Management of Zebra Chip in the USA

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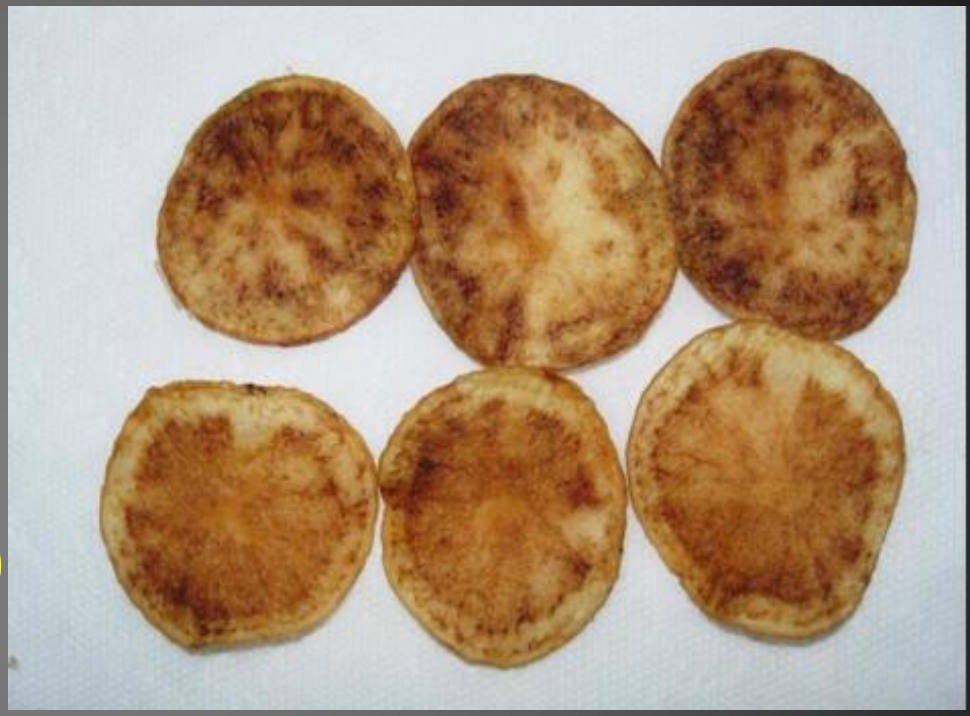
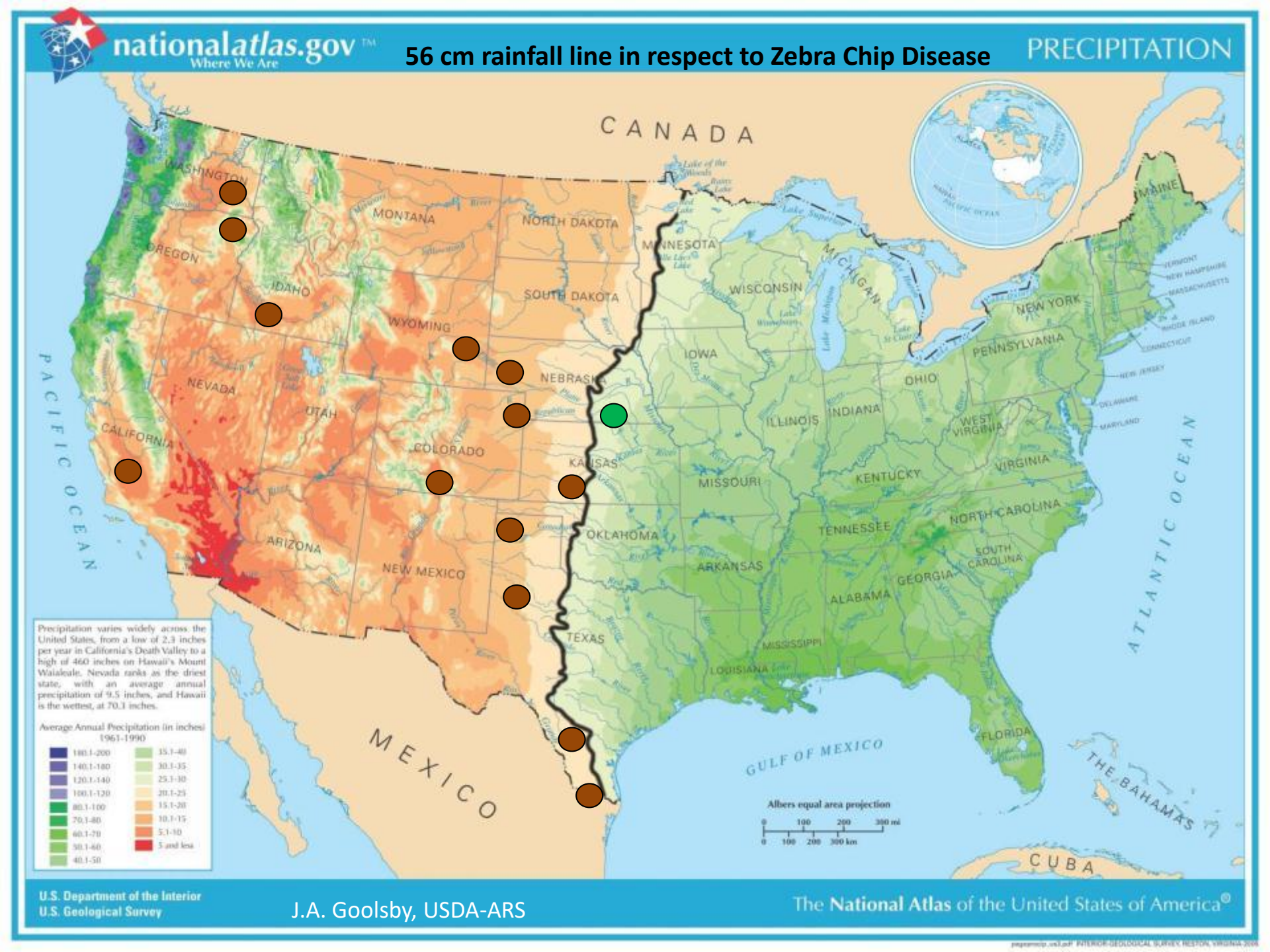
Zebra Chip Disease of Potato

- Putative pathogen is *Candidatus* Liberibacter solanacearum (CLso)
- In the USA, three haplotypes of CLso, A, B, & J; only A in NZ
- Tomato-Potato psyllid (TPP) *Bactericera cockerelli (Bc)* vectors CLso
- Three haplotypes of Bc; central, western, northwestern




nationalatlas.gov
Where We Are
56 cm rainfall line in respect to Zebra Chip Disease
PRECIPITATION
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
CALIFORNIA
KANSAS
IOWA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
MAINE
MISSOURI
WEST VIRGINIA
KENTUCKY
VIRGINIA
NORTH CAROLINA
TENNESSEE
SOUTH CAROLINA
OKLAHOMA
ARKANSAS
GEORGIA
ALABAMA
MISSISSIPPI
TEXAS
LOUISIANA
FLORIDA
ARIZONA
NEW MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
THE BAHAMAS
CUBA
Precipitation varies widely across the United States, from a low of 2.3 inches per year in California's Death Valley to a high of 460 inches on Hawaii's Mount Waialeale. Nevada ranks as the driest state, with an average annual precipitation of 9.5 inches, and Hawaii is the wettest, at 70.3 inches.
Average Annual Precipitation (in inches) 1961-1990
180.1-200
140.1-180
120.1-140
100.1-120
80.1-100
70.1-80
60.1-70
50.1-60
40.1-50
35.1-40
30.1-35
25.1-30
20.1-25
15.1-20
10.1-15
5.1-10
5 and less
Albers equal area projection
0 100 200 300 mi
0 100 200 300 km
U.S. Department of the Interior
U.S. Geological Survey
J.A. Goolsby, USDA-ARS
The National Atlas of the United States of America®

Other Hosts for TPP in USA

- Tomato & potato principle and economically important hosts
- Capsicum peppers & eggplant reproductive hosts
- In nature, matrimony vine (*Lycium barbarum*) and silverleaf nightshade (*S. elaeagnifolium*) are important perennial overwintering hosts for TPP and CLso

Matrimony Vine

Silverleaf Nightshade

A- Early ZC

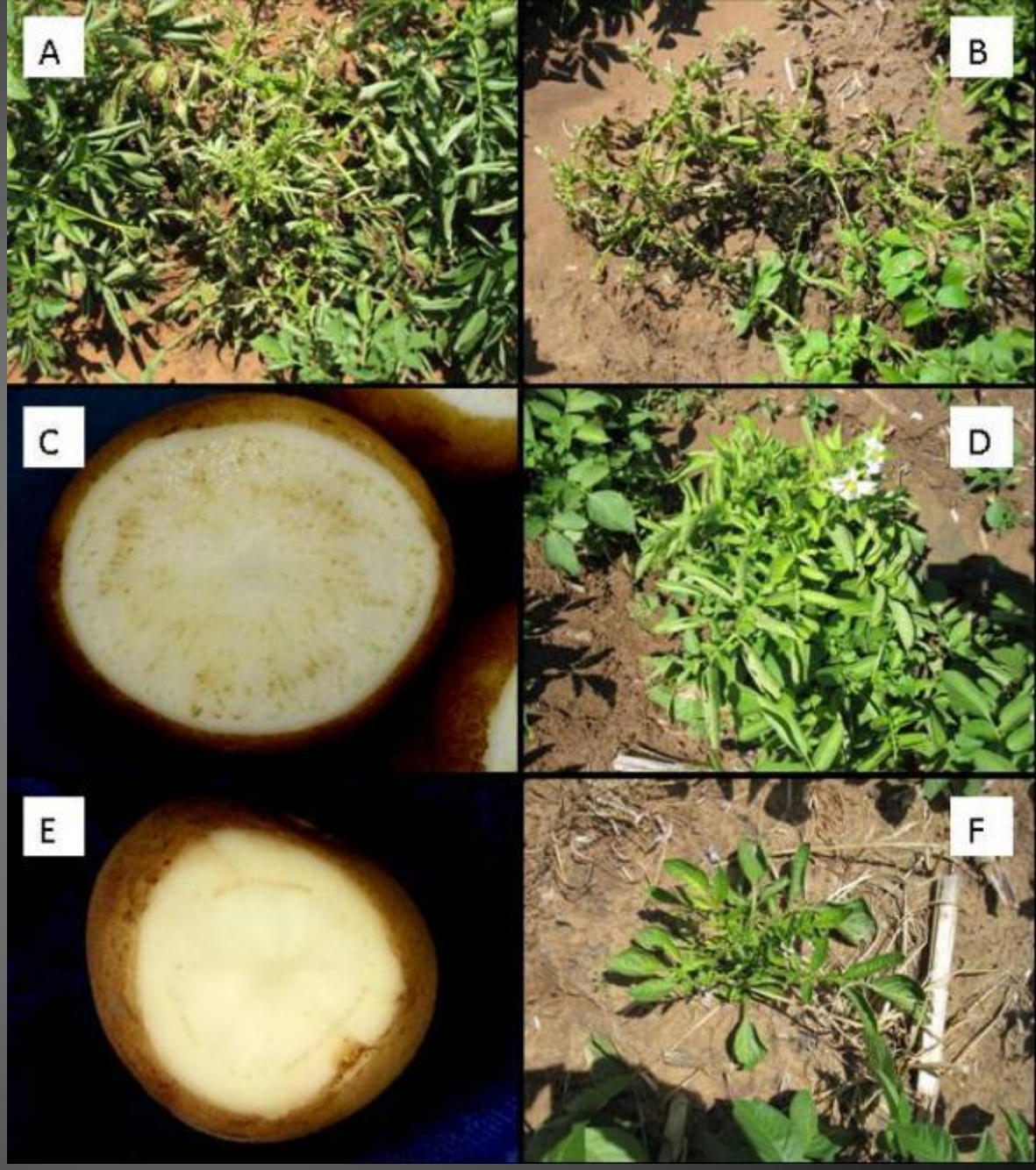
B- Advanced ZC

C- Tuber symptom ZC

D- Psyllid Yellows

E- Vascular ring due to PY

F- Seedborne ZC, (haywire)



Potato Psyllid Lifecycle

Eggs (5 days)

Nymphs 3 weeks

Adults (1 week)

1 month lifecycle

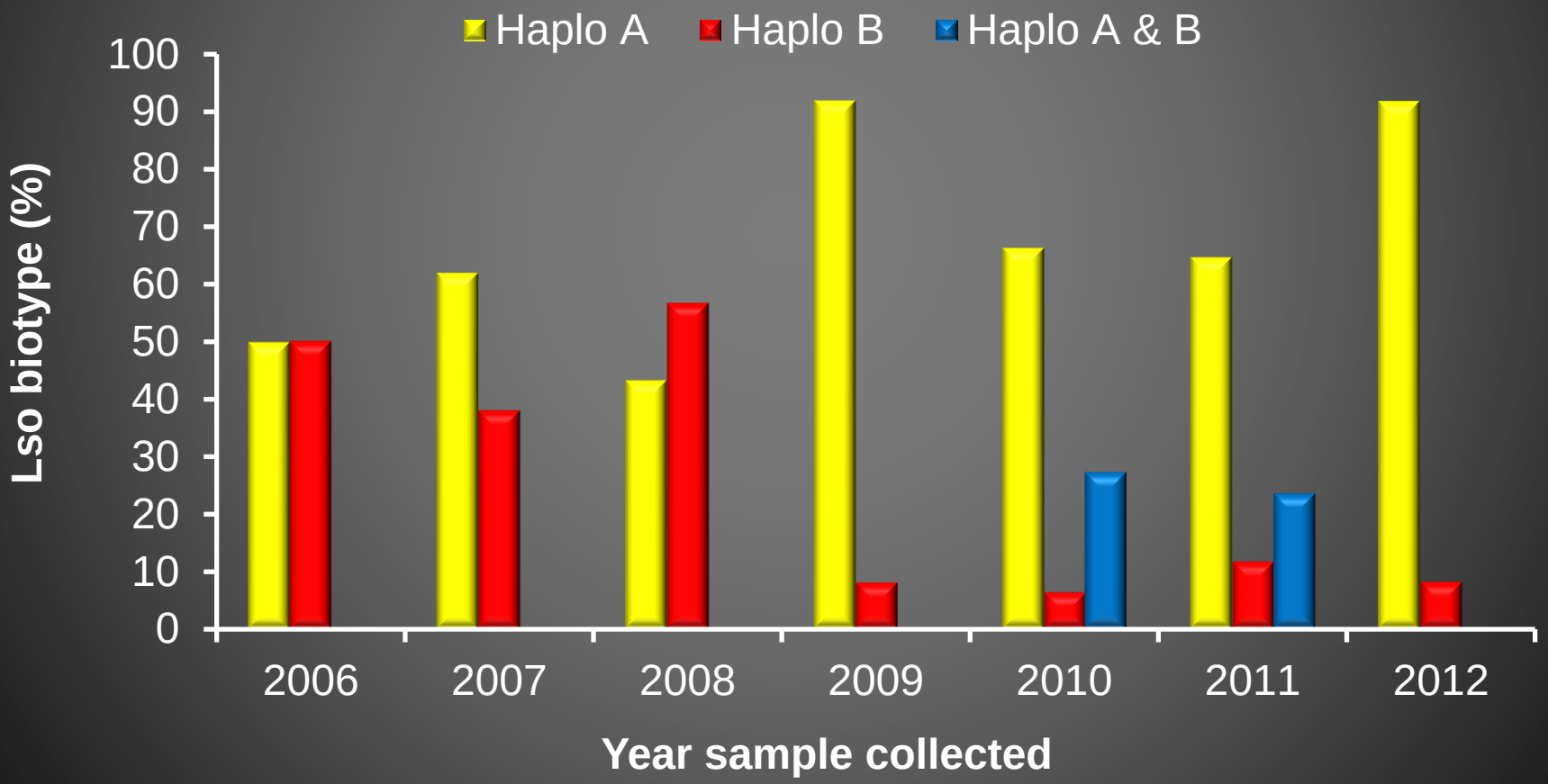

SEP 15 2005

ZC in 2018

Cluster of ZC Infected Plants

ZC Caused by Haplotype A

Total Spatial-Temporal Distribution of Lso Haplotypes

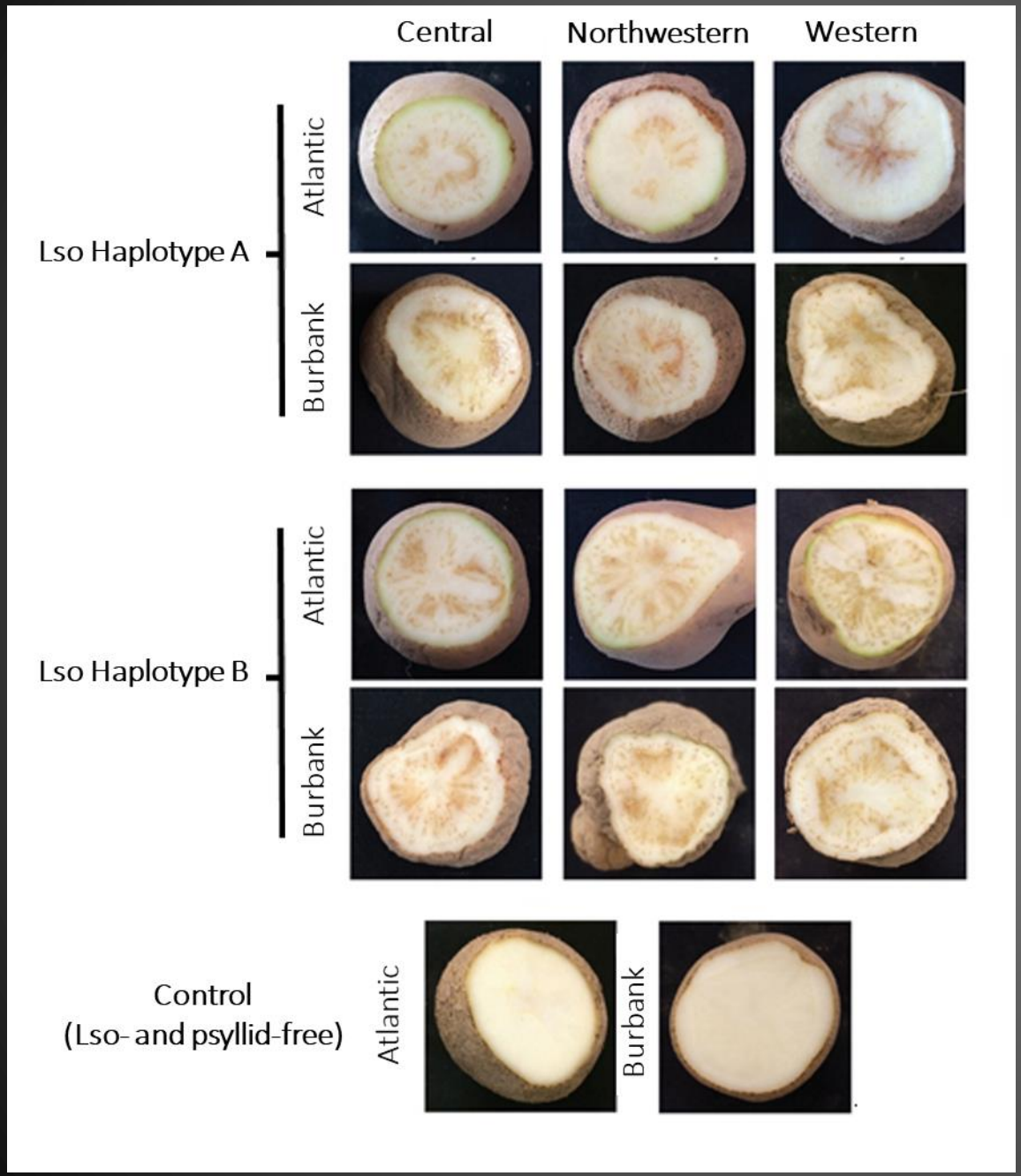


Wen, et al. 2013. AJPR

Haplotype A vs B

Haplotype A Field Symptoms

Haplotype B Field Symptoms

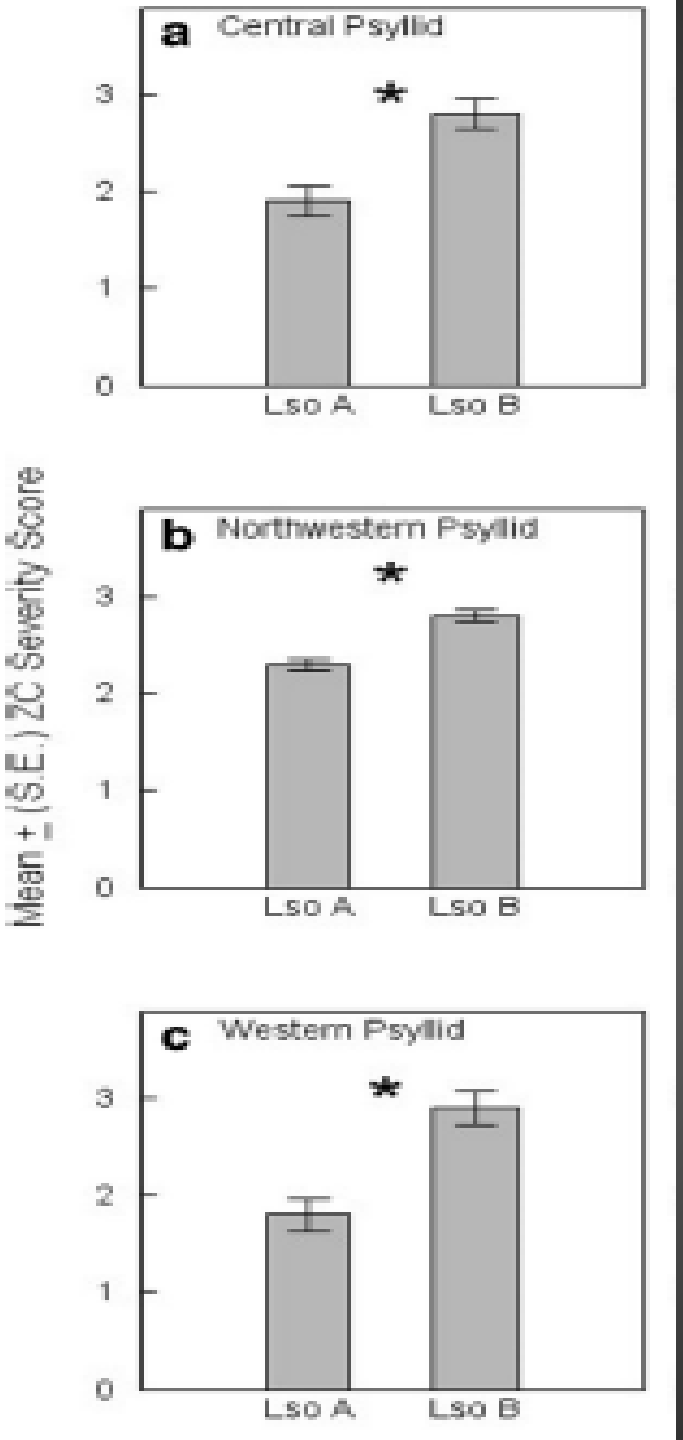


The most severe ZC tuber symptoms caused by haplotype A and B CLso transmitted by three haplotypes of TPP.

Swisher et al. 2018
AJPR

Psyllid & Clso Haplotype Interactions- Tuber Disease Severity

- Tuber disease severity between CLso haplotypes transmitted by three psyllid haplotypes
- Disease severity averaged across seven potato cultivars
- Disease severity scored using a 0-3 scale
  - 0= no disease
  - 1= Mild disease symptoms
  - 2= Moderate symptoms
  - 3= Severe symptoms
- Psyllid haplotype did not affect disease severity



Swisher et al. 2018 AJPR

ZC Management in the USA

- Cultural Practices:
  - Avoid highly susceptible varieties if possible; highly susceptible cultivars such Atlantic have been discontinued
  - Delay planting; psyllids emerging from overwintering hosts tend to have higher frequencies of Lso
  - Plant field edges (8-12 rows) in a circular pattern so they can be harvested separately if necessary
- Monitor psyllid population throughout season; trap adults in field and along field edges, leaf samples for nymph stages, adults assayed for Lso frequency (higher frequency early season)
  - High adult numbers trigger knockdown with specific insecticides; stage of nymphs also affects choice

Economic Management of ZC

Planting field perimeter in a perpendicular (circular) direction permits the harvest of highly ZC-infected potatoes for market segregation.

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Psyllid Monitoring

Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid	Date	Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid	Date	Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid	Date	Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid	Date
115	B2,A4	GR	7	6	0	11	10-Jul	115	S1	GR	6	4	0	92	17-Jul	115	TR1,A5	GR	54	32	1	179	24-Jul	115	T1	GR	77	118	12	345	1-Aug
115	11		3	2		12	10-Jul	115	9		6	0		118	17-Jul	115	156		137	1		116	24-Jul	115	71		85	9		202	1-Aug

Adult psyllid numbers tend to be higher on field perimeters. Increases in either nymphs or adults triggers modifications in insecticide use!

ZC Management in the USA

- Insecticides active on TPP:

  - **Neonicotinoids**- effective early season, some resistance to 4A subgroup, 4C sulfoxaflor superb on all nymph instars
  - **Abamectins-** primarily effective on adults (group 6)
  - **Pymetrozine & Flonicamid-** feeding blockers, effective on small nymphs, 1st & 2nd instars (groups 9B & 29, respectively)
  - **Tetronic & Tetramic acid derivatives-** highly systemic, effective on all nymph instars (group 23)
  - **Tolfenpyrad-** active only on adults (group 21A)
  - **Cyazypyr-** active only on 1st instar (group 28)

ZC Management in the USA cont'd

- It is important to remember that in a number of potato production areas in the USA, TPP needs to be managed in the absence of CLso and ZC as it is an insect pest on its own!

- Ring fields with insecticide to reduce psyllids from achieving residency in your field

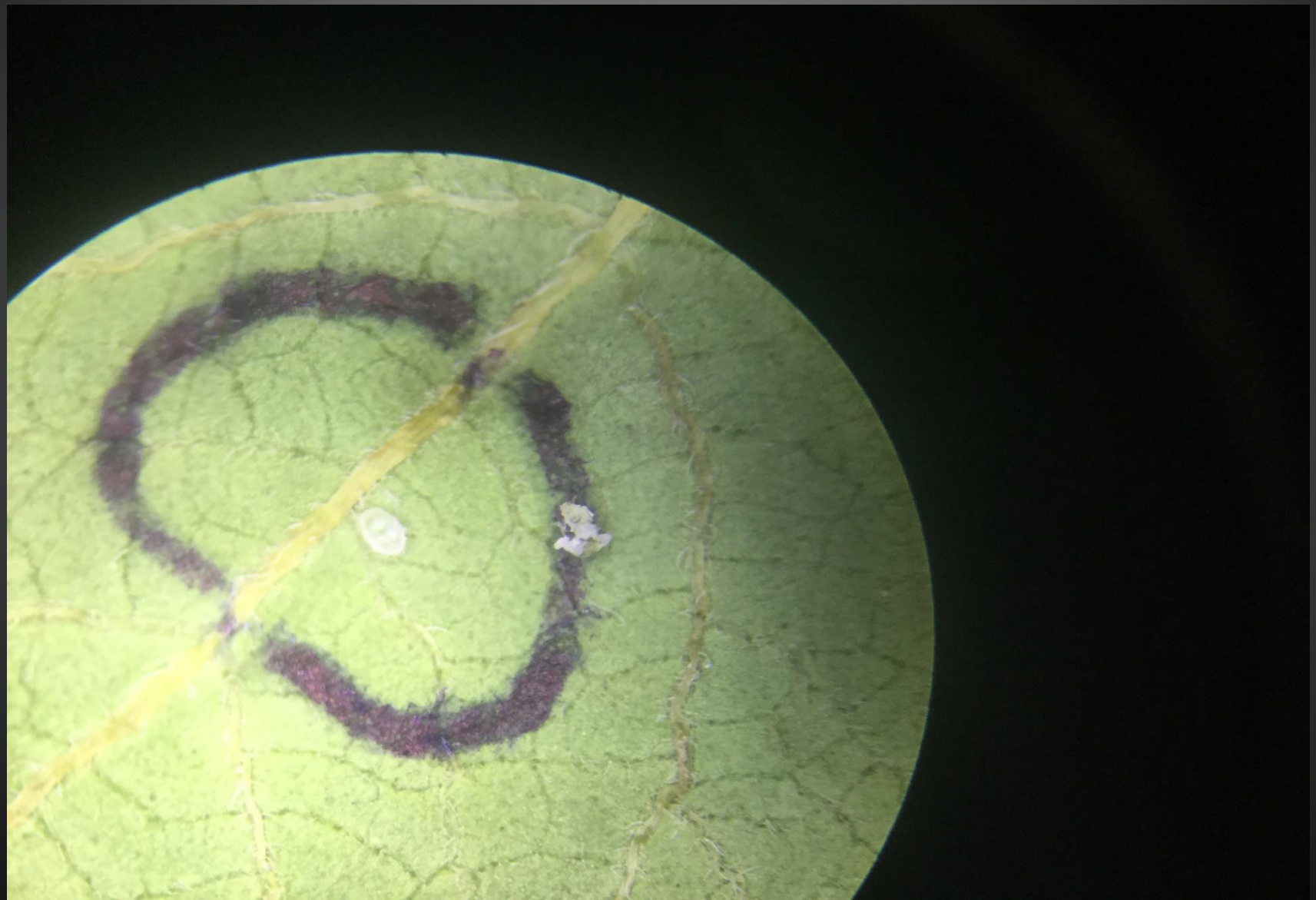
- Pyrethroids can flare TPP populations- AVOID!

ZC Management in the USA cont'd

- Biological alternatives used to manage TPP:

  - ***Chromobacterium subtsugae* strain PRAA4-1**- active on all nymph stages but usually used at end of season due to cost
  - ***Beauvaria bassiana*-** strain SP120 appears to be most active on psyllid nymphs, applied IF primarily, endophytic
  - **Minute Pirate Bugs-** applied typically 2-3 times a year, predators that appear to take pleasure in killing psyllids
  - **Hydrolyzed fish waste-** horrible smell, may mask volatiles given off by potato that attract TPP adults
  - **Kaolin-** adults do not appear to like landing on treated foliage

Beauvaria bassiana



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In-Season Insecticide Plan

- Adult influx of TPP begins prior to emergence. Weekly sticky traps are sent to lab either on- or off-farm. Adult numbers determined and then sent off for Lso testing.
- All insecticides applied in pairs (back to back) before moving onto another chemistry except with seed trt/IF insecticides.

  - A neonicotinoid applied IF at planting, or Bb applied as seed treatment or IF
  - The first post-emergence insecticide typically applied between 50-70% ground cover as early psyllid usually have a high frequency of carrying Lso, usually a group 9B or 29
  - Spirotetramat after 100% ground cover to take advantage of phloem systemicity

In-Season Insecticide Plan cont'd

- A number of insecticides are used either alone or in combination to manage increases in either a significant influx of psyllid adults or dramatic increases in eggs or hatches

  - An abamectin or tolfenpyrad may be used alone to knock down high adult numbers or in combination with other chemistry
  - Sulfoxaflor or flonicamid, depending on nymph instars present, used to knock down nymph numbers, frequently tank-mixed with tolfenpyrad or abamectin

Insecticide Modifications Due to Changes in Psyllid Stages

Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid	Date	Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid	Date	Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid
513	B1	GR	12	19	0	10	12-Jul	513	A3	GR				11		513						
296	B1	GR	7	9	0	21	10-Jul	296	B2	GR	29	2	0	18	19-Jul	296			29	2	0	21
375	G2	GR	10	17	0	17	11-Jul	375	B1	GR	18	11	0	16	20-Jul	375	A3	GR				
536	G2	GR	23	2	0	5	11-Jul	536	B1	GR	0	6	3	25	20-Jul	536	B2,A3,	GR	0	6	3	22
527	G2	GR	22	4	0	3	14-Jul	527	B1	GR	27	9	3	26	20-Jul	527	B2,A3,	GR	27	9	3	19
113	B1	GR	0	1	0	15	10-Jul	113		GR	91	27	1	10	17-Jul	113	B2,A3,	GR	17	4	1	53
231	B1	GR	2	0	0	10	11-Jul	231		GR	21	1	0	4	19-Jul	231	B2,A3,	GR	21	1	0	33
111	B2,A4	GR	0	0	0	17	10-Jul	111	S1	GR	5	2	0	35	17-Jul	111	TR1,A5	GR	13	32	3	93
115	B2,A4	GR	7	6	0	11	10-Jul	115	S1	GR	6	4	0	92	17-Jul	115	TR1,A5	GR	54	32	1	179

Insecticide Modifications Due to Changes in Psyllid Stages

Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid	Date	Field #	Chemical		Eggs	Small Nymph	Large Nymph	Traps Adult Psyllid
386	B2	GR	100	44	2	31	24-Jul	386	G2	GR	66	85	4	140
377	TR1,A3,	GR	185	28	3	40	25-Jul	377	TR2,A4,	GR	284	103	2	295
378	TR1,A3,	GR	248	52	2	27	24-Jul	378	TR2,A4,	GR	74	113	6	525
505	B2,A3,	GR	0	8	0	25	25-Jul	505	G2	GR	24	16	0	70
48	B2,A3,	GR	12	3	0	66	24-Jul	48	G2	GR	9	6	0	214

Summary/Conclusions

- The management of tomato-potato psyllids and zebra chip are a significant challenge in the USA
- Since 2010 there have only been sporadic economic losses due to ZC in the USA
- A primary reason that ZC has become of little economic importance is largely due to two factors:
  - Abandonment of the most ZC susceptible cultivars
  - Delayed planting to avoid TPP with CLso
- However, even in the absence of significant ZC, economic losses due to TPP are significant in several production areas such as CO, NE, OK, NM, & TX largely due to the cost of control

Thank You!

QUESTIONS?