On the Economics of PVY
Christopher S. McIntosh
Potato Virus Y

- Previous studies have shown that PVY reduces potato yields.
- Tuber necrotic strains of PVY (PVYNNTN) can render harvested potatoes unmarketable due to PTNRD.
PVY as a Seed Borne Problem

- Planting infected seed leads to spread of PVY during the growing season
- Some varieties have only mild or latent foliar symptoms while in others the symptoms are readily observed.
- Losses of up to 80% have been reported from PVY
- Nolte, et al. reported yield loses of 1.75 cwt/acre for each percentage of PVY infection in Russet Burbank potatoes
Thus, we have a problem

PVY poses a threat for producers of both seed and commercial potatoes.

Here we will examine two aspects of this problem:

1. The per acre yield and income impacts due to known levels of PVY
2. The impacts that PVY has on the economy of the state of Idaho
Thus, we have a problem

PVY poses a threat for producers of both seed and commercial potatoes.

Here we will examine three aspects of this problem:

1. Infection levels present in seed stock and the relationship of emergence PVY to harvest PVY levels

2. The per acre yield and income impacts due to known levels of PVYO

3. The impacts that PVY has on the economy of the state of Idaho
PVY in Seed Stocks: An Examination of data from Montana, Wisconsin and Idaho

Christopher S. McIntosh, Boya Liu, and Gina Greenway
Seed Certification Data

As part of the SCRI PVY project, data were collected from a number of seed certification agencies

- Current season mosaic readings (either visual or ELISA)
- Winter grow-out readings (ELISA)

Data consistent enough for analysis were received from Wisconsin, Montana and Idaho/
Seed Certification Data

Wisconsin: 2003 – 2010
Montana: 2005 – 2010
Idaho 2009 – 2010

As many of the readings in these data are zeros, the data does not lend itself to statistical analysis. We will summarize the data by examining two events by variety.
Summary

First we summarize, by variety, the incidences when the *winter grow-out tests show a higher percentage of infection* than the summer tests.

Second, we summarize, by variety, the instances when the summer tests show *readings of less than two percent mosaic* while the winter grow-out tests indicate infection levels greater than two percent.
## Percentage of Winter Tests with Greater PVY Readings than Corresponding Summer Tests

<table>
<thead>
<tr>
<th>Variety</th>
<th>Wisconsin</th>
<th>Montana</th>
<th>Idaho</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alturus</td>
<td></td>
<td>16.0</td>
<td>50.0</td>
</tr>
<tr>
<td>Atlantic</td>
<td>60.8</td>
<td></td>
<td>66.7</td>
</tr>
<tr>
<td>Amisk</td>
<td></td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td>DR Norland</td>
<td>19.7</td>
<td>1.1</td>
<td>38.1</td>
</tr>
<tr>
<td>Goldrusher</td>
<td>64.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pike</td>
<td>57.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ranger Russet</td>
<td></td>
<td>10.8</td>
<td>62.7</td>
</tr>
<tr>
<td>Russet Burbank</td>
<td>76.7</td>
<td>11.4</td>
<td>51.7</td>
</tr>
<tr>
<td>Russet Norkotah</td>
<td>77.7</td>
<td>32.1</td>
<td>22.0</td>
</tr>
<tr>
<td>Shepody</td>
<td></td>
<td>45.2</td>
<td>67.9</td>
</tr>
<tr>
<td>Umatilla</td>
<td></td>
<td>11.1</td>
<td>19.2</td>
</tr>
<tr>
<td>Yukon Gold</td>
<td>41.4</td>
<td>6.3</td>
<td>46.2</td>
</tr>
</tbody>
</table>
Percentage of Winter Tests with Greater PVY Readings than Corresponding Summer Tests

Variety:
- Alturas
- Atlantic
- Amisk
- Dark Red Norland
- Goldrush
- Pike
- Ranger Russet
- Russet Burbank
- Russet Norkotah
- Shepody
- Umatilla
- Yukon Gold

Locations:
- Wisconsin
- Montana
- Idaho
## Percentage of Winter Tests with Greater than Two Percent PVY Corresponding to Summer Tests with less than Two Percent

<table>
<thead>
<tr>
<th>Variety</th>
<th>Wisconsin</th>
<th>Montana</th>
<th>Idaho</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alturus</td>
<td>5.0</td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td>Atlantic</td>
<td>7.4</td>
<td></td>
<td>22.0</td>
</tr>
<tr>
<td>Cal White</td>
<td>9.0</td>
<td></td>
<td>26.3</td>
</tr>
<tr>
<td>DR Norland</td>
<td>7.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goldrush</td>
<td>6.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pike</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ranger Russet</td>
<td>0.7</td>
<td></td>
<td>16.7</td>
</tr>
<tr>
<td>Russet Burbank</td>
<td>10.8</td>
<td>0.4</td>
<td>9.2</td>
</tr>
<tr>
<td>Russet Norkotah</td>
<td>21.8</td>
<td>8.0</td>
<td>6.4</td>
</tr>
<tr>
<td>Shepody</td>
<td>7.0</td>
<td></td>
<td>14.3</td>
</tr>
<tr>
<td>Yukon Gold</td>
<td>2.3</td>
<td></td>
<td>7.7</td>
</tr>
</tbody>
</table>
Percentage of Winter Tests with Greater than Two Percent PVY Corresponding to Summer Tests with less than Two Percent

Variety

- Alturas
- Atlantic
- Amisk
- Cal White
- Dark Red Norland
- Goldrush
- Pike
- Ranger Russet
- Russet Burbank
- Russet Norkorah
- Russet Norkorah 3
- Steptoe
- Snowden
- Superior

Percent

- Wisconsin
- Montana
- Idaho
Discussion

It is difficult to use summer test data to predict the amount of virus that would be found in the winter tests with any degree of confidence.

Varieties with high readings from more than one location:

- Alturus
- Atlantic
- Dark Red Norland
- Ranger Russet
- Russet Burbank
- Russet Norkotah
- Shepody
- Umatilla
- Yukon Gold
Discussion

The results indicate:

• A need to check winter test results for seed that you plan to purchase
• A need to have all testing done with ELISA or other laboratory method
• Planting PVY-free seed is the best PVY management tool
PVY at Emergence vs. PVY at Harvest:

Results based on Experimental Data from Idaho

Christopher S. McIntosh, Giri Raj Aryal Phillip Watson and Phil Nolte
Seed Borne PVY

Planting virus free seed remains the best option to minimize incidence of PVY.

The presence of several non-colonizing cereal aphids such as *R. maidis*, *R. padi*, and *S. graminum*, virtually insures the spread of PVY that is already present in a potato field.

Field experiments with two varieties Russet Burbank and Russet Norkotah.
Experimental Data

Data were generated in plots consisting of five treatments with four replications of each with the following target levels of PVY at emergence for years 2010 and 2011: treatment1 - 0%, treatment2 - 5%, treatment3 - 10%, treatment4 - 25%, and treatment5 - 50%.

For 2012 (RB Only): treatment1 - 0%, treatment2 - 5%, treatment3 - 10%, treatment4 - 30%,

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Field Experiment

- Seed lots with PVY Identified
- Tubers ELISA tested for PVY + or –
- After ELISA, healthy & PVY + kept separate
- Same storage facility and methods to avoid physiological aging issues
- At planting + and - seed pieces cut
- PVY - and PVY + blended at desired ratios
- Planted in commercial potato field
### Actual Levels at Emergence

Russet Burbank Emergence % PVY Measured by ELISA

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Target</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>4.4</td>
<td>12.0</td>
<td>6.9</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>10.2</td>
<td>13.8</td>
<td>10.8</td>
</tr>
<tr>
<td>3</td>
<td>10 (15)</td>
<td>16.3</td>
<td>13.1</td>
<td>17.2</td>
</tr>
<tr>
<td>4</td>
<td>25 (30)</td>
<td>30.2</td>
<td>30.9</td>
<td>30.5</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>51.3</td>
<td>49.7</td>
<td></td>
</tr>
</tbody>
</table>
### Actual Levels at Emergence

Russet Norkotah Emergence % PVY Measured by ELISA

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Target</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1.9</td>
<td>8.2</td>
<td>1.3</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>7.7</td>
<td>14.7</td>
<td>8.2</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>8.1</td>
<td>22.0</td>
<td>14.5</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>26.3</td>
<td>31.5</td>
<td>29.3</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>50</td>
<td>58.3</td>
<td>51.3</td>
</tr>
</tbody>
</table>
Russet Burbank

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R² = 0.946
Russet Norkotah

![Graph showing the relationship between EOS % PVY and Emergence % PVY for different years: 2010, 2011, and 2012. The graph includes linear trend lines for each year and an R² value of 0.936.](image-url)

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EOS PVY = f(Emergence PVY)

The relationship between end of season and emergence PVY is quite strong – even without data on aphid flights.

Russet Burbank:
2010 - 2012: \( EOS \ PVY = 1.51 + 1.09 \times BOS \ PVY \)
2011: \( EOS \ PVY = 11.93 + 1.29 \times BOS \ PVY \)

Russet Norkotah:
2010: \( EOS \ PVY = 11.51 + 1.10 \times BOS \ PVY \)
2011: \( EOS \ PVY = 59.21 + 0.73 \times BOS \ PVY \)
2012: \( EOS \ PVY = 3.11 + 1.10 \times BOS \ PVY \)
EOS PVY = f(Emergence PVY)

**Russet Burbank EOS PVY:**

<table>
<thead>
<tr>
<th>Emergence PVY</th>
<th>2010/2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.60</td>
<td>13.22</td>
</tr>
<tr>
<td>2</td>
<td>3.69</td>
<td>14.51</td>
</tr>
<tr>
<td>10</td>
<td>12.41</td>
<td>24.83</td>
</tr>
</tbody>
</table>

**Russet Norkotah EOS PVY:**

<table>
<thead>
<tr>
<th>Emergence PVY</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12.61</td>
<td>59.94</td>
<td>4.21</td>
</tr>
<tr>
<td>2</td>
<td>13.71</td>
<td>60.67</td>
<td>5.31</td>
</tr>
<tr>
<td>10</td>
<td>22.51</td>
<td>66.51</td>
<td>14.11</td>
</tr>
</tbody>
</table>
Yield Impacts

Totals for grade and size class were measured from harvested tubers.

Further analysis on the harvested plots was conducted to determine the yield and income impacts of differing disease levels.

All U.S. No. 1 and U.S. No. 2 less than 4 ounces were classified as washed process grade and valued at WPG prices. All others were sized and valued at both fresh and process market prices.
Russet Burbank

Under 4 oz  4-6 oz  6-10 oz  10-14 oz  >14 oz

< 10% PVY

> 10% PVY
Yield Impacts

Ordinary Least Squares (OLS) regression techniques were used to estimate * Marketable Yield* (total yield minus culls) as a function of *Percent PVY (End of Season)* and *Year*.

This is the approached used by Nolte, et al. (2004).
Russet Burbank

\[
y = -1.1741x + 5001.3
\]

\[
y = -1.1741x + 440.39
\]
Russet Norkotah

Marketable Yield (cwt/acre)

EOS PVY (%)

- $y = -1.1687x + 534.89$
- $y = -1.1687x + 505.36$
- $y = 1.0806x + 371.81$

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### Grower Returns by Size/Grade ($/cwt)

Prices based on 5 year averages

<table>
<thead>
<tr>
<th>Size/Grade</th>
<th>Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesh 5-lb</td>
<td>$6.32</td>
</tr>
<tr>
<td>Mesh 10-lb</td>
<td>$6.14</td>
</tr>
<tr>
<td>Film 5-lb</td>
<td>$6.79</td>
</tr>
<tr>
<td>Film 10-lb</td>
<td>$6.02</td>
</tr>
<tr>
<td>40-count</td>
<td>$20.41</td>
</tr>
<tr>
<td>50-count</td>
<td>$20.34</td>
</tr>
<tr>
<td>60-count</td>
<td>$20.31</td>
</tr>
<tr>
<td>70-count</td>
<td>$19.81</td>
</tr>
<tr>
<td>80-count</td>
<td>$16.89</td>
</tr>
<tr>
<td>90-count</td>
<td>$13.88</td>
</tr>
<tr>
<td>100-count</td>
<td>$12.55</td>
</tr>
<tr>
<td>U.S. No. 2 (6 oz min.)</td>
<td>$8.33</td>
</tr>
<tr>
<td>U.S. No. 2 (10 oz min.)</td>
<td>$12.69</td>
</tr>
</tbody>
</table>
Impacts on Marketable Yield

The marginal impact of a 1 percent level of PVY infection:

- Russet Norkotah
  - 1.169 cwt/acre (based on 2010 and 2012)

- Russet Burbank
  - 1.174 cwt/acre

Note that in both cases these results are statistically significant.
Dollar Impacts of PVY

The potatoes from the field experiments were evaluated using both a fresh-market and process-market in a way that accounts for the specific pack-out characteristics and changes caused by increasing levels of PVY.

**Fresh-Market**

A net-to-grower price was calculated using a five-year average of shipping point prices for the various sizes and grades of potatoes less estimated packing costs.
Dollar Impacts of PVY

Process-Market

The gross returns for processing potatoes were obtained by multiplying the total yield by the processing price computed using potato grade and quality incentives. In calculating the incentive-adjusted processing price, the quality incentives (penalties) are added (subtracted) to (from) the base price as determined at the time of contract between the growers and processors.
Dollar Impacts of PVY

**Russet Burbank – Fresh Market**
Each percent PVY infection = $5.13 to $18.06 per acre loss.

With a 10% level of infection you could expect to lose $115.93 per acre

**Russet Burbank – Processing Market**
Each percent PVY infection = $4.26 to $14.08 per acre loss.

With a 10% level of infection you could expect to lose $91.69 per acre
Dollar Impacts of PVY

Russet Norkotah – Fresh Market
Each percent PVY infection = $7.24 to $17.30 per acre loss.
With a 10% level of infection you could expect to lose $122.74 per acre

Russet Norkotah – Processing Market
Each percent PVY infection = $5.22 to $13.08 per acre loss.
With a 10% level of infection you could expect to lose $91.47 per acre
Dollar Impacts of PVY - RB

Fresh-Pack Price Gross Returns ($/acre)

EOS PVY(%)
Dollar Impacts of PVY - RB

Processing Priced Gross Returns ($/acre)

EOS PVY (%)

- 2010
- 2011
- 2012

Linear (2010/11)
Linear (2012)
Dollar Impacts of PVY - RN

Fresh-Pack Priced Gross Returns ($/acre)

EOS PVY (%)
Dollar Impacts of PVY - RN

Processing Priced Gross Returns ($/cwt)

EOS PVY (%)
Conclusions

• Seed that is positive for PVY has a statistically significant impact on total yield and the size distributions of harvested tubers.

• With a 10% level of infection in your seed, you could see income reductions of approximately $90 to $120 per acre depending on the variety and market channel.
The Idaho Potato Industry

The Idaho potato industry is the largest producer of potatoes in the United States and provides an important contribution to the state economy.

- Over 340,000 acres
- Over 141,000,000 cwt produced
- Value of production over $1 Billion

(USDA NASS, Potatoes Annual Summary, 9/19/2013)
Statewide Impacts of PVY - Idaho

As with most states, the Idaho economy is comprised of a large number of sectors. A shock in economic activity to one sector not only affects the directly impacted sector but also creates a wave of effects extending to all related sectors.

A reduction in output caused by PVY (or any other factor) is felt not only by producers, but also those businesses supplying transportation, utilities, insurance, business services and so on.
Statewide Impacts

Based on the average amount of PVY found by the Idaho Crop Improvement Association, and using the estimates of PVY spread and yield impacts discussed previously, we estimated that the shrinkage-adjusted total impact of PVY in a reduction in output of 2.32 Million cwt.

This reduction resulted in an estimated reduction in sales to the fresh-pack, frozen, and dehydrated processing sectors were reduced by $5 million, $6.7 million and $2.7 million.
An Important Assumption

The economic impact calculations that follow are based on the estimated reduction in output that could be attributable to PVY.

No price impacts are included

That is – the reduction in output is not reflected by price changes for these calculations.
Economic Impact of PVY

The impact that PVY has on the overall economy was estimated using a model based on the 2011 IMPLAN software.

We measure the impact of reduced potato yields using a Leontief Input-Output model.
Output Impacts

The *direct* output impact of a sector of potato industry to the economy is the reduction in the sector’s own output due to PVY.

The *indirect* output impact to the economy due to reduction in output of the directly impacted sector is the sum of the reductions in outputs of all other remaining endogenous sectors which are linked with the potato production sector.
## Output Impacts

<table>
<thead>
<tr>
<th></th>
<th>Total Impact</th>
<th>Direct Impact</th>
<th>Indirect Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato Production</td>
<td>$16,149,795</td>
<td>$8,707,468</td>
<td>$7,442,327</td>
</tr>
<tr>
<td>Frozen Processing</td>
<td>$10,050,032</td>
<td>$5,629,073</td>
<td>$4,420,959</td>
</tr>
<tr>
<td>Dehydrated Processing</td>
<td>$3,934,293</td>
<td>$2,364,561</td>
<td>$1,569,732</td>
</tr>
<tr>
<td>Fresh-Packing</td>
<td>$3,798,763</td>
<td>$2,862,135</td>
<td>$936,628</td>
</tr>
<tr>
<td>Industry Output Impact</td>
<td><strong>$33,932,883</strong></td>
<td><strong>$19,563,237</strong></td>
<td><strong>$14,369,646</strong></td>
</tr>
</tbody>
</table>
Employment Impacts

Based on the output impacts we estimate the number of jobs lost due to reductions from PVY.

<table>
<thead>
<tr>
<th></th>
<th>Total Impact</th>
<th>Direct Impact</th>
<th>Indirect Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato production</td>
<td>91</td>
<td>19</td>
<td>72</td>
</tr>
<tr>
<td>Frozen potato processing</td>
<td>50</td>
<td>17</td>
<td>33</td>
</tr>
<tr>
<td>Dehydrated potato</td>
<td>16</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>packing</td>
<td>27</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td><strong>Industry Employment Impact</strong></td>
<td><strong>184</strong></td>
<td><strong>60</strong></td>
<td><strong>124</strong></td>
</tr>
</tbody>
</table>
Wages are also impacted by reduced outputs.

<table>
<thead>
<tr>
<th>Industry Wages Impact</th>
<th>Total Impact</th>
<th>Direct Impact</th>
<th>Indirect Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato Production</td>
<td>$3,268,800</td>
<td>$1,170,192</td>
<td>$2,098,608</td>
</tr>
<tr>
<td>Frozen Potato Processing</td>
<td>$1,963,692</td>
<td>$846,489</td>
<td>$1,117,203</td>
</tr>
<tr>
<td>Dehydrated Potato Processing</td>
<td>$612,705</td>
<td>$221,449</td>
<td>$391,254</td>
</tr>
<tr>
<td>Fresh-Packing</td>
<td>$633,457</td>
<td>$372,251</td>
<td>$261,206</td>
</tr>
<tr>
<td><strong>Industry Wages Impact</strong></td>
<td><strong>$6,478,654</strong></td>
<td><strong>$2,610,382</strong></td>
<td><strong>$3,868,272</strong></td>
</tr>
</tbody>
</table>
Value-Added Impacts

Value-added impacts are the sum of employee compensation, proprietor income, other property-type income, and indirect business taxes (includes wages).

<table>
<thead>
<tr>
<th>Industry</th>
<th>Total Impact</th>
<th>Direct Impact</th>
<th>Indirect Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato production</td>
<td>$8,942,391</td>
<td>$4,625,256</td>
<td>$4,317,135</td>
</tr>
<tr>
<td>Frozen potato processing</td>
<td>$3,405,169</td>
<td>$1,181,300</td>
<td>$2,223,868</td>
</tr>
<tr>
<td>Dehydrated potato processing</td>
<td>$1,181,841</td>
<td>$407,814</td>
<td>$774,027</td>
</tr>
<tr>
<td>Fresh-packing</td>
<td>$1,073,177</td>
<td>$559,965</td>
<td>$513,211</td>
</tr>
<tr>
<td>Industry Value-Added Impact</td>
<td>$14,602,578</td>
<td>$6,774,336</td>
<td>$7,828,242</td>
</tr>
</tbody>
</table>
Conclusions

• PVY reduces marketable yields and changes the composition of the crop produced
• Grower returns are significantly reduced by PVY
• PVY is estimated to have impacts of:
  • $33.93 million on the Idaho economy (output impact)
  • 186 fewer jobs and $6.5 million in wages
  • $14.6 million in lost value-added (includes $6.5 million wage impact)
Thanks to:

- USDA, NIFA Specialty Crop Research Initiative for funding the majority of this research
- The Idaho Agricultural Experiment Station
- Idaho Crop Improvement Association
- Melissa Bertram and Melinda Lent – UI Idaho Falls
- Paul Patterson and Levan Elbakidze – UI Moscow
- Each of you for your time and your attention