Strain-specific and other types of resistance to PVY

Alexander V. Karasev
**Potato virus Y - potato**

- *Potyviridae (potyvirus)*
- Particles: flexuous filaments
- Wide natural host range (*solanaceae*)
- Transmission: mechanical, through seed, by aphids
- Aphid transmission: non-persistent (very quick)
- Exists as a complex of strains
PVY genetic diversity

- Five non-recombinant parents
- One recombinant parent
- 36 recombinant structures ("strains")
- Only 6 recombinant strains found in the U.S. Potato
- Only 3 recombinants associated with PTNRD
- And only one of these recombinants, PVYN TN, is prevalent in the U.S. potato

Green et al. (2018)
“Leaf-drop” in Ranger

Mosaic and crinkling in Russet Burbank

Chlorotic mosaic in Ranger

Severe mosaic in Russet Burbank
Columbia Basin seed lot trials

- WA produces 20% of the U.S. Potato
- Unlike ID or MT, WA has small seed potato industry
- Hence, WA must import lots of seed potato
- These seed potatoes are tested in Othello and in Hermiston
- When we test potato lots in Othello, we test potato from many states
- This is ideal for PVY strain surveillance
How to monitor and evaluate PVY strain composition in Washington potato seed lot trials?

- Need to analyze large number of seed lots
  - Each year up to 350 seed lots are submitted for trials
- Need to identify PVY-positive samples and then type them to strain
  - Up to 14 different genome structures are known for PVY, 9 strains established
- This testing needs to be conducted each year of trials, to see any dynamic changes
- We conducted testing of the PVY strain composition in the Othello grow-outs between 2011 and 2019
PVY typing – RT-PCR

Chikh-Ali et al., 2013
Testing of seed potato – Othello grow-out

Leaf samples analyzed

<table>
<thead>
<tr>
<th>Year</th>
<th>Total samples</th>
<th>PVY-positive, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>246</td>
<td>88</td>
</tr>
<tr>
<td>2012</td>
<td>235</td>
<td>84</td>
</tr>
<tr>
<td>2013</td>
<td>283</td>
<td>88</td>
</tr>
<tr>
<td>2014</td>
<td>222</td>
<td>91</td>
</tr>
<tr>
<td>2015</td>
<td>431</td>
<td>93</td>
</tr>
<tr>
<td>2016</td>
<td>362</td>
<td>85</td>
</tr>
<tr>
<td>2017</td>
<td>317</td>
<td>81</td>
</tr>
<tr>
<td>2018</td>
<td>384</td>
<td>83</td>
</tr>
<tr>
<td>2019</td>
<td>353</td>
<td>82</td>
</tr>
</tbody>
</table>

• 200-tuber samples from each seed lot are submitted by growers
• These tuber samples are planted in Othello, WA, and read/tested in June
• Symptomatic leaf samples are taken to UI-Moscow for testing and typing
• Samples are typed using ELISA with monoclonal antibodies, O and N specific
• PVY-positive samples are typed using immuno-captured RT-PCR
PVY strain composition in Columbia Basin: 2011-2019

- In the past few years, prevalence of PVY\textsuperscript{O} decreased dramatically
- Prevalence of recombinants reached over 90%
- PVY\textsuperscript{N-Wi} is the most prevalent type currently, at above 60%
- However, the set of recombinants remains stable

Funke et al. (2017)
Types of resistance to PVY in potato

- Extreme resistance or immunity ($R_{adg}$, $R_{sto}$, $R_{chc}$)
  - Broad, strain non-specific, durable
- Hypersensitive resistance ($Ny$, $Nc$, $Nz$, etc)
  - Strain-specific, sensitive to temperature
- Age-related (mature) resistance
  - Is dependent on the age of the plant
  - Older plants exhibit resistance to the virus
- Can we use mature resistance to manage PVY?
Questions for the current season PVY management:

• What is the critical period for the vector management?
• Is it early in the season, when aphids bring the virus to the field and establish reservoirs in the field?
• Or is it late in the season when aphids spread the virus which goes directly to tubers?
• And if it is late season spread, where is this mature resistance?
**Pilot experiment in 2017-2018**

- One potato cultivar – Yukon Gold
- One PVY strain – PVY\textsuperscript{NTN}
- Potato plantlets planted into soil (greenhouse), and infected with PVY\textsuperscript{NTN} every week for eight weeks
- Each time point is analyzed for systemic infection, and tuber quality at harvest and 1 month storage – current season
- Collected tubers for each plant are planted to test for a seed-borne infection – “translocation to tubers without systemic infection” control
Foliar symptoms

- W1-4 local HR and systemic HR and mottle
- W1-6 local and systemic HR
- W7-8 local HR and occasional systemic HR

Systemic infection in potato foliage measured at 4 wpi

Percentage of systemic infection per treatment n=15

% of PVY infected plants

Age at inoculation

Healthy
Efficiency of virus translocation: yield loss and PTNRD at harvest time

Grow-out data – secondary systemic infection

<table>
<thead>
<tr>
<th>Plant age at inoculation</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>20/20</td>
<td>25/25</td>
</tr>
<tr>
<td>W2</td>
<td>28/28</td>
<td>21/21</td>
</tr>
<tr>
<td>W3</td>
<td>24/29</td>
<td>25/26</td>
</tr>
<tr>
<td>W4</td>
<td>8/30</td>
<td>17/30</td>
</tr>
<tr>
<td>W5</td>
<td>6/30</td>
<td>2/30</td>
</tr>
<tr>
<td>W6</td>
<td>2/30</td>
<td>3/30</td>
</tr>
<tr>
<td>W7</td>
<td>0/26</td>
<td>0/30</td>
</tr>
<tr>
<td>W8</td>
<td>1/30</td>
<td>0/30</td>
</tr>
<tr>
<td>Healthy</td>
<td>0/30</td>
<td>0/30</td>
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- Two tubers from each primary-inoculated plant
- Planted into a 1-gallon pot
- Grown until flowering
- Systemic infection determined by ELISA, and PVY strain typed by RT-PCR
- Up to 30 plants per time of primary inoculation
PTNRD at harvest time

W4 and W6 appeared at 1 mph but not at harvest time

PTNRD data

**2017**

- **Percentage of tubers with PTNRD at 1 month post harvest**
- **Average of necrotic rings/tuber at 1 month post harvest**

**2018**

- **Average of tubers with PTNRD at 1 mph**
- **Average of necrotic ringsports per tuber at 1 mph**
Yield loss as a function of time of infection

2017

Average tuber weight at harvest time

<table>
<thead>
<tr>
<th>Age at inoculation</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>W7</th>
<th>W8</th>
<th>Healthy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight /g</td>
<td>100</td>
<td>125</td>
<td>150</td>
<td>175</td>
<td>200</td>
<td>225</td>
<td>250</td>
<td>275</td>
<td>300</td>
</tr>
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2018

Average tuber weight at harvest time

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<th>Age at inoculation</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
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Yield 2017 and 2018

Preliminary conclusions

- Age-related (mature) resistance is expressed by Yukon Gold against PVY\textsuperscript{NTN}
- It is very efficient, almost 100% after 3 weeks post-transplantation in a greenhouse experiment
- This age-related resistance blocks systemic infection of the virus, but also virus translocation to tubers
- Take-home message: it may be the early stage of the plant development which is critical and in need of protection
- Later in the season, plant may not need additional protection
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