Intercropping as a disease management strategy

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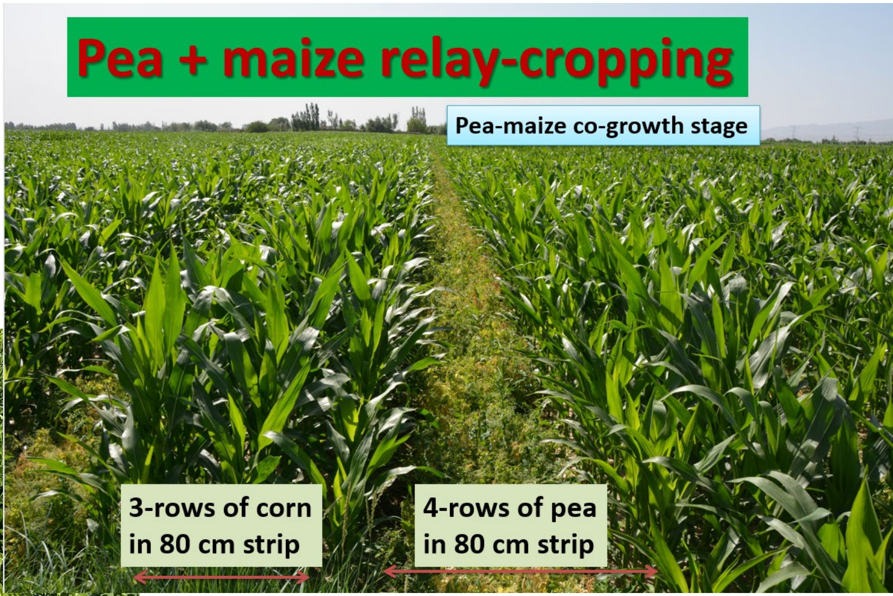
Canada

What is intercropping?

Two or more crops in the same space with at least some overlap in time



Types of intercropping

- **Mixed Intercropping**
  - Seeded together, harvested together
- **Row Intercropping**
  - Alternate rows or set of rows / Strip cropping
  - Alley cropping with trees
- **Fast Crop / Slow Crop**
  - Seeded together, not harvested together
- **Relay Cropping**
  - 2nd crop sown after 1st, but before harvest of 1st
  - Harvest of 1st crop allows 2nd crop to fully develop

Why intercropping?

- Increased diversity
- Multiple potential benefits (Brooker et al. 2015)
  - Increased yield (over yielding)
  - Increase diversity and resource utilization
  - Change microclimate
  - Manage disease
  - Reduce risk
  - Improve soil health
  - Manage weeds
  - Manage insect pests

Booker et al. 2015. New Phytologist 206: 107-117

Barriers

- Lack of knowledge
- Weed control
- Rotations
- Technological
  - Seeding
  - Harvest
  - Seed separation

Derek Axten seeder

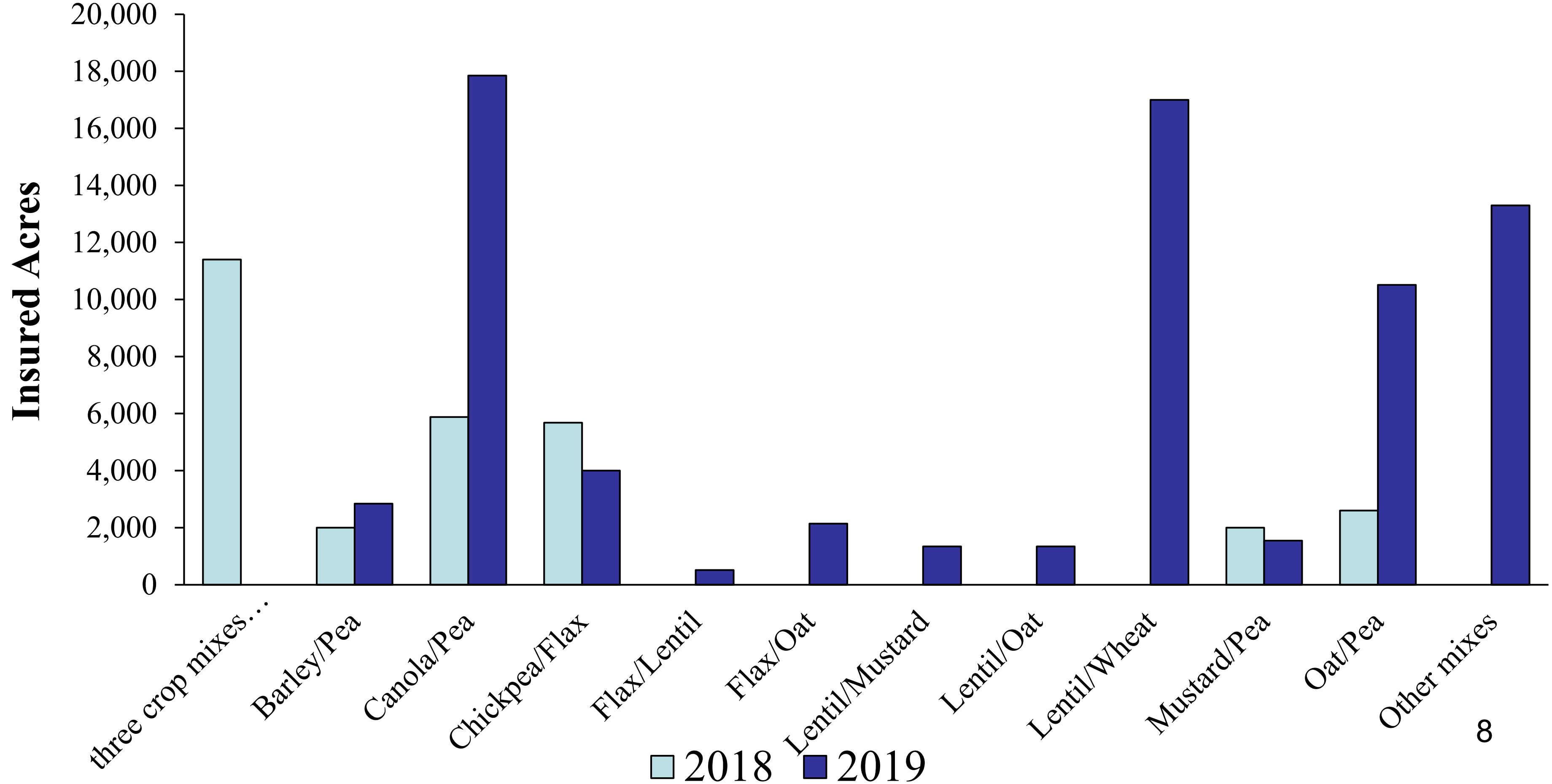
Harvest

On-farm seed separation

Hursh Farm
Photo: M Hubbard

Insured Acres in Saskatchewan

- Acres ~ doubled from 2018 to 2019
- Many uninsured acres



Examples

Carinata mustard and fababean
(Photo – Lana Shaw)

Pea lentil mustard
(Photo – Lana Shaw)

Intercropping Pea & Canola:
Row/Crop Configuration & N Fertility

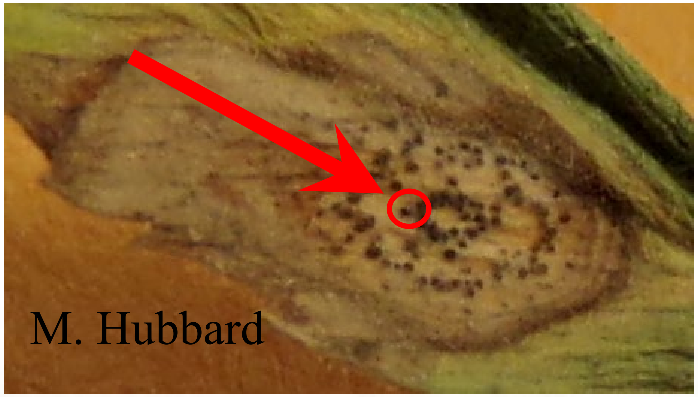
Chris Holzapfel, IHARF
Scott Chalmers, WADO


Canada
SASKATCHEWAN pulse Growers

Chickpea-Flax (commercial)

Ascochyta blight in Chickpea

- *Ascochyta rabiei*
- Severe crop loss (Chongo and Gossen 2001, 2003)



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.

Environment

- High humidity ↑ risk (Armstrong et al. 2004; Riaz et al. 2017)
- Most disease risk at ~20°C (Riaz et al. 2017)

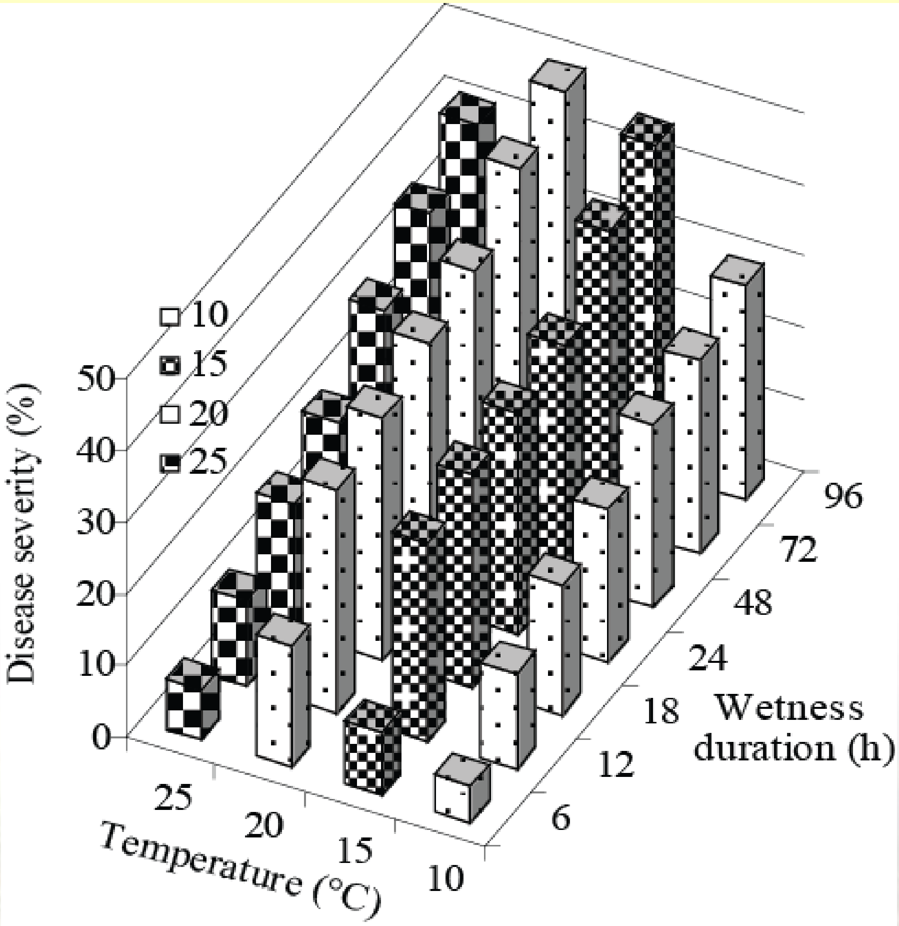


Fig. 1. Effect of temperature and wetness period on … *Ascochyta rabiei* (Raiz et al. 2017)

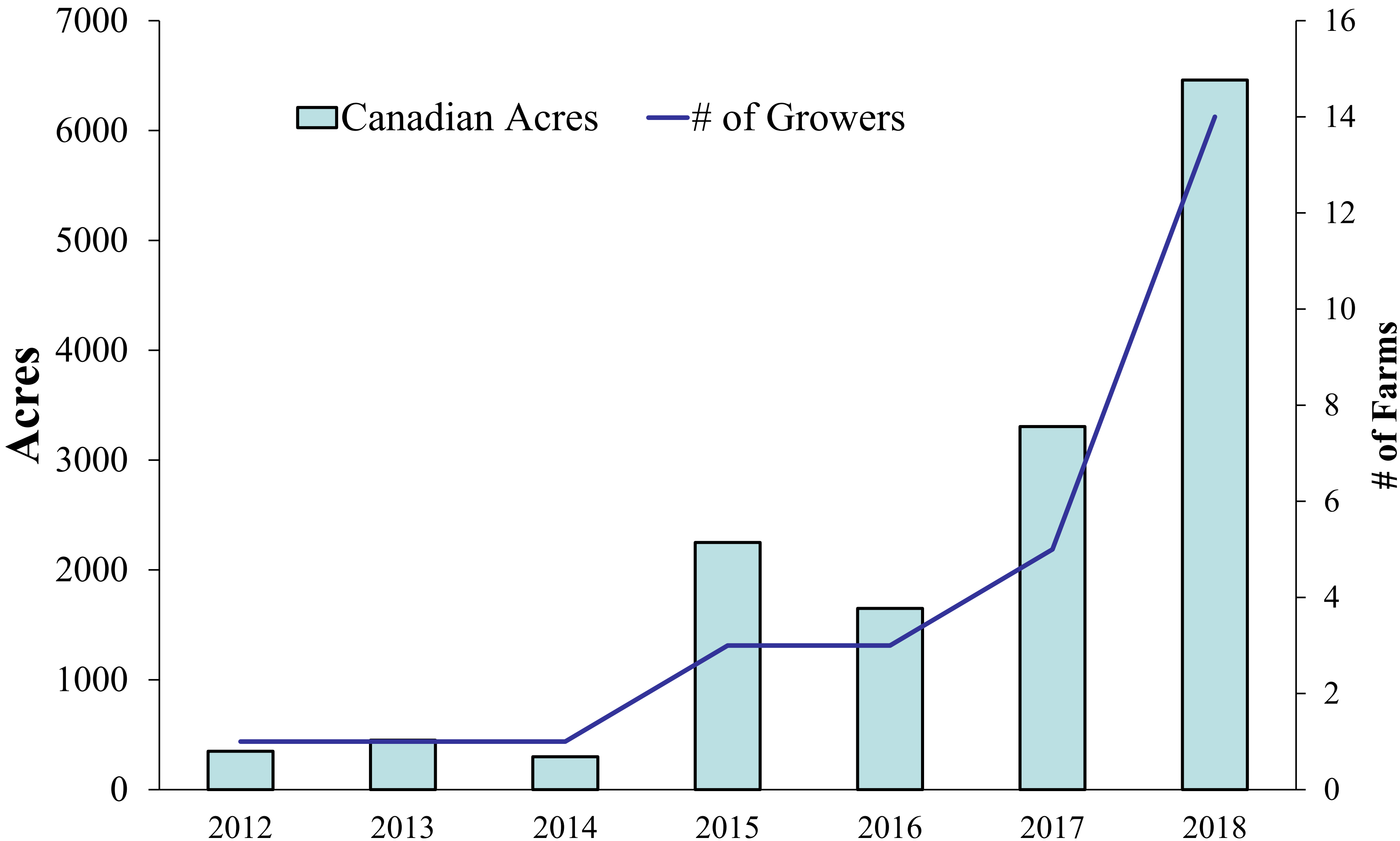
Armstrong-Cho et al. 2004. Can J Plant Path . 26: 134-141
Riaz et al. 2017. Pakistan J Bot. 49: 1971-1974.

Current management

- Disease-free seed
- Seed treatments
- Crop rotation
- Genetic resistance
  - Incomplete
  - Can be overcome
- **Fungicides** (Gan et al. 2006; Gossen et al. 2014)
  - $$
  - Time consuming
  - Risk of fungicide resistance
    - Especially to strobilurins

Gan et al. 2006. Field Crops Res. 97:121-134
Gossen et al. 2014. Can. J. Plant Path. 36: 327-340

Commercial acres of Chickpea-Flax



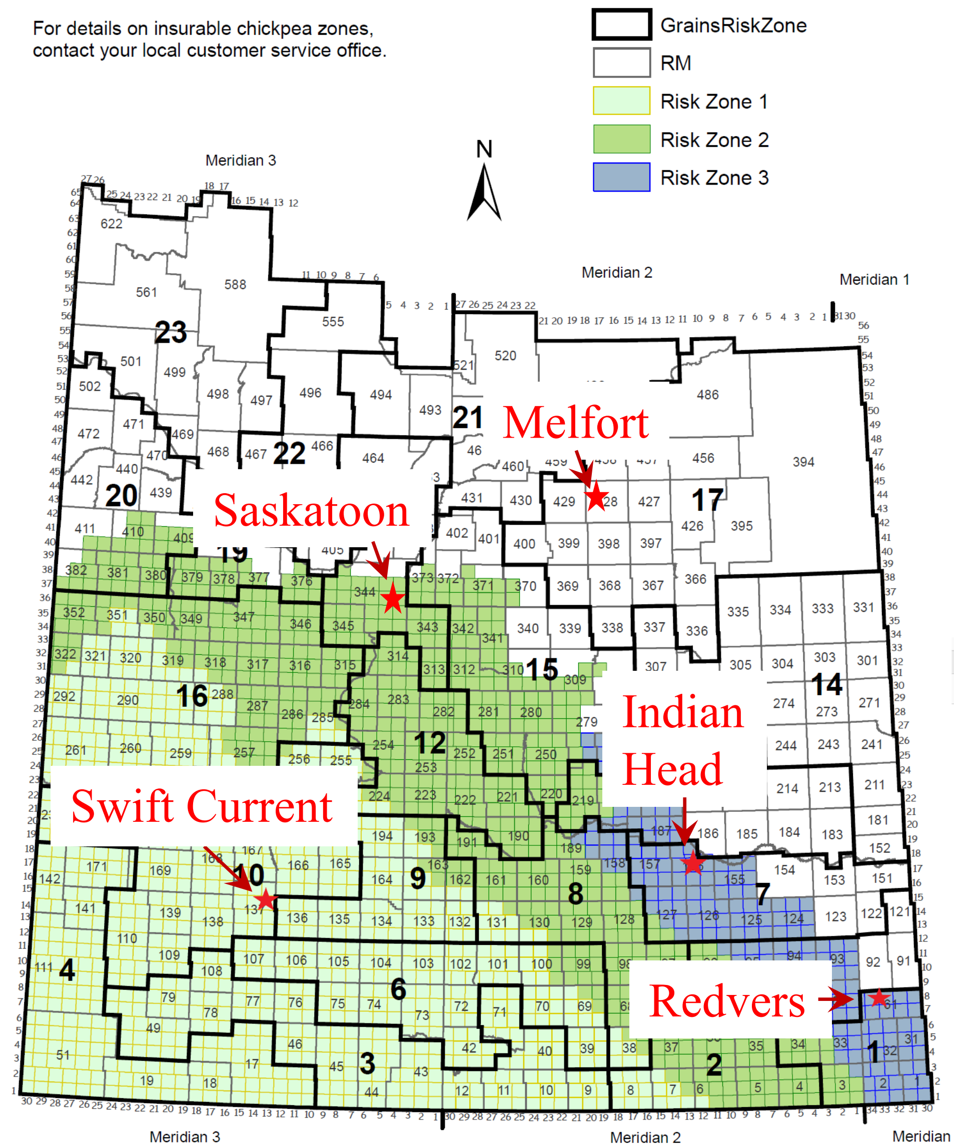
Shaw. 2018

Trial sites in Saskatchewan

- Four small plot field sites
  - Swift Current
  - Indian Head
  - Redvers
  - Melfort
- Saskatoon site planned for 2020-2022

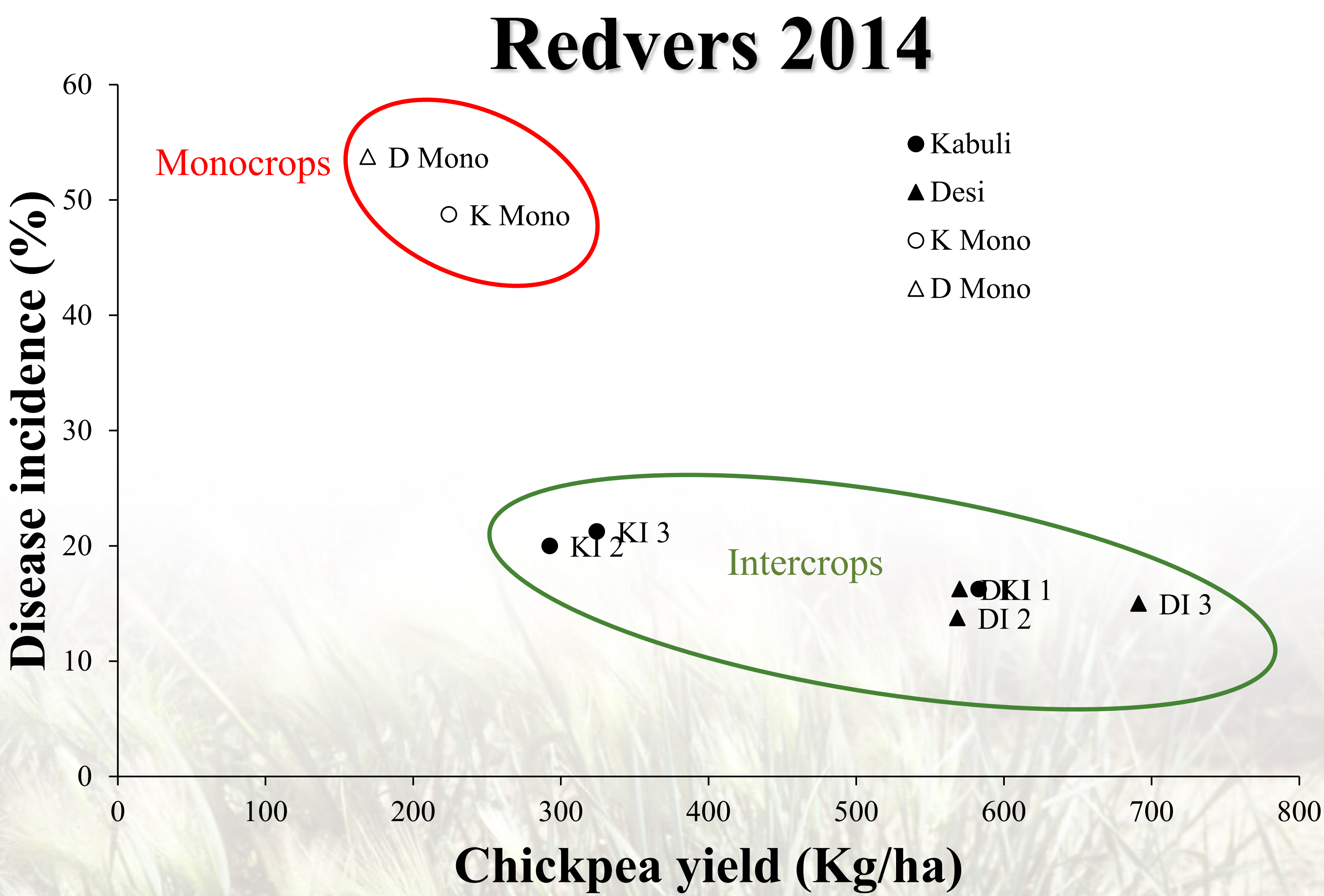
Chickpea Insurable Zones

For details on insurable chickpea zones, contact your local customer service office.



RM Boundary Source: Information Services Corporation, Sask.

Disease and yield in a wet year

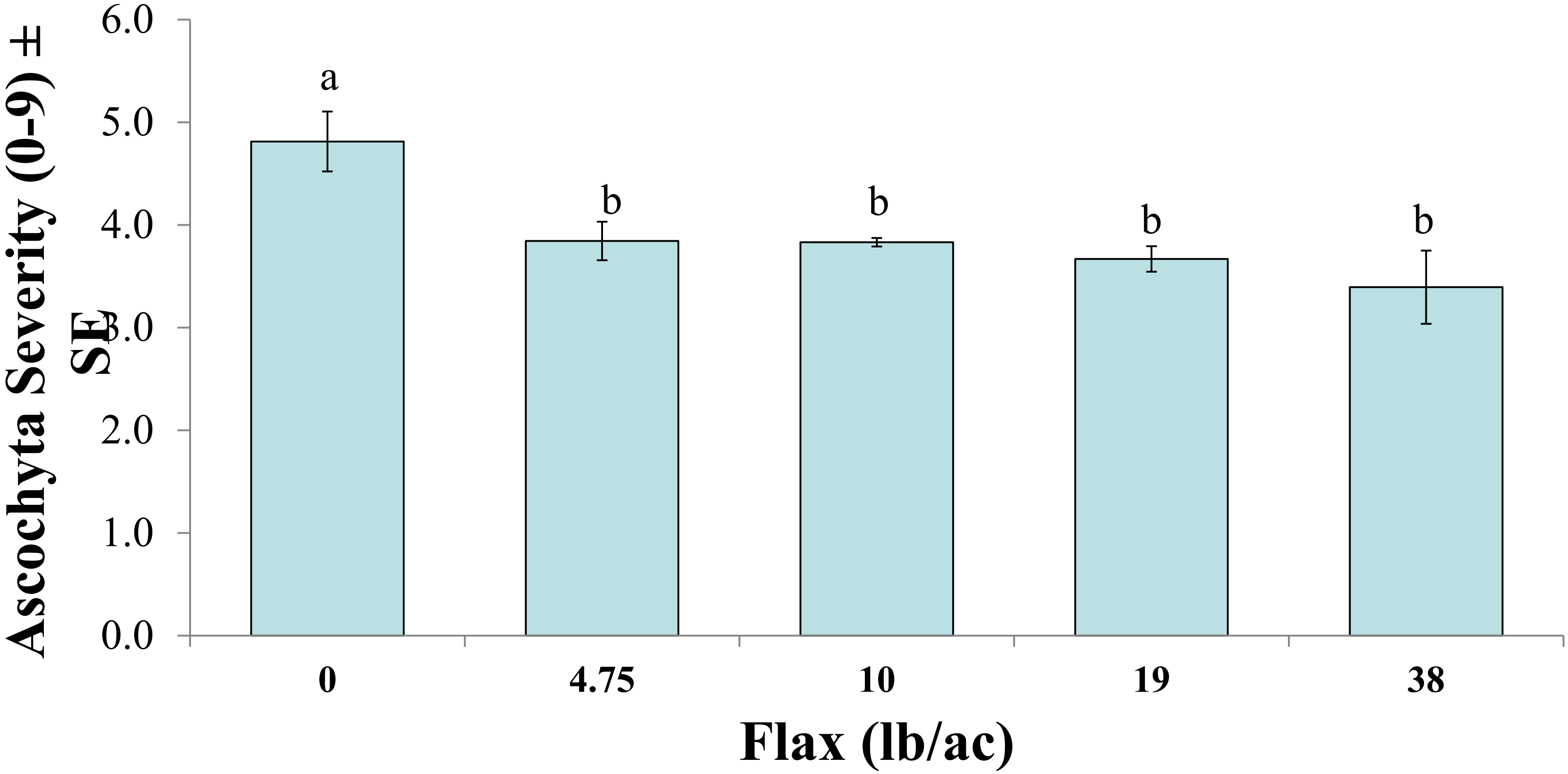


Shaw. 2015. ADOPT Interim Report. Project Number: 20130457

Treatments
2018 & 2019-2021

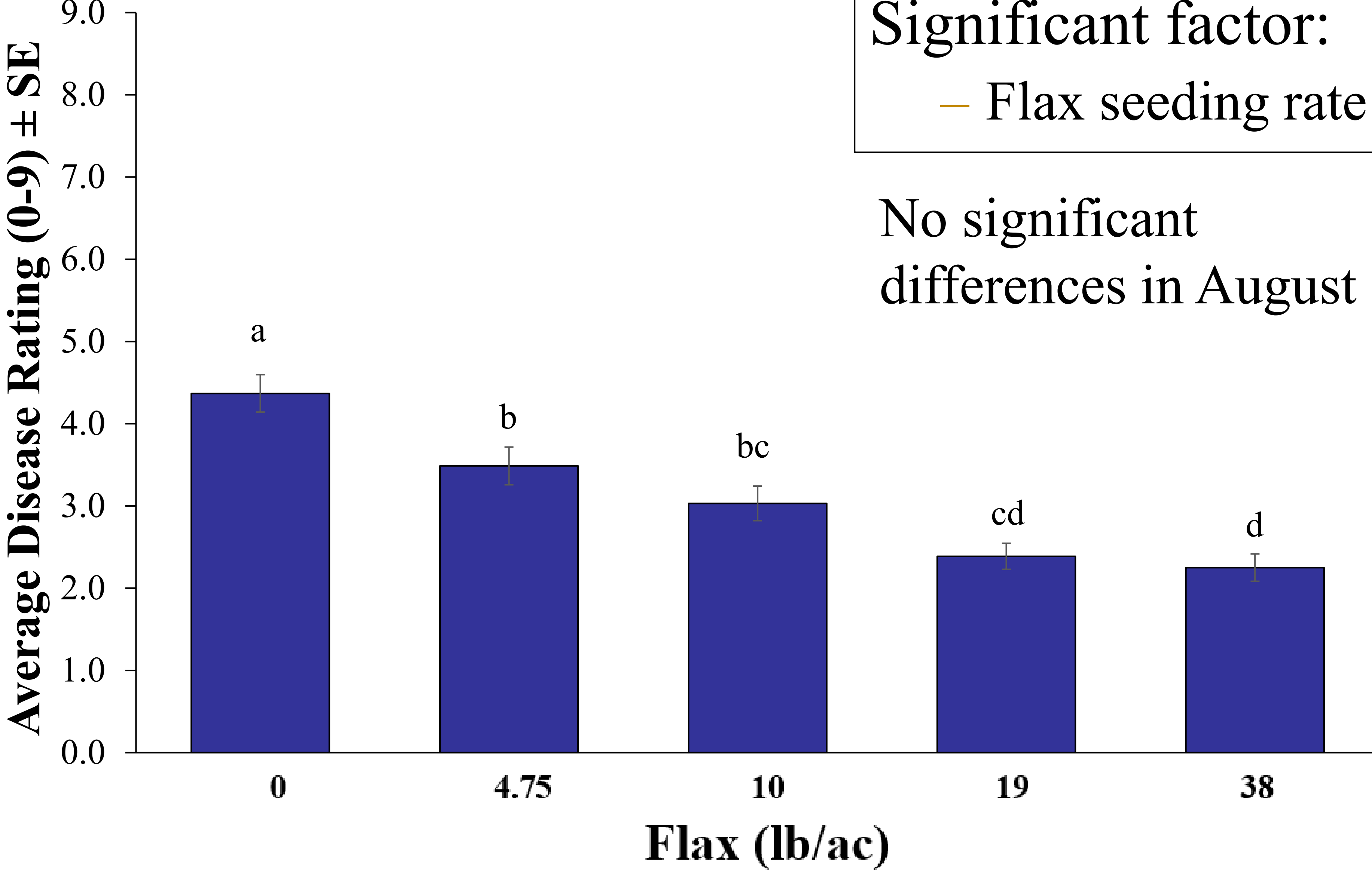
- Chickpea seeding rate constant
- Flax planting rate varied
- Flax placement:
  - Mixed rows: chickpea and flax in the same row
  - Alternating rows (Omitted in Swift Current, 2018)
  - Paired rows (Swift Current, 2018)
- Nitrogen fertilizer (0 or 60 kg/ha)

Ascochyta severity in Redvers, 2018



- Higher in monocrop chickpeas than any intercrop treatment

Redvers, July 2019



Significant factor:

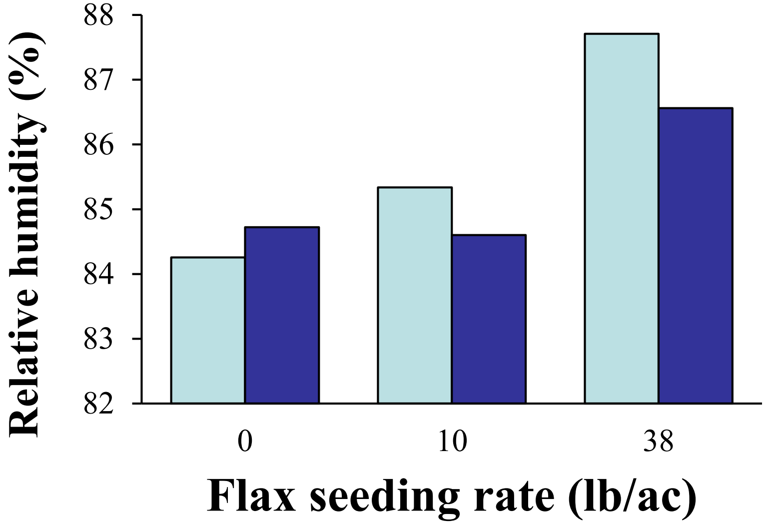
– Flax seeding rate

No significant differences in August

Redvers canopy microclimate

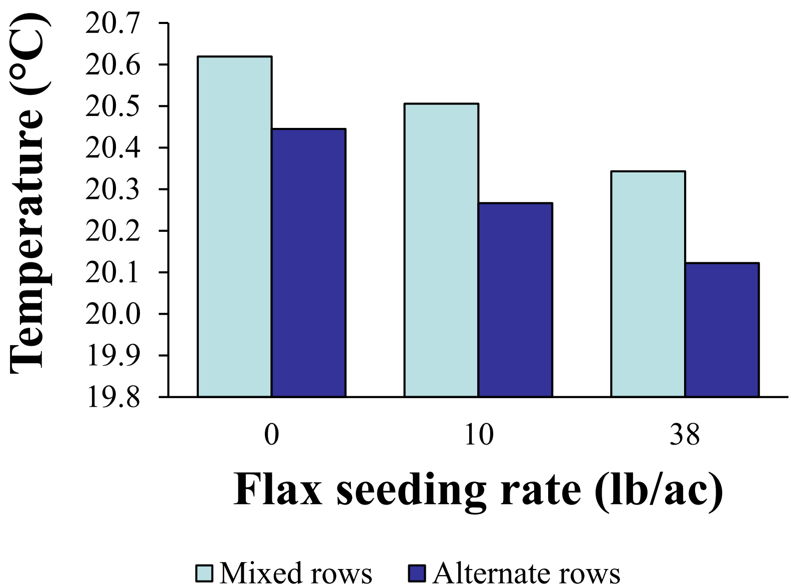
Relative humidity

- Flax seeding rate has significant impact
- ↑ at higher flax
- Only at some time points

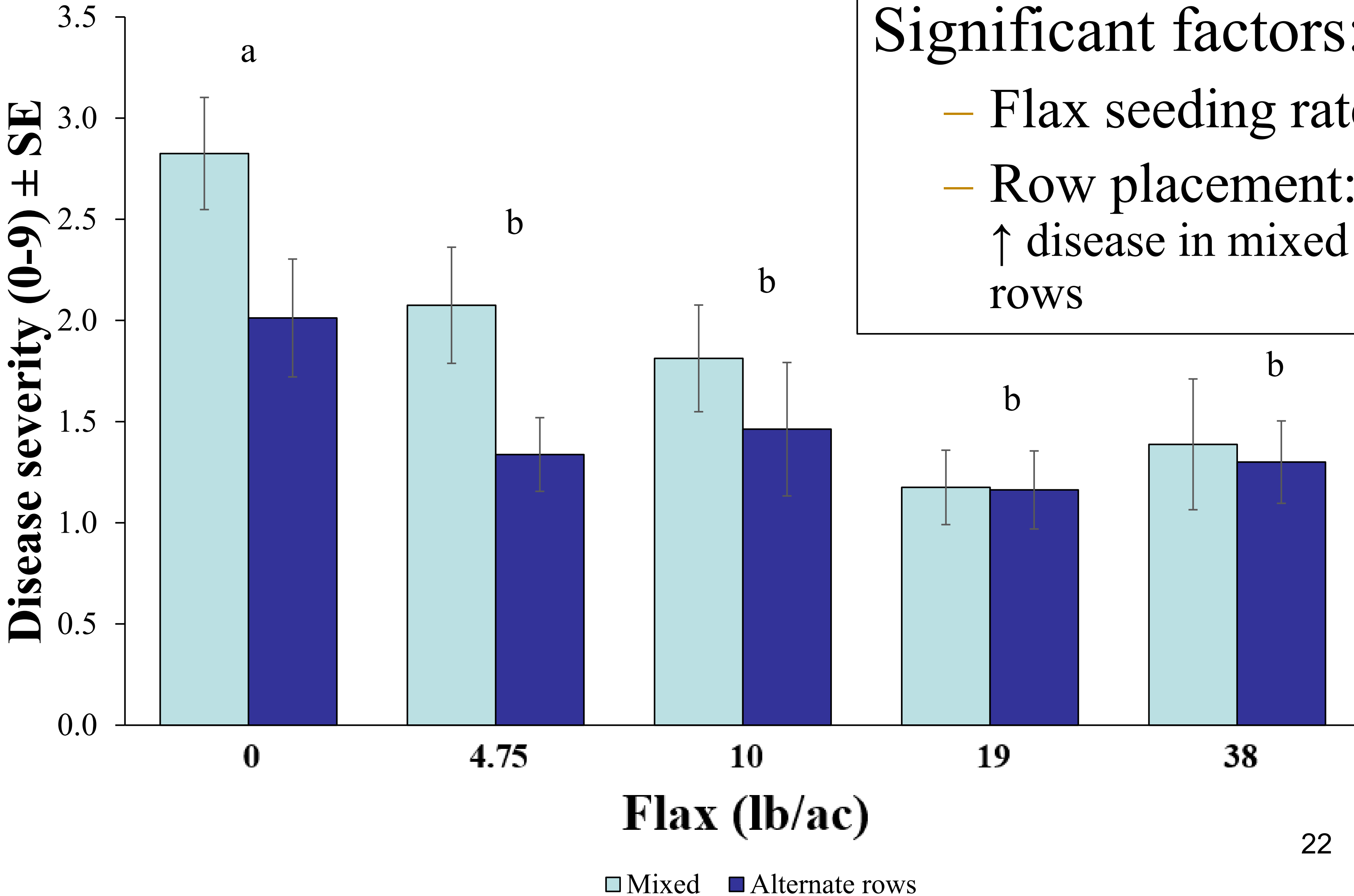


Temperature

- Flax seeding rate and row placement have significant impact
- Cooler with higher flax and alternating rows
- Differences very small (<1°C)
- Only at some time points



Melfort, Aug 2019



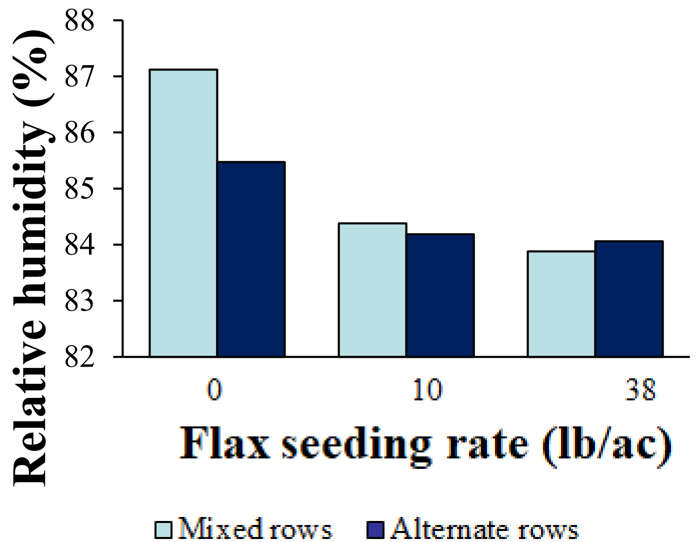
Significant factors:

- Flax seeding rate
- Row placement: ↑ disease in mixed rows

Melfort canopy microclimate

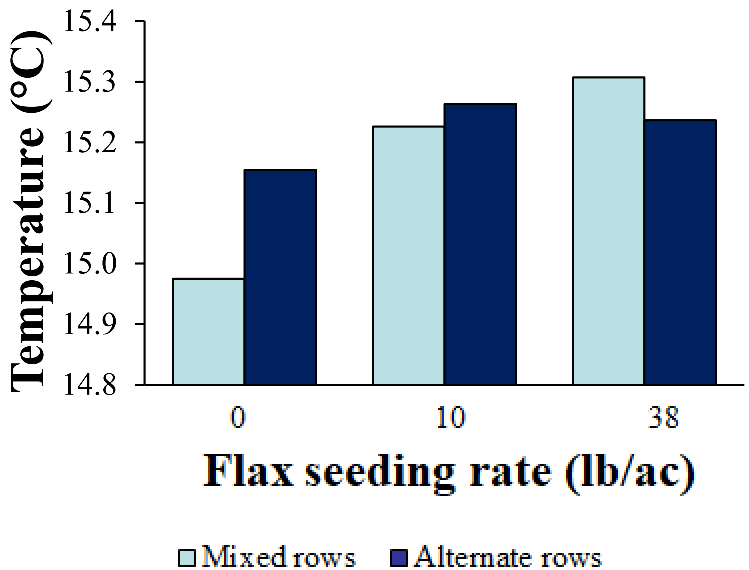
Relative humidity

- Flax seeding rate has significant impact
- **↓ at higher flax – opposite of Redvers**
- Only at some time points

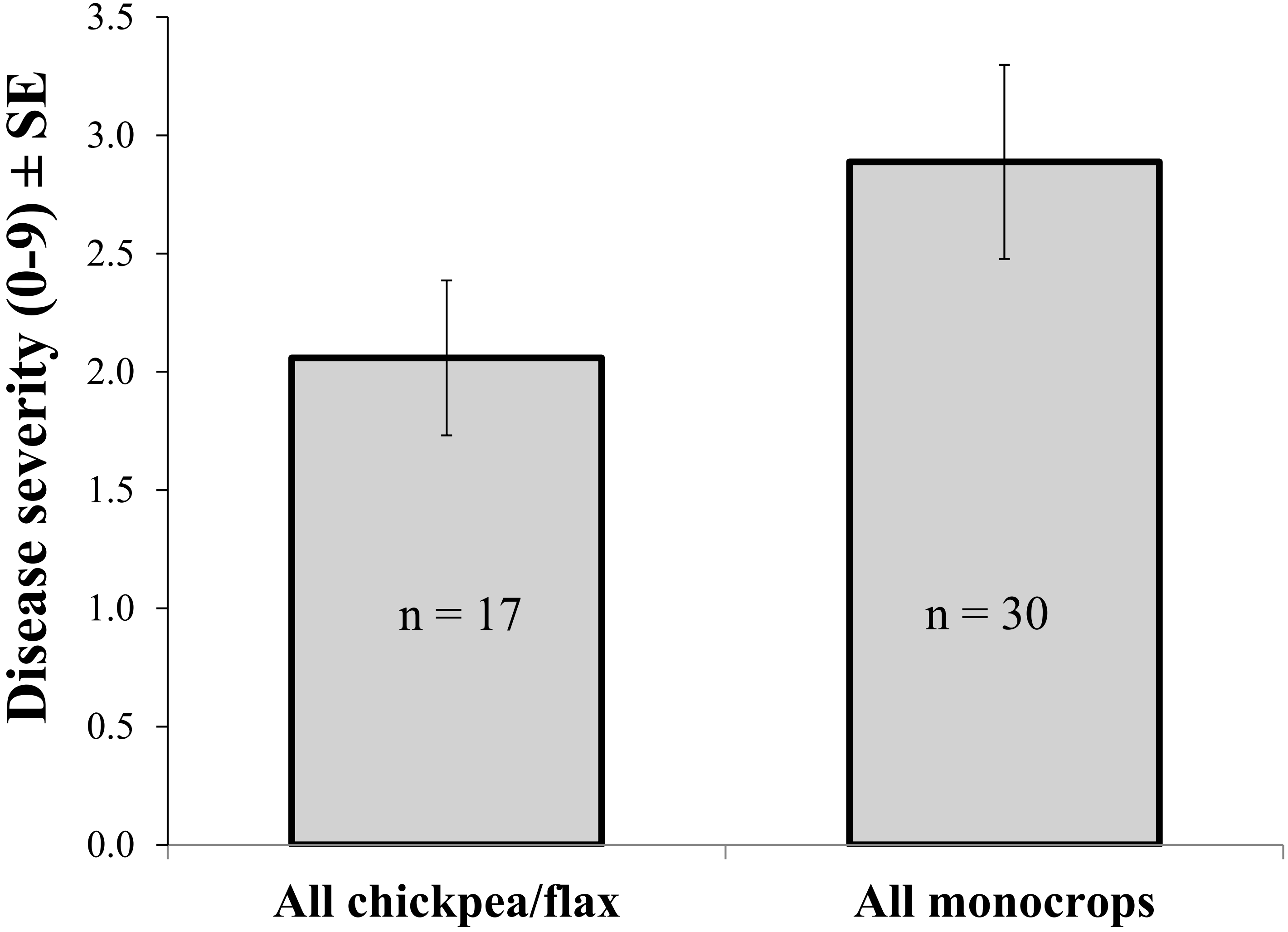


Temperature

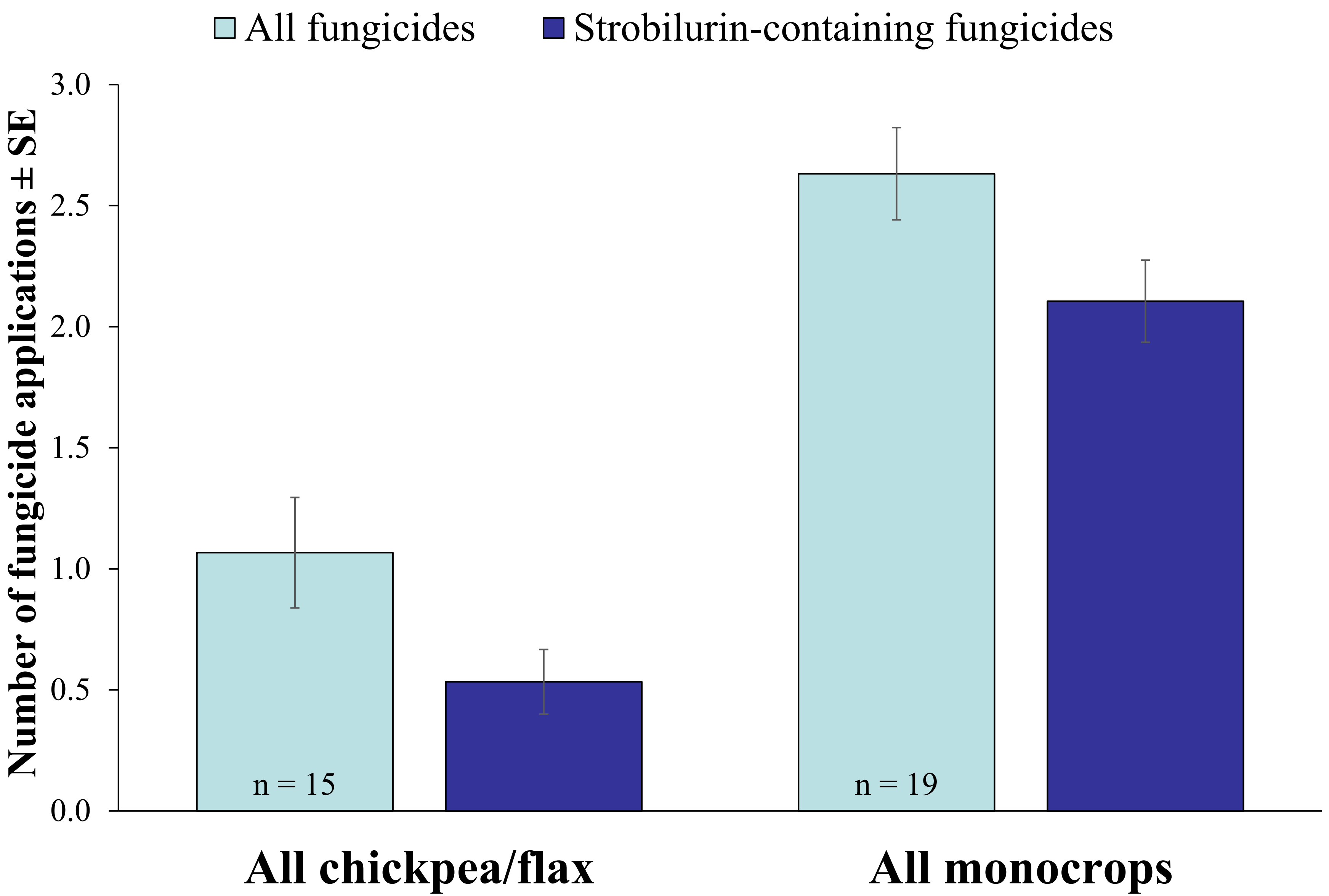
- Only flax seeding rate has significant impact
- Cooler at lower rates of flax – **opposite of Redvers**
- Only at some time points



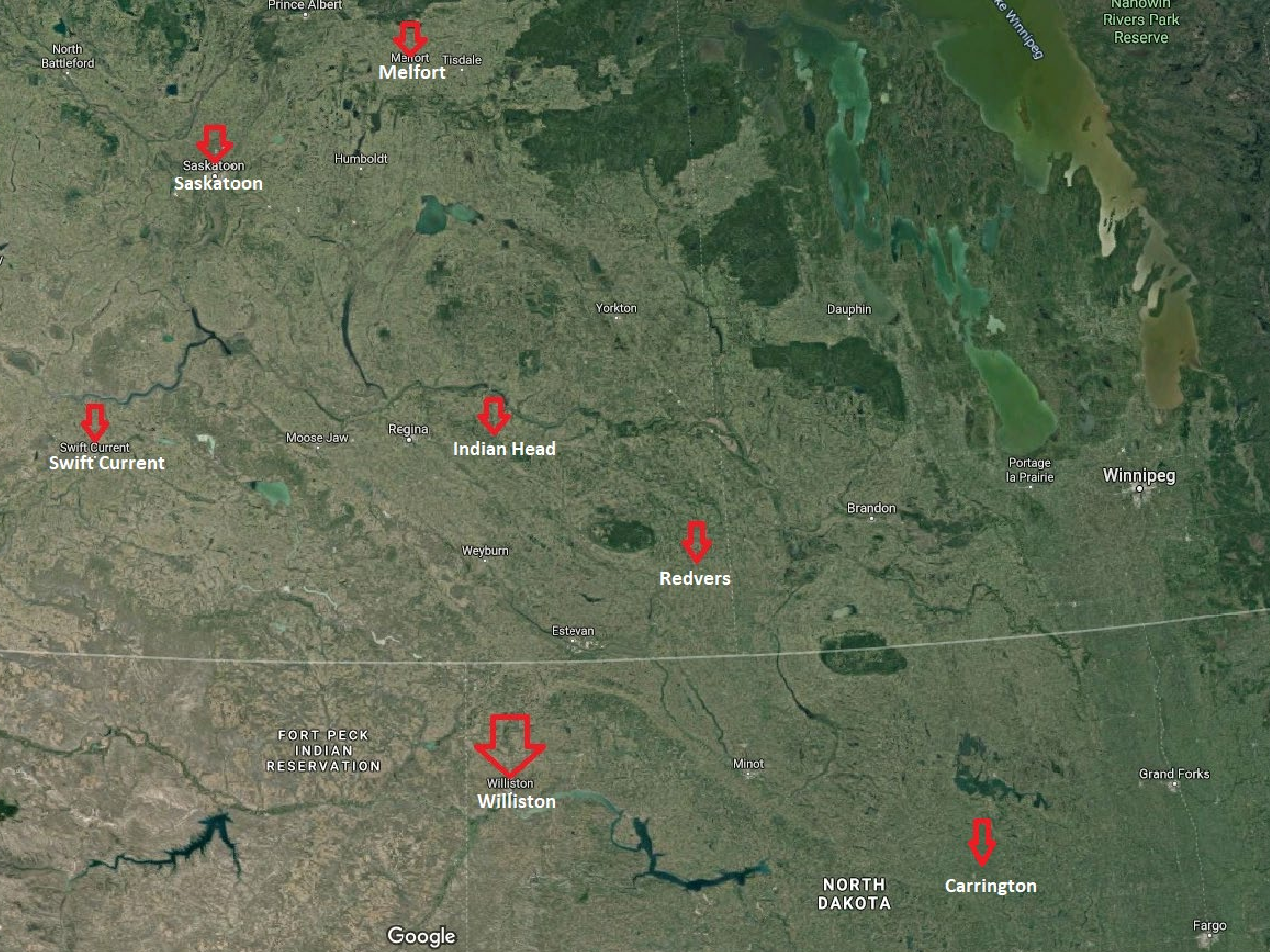
Disease: Survey SK 2019



Fungicides



All fungicides
Strobilurin-containing fungicides
Number of fungicide applications ± SE
3.0
2.5
2.0
1.5
1.0
0.5
0.0
n = 15
n = 19
All chickpea/flax
All monocrops



Prince Albert
North Battleford
Melfort
Melfort
Tisdale
Saskatoon
Saskatoon
Humboldt
Nanowin Rivers Park Reserve
Yorkton
Dauphin
Swift Current
Swift Current
Moose Jaw
Regina
Indian Head
Portage la Prairie
Winnipeg
Brandon
Weyburn
Redvers
Estevan
FORT PECK INDIAN RESERVATION
Minot
Williston
Williston
Grand Forks
NORTH DAKOTA
Carrington
Fargo
Google

Williston, ND, 2018

Ascochyta severity (0-10)

Treatment	Jul-17	Jul-31
Pure chickpea	3.0	7.3 A
Chickpea + 5 lb flax	2.3	5.3 AB
Chickpea + 10 lb flax	2.5	4.0 B
Chickpea + 15 lb flax	2.8	3.5 B
Chickpea + 20 lb flax	3.0	3.3 B
Chickpea + 40 lb flax	2.8	3.0 B
	NS	$P<0.05$

- Sometimes higher in monocrop chickpeas than intercrop
- 2 proline applications

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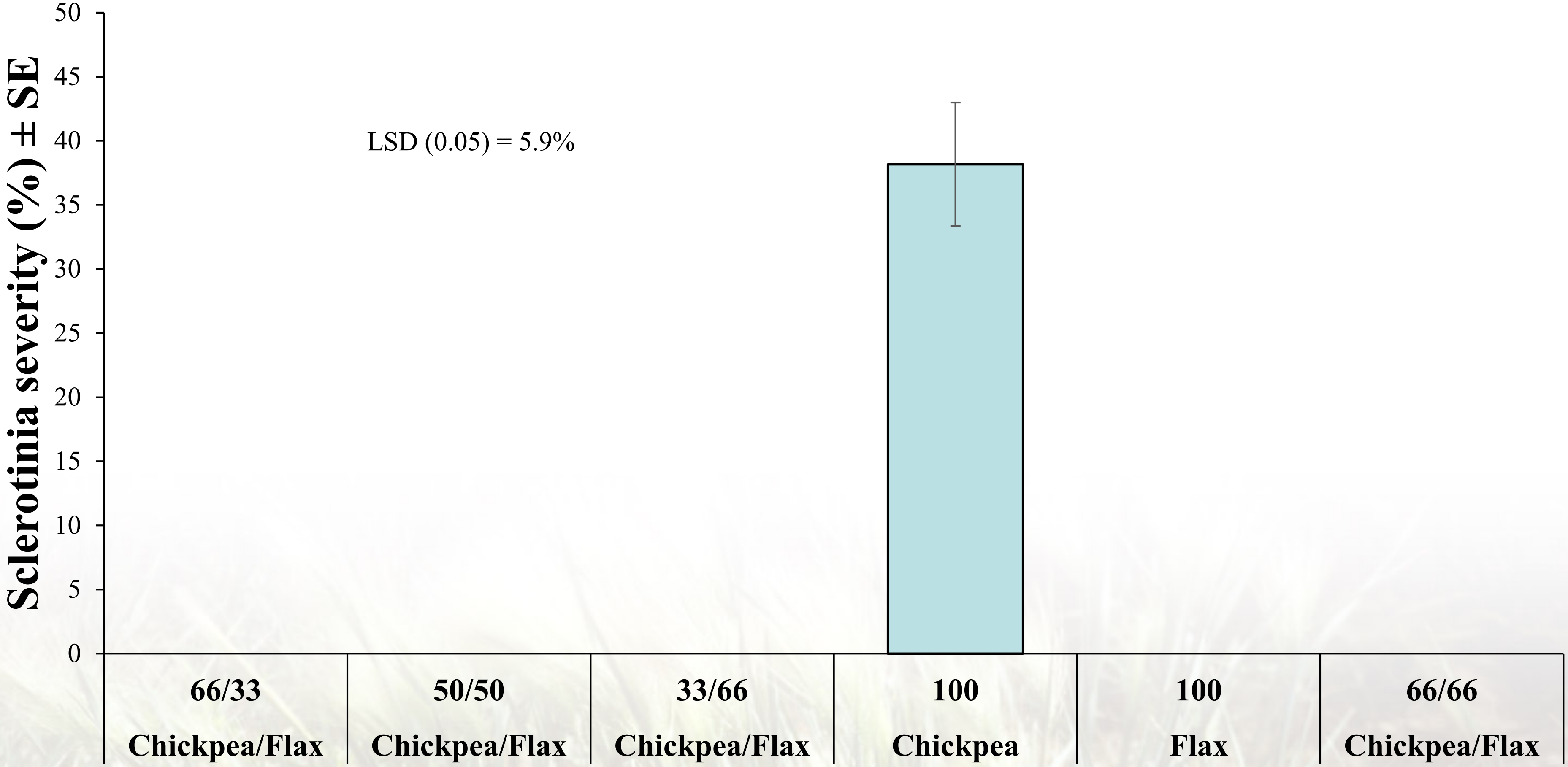
NDSU NORTH DAKOTA STATE UNIVERSITY

Carrington, 2018



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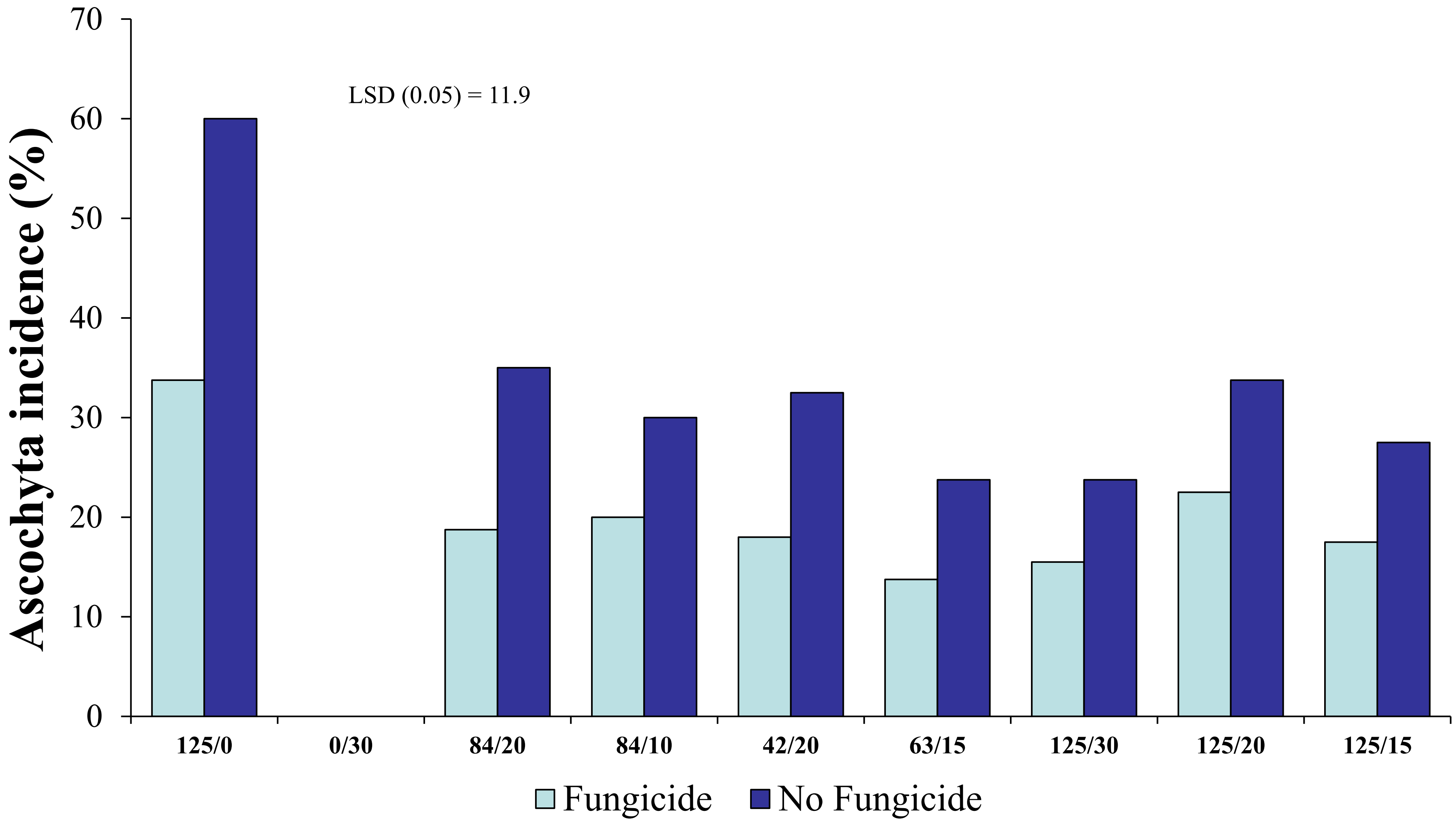
- Sclerotinia (white mold) ONLY in monocrop

Carrington, 2019



Fungicide = proline 2x

Mike Ostlie

Conclusions

- Chickpea/flax intercropping can help manage Ascochyta blight and sclerotinia in chickpea
  - Not in all situations – more research needed
- Improve chickpea adaptation to wetter environments
- Compliments fungicide application
- Impacts canopy microclimate
  - More research needed
- Mechanisms remain to be explored

Mycosphaerella blight in pea

- Foliar disease
- Impacts pea around the world

Photos: S. Boecher

Mycosphaerella pinodes

Risk factors

- Canopy density
- Leaf wetness/ humidity
- Weather forecast
- Symptoms

Current management

- Clean seed
- Fungicide ~ early flower
- Moderate genetic resistance (4-5 on 0-9 scale)
- Crop rotation

SASKATCHEWAN pulse Growers — PULSES — 2016 INTERNATIONAL YEAR OF PULSES

Fungicide Decision Support Checklist for Ascochyta & Mycosphaerella Blight in Pea

Sherrilyn Phelps, Agronomy and Seed Program Manager, Saskatchewan Pulse Growers
Sabine Banniza, Professor – Plant Sciences, Crop Development Centre, University of Saskatchewan
Faye Dokken-Bouchard, Former Provincial Specialist, Plant Disease, Saskatchewan Ministry of Agriculture

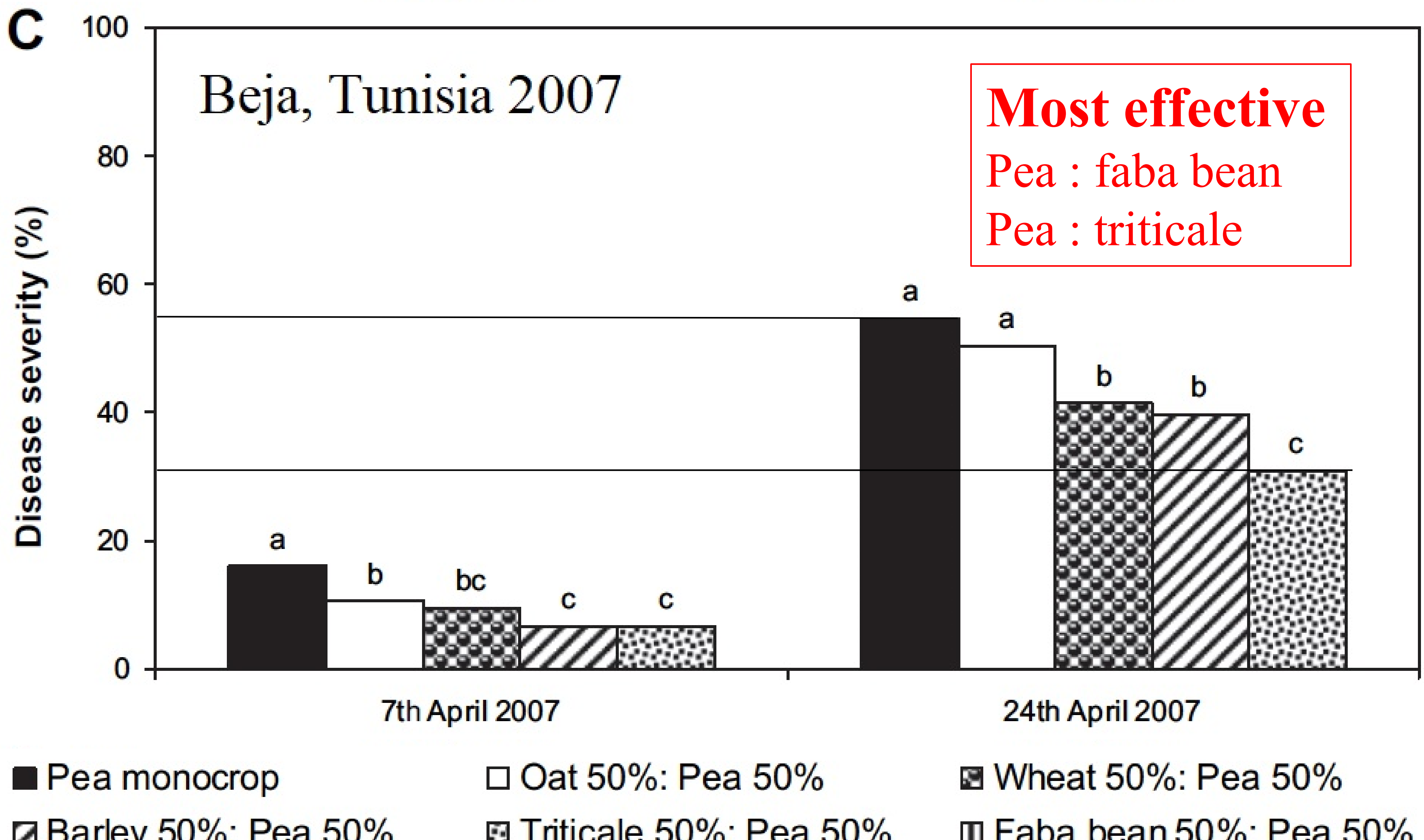
Disease in pea is a serious concern and can have dramatic yield implications if not monitored and no appropriate control measures are taken when risk is high. To determine the risk associated with ascochyta and mycosphaerella blight in pea, there is a disease decision support checklist has been developed by Alberta Agriculture and Rural Development (AARD) as a working tool for producers, to help in establishing thresholds for fungicide application.

A. Crop Canopy	**Risk Factor**
1. Thin (high weed pressure, low yield expectations)	0
2. Moderate (some weeds, possibly low yield)	10
3. Normal (about 8 lentil plants/ft^2 or 85/m^2)	15
4. Dense (more plants than normal, lush growth)	30
B. Leaf wetness/humidity/dew at noon	**Risk Factor**
1. None	0
2. Low	10
3. Moderate	20
4. High	40
C. The five day weather forecast	**Risk Factor**
1. Dry	0
2. Unpredictable	10
3. Light showers	15
4. Rain	20
D. Symptoms on pea plants	**Risk Factor**
1. No visible symptoms	0
2. Up to 20 per cent of plants showing symptoms	15
3. 20 to 50 per cent of plants showing symptoms	25
4. 50 to 100 per cent of plants showing symptoms	40
TOTAL SCORE OF RISK FACTORS	

Source: K. J. Lopetinsky[1] and S Strydhorst[2] 2002
[1]Ag Research Division, AARD, Barrhead [2]University of Alberta, Edmonton, Alberta, Canada

Mycosphaerella blight in intercrops

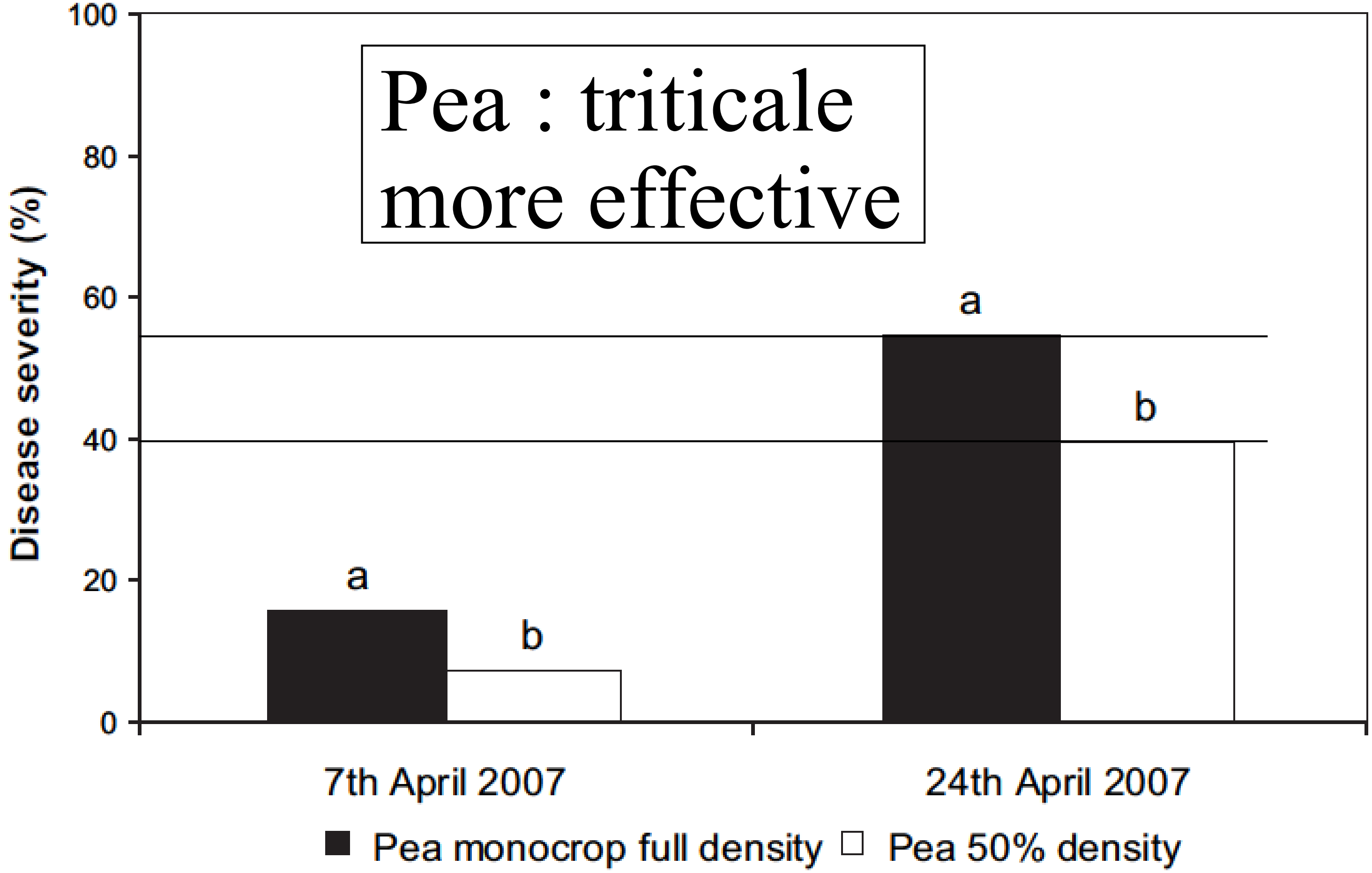
M. Fernández-Aparicio et al. / Crop Protection 29 (2010) 744–750



Planting rate

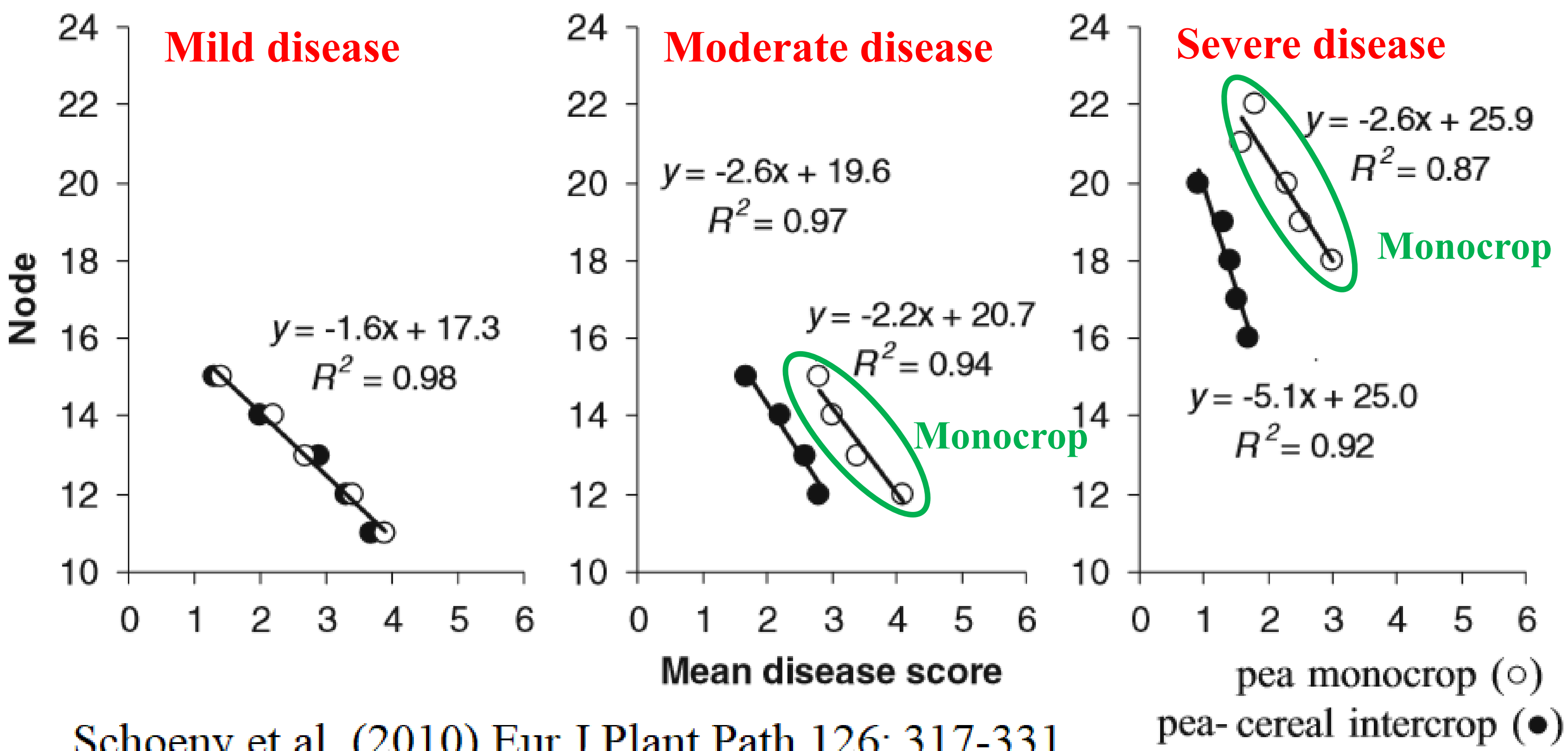
- Reduced pea planting rate ↓ disease

M. Fernández-Aparicio et al. / Crop Protection 29 (2010) 744–750



Plant organs and disease severity

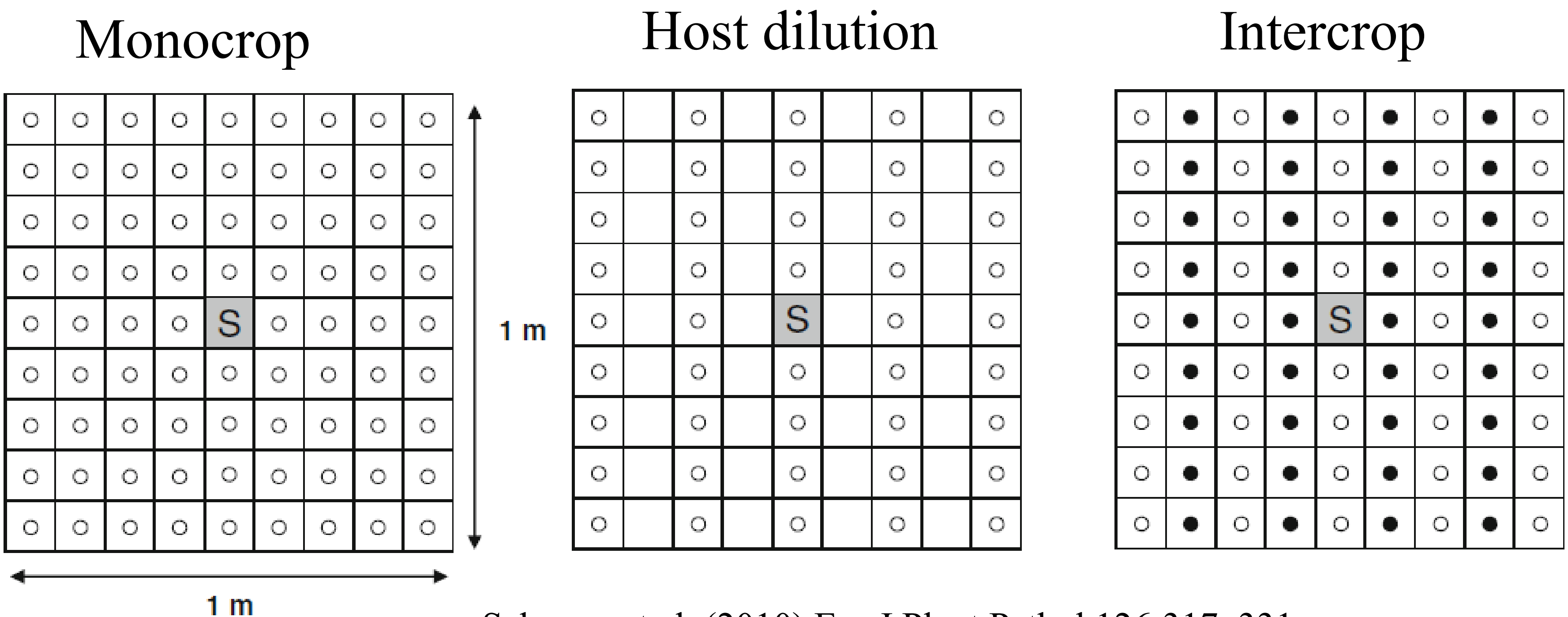
- Intercropping with wheat did **not** change disease on stipules
- ↓ disease on stems and pods if disease was moderate or severe



Schoeny et al. (2010) Eur J Plant Path 126: 317-331

Mechanisms

- Canopy microclimate
  - ↓ leaf wetness at and after flowering
- Barrier to spore dispersal / dilution of host plants
  - Splash spreading of spores ↓



Schoeny et al. (2010) Eur J Plant Pathol 126:317–331

Chocolate spot in faba bean

- Foliar disease
- Caused by *Botrytis fabae* and/or *Botrytis cinerea*

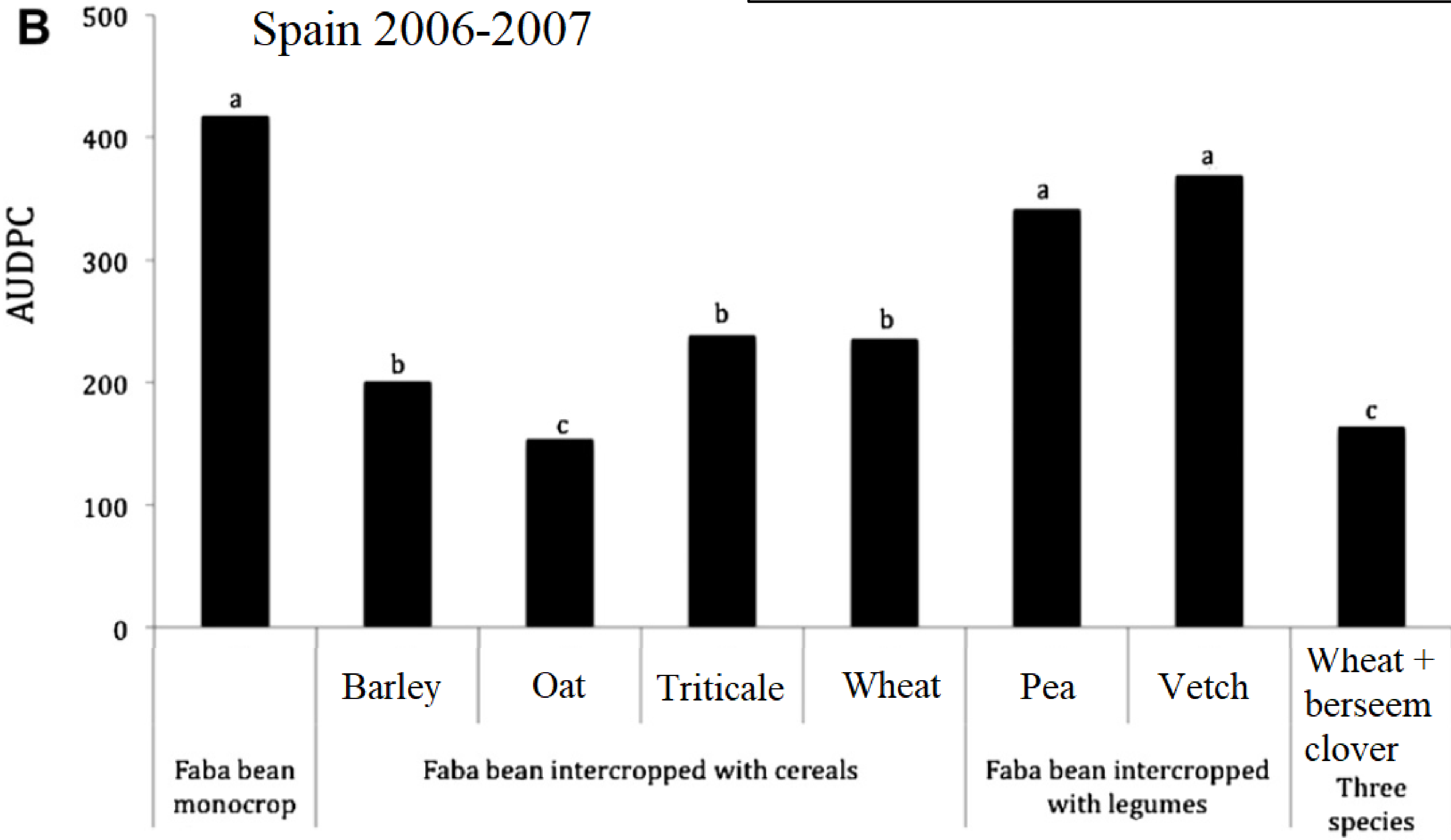
Surinder Kaur, Sabine Banniza, Carter Peru, and Syama Chatterton. Survey for Chocolate Spot and Other Foliar Disease on Faba Bean in Saskatchewan in 2019 in 2019 Pulse Situation Report

Risks	Management
• Moisture • Dense canopy • Diseased seed • No Canadian resistant varieties available	• Avoid high seeding rates • Plant clean seed • Early seeding • Fungicides

Intercropping

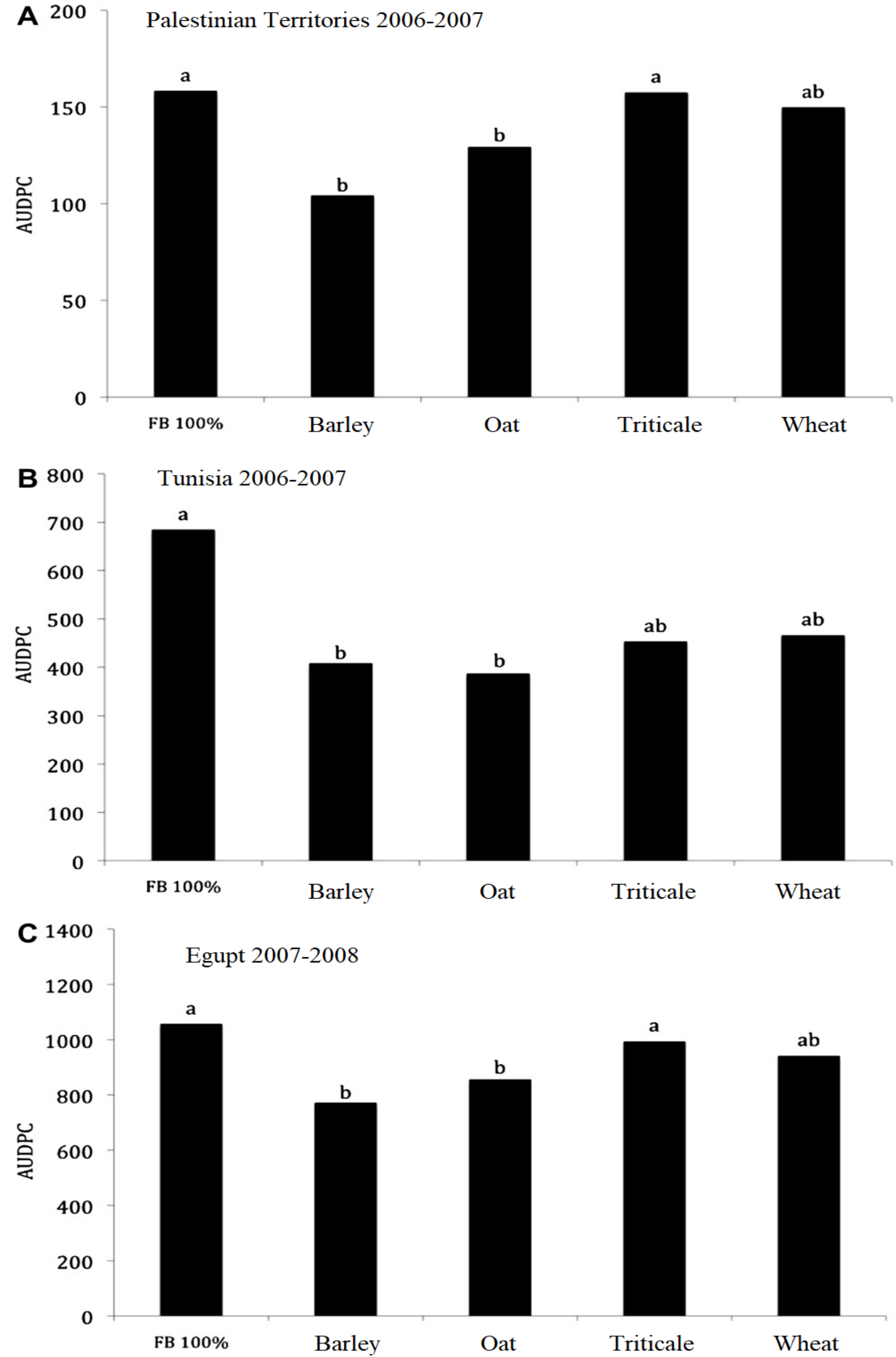
M. Fernández-Aparicio et al. / Crop Protection 30 (2011) 1015e1023

Faba bean + cereal more effective than faba bean + legume



Different regions

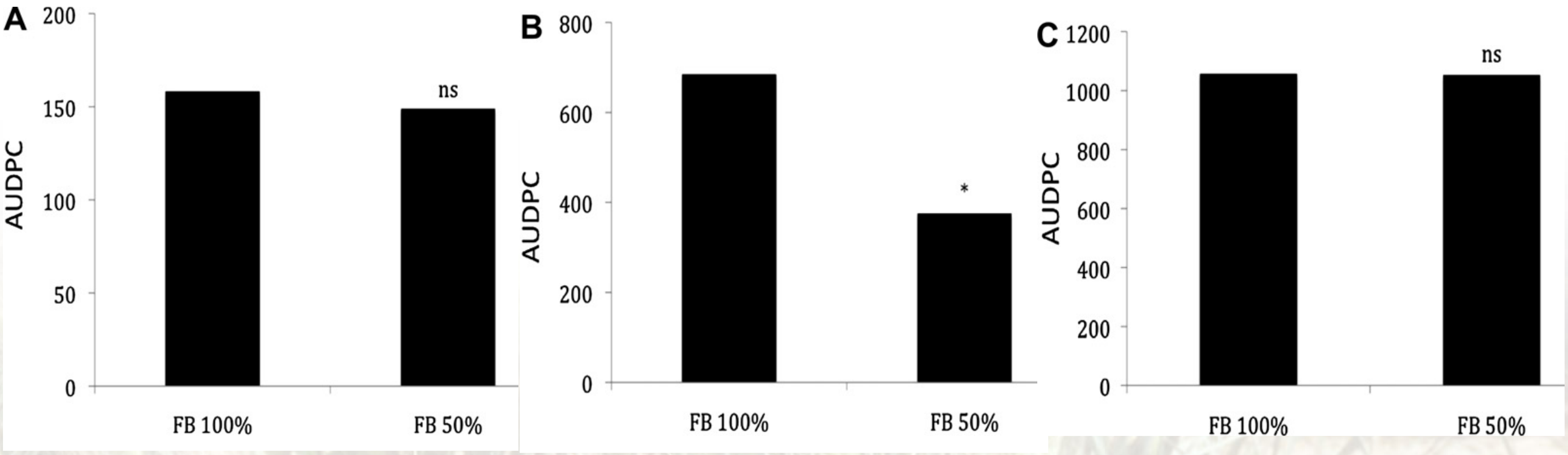
- Results consistent between regions



M. Fernández-Aparicio et al. / Crop Protection 30 (2011) 1015e1023

Faba bean planting rate

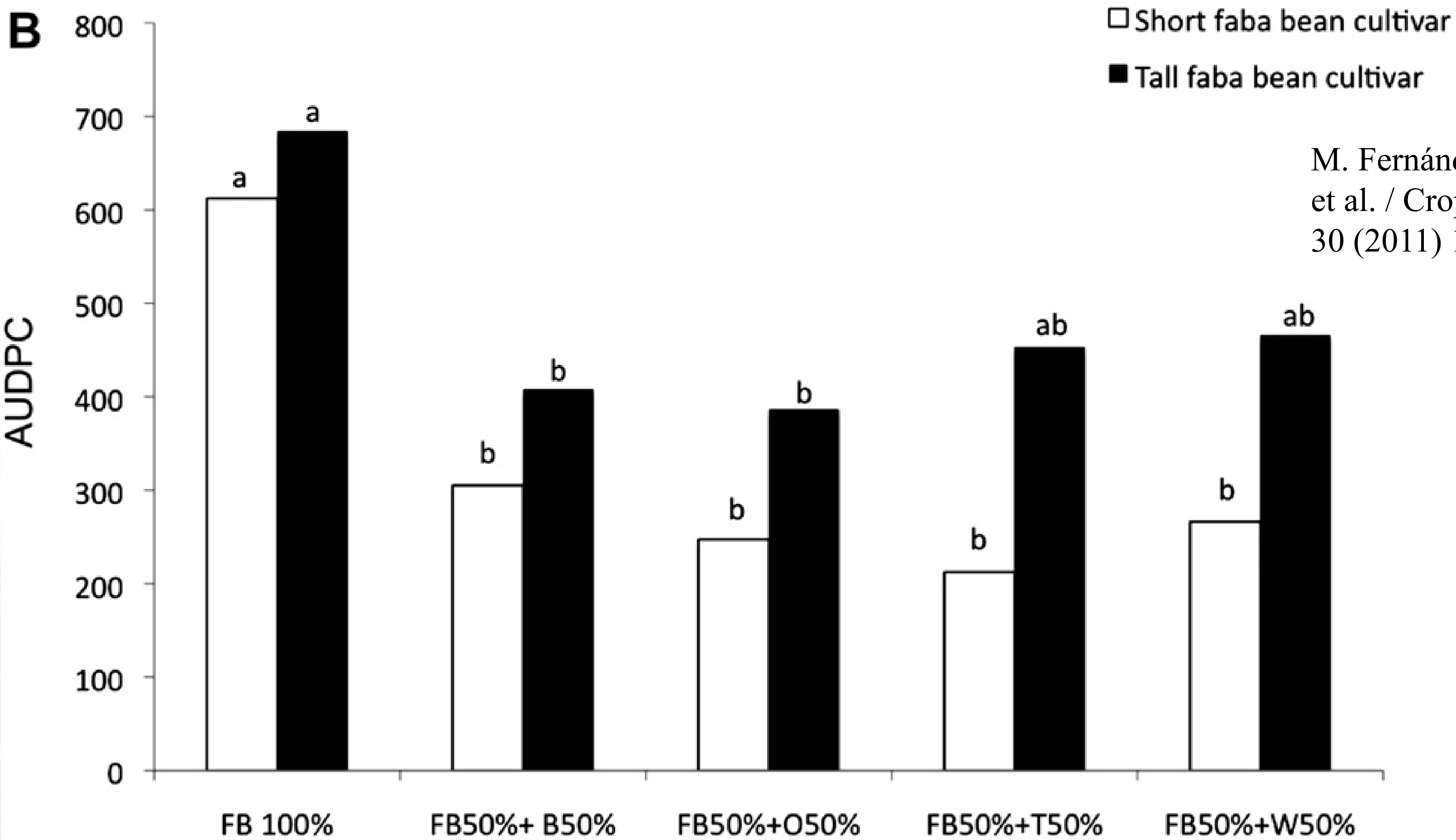
- 50% faba bean seeding only sometimes ↓ disease
  - Even under high disease pressure



M. Fernández-Aparicio et al. / Crop Protection 30 (2011) 1015e1023

Short vs. tall faba beans

- Tall cultivars > disease than short cultivars
- Intercropping more effective in short cultivars

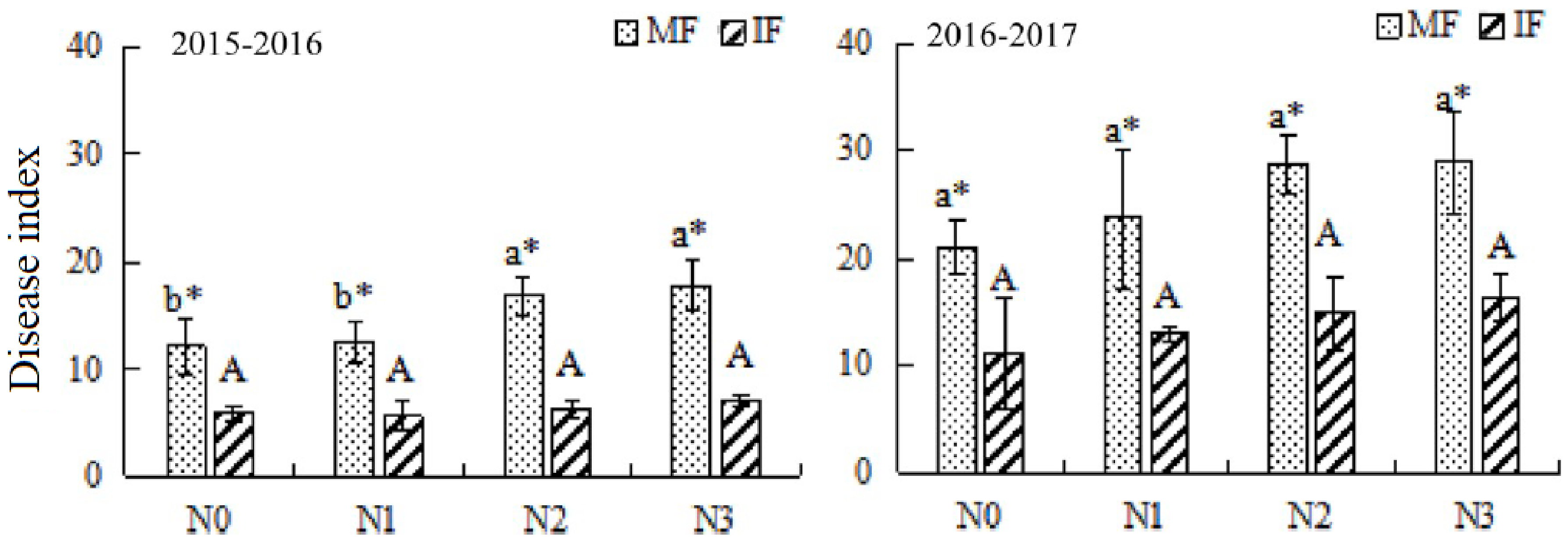


M. Fernández-Aparicio et al. / Crop Protection 30 (2011) 1015e1023

N fertilizer

- ↑ N → ↑ disease, or no difference
- Monocrop had more disease than intercrop

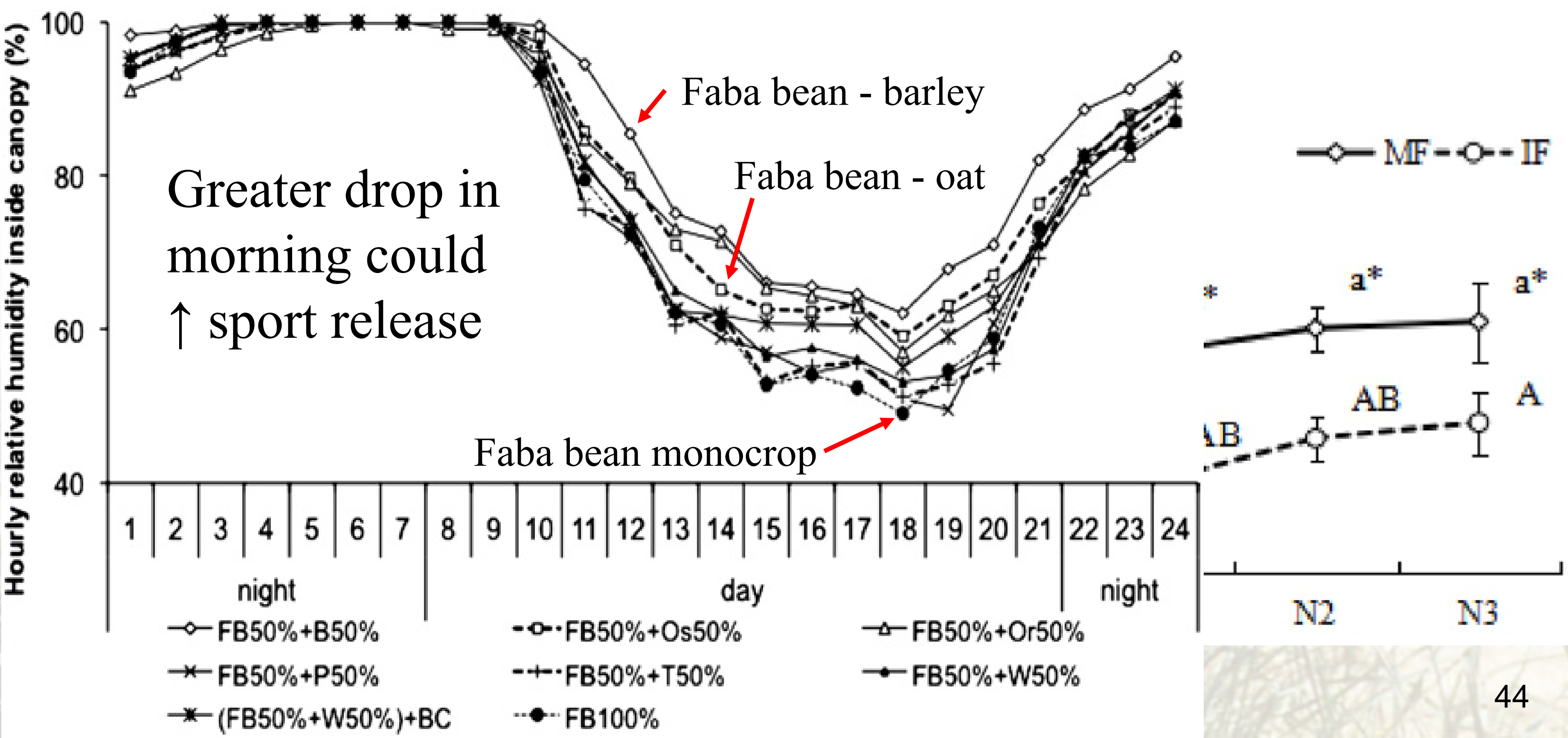
Z. Guo et al. Crop Protection 127 (2020) 104972



Intercrop: Faba bean + wheat

Canopy microclimate

- Monocrop more humid (Guo et al. 2020 Crop Protection 127 104972)
- Monocrop potentially drier (M. Fernández-Aparicio et al. / Crop Protection 30 (2011) 1015e1023)



Intercropping and foliar disease

- Can reduce disease in some situations
- Have to choose crop combinations well
- Potential mechanisms
  - Barrier
  - Host dilution
  - Canopy microclimate
  - Changes to crop growth
  - Stimulation of plant defenses

Intercropping and root rot

Root rot is caused by a complex of

- Fusarium species
- Pythium species
- *Rhizoctonia solani*
- *Aphanomyces euteiches*

Fusarium


Courtesy of S. Chatterton, AAFC

Infects many different plants

Courtesy of F. Dokken-Bouchard, SMA

Aphanomyces

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

Courtesy of S. Chatterton, AAFC

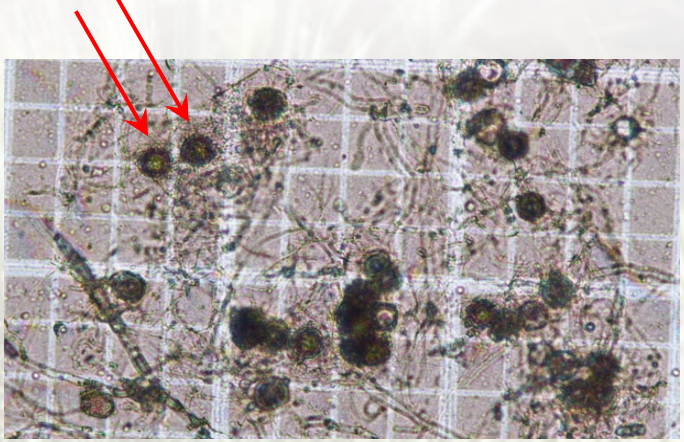
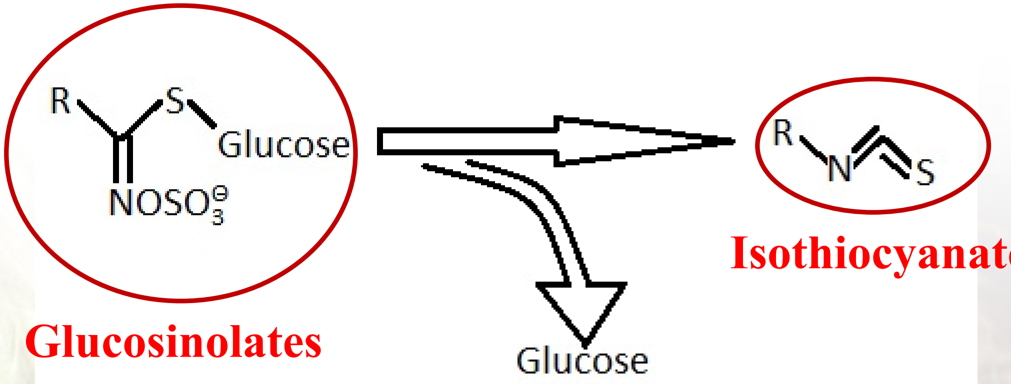


Photo: M Hubbard,
Axten Farm
Pea/mustard

Root rot &
Pea/brassica Intercropping

- Soil "bio-fumigation"

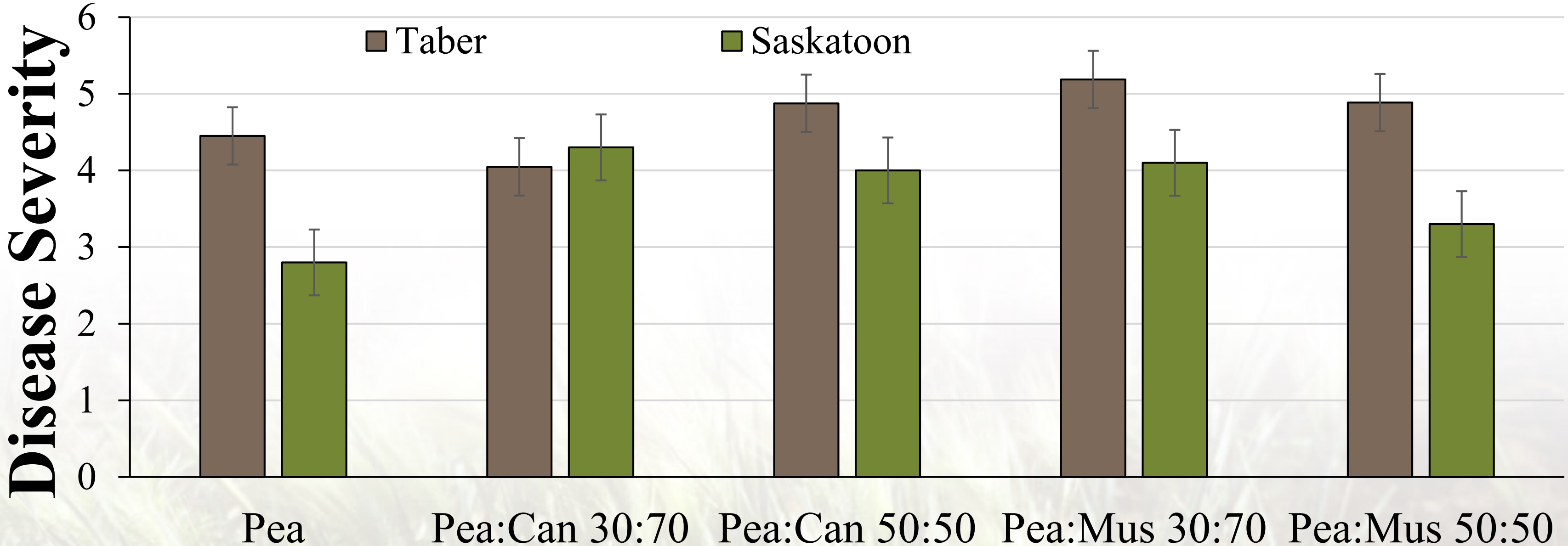


Glucosinolates

Isothiocyanates

Root rot

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



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

Yield and Land Equivalency Ratio (LER)

	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.

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Saskatchewan Pulse Growers
Alberta Pulse Growers
ACIDF Alberta Crop Industry Development Fund Ltd.
Alberta Government
Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada
Government of Saskatchewan, Ministry of Agriculture
University of Saskatchewan, Crop Development Centre
Western Grains Research Foundation
NSERC CRSNG
SaskFlax

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