Potato Psyllid & Zebra Chip Disease of Potato

Dr. Joe Munyaneza
USDA-ARS Yakima, Wapato, WA
History and Distribution of Zebra Chip

• First identified in Mexico (Saltillo area) in 1994 and United States (Texas) in 2000

• Disease subsequently documented in NM, NV, AZ, CA, NE, CO, KS, & WY

• Reported in ID, OR, & WA in Aug/Sept 2011

• The disease has also been documented in Central America (Guatemala, Honduras, Nicaragua, El Salvador) and New Zealand
Zebra chip distribution in the Americas

ZC

Zebra chip distribution in the Americas
Zebra Chip Symptom Identification
Leaf scorching

Photo: Gary Secor

Photo: Jim Crosslin
Chiligatorio, Intibucá, Honduras (2009)
Zebra chip-damaged fields in Texas
Zebra chip-damaged field in Honduras

Photo by J. Brown
University of Arizona
New Zealand
(March 2010)
Columbia Basin, WA
(September 2011)
Brown to pinkish (collapsed) stolons

Healthy Tuber
Zebra Chip Causal Agent and Insect Vector
ZC was first associated with the potato psyllid Bactericera (= Paratrioza) cockerelli in 2006 by Munyaneza et al. (2007)

In 2008, it was discovered that ZC is associated with a previously undescribed species of the bacterium liberibacter named "Candidatus Liberibacter solanacearum" [Lso] (also known as "Ca. L. psyllaaurous"), transmitted by the potato psyllid.

This new bacterium is related to, but different from, Liberibacter species that cause citrus greening disease or Huanglongbing disease (in Brazil, Mexico, USA, Asia, Africa, and elsewhere in the world).

This pathogen severely affects other solanaceous crops in the Americas & New Zealand and carrot in Europe (Munyaneza et al. 2010).
First report of Lso by Munyaneza et al. 2009 (& Jose A. Garzon)
First report of Lso by Munyaneza et al. 2009 (& Jose A. Garzon)
Tobacco (Nicaragua, 2012)
Carrots in Finland
Carrot Psyllid

Trioza apicalis

Restricted to northern and central Europe
Sweden & Norway, 2012

(Munyaneza et al. 2012a,b)
Potato psyllid adults
Potato psyllid nymphs
Potato Psyllid eggs
Distribution map of the potato psyllid in the Americas

- Lighter blue areas are colonized intermittently

Map: Scott Burton
FDACS/ Div. Plant Industry
Mexico (2010)
Honduras (2010)
Honduras (2010)
• The potato psyllid is native to North America and occurs in Mexico, north to southern Canada
• Present in Central America (Honduras, Guatemala, & Nicaragua)
• Overwinters in desert areas along the border between USA (Texas to California) and Mexico
• In U.S., the insect migrates annually with wind and high temperatures in late spring to northerly regions (as far as British Columbia to Saskatchewan in Canada)
• Recently introduced into New Zealand, apparently from western United States
Potato Psyllid in the PNW
Number of psyllids/100 sweeps or leaves

Sampling date

Prosser, 2008

Adults
Nymphs
Prosser, 2011

Mean Number/100 ft-row or 25 leaves

Sampling Date

Eggs
Nymphs
Adults
Mean Number of Psyllids/100 ft-Row or 25 Leaves

Sampling Date

Hermiston, 2009

Adults
Eggs
Nymphs
Mean Numbers of Psyllids/100 ft-Row or 25 Leaves

Sampling Date

Hermiston, 2010

- Adults
- Eggs
- Nymphs
Why Zebra Chip Absent in the Basin Prior to 2011?
Prosser, 2011-2012
(< 40 miles from McNary field)

No Zebra Chip

Heavy Psyllid Damage
• Moxee, WA – 2009-2011 samples: no liberibacter
• Prosser, WA – 2009-2011 samples: no liberibacter
• Hermiston, OR – 2009-2010 samples: no liberibacter

• Hermiston, OR – 2011: 11/95 (11.5%), 10/96 (10.4%), & 12/90 (13.3%) of insect collected on Sept 12, 19, & 26, respectively, were positive for liberibacter
• McNary, WA – 2011: 7/108 (6.4%) of insects collected on Sept 30 were positive for liberibacter

• Psyllids collected from Hermiston and McNary in 2011 are genetically related to Western/CA biotype whereas those from Prosser and Moxee appear different from Western and Central/TX biotypes, suggesting a new biotype: “Northwestern biotype” (No ZC!)
Potato psyllid found to overwinter on this weed in Boise area (Andy Jensen) and other parts of WA, OR, and ID (Munyaneza, Rondon)

The Northwestern Biotype psyllid appears to survive very cold temperatures in the PNW and may biologically behave differently from other biotypes (studies underway in Munyaneza Lab)
Liberibacter infection symptoms about 3 weeks after inoculation with hot psyllids (Munyaneza Lab)

Potato psyllid life cycle completed in about 3 weeks
Lso Positive

2-3 months
Three months after Lso inoculation
Transmission of Liberibacter & Zebra Chip Epidemiology
• To cause zebra chip, psyllids must carry liberibacter (Lso-free psyllids can cause “psyllid yellows disease”)
• Potato psyllids acquire liberibacter by feeding on infected plants (horizontal transmission) and through mother to offspring (transovarial or vertical transmission)
• As few as one liberibacter-infected potato psyllid per plant can cause zebra chip after a relatively short inoculation access period (about 6 hrs)
• It takes about 3 weeks after liberibacter inoculation for ZC symptoms to develop in tubers, even before symptoms are visible in plants
• Tuber development stops, significant increase in reducing sugars (glucose & fructose), and decrease in specific gravity (starch) at the onset of symptoms
• Similarly to the potato psyllid, ZC liberibacter appears heat-sensitive and does not tolerate high temp (>32 °C)
<table>
<thead>
<tr>
<th>Cultivar</th>
<th>ZC Incidence in Plants (%)</th>
<th></th>
<th></th>
<th>Yield Loss (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2009</td>
<td>2010</td>
<td>2009</td>
<td>2010</td>
</tr>
<tr>
<td>Alturas</td>
<td></td>
<td>82.5</td>
<td>100</td>
<td>87.2</td>
<td>63.4</td>
</tr>
<tr>
<td>Atlantic</td>
<td></td>
<td>100</td>
<td>100</td>
<td>73.8</td>
<td>58.4</td>
</tr>
<tr>
<td>Ranger Russet</td>
<td></td>
<td>100</td>
<td>100</td>
<td>74.7</td>
<td>53.4</td>
</tr>
<tr>
<td>Russet Burbank</td>
<td></td>
<td>100</td>
<td>100</td>
<td>86.6</td>
<td>63.0</td>
</tr>
<tr>
<td>Russet Norkotah</td>
<td></td>
<td>100</td>
<td>100</td>
<td>63.4</td>
<td>62.7</td>
</tr>
<tr>
<td>Shepody</td>
<td></td>
<td>100</td>
<td>100</td>
<td>84.4</td>
<td>63.3</td>
</tr>
<tr>
<td>Umatilla Russet</td>
<td></td>
<td>100</td>
<td>100</td>
<td>49.9</td>
<td>62.1</td>
</tr>
<tr>
<td>FL 1867</td>
<td></td>
<td>89</td>
<td>100</td>
<td>55.5</td>
<td>53.2</td>
</tr>
<tr>
<td>FL 1879</td>
<td></td>
<td>100</td>
<td>100</td>
<td>61.7</td>
<td>62.0</td>
</tr>
</tbody>
</table>

Susceptibility of Selected Potato Cultivars to ZC
Do Fresh Potatoes or Seed Spread ZC?
ZC-Infected Tubers

ZC-Free Tubers

FL 1867; 4 months; Room Temp (65-70 °F)
Atlantic & Ranger Seed
Exposed to psyllids with or without liberibacter

Wapato, WA (2010)
Liberibacter-free or psyllid yellows seed

Liberibacter-affected Seed (ZC)
Liberibacter-affected Seed (ZC)

Liberibacter-free or psyllid yellows seed
ZC Seed

ZC-Free Seed

ZC/liberibacter-free plants

ZC Seed
## Plant Emergence Rate (2010-2011)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>ATLANTIC</th>
<th>RANGER</th>
<th>ATLANTIC</th>
<th>RANGER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emergenc rate (%)</td>
<td>Days to emergence</td>
<td>% ZC</td>
<td>Emergenc rate (%)</td>
</tr>
<tr>
<td>Controls</td>
<td>95.8</td>
<td>100</td>
<td>100</td>
<td>91.8</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>L-free Psyllids (PY)</td>
<td>95.8</td>
<td>100</td>
<td>100</td>
<td>95.8</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Psyllids + Liberi (ZC)</td>
<td>12.5</td>
<td>53.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5.5</td>
<td>35</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>70</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Liberibact alone (ZC)</td>
<td>25.8</td>
<td>52.7</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>16.7</td>
<td>29</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>65</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Washington (2011)

Moxee Farm
<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Texas Trial</th>
<th></th>
<th>Washington Trial</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Emergence</td>
<td>% ZC</td>
<td>% Emergence</td>
<td>% ZC</td>
</tr>
<tr>
<td>Norkotah</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Norkotah (ZC)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Umatilla</td>
<td>95</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Umatilla (ZC)</td>
<td>5</td>
<td>0</td>
<td>5.5</td>
<td>0</td>
</tr>
<tr>
<td>Shepody</td>
<td>100</td>
<td>0</td>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td>Shepody (ZC)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Burbank</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Burbank (ZC)</td>
<td>16</td>
<td>0</td>
<td>5.5</td>
<td>0</td>
</tr>
<tr>
<td>Alturas</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Alturas (ZC)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FL1879</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>FL1879 (ZC)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FL1867</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>FL1867 (ZC)</td>
<td>0</td>
<td>0</td>
<td>22.2</td>
<td>0</td>
</tr>
</tbody>
</table>
### Effect of Liberibacter Infection Timing

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Texas Trial</th>
<th>Washington Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Emergence</td>
<td>% ZC</td>
</tr>
<tr>
<td><strong>Weeks &lt; Harvest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Atlantic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 weeks (ZC+)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10 weeks (ZC+)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6 weeks (ZC+)</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td><strong>FL1867</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 weeks (ZC+)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10 weeks (ZC+)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6 weeks (ZC+)</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>
• ZC-infected tubers **generally** do not sprout and if they do, take a long time to emerge (up to 2.5 months), and produce hair sprouts and weak **BUT usually** ZC-free and short-lived plants

• ZC **diminishes** potato seed quality (germination) but seed **does not appear to significantly contribute to the disease spread; rather WATCH POTATO PSYLLID** spread (migration or introduction on plant/produce material)!!!!

• Controlling potato psyllid and preventing its spread are currently the only means to manage ZC
ZC Late Infection and Postharvest Issues
• All potato plant growth stages are susceptible to ZC

• Late (3 weeks or less before harvest) liberibacter infected potato plants usually result in symptomless plants and tubers

• Little is known about development of ZC symptoms in storage (important in the Pacific Northwest)

• Preliminary studies were initiated in Munyaneza lab (2010 & 2011; with Atlantic) to investigate the issue
### Atlantic: Two Months in Storage (ZC: 10-22%)

<table>
<thead>
<tr>
<th>Exposed</th>
<th>Exposed</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvested 08/31/2011</td>
<td>Fried at harvest</td>
<td>Fried after 2 months</td>
</tr>
<tr>
<td>Harvested 09/06/2011</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Atlantic: Three Months in Storage (ZC: 46-66%)
Potato Psyllid Monitoring and Management
Potato psyllid monitoring

• Yellow sticky traps (adults)
  – Limited sensitivity to low populations

• Leaves (eggs and nymphs)
  – 100 leaves (10 from 10 locations along field perimeter)
  – Labor-intensive
D-Vacuum device made of a leaf blower/mulcher is effective in collecting psyllids from potato fields
Some of the Insecticides Commonly Used to Control Potato Psyllids in Texas

- Admire Pro (imidacloprid)          Oberon (LBI)
- Platinum (thiametoxam)            Beleaf (flonicamid)
- Movento (spirotetramat)           Baythroid (cyfluthrin)
- Agri-Mek (abamectin)              Leverage
- Fulfill (pymetrozine)             Asana (esfenvalerate)
- Knack (IGR)                       Rimon (IGR)
- Venom (dinotefuran)               Radiant (spinetoram)

Visit:  http://zebrachip.tamu.edu
Use of Biorational Pesticides

• Some mineral and plant oils have shown excellent efficacy as repellent or oviposition deterents
  – MOI-201 (Marrone Organic Innovations, Davis, CA)
  – Requiem (AgraQuest, Inc., Davis, CA)
  – BugOil (Arysta Lifescience North America, Cary, NC)
  – SunSpray oil (Sun Company, Philadelphia, PA)

• Kaolin/Surround (Trumble 2009 & Liu et al. 2010)
• Pheromone (studies underway at USDA-ARS Wapato to develop potato psyllid pheromone)
Entomopathogenic Fungi, Predators, and Parasitoids

- Some entomopathogenic fungi have shown to be effective in controlling the potato psyllid (Lacey et al. 2011):
  - *Isaria fumosorosea* (Pfr 97), by Certis USA
  - *Metarhizium anisopliae* (F52), by Novozymes Inc.
  - *Beauveria bassiana* (Botanigard), by BioWorks
  - *Lecanicillium moscarium* (Vertilac), by Koppert Biological

- **Predators:** ladybugs, minute pirate bugs, big-eyed bugs, and other predators
- **Parasitoids:** *Tamarixia* species
• Caution should be used when selecting and applying insecticides targeted against the potato psyllid (nymphs and adults prefer the underside of leaves, so insecticides with translaminar/systemic activities are recommended)

• Target the right insect stage as insecticides do not necessary control psyllid adults, nymphs, and eggs

• Rotate insecticides with different modes of action to prevent/delay insecticide resistance

• Integration of biopesticides and biological control agents into the potato psyllid management is desirable

Potato Psyllid Control

• Chemical control options for the Pacific Northwest, visit:

http://potatoes.com/Research.cfm
(Schreiber et al. 2012)
Summary

- ZC is a very serious and devastating disease.
- ZC is associated with Lso, transmitted by potato psyllid.
- Fresh potatoes/potato seed do not seem to significantly contribute to ZC spread.
- Controlling potato psyllid and preventing its spread are currently the only means to manage ZC.
