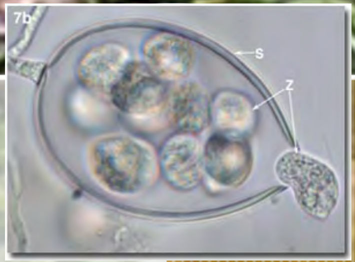
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada



From Top to Bottom: Disease Pressure on the PEI Potato Crop in 2016

Rick D. Peters

Agriculture and Agri-Food Canada, Charlottetown

February 15, 2017
PEI Potato Day, Summerside, PE

Canada

Symptoms of Late Blight *on Potato*

Symptoms of Late Blight *on Tomato*

Late Blight (*Phytophthora infestans)* Canadian Surveys

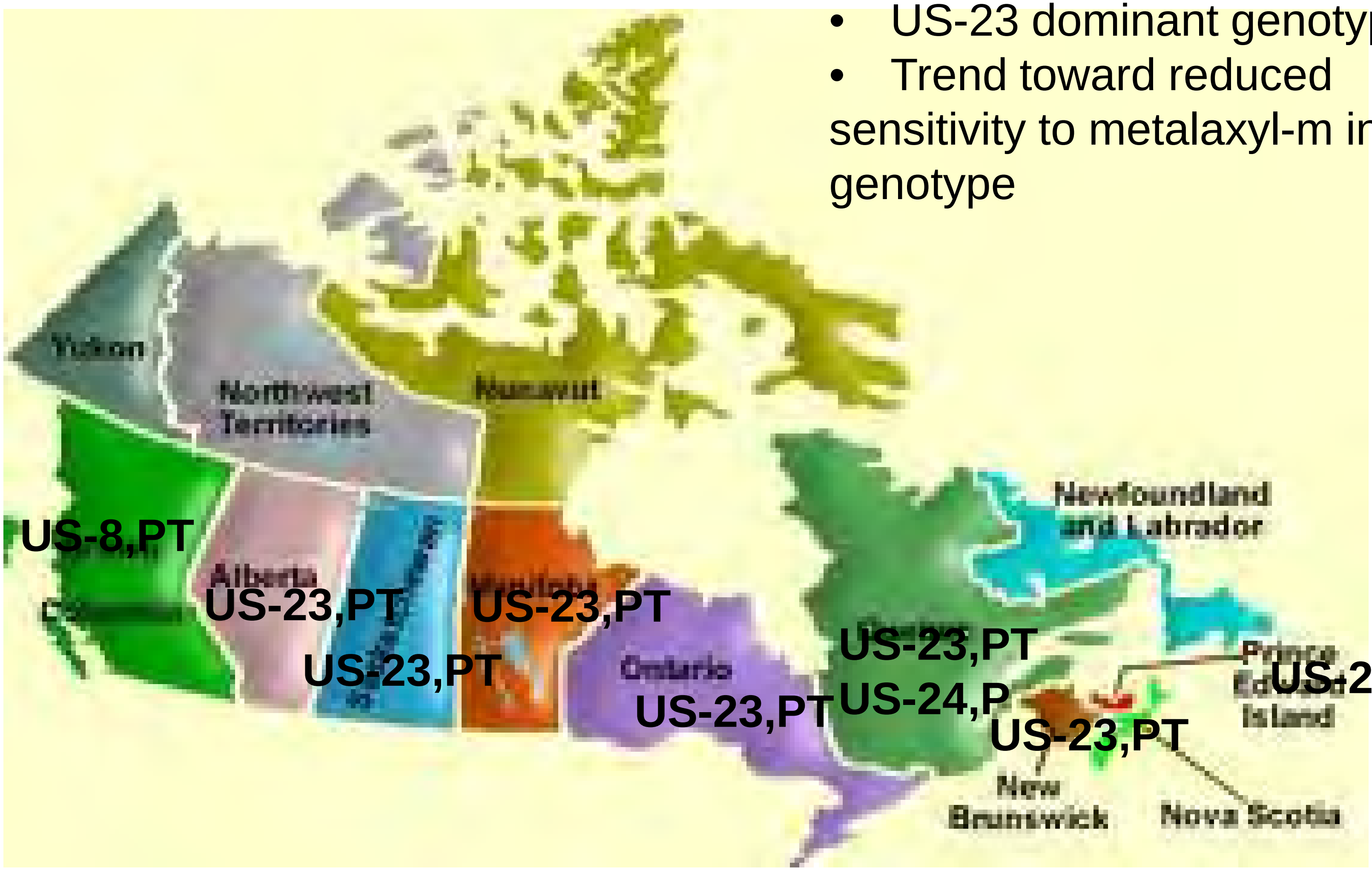
(Project ID: 1891; P347-CHC-Activity 1-3: Characterization and tracking of strains of the potato blight pathogen in CanadaL01 – Agri-Innovation Program – Industry-led Research and Development with Larry Kawchuk, AB

- samples of infected potato and tomato tissue collected and sent to closest researcher
- isolation of pathogen into pure culture
- isolates sent to:

Charlottetown	- mating type, metalaxyl sensitivity - allozyme genotype
Lethbridge	- DNA fingerprinting (RFLP with probe RG57)

Late Blight (*Phytophthora infestans)* 2015 and 2016 Canadian Surveys

- US-23 dominant genotype
- Trend toward reduced sensitivity to metalaxyl-m in this genotype



Late Blight (*Phytophthora infestans*)
Origin of New Genotypes in Recent Years

US-23,PT **US-24,P**

US-25,T

A1 + A2 =

Late Blight (*Phytophthora infestans)*
Origin of New Genotypes in Recent Years

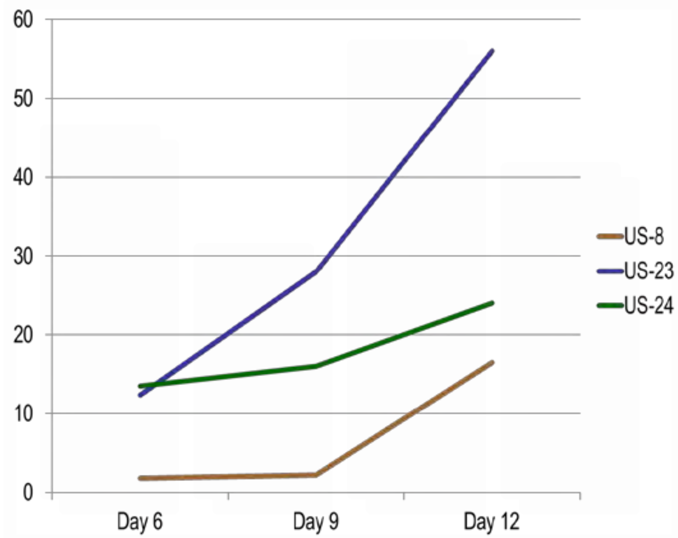
2013 Late Blight – Host/Genotype Interactions
Greenhouse Trials
Anne MacPhail and Marleen Clark

Hosts	Potato Tomato Pepper Petunia
Pathogen	*Phytophthora infestans* (US-8, US-23 and US-24)
Rating	% tissue diseased sporulation (0-3 scale)

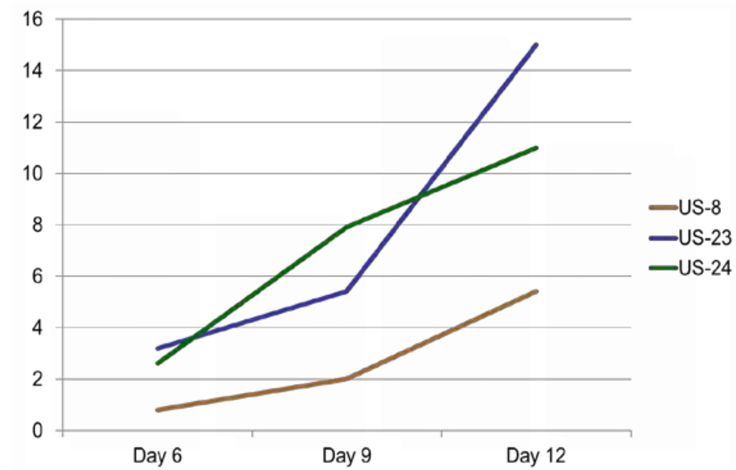
2013 Late Blight – Host/Genotype Interactions
Greenhouse Trials

2013 Late Blight – Genotype Aggressiveness Tomato

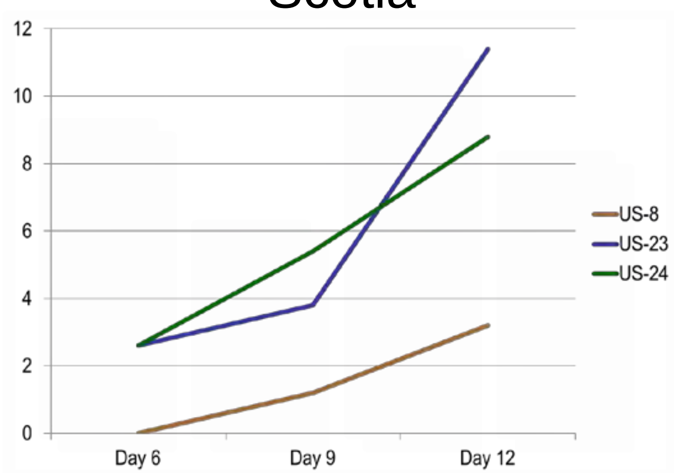
% diseased foliage



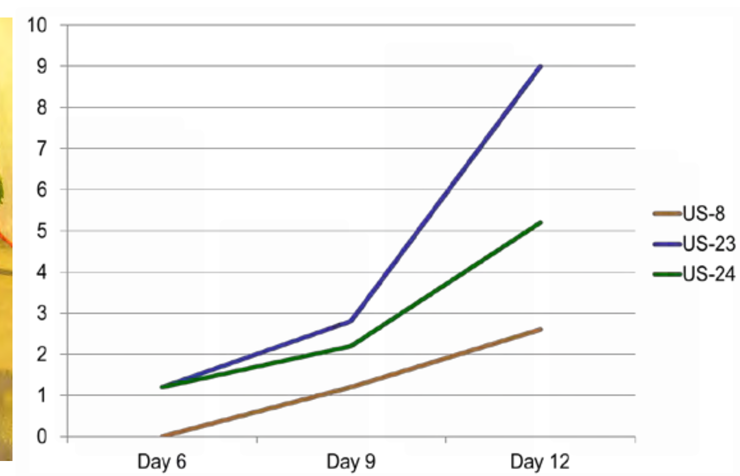
Scotia



Plum Regal



Defiant



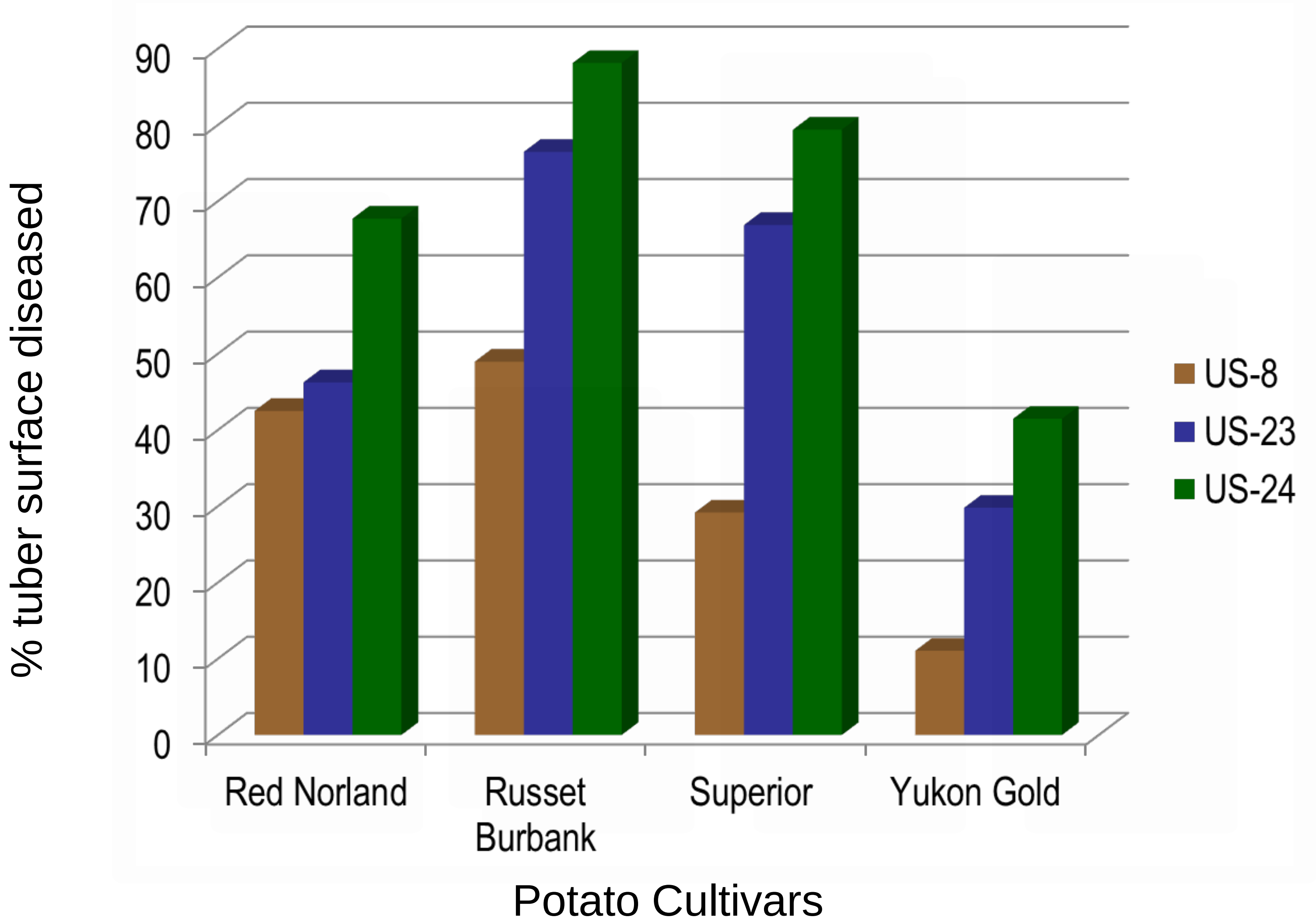
Mountain Magic

Days after inoculation

Potato cultivar inoculation trials: US-8, US-23, US-24

Anne MacPhail and Marleen Clark

2013 Late Blight – Genotype Aggressiveness
Potato Tuber Inoculations



Late Blight (*Phytophthora infestans)*

Summary Comments

- Genotypes vary in host preference and aggressiveness
- US-8 was most aggressive on potato foliage and less so on tomato foliage; conversely, US-23 was most aggressive on tomato foliage and less so on potato foliage; US-24 provided intermediate responses on both hosts
- Some genotypes could produce sporulating lesions on pepper and petunia
- All genotypes were very aggressive on potato tubers
- US-23 now predominant genotype in Canada, but each year, pockets of other genotypes occur, including recombinants
- Tomato varieties with genes for late blight resistance effectively suppress disease development (Mountain Magic, Defiant, Mountain Merit, Jasper, etc.)
- Epidemiology and disease management has been significantly altered following recent strain displacement wave

P. infestans - DISEASE MANAGEMENT

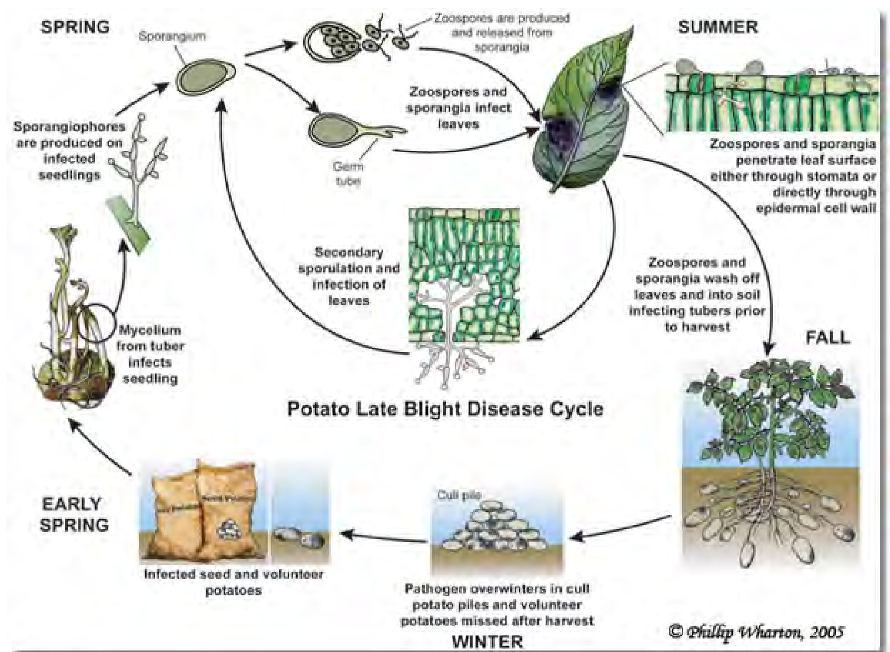
Alternate Hosts

- several plant species have been found to be susceptible to late blight
  - potato
  - tomato
  - pepper
  - eggplant
  - petunia
  - nightshades (climbing, hairy)
- do not plant near susceptible crops; destroy nightshade weeds

P. infestans - DISEASE MANAGEMENT

Sources of Inoculum – Infected Seed

- certified seed from a reliable source
- sporulation from seed pieces (spread to healthy during cutting)
  - grade out diseased seed (do not plant!)
  - disease is not spread by tomato seed (but transplants are a serious problem!)
  - seed treatments can be helpful



P. infestans - DISEASE MANAGEMENT

Manage Sources of Inoculum! – Volunteers

- destroy volunteer potatoes
- do not plant in fields where volunteers may be a problem

P. infestans - DISEASE MANAGEMENT

Manage Sources of Inoculum! – Cull Piles

- dispose of cull piles (as early as possible prior to June 15)
- burial (with permit), composting, covered and tarped, covered for feed
- sprouting not necessary for spore production!!!

P. infestans - DISEASE MANAGEMENT

Crop Scouting

- monitor crop health and alert to problems
- disease diagnostics service
- quick response needed if disease found
  - destroy affected plants and adjacent plants without symptoms

P. infestans - DISEASE MANAGEMENT

Late Blight Fungicides

- a preventative program that starts early in the season is critical
- good coverage is key
- frequent application to protect new foliage
- specialty products when weather conditions are conducive to disease and /or disease risk is high

P. infestans - DISEASE MANAGEMENT

Manage Late Blight in Tomatoes!

- Look for disease in transplants (industry and home-owner awareness)
- Manage the disease in tomatoes grown in home gardens
  - destroy and bag diseased plants
  - grow resistant varieties!
  - awareness of issue in general public

P. infestans - DISEASE MANAGEMENT

Aggressive Home-Gardener Outreach Program

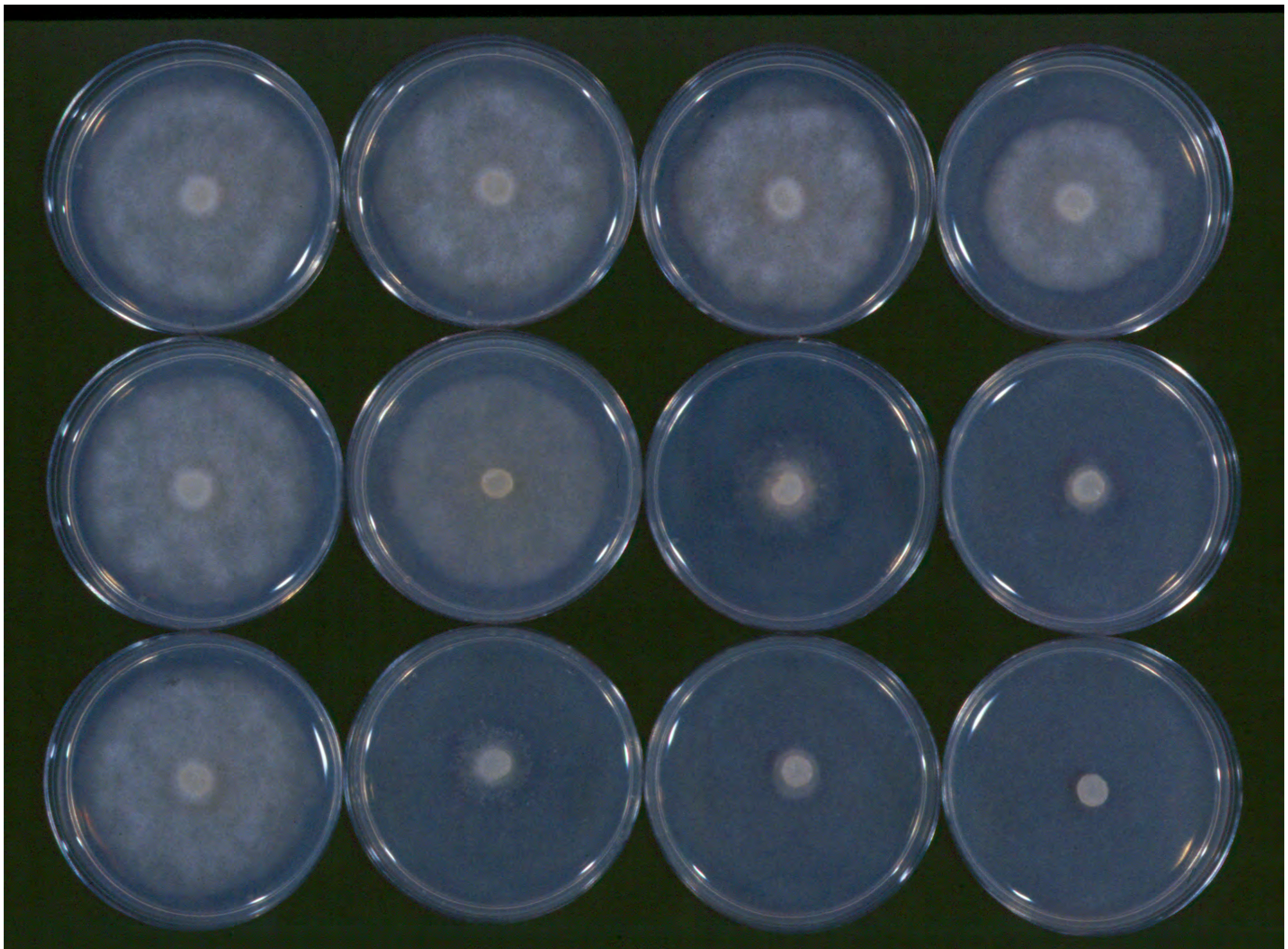
- industry meetings with Garden Centre staff
- meetings with garden clubs
- distribution of free LB-resistant tomato seed
- local and national newspapers, radio and television programs
- posters and brochures
- starting to see results! (no or minimal late blight in PEI, AB in the past 2 years)

Potato Pink Rot

Causal Agent: *Phytophthora erythroseptica*

Sensitivity of *P. erythroseptica* to Ridomil Gold (metalaxyl-m)

0 1 10 100



MHR

MMR

MS

2013-2015 Pink Rot Survey

Resistance of *Phytophthora erythroseptica* to Ridomil (metalaxyl-m)

*Bennett Crane, AAFC + UPEI

Province	# of Samples	# of Isolates	% Isolates MS	% Isolates MMR+MHR
Prince Edward Island	14	83	58	42
Nova Scotia	1	3	0	100
New Brunswick	22	74	51	49
Ontario	5	25	52	48
Manitoba	19	91	89	11
Alberta	9	32	94	6
British Columbia	1	3	100	0
Total	71	311	68	32

Alternative Management of Pink Rot – Field Trials

*Bennett Crane, AAFC + UPEI

Cultivar = Shepody

Reps = 4 (RCBD)

Pathogen Inoculum

- 9913 (Strain sensitive to metalaxyl-m; Ridomil)
- 1204 (Strain resistant to metalaxyl-m; Ridomil)

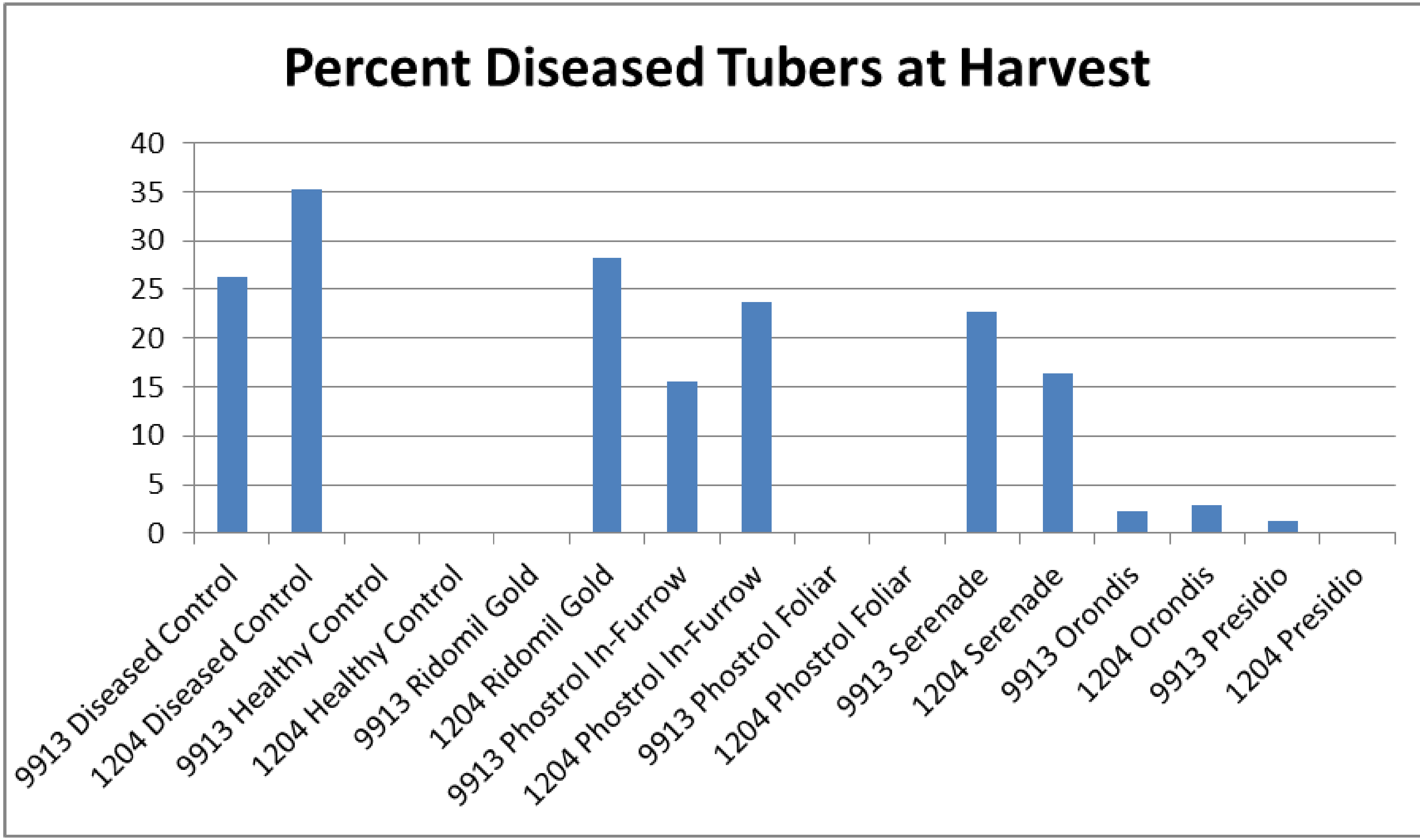
Treatments

- Control – Inoculated
- Control – Not Inoculated
- In-furrow: Orondis (oxathiapiprolin)
- In-furrow: Phostrol (phosphite)
- Foliar: Phostrol (phosphite)
- In-furrow: Serenade (*Bacillus subtilis*)
- In-furrow: Ridomil Gold (metalaxyl-m)
- In-furrow: Presidio (fluopicolide)

Alternative Management of Pink Rot – Field Trials

Tubers from plots inoculated with the pink rot pathogen

Alternative Management of Pink Rot
Field Trial Results



Implications and Next Steps

- Continue national survey on the incidence of Ridomil resistance in pathogen populations in Canada

- Data for individual farms can provide the basis for pink rot management decisions

- More research into alternative disease control strategies is needed

- Phosphites may play a more important role in the management of pink rot if Ridomil resistance becomes more widespread

- Other in-furrow treatments to manage pink rot in daughter tubers appear promising

2016 PEI Pink Rot Experience

*with Erica MacDonald, A&L Labs and Participating Growers

Cultivar = Russet Burbank
Treatments = Confine Extra

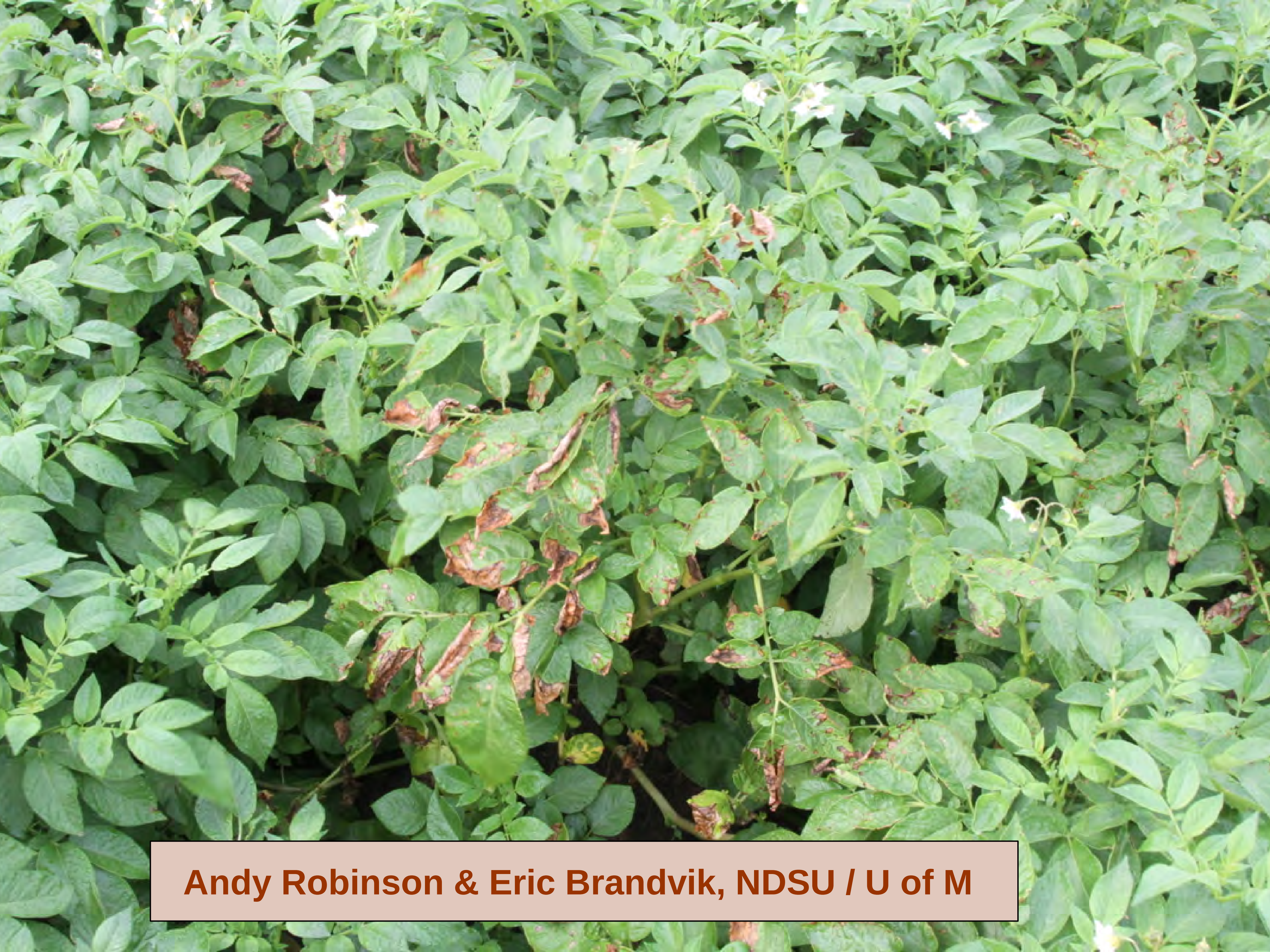
Field I – 7 sprays about 1L/acre = 7.0 L/acre – Non-Irrigated
Field I – 3 sprays at 2.3 L/acre = 6.9 L/acre – Non-irrigated
Field II – 7 sprays about 1L/acre = 7.0 L/acre – Non-irrigated
Field II - 3 sprays at 2.3 L/acre = 6.9 L/acre – Non-irrigated

2016 PEI Pink Rot Experience
Results of Tuber Inoculations

Field	Percent of Tubers with Disease Symptoms	Statistical Difference
Inoculated Control	58	d
Non-inoculated Control	0	a
FI (7.0 L/7 apps) non-irrigated	16	bc
FI (6.9 L/3 apps) non-irrigated	18	c
FII (7.0 L/7 apps) non-irrigated	4	ab
FII (6.9 L/3 apps) non-irrigated	9	abc

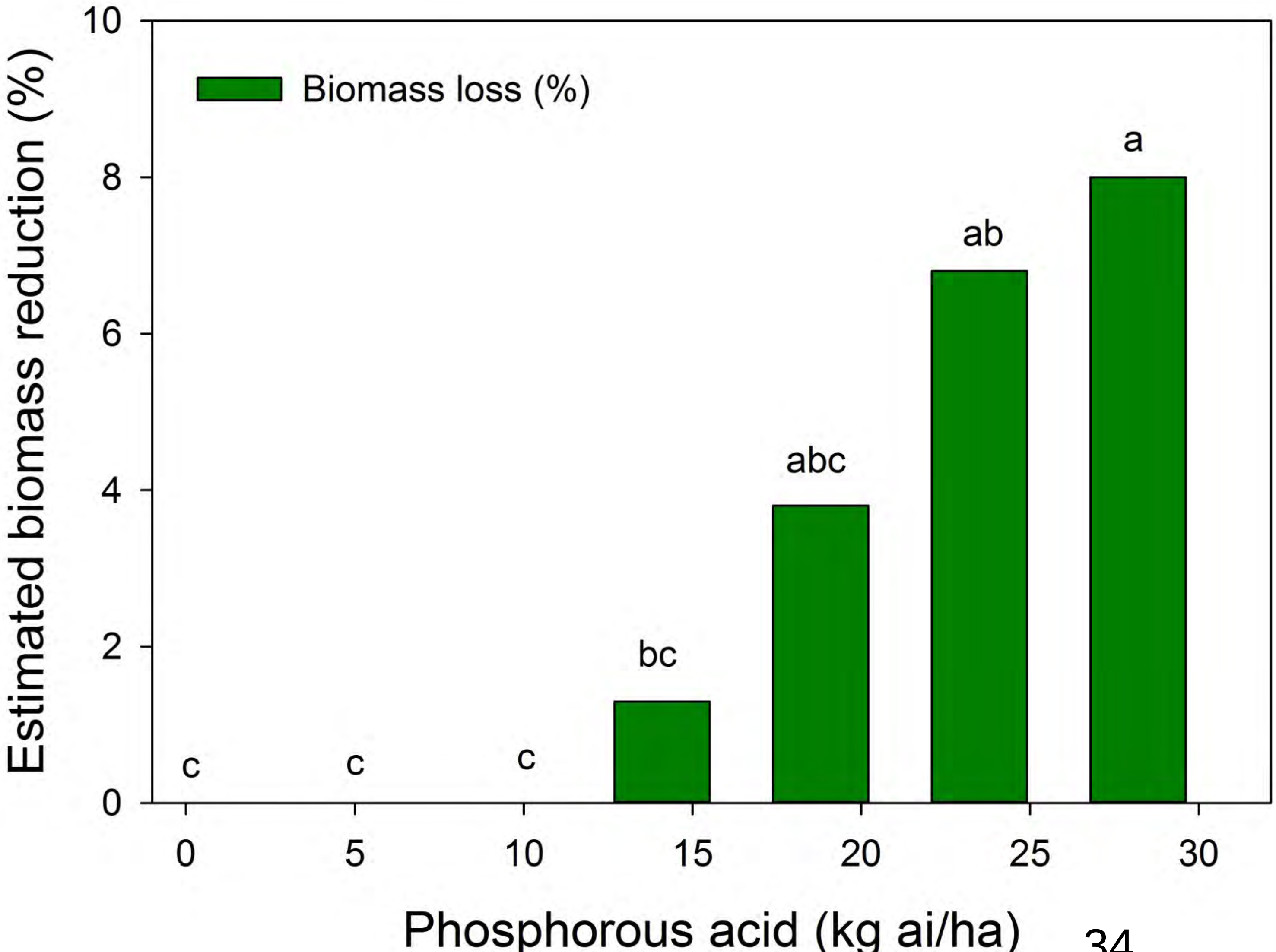
Adverse Physiological Effects of Confine

- noted with high dose, aging plants, water-stressed plants


Andy Robinson & Eric Brandvik, NDSU / U of M

Estimated Biomass Reduction

Andy Robinson & Eric Brandvik, NDSU / U of M



Summary of best approach for phosphite application:

Foliar

- Start early ! (especially before late blight is found)
- Control of oomycetes
- Stimulates plant health and management of other pathogens
- Need sufficient dose to get disease control (season total of 7-10 L/ac [min. about 2 gallons/ac] is reasonable)
- 3-4 spaced applications
- Reduce rates as plants age or in times of stress (drought)
- Watch the weather to avoid wash-off
- Risk to seed fields - Still cautious about fields destined for seed (more research is needed on quantity of phosphite in plant tissue that may cause concern and interactions with other nutrients and environmental and crop factors)

Post-Harvest

- Apply at label rate as soon as possible after harvest
- Manage water volumes
- Control of silver scurf a bonus
- Perhaps some risk to seed (conflicting evidence) – best mitigated by strict adherence to label rate

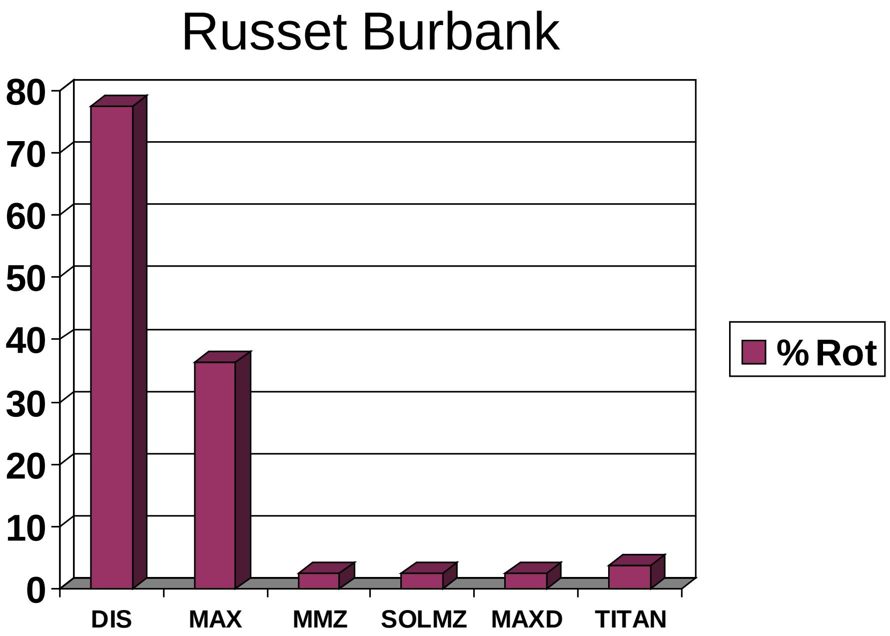
Fusarium Dry Rot and Seed Piece Decay

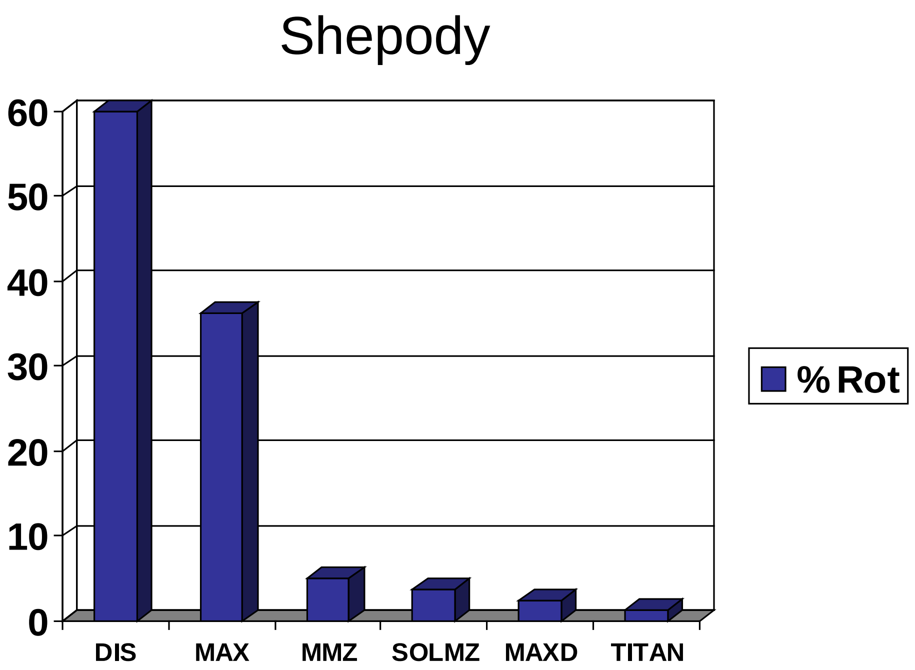


Overall Results – Seed Survey 2011

Species	Total Number of Isolates	Thiabendazole		Fludioxonil	
		Sensitive	Resistant	Sensitive	Resistant
F. sambucinum	185	26	159	61	124
F. coeruleum	21	16	5	14	7
F. avenaceum	22	21	1	19	3
F. oxysporum	74	74	0	0	74
F. spp.	458	443	15	447	11
Total	760	580	180	541	219

2011 Seed Treatment Trial
Seed inoculated, treated and placed in storage
ACIDF Fusarium Project





Fusarium - DISEASE MANAGEMENT

AT PLANTING

1. Use clean seed; store in a disinfected facility
2. Warm seed tubers prior to cutting to promote rapid healing
3. Remove diseased tubers prior to cutting
4. Disinfect seed cutting and handling equipment often and ensure that cutters are sharp to make a clean cut that heals quickly
5. Store cut seed with adequate ventilation
6. Use a registered fungicide seed treatment, but follow a resistance management strategy
7. Plant when soil and temperature conditions promote rapid sprout growth and emergence

Fusarium Dry Rot in Storage

Evaluation of products applied post-harvest for control of Fusarium dry rot (*F. sambucinum*) in storage 2010

Mean depth of internal necrosis (mm) caused by dry rot in tubers of three cultivars inoculated with a virulent isolate of *Fusarium sambucinum* and evaluated after 6 months in storage.

Treatment (Inspire + Quadris + Maxim)	**Cultivar**		
	Superior	**Yukon Gold**	**Shepody**
Untreated, uninoculated	**3.3d**	**1.7d**	**3.9d**
Untreated, inoculated	**16.7a**	**8.3a**	**12.3b**
AZ (0.49) + FL (0.45)	**11.7b**	**5.4b**	**22.1a**
DF (0.352)	**3.7d**	**2.2cd**	**13.1b**
AZ (0.49) + DF (0.176) + FL (0.45)	**8.9bc**	**2.7cd**	**9.7bcd**
AZ (0.49) + DF (0.352) + FL (0.45)	**6.3cd**	**2.4cd**	**10.8bc**
AZ (0.49) + DF (0.53) + FL (0.45)	**7.2cd**	**3.2c**	**7.7bcd**
AZ (0.49) + DF (0.704) + FL (0.45)	**3.5d**	**3.0cd**	**4.9cd**
F prob.	**<0.001**	**<0.001**	**<0.001**
LSD*	**3.9**	**1.4**	**6.0**

Fusarium - DISEASE MANAGEMENT

AT HARVEST and IN STORAGE

1. Reduce tuber injury during harvest and handling operations

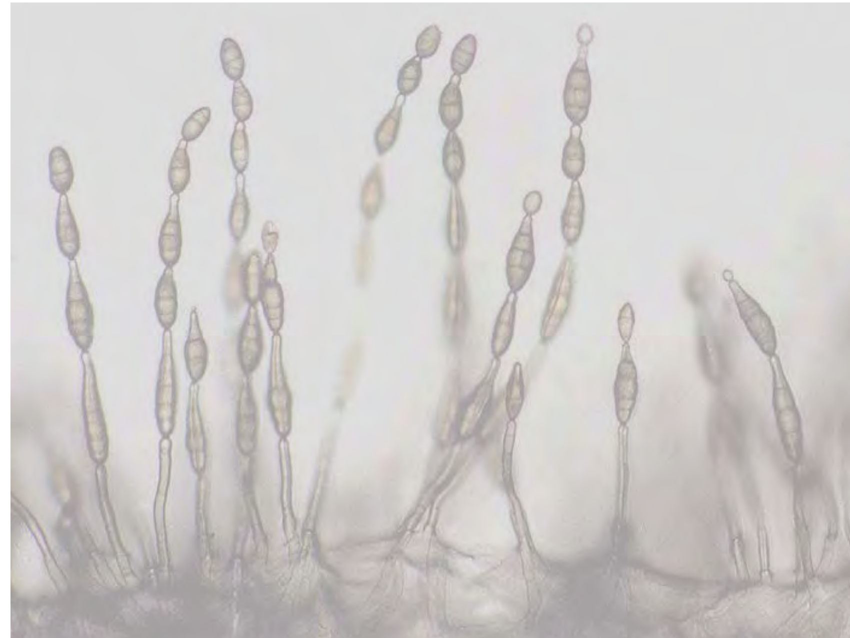
2. Provide conditions for rapid would healing early in storage, then drop temperatures

3. Monitor storage conditions

4. Post-harvest treatments with Mertect will control some *Fusarium* spp. (but not the major ones)

5. Post-harvest applications of Stadium have shown to be effective

Early Blight and Leaf Disease Complex
Alternaria solani and others



Conidial morphology

A. solani:

- long/slender
- beak present
- solitary

A. alternata:

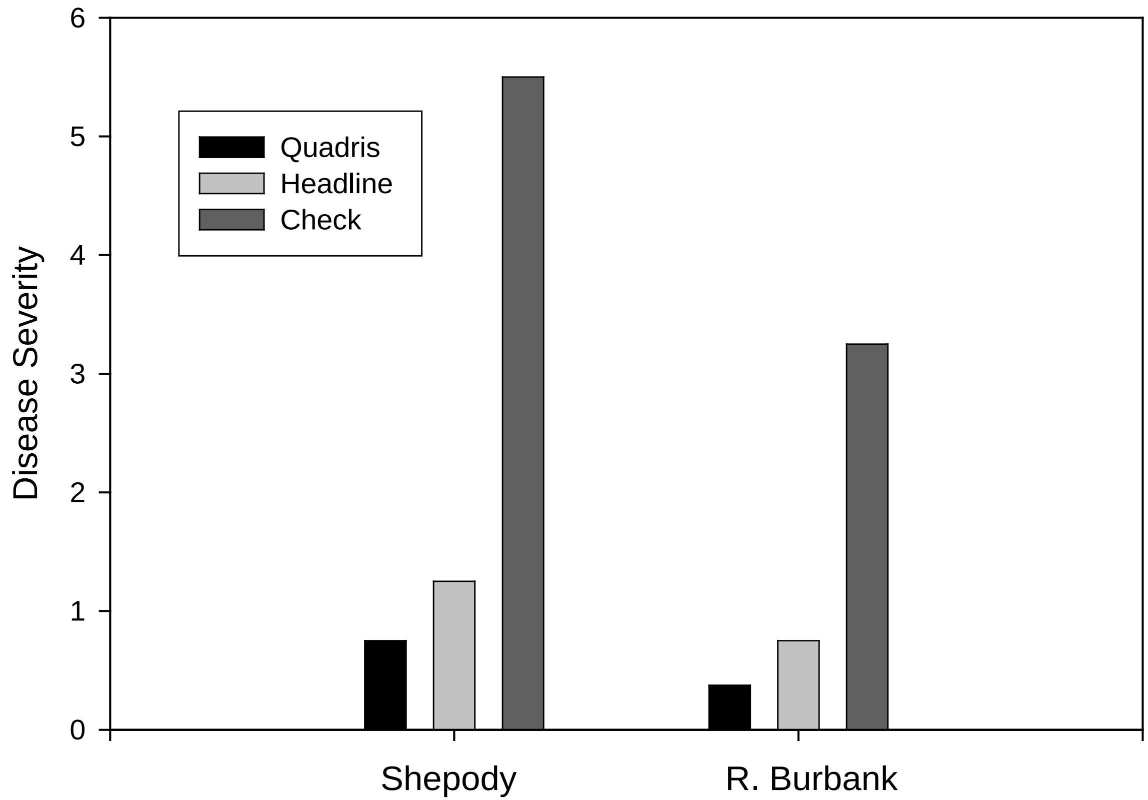
- short/club-shaped
- no beak
- chains

PEI: EC_{50} (μg/mL) results (2003 and 2004)

	A. solani	*A. alternata and others*
range:	0.003 – 0.014	0.001 – 0.023
mean:	0.010	0.011

These values indicate that both species are quite susceptible to azoxystrobin

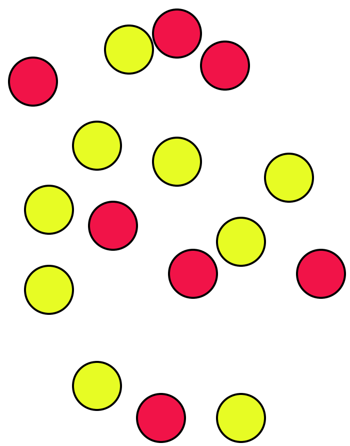
Foliage rating results



Strobilurin fungicides were able to suppress the development of potato early blight

Resistance to strobilurins

% F129L mutants in *A. solani* population 2002-2006



Idaho	15.4%
Wyoming	23.1%
Oregon	60%
Washington	12.5%

Total from 11 potato producing states 96.5%

(Pasche and Gudmestad, 2007)

Manitoba – 2007

Sensitivity of *A. solani* to azoxystrobin

- 9 isolates from Manitoba tested for in vitro sensitivity to azoxystrobin using a spore germination assay
- EC_{50} = 0.2-0.8 ppm
- EC_{50} of ND 'reduced sensitive' standard = 0.2 ppm
- EC_{50} of ND sensitive standard = 0.02 ppm
- EC_{50} of PEI isolate = 0.04 ppm
- F129L mutation confirmed in MB isolates by Gudmestad lab

Canadian Survey – 2008
Sensitivity of *A. solani* to strobilurins

Province	No. of isolates	Mutant	Wild-type
ON	27	26	1
MB	12	12	0
AB	55	53	2
PE	3	0	3

Canadian Survey – 2008

Sensitivity of *A. solani* to strobilurins

- F129L mutation confirmed by Gudmestad lab in isolates from central and western Canada
- no mutants recorded from eastern Canada

(none from PEI)

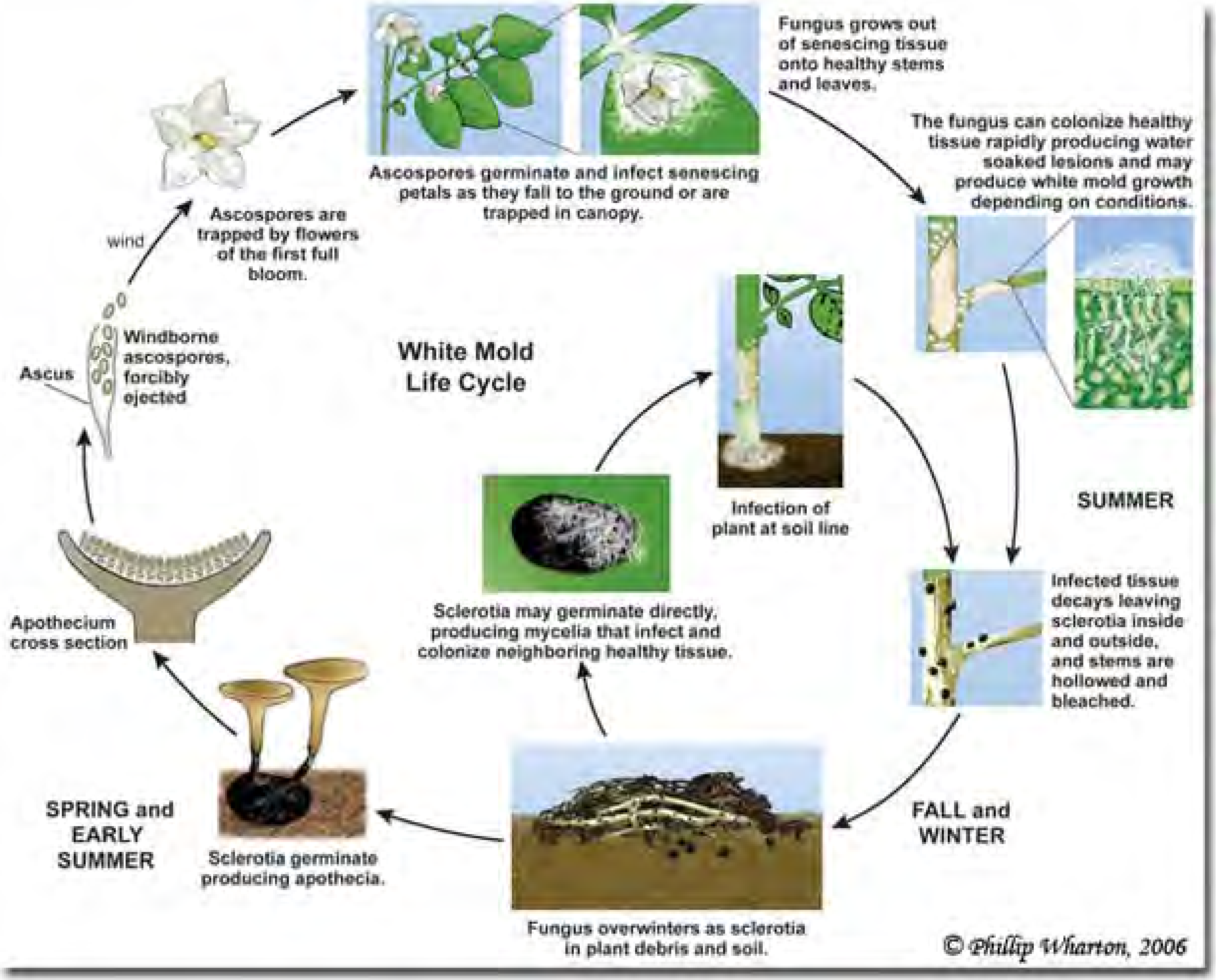
PEI Survey – 2017

Sensitivity of *Alternaria* spp. from potatoes and carrots to current chemistries

- AAFC-CRDC, Genesis Crop Systems, PEI Horticultural Association, PEIDAF, chemical companies, participating growers

White Mold
Sclerotinia sclerotiorum

White Mold – Disease Cycle



White Mold – Management

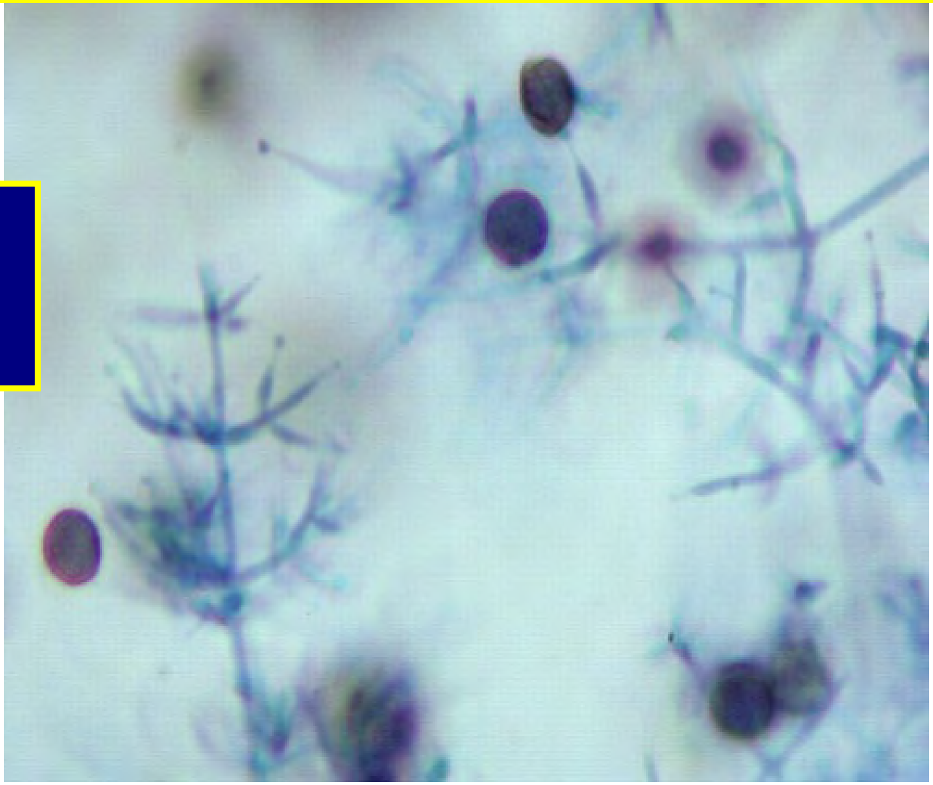
- protectant fungicides applied before infection (number depends on length of time of apothecia production in the area)
- Washington State – best to apply fungicides at full bloom of primary inflorescences
- manage canopy to reduce conducive microclimates (fertility, irrigation, etc.)

Verticillium Wilt = *Verticillium* spp.

Verticillium Wilt – Causal Agent

Verticillium dahliae **– microsclerotia**
Verticillium albo-atrum **– septate, resting, dark mycelia**

verticillate whorls



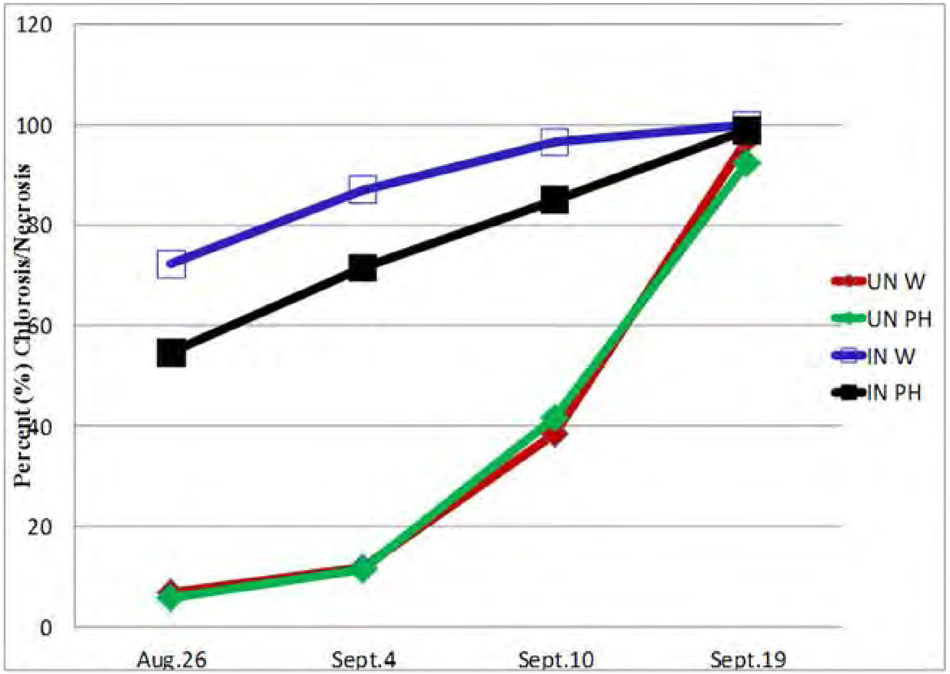
Verticillium Wilt – Disease Cycle

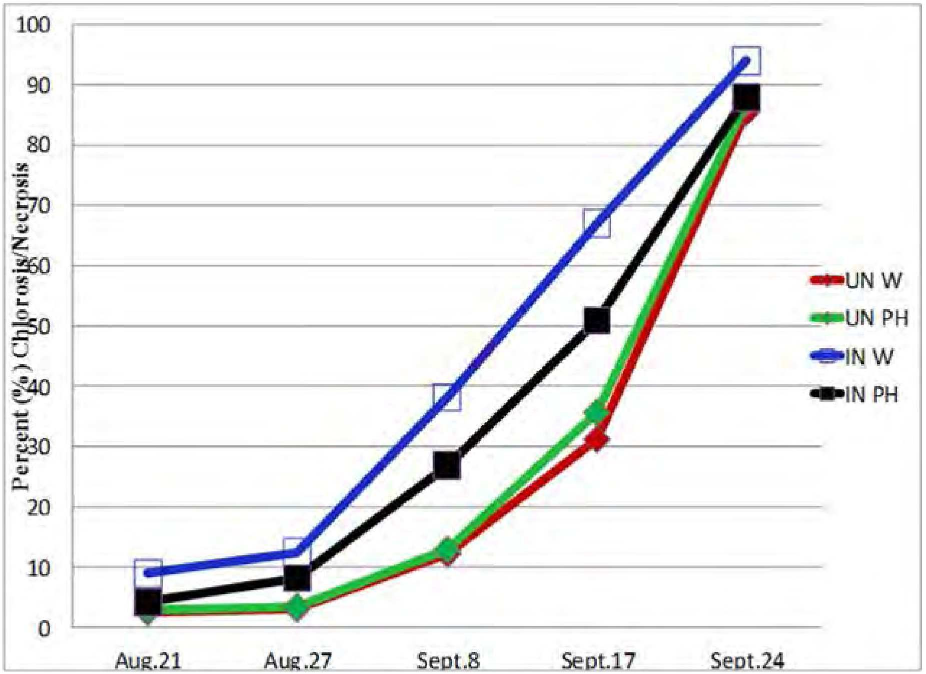
- contaminated soil; infected or infested seed
- survive via microsclerotia or resting hyphae
- infect roots, moves to vascular system
- cooler climates usually favour albo-atrum
- wide host range
- synergistic interaction with root lesion nematode, *Colletotrichum coccodes, etc. (early dying complex)*

Verticillium Wilt – Management

- resistant and tolerant cultivars
- adequate fertility reduces disease severity
- avoid water stress
- cropping systems, green manure crops, etc.
- detection and quantification tools now available
- various studies being developed (NB, PEI) to examine impacts of fumigation, plow downs, etc.

Effect of foliar-applied phosphites on severity of Verticillium wilt





- Similar results with in-furrow application of Aprovia in 2016
- Will test both Aprovia and Velum Prime in 2017

Cropping Factors that Influence Disease

- **Length of rotation between susceptible crops**
- **Type of crops in the rotation**
- **Tillage methods**
- **Soil amendments/green manures/plow downs**

Cropping Factors that Influence Disease

- **Length of rotation between susceptible crops**

  - aids in the natural mortality of pathogen spores that are not long-lived
  - allows ecological competition, antibiosis, and other inhibitive factors to operate
  - very effective against some pathogens
  - less effective against pathogens with long-term survival structures

Cropping Factors that Influence Disease

- **Type of crops in the rotation**
  - **- generally try to choose non-host crops to avoid pathogen build-up**
  - **- some crops can have inhibitory effects on soil-borne pathogens (root exudates for example)**

Cropping Factors that Influence Disease

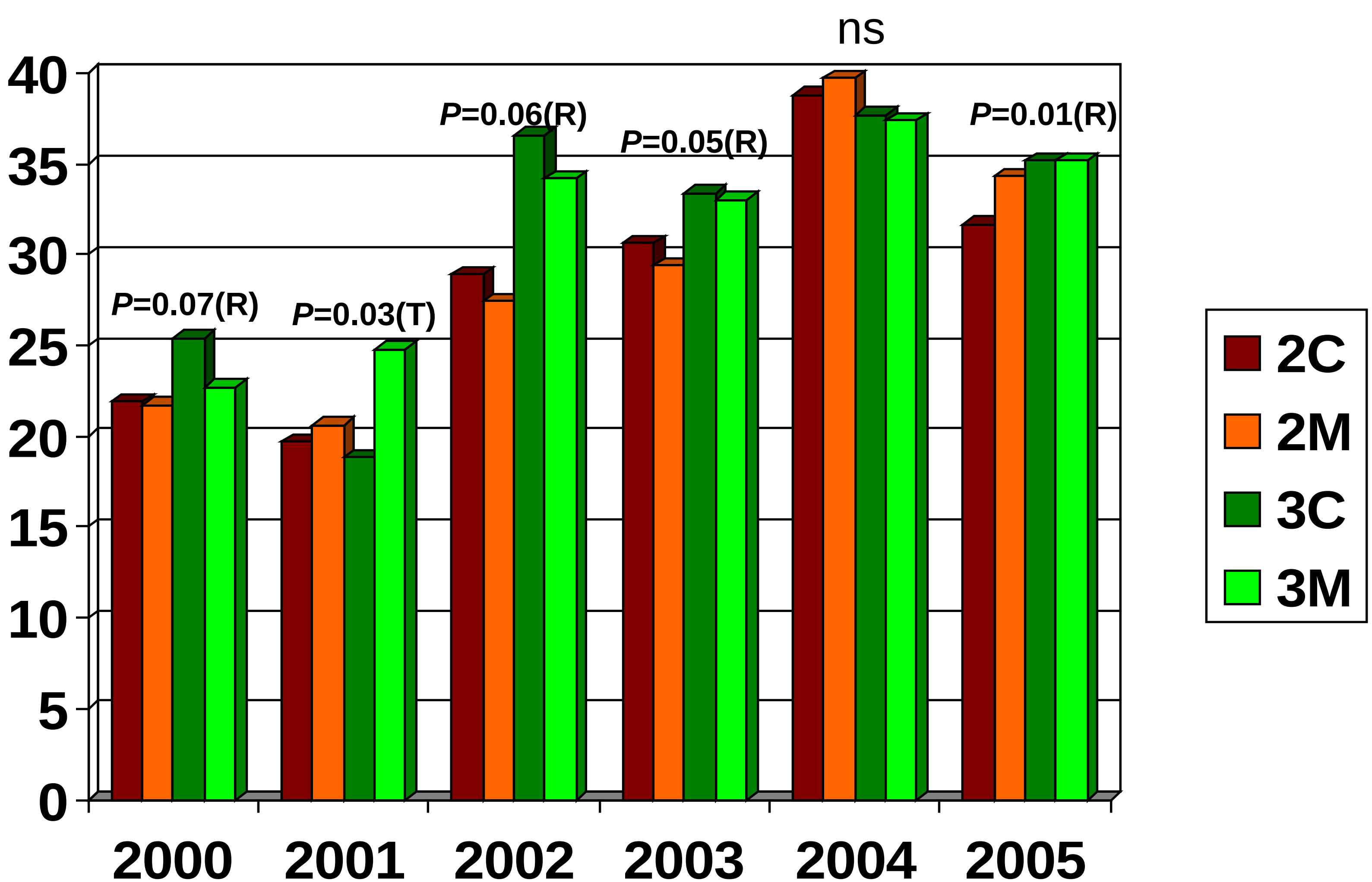
- **Tillage methods**

  - can impact soil residues, organic matter, and biological/physical properties to the benefit or detriment of plant pathogens

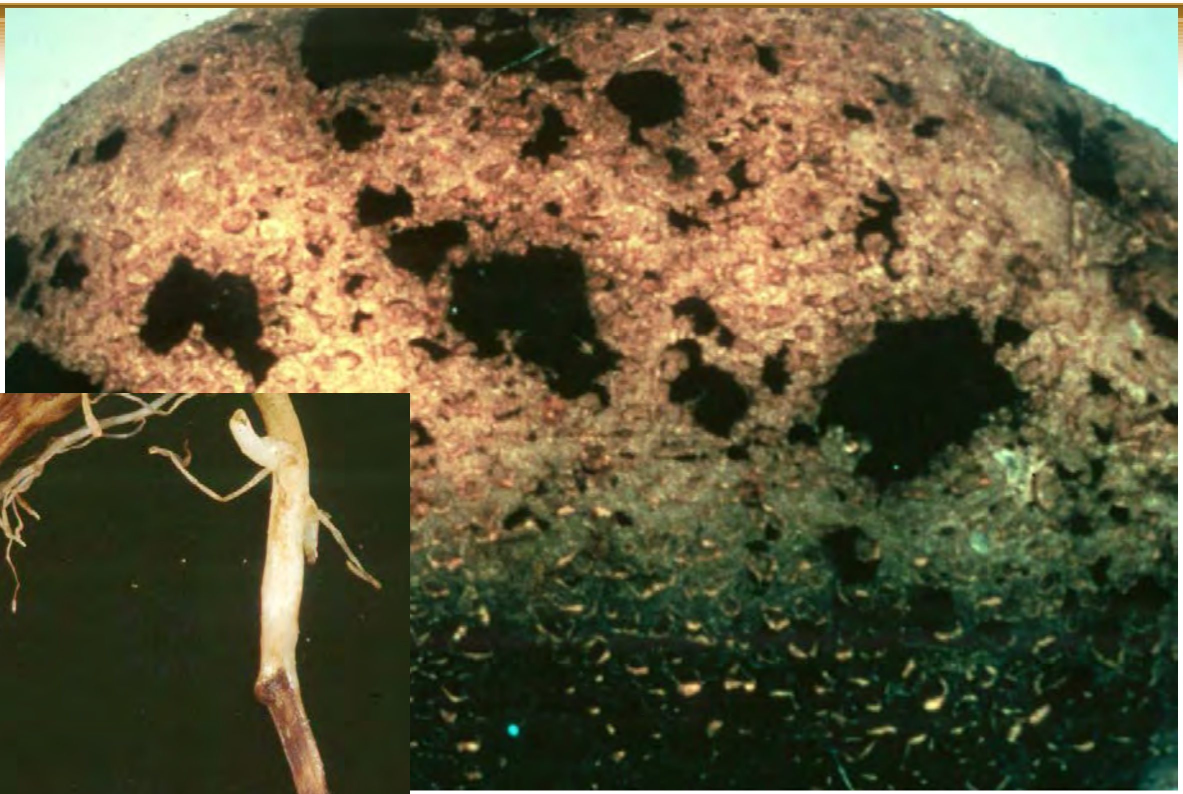
Cropping Factors that Influence Disease

- **Soil amendments/green manures/plow downs**
  - can contribute to biofumigation effects
  - can stimulate soil microbes that are antagonistic to pathogens

Marketable Potato Yield (Mg/ha)



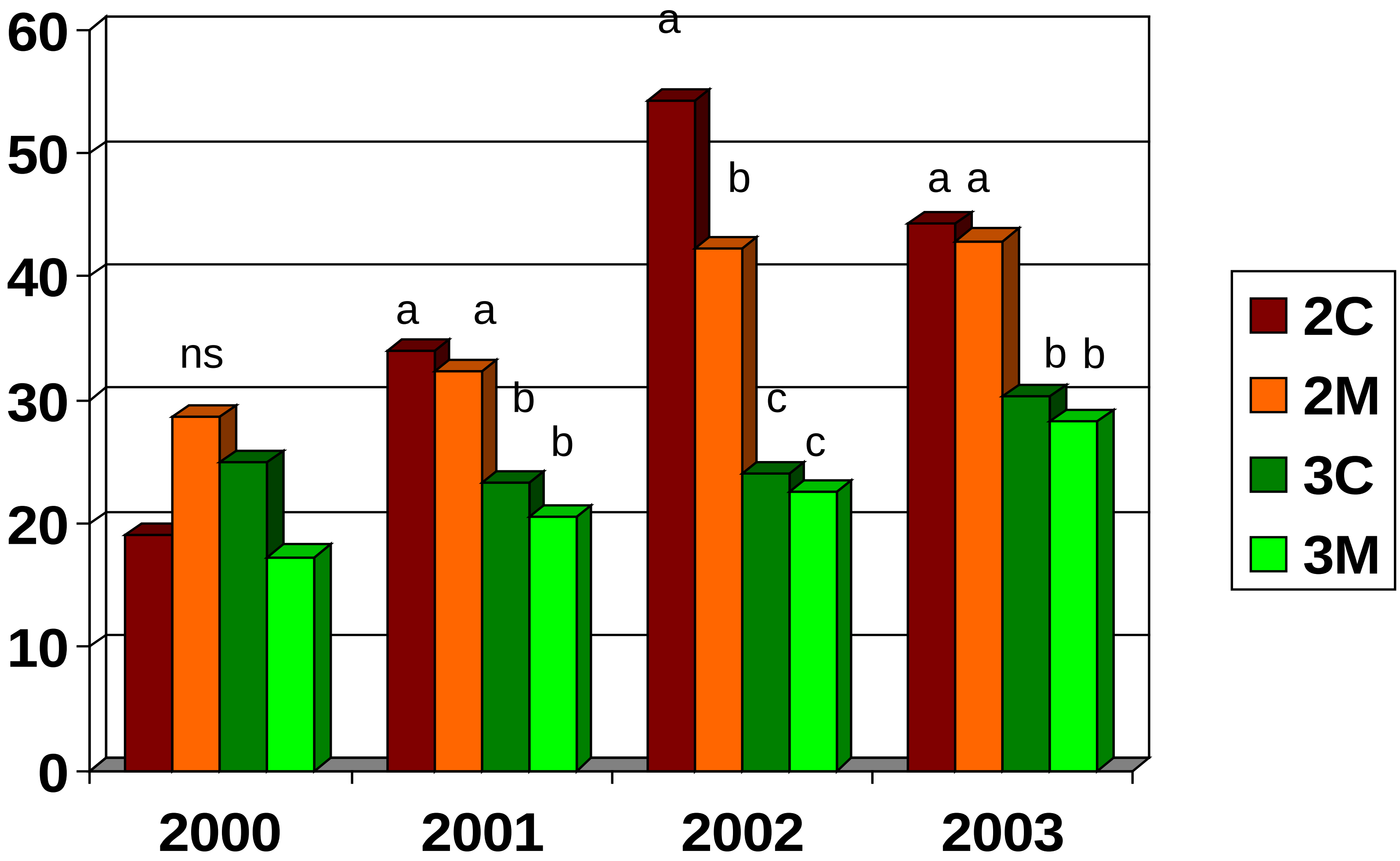
Rhizoctonia solani



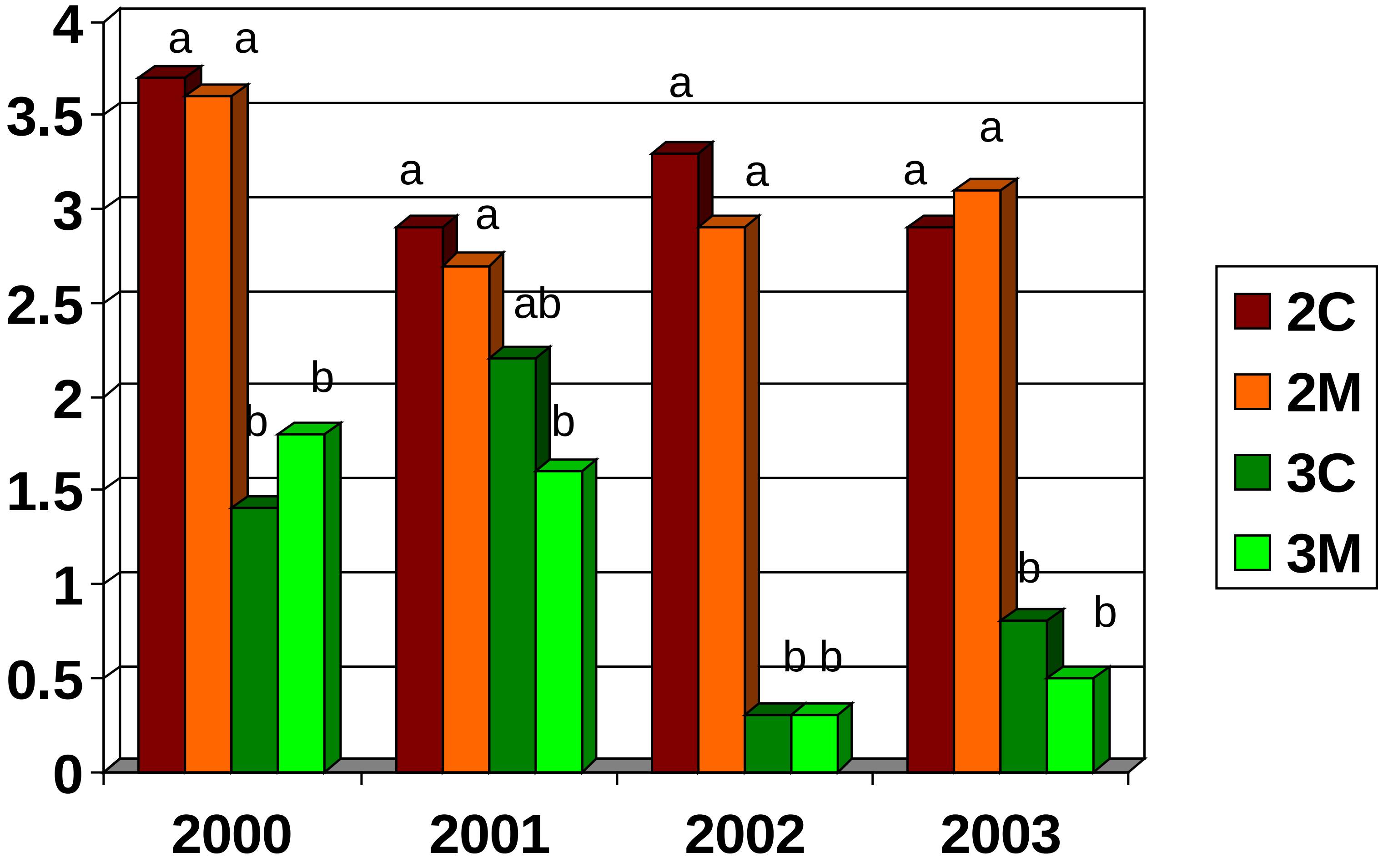
Black scurf

Rhizoctonia stem and stolon canker

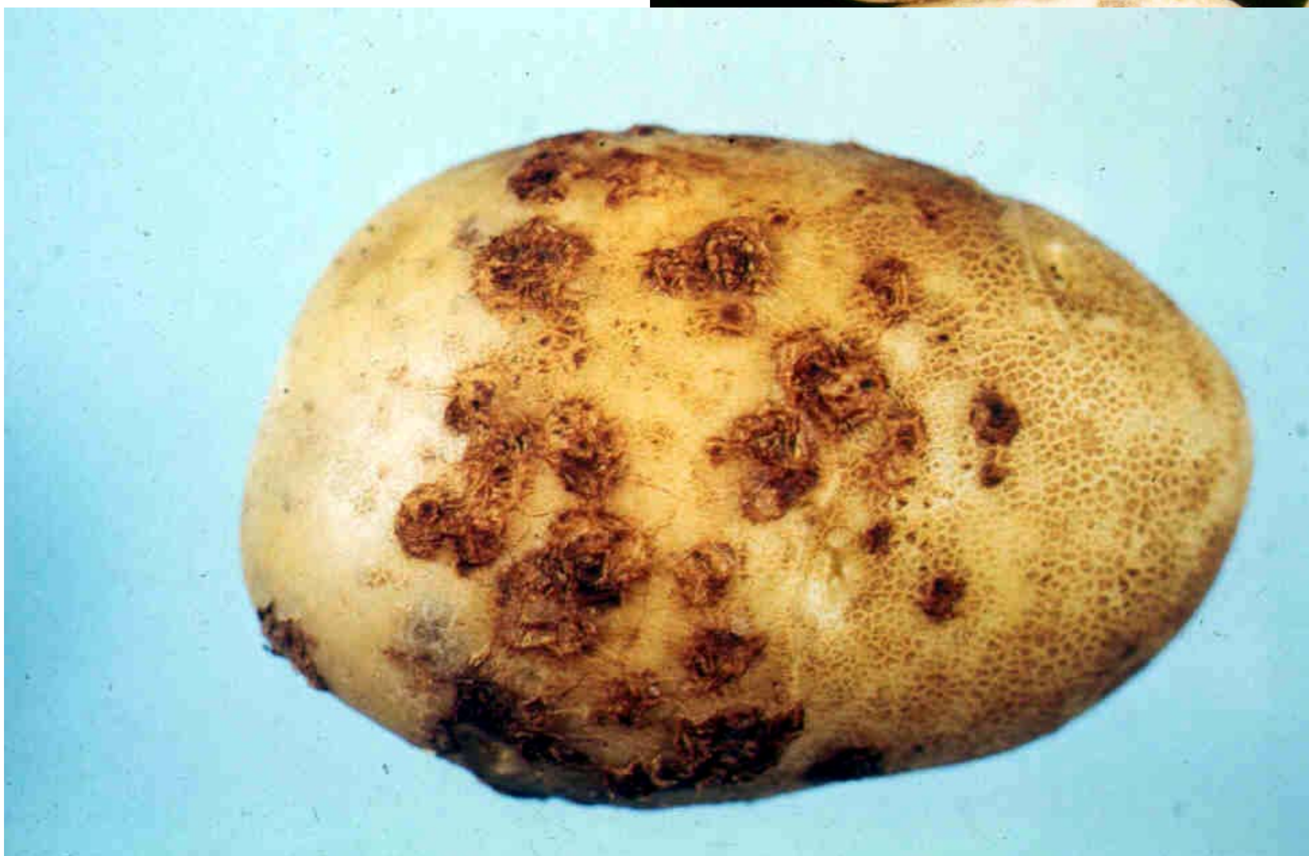
Rhizoctonia Stem Canker
Stem Canker Severity (%)



Rhizoctonia solani
Black Scurf Severity (%)



Streptomyces scabiei



Common scab

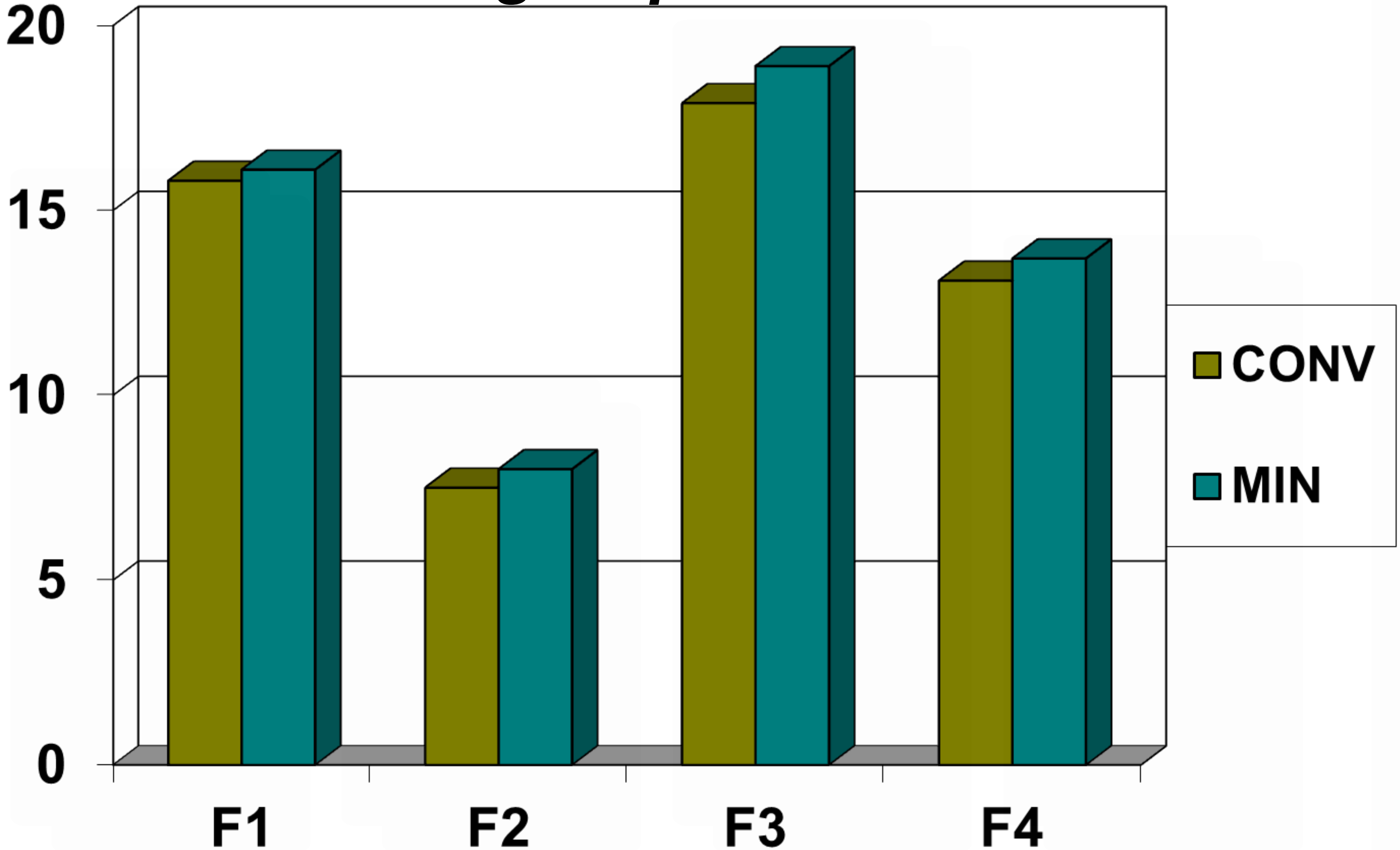
On-Farm Trials – A Decade of Experience

*with Tyler Wright, PEIDAF and participating growers

- 2 locations in each year
- various regions of PEI
- various cultivars
- treatments comparing traditional fall plowing methods with various soil conservation approaches

On-Farm Trials

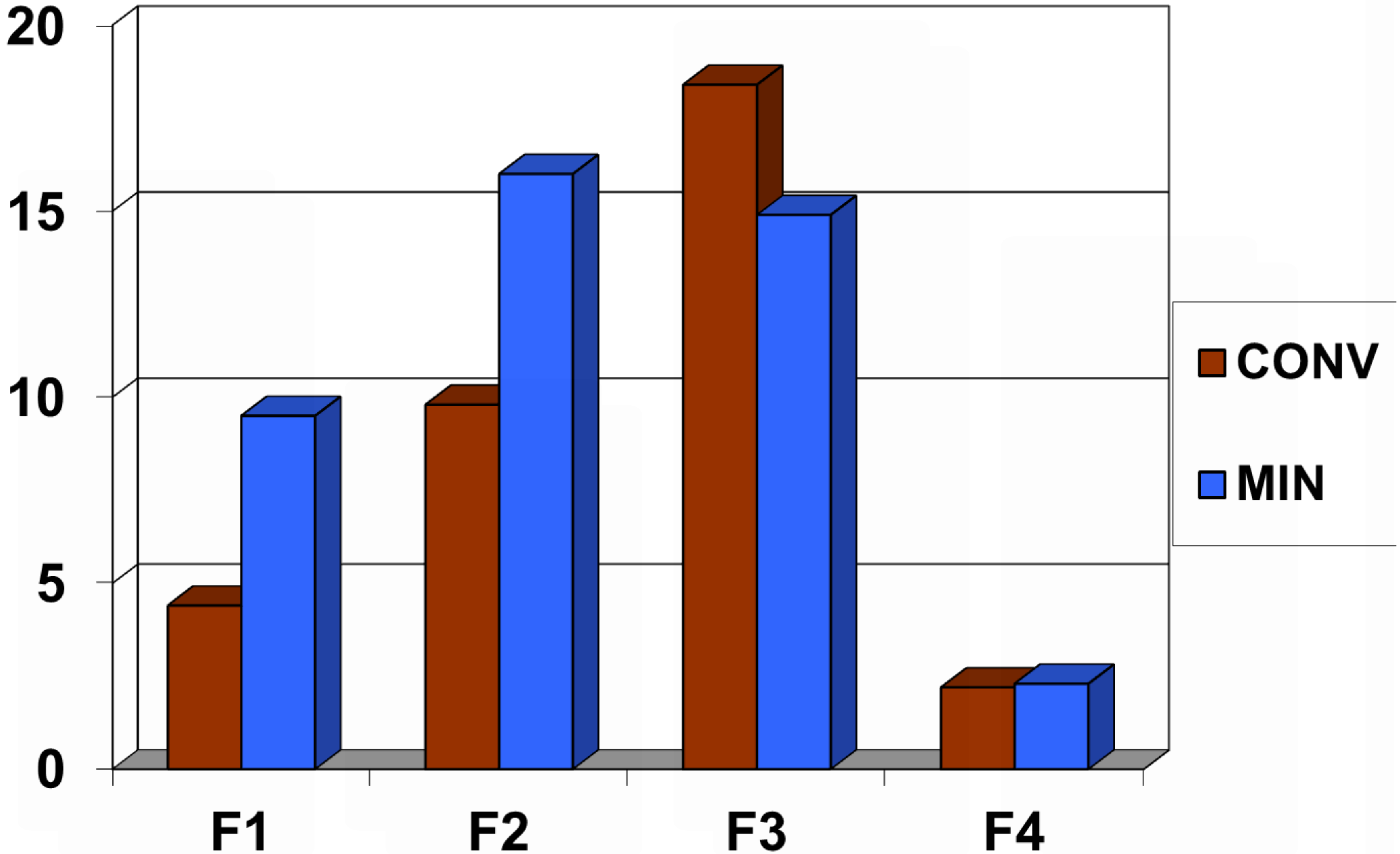
Total Yield kg/10 plants



* with T. Wright

On-Farm Trials

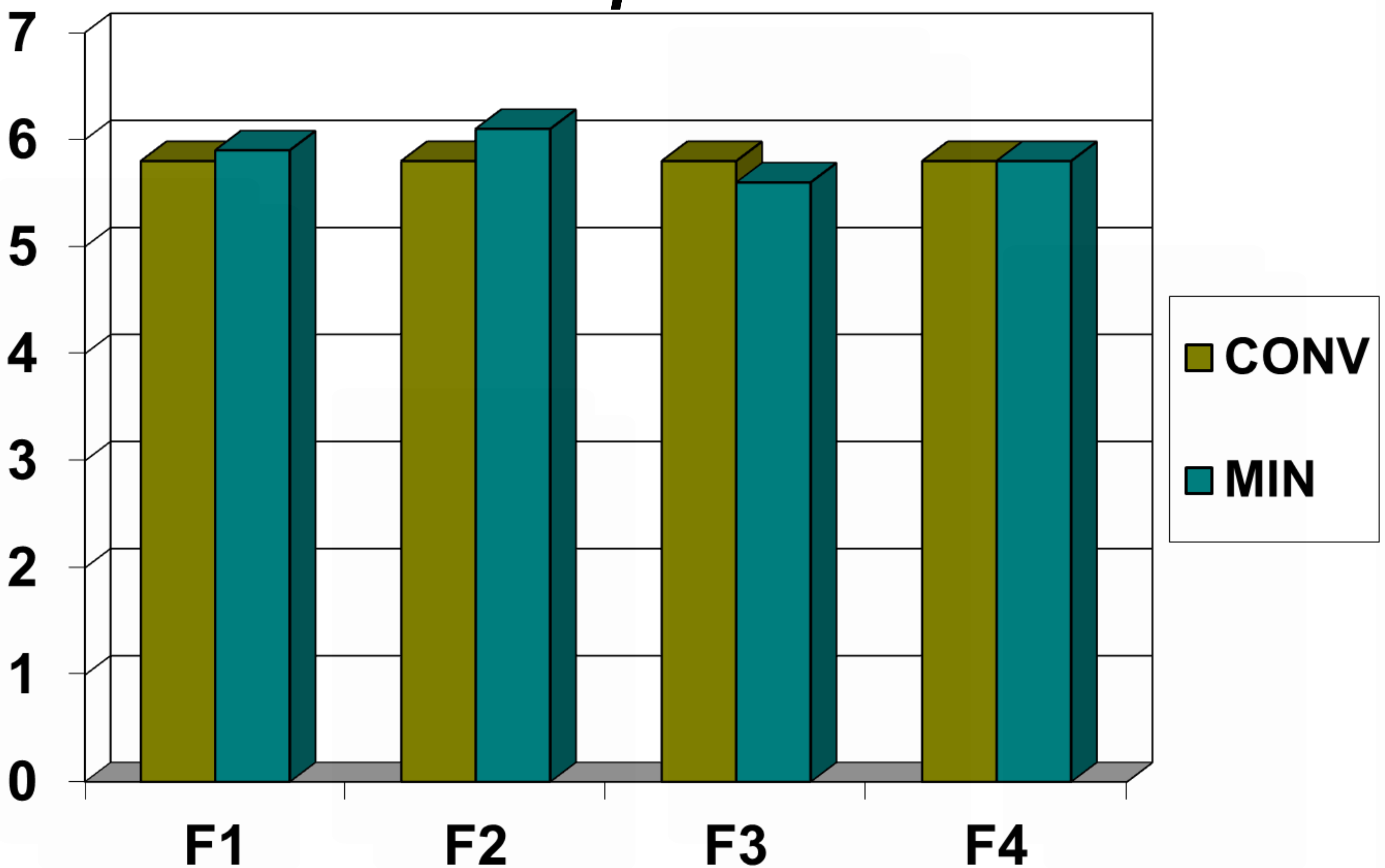
Streptomyces scabiei
Common Scab Severity (%)



* with T. Wright

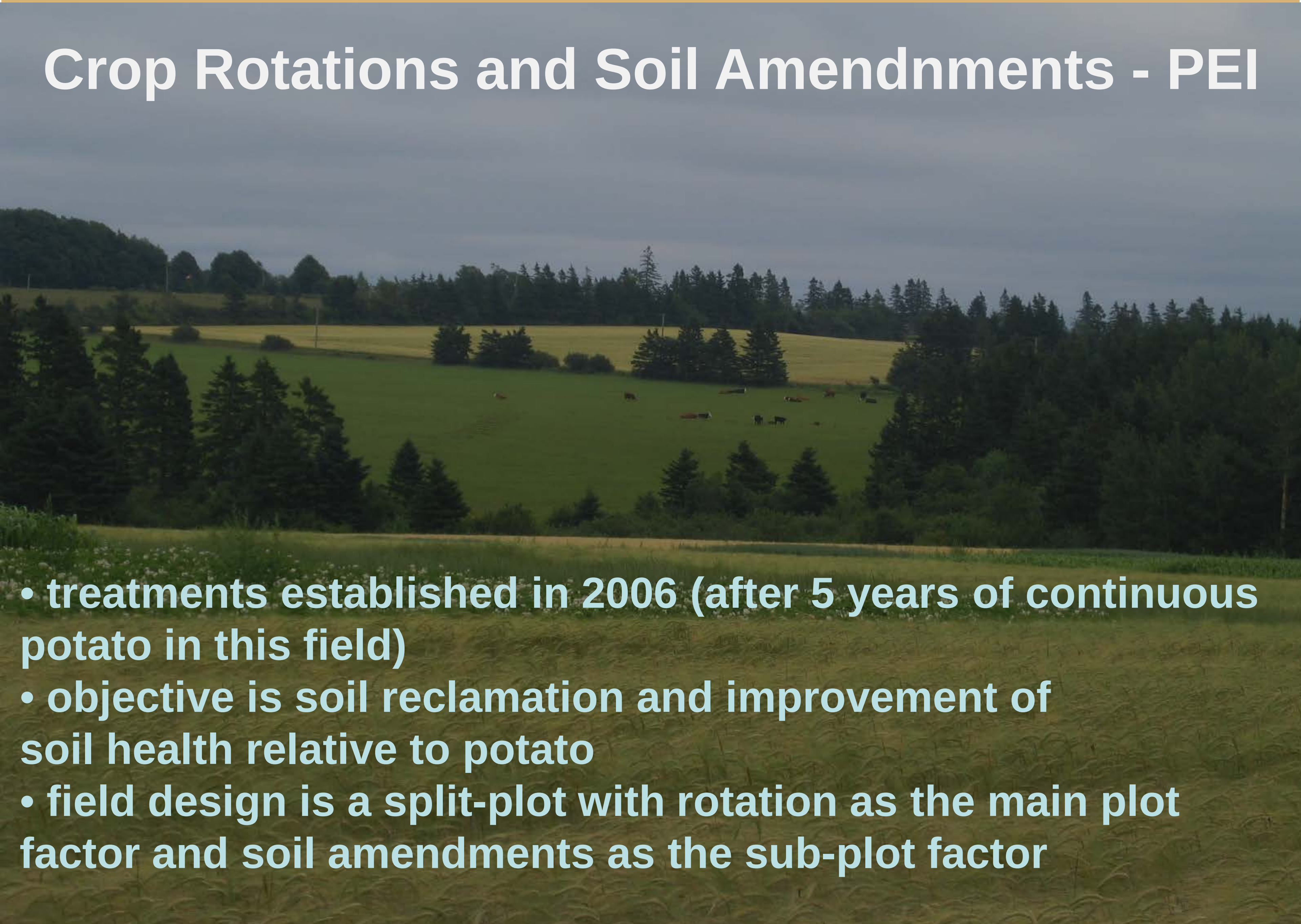
On-Farm Trials

Soil Analysis pH



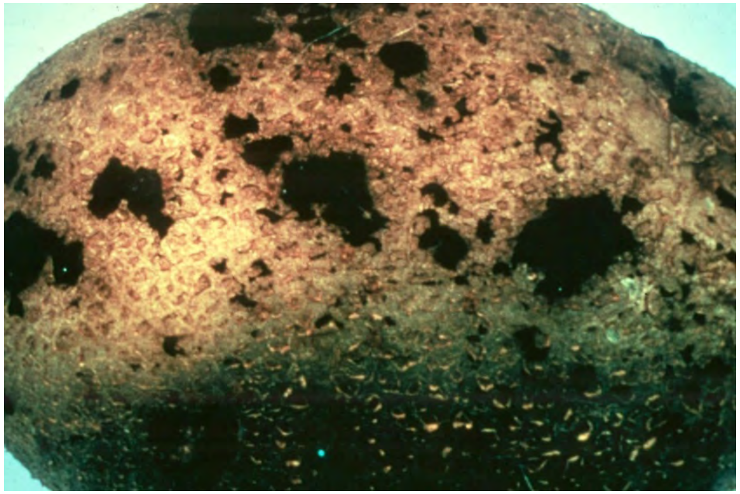
* with T. Wright

Crop Rotations and Soil Amendnments - PEI



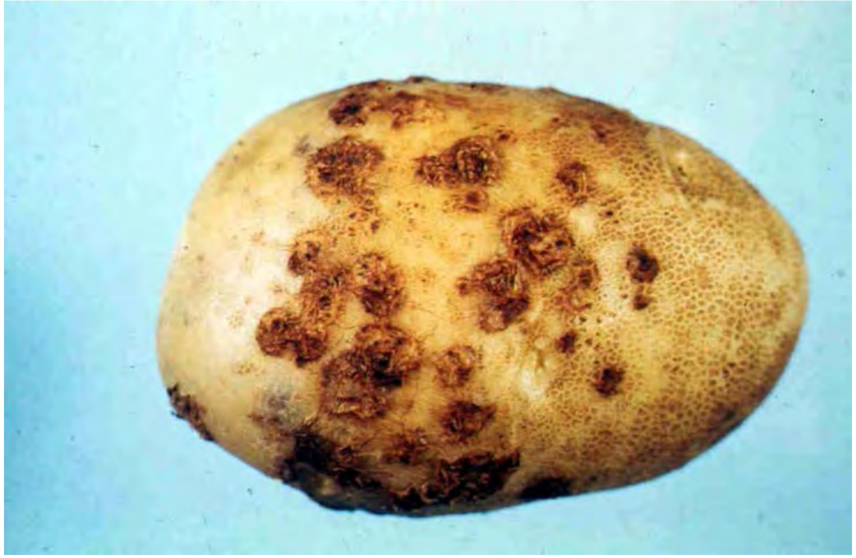
- treatments established in 2006 (after 5 years of continuous potato in this field)
- objective is soil reclamation and improvement of soil health relative to potato
- field design is a split-plot with rotation as the main plot factor and soil amendments as the sub-plot factor

Mean percent black scurf on tubers



Rotation	P	P-B	P-B-CL	P-SG-CN
	3.3	2.6	1.1	1.0

Mean percent common scab on tubers



Rotation	P	P-B	P-B-CL	P-SG-CN
	23.1	25.8	9.7	13.1

Mean weight of marketable tubers in tonnes/ha

Rotation	P	P-B	P-B-CL	P-SG-CN
	16.1	21.0	22.2	25.1

Early Dying Complex

Summary Points

- **Lengthening the time between susceptible crops can be a key factor in reducing disease (ie. *Rhizoctonia* diseases)**
- **2 complete rotational cycles are required for soil properties to stabilize so they can be truly evaluated**
- **Types of crops in the rotation can influence disease pressures**
- **Tillage methods can influence various diseases differently**
- **Soil amendments/green manures/plow downs can alter soil microflora to benefit disease control**
- **Production systems have regional variation – data from local soil, climate and cropping systems is needed to make informed decisions**

Acknowledgments

Funding

Various A-Base, AIP and CRDA

Acknowledgments

AAFC Charlottetown

Rick Peters
- Kathy Drake
- Anne MacPhail
- Dorothy Gregory
- Bennett Crane

Scott Anderson

AAFC Lethbridge
- Larry Kawchuk + team

Prince Edward Island
- Brian Beaton
- Marleen Clark

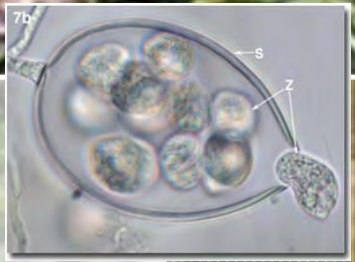
Veseys
- Angus Mellish

Participating Potato and Tomato Growers

Provincial Government Reps & Diagnostic Clinics

Industry Reps

www.gov.pe.ca



Thank you !

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Canada