel, Traminette, Norton, Seyval</td>
</tr>
<tr>
<td>Hardy</td>
<td>-15 to -20</td>
<td>Most V. labrusca</td>
<td>Catawba, Concord, Delaware</td>
</tr>
<tr>
<td>Very hardy</td>
<td>-20 to -30</td>
<td>Some hybrids</td>
<td>Frontenac, Foch, LaCrescent</td>
</tr>
</tbody>
</table>

2014 Polar Vortex: -4°F to -24°F

Genetic potential of the genotype (variety)

(Zabadal et al. 2007)
2014 Polar Vortex: -20°C (-4F) to -31°C (-24F)

Lowest Minimum Temperature, Jan - Feb (2014)

(Courtesy: MRCC)
Primary Bud Damage During 2014 Polar Vortex

23 Varieties

hybrids

Dead I bud

WOOSTER

Cultivars
Winter Damage in Ohio after 2014 Polar Vortex

American: 30%  
Hybrid: 60%  
Vinifera: 97%  
$12 Million crop loss  
(Dami & Lewis 2014)
Vine die-back in 2014: How to rehabilitate?

Issue: lack of research-based information on optimum vine recovery
2015 Min Temp: -20°C (-5°F) to -36°C (-33°F)

(Courtesy: MRCC)
Back to Back Winter Injury

Spring 2014

Spring 2015

Spring 2015

Spring 2015
Goal

Provide research-based information on how to mitigate freezing damage

Objectives

1) Evaluate the impact of **cane morphology** on freezing tolerance (FT) of bud and vascular tissues in relation to carbohydrate concentrations and anatomical structures of cold sensitive cultivars.

2) Evaluate several **training systems** for trunk renewal including cost, growth, yield, and fruit quality in three important cold sensitive cultivars in Ohio.

Determine best **cane size**, and **training system** to use following severe cold damage in cold tender cultivars.
Study 1: Cane morphology ‘Cabernet franc’

- Spring
- Summer
- Fall

Cane morphology:

- Normal: 7-9 mm
- Pencil: 8 mm
- Large: >12 mm
What is a “Bull Cane”? 

**Characteristics of “bull” shoot/cane**

- Rapid and vigorous growth
- Long internodes (5-6 inches)
- Large diameter (>1/2 inch)
- Flattened shape
- Poorly fruitful

‘Cabernet Franc’ Bull cane

*(E-Extension; Todaro & Dami, 2017)*
Vegetative growth characteristics

- Shoot length (summer)
- Lateral length (summer)
- Internode diameter (summer)
- Leaf area (Fall)
- Pruning weight (winter)
Freezing Tolerance
Bud & Cane Tissue Assessment

Live Buds

Dead I bud

Live Phloem

Phloem Injury

Determine LT50 = Lethal temperature to 50% of tissues
Carbohydrate analysis

C.E. machine

Freeze drier

Cryo-mill
Anatomy

Light microscopy

Electron microscopy
Results: Vegetative growth characteristics

A. Shoots/vine

B. Shoot length (cm)

C. Pruning weight/vine (kg)

D. Total laterals and Laterals >30 cm

(Todaro and Dami, 2017)
Freezing tolerance

(A) Primary bud LT50 (°C)
(B) Secondary bud LT50 (°C)
(C) Tertiary bud LT50 (°C)
(D) Phloem LT50 (°C)

(Todaro and Dami, 2017)
Carbohydrates

A Total sugars

B Glucose

C Fructose

D Sucrose

E Raffinose

F Stachyose

(Todaro and Dami, 2017)
Anatomy

Large cane (14mm Diam)  Normal cane (7mm Diam)

A

Surface area (mm²)

Large  Normal

Pith

Xylem

Phloem

B

VTU area (mm²)

Large  Normal

Xylem VTU

Phloem VTU

C

VTU number

Large  Normal

D

Number/VTU

Xylem Vessels  Phloem fibers

(Todaro and Dami, 2017)
Summary of Findings

Vegetative growth
- **Large canes**
  - longer, wider and heavier shoots
  - longer and more laterals

Anatomy
- **Large canes**
  - Larger and more numerous vascular structures

Freezing tolerance
- **Large canes**
  - Less cold hardy buds
  - Less cold hardy phloem

Recommendations:
- Remove large “bull” canes
- Retrain vines using normal sized canes (7-9 mm)
Study 2: Training Systems for Trunk Renewal

Hypotheses
Training system impacts vine recovery to pre-damage crop production

Objectives

1) Determine work hours required to implement
2) Evaluate vine growth, yield components, and fruit quality
3) Determine quality of renewed trunks
Data collection

1) Vegetative growth characteristics
   • Bud and shoot counts
   • Retraining time
   • VSP conversion time
   • Leaf area

2) Yield components
   • Cluster number
   • Crop wt.

3) Fruit composition
   • Total soluble solids (Brix)
   • pH
   • Titratable acidity

4) Trunk quality
   • Diameter
   • Crown gall incidence
Year 1: 2015

A. Fan

B. Bilateral training (VSP)

C. Fan-VSP

- Catch wires

Fruit wire

- Shoot

- New trunks (>4)

- New trunks (4)

- Graft union

- Soil

- 30"

- 4’
‘Cabernet franc’

4 June 2015

Fan

10 June 2015 (Before)

VSP

10 June 2015 (After)

Fan-VSP
Summer

29 July 2015

Fan

VSP

Fan-VSP
Initial retraining time in spring

![Graph showing initial retraining time in spring for Fan, VSP, and Combination (Fan-VSP). The chart indicates that VSP requires the most time, followed by the combination, and Fan requires the least time.](image-url)
2015 Yield components

Cabernet franc

Clusters / vine

<table>
<thead>
<tr>
<th></th>
<th>Fan</th>
<th>Fan-VSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A clusters / vine</td>
<td><img src="imageA" alt="Diagram" /></td>
<td><img src="imageB" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Clusters / vine

<table>
<thead>
<tr>
<th></th>
<th>Fan</th>
<th>Fan-VSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>B clusters / vine</td>
<td><img src="imageC" alt="Diagram" /></td>
<td><img src="imageD" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Yield / vine (kg)

<table>
<thead>
<tr>
<th></th>
<th>Fan</th>
<th>Fan-VSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>C yield / vine (kg)</td>
<td><img src="imageE" alt="Diagram" /></td>
<td><img src="imageF" alt="Diagram" /></td>
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</tbody>
</table>

Pinot gris

Yield / vine (kg)

<table>
<thead>
<tr>
<th></th>
<th>Fan</th>
<th>Fan-VSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>D yield / vine (kg)</td>
<td><img src="imageG" alt="Diagram" /></td>
<td><img src="imageH" alt="Diagram" /></td>
</tr>
</tbody>
</table>
2015 Fruit composition

**Cabernet franc**

- **A** Soluble solids (Brix) for Fan and Fan-VSP
- **C** pH for Fan and Fan-VSP
- **E** Titratable acidity (g/L) for Fan and Fan-VSP

**Pinot gris**

- **B** Soluble solids (Brix) for Fan and Fan-VSP
- **D** pH for Fan and Fan-VSP
- **F** Titratable acidity (g/L) for Fan and Fan-VSP
Late fall (2015)

12 December

Fan training

VSP

Combination (Fan-VSP)
Year 2: 2016

Before converting to VSP

Fan

VSP

Fan-VSP

After converting to VSP

VSP

F-2T2C

F-4T4C

VSP

VSP-4T4CS

F/VSP-4T4C

F/VSP-4T4CS

Pruning cut

* retained canes

● buds (fruitful)

(3-bud spur)
Before VSP conversion (yr 1: 2015)

Fan
- F-2T2C
- F-4T4C

F/VSP
- F/VSP-4T4C
- F/VSP-4T4CS

VSP
- VSP-4T4CS

After conversion to VSP (yr 2: 2016)

Pre-bud break → 3-6” shoot growth → Harvest → Leaf fall
Results: Labor

40% of vines required cordon replacement
Vegetative characteristics

SPOILER ALERT!!!!

SPOILER ALERT!!!!
Fruit composition

**Total soluble solids (Brix)**

- **Cabernet franc**
- **Pinot gris**
- **Pinot noir**

**pH**

- **Cabernet franc**
- **Pinot gris**
- **Pinot noir**

**Titratable acidity (g/L)**

- **Cabernet franc**
- **Pinot gris**
- **Pinot noir**
Leaf area : Yield ratio

(Kliewer and Dokoozlian, 2005)
Leaf area : Yield ratio

**Pinot gris**

- **Undercropped (over vigorous)**
- **Optimum (Balanced vine)**

Leaf area (m$^2$) : Yield (kg)

- F-2T2C
- F-4T4C
- F/VSP-4T4C
- F/VSP-4T4CS
- VSP-4T4CS

Overcropped
Leaf area : Yield ratio

Pinot noir

Leaf area (m) : Yield (kg)

- Optimum (Balanced vine)
- Undercropped (over vigorous)
- Overcropped

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Leaf area (m)</th>
<th>Yield (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-2T2C</td>
<td>2.2</td>
<td>2.6</td>
</tr>
<tr>
<td>F-4T4C</td>
<td>1.4</td>
<td>1.8</td>
</tr>
<tr>
<td>F/VSP-4T4C</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>F/VSP-4T4CS</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>VSP-4T4CS</td>
<td>0.4</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Note: Different letters (a, b, c, d) indicate significant differences at the 0.05 level.
Yield : Pruning weight ratio  (Crop Load)

Crop wt. (kg) : Pruning wt. (kg)

- Cabernet franc
- Pinot gris
- Pinot noir

F-2T2C  F-4T4C  F/VSP-4T4C  F/VSP-4T4CS  VSP-4T4CS

Optimum

Overcropped (over vigorous)

Undercropped

Legend:
- F-2T2C
- F-4T4C
- F/VSP-4T4C
- F/VSP-4T4CS
- VSP-4T4CS
Trunk (2-year old) quality:

- Cabernet franc
- Pinot gris
- Pinot noir

The graph shows the trunk diameter (mm) of different vines and variants, with trunk quality indicated by letters (a, b, c) for each group.
### Summary

#### Cabernet franc

<table>
<thead>
<tr>
<th>Var.</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Retraining (hrs/acre)</th>
<th>Yield (T/A)</th>
<th>TSS (Brix)</th>
<th>Leaf area: yield (m²/kg)</th>
<th>Yield : pruning wt. (kg/kg)</th>
<th>Trunk diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan</td>
<td>F-2T2C</td>
<td>55c</td>
<td>4.6c</td>
<td>20.6a</td>
<td>1.2a</td>
<td>6.6b</td>
<td>13.0c</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F-4T4C</td>
<td>69bc</td>
<td>5.5b</td>
<td>20.2a</td>
<td>1.1ab</td>
<td>7.4b</td>
<td>13.3c</td>
<td></td>
</tr>
<tr>
<td>Fan-VSP</td>
<td>F/VSP-4T4C</td>
<td>91a</td>
<td>4.7c</td>
<td>20.0ab</td>
<td>1.0b</td>
<td>8.7b</td>
<td>14.1b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F/VSP-4T4CS</td>
<td>91a</td>
<td>5.3b</td>
<td>19.6b</td>
<td>0.90b</td>
<td>10.7a</td>
<td>14.5b</td>
<td></td>
</tr>
<tr>
<td>VSP</td>
<td>VSP-4T4CS</td>
<td>99a</td>
<td>6.3a</td>
<td>18.8c</td>
<td>1.3a</td>
<td>12.1a</td>
<td>18.3a</td>
<td></td>
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</table>

#### Pinot gris

<table>
<thead>
<tr>
<th>Var.</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Retraining (hrs/acre)</th>
<th>Yield (T/A)</th>
<th>TSS (Brix)</th>
<th>Leaf area: yield (m²/kg)</th>
<th>Yield : pruning wt. (kg/kg)</th>
<th>Trunk diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan</td>
<td>F-2T2C</td>
<td>70c</td>
<td>4.5b</td>
<td>20.5a</td>
<td>1.2a</td>
<td>8.4b</td>
<td>11.0c</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F-4T4C</td>
<td>71c</td>
<td>4.8ab</td>
<td>20.1a</td>
<td>1.2a</td>
<td>7.4b</td>
<td>12.4b</td>
<td></td>
</tr>
<tr>
<td>Fan-VSP</td>
<td>F/VSP-4T4C</td>
<td>86b</td>
<td>5.1a</td>
<td>19.7ab</td>
<td>1ab</td>
<td>15.7a</td>
<td>11.7bc</td>
<td></td>
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<tr>
<td></td>
<td>F/VSP-4T4CS</td>
<td>93ab</td>
<td>5.3a</td>
<td>19.5b</td>
<td>0.85b</td>
<td>18.0a</td>
<td>12.2bc</td>
<td></td>
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<tr>
<td>VSP</td>
<td>VSP-4T4CS</td>
<td>103a</td>
<td>3.9c</td>
<td>18.3c</td>
<td>0.80b</td>
<td>16.7a</td>
<td>15.5a</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• Medium cane size is optimum with increased freezing tolerance.
• Training systems with high bud number have increased shoot number and yield but delayed fruit ripening.
• Fan/VSP training is not recommended!
• Optimum training system / pruning : Fan-4T4C
Practical application to growers

**Year 1:** Retain all shoots using fan system.

**Year 2:** When pruning, select normal cane [(7-9mm diameter) optimum for trunk renewal] and train using 4 trunks and 4 canes.
Acknowledgments

Advising mentors and experts
- Dr. Dami
- Dr. Cardina
- Dr. Scheerens

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- Dr. Blakeslee
- Dr. Channon

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- Tori Massaro, Bailey Miller
- Yvonne Woodworth, Andrew Kirk
Thank you for your time
MSU Extension would like your feedback!

Please visit
https://tinyurl.com/msufruitsurvey
to fill out the Fruit Team Survey!

The survey will close on
Dec 12th 5:00 PM EST.