

Rethinking pulse crop production in the era of Aphanomyces root rot

Sabine Banniza

Sherrilyn Phelps, Syama Chatterton, Michelle Hubbard & Barb Ziesman

University of Saskatchewan

Agriculture and Agri-Food Canada

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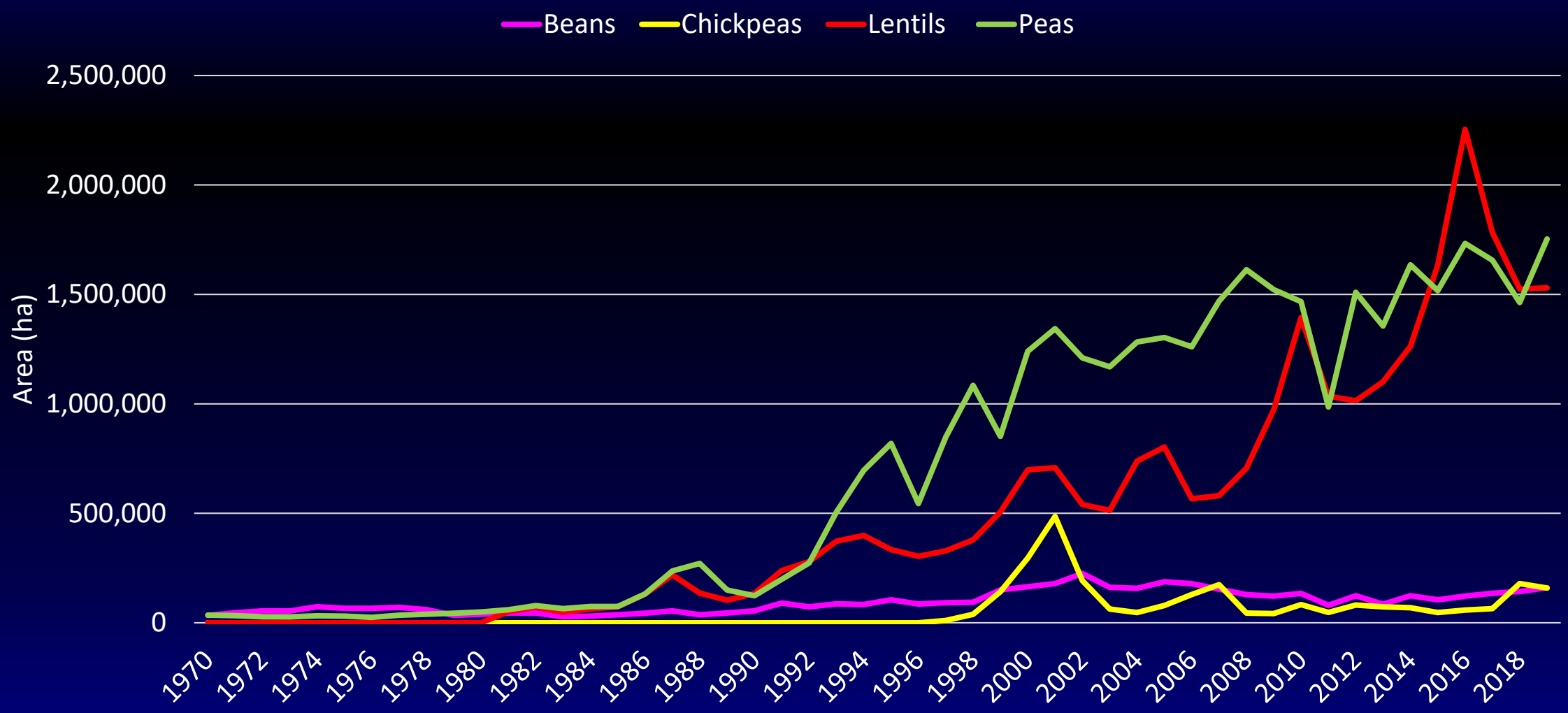
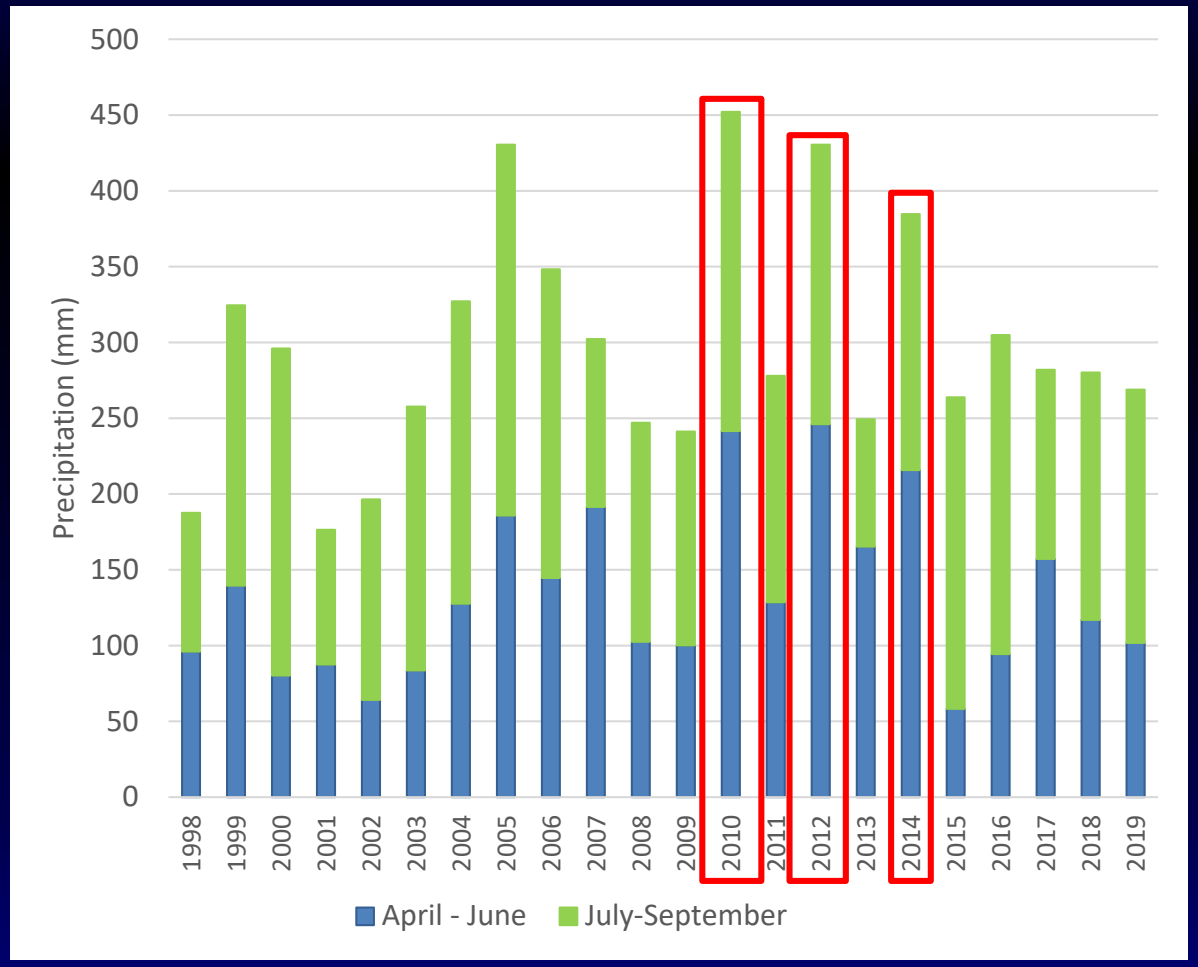
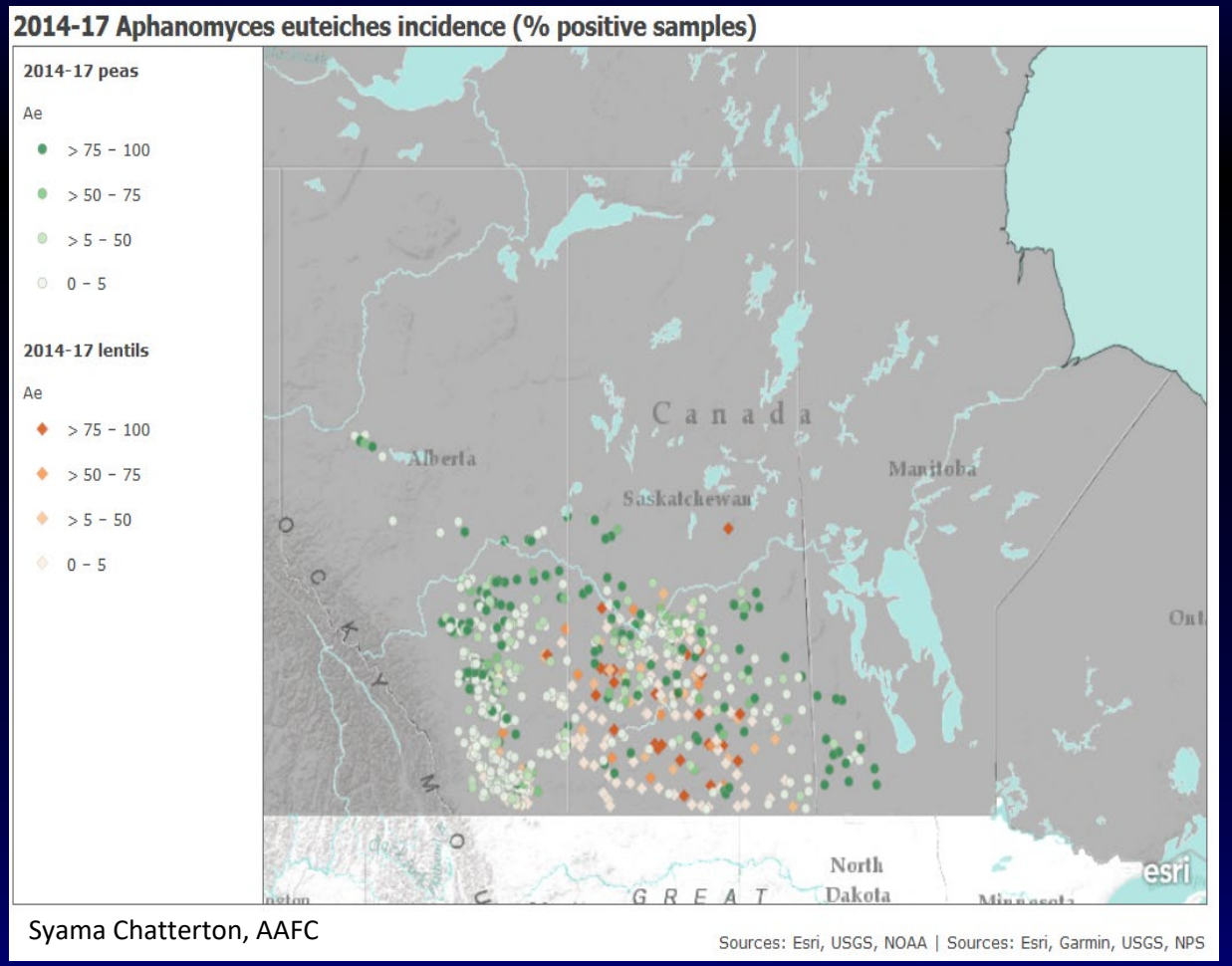
Saskatchewan pulse Growers


Beans
Chickpeas
Lentils
Peas
Area (ha)
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018

Ahanomyces euteiches

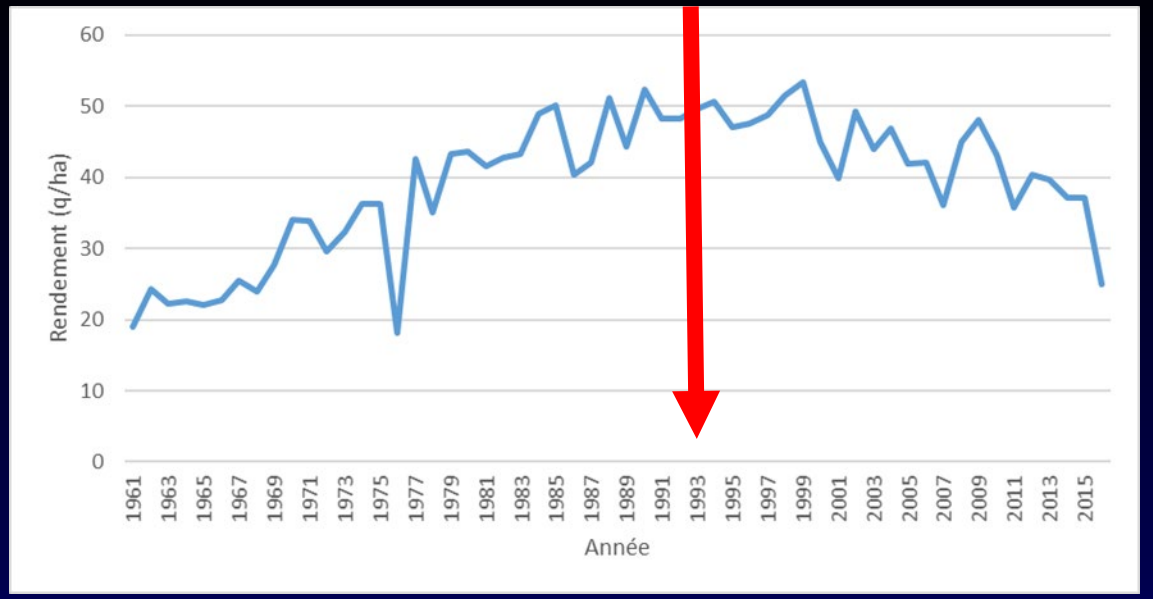




Syama Chatterton, AAFC

Effect of Aphanomyces root rot on pea yield stability in France

- Identification of *A. euteiches* in 1993
- Increasing yield instability then
- Replacement of pea with faba bean in severely infested regions

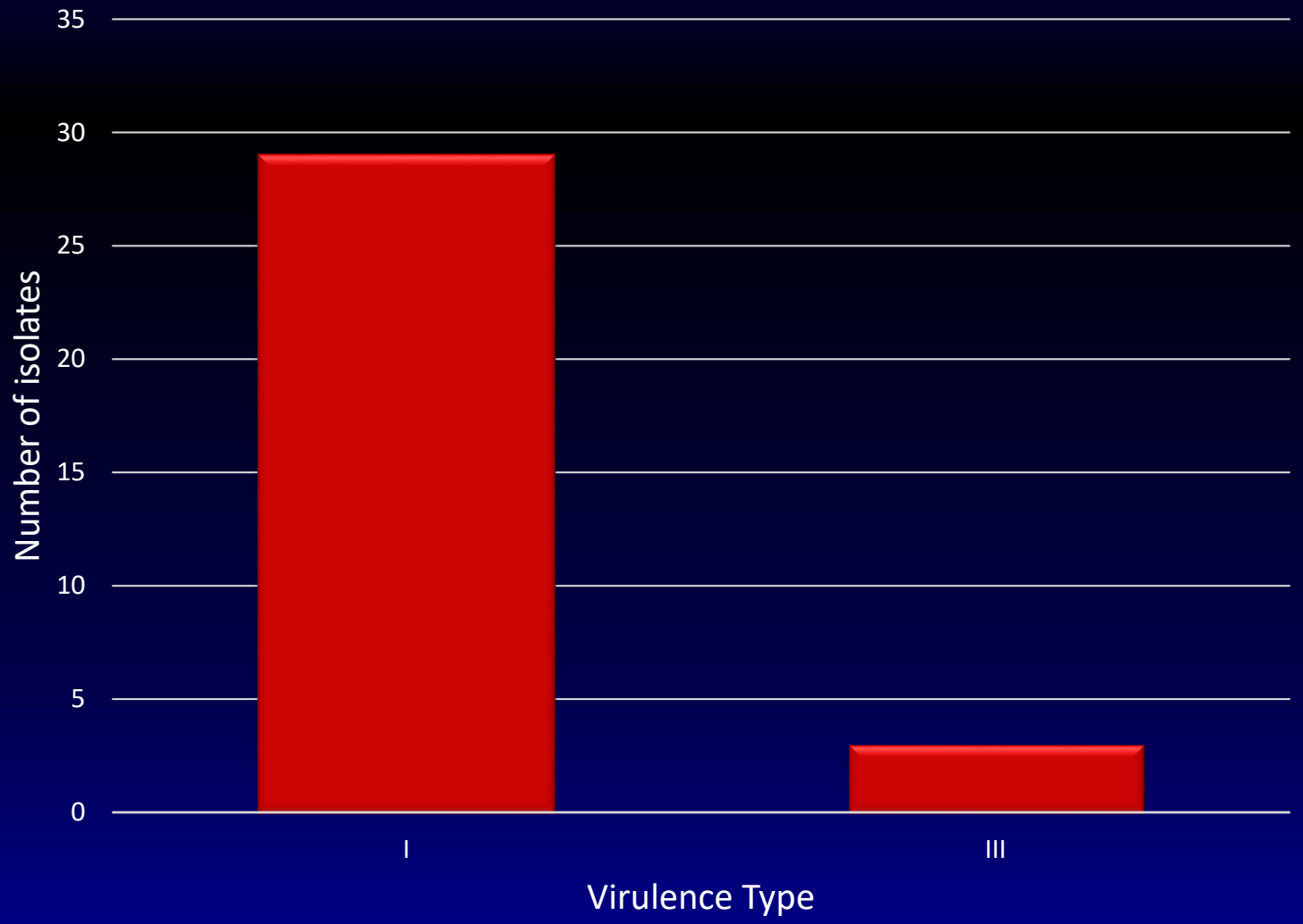


Pathotypes	DISEASE RESPONSE ON THE GENOTYPE						NUMBER OF ISOLATES
	BACCARA	CAPELLA	MN313	902131	552	PI 180693	
I	+	+	+	+	+	+	82
II	+	+	+	+	+	-	5
II	+	+	-	+	+	+	2
IV	+	+	-	+	-	+	1
V	+	+	+	-	+	-	1
VI	+	-	-	-	-	-	3
VII	+	+	+	+	-	-	1
VIII	+	+	-	+	-	-	2
IX	+	-	+	+	-	-	1
X	+	+	+	-	-	-	2
XI	+	+	+	-	-	-	1

Root rot severity rated with a 0-5 index, score < 1 indicated non-pathogenic (-), ≥ 1 pathogenic (+)

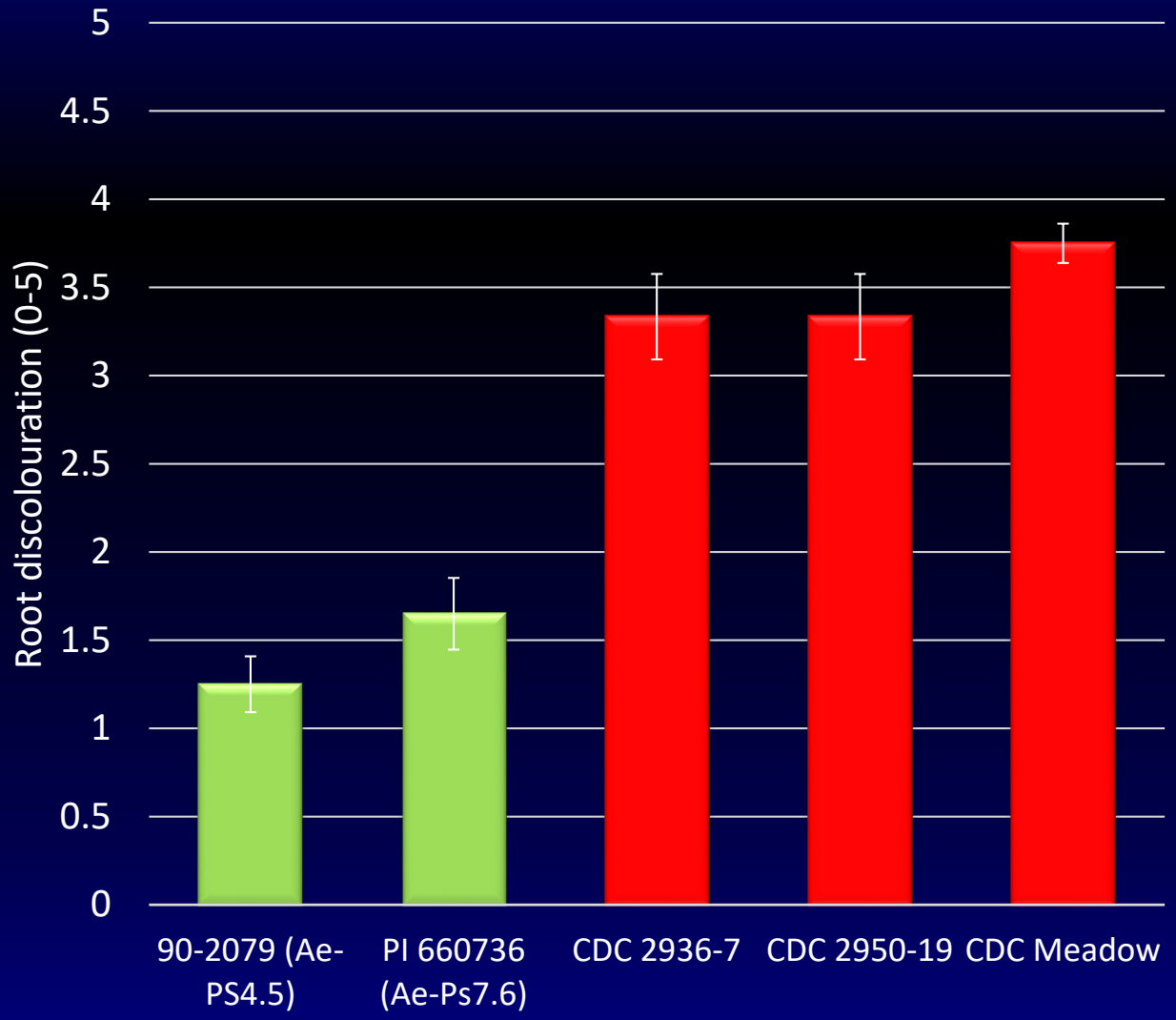
Adapted from Wicker & Rouxel 2001. European Journal of Plant Pathology 107, 919–929.

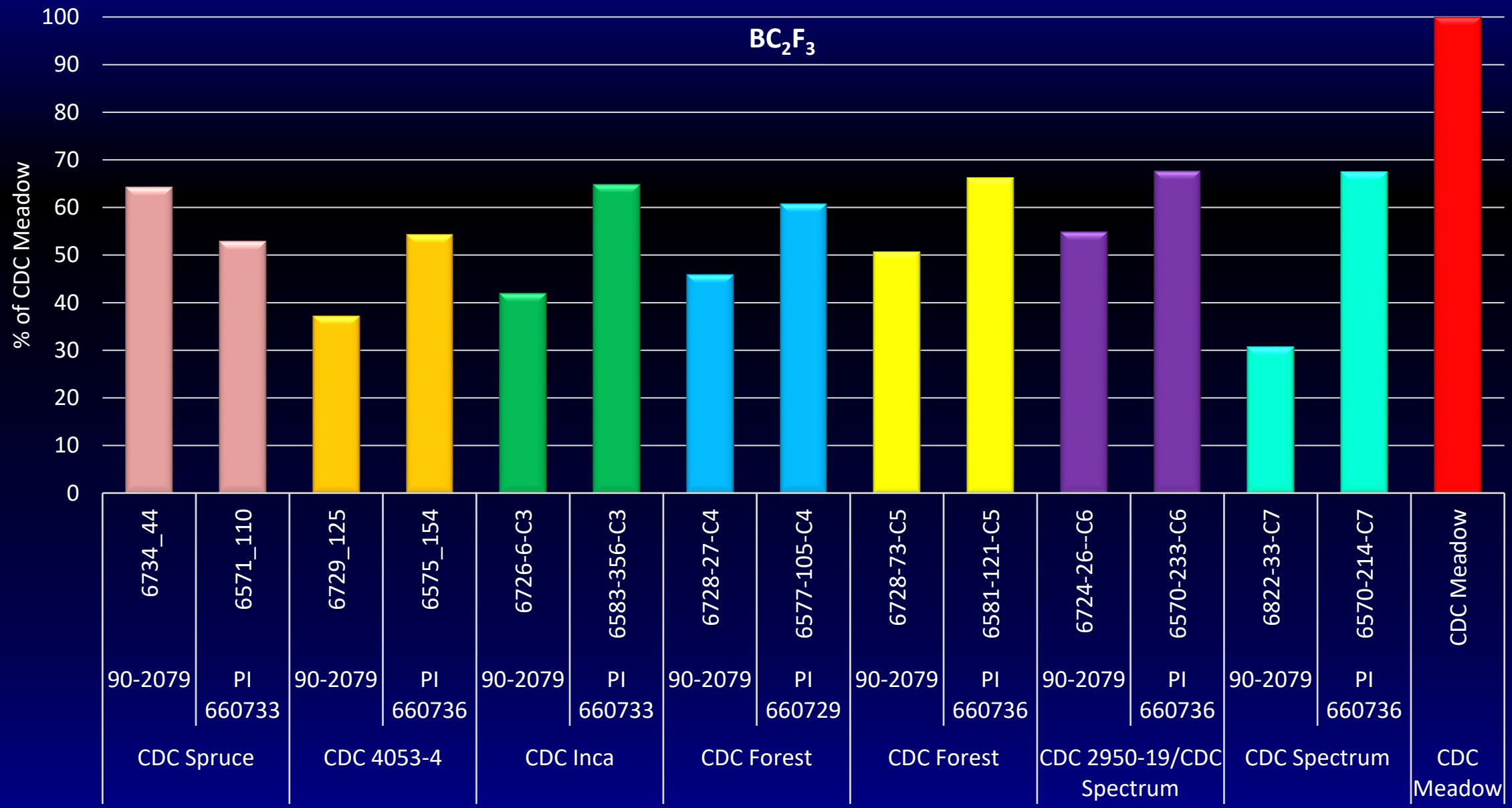
Pathotypes in Saskatchewan and Alberta



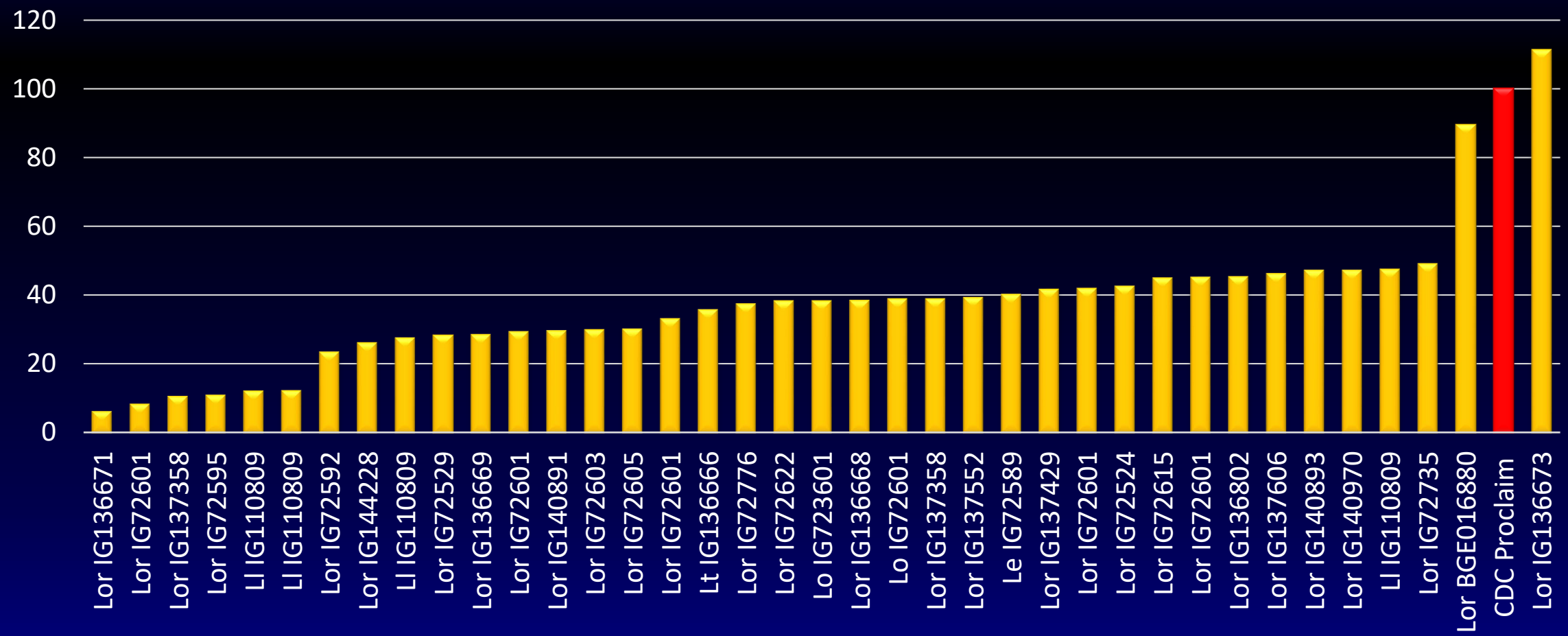
Breeding for resistance in pea at CDC

- 7 CDC pea varieties
- Sources of 2 of the 7 major QTLs:




BC_2F_3
% of CDC Meadow
100
90
80
70
60
50
40
30
20
10
0
6734_44
90-2079
6571_110
PI 660733
CDC Spruce
6729_125
90-2079
6575_154
PI 660736
CDC 4053-4
6726-6-C3
90-2079
6583-356-C3
PI 660733
CDC Inca
6728-27-C4
90-2079
6577-105-C4
PI 660729
CDC Forest
6728-73-C5
90-2079
6581-121-C5
PI 660736
CDC Forest
6724-26--C6
90-2079
6570-233-C6
PI 660736
CDC 2950-19/CDC Spectrum
6822-33-C7
90-2079
6570-214-C7
PI 660736
CDC Spectrum
CDC Meadow
CDC Meadow

Breeding for resistance in lentil at CDC

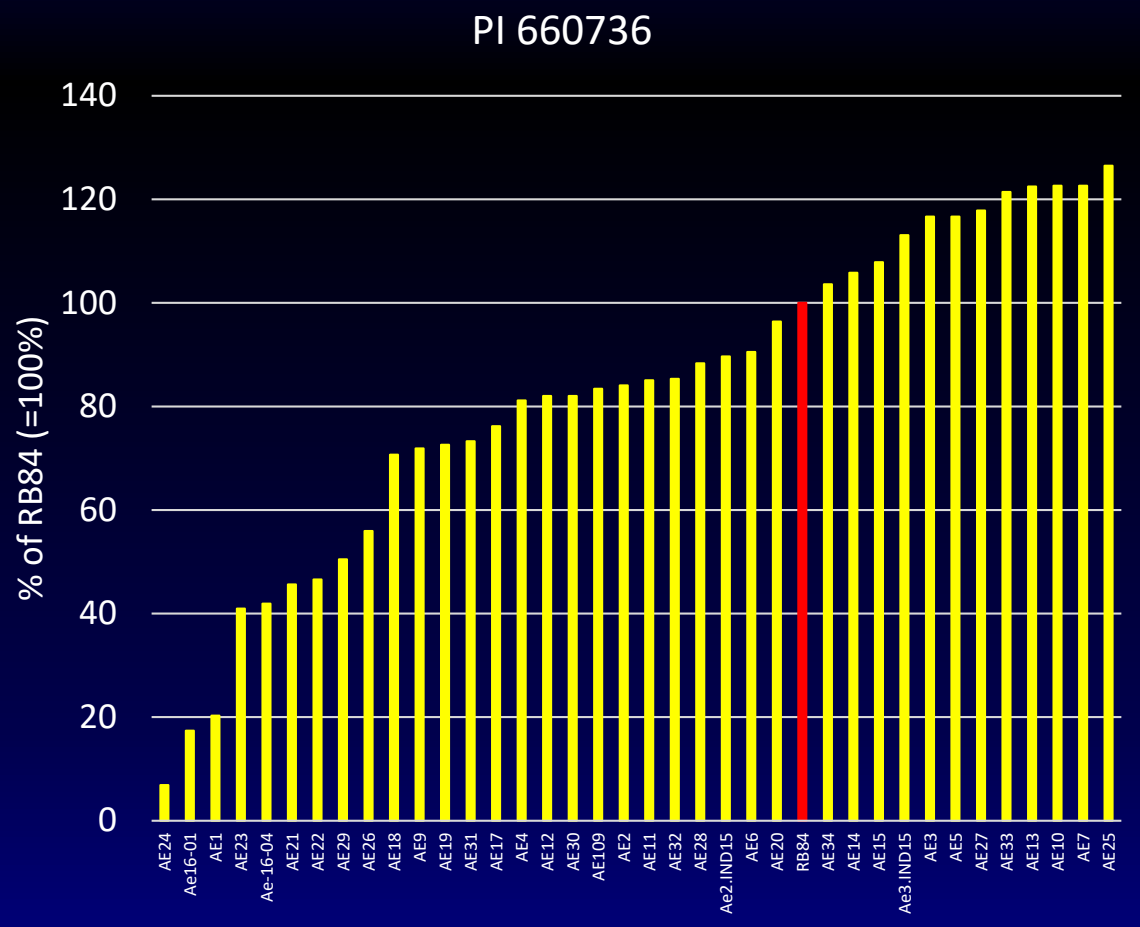


Lor: *Lens orientalis*, Ll: *L. lamottei*, Lt: *L. tomentosus*, Lo: *L. odemensis*, Le *L. ervoides*

Wanted: Magic Plant Breeder

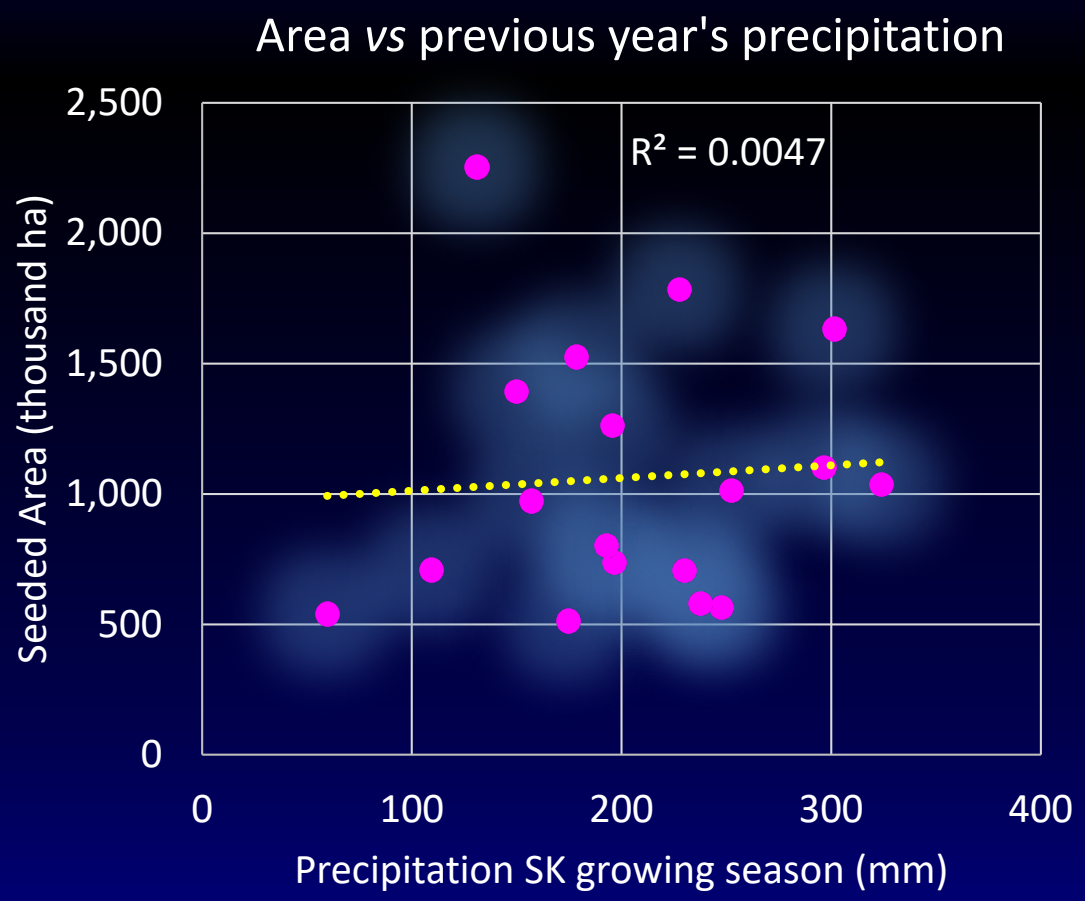
Durability of the resistance in pea (and lentil)

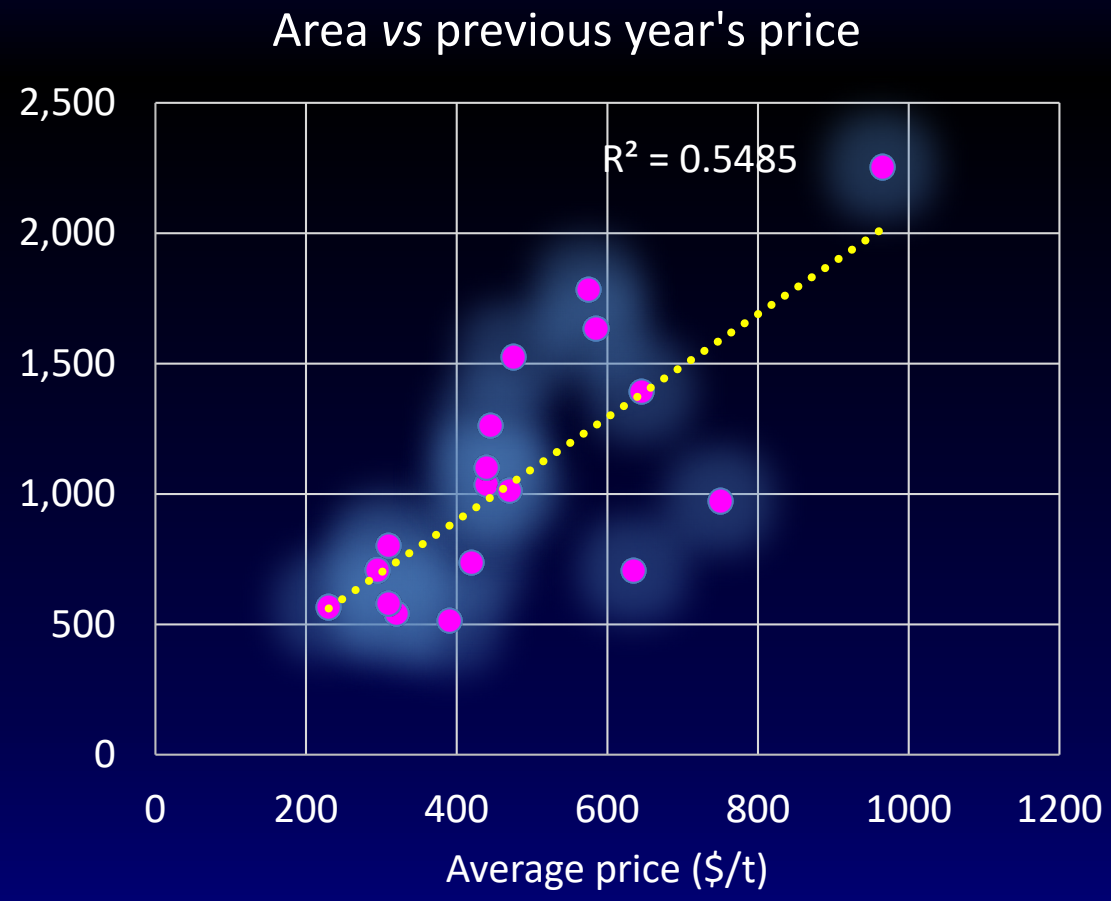
- After 20 years of research and breeding no release yet of pea variety with partial resistance in France
- Highly virulent isolates in the Canadian population?
- Field resistance of new varieties?
- Resistance management in Canada?



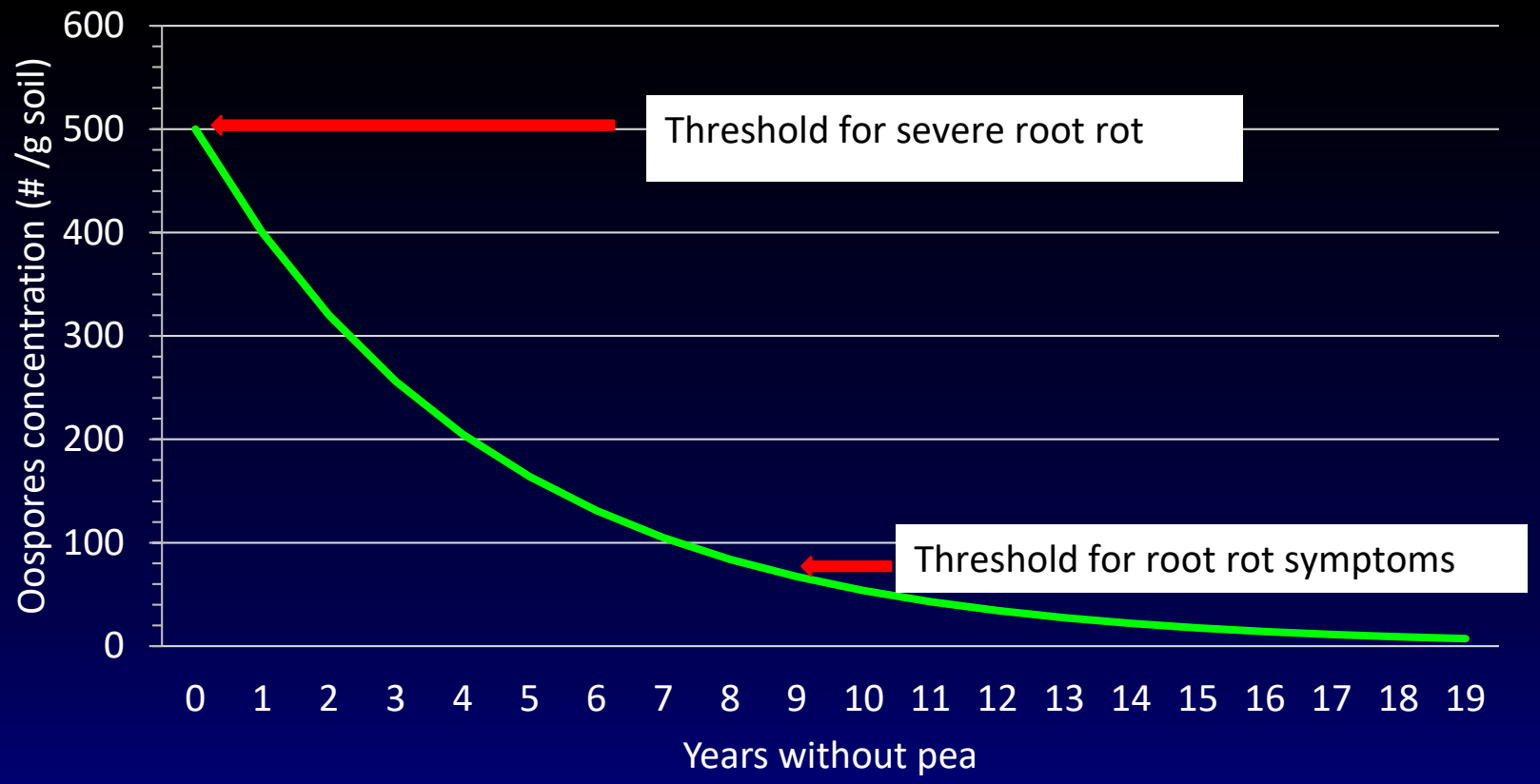
RESISTANCE WILL NOT SOLVE APHANOMYCES ROOT ROT

Biology *versus* Economics: Lentil





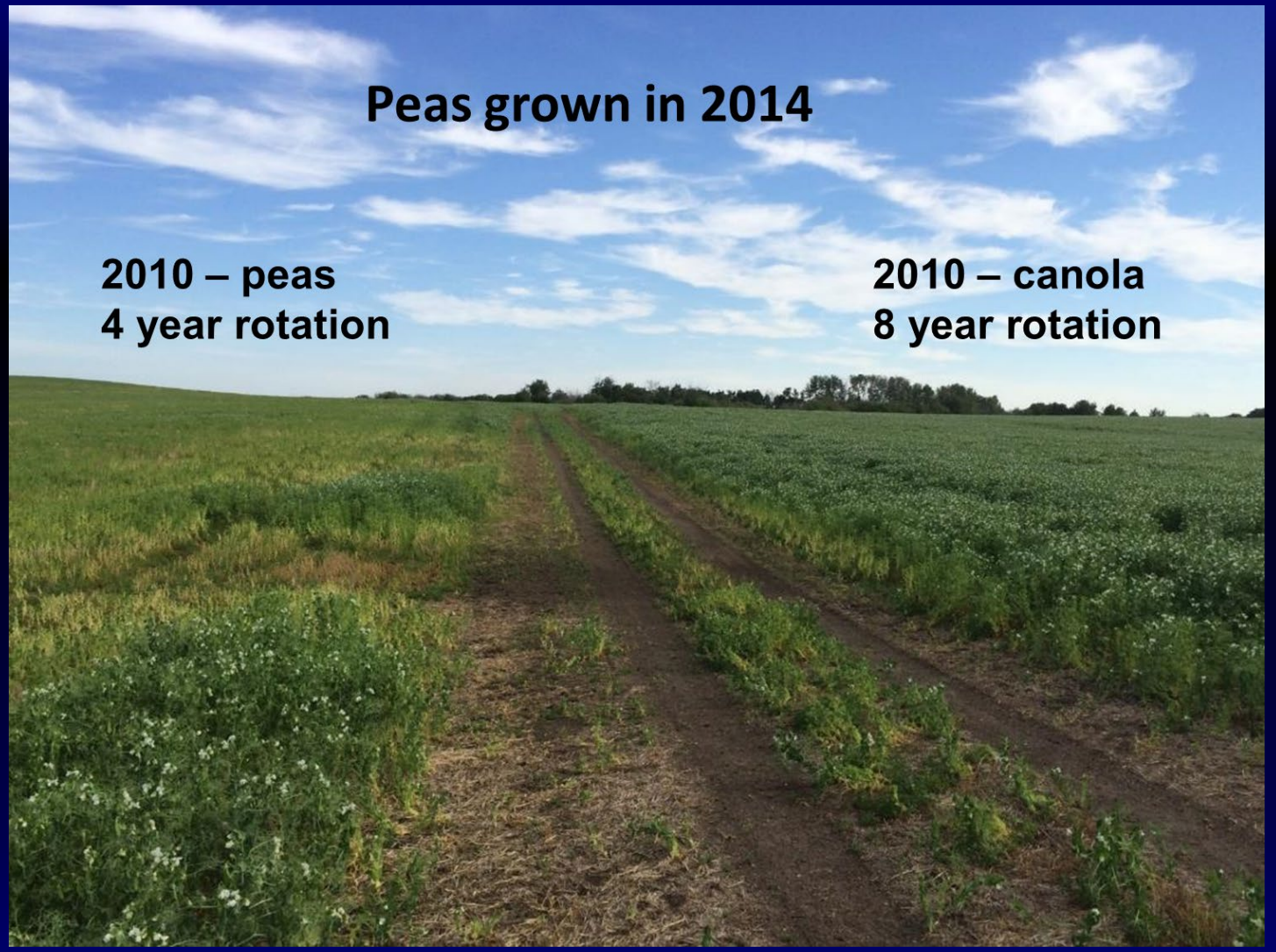
Theoretical oospore survival of *Aphanomyces euteiches* in the soil



Estimated 20 % mortality per year based on data of Pfender & Hagedorn 1983. Phytopathology 73,1109-1113.

Rotation

- Meskotascikewin
- Rotation des cultures
- Fruchtfolge
- Сівозміни
- Vetésforgó
- Växtföljd
- Vuoroviljely
- फसल का चक्रिकरण
- 轮作



S. Phelps, SPG

Crop Choices: Hosts for Aphanomyces

Crop	Disease reaction	Oospores
Pea	Susceptible	Yes
Lentil	Susceptible	Yes
Cicer milkvetch	Susceptible	Yes
Dry bean	Variable	Few
Alfalfa	Variable	Yes
Chickpea	Resistant	Few
Sainfoin	Resistant	Few
Faba bean	Resistant	No
Soybean	Non-host	No
Fenugreek	Non-host	No

Source: Dr. S. Chatterton, AAFC & Dr. S. Banniza U of S

Rotation Project with Resistant Pulses (2018-2023)

- Can resistant pulse crops reduce / exhaust oospore reservoir?
- Field sites had pea in 2017 (Swift Current) or 2016 (all other sites).

	Primary Pulse	Alternate Pulse	Production	Treatments
Brown:				
Brooks, AB	Pea	Soybean	Irrigated	10
Swift Current, SK	Pea	Chickpea	Dryland	10
Dark Brown				
Lethbridge, AB	Pea	Chickpea	Irrigated	10
Saskatoon, SK	Pea	Faba bean	Dryland	10
Black				
Lacombe, AB	Pea	Faba bean	Dryland	10
Redvers, SK	Pea	Soybean	Dry land	10
Morden, MB*	Pea	Soybean	Dryland	10

Breaks between peas	Year 1	Year 2	Year 3	Year 4	Year 5
	2018	2019	2020	2021	2022*
1-year break	Pea	Cereal	Pea	Cereal	Pea
1-year break + pulse crop	Chickpea	Cereal	Chickpea	Cereal	Pea
2 year break	Canola	Pea	Canola	Cereal	Pea
2 year break + pulse crop	Chickpea	Pea	Canola	Chickpea	Pea
3-year break	Canola	Cereal	Pea	Cereal	Canola
3-year break + pulse crop	Chickpea	Cereal	Pea	Cereal	Chickpea
4-year break	Canola	Cereal	Canola	Pea	Cereal
4-year break + pulse crop	Chickpea	Cereal	Canola	Pea	Cereal
5-year break	Canola	Cereal	Canola	Cereal	Pea
5-year break + pulse crops	Chickpea	Cereal	Canola	Cereal	Pea

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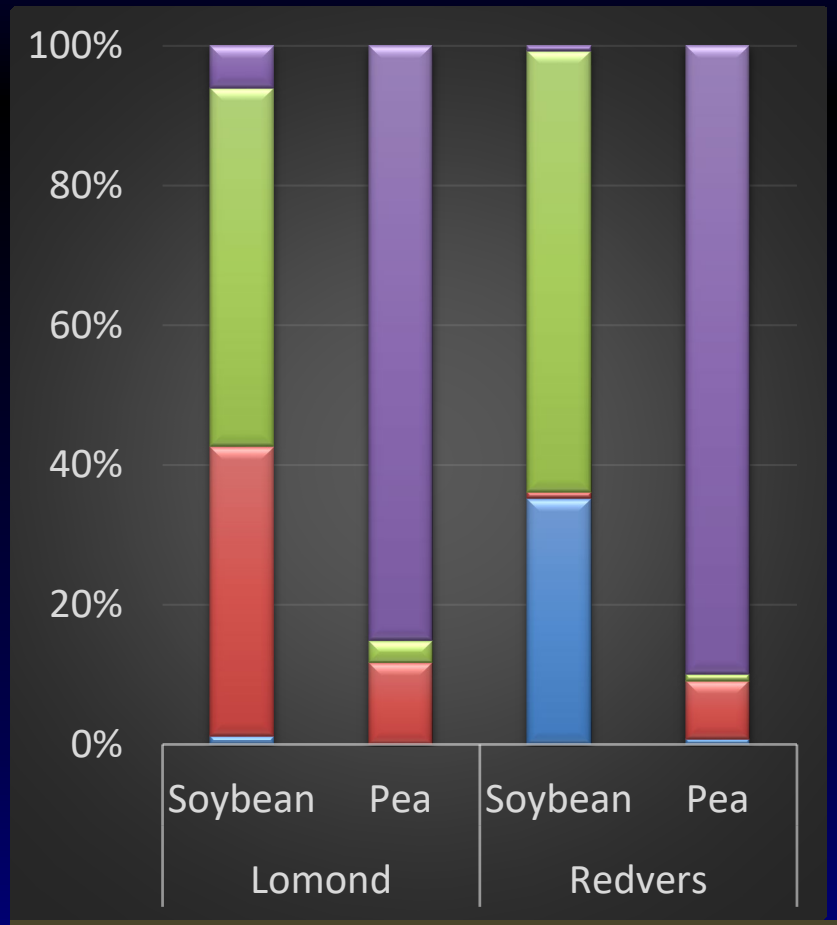
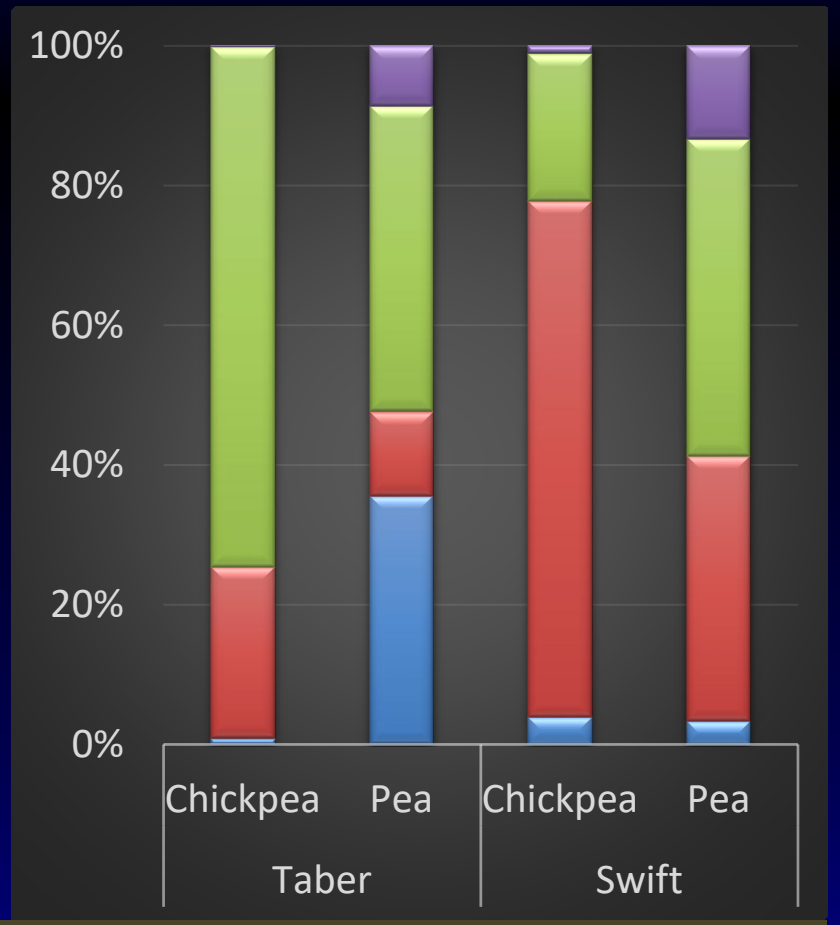
Courtesy of Drs. Hubbard/Chatterton, AAFC Swift Current/Lethbridge

Rotation Project with Resistant Pulses

(Dr. Hubbard, AAFC Swift Current)





Aph = *Aphanomyces euteiches* **Fred** = *Fusarium redolens* **Fsol** = *Fusarium solani* **Fave** = *Fusarium avenaceum*

Numbers represent numbers of fungal cells/gram of root tissue

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Rotation with potentially suppressive crops

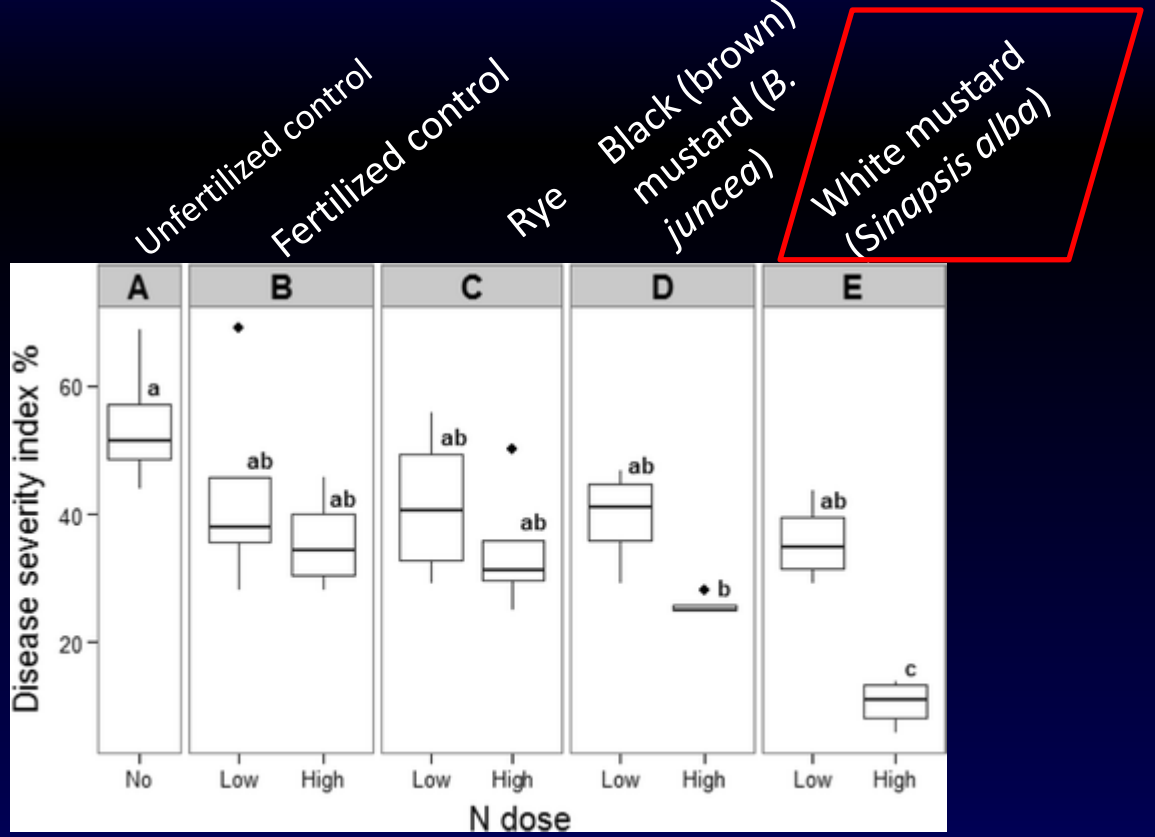
- Certain brassicas (e.g. white mustards)
- Oats
- Others?

https://en.wikipedia.org/wiki/White_mustard

https://en.wikipedia.org/wiki/Oat

Rotation with suppressive crops – *Brassica* species

- Swedish pot trial with infested field soil showed positive effect of white mustard cover crop and fertilization on subsequent pea
  - ➢ Glucosinolates
  - ➢ volatile isothiocyanates (ITCs)
  - ➢ BUT negative effect on nodulation



Incidence of Aphanomyces pea root rot (disease severity index, DSI) on peas grown for 4 weeks in a bioassay after growing cover crops for 11 weeks at a low or high N dose in Aphanomyces euteiches infested soil, and removal of both shoots and roots of cover crops (Adapted from Hossain et al. 2015. Plant and Soil392, 227–238)

Rotation project with Brassicas and other potentially beneficial rops

Syama Chatterton & Christopher Morrison, AAFC Lethbridge

- Includes oats, rye, mustard, *Brassica carinata,* faba bean (control) as green manure or seed crop
- Legume (clover or vetch) - Brassica cover crop (biofumigation and/or Aphanomyces increases?)
- Assorted combinations of *Brassica* species, based on species with high glucosinolate levels and availability of seed from Canadian seed suppliers

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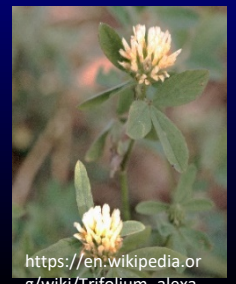
https://michiganflora.net/species.aspx?id=1335

https://en.wikipedia.org/wiki/Trifolium_incarnatum

https://www.britannica.com/plant/alfalfa

Species	Grau et al. Plant Disease 1991, 75 (11), 1153-1156	Chatterton 2020 (AAFC Lethbridge)
Arrowleaf clover (*Trifolium vesiculosum*)	R	
Aslike clover (*T. hybridum*)	R	
Berseem clover (*T. alexandrinum*)	S	R
Bird's-foot trefoil (*Lotus corniculatus*)	R	
Chickling vetch (*Lathyrus sativus*)		S
Cowpea (*Vigna unguiculata*)	R	
Crimson clover (*T. incarnatum*)	S	S
Crown vetch (*Securigera varia*)	R	
Ebena vetch (*Vicia sativa*)		S
Faba bean	S	
Field pea	S	
Garden pea	S	
Hungvillosa vetch (*Vicia villosa*)		S
White Dutch/Ladino clover (*T. repens*)	R	R
Lima bean (*Phaseolus lunatus*)	S	
Lucerne/alfalfa (*Medicago sativa*)	S	
Lupine (*Lupinus* spp.)	R	R
Persian clover (*T. resupinatum*)		Maybe S
Red clover/Sweet red clover (*T. pretense*)	S	R
Snap bean (*Phaseolus vulgaris*)	S	
Soybean	R	
Subterranean clover (*T. subterraneum*)		R
White sweet clover (*Melilotus albus*)	S	
Yellow blossom/sweet clover *(M. officinalis*)		***Maybe S***



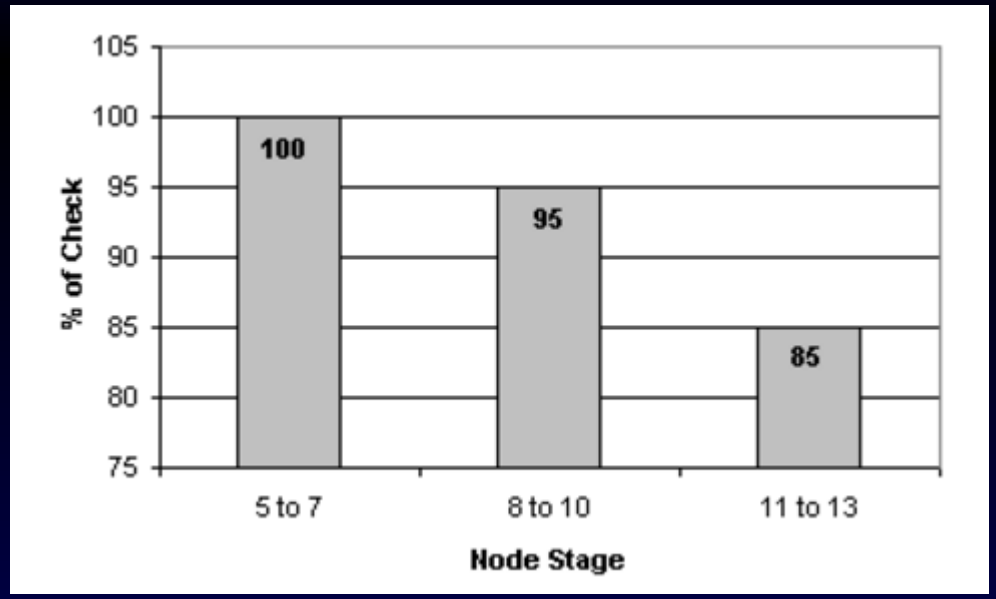
https://en.wikipedia.org/wiki/Trifolium_alexandrinum

https://en.wikipedia.org/wiki/Vicia_villosa

https://www.plant-world-seeds.com/store/view_seed_item/3964

Managing root rots

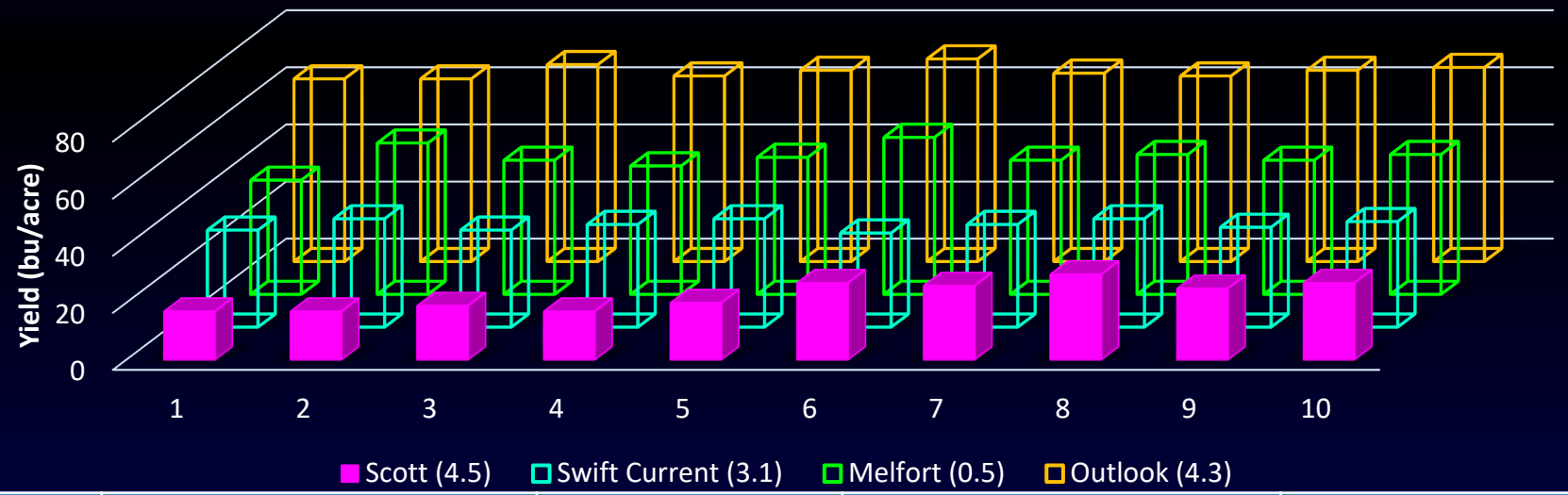
- Avoidance of soil compaction
  - Avoid rolling wet soils
  - Delay rolling beyond crop emergence when top soil is wet
    - 5th node (3rd true leaf) PEA
    - 7th node (5th true leaf) LENTIL
- Tilling?
  - Z. Kendel (PAMI) (2 years, Swift Current, Indian Head, Prince Albert)
  - No difference to date among zero, conservation or vertical till treatments



Adapted from Whatley, 1993 - LENTILS

Agronomics to Protect Pea Yield (WARC)

1 site year (2019 preliminary) – Jessica Weber, WARC

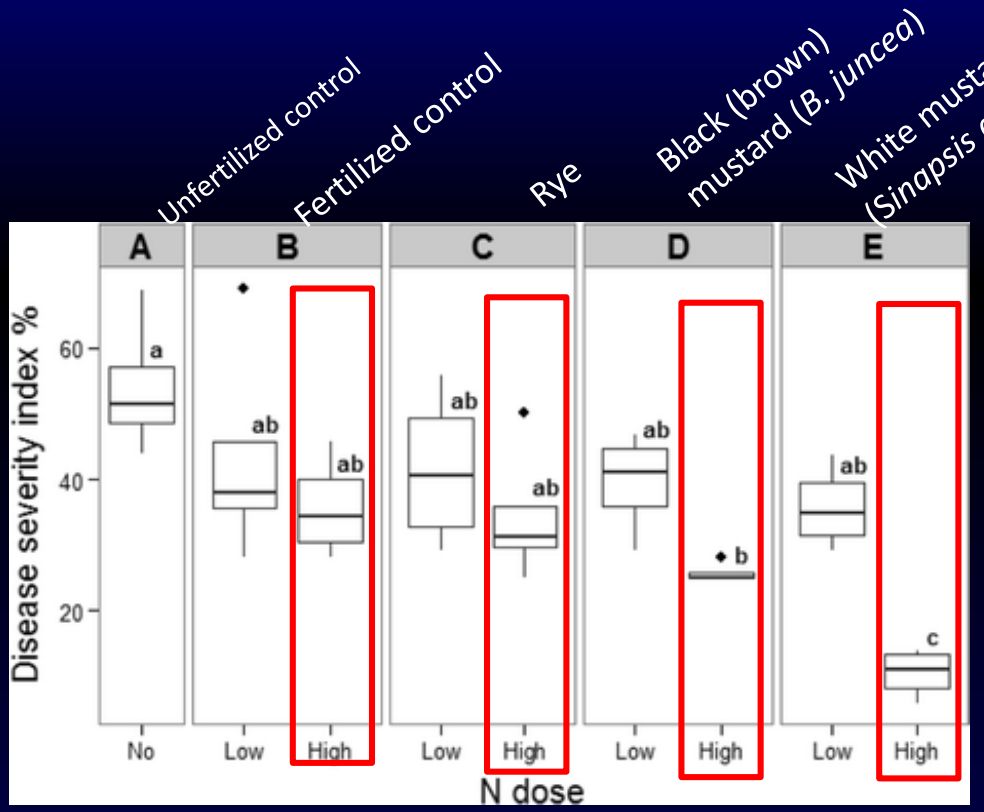


TRT	Pre-Seed Herbicide	Fertilizer (lb/ac)	Seed Treatment	Foliar Nutrient
1	Glyphosate	4N, 20 P	None	N/A
2	Glyphosate	4N 20 P	Vibrance Maxx + Intego	N/A
3	Glyphosate + Trifluralin	4N 20 P	Vibrance Maxx	N/A
4	Glyphosate + Trifluralin	4N 20 P	Vibrance Maxx + Intego	N/A
5	Glyphosate + Trifluralin	4N 20 P	Vibrance Maxx + Intego	Rogue II (Fn)
6	Glyphosate	20N, 50 P, 20 K, 10 S	None	N/A
7	Glyphosate	20N, 50 P, 20 K, 10 S	Vibrance Maxx + Intego	N/A
8	Glyphosate + Trifluralin	20N, 50 P, 20 K, 10 S	Vibrance Maxx	N/A
9	Glyphosate + Trifluralin	20N, 50 P, 20 K, 10 S	Vibrance Maxx + Intego	N/A
10	Glyphosate + Trifluralin	20N, 50 P, 20 K, 10 S	Vibrance Maxx + Intego	Rogue II

Fertility

- Starter N: 15 lbs/acre available N (up to 10 lbs/acre safe)
- Replacement of P:
  - 50 bu pea = 35 lbs P removed
  - 40 bu lentil = 24 lbs P removed
- Up to 15 - 20 lb P/acre actual seed placed is safe

Nutrient Removal Rates (lbs/bu)			
Crop	**Phosphorus**	**Potassium**	**Sulfur**
Pea	0.7	0.7	0.1
Lentil	0.6	1.1	0.2
Canola	*1.0*	*0.5*	*0.3*
Wheat	*0.6*	*0.4*	*0.1*



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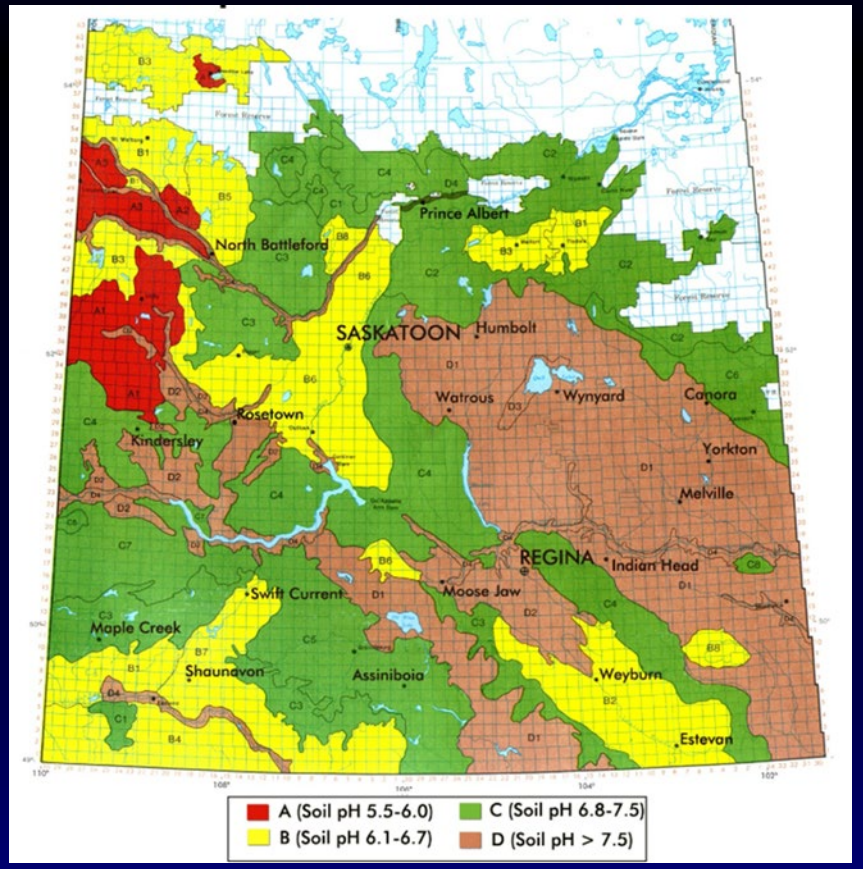
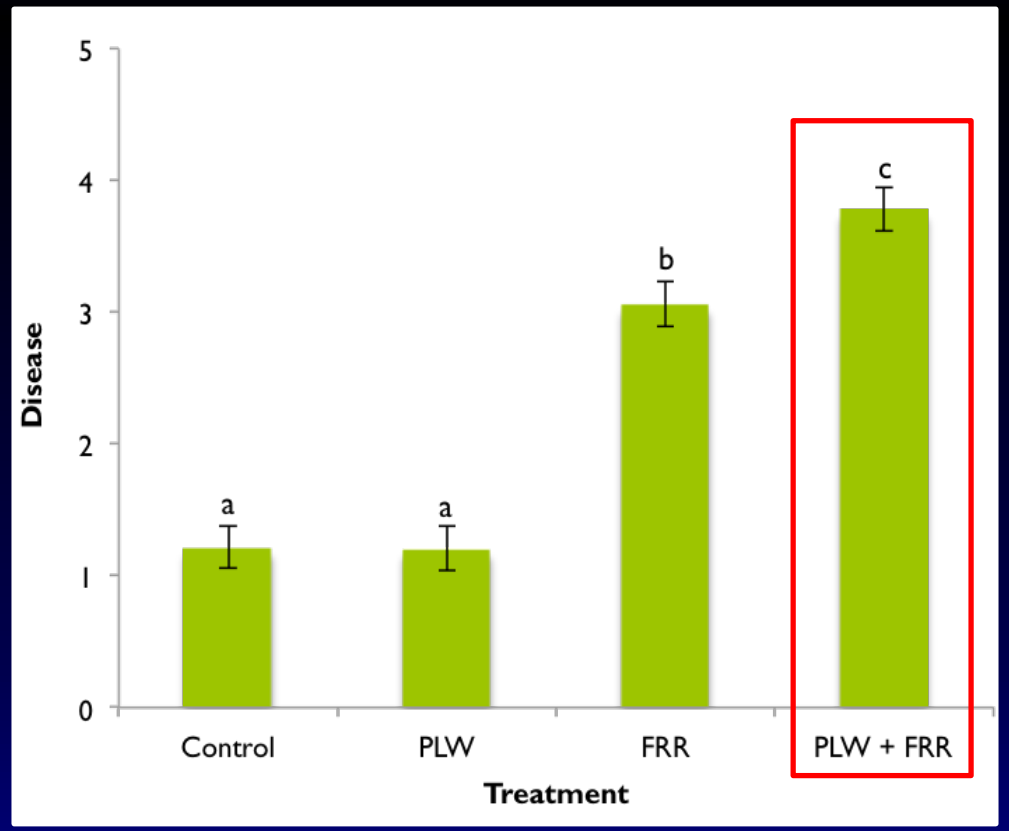
Managing root rots

- Increasing soil pH in acidic soils
  - Low pH stresses pea & lentil
  - Aphanomyces prefers acidic soils
- Increasing Ca in the soil?
- Weed management
  - Herbicide injury = stress
  - Weeds susceptible to aphanomyces root rot (shepherd's purse, chickweed, vetches, pansy



Control of Pea Leaf Weevil

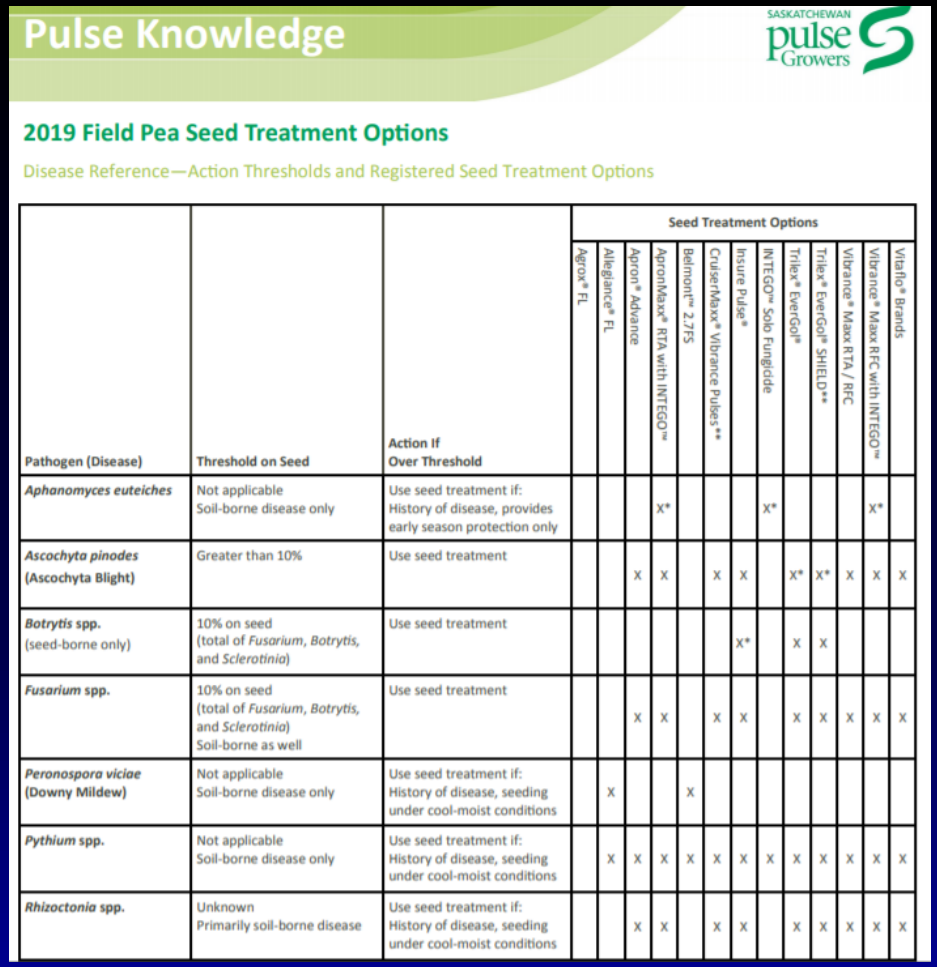
- Mutualistic interaction between *Fusarium avenaceum* (FRR) and *Sitonia lineatus* larvae (PLW)
  - Increased infection through wounded nodules
  - Reduced PLW mortality, possibly through fungal detoxification of pisatin
- Increase in disease severity
  - Fungal colonization of injured root nodules
  - Reduced N fixation



Willsey et al 2019. Crop Protection 116, 108-114

Seed Treatments

- Lots for *Fusarium*, *Rhizoctonia* and *Pythium*
- Aphanomyces
  - Intego Solo / Ethaboxam (NuFarm)
- Biologicals?



Pulse Knowledge

SASKATCHEWAN pulse Growers

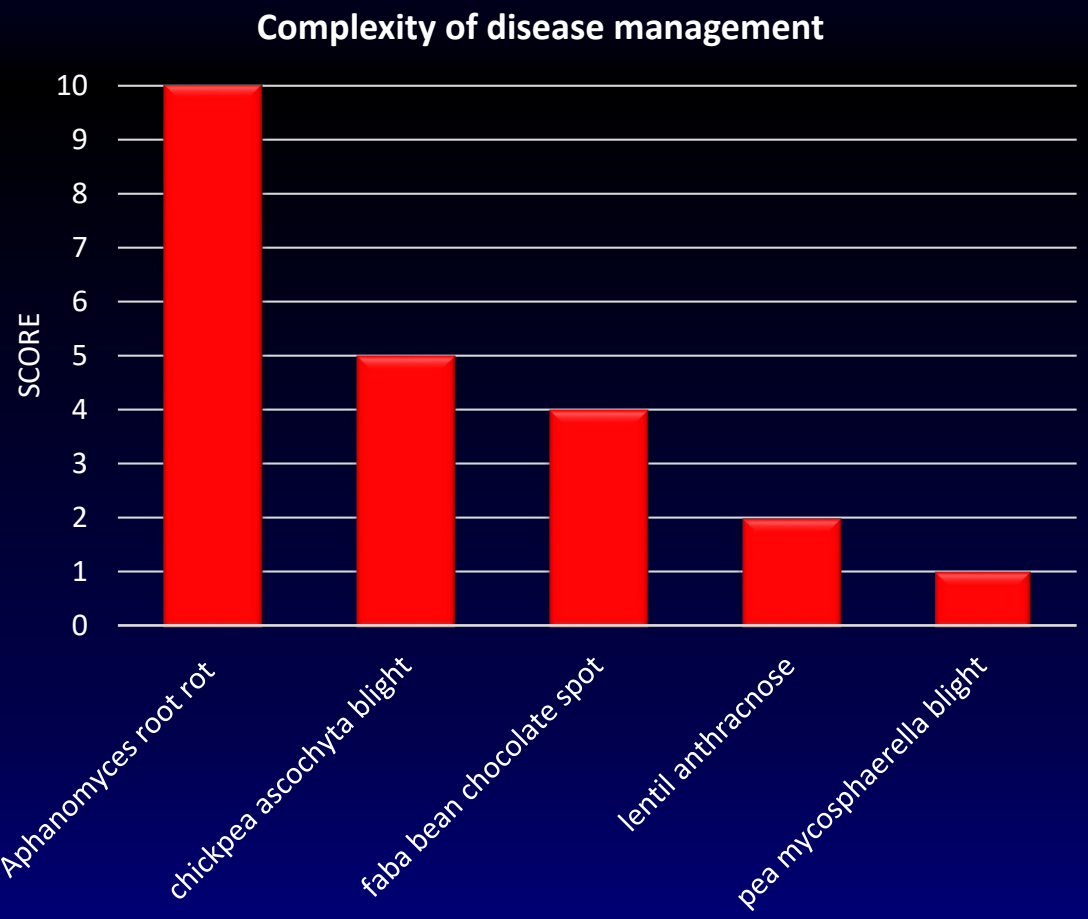
2019 Field Pea Seed Treatment Options

Disease Reference—Action Thresholds and Registered Seed Treatment Options

Pathogen (Disease)	Threshold on Seed	Action If Over Threshold	Seed Treatment Options												
			Agrox® FL	Allegiance® FL	Apron® Advance	ApronMaxx® RTA with INTEGO™	Belmont™ 2.7FS	CruiserMaxx® Vibrance Pulses**	Insure Pulse®	INTEGO™ Solo Fungicide	Trilex® EverGol®	Trilex® EverGol® SHIELD**	Vibrance® Maxx RTA / RFC	Vibrance® Maxx RFC with INTEGO™	VitaFlo® Brands
Aphanomyces euteiches	Not applicable Soil-borne disease only	Use seed treatment if: History of disease, provides early season protection only				X*				X*				X*	
Ascochyta pinodes **(Ascochyta Blight)**	Greater than 10%	Use seed treatment			X	X		X	X		X*	X*	X	X	X
***Botrytis* spp.** (seed-borne only)	10% on seed (total of *Fusarium*, *Botrytis*, and *Sclerotinia*)	Use seed treatment							X*		X	X			
***Fusarium* spp.**	10% on seed (total of *Fusarium*, *Botrytis*, and *Sclerotinia*) Soil-borne as well	Use seed treatment			X	X		X	X		X	X	X	X	X
Peronospora viciae **(Downy Mildew)**	Not applicable Soil-borne disease only	Use seed treatment if: History of disease, seeding under cool-moist conditions		X			X								
***Pythium* spp.**	Not applicable Soil-borne disease only	Use seed treatment if: History of disease, seeding under cool-moist conditions		X	X	X	X	X	X	X	X	X	X	X	X
***Rhizoctonia* spp.**	Unknown Primarily soil-borne disease	Use seed treatment if: History of disease, seeding under cool-moist conditions			X	X		X	X		X	X	X	X	X

Pulse crop production in the futures

- Diverse crop rotations with long breaks between pea and lentil
  - Promotion of alternative crops, e.g. faba bean, chickpea
- Mixed/intercropping with suppressive species
- Comprehensive integrated crop management system
- Careful management of resistant germplasm



Acknowledgements

Acknowledgments

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Biologist: Zakir Hossain
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Government of Saskatchewan, Ministry of Agriculture,
Crop Extension Specialists:
Shannon Chant (Swift Current), Kaeley Kindrachuk (Outlook), Sherri Roberts (Weyburn), John Ippolito (Kindersley) and Allie Noble (Prince Albert)
Carter Peru, Integrated Pest Management Agrologist and Megan Pearce, intern (both based in Regina)

Melanie Leppa, independent agronomist, Soils and Such,
Lyndon Stoll, an independent agrologist of Sustainable Agronomics L.S. Ltd.

Sherrilyn Phelps, Agronomy Manager with Saskatchewan Pulse Growers,

Betty Johnson, Plant Health Officer, Saskatchewan Association of Rural Municipalities (SARM)

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