University of Saskatchewan

Crop Development Centre

Saskatchewan Pulse Growers

Government of Saskatchewan
Ministry of Agriculture

Pulse Disease Issues
Chickpea & Lentil

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Western Grains Research Foundation

NSERC CRSNG

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Chickpea disease

- Ascochyta blight (fungus *Ascochyta rabiei*)

Chongo and Gossen. 2001. Can. J. Plant Pathol. 23: 358-363
Chongo and Gossen. 2003. Diseases of chickpea. *in* Bailey et al. eds. Diseases of field crops in Canada. Can Phytopath Society, Saskatoon, SK.

2019 situation

- Severe damage to chickpea in some parts of south west SK
- CDC Orion worse than CDC Leader
  - Historically, Leader slightly more resistant

Market Class	Variety	Ascochyta Blight (0-9)
Kabuli	CDC Orion	**5.0**
Kabuli	CDC Leader	**4.5**
Kabuli	CDC Palmer	4.8
Kabuli	CDC Alma	6.0
Desi	CDC Consul	3.9
Desi	CDC Cory	4.2

2019 Symptoms

- Examples

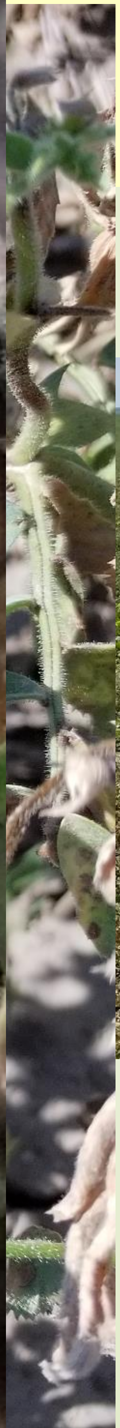
Photos:
M. Hubbard

20

- Examples

Photos:
M. Hubbard

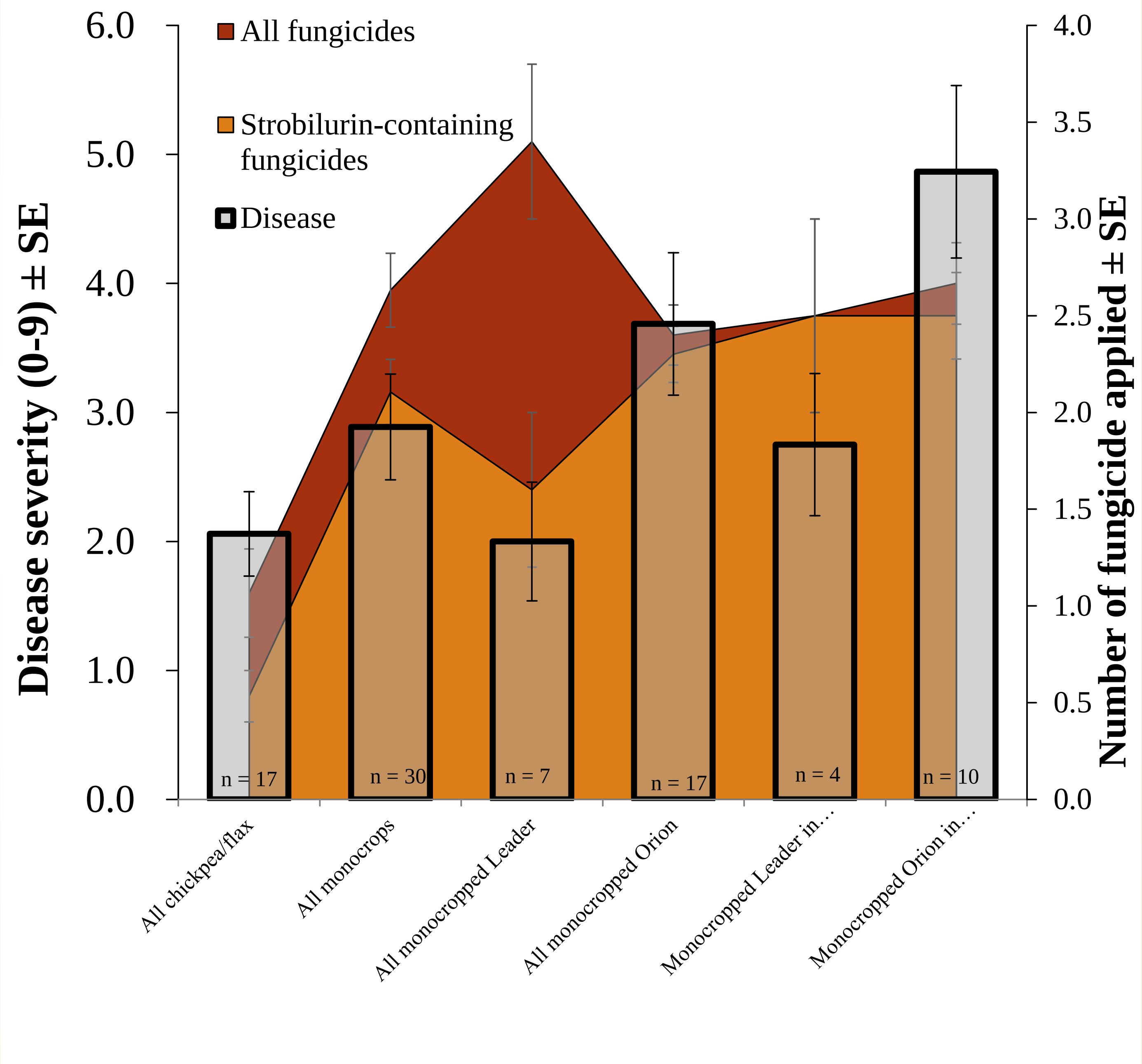
- Examples



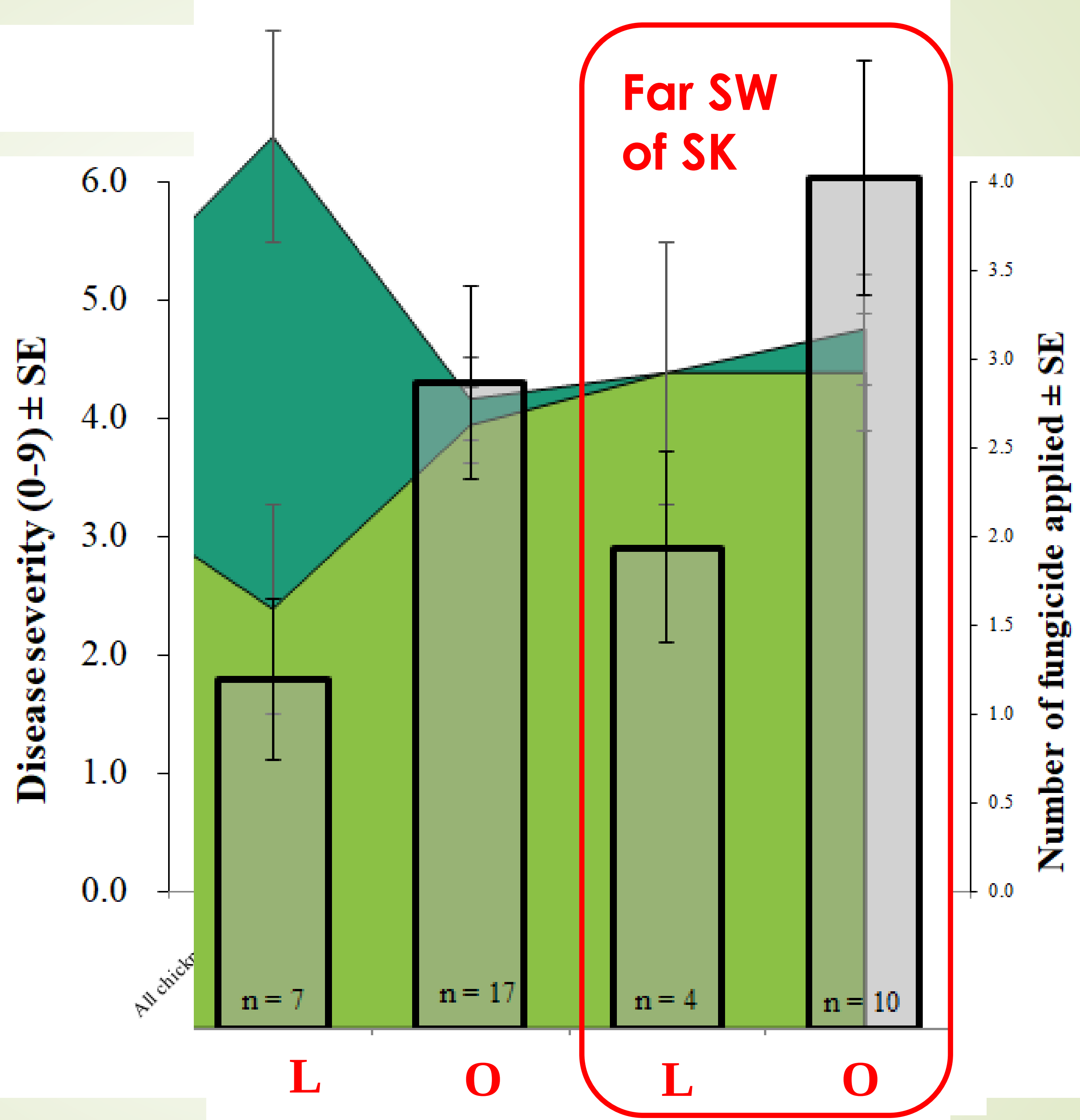
Photos:
M. Hubbard

2019 survey

- Complicated!
- 48 fields surveyed
- Every field with confirmed Ascochyta had **strobilurin resistance**

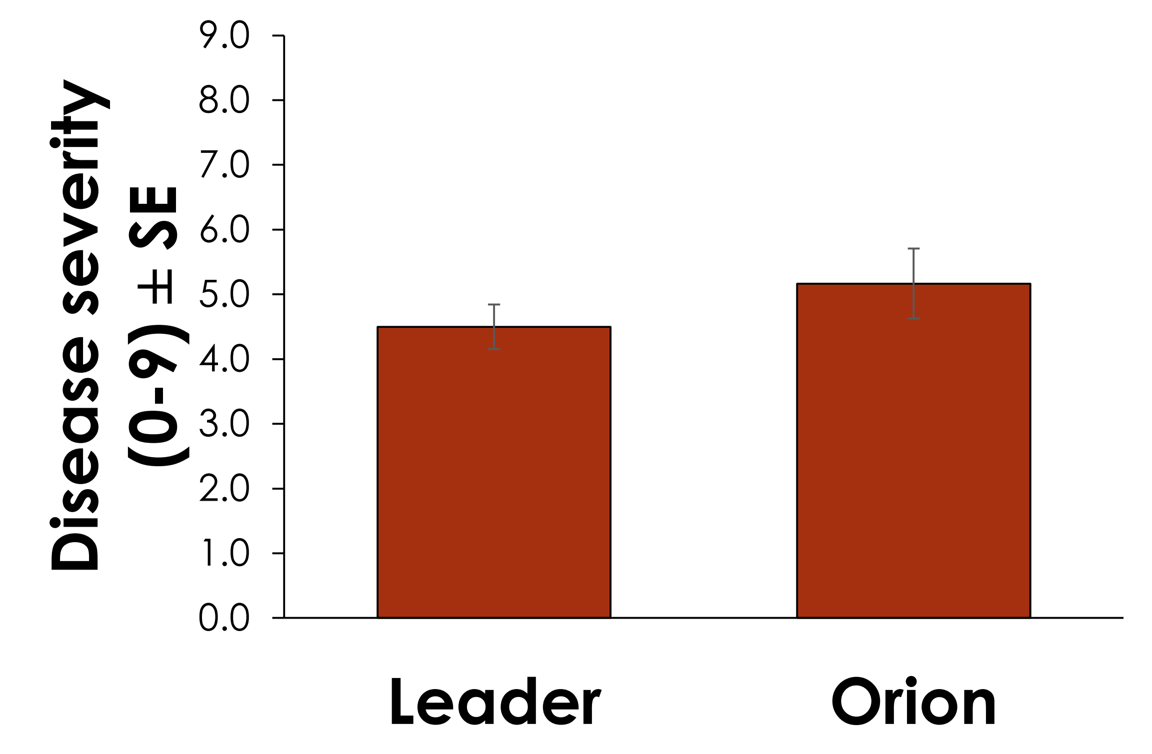


Leader vs Orion



Growth chamber

- Multiple experiments, similar results



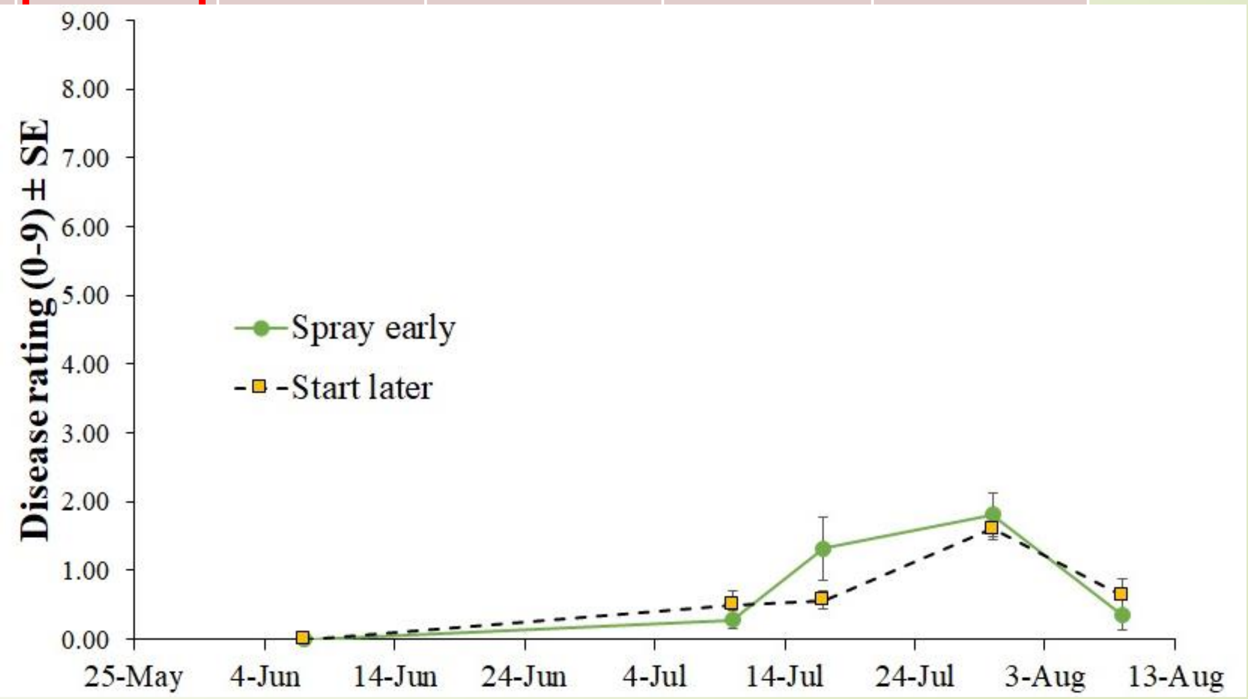
Strobilurin resistance

- Strobilurin resistance can change over a season

	July 10, 2019 collection*			July 31, 2019 collection			August 9, 2019 collection		
Treatment	Fungicides applied at time of collection	Strobilurin sensitive A. rabiei?	Strobilurin resistant A. rabiei?	Fungicides applied at time of collection	Strobilurin sensitive	Strobilurin resistant	Fungicides applied at time of	Strobilurin sensitive	Strobilurin resistant
1	Delaro, Elatus	100%	67%	Delaro, Elatus, Dyax					
2	Delaro	100%	67%	Delaro, Dyax					

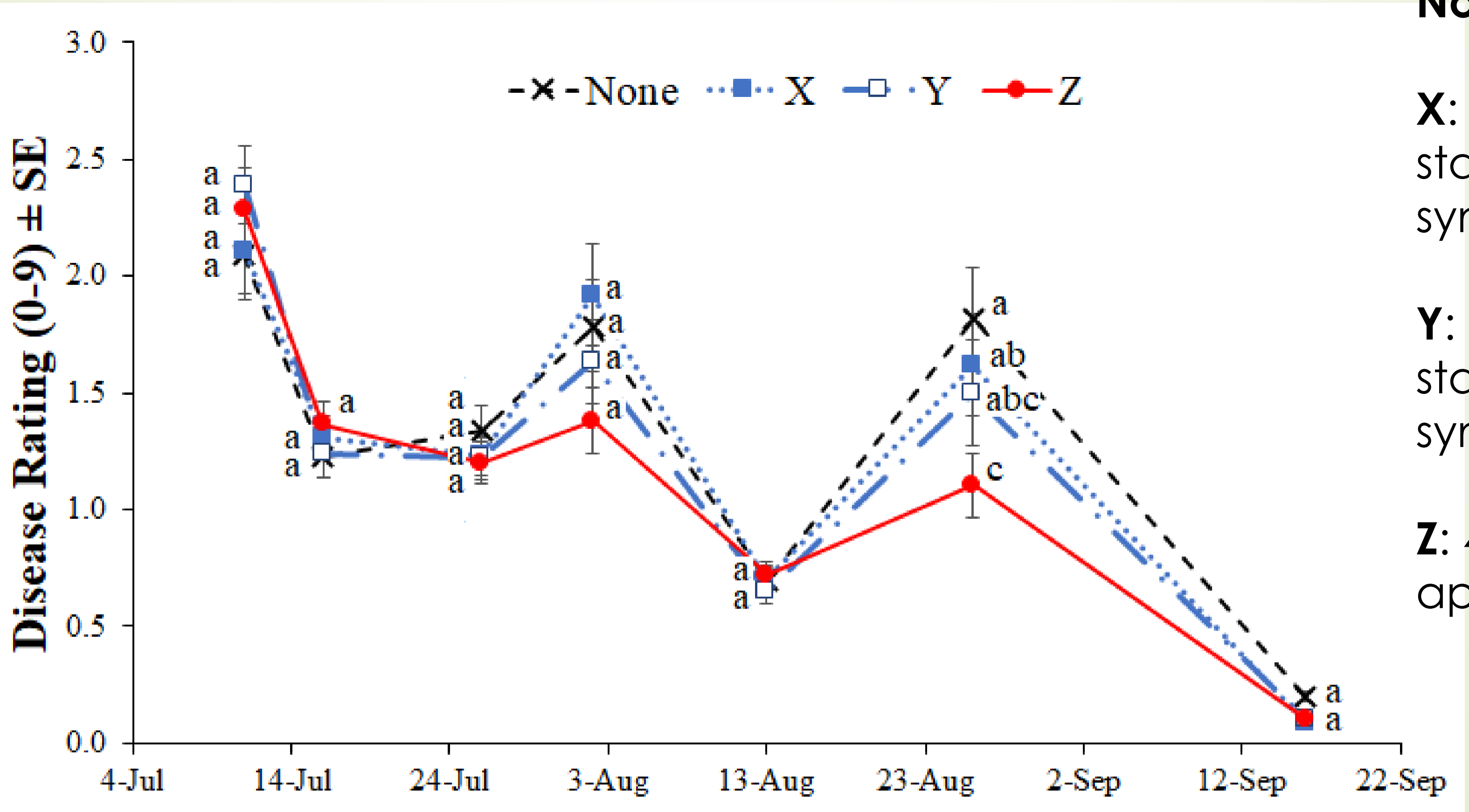
Delaro (group 11 and 3)
Elatus (group 11 and 7)
Dyax (group 11 and 7)

Dyax spray July 16



Fungicides and disease

- Very little benefit in dry conditions



None: no fungicides

X: 2 fungicides, starting before symptoms

Y: 2 fungicides, starting after symptoms

Z: 4 fungicide application

Herbicides 2019 SK survey

- Data from 25 fields

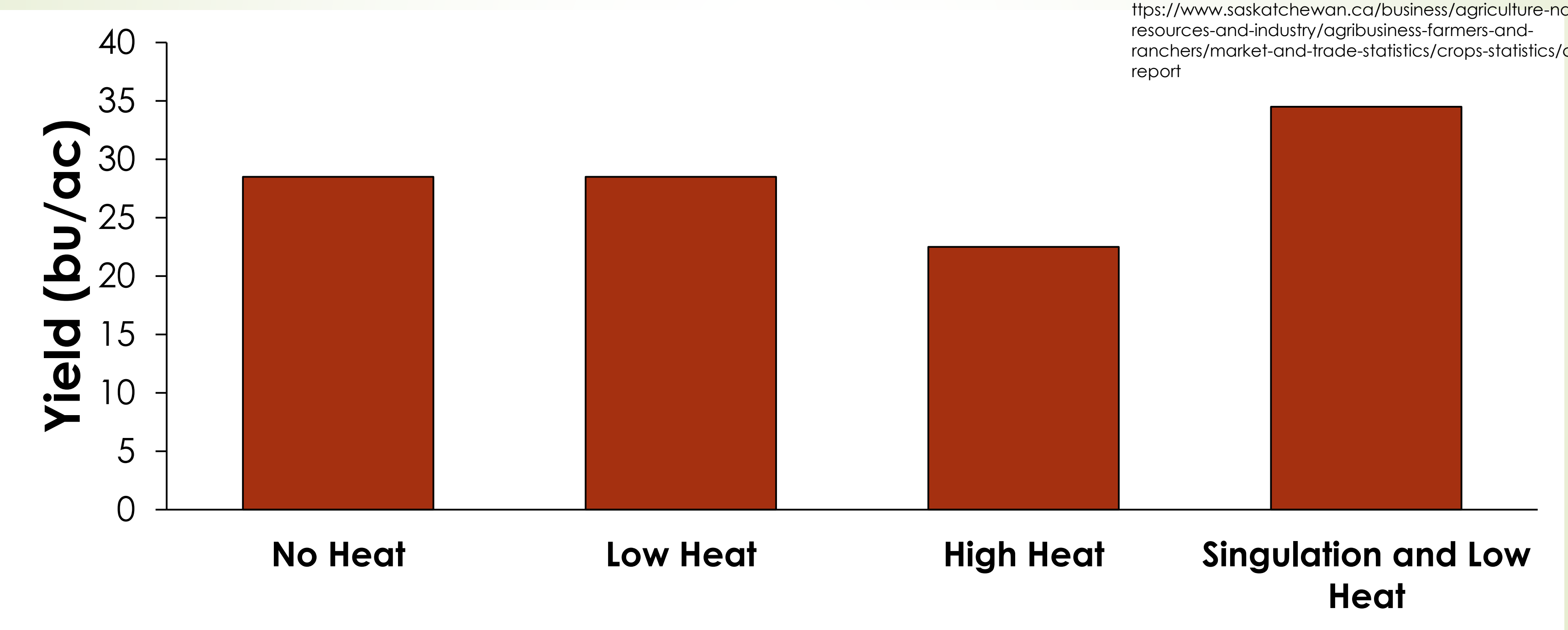
Herbicide	Group	Active ingredient	# of fields	Timing
Edge	3	ethalfluralin	4	fall
Rival	3	trifluralin	5	pre-seed or emerg
Glyphosate	9	glyphosate	13	pre-seed or emerg
Valtera	14	flumioxazin	1	pre-seed or emerg
Heat	14	saflufencil	9	pre-seed or emerg
Authority	14	sulfentrazone	6	pre-seed or emerg
Arrow	1	clethodim	5	post-emerg
Centurion	1	clethodim	1	post-emerg
Assure 2	1	quizalofop-p-ethyl	6	post-emerg
Yuma	1	quizalofop-p-ethyl	4	post-emerg
Merge	n/a	surfactant	4	

Heat and yield

- Field not included in survey
- CDC Orion
- Just 1 field = anecdotal, not scientific

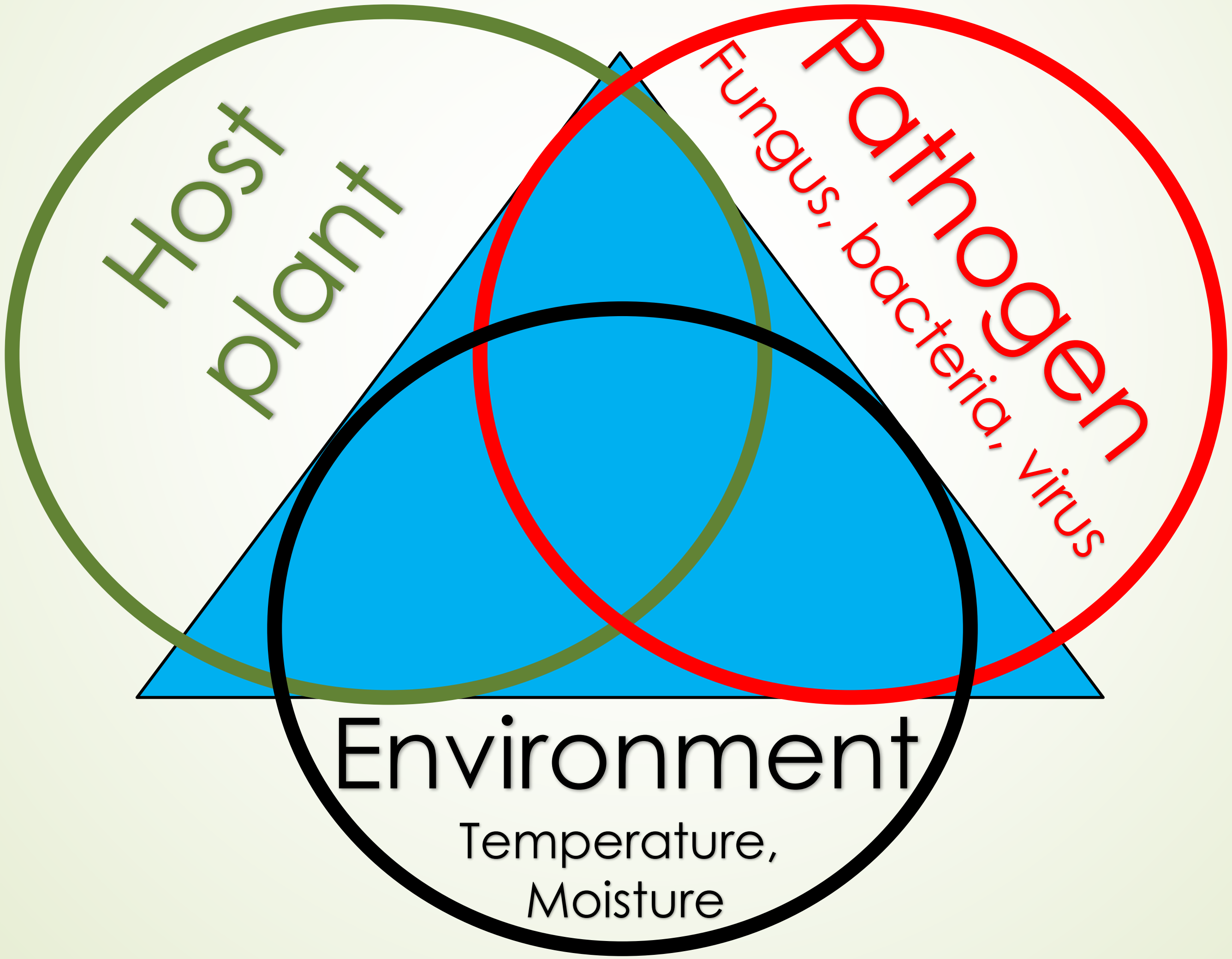
	Chickpea yield (lbs/ac)	Chickpea yield (bu/ac)
Southeast	1,497	25.0
Southwest	1,363	22.7
East Central	800	13.3
Provincial	1,391	23.2
10 yr. prov. avg. (2009-2018)	1,316	21.9

SK Ministry of Ag:
ttps://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/market-and-trade-statistics/crops-statistics/crop-report



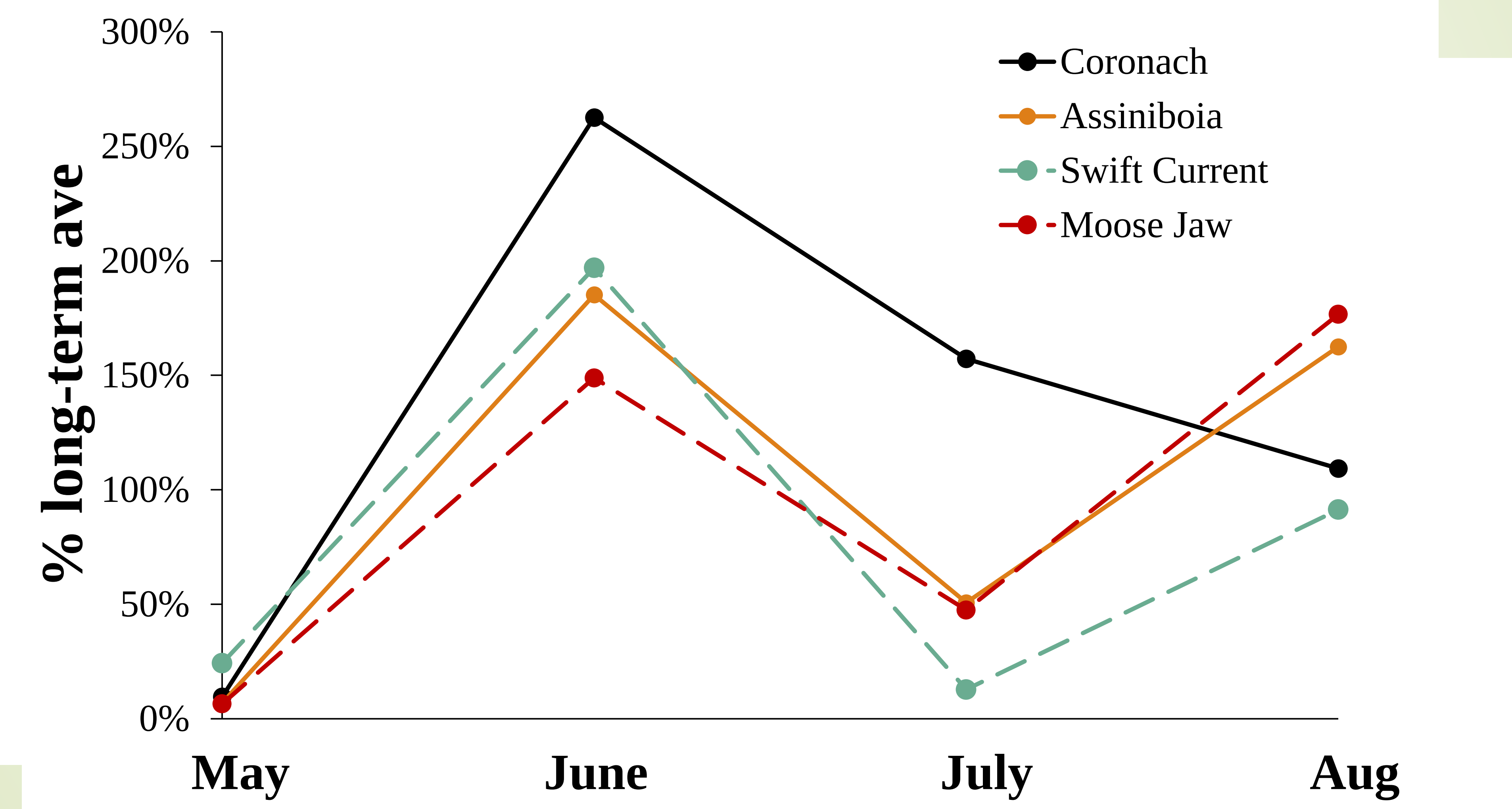
Environment

Disease Triangle



Why the South West?

- Weather

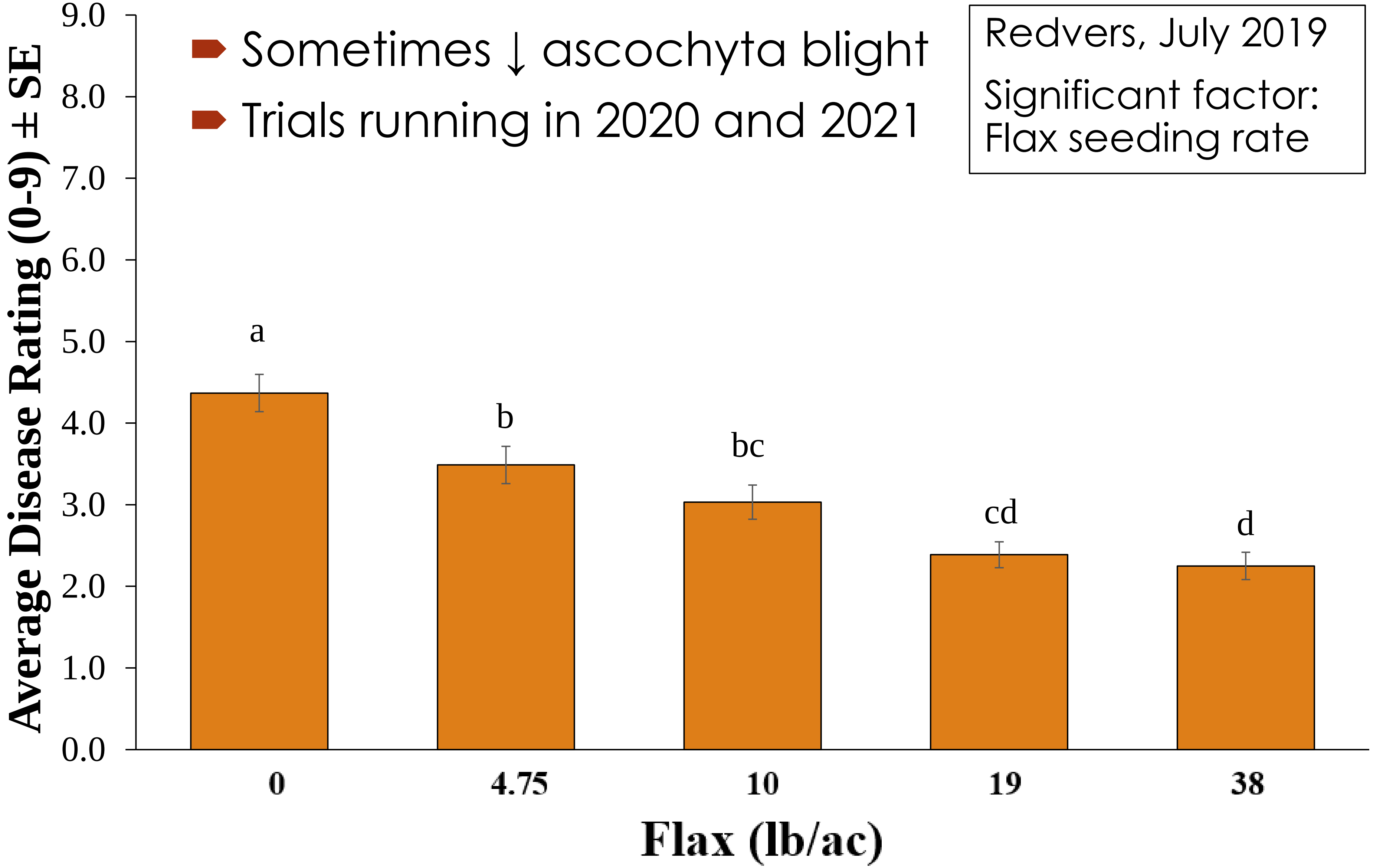


Intercropping chickpea/flax

- Sometimes ↓ ascochyta blight
- Trials running in 2020 and 2021

Redvers, July 2019

Significant factor:
Flax seeding rate



Chickpea root rot

In general:

- Pythium species
- Fusarium species
- *Rhizoctonia solani*

Leiso et al. (2011) Can. J. Plant Pathol. 33(3): 400–409

Chickpea root rot 2019
Photo: M Hubbard
Sample: S. Phelps

Chickpea root rot in SK, 2019

- Severe damage to chickpea in far south west of SK in July

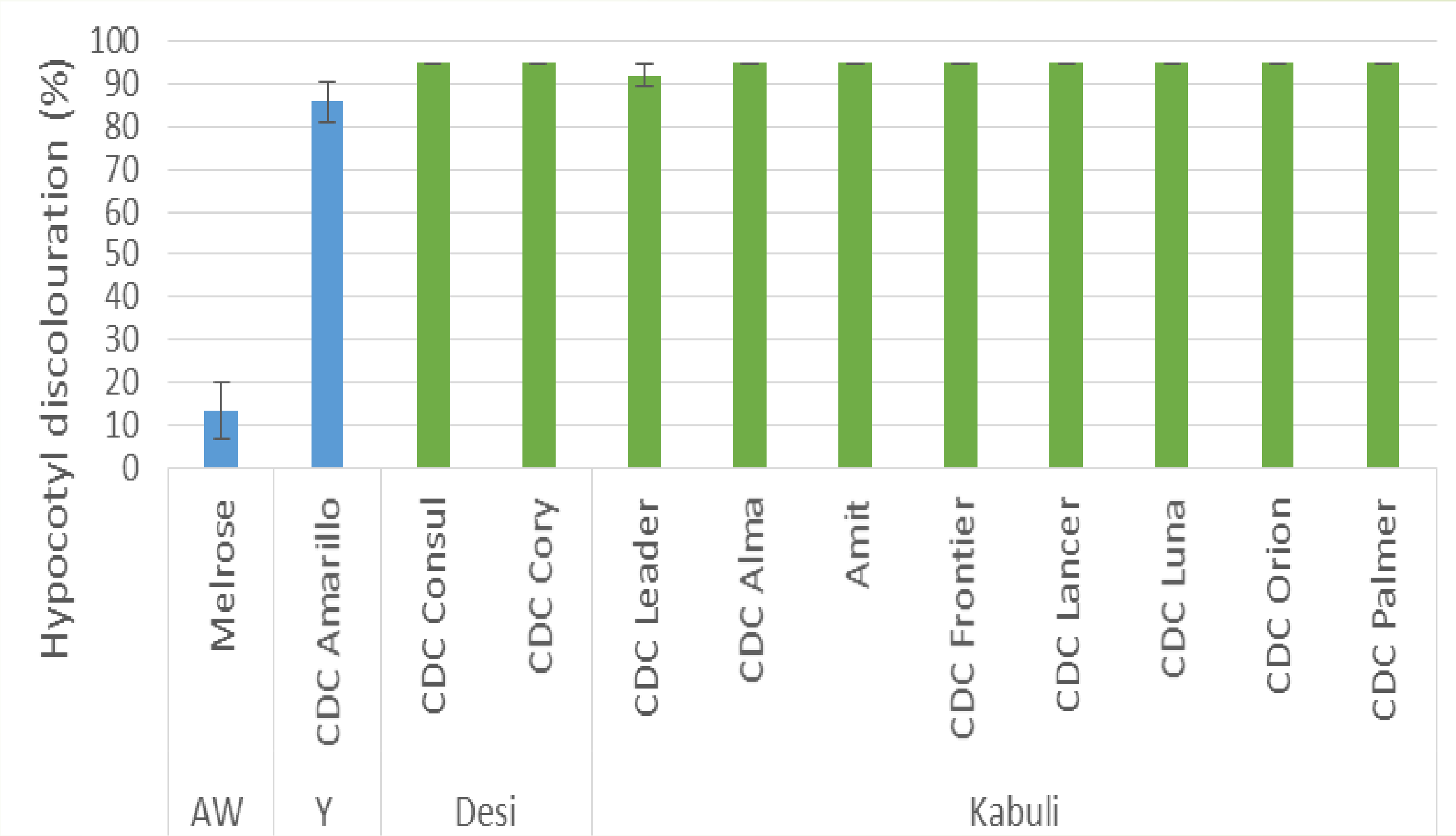
- Chickpea is resistant to Aphanomyces

- Pathogens in SK unknown
- Survey starting this year! Dr. Sabine Banniza, U of S

- Five diseased samples:
  - *Fusarium redolens*,
  - *F. solani* (possibly *forma specialis pisi*),
  - *F. avenaceum* and
  - *Phytophthora medicaginis*

Genetic resistance in chickpea

- Not much resistance currently
- Resistance to other pathogens could be important
- SURVEY



Fusarium avenaceum resistance in chickpea
Dr. Sabine Banniza, University of Saskatchewan, Crop Development Centre

Pest surveys – Get involved

- To obtain meaningful information and reduce bias we need a large number of fields located across the province
- **We need your help!** Please sign up to allow us access to your land

Lentil diseases

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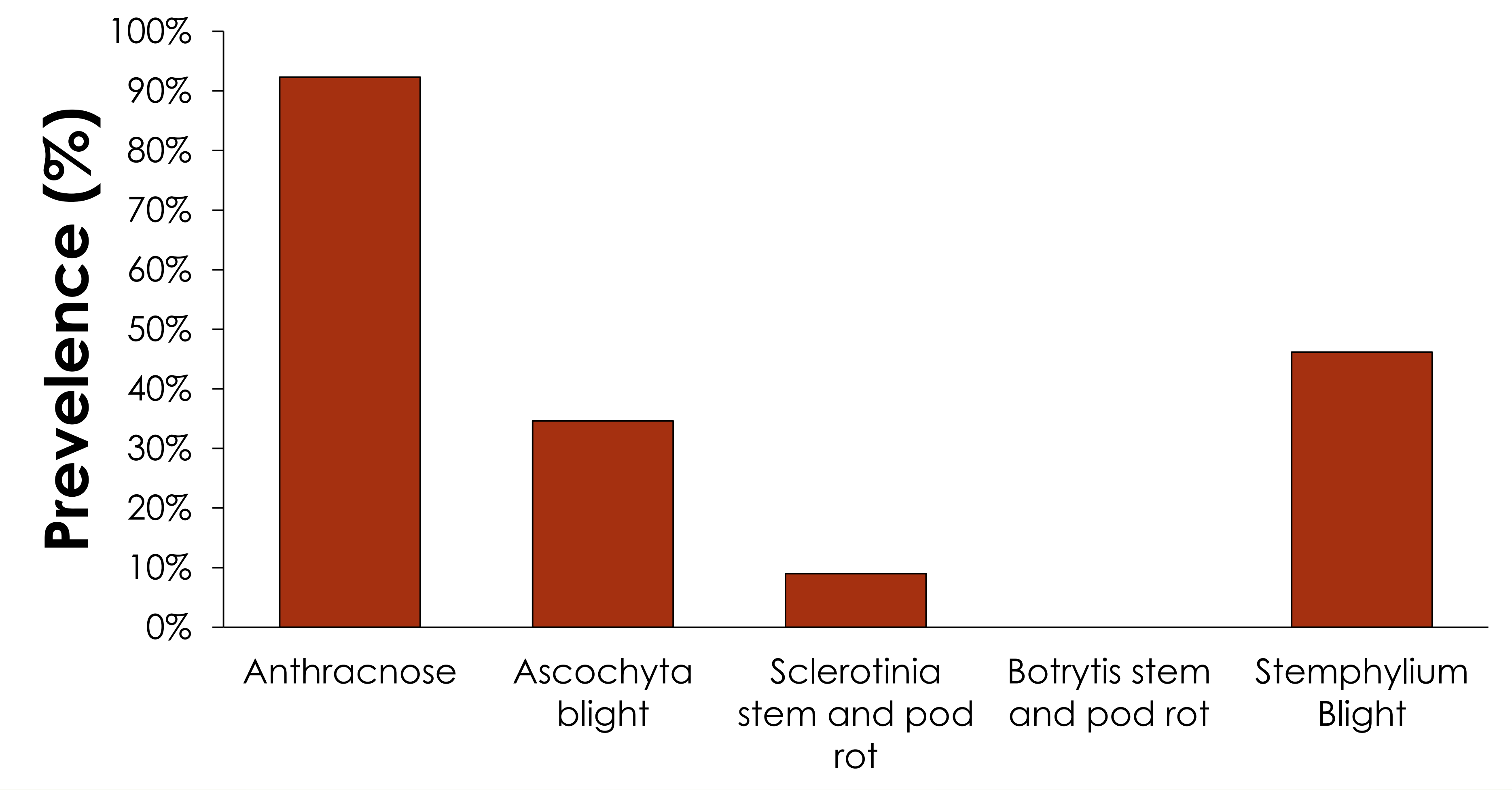
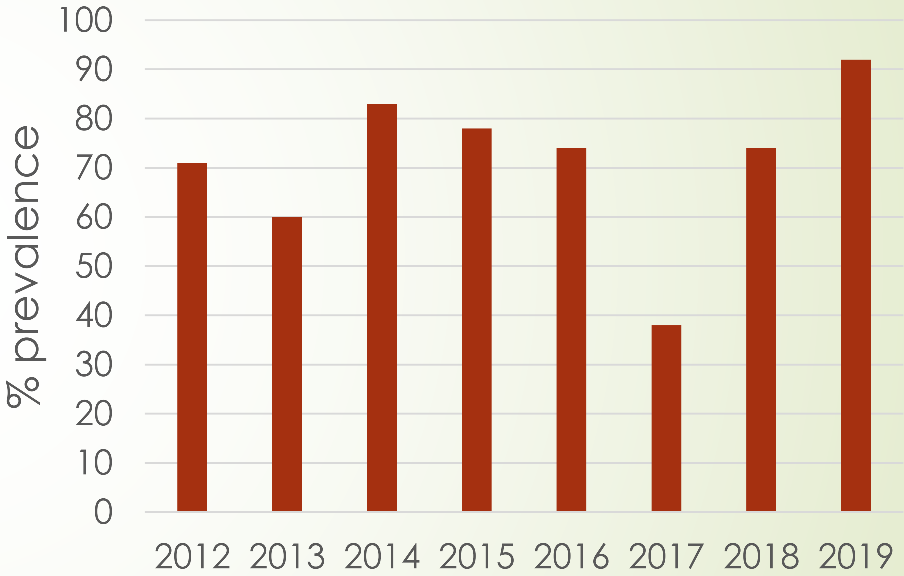
Lentil foliar diseases



Anthracnose in Lentil

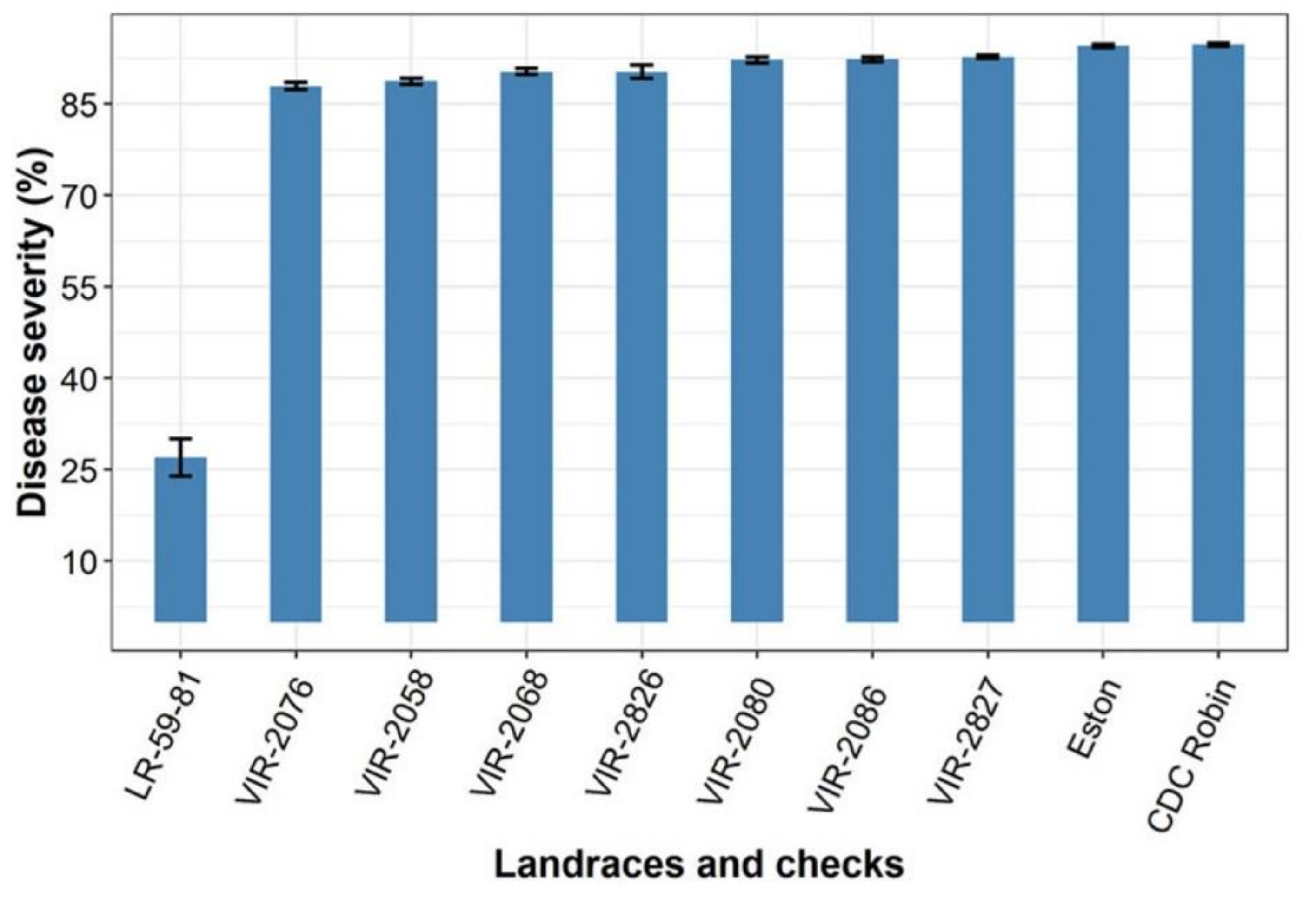
- 2019 was historically high

- Manage via crop rotations and foliar fungicides



Genetic resistance in Lentil

- 2 races of Anthracnose
  - Race 1
  - Race 0
- No resistance to the race that causes more serious disease (race 0)



Gela et al. (2020) Plant Gen. Res. Char. Util. 1-7.

Root rot in Lentil and Pea

- Range of pathogens
  - Fusarium species
  - Pythium species
  - *Rhizoctonia solani*
  - *Aphanomyces euteiches*

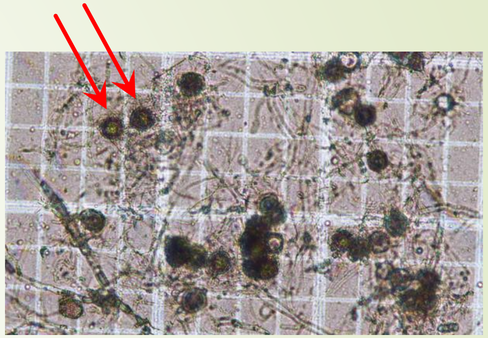
Fusarium

Infects many different plants

Courtesy of F. Dokken-Bouchard, SMA

Aphanomyces

Oospores



- Infects lentil and pea
- Oospores = resting spores
  - More vulnerable after they germinate
- Zoospores: can swim short distances

- Every time a plant gets infected, the amount of Aphanomyces in the soil ↑

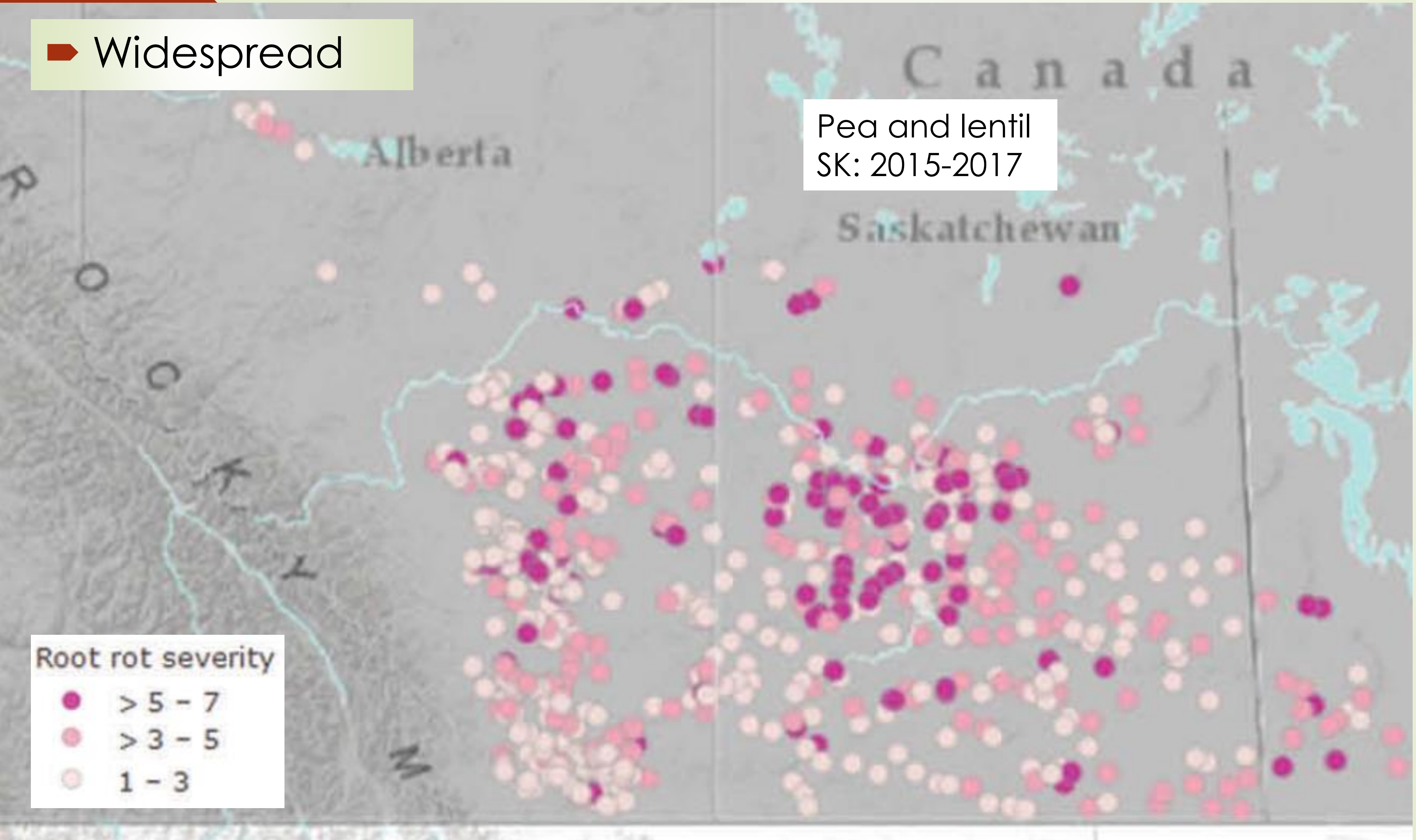
of F. Dokken-Bouchard, SMA

Environmental preferences

.....according to the literature

Organism	Temperature optimum (°C)	Optimum Soil Moisture	Optimum pH
Aphanomyces	22 to 27	Excessive	pH 4.5 to 6.5
Fusarium	25 to 30	Moderate	
Pythium	17 to 23	Wet	
Rhizoctonia	Can damage at 18 but most aggressive at 24 to 30	Wide range of conditions	

Aphanomyces survey from 2014-2017



Chatterton et al. (2018) Can. J. Plant Path.

Lentil root rot 2019 in SK

- 59% prevalence

Region	Number of Fields surveyed	Prevalence (%)
Southwest	23	61
Southeast	12	75
East-central	8	63
West-central	34	50
Northeast	1	100
Overall	78	59

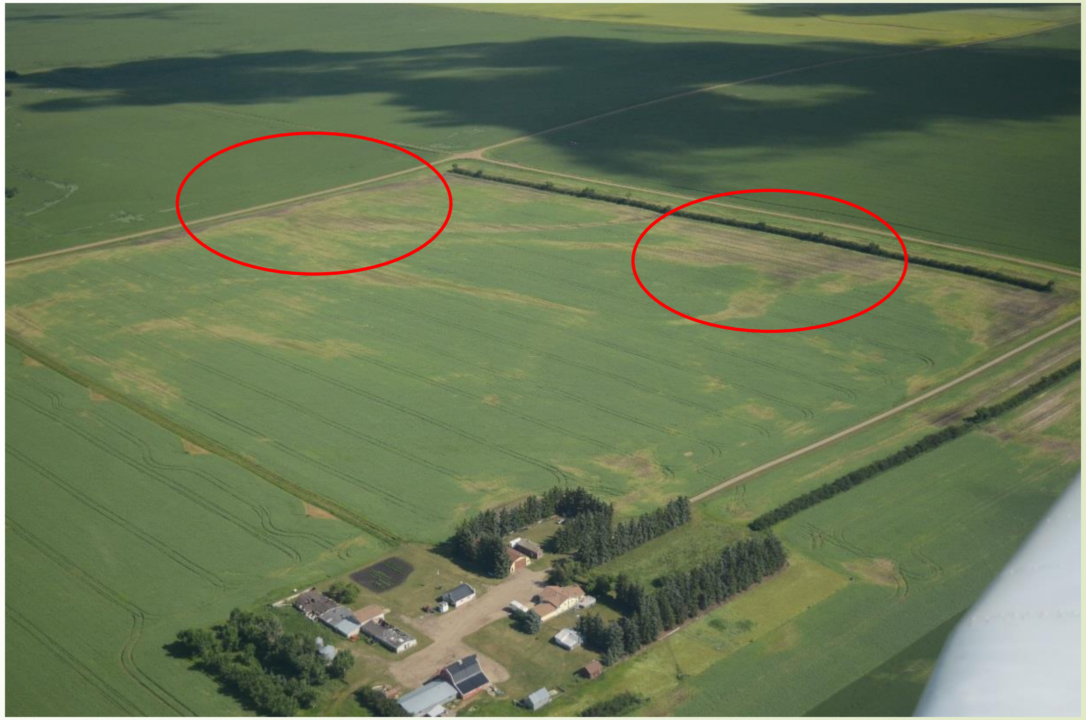
Source: Pulse Situations Report 2019, Lentil Disease Survey, Barb Zeisman, SK ministry of Agriculture

What can you do?

- Avoid certain fields
- Crop rotation

Field avoidance

- Compaction
- Poor drainage
  - Fine-textured soil
- History of root rot



Syama Chatterton, AAFC Lethbridge

Crop rotation

- For Aphanomyces, 6-8 year break between pea or lentil crops
- Every time you grow pea or lentil, pathogens increase

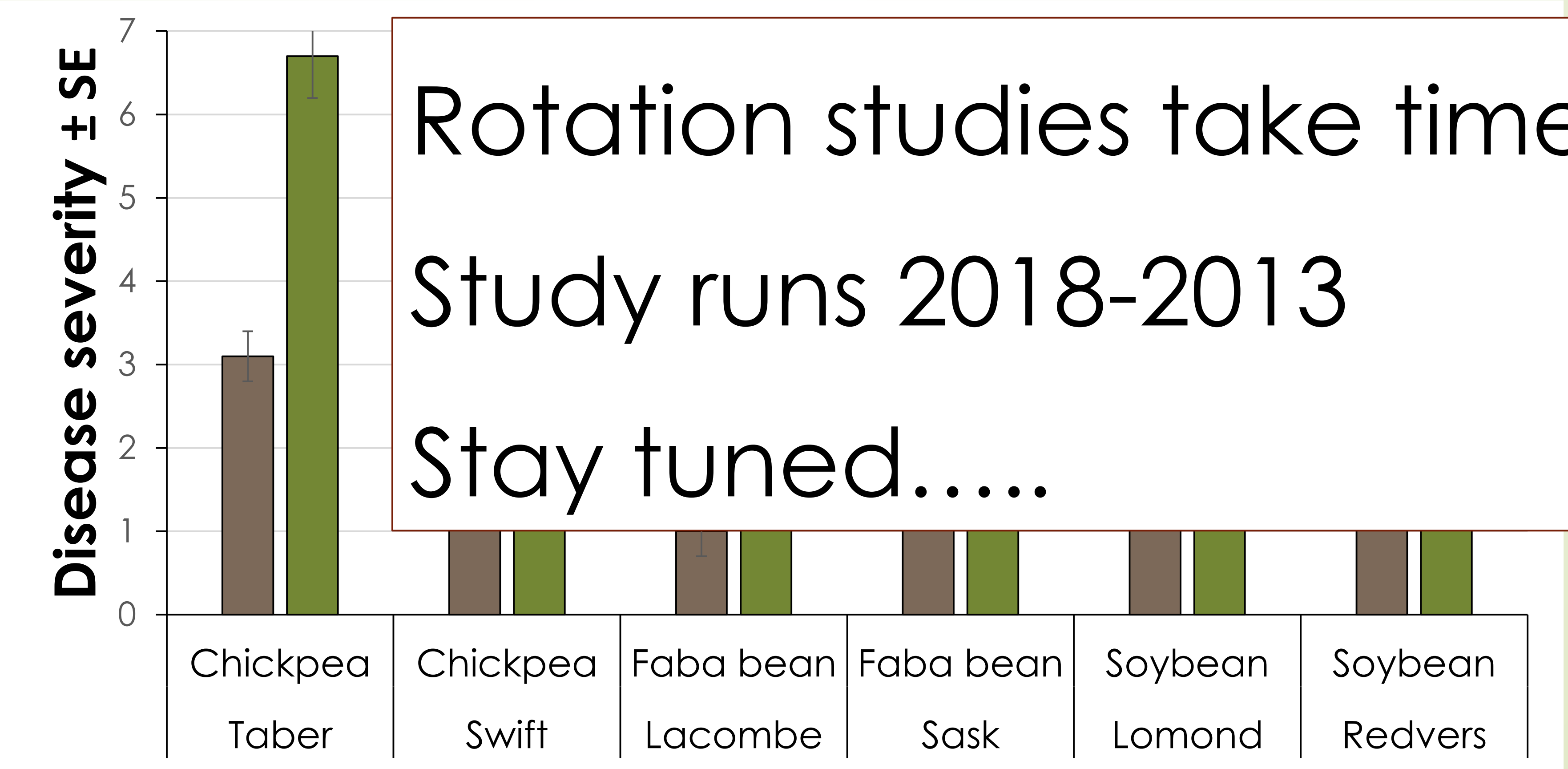
Other possibilities

- Specific rotations
  - Resistant pulses
  - Brassicas
  - Oats
- Green manures
- Intercropping
- Soil pH modification
- Tillage
- Herbicides
- Nutrition
- Mycorrhizae
- Antagonistic bacteria

Rotations with a resistant pulse

- Chickpea, faba bean, soybean
- Theory: oospores germinate → die

  (do not produce more oospores)



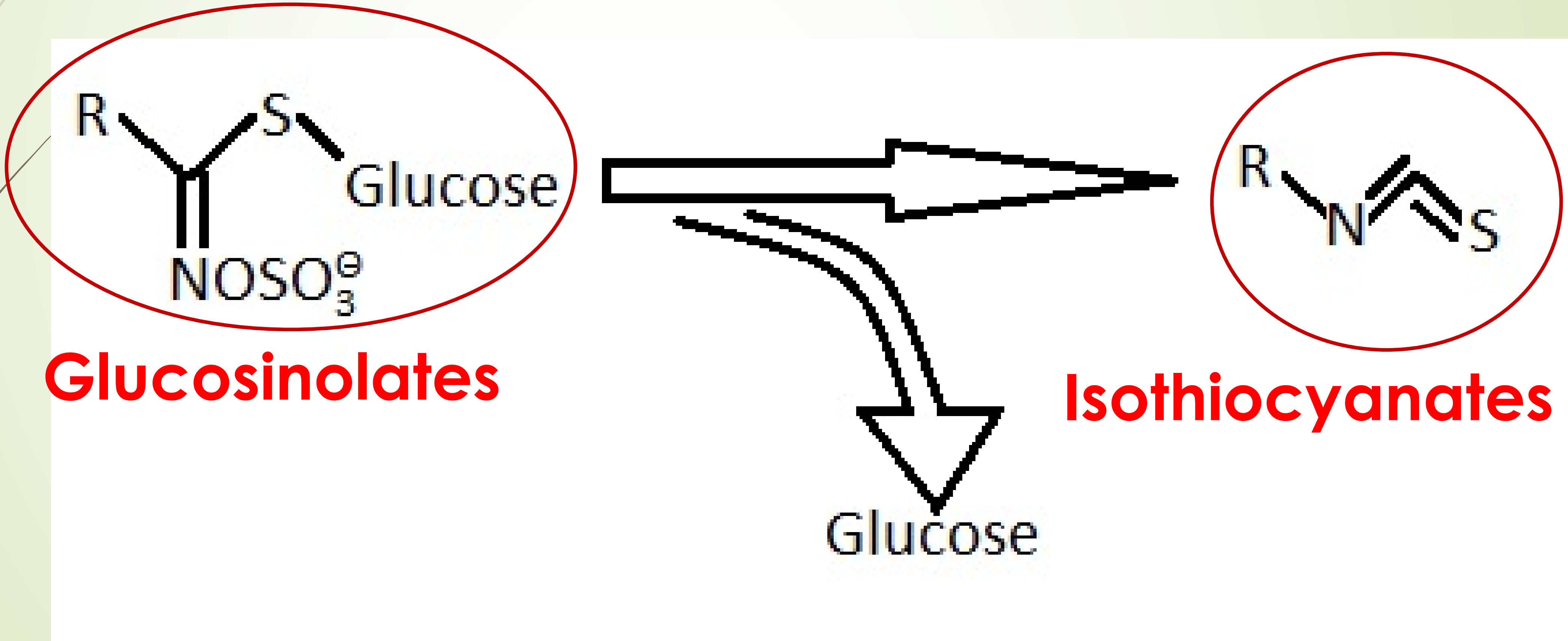
Rotation studies take time

Study runs 2018-2013

Stay tuned…..

Brassicas and root rots

- Potential to "bio-fumigate" soil



https://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals/isothiocyanates#metabolism-bioavailability

Oats and Aphanomyces

- Potential to stimulate oospore germination (Shang et al. 2000)
  - After germination, oospores are vulnerable

Shang et al. (2000)
Plant Dis. 84: 994-998.

- Potential to kill oomycete zoospores (Deacon and Mitchell 1985)
  - Possibly due to saponins

J. W. Deacon and R. T. Mitchell 483

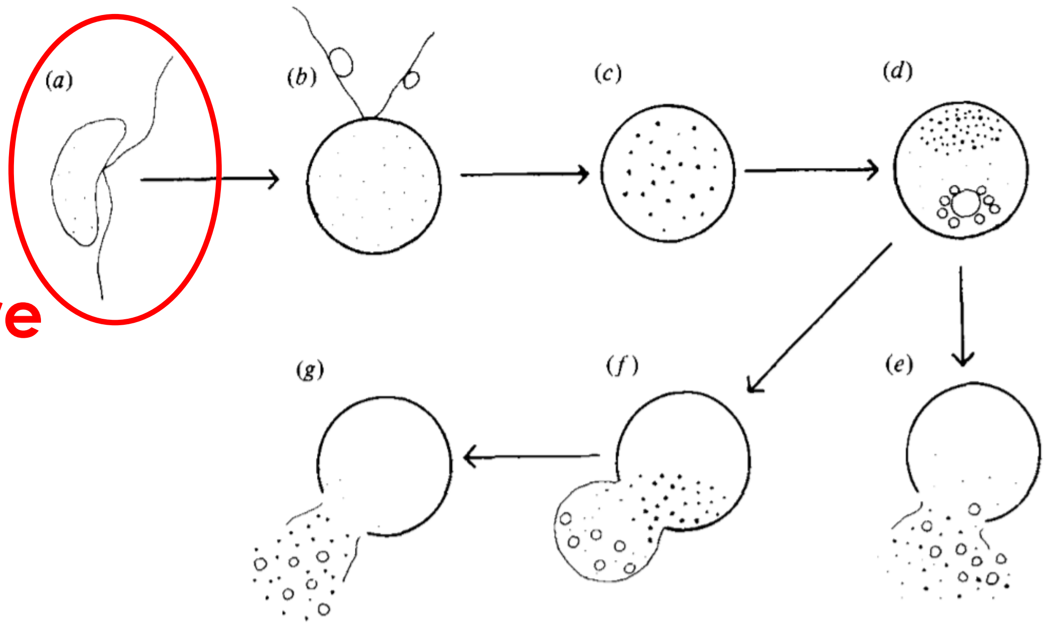


Fig. 2. Diagrammatic representation of zoospore responses to oat root toxin or β-aescin. (*a*) Motile zoospore; (*b*) immobilization and rounding-up; (*c*) development of phase-dark granules; (*d*) localization of granules and development of vacuoles; (*e*) lysis; (*f*) ballooning; (*g*) lysis, sometimes preceded by separation of the balloon-like swelling (not shown). Flagella with loops or beads (*b*) can be present throughout.

Deacon and Mitchell (1985) Trans. Br. Mycol. Soc. 84 (3), 479-487

Green manures

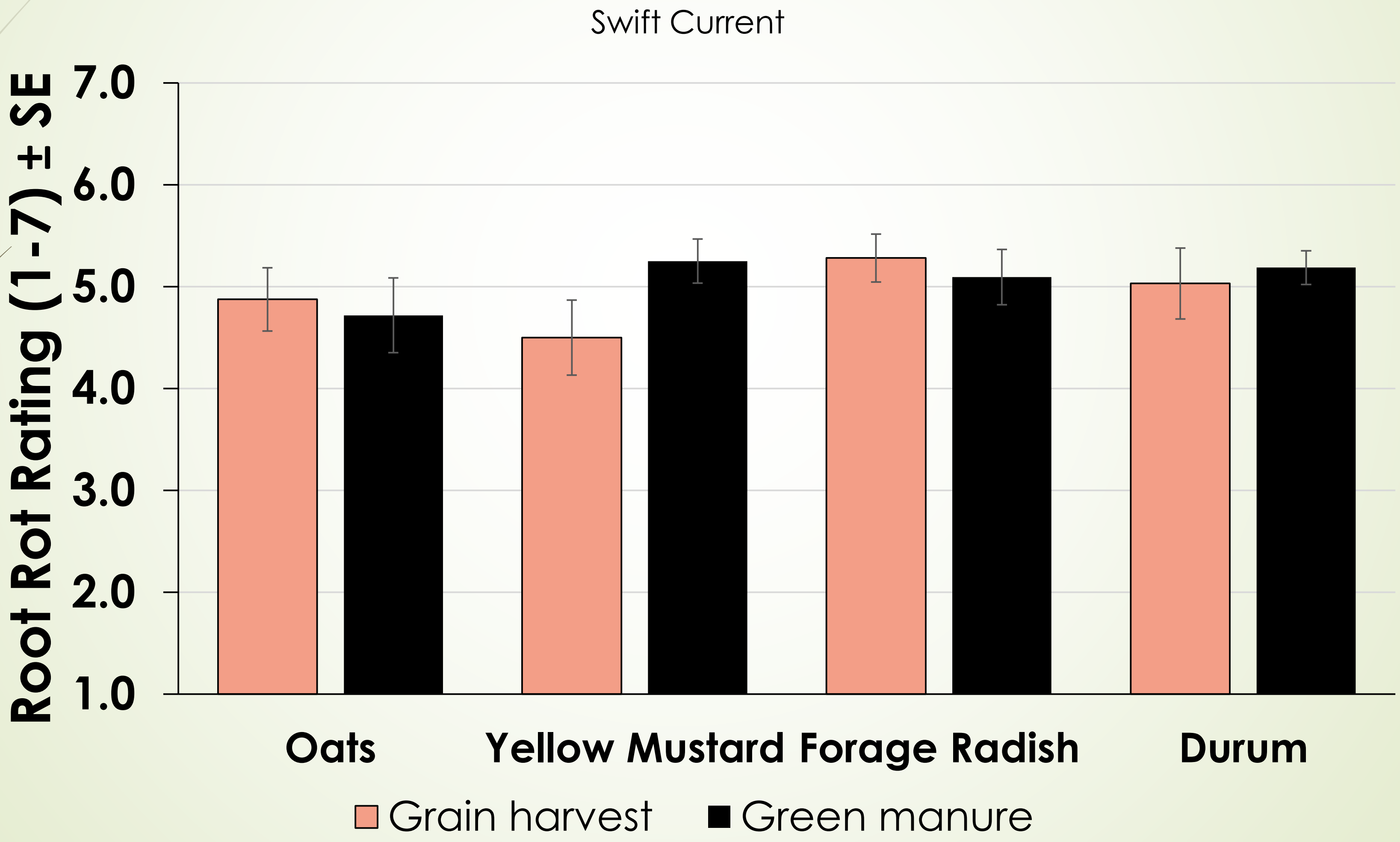
- May promote breakdown → release of "bio-fumigants"
- Crops
  - Oat
  - Yellow mustard
  - Forage radish
  - Durum

Forage radish
July 2018, Swift Current
M. Hubbard

- Grain harvest or green manure in 2018
- Pea in 2019

Green manure results

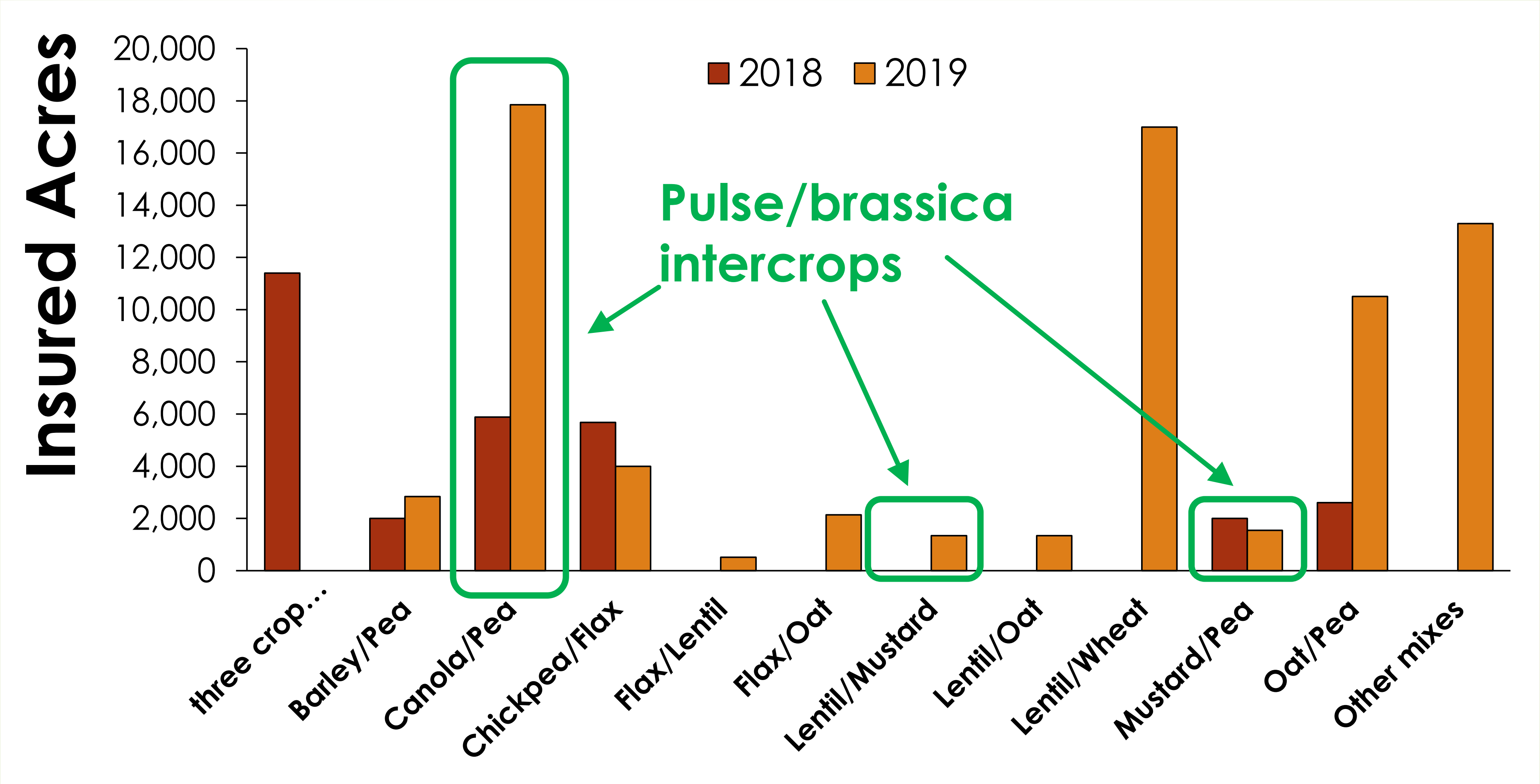
- No clear impact



Dr. Luke Bainard

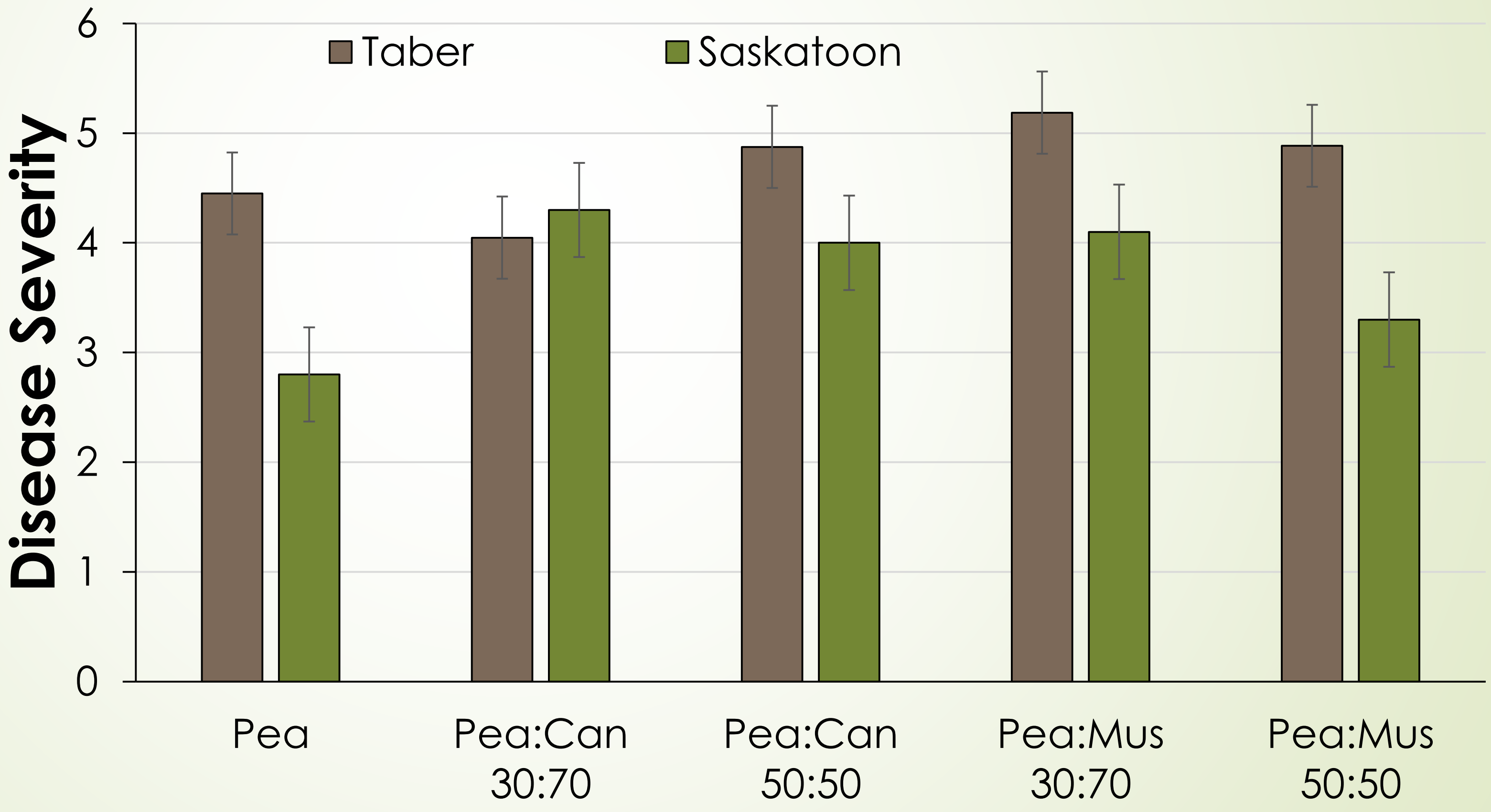
Intercropping

- Growing two or more crops together
- Insurable starting in 2017



Pea/brassica Intercropping

- 2018 results: Disease severity on pea was **not** significantly different on intercrop compared to monocrop pea roots



Chatterton et al. 2019. Can. Phytopath. Society Annual meeting.

Pea/brassica Intercropping

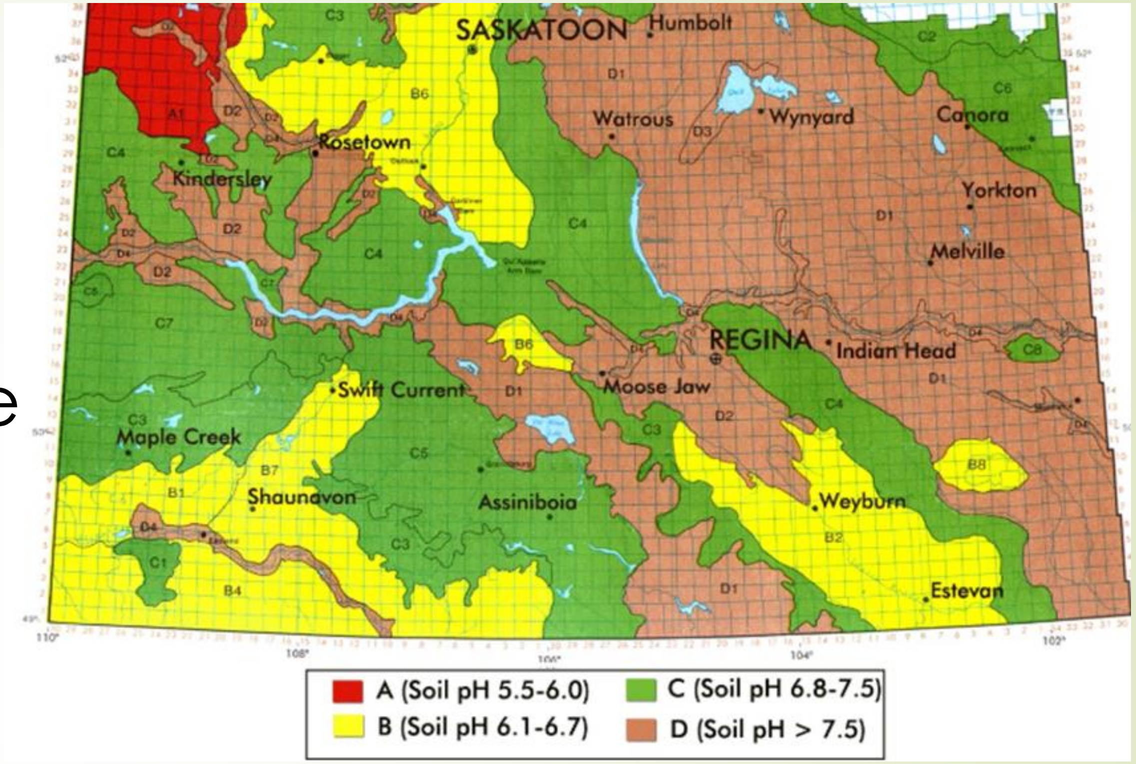
	Saskatoon			Taber		
	Pea yield	Total yield	LER^	Pea yield	Total yield	LER^
Pea	637.7	637.7	1.00	542.7	594.2	1.00
Canola (Can)		1066.2			604.5	
Mustard (Mus)		826.3			387.9	
Pea:Can 30:70	102.5	1040.0	1.00	287.0	709.7	1.16
Pea:Can 50:50	276.2	1028.0	1.18	250.0	705.8	1.27
Pea:Mus 30:70	227.2	987.6	1.28*	246.5	456.2	0.99
Pea:Mus 50:50	583.9	1083.9*	1.53*	310.0	624.6*	1.35*

^LER = yield crop A in intercrop/ yield crop A in monocrop + yield crop B in intercrop/ yield crop B in monocrop
*significantly different than monocrop yield or LER at P = 0.05

Chatterton et al. 2019.
Can. Phytopath. Society
Annual meeting.

Soil pH

- Acidic soils may ↑ risk
  - Lentil and pea don't like low pH (acid)
- Ammonium (NH_4^+) N-fert can lower soil pH
- Calcium may help ↓ root rot (Heyman et al. 2007)
- Adding lime may help
  - But may not be feasible



Soil	Disease Severity
#4	80a
#4 + $CaCO_3$	73b
#4 + $CaSO_4$	11d

Heyman et al. (2007) Soil Bio. and Biochem. 39: 2222-2229

Courtesy of S. Phelps, SPG

Tillage

Theory

- May dry soil and/or
- ↓ compaction

Reality

- Does not seem to help
  - Conventional tillage
  - Vertical till
  - No till

(research led by PAMI)

Potential downsides

- Risk of erosion
- Damaging soil structure
- Harm to soil biology
- Labor, time, fuel $$

Courtesy of S. Phelps, SPG

Herbicides

- Herbicide damage can weaken plants
- Weeds host aphanomyces:
  - shepherd's purse,
  - chickweed,
  - vetches
  - (kochia?, lamb's quarters?)
- Fusarium species can infect many weeds

Courtesy of S. Phelps, SPG

Trifluralin

- Trifluralin and dinitramine
  - ↓ growth, zoospore production and movement in lab
  - slightly ↓ root rot in field
- **No impact** found in research in Western Canada so far

Minnesota field trials

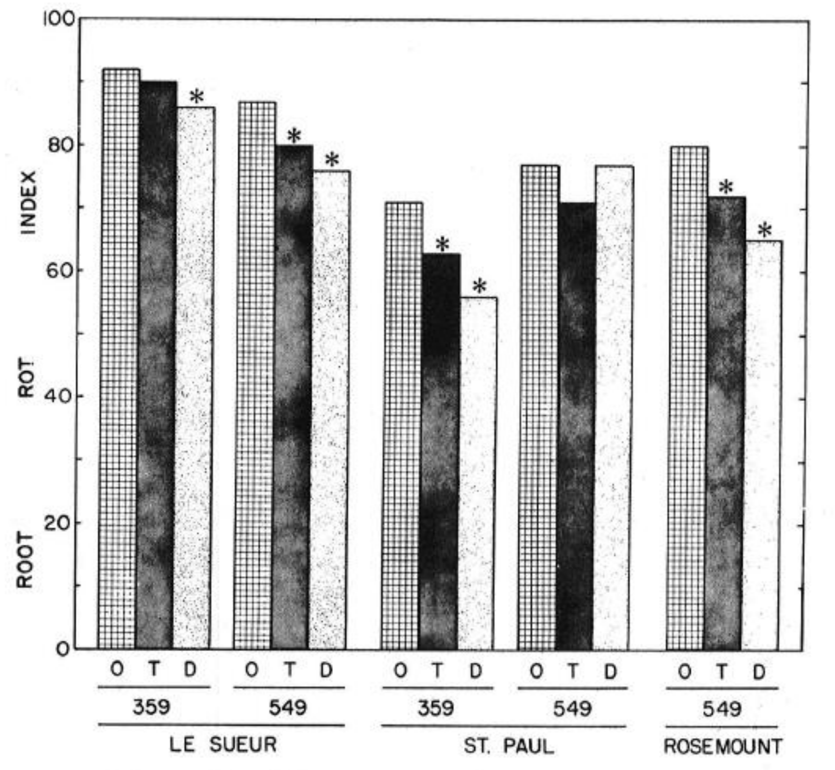


Fig. 1. The effect of trifluralin (T) and dinitramine (D) on the root disease severity (scale: 0 = healthy and 100 = rotted roots and epicotyls) on two pea cultivars (GG 359 and 549) at three locations in Minnesota. Asterisks designate values statistically different ($P = 0.05$) according to Tukey's test. Rates of trifluralin were 0.74 kg/hectare (ha) at Le Sueur and 0.84 kg/ha at St. Paul and Rosemount, and of dinitramine were 0.74 kg/ha at Le Sueur and 0.56 kg/ha at St. Paul and Rosemount.

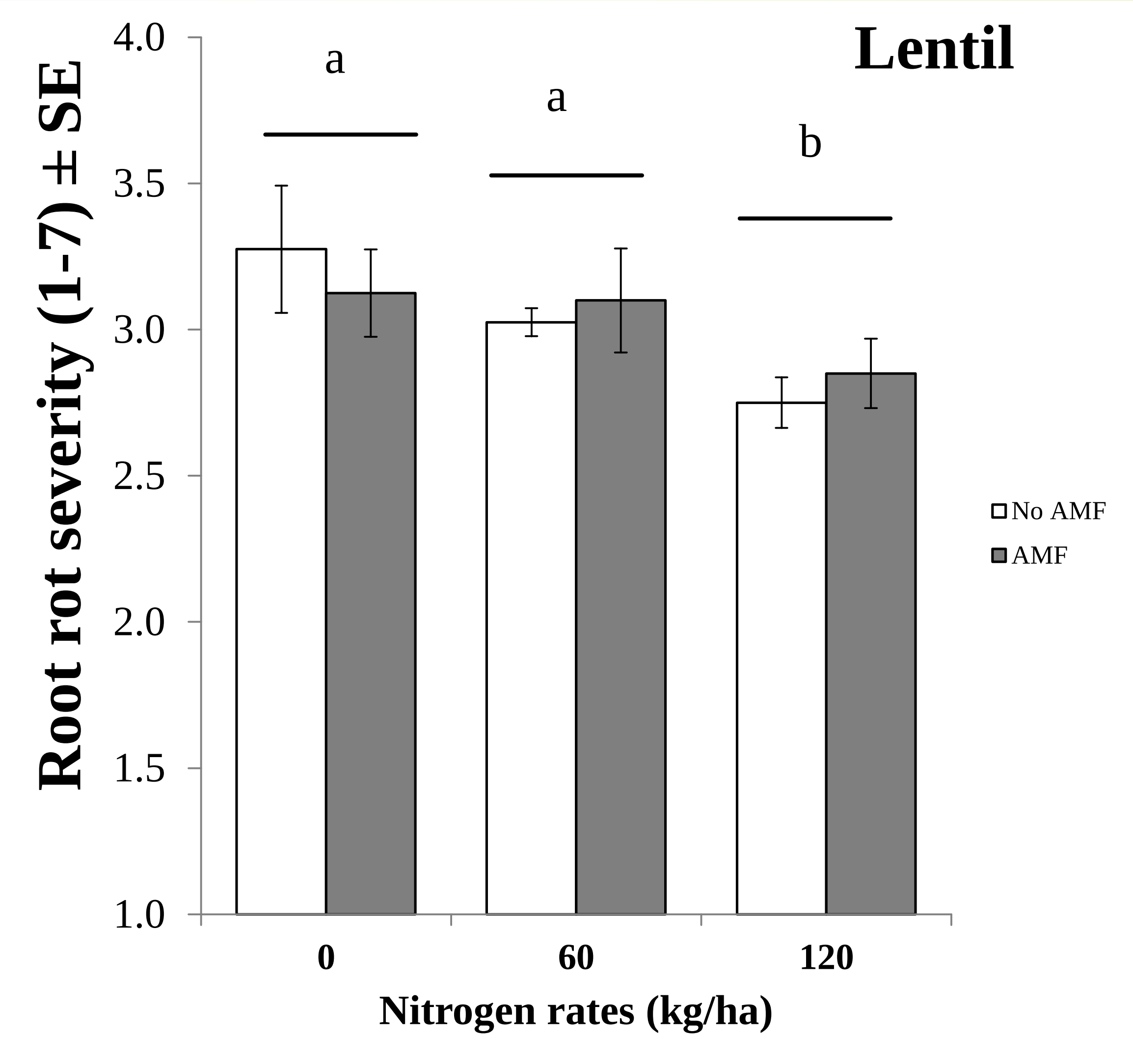
Grau and Reiling. 1977. Phytopathology 67:273-276.

Nitrogen and/or Mycorrhizae

- N may
  - cause "woodiness" of roots
  - improve growth if nodulation is poor
  - ↓ nodulation
  - ↑ disease (?)
    - Liu et al. (2016) found that *Rhizoctonia*-diseased soybean came from soils with higher N levels
- Mycorrhiza (AMF)
  - ↑ disease resistance
  - Help plants access nutrients (esp. P)

Results - Root rot in Swift Current

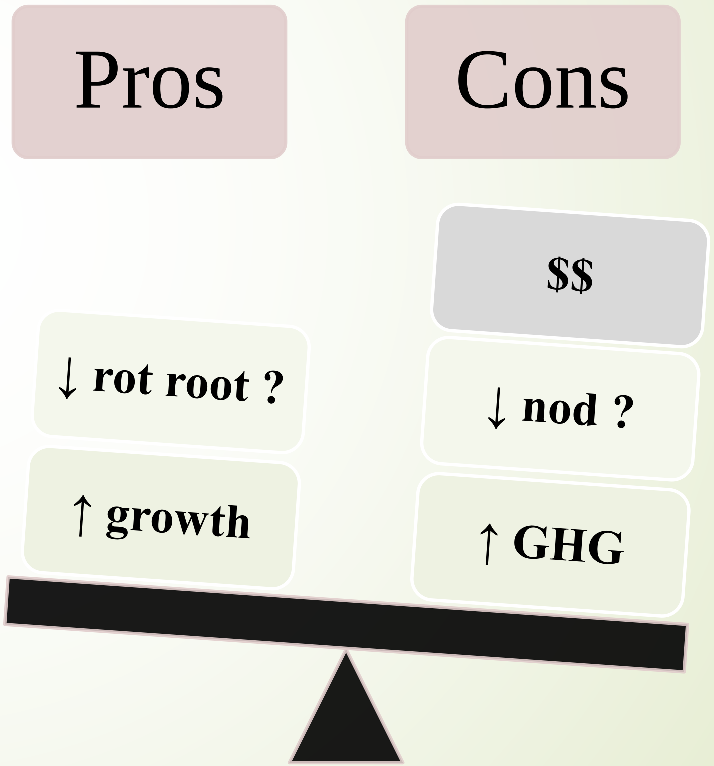
- Nitrogen-fertilized crops had lower root rot scores than unfertilized plants
  - On the "Aphanomyces" (0-5) scale for pea,
  - On the "Fusarium" (1-7) scale for lentil,
- Commercial AMF inoculum had no impact



Nitrogen fertilization of pulses

- Sometimes "starter" N is recommended
  - Low rates (~10-15kg/ha)

- Might reduce yield losses due to root rot
- Has costs:
  - Financial
  - Nitrogen balance



Biologicals

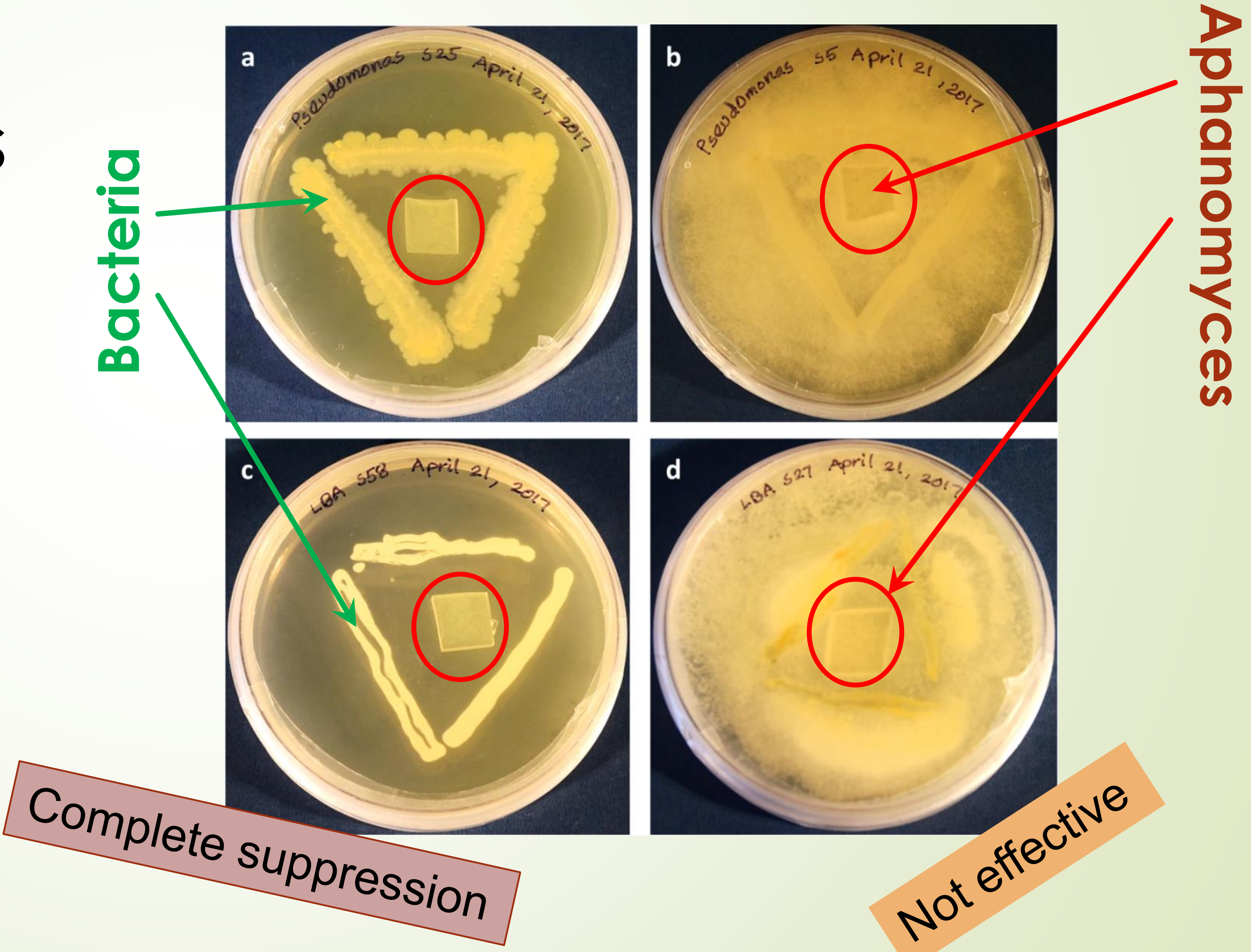
- Compete with pathogens
- Stimulate root growth/health
- Antimicrobial compounds/activities
- Other modes of action

- Potential organisms or products:
  - Pseudomonads – antibiotic compounds
  - Streptomyces – antibiotic compounds
  - Trichoderma (RootShield) - competition
  - *Clonostachys rosea* - ?
  - Saponins (HeadsUp)
  - Others

Remember this from the oats?

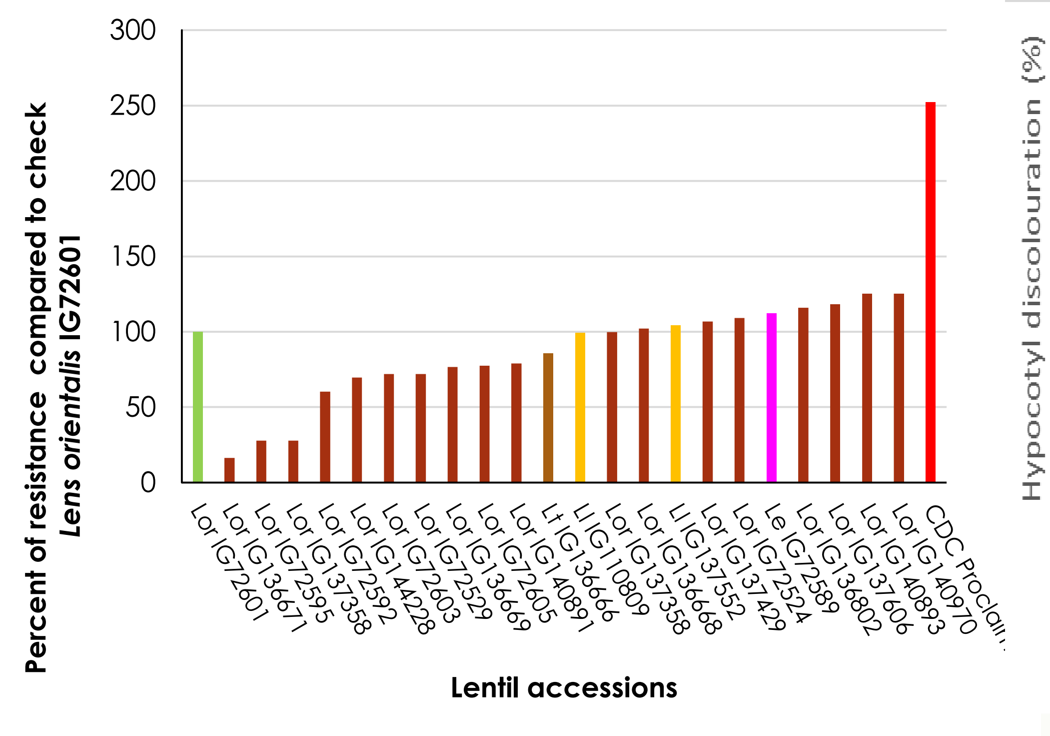
Bacterial antagonists

- Bacteria from SK fields
- Tested in
  - Petri plates
    - Completely stopped growth
  - Greenhouse
    - ↓ disease
  - Outdoors

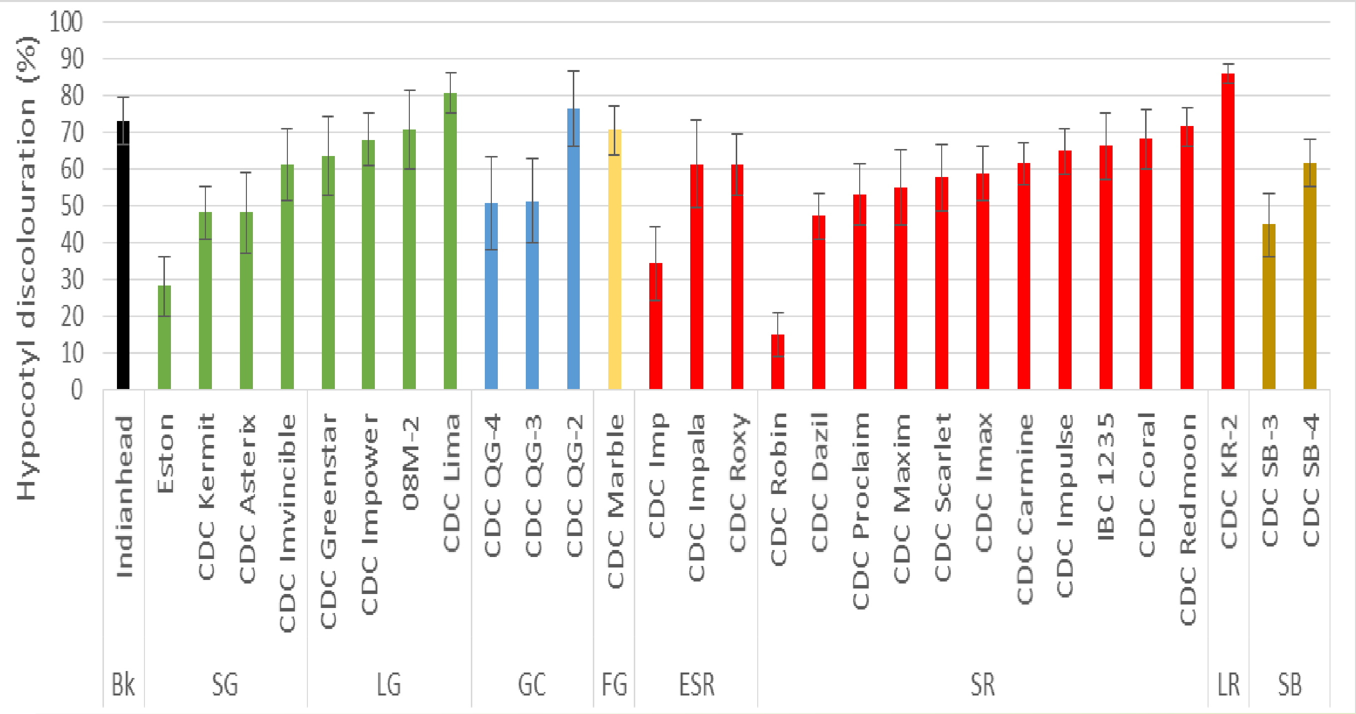


Genetic resistance in lentil to

Aphanomyces



Fusarium



Research at U of S, Crop Development Centre, Drs. Sabine Banniza, Tom Warkentin and Bert Vandenberg (SPG funded)

- Higher tannin class more tolerant (Maple, Dunn pea)
- Molecular tools

Saskatchewan Pulse Growers website

Conclusions

Chickpea

- Ascochyta blight
  - Devastating in some conditions
  - May be interacting with root rot and/or other factors
  - Intercropping may help
- Root rot
  - Survey starting in 2020

Lentil

- Anthracnose
  - Most serious foliar disease in SK in 2019
- Root rot
  - Aphanomyces and Fusarium
  - Long rotations and field avoidance
  - Resistance being developed

Acknowledgements

- We thank C. Vucurevich, A. Erickson, N. Thangam, T. Dubitz, G. Daniels, D. Burke, L. Poppy, L. Syrovy, W. May, R. Davies, G. Peng, S. Ginter, B. Evans, S. Campbell and numerous laborers and students.

Crop Development Centre

Questions?

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