Crown Gall Biology and Management

Tom Burr
Professor
Cornell University
Crown Gall on Grapevines

Specificity of *Agrobacterium vitis* on grape

Systemic colonization in grapevines

Infections are initiated at wound sites; freeze injuries, disbudding points, graft unions, etc.
Nursery and field, rootstocks and scion varieties

Vine vigor and yield are significantly reduced when 50% or greater of trunk circumference is covered with gall.

Schroth et al. 1988. Plant Disease
A. *vitis* Causes Necrosis on Grape

- Affects root development
- Facilitates survival of *A. vitis* in soil
- Inhibits graft take

**Grape necrosis**
Effects of *A. vitis* on Graft Unions of Grapevines

- Disease in grape nursery
- Water
- Tumorigenic strain
- Non-tumorigenic strain
Grape Crown Gall Disease Cycle

In spring, bacteria can be detected in the sap of bleeding vines.

Bacteria are disseminated in apparently healthy cuttings.

Parts of diseased vines become weakened and die.

Bacteria can cause necrotic lesions on roots and persist in vine debris in the soil when the vine is removed.

Galls develop at injuries or graft unions.

Freeze injuries are common sites for infection.

Bacteria survive systemically in xylem vessels throughout the dormant vine.
Current Management Practices

- **Cultivar choice.** Plant varieties and rootstocks that are tolerant of the disease.

- **Site Selection.** Plant vineyards on sites that have good air drainage and well drained soils to minimize freeze injury.

- **Hilling up.** Mounding soil over the graft union in the fall protects it from extreme cold events, and ensures survival of scion buds for trunk renewal.
Current Management Practices

- **Multiple trunks.** Establishing multiple trunks allows for removal and replacement of galled trunks while maintaining production.

- **Regular monitoring and replacement or renewal.** Evaluate trunk and vine health on a regular basis, mark and replace trunks and vines.

- **Cropping levels and fertility.** Manage cropping levels, irrigation and nutrition such that active vegetative growth slows by veraison.

- **Water management.** Prevention of vigorous growth late in season.
Relative Susceptibility of Grape Rootstocks to Crown Gall

Highly resistant; Paulsen 775, R. gloire

Resistant; 3309 C, 101-14 Mgt, Freedom, Harmony, Kober 5BB

Moderately susceptible; Teleki 5C, SO4,

Susceptible; Paulsen 1103

Highly susceptible; 110R, Ramsey, K5140

* Even highly resistant rootstocks may carry A. vitis internally (V. riparia – wild grapes)
Crown Gall Management

- Hot water treatments
  - 50 to 53 C for 30 min
    - Reduces >90% of pathogen in cuttings

- Treating galls with antibacterial compounds (Gallex, Cu, etc.)
  - A. vitis persists internally in vines
  - Biological control strain K84 does not control crown gall on grapes.
Improved Detection of *A. vitis*

Magnetic Capture Hybridization (MCH) allows precise detection of specific gall-forming types of *A. vitis*.

A capture probe was designed to selectively trap the target DNA sequence (*virD2 gene*) that is required for *A. vitis* to cause crown gall. Final identification by Real-time PCR.
Summary of MCH assay

The real-time PCR primers are specific for wide range of *A. vitis* strains (*virD2*).

3-4 days to complete assay compared to weeks for previous methods

Only strains that cause crown gall are detected.

Will detect as few as 10 cells per sample.
Use of MCH for detecting *A. vitis* in dormant cuttings

- Proper vine sampling procedure
  - Relative distribution of *A. vitis* in vines (canes)
  - Hypothesis: *pathogen at highest level near cane base and at nodes*
## Distribution of A. *vitis* in Canes

<table>
<thead>
<tr>
<th>Vine number</th>
<th>1N</th>
<th>1L</th>
<th>2N</th>
<th>2L</th>
<th>3N</th>
<th>3L</th>
<th>4N</th>
<th>4L</th>
<th>5N</th>
<th>5L</th>
<th>6N</th>
<th>6L</th>
<th>7N</th>
<th>7L</th>
<th>8N</th>
<th>8L</th>
<th>9N</th>
<th>9L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3A</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4A</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4B</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5A</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6A</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6B</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8A</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9A</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9B</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10A</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10B</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Collected from vines with crown gall
Can We Produce and Maintain A. *vitis* –free Grapevines for Commercial Production?

- Shoot tip and meristem culture as means to eliminate pathogens from plant material.
- How effective?
- Environmental sources of pathogen that may contaminate the clean plants?
Producing Clean Plants in Tissue Culture

2013 - shoot tips from cuttings taken in infected vineyard.
  – 22 of 58 positive

2014 – shoot tips from infected vines.
  – 0 of 49 positive

2015 – vines propagated from tips taken from cuttings collected from infected vines.
  
Thus far all in tissue culture are clean.
Where Does A. *vitis* Live in the Environment?

- **In Grapevines**
  - Cultivated and wild grapevines
  - Trunks, canes, roots, dormant buds

- **On Grapevines**
  - On surfaces of shoot tips and leaves

- **Others to investigate**
  - Water, soil, other plants
Wild Grape as Significant Source of Pathogen

Wild grapes, NY – *V. riparia*
- 2013 – 18 of 54 positive for *A. vitis*
- 2014 – 12 of 41 positive for *A. vitis*

Wild grapes, CA
- 2014-15 – 25 of 87 positive for *A. vitis*
Conclusions

A. *vitis* can be randomly distributed in dormant grape canes.

Vines free of the pathogen can be developed through tissue culture*.

– Preventing crown gall in the early years of a vineyard will reduce economic impact

Wild grapevines are a significant source of the pathogen in nature.
Conclusions

- Site selection and vine growth management are key considerations in disease management.
- Environmental sources of *A. vitis* will contribute to infection of vineyards.
- Biological control is being developed for reducing infections particularly at grafts and base of rooted cuttings.
Acknowledgements

Cornell University
Marc Fuchs, Plant Pathology & Plant Microbe Biology, NYSAES
Cherie Reid, Plant Pathology & Plant Microbe Biology, NYSAES
Desen Zheng, Plant Pathology & Plant Microbe Biology, NYSAES
Kameka Johnson, Plant Pathology & Plant Microbe Biology, NYSAES
Tim Martinson, Cornell Cooperative Extension

UC Davis Foundation Plant Services
Deborah Golino, Director Foundation Plant Services, UC Davis

NYS Department of Ag and Markets
Margaret Kelly, Assistant Director, Division of Plant Industry

NY Nursery Owners
Eric Amberg, Grafted Grapevines Nursery
Fred Merwarth, Hermann J. Wiemer Vineyards
Dennis Rak, Double A Vineyards

National Clean Plant Network
Erich Rudyj, USDA Aphis NCPN Coordinator
Rose Gergerich, NCPN Outreach Coordinator

Funding Support:
USDA-APHIS National Clean Plant Network, USDA Federal Capacity Funds, SCBG – USDA- NYSDAM, NYWGF.
“The value of virus-tested plant material”

Shadi S. Atallah, Assistant Professor
University of New Hampshire

March 24, 2016
Results based on:

- Economic Impact of Grapevine Leafroll Disease on *Vitis vinifera* cv. Cabernet franc in Finger Lakes Vineyards of New York


- And additional calculations based on the theory of economic risk.
Paper content also available:

As a 2-page report at:
https://grapesandwine.cals.cornell.edu/sites/grapesandwine.cals.cornell.edu/files/shared/Economics%20of%20Leafroll%20Viruses.pdf

and as a presentation at:
1. The leafroll study
Leafroll disease

Yield losses: 30-75%

Quality losses: prices paid for grapes, 10-70% lower

Healthy vine

Infected vine

Healthy

Infected

Photos: M. Fuchs 2011 and N. Rayapati 2012

Photos: P. Gugerli, 2009
Disease Control

- no control, roguing and replanting, or vineyard replacement
- based on a variety of factors but not on economic impact may not be profit-maximizing
Survey

• Survey of Finger Lakes vineyard managers (2009-2010)
Methodology

• Survey of vineyard managers (2009-2010)

• Scenarios:
  (1) baseline (i.e., no leafroll infection)
  (2) no disease control
  (3) leafroll prevention: virus-tested certified vines
  (4) roguing (removal and replanting)
  (5) vineyard replacement, and
  (6) late vector-mediated GLRD infection
Methodology

• Economic analysis: NPV
  – Financial tool: Net Present Value over 25 years
  – Cash flow

• Revenues:
  – Incorporate yield losses
  – Account for new replants’ unproductive period
  – Incorporates quality penalty

<table>
<thead>
<tr>
<th>Yr</th>
<th>Revenues</th>
<th>Costs</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>6097</td>
<td>(6097)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>10079</td>
<td>(10079)</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>839</td>
<td>(839)</td>
</tr>
<tr>
<td>3</td>
<td>5610</td>
<td>1526</td>
<td>4084</td>
</tr>
<tr>
<td>4</td>
<td>4488</td>
<td>3606</td>
<td>882</td>
</tr>
<tr>
<td>5</td>
<td>3927</td>
<td>2899</td>
<td>1028</td>
</tr>
<tr>
<td>6</td>
<td>3647</td>
<td>2744</td>
<td>903</td>
</tr>
<tr>
<td>7</td>
<td>3820</td>
<td>2629</td>
<td>1192</td>
</tr>
<tr>
<td>8</td>
<td>4712</td>
<td>2514</td>
<td>2199</td>
</tr>
<tr>
<td>9</td>
<td>5189</td>
<td>2514</td>
<td>2676</td>
</tr>
<tr>
<td>10</td>
<td>5436</td>
<td>2514</td>
<td>2922</td>
</tr>
<tr>
<td>11</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>12</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>13</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>14</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>15</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>16</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>17</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>18</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>19</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>20</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>21</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>22</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>23</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>24</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>25</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
</tbody>
</table>

NPV 6,671
Methodology

• Economic analysis: NPV
  – Financial tool: Net Present Value over 25 years
  – Cash flow

• Revenues:
  – Incorporate yield losses
  – Account for new replants’ unproductive period
  – Incorporates quality penalty

• Costs:
  – Add roguing and replanting cost

<table>
<thead>
<tr>
<th>Yr</th>
<th>Revenues</th>
<th>Costs</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>6097</td>
<td>(6097)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>10079</td>
<td>(10079)</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>839</td>
<td>(839)</td>
</tr>
<tr>
<td>3</td>
<td>5610</td>
<td>1526</td>
<td>4084</td>
</tr>
<tr>
<td>4</td>
<td>4488</td>
<td>3606</td>
<td>1028</td>
</tr>
<tr>
<td>5</td>
<td>3927</td>
<td>2899</td>
<td>903</td>
</tr>
<tr>
<td>6</td>
<td>3647</td>
<td>2744</td>
<td>1192</td>
</tr>
<tr>
<td>7</td>
<td>3820</td>
<td>2629</td>
<td>2199</td>
</tr>
<tr>
<td>8</td>
<td>4712</td>
<td>2514</td>
<td>2676</td>
</tr>
<tr>
<td>9</td>
<td>5189</td>
<td>2514</td>
<td>2922</td>
</tr>
<tr>
<td>10</td>
<td>5436</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>11</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>12</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>13</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>14</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>15</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>16</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>17</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>18</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>19</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>20</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>21</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>22</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>23</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>24</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>25</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
</tbody>
</table>

NPV 6,671
Methodology

• Economic analysis: NPV
  – Financial tool: Net Present Value over 25 years
  – Cash flow

• Revenues:
  – Incorporate yield losses
  – Account for new replants’ unproductive period
  – Incorporates quality penalty

• Costs:
  – Add roguing and replanting cost

<table>
<thead>
<tr>
<th>Yr</th>
<th>Revenues</th>
<th>Costs</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>6097</td>
<td>(6097)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>10079</td>
<td>(10079)</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>839</td>
<td>(839)</td>
</tr>
<tr>
<td>3</td>
<td>5610</td>
<td>1526</td>
<td>4084</td>
</tr>
<tr>
<td>4</td>
<td>4488</td>
<td>3606</td>
<td>1028</td>
</tr>
<tr>
<td>5</td>
<td>3927</td>
<td>2899</td>
<td>903</td>
</tr>
<tr>
<td>6</td>
<td>3647</td>
<td>2744</td>
<td>1192</td>
</tr>
<tr>
<td>7</td>
<td>3820</td>
<td>2629</td>
<td>2199</td>
</tr>
<tr>
<td>8</td>
<td>4712</td>
<td>2514</td>
<td>2676</td>
</tr>
<tr>
<td>9</td>
<td>5189</td>
<td>2514</td>
<td>2922</td>
</tr>
<tr>
<td>10</td>
<td>5436</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>11</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>12</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>13</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>14</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>15</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>16</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>17</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>18</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>19</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>20</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>21</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>22</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>23</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>24</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
<tr>
<td>25</td>
<td>5554</td>
<td>2514</td>
<td>3040</td>
</tr>
</tbody>
</table>

NPV 6,671
2. Assessing the value of virus-tested plant material: using this study and application of risk theory
• In order to assess the value of virus-tested plant material, we need to compare:
  1. Net revenues if a manager invests in virus-tested plant material and therefore does not introduce the virus with
  2. Net revenues if a manager does not invest in virus-tested plant material and runs the risk of introducing the virus
1. Net revenues, if a manager invests in virus-tested plant material and therefore does not introduce the virus:
   
   • Pay 25% premium on the base price;
   • That is, pay $0.815 premium on top of a $3.25 vine.
   • NPV (virus-tested vines, no disease) = $31,291 (table 5 in Atallah et al. 2012);
   • Assumes virus-tested=virus-free;
   • Assumes no infection through vectors from neighboring vineyard.
• In order to assess the value of virus-tested plant material, we need to compare:

1. Net revenues if a manager invests in virus-tested plant material and therefore does not introduce the virus

with

2. Net revenues if a manager does *not* invest in virus-tested plant material and runs the risk of introducing the virus
• We need to know:
  – Revenues if manager is *unlucky* and one of the vines used for replants has the virus; manager controls the disease through vine removal and replanting; NPV=$25,007
  – Revenues if manager is *lucky* and none of the vines have the virus and does not need to manage any disease: NPV=$33,122;
  – Risk that a vine might have the virus: we don’t have an estimate of this risk/probability.
Another way to understand that risk is to note that:

- Whether a manager decides to self-protect or not says something about what they believe that risk is, according to risk theory.

- Tell me if you self-protect or not, and I can tell you what assumption you are making on how big you think this risk is;
Certified vs. Non-certified vines

Manager A buys certified vines
Manager B buys non-certified vines

(1) Revenues A: known

(2) Expected revenues B = revenues (if virus) * (prob virus) + revenues (if no virus) * (prob no virus)

A manager who buys virus-tested certified vines believes that
- Revenues A > Revenues B

A manager who buys non-virus-tested certified vines believes that
- Revenues A < Revenues B

A manager who is indifferent between buying non-virus-tested and virus-tested vines believes that:
- Revenues A = Revenues B
Certified vs. Non-certified vines

Manager A buys certified vines
Manager B buys non-certified vines

Revenues A = $31,291

Expected revenues B = revenues (if virus) * (prob virus) + revenues (if no virus) * (prob no virus)

$25,007 ? $33,122 ?

Question: For what level of risk/probability is:
Revenues A = Expected revenues B?
Revenues A > Expected revenues B?
Revenues A < Expected revenues B?
Certified vs. Non-certified vines

Using the principle of risk theory, we can solve for the probability that justifies a manager’s action:

**Answer**: probability/risk virus = 20% if managers are risk-averse (and slightly higher if manager is risk-neutral).

*Interpretation*: a manager that does not self-protect through purchase of certified vines (manager B) must think that their probability of introducing the virus over 25 years through routine replants is less than 20%.
Certified vs. Non-certified vines

• A 20% risk over 25 years is equivalent to saying that:

• A manager that does not self-protect must think that their probability of introducing the virus in any single year is less than 1%.

• Making the (optimistic) assumption that the disease can only be introduced in any year by routine non-disease related vine replanting (3% or 60 vines per year in this analysis), as opposed to introduction also at the time of establishment;

• A manager that does not self-protect must think that their probability of introducing the virus in any single year, through any single grapevine that is being replanted is less than 0.01% or 1/10,000
Certified vs. Non-certified vines

- Probability of introducing the virus in any single year, through any single replant, is less than 0.01% or 1/10,000

- Is this high? Is this low probability?
- If low, how low is it? How low must manager B believe that risk to be?
- Let’s put this in perspective:
Manager B must believe that the risk of a procured vine being infected (1/10,000) is as low as the risk of being struck by lightning.
Certified vs. Non-certified vines

• If a manager believes that the probability of a replant having the disease is greater than the probability of being struck by lightening (manager A),

• Then s/he would self-protect by investing in virus-tested vines (we have assumed a premium of 25% in this analysis).
• Recall that what drives these numbers is the difference between:

1. Net revenues if a manager invests in virus-tested plant material and therefore does not introduce the virus

with

2. Net revenues if a manager does *not* invest in virus-tested plant material and runs the risk of introducing the virus

• Results are driven by the value of the resource at stake (recall that the analysis looks at wine production).
Main point

• Given what is at stake ($ losses), perceived risk must be unrealistically small for a manager to decide not to procure virus-tested vines.

• The grapevine is arguably one of the most valuable and critical inputs in the business of wine making and grape growing.

• Insuring it against risk is worthwhile (unless one believes being struck by lightening is more likely than getting an infected vine).
Thank you for opportunity to participate in this webinar.

Questions?

Shadi S. Atallah
shadi.atallah@unh.edu
603-862-3233