Potato Psyllid & Zebra Chip Disease of Potato

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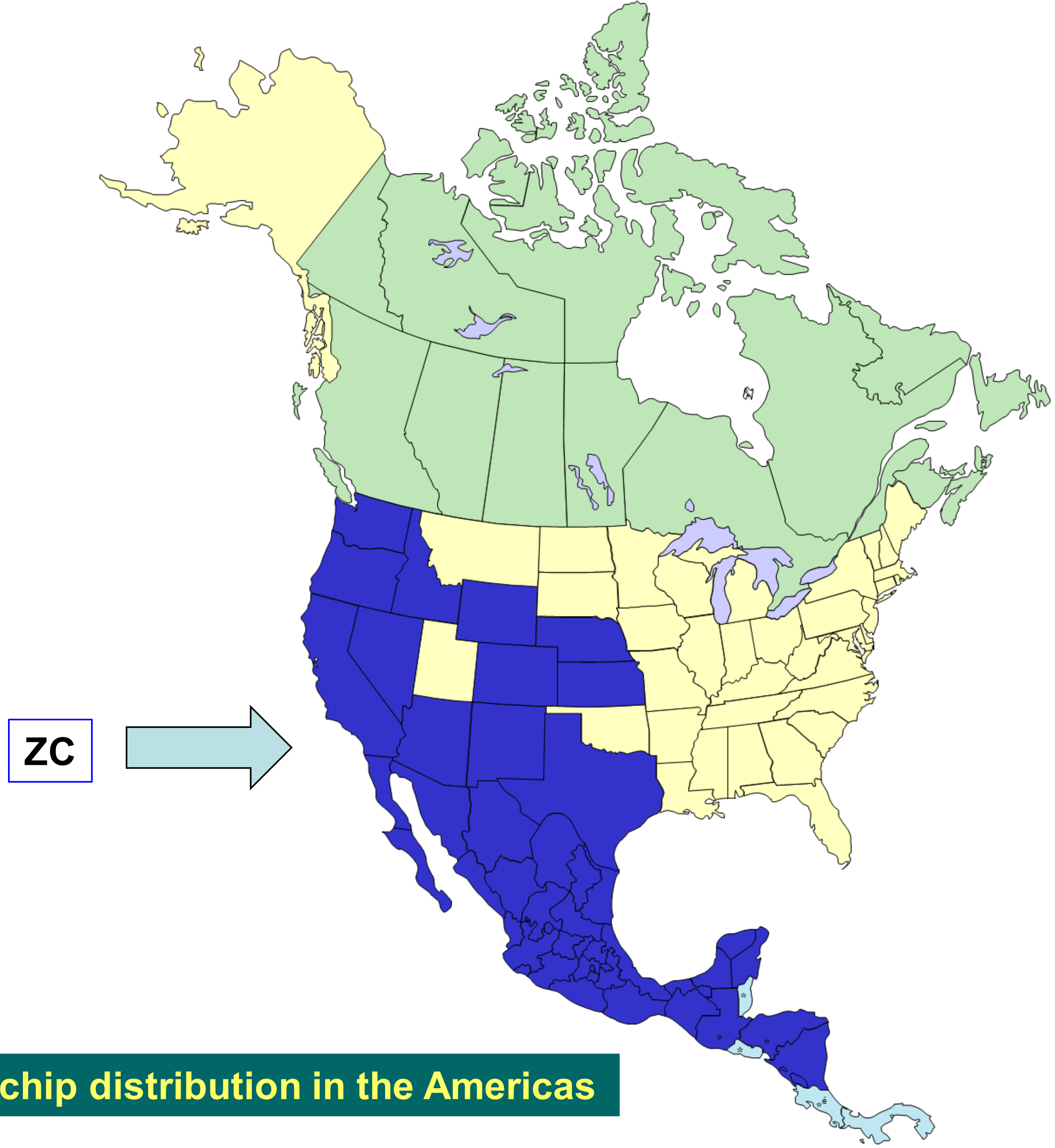
History and Distribution of Zebra Chip

- 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

Zebra Chip Symptom Identification


Photo by J. Melgar
FHIA, Honduras


Photo by J. Melgar
FHIA, Honduras

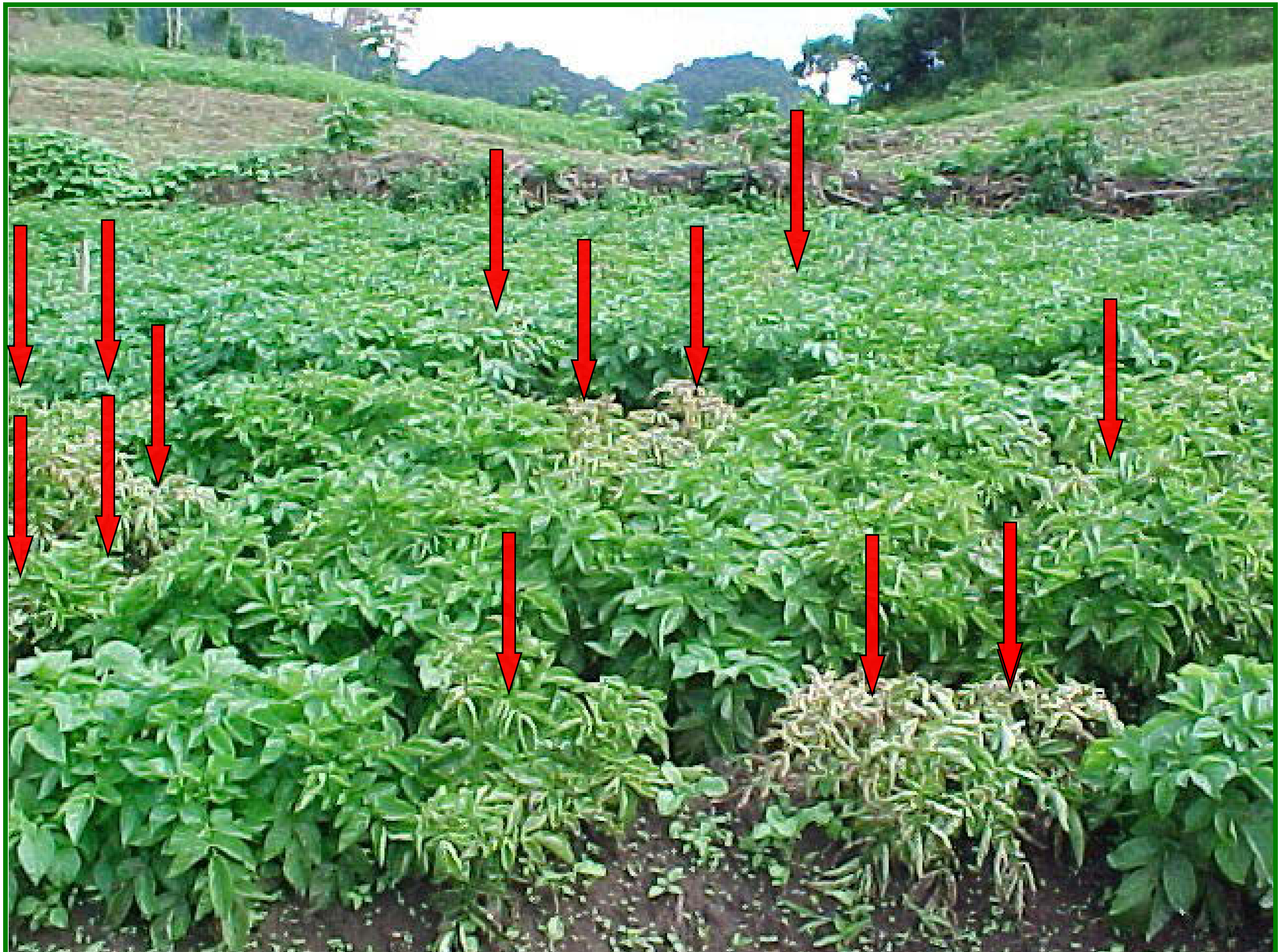

Photo by J. Melgar
FHIA, Honduras


Photo by J. Melgar
FHIA, Honduras

Purple Top vs. Zebra Chip (?)

Leaf scorching

Chiligatoro, Intibucá, Honduras (2009)



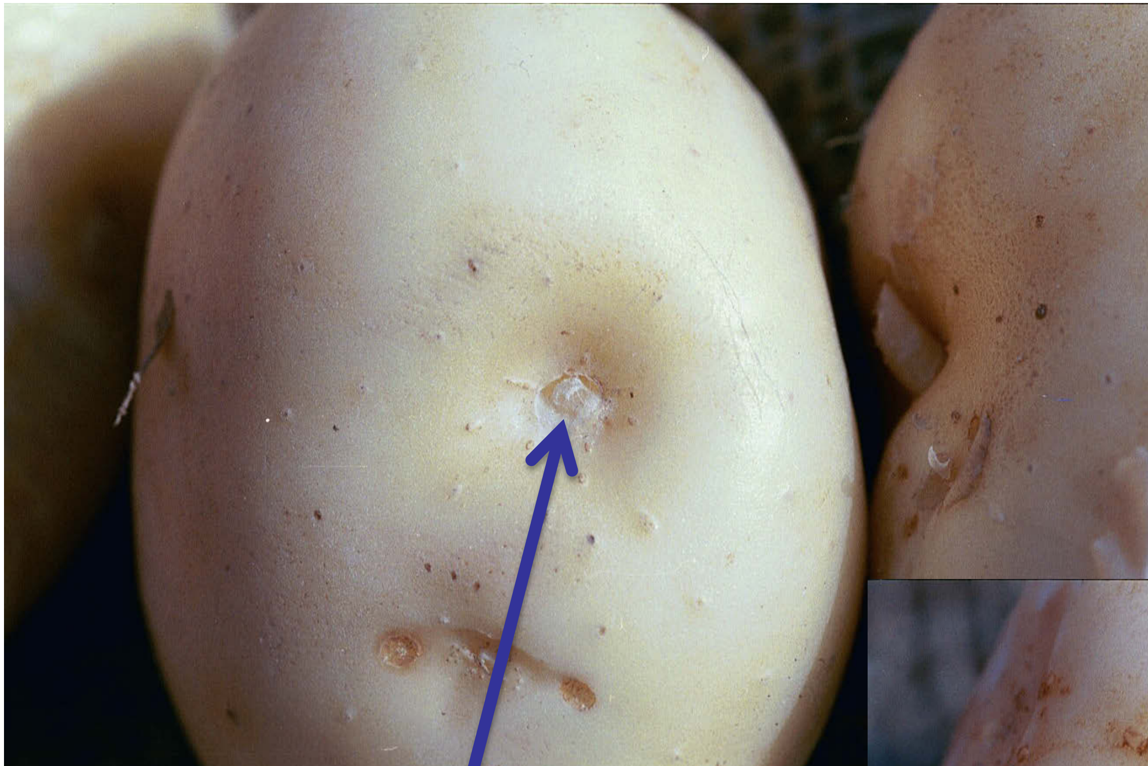
Zebra chip-damaged fields in Texas


Zebra chip-damaged field in Honduras
Photo by J. Brown University of Arizona


New Zealand
(March 2010)

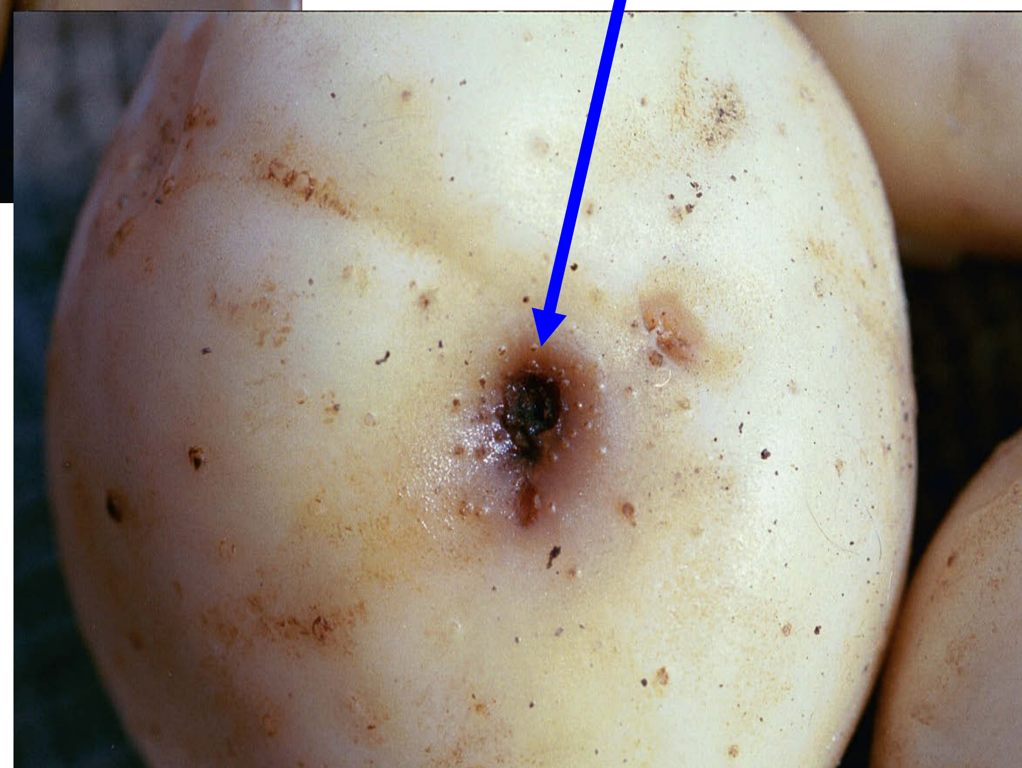

Columbia Basin, WA
(September 2011)

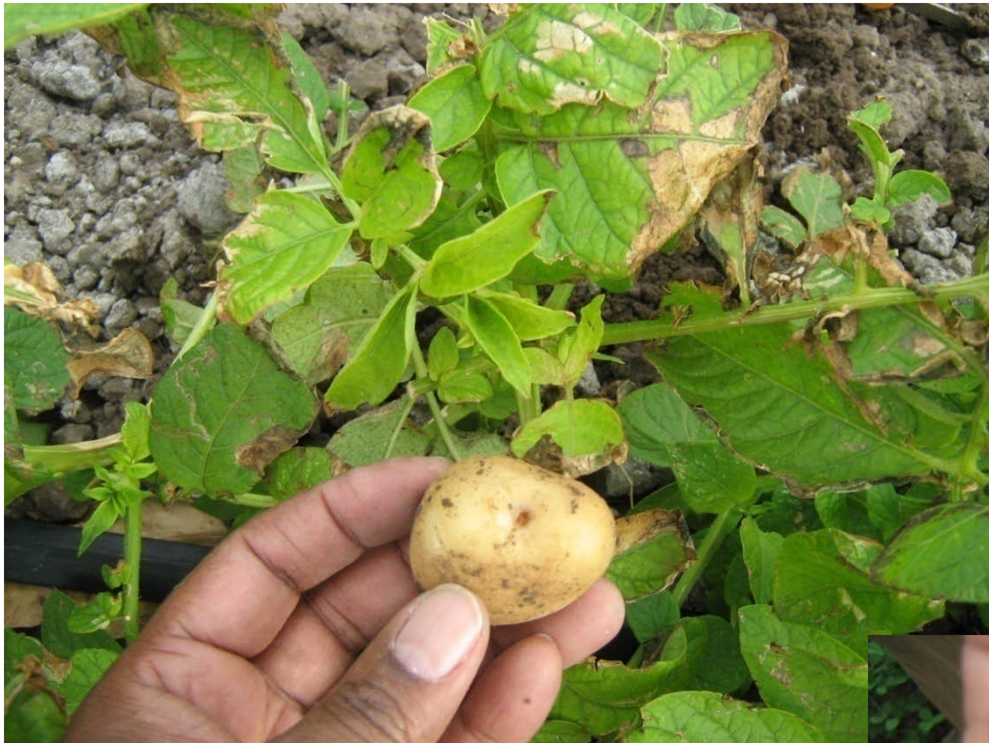

Columbia Basin, OR
(September 2011)



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. psyllaurous"), 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)

Mexico

First report of Lso by Munyaneza et al. 2009 (& Jose A. Garzon)


Mexico
First report of Lso by
Munyaneza et al. 2009
(& Jose A. Garzon)

Tobacco
(Nicaragua, 2012)

Nicaragua


Northern Europe

Carrots in Finland

Carrot Psyllid

Restricted to northern and central Europe

Trioza apicalis


Sweden & Norway, 2012
(Munyaneza et al. 2012a,b)

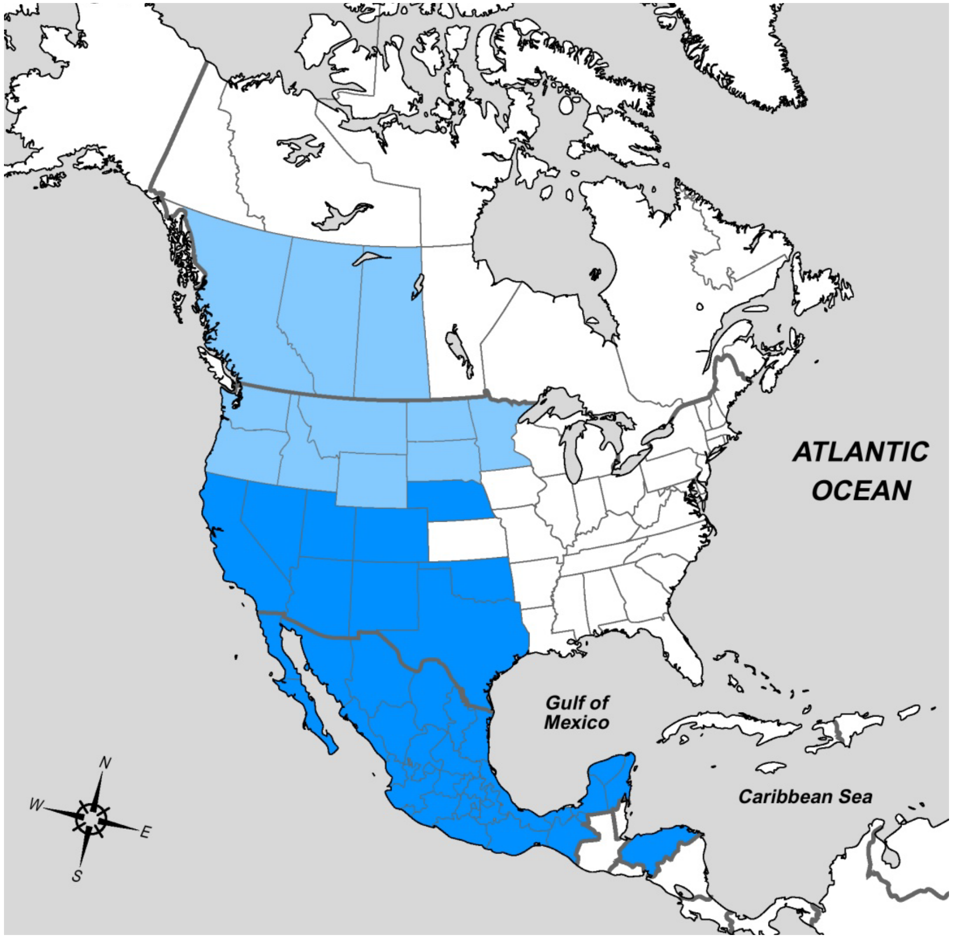
Potato psyllid adults

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)

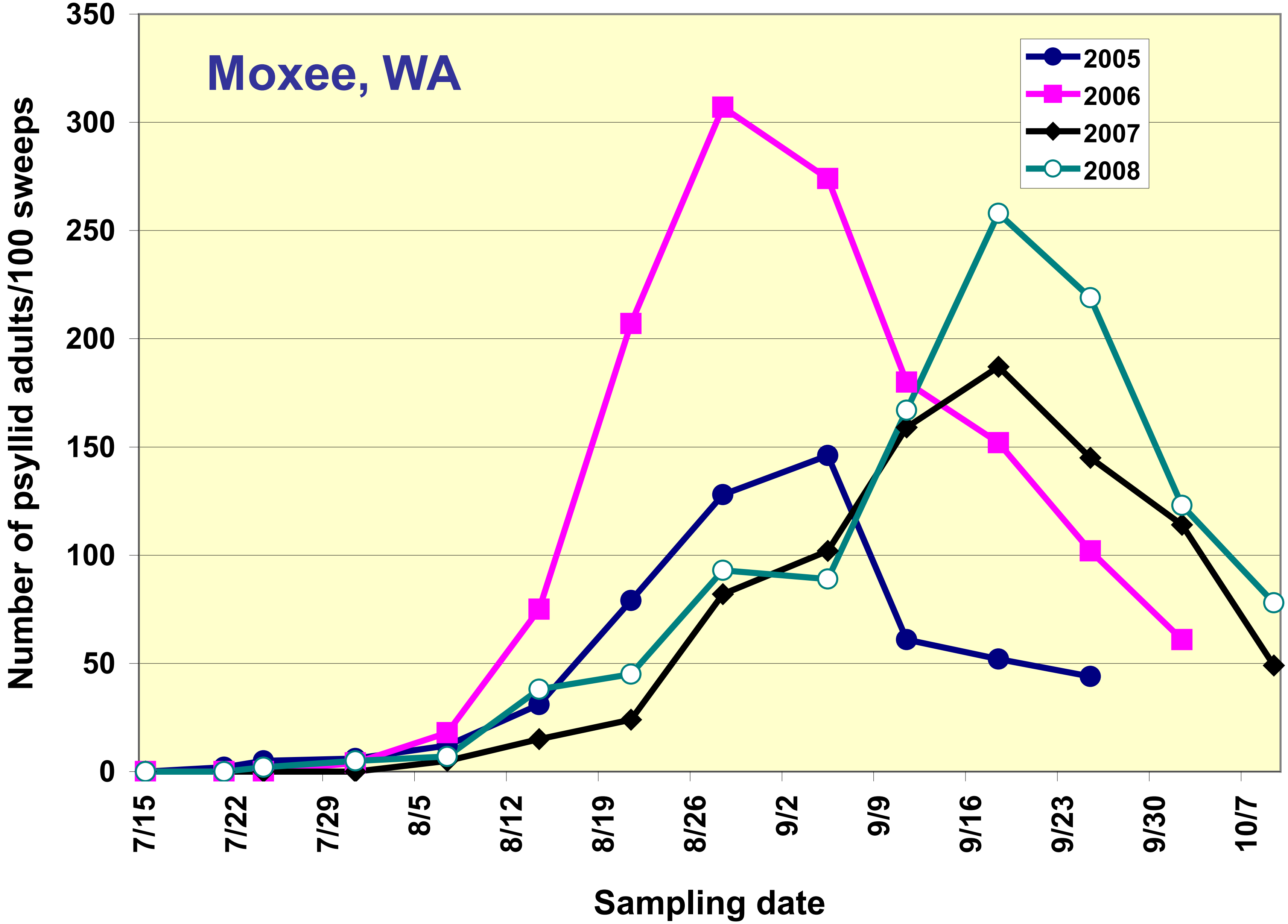
Honduras (2010)

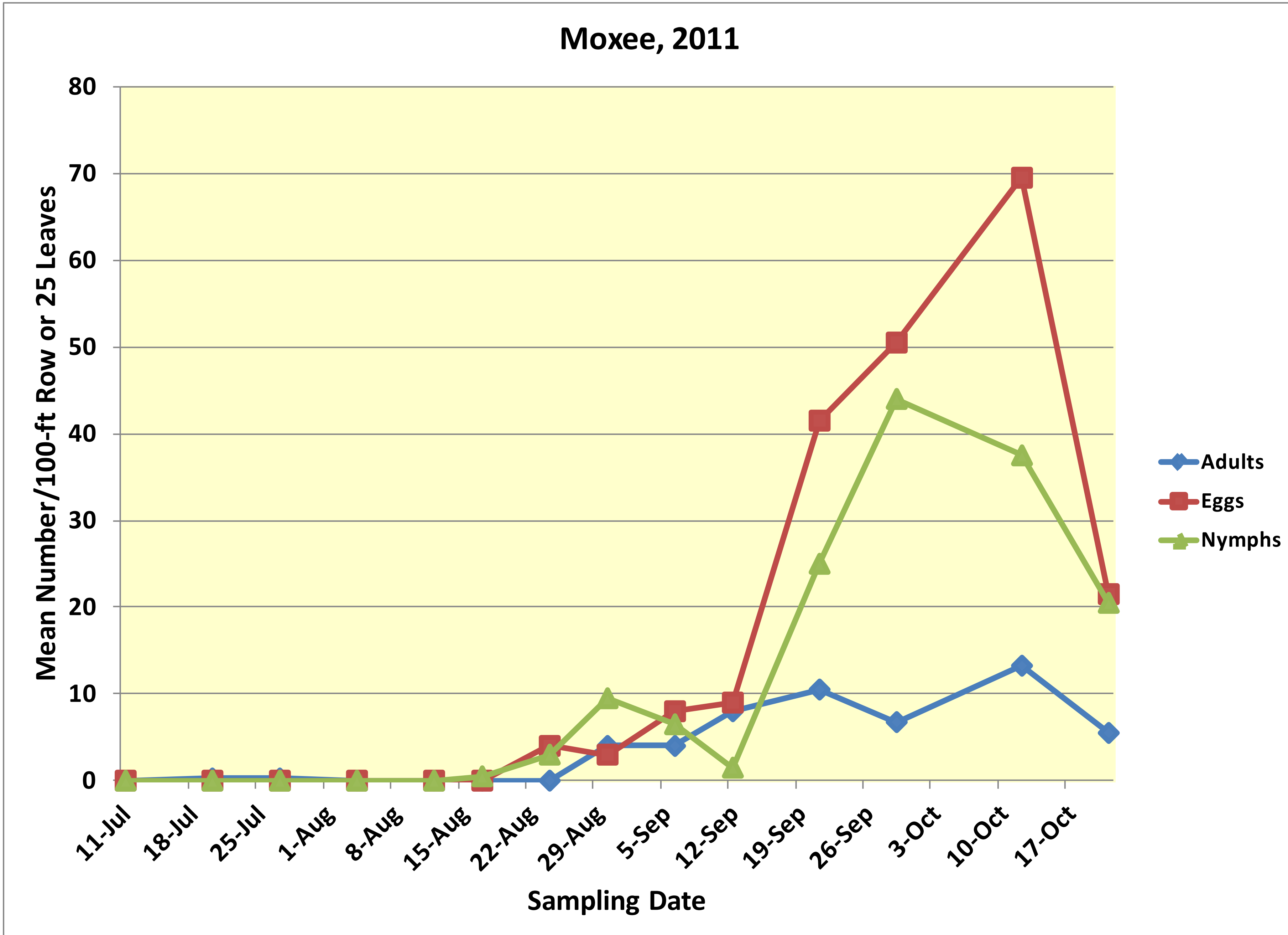
Honduras (2010)


New Zealand
(March 2010)

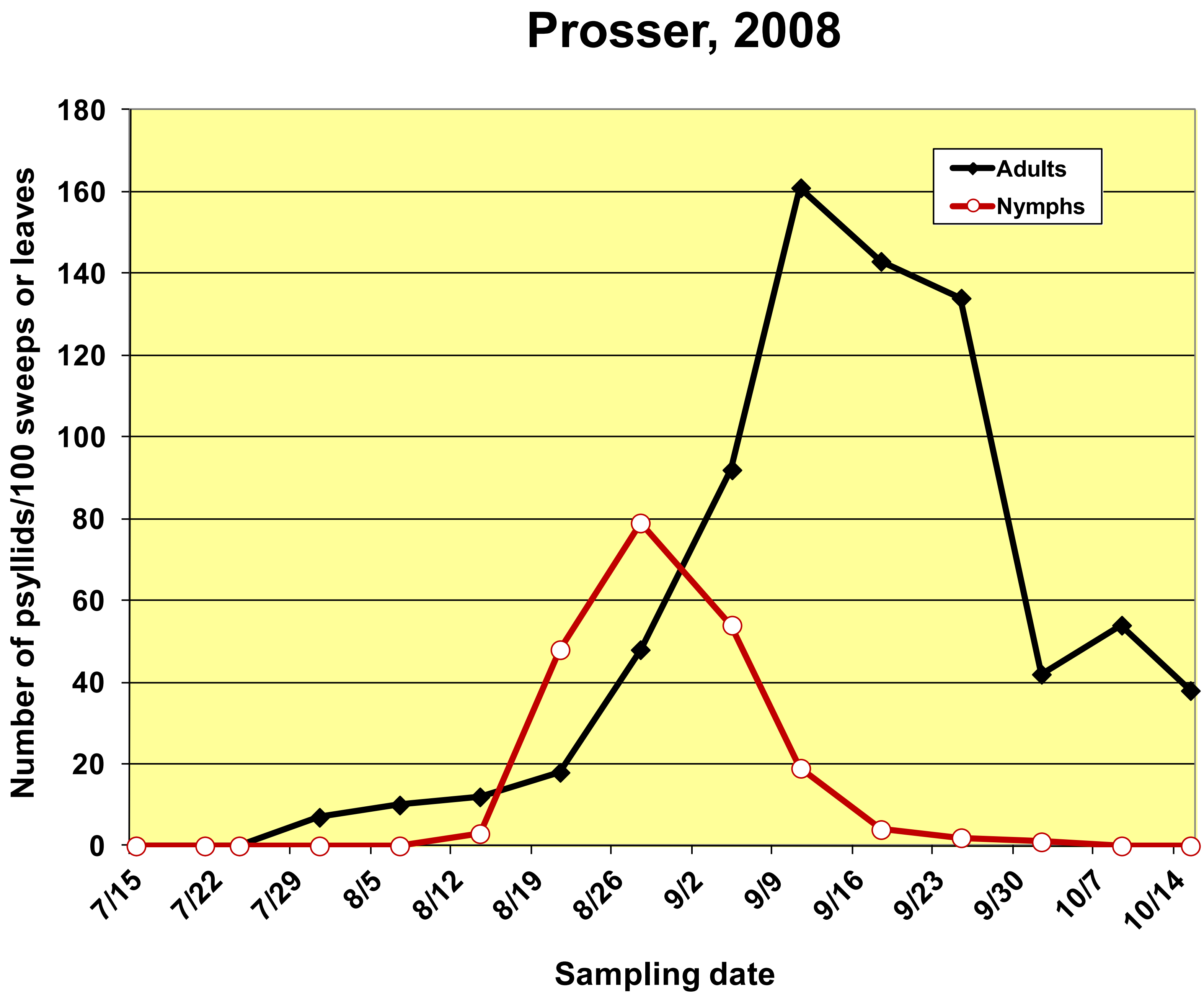
- The potato psyllid is native to North America and occurs in Mexico, north to southern Canada
- Present in Central America (Honduras, Guatemala, & Nicaragua)
- Overwinters in desert areas along the border between USA (Texas to California) and Mexico
- In U.S., the insect migrates annually with wind 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

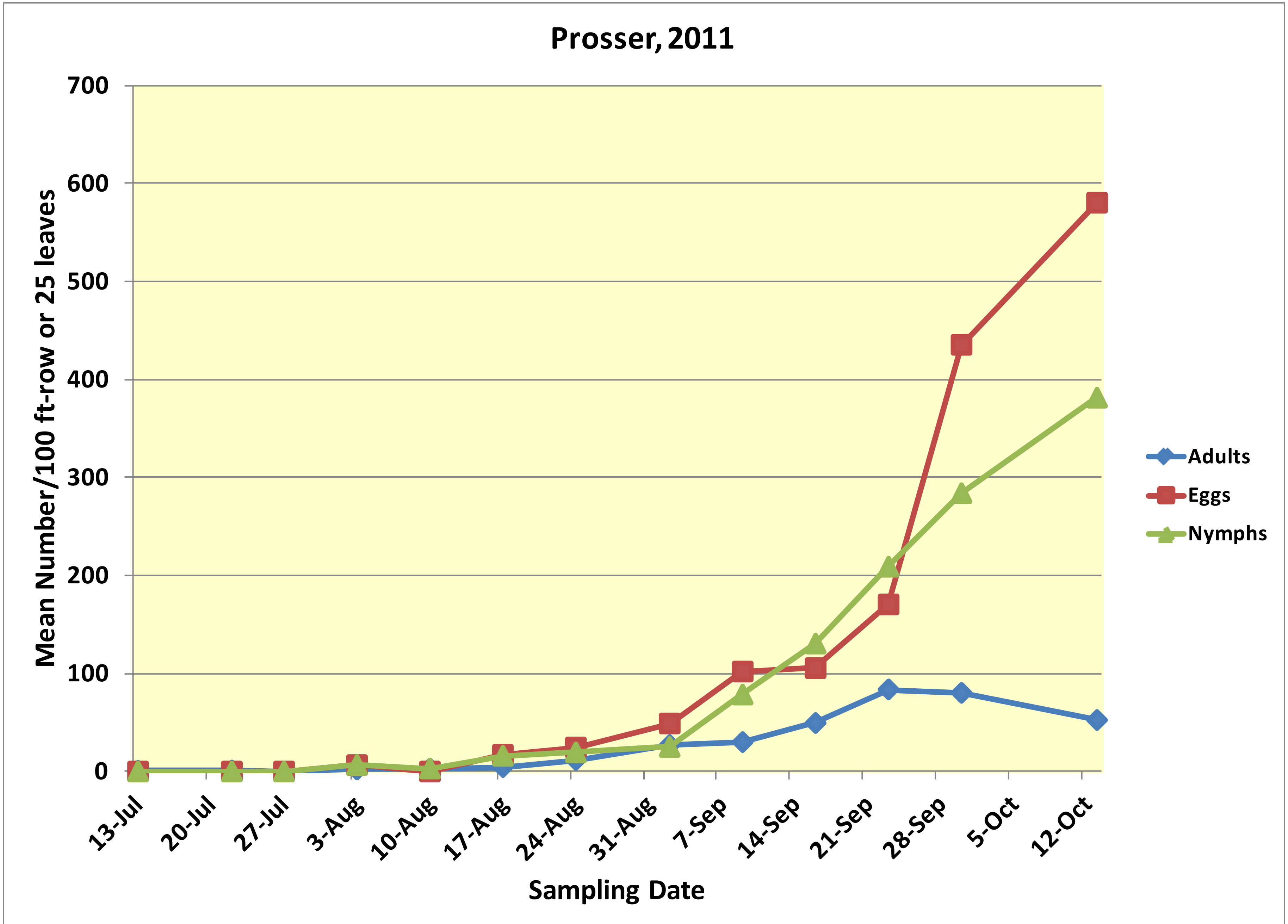
Potato Psyllid in the PNW


Moxee, WA
2005
2006
2007
2008
Number of psyllid adults/100 sweeps
350
300
250
200
150
100
50
0
7/15
7/22
7/29
8/5
8/12
8/19
8/26
9/2
9/9
9/16
9/23
9/30
10/7
Sampling date

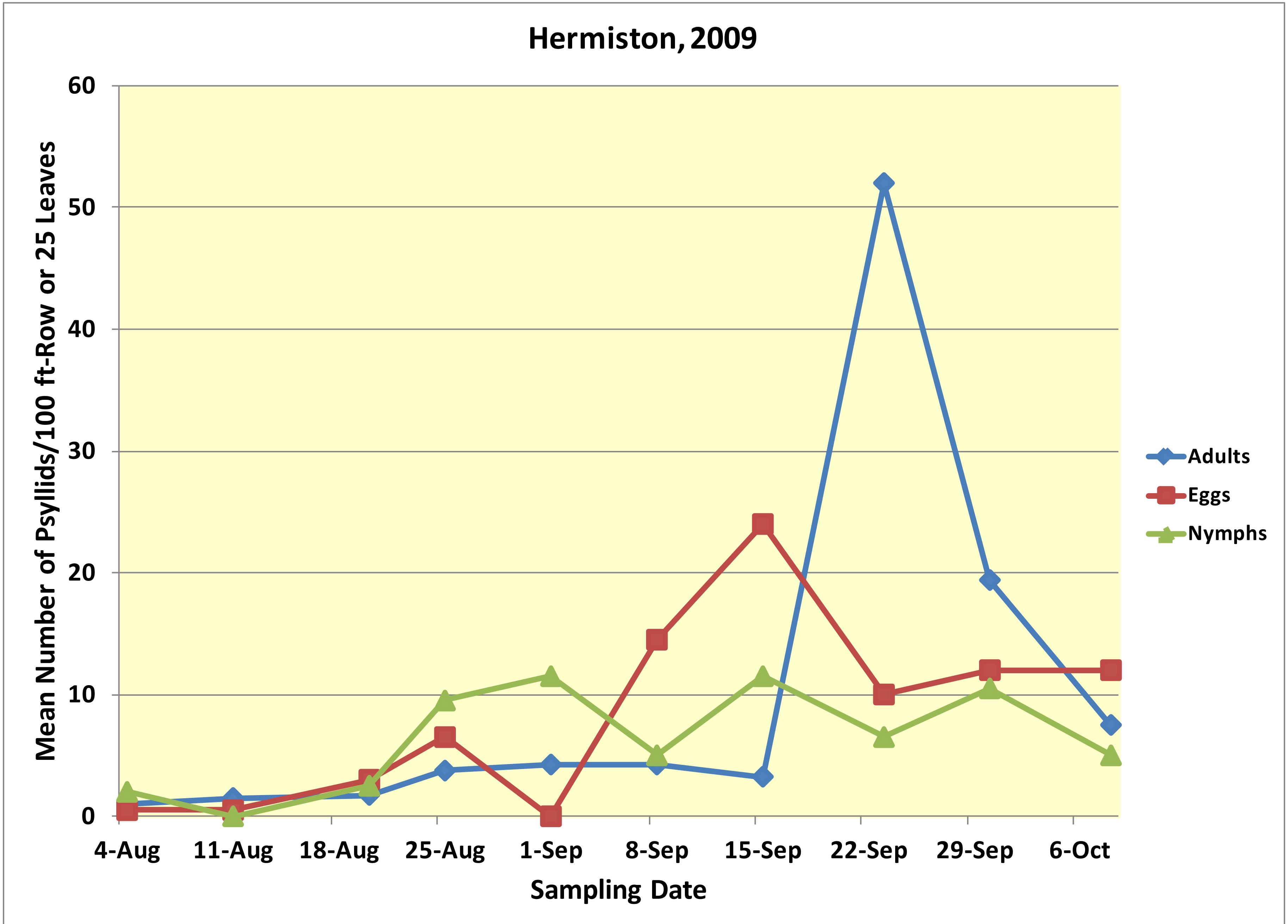


Moxee, 2011
Mean Number/100-ft Row or 25 Leaves
0
10
20
30
40
50
60
70
80
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
15-Aug
22-Aug
29-Aug
5-Sep
12-Sep
19-Sep
26-Sep
3-Oct
10-Oct
17-Oct
Sampling Date
Adults
Eggs
Nymphs

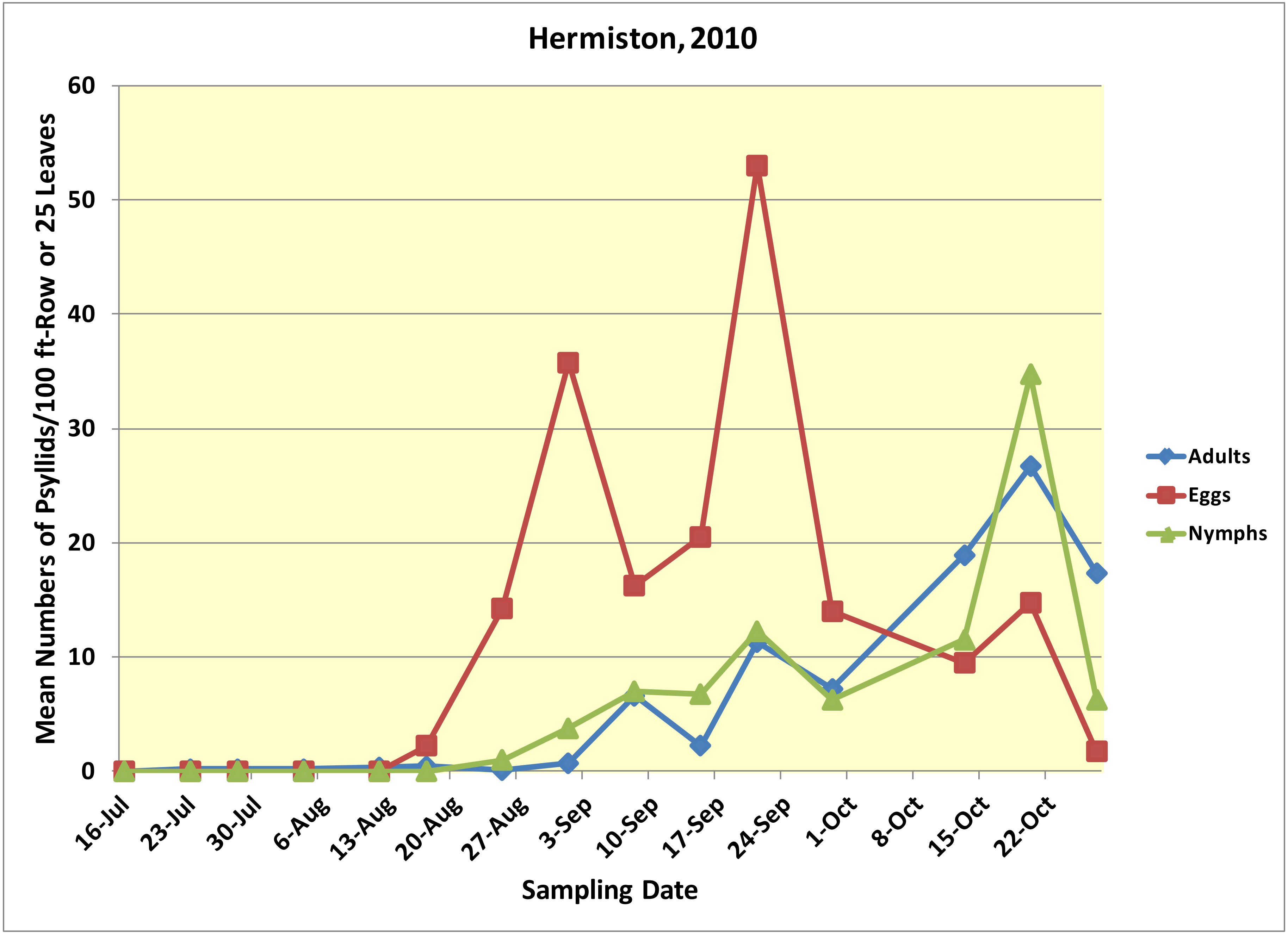

Prosser, 2008
Number of psyllids/100 sweeps or leaves
180
160
140
120
100
80
60
40
20
0
7/15
7/22
7/29
8/5
8/12
8/19
8/26
9/2
9/9
9/16
9/23
9/30
10/7
10/14
Sampling date
Adults
Nymphs



Prosser, 2011
Mean Number/100 ft-row or 25 leaves
700
600
500
400
300
200
100
0
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
21-Sep
28-Sep
5-Oct
12-Oct
Sampling Date
Adults
Eggs
Nymphs



Hermiston, 2009
Mean Number of Psyllids/100 ft-Row or 25 Leaves
0
10
20
30
40
50
60
4-Aug
11-Aug
18-Aug
25-Aug
1-Sep
8-Sep
15-Sep
22-Sep
29-Sep
6-Oct
Sampling Date
Adults
Eggs
Nymphs



Hermiston, 2010
Mean Numbers of Psyllids/100 ft-Row or 25 Leaves
0
10
20
30
40
50
60
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
1-Oct
8-Oct
15-Oct
22-Oct
Sampling Date
Adults
Eggs
Nymphs

Why Zebra Chip Absent in the Basin Prior to 2011?


Near McNary, WA
(September 2011)

Prosser, 2011-2012

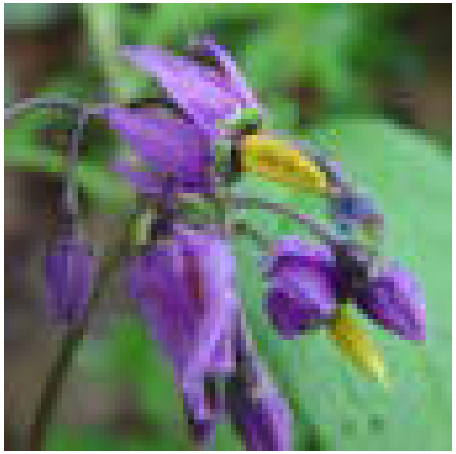
(< 40 miles from McNary field)

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!)



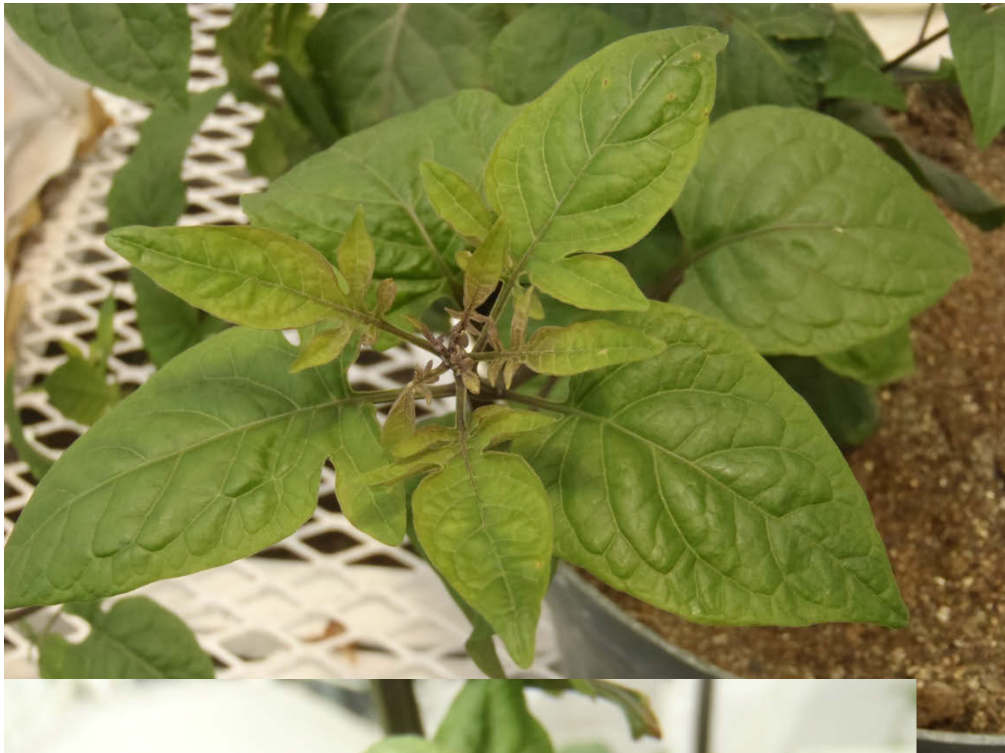
Bittersweet Nightshade

(Solanum dulcamara)

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)

Potato psyllid life cycle completed in about 3 weeks



Liberibacter infection symptoms about 3 weeks after inoculation with hot psyllids (Munyaneza Lab)

Lso Positive

2-3 months


Three months after Lso inoculation


Lso Negative
Lso Positive
1A
1B

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 <u>one</u> liberibacter-infected potato psyllid per plant can cause zebra chip after a relatively short inoculation access period (about 6 hrs)
- It takes about <u>3 weeks</u> 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)

Susceptibility of Selected Potato Cultivars to ZC

Cultivar	ZC Incidence in Plants (%)		Yield Loss (%)	
	2009	2010	2009	2010
Alturas	82.5	100	87.2	63.4
Atlantic	100	100	73.8	58.4
Ranger Russet	100	100	74.7	53.4
Russet Burbank	100	100	86.6	63.0
Russet Norkotah	100	100	63.4	62.7
Shepody	100	100	84.4	63.3
Umatilla Russet	100	100	49.9	62.1
FL 1867	89	100	55.5	53.2
FL 1879	100	100	61.7	62.0

Do Fresh Potatoes or Seed Spread ZC?

ZC-Infected Tubers

ZC-Free Tubers

FL 1867; 4 months; Room Temp (65-70 °F)


Wapato, WA
(2010)
Atlantic & Ranger Seed
Exposed to psyllids with
or without liberibacter

Liberibacter-free or psyllid yellows seed

Liberibacter-affected Seed (ZC)

Liberibacter-free or psyllid yellows seed

Liberibacter-affected Seed (ZC)

ZC/liberibacter-free plants

Plant Emergence Rate (2010-2011)

	ATLANTIC			RANGER		
Treatment	Emergenc rate (%)	Days to emergence	% ZC	Emergenc rate (%)	Days to emergence	% ZC
Controls	95.8 100 100	25.8 18 35	0 0 0	91.8 100 100	23 20 35	0 0 0
L-free Psyllids (PY)	95.8 100 100	23.9 18 35	0 0 0	95.8 100 100	24 18 35	0 0 0
Psyllids + Liberi (ZC)	12.5 5.5 0	53.3 35 70	0 0 0	0 5 0	--- 65 65	0 0 0
Liberibact alone (ZC)	25.8 16.7 0	52.7 29 65	0 0 0	4.2 22 0	64 65 74	0 0 0

Texas (2011)

Weslaco

Washington (2011)

Moxee Farm

Additional Varieties Trial (2011)

	Texas Trial		Washington Trial	
Cultivar	% Emergence	% ZC	% Emergence	% ZC
Norkotah	100	0	100	0
Norkotah (ZC)	0	0	0	0
Umatilla	95	0	100	0
Umatilla (ZC)	5	0	5.5	0
Shepody	100	0	75	0
Shepody (ZC)	0	0	0	0
Burbank	100	0	100	0
Burbank (ZC)	16	0	5.5	0
Alturas	100	0	100	0
Alturas (ZC)	0	0	0	0
FL1879	100	0	100	0
FL1879 (ZC)	0	0	0	0
FL1867	100	0	100	0
FL1867 (ZC)	0	0	22.2	0

Effect of Liberibacter Infection Timing

Cultivar	Texas Trial		Washington Trial	
Weeks < Harvest	% Emergence	% ZC	% Emergence	% ZC
Atlantic				
14 weeks (ZC+)	0	0	0	0
10 weeks (ZC+)	0	0	17	0
6 weeks (ZC+)	5	0	5	0
Control	100	0	100	0
FL1867				
14 weeks (ZC+)	0	0	60	0
10 weeks (ZC+)	0	0	55	0
6 weeks (ZC+)	28	0	17	0
Control	100	0	100	0

- 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

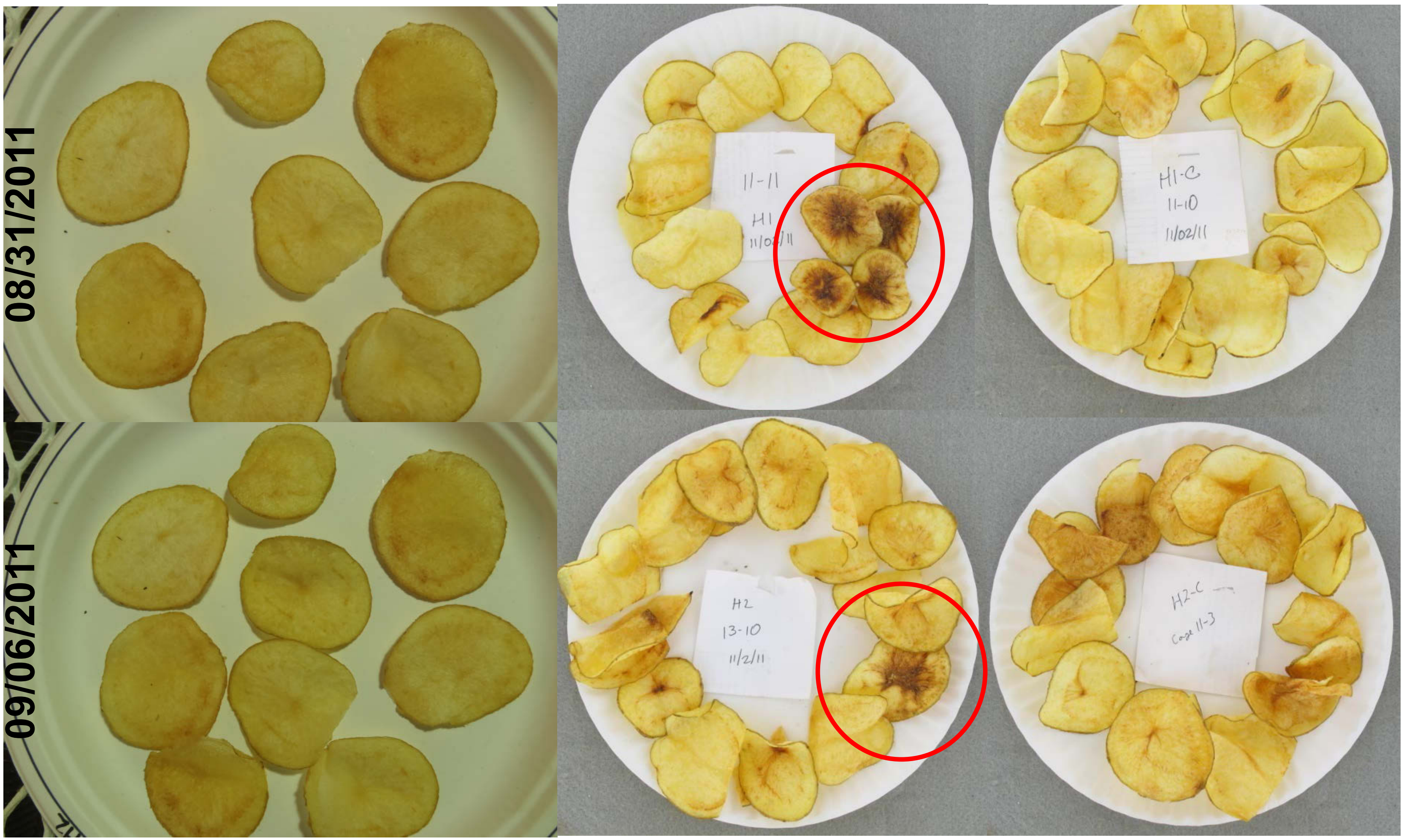
- All potato plant growth stages are susceptible to ZC
- Late (3 weeks or less before harvest) liberibacter infected potato plants usually result in symptomless plants and tubers
- Little is known about development of ZC symptoms in storage (important in the Pacific Northwest)
- Preliminary studies were initiated in Munyaneza lab (2010 & 2011; with Atlantic) to investigate the issue

Atlantic: Two Months in Storage (ZC: 10-22%)

Exposed | **Exposed** | **Control**

Harvested 08/31/2011

Harvested 09/06/2011



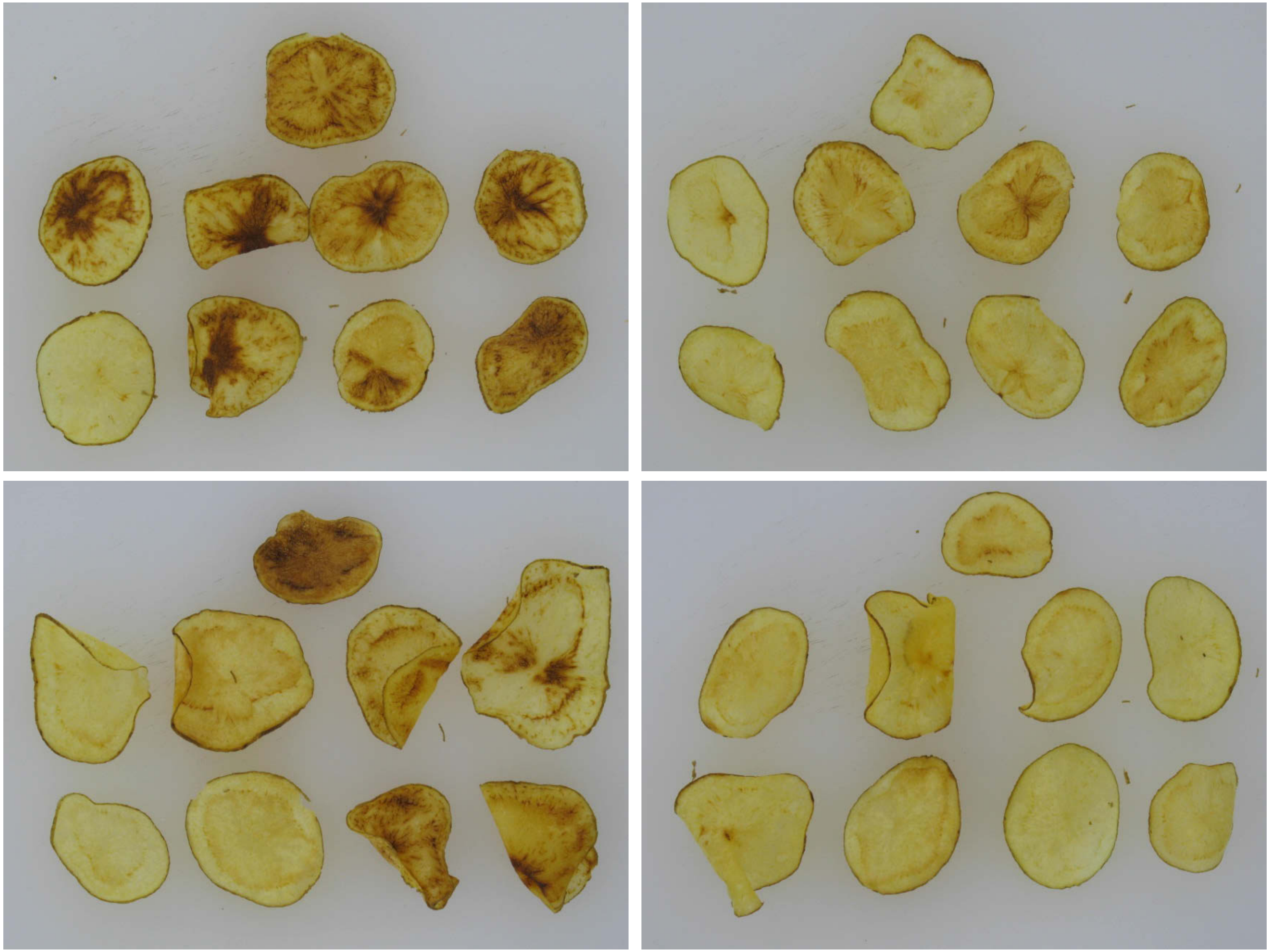
Fried at harvest

Fried after 2 months

Atlantic: Three Months in Storage (ZC: 46-66%)

Exposed

Control




Weslaco, TX
Atlantic
FL1867
FL 1879
Pike
Alturas
Burbank
Norkotah
Ranger
Umatilla
Moxee, WA

Potato Psyllid Monitoring and Management


02.12.2009 11:23


02.09.2009 12:47

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)
- Platinum (thiametoxam)
- Movento (spirotetramat)
- Agri-Mek (abamectin)
- Fulfill (pymetrozine)
- Knack (IGR)
- Venom (dinotefuran)

Oberon (LBI)
Beleaf (flonicamid)
Baythroid (cyfluthrin)
Leverage
Asana (esfenvalerate)
Rimon (IGR)
Radiant (spinetoram)

Visit: **http://zebrachip.tamu.edu**
https://www.fritolayag.com/public/zc/Goolsby_John_ZC2009.pdf

Use of Biorational Pesticides

- Some mineral and plant oils have shown excellent efficacy as repellent or oviposition deterrents
  - 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

Munyaneza, J.E. 2012. Zebra chip disease of potato: biology, epidemiology, and management. Am. J. Potato Res. 89:329-350 (Joseph.Munyaneza@ars.usda.gov or visit http://zebrachip.tamu.edu)

Potato Psyllid Control

- Chemical control options for the Pacific Nothwest, 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

- **Munyaneza, J.E. 2012. Zebra chip disease of potato: biology, epidemiology, and management. Am. J. Potato Res. 89:329-350**

Questions?

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