Potato zebra chip at the global level: Diagnostic and management options

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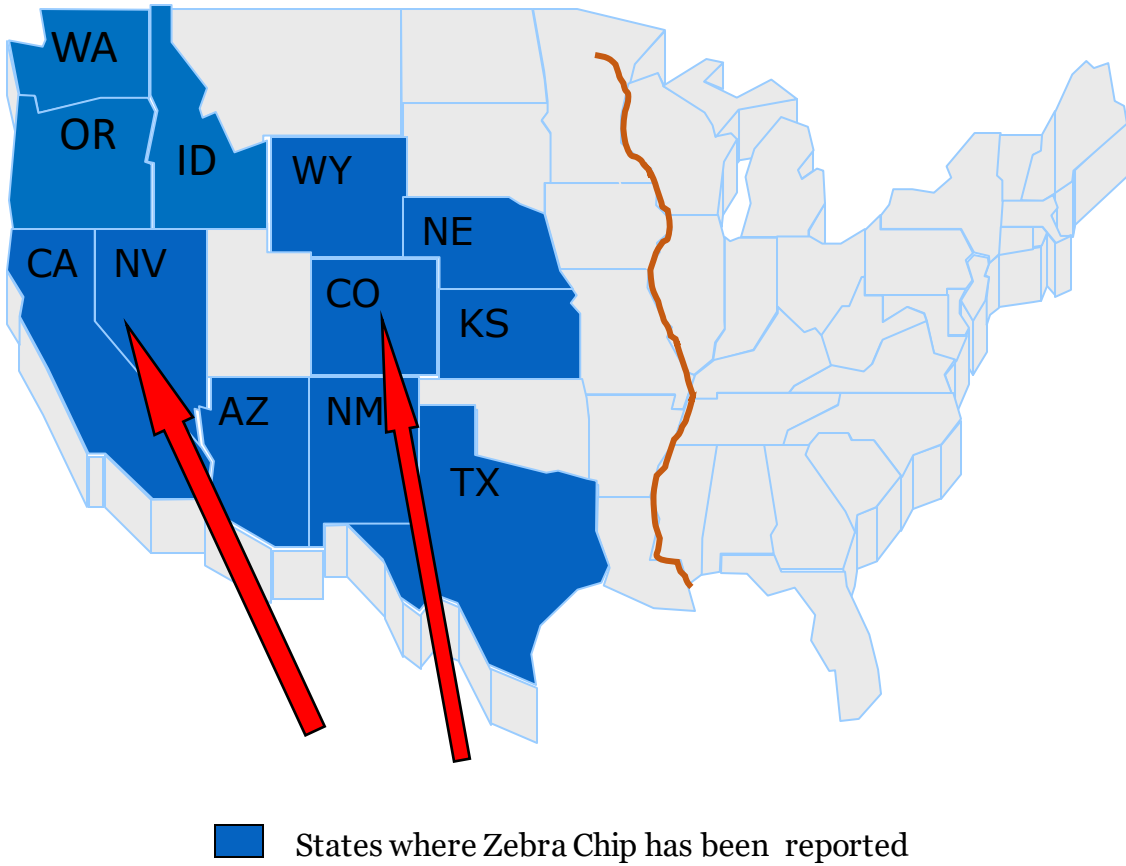
Andean Potato Emerging Pest and Disease Workshop
Lima, Peru
20-22 January 2020

NDSU NORTH DAKOTA STATE UNIVERSITY

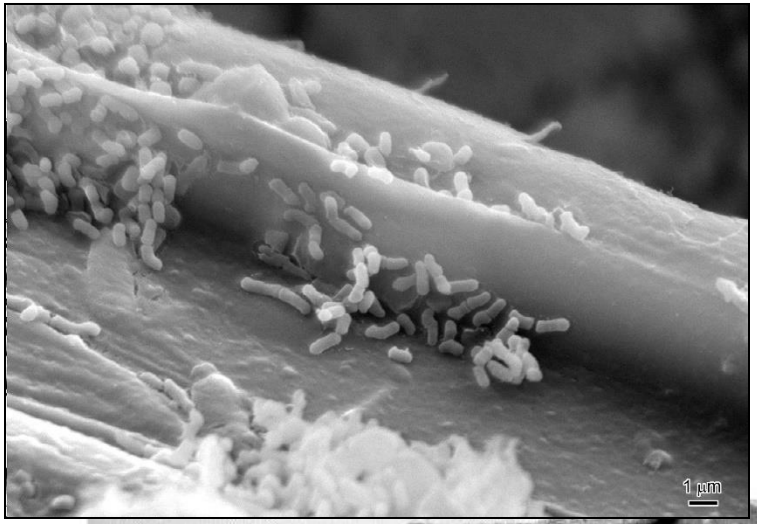
History

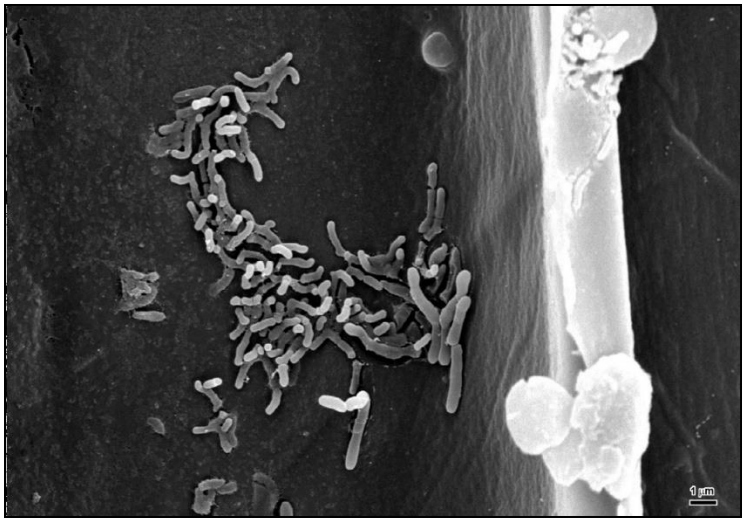
- Zebra chip is a disease of potato, first observed as a defect of potato chips in northern Mexico in 1994
  - Noticed by Sabritas
  - New disease
  - Cause unknown
  - Before molecular tools
- Results in darkened stripes or blotches in chips, hence the name
- Now we know it also affects fries and fresh quality

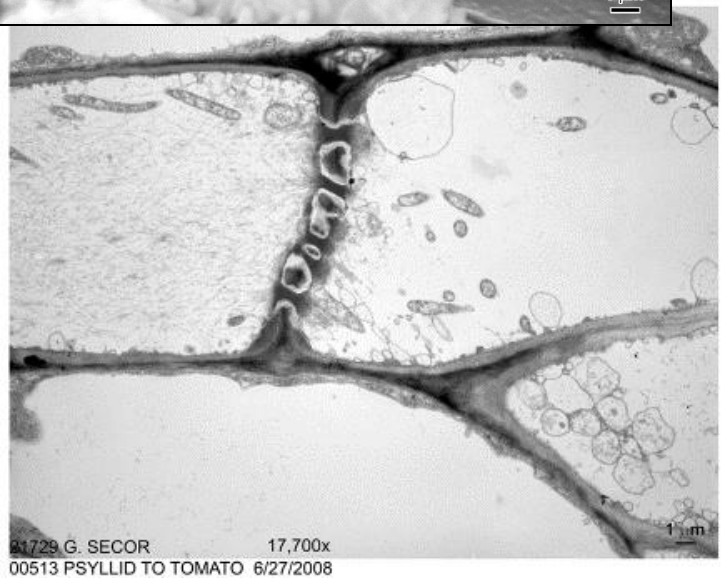
- Detected in the US in 2000
  - First in TX
  - Now in most western states
  - Not reported east of the Mississippi River in central US
- Also in
  - Mexico
  - Central America
    - Nicaragua, Honduras, Guatemala
  - New Zealand
- Not in south America??
- All market classes impacted
  - Seed
  - Fresh
  - Processing



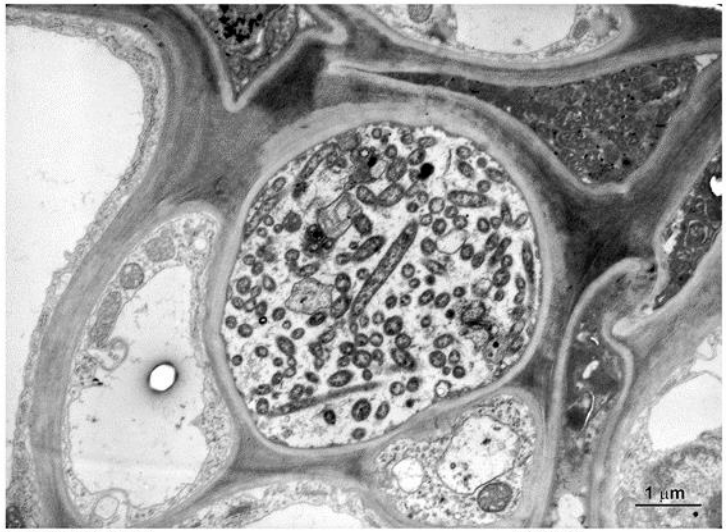
- First report in 2004 at ALAP meeting in Valdivia, Chile
- 2007 Munyaneza et al determined that ZC was associated with the potato psyllid *Bactericera cockerelli*
  - Strong association in Guatemala
- 2008 scientists in NZ (Liefting) and US (Hansen) established the association of ZC with a previously undescribed bacterium tentatively named *Candidatus* Liberibacter solanacearum (Lso) transmitted by the potato psyllid
  - Synonym C. Liberibacter psyllaurous proposed for tomato
  - Gram negative rod in Rhizobiaceae family
  - Lso is phloem restricted
  - Fastidious prokaryote that cannot be cultured
  - Now considered the cause but Koch's Postulates not fulfilled
  - Eight haplotypes reported, three in potato in the US (A,B,F)
  - Related to Huanglongbing/citrus greening bacteria







91729 G. SECOR 17,700x
00513 PSYLLID TO TOMATO 6/27/2008



17292 G. SECOR 23,500x
00514 BII C3 POTATO #802 GRAFT TO TOMATO, PETIOLE 6/23/2008

Tuber Symptoms

- Discoloration of medullary rays; ranging from mild to severe
- Affects the entire length of the tuber 'diagnostic symptom'
  - Can resemble leaf roll virus net necrosis, but net necrosis limited to vascular ring of the stem end

Tuber symptoms

Underground Symptoms

- Vascular browning and flecking of stems
- Enlarged lenticels of tubers and underground stems
- Visibly colored stolon attachment
  - ‘Pink belly button’

Foliar Symptoms

Resemble symptoms caused by Phytoplasmas and Fusarium wilt

- Swollen nodes
- Growth of axillary buds
- Aerial tubers
- Zigzag stems
- Leaf curling
- Stunting
- Yellowing
- Scorching
- Wilt

Field Patterns

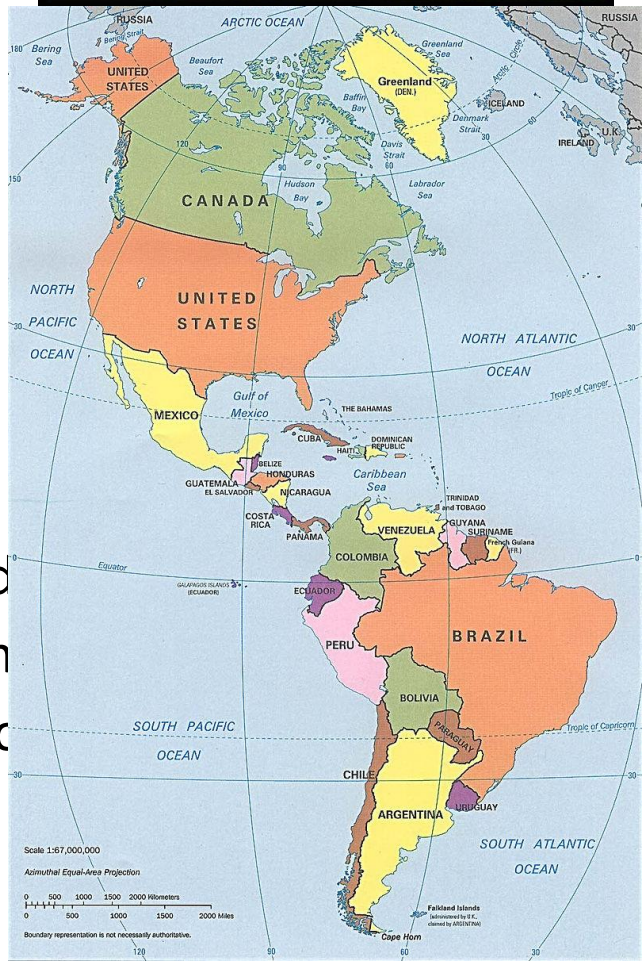
- ZC is not in traditional seed production areas
  - Infected tubers rarely sprout, or produce weak plants or hair sprouts
  - Seed does not contribute to epidemic (Rush et al)
- Sporadic in volunteer potatoes in TX
- All cultivars appear susceptible (so far)
- ZC usually appears as scattered plants or small clusters in the field, especially along edges of fields or pivot roads
- Can occur as larger coalesced areas

Host range

- Host range includes the solanaceous plants potato, tomato, pepper, eggplant, Physalis (ground cherry), tamarillo, Datura, silver nightshade, Physalis peruviana (cape gooseberry), wolfberry (Lycium barbarum, matrimony vine)
  - And carrot, parsnip and celery in Europe
  - Different psyllid vectors, not B. cockerelli

Transmission and Spread

- Lso transmitted only by potato/tomato psyllid *Bactericera (Paratrioza) cockerelli*
- The potato psyllid is native to North America and occurs in Central America north to southern Canada
- Present in Central America
  - (Guatemala, Honduras, Nicaragua)
- Overwinters in desert areas along the border between USA (Texas to California) and Mexico and Central America
- In the US the insect migrates annually with wind and warm temperatures in late spring and summ to northerly regions as far as British Columbia to Manitoba in Canada



Potato psyllid adults


Feeding nymphs


Mature instar with wing pads


Egg


Adult

Psyllid transmission details

- Transmitted by adults and nymphs
  - Persistent, propagative, circulative
  - Piecing-sucking mouthparts
  - Nymphs don't move much; adults spread
- Feeding time to successfully transmit disease is one hour
    - Transmission rate of 20%
    - Two hour feeding transmission rate is 50%
    - Four hour feeding transmission rate is 100%
    - Two week latent period from acquisition to transmission
    - Reduces fitness of the psyllid vector
- Three weeks from transmission to tuber symptoms
- Optimum temperature 25 to 30 C
- Lso probably multiplies in the psyllid
  - Implies psyllid able to transmit for the entire life of the psyllid
  - Implies passage through eggs; not 100%
  - Reduces importance of "between season" hosts

Munyaneza et al

Liberibacter-free psyllids (particularly nymphs) can induce foliar symptoms ("psyllid yellows") similar to those of zebra chip and potato purple top, especially early

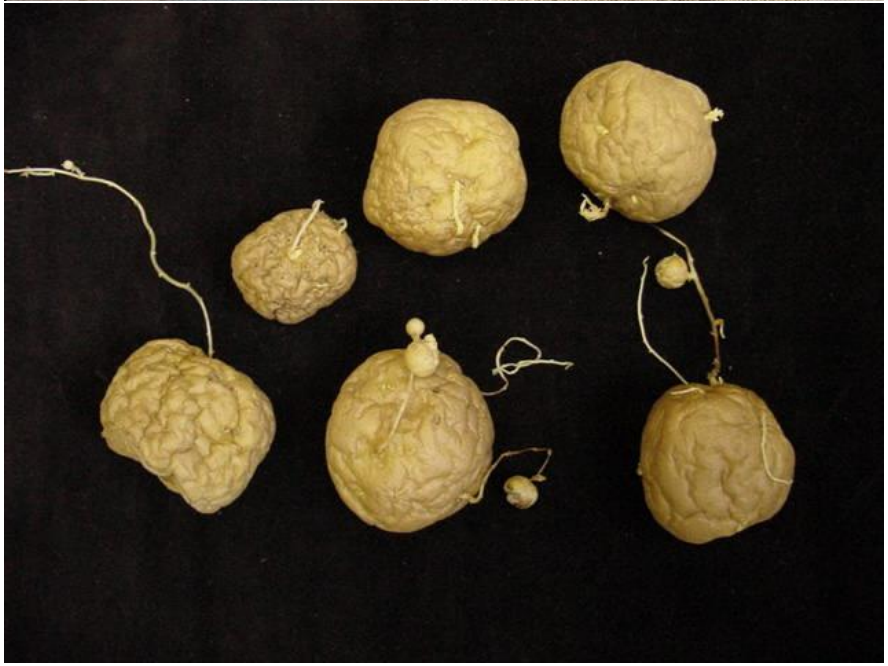
Psyllid feeding causes psyllid yellows

- Psyllid yellows resembles ZC but is distinct from ZC
  - Cause not known
  - Foliar symptoms similar to ZC and phytoplasma diseases
  - Psyllid yellows does not cause serious tuber necrosis
  - Does reduce yield
  - Does affect quality of raw and chips
  - Tubers from psyllid yellows affected plants do not appear to affect seed germination or normal plant growth from seed

Transmission by Grafting

- From potato to potato
  - Multiple sequential generations
- Also from potato to tomato
  - Phytoplasma like symptoms
  - Stunted plants, small leaves, purpling
- And from tomato back to potato

- Seed transmission <u>is not</u> important
- Infected seed does not emerge or emerges with hair sprouts
- Not a source of inoculum

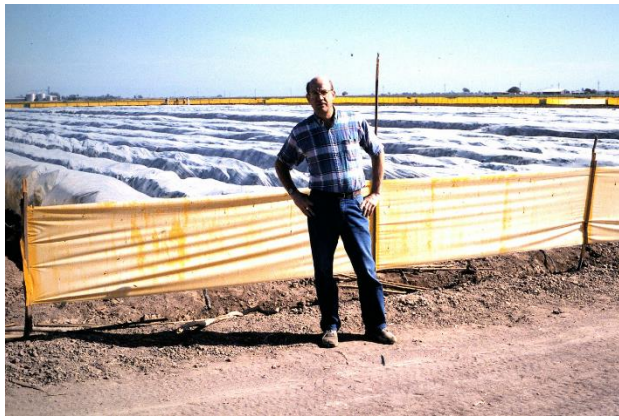


Detection of Lso

- Grafting too slow but reliable
- Electron microscopy too expensive and difficult
- PCR test easy, reliable, fast and most frequently used
  - Conventional or qPCR
- Primer combination Clipo/O12c has been most reliable
- No false positives
- Best tissue to use is stolons > broken axillary buds > petioles > tuber stolon end > whole tuber
- Can be used to test psyllids
  - Adults, nymphs, eggs
- Psyllid yellows test negative

Management

- Field scouting
  - Sweep nets
  - Other solanaceous crops – tomato and pepper
- Psyllid monitoring
  - Yellow sticky cards best
  - In 2009, thousands of psyllids tested for Lso incidence < 1% (Crosslin and Munyaneza)
  - Psyllids overwinter locally in TX, especially on wolfberry (*Lycium barbarum*) and other solanaceous plants
  - Immigrant psyllid population from Mexico is most important for establishing ZC epidemics
  - Mexico grows three hosts of ZC – potato, tomato, pepper
  - There may be psyllid forecasting systems
- Barriers
  - Psyllid proof netting
  - Oil covered plastic sheeting
  - Surround kaolin clay that irritates psyllids
- Resistance
  - No psyllid or Lso resistant potato varieties from US potato breeding programs
  - Mexican cv Citlali reported resistant



Extreme ZC management in Mexico 1994

- Insecticides
  - Insecticide scheduling can manage psyllid numbers
  - Cost ~700 USD/ha
  - Kills beneficial insect predators
  - Resistance development
  - No organics

Some of the Insecticides Commonly Used to Control Potato Psyllids in Texas

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

- Mineral oils help
- Foliar application rotations during the season of Venom, Oberon , Movento, Fulfill, Beleaf, Agrimek, Leverage, Spintor
  - Leverage, Venom; mixed results on control Leverage, Venom; mixed results on control
  - Agrimek has good adult knockdown but short persistence
  - Oberon, Movento, Endigo for third instar nymphs
  - Fulfill, probably Beleaf, have good activity against early nymphal stages
  - Need to reduce eggs, nymphs, adults and ZC
  - Ring the field with insecticide
  - Psyllid nymphs on bottom of leaves; need to apply so leaf bottoms exposed to insecticide

Insecticide Rotation Trial

Appl #	Insecticide Rotation				Ranking
1	Admire Pro	Oberon	Agri-Mek	Radiant	***
2	Platinum	Agri-Mek	Radiant	Fulfill	***
3	Movento	Radiant	Oberon	Knack	***
4	Rimon	Fulfill	Agri-Mek	Movento	***
5	Knack	Movento	Knack	Agri-Mek	***
6	Fulfill	Rimon	Fulfill	Oberon	**
7	Radiant	Knack	Movento	Fulfill	***
8	Agri-Mek	Fulfill	Rimon	Movento	***
9	Oberon	Movento	Radiant	Agri-Mek	***

https://www.fritolayag.com/public/zc/LiuTX_ZC-Report.pdf

The future

- Will climate change affect the timing and frequency of psyllids in the Andes and the likelihood of ZC??
- Migration pattern changes with temperature and wind patterns??
- No evidence of Lso in potato plants in NW South America
- Continue monitoring
- Questions and comments are welcome