Crop Rotation Decisions: $$ and Sense

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Retired Oilseed Specialist

Rotation benefit is real and really complex

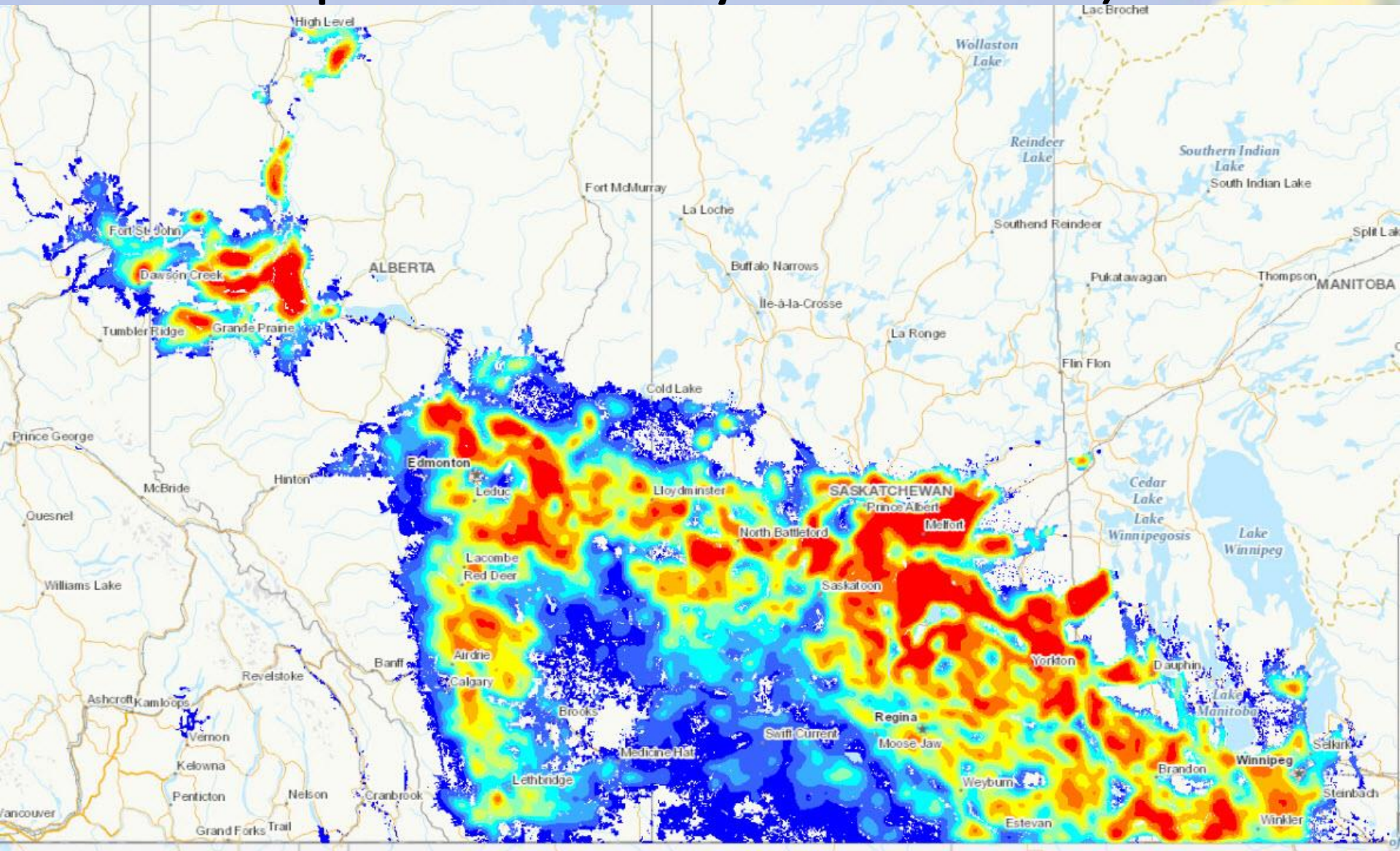
- A large number of factors
  - Moisture
  - Fertility
  - Pests (disease, weeds, insects)
  - Unknown factors
    - Allelopathy, root microbiome interactions
- Rotation yield benefit has not been partitioned for individual factors
    - Creates uncertainty for $ value of IPM to growers

Canola Rotations Eons Ago

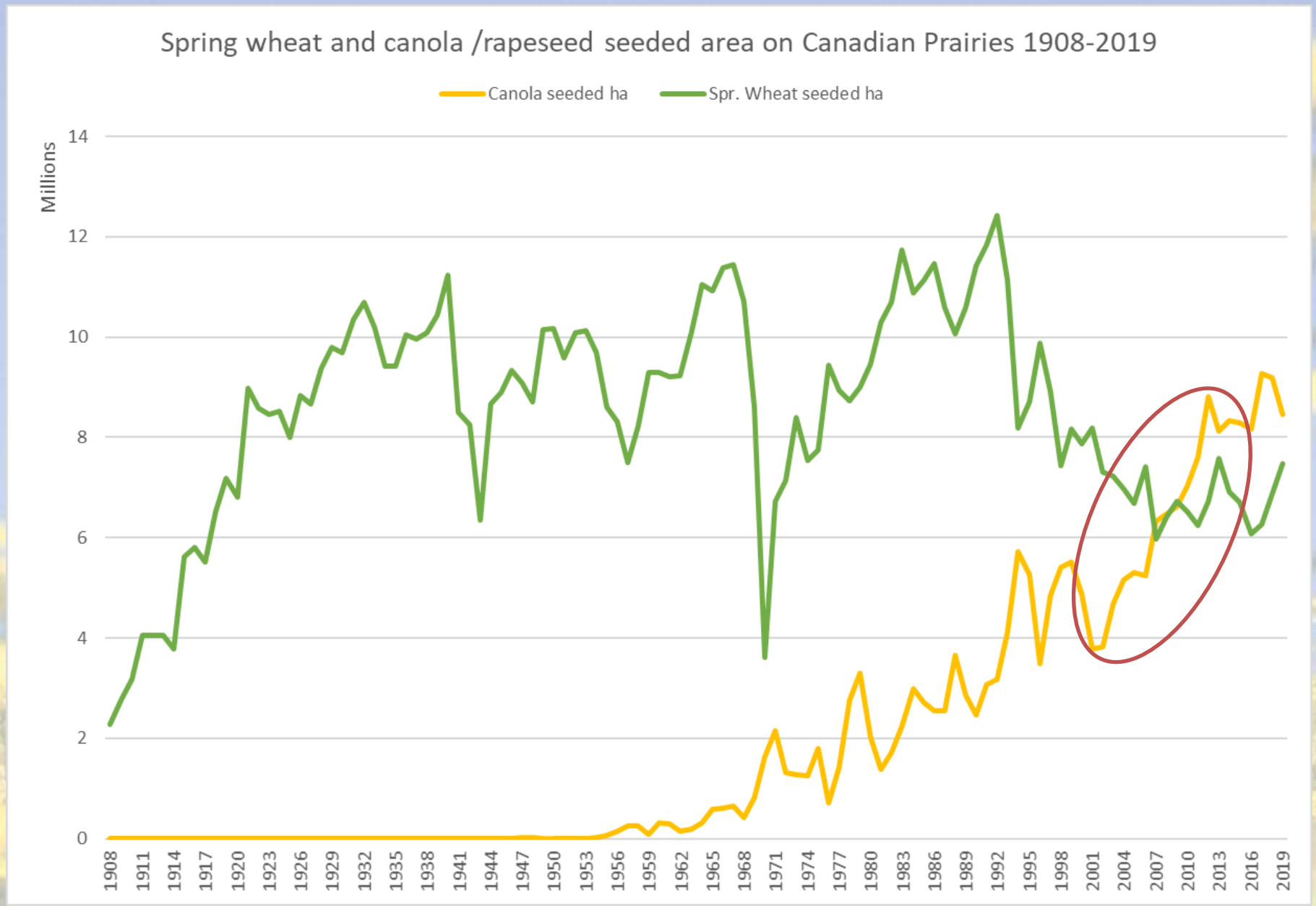
- Canola Production survey conducted by Alberta Agriculture in 1991/92
  - 322 canola growers from different areas in Alberta, proportionate to % of canola
  - Prior to herbicide tolerance, hybrid adoption

Beneficial break crops before canola	% of respondents	Reported yield bu /ac
3 to 4	70	30
2	22	28
1	5	26
0	2	25

Canola Frequency on Prairies (2009-16 Spatial Density from AAFC)



Why is canola popular now?



Short Rotation Canola Experiments

- Initially short rotation studies were mainly created to look at short rotation impacts on blackleg
- Small plots may underestimate rotation effect due to disease, weed or insect trespass between plots or from same crop bordering experimental area
  - Lack of rotation research assessing impact of adjacent fields or area intensity

Long-Term Canola Rotation Study

North Central Research Extension Center

North Dakota

Brian Jenks

Materials and Methods

- Established in 2000
- 5 Rotations
  - 4 crops
- RCBD
  - 4 replications
- Fungicide
  - Ronilan (Vinclozolin)
- 30’ x 180’ plots
- 3 Disease Evaluations
- Yield

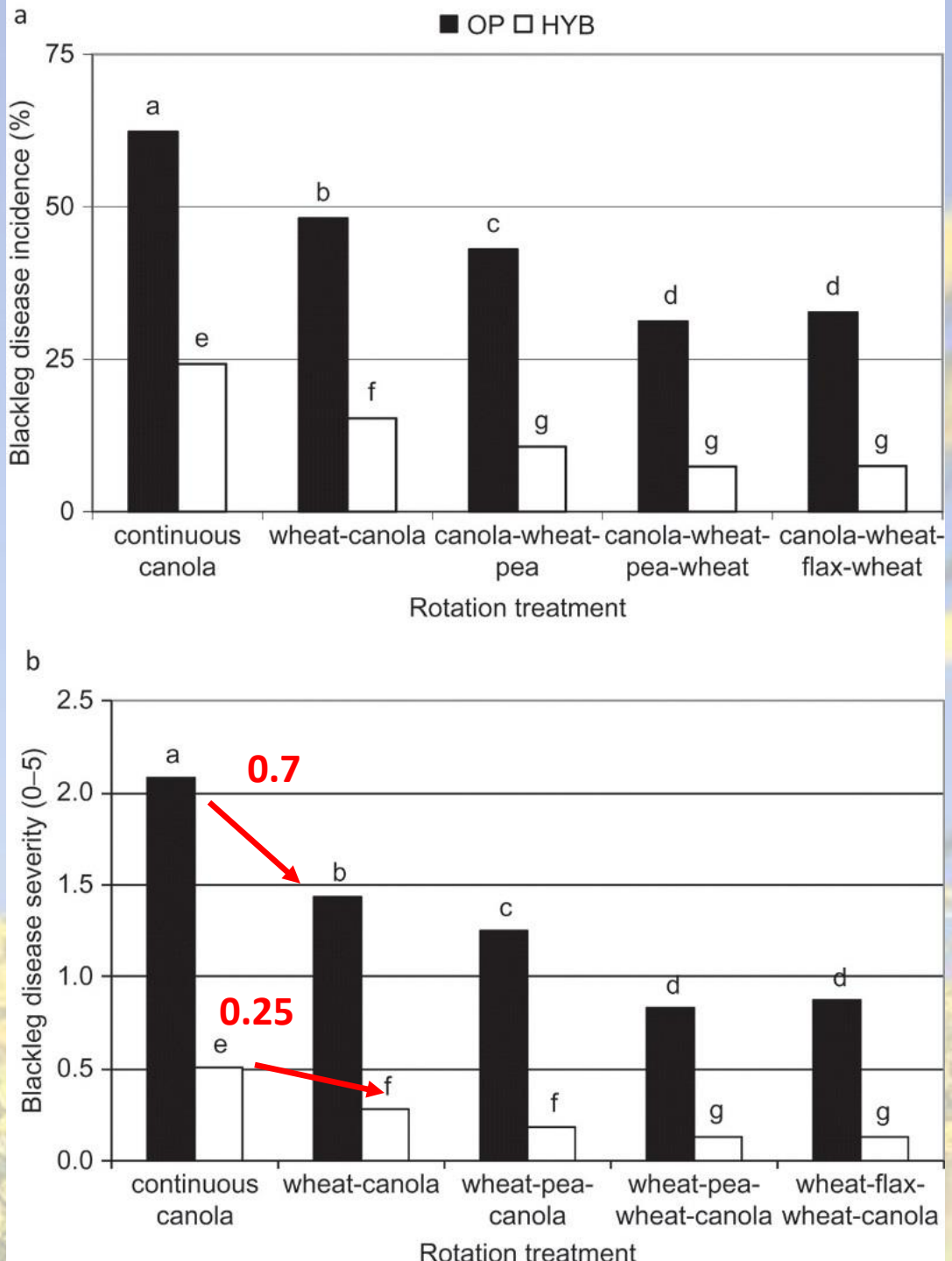
Canola varieties alternate RR / LL

Disease impacts from areas between plots, equipment sanitation

Fig. 1. a, Blackleg disease incidence (%) and b, blackleg disease severity (0–5 scale) for each rotation treatment and cultivar. Data are the means of 15 site-years (Melfort 2000–2006, except 2005, and Scott 1999–2007)

Yield loss per unit blackleg severity
HYB 12%
OP 16%

(Kutcher et al., Can. J. Plant Pathol. 2013)



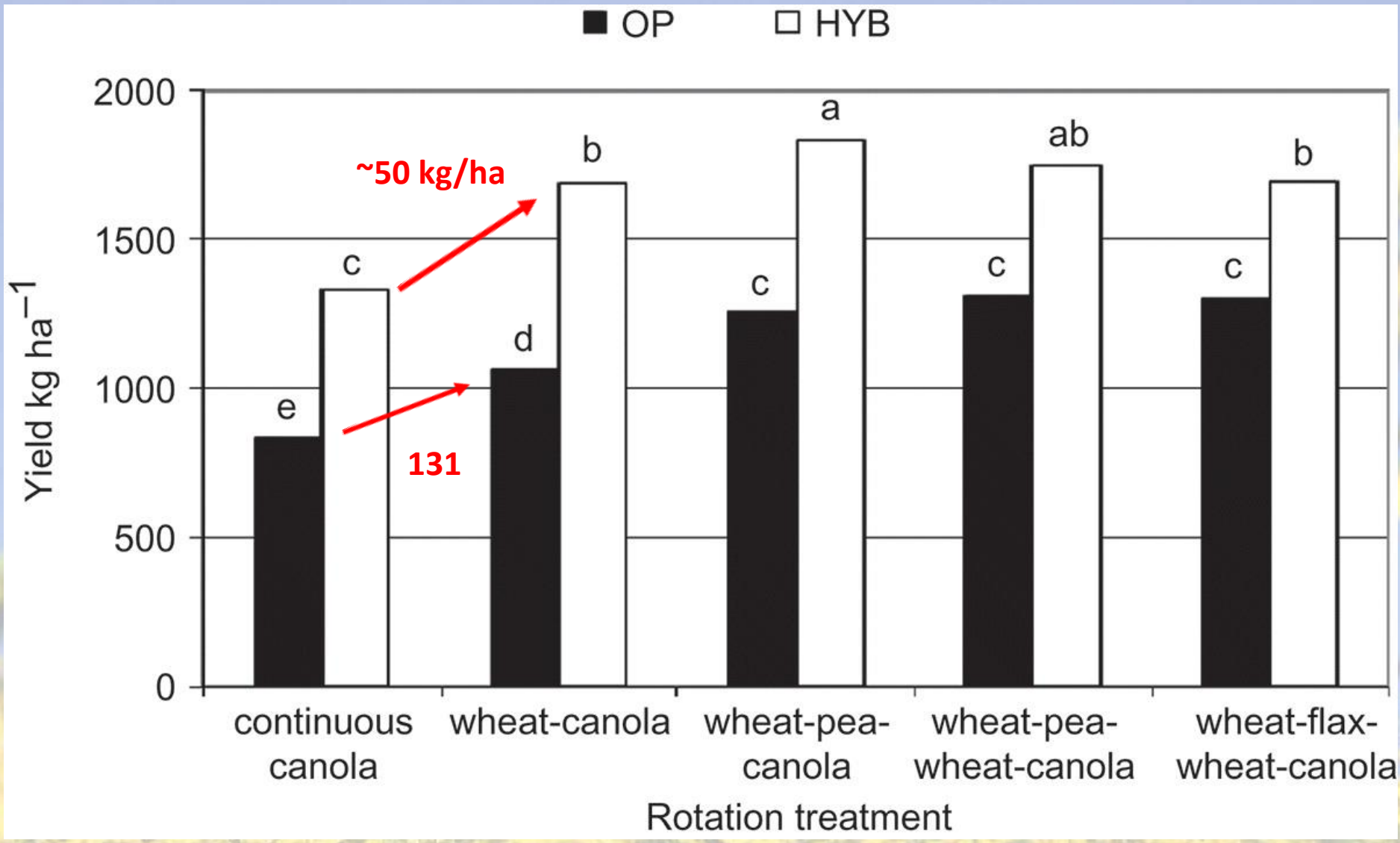
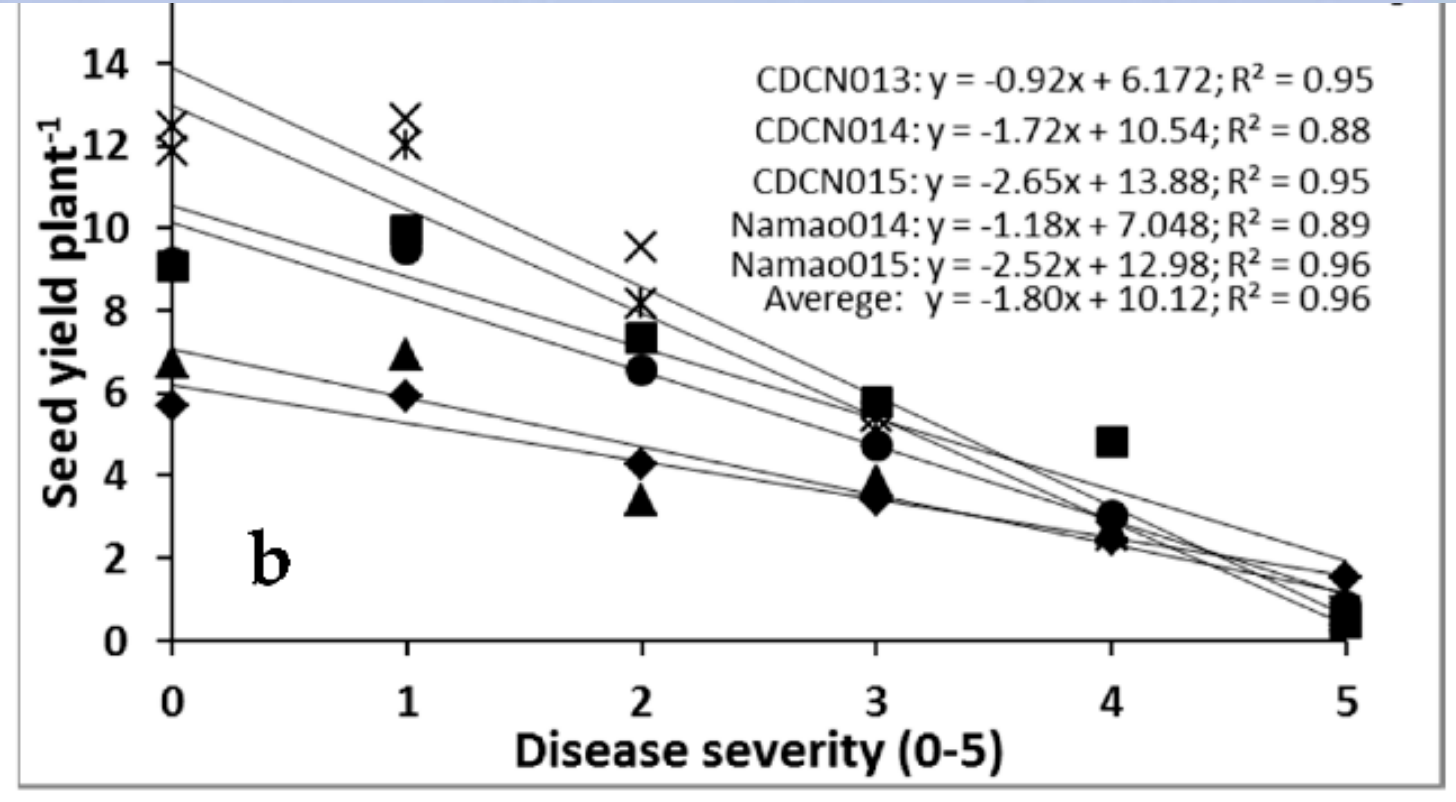


Fig. 3. Yield of each canola cultivar (OP and HYB) for each rotation treatment. Data are the means of 16 site-years (Melfort 2000–2006 and Scott 1999–2007).

Yield loss models to partition rotation benefits



17% yield loss per 1 unit severity

Hwang et al. 2016 Figure 2

Kutcher 2013 Yield loss per blackleg severity unit

HYB 12% OP 16%

Canola Rotation Frequency Trial

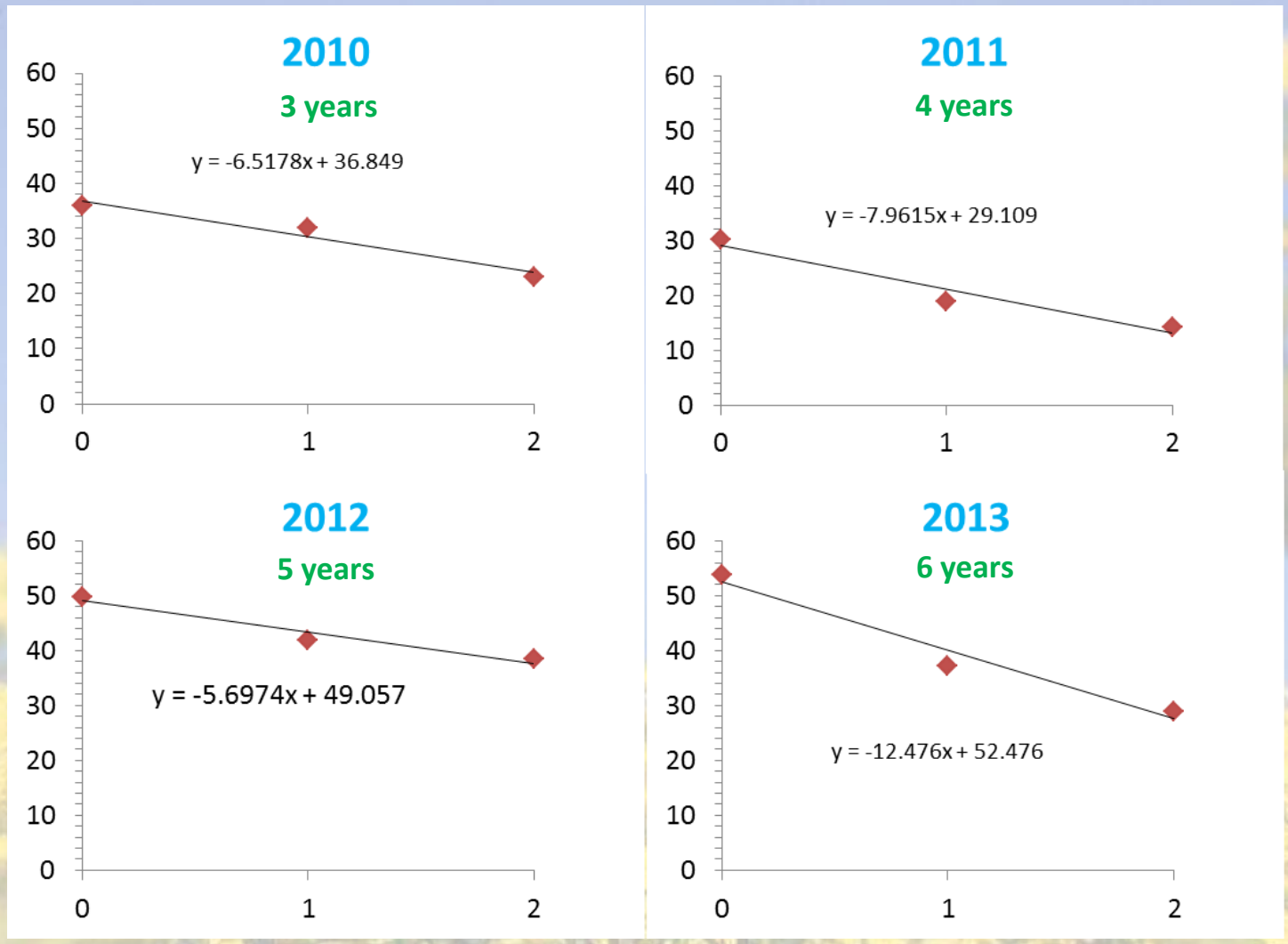
Harker et al. 2015. Can J. Plant Sci. 95:9-20

- In 2008, direct-seeded, all phases rotation experiments were established at 5 AAFC locations on the Canadian Prairies
- Continuous RR or LL canola (0) was compared to canola rotated with wheat (1) or barley and peas (2)
- Yield and pests were evaluated in canola phases from 2010 to 2013 (years 3 to 6)
  - Weed density differences not associated with canola yield

Canola Rotation Frequency

- Effect on Blackleg Incidence (%)

- 5 site means



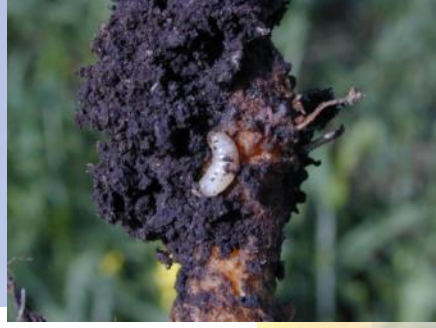
Similar trends with severity
CC average severity was 0.8

Average severity decrease per year break was 0.21

Canola Rotation Frequency

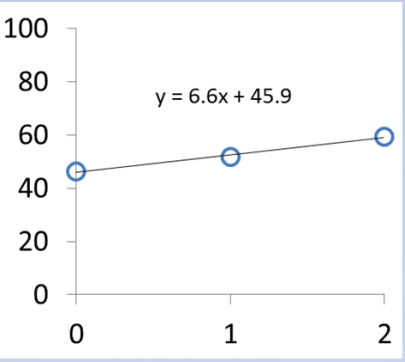
- Effect on Root Maggot Damage (0-5)

- 5 site means

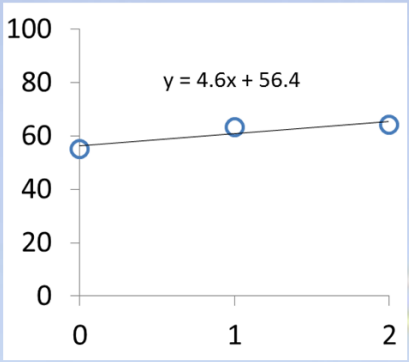


Bu/ac Yield - All Sites: how much yield loss was due to blackleg or root maggots?

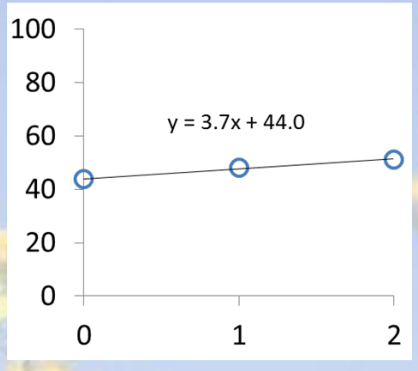
2010
Y3



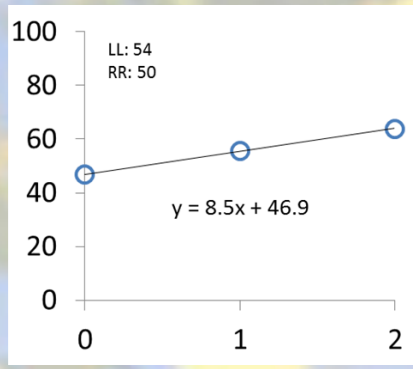
2011
Y4



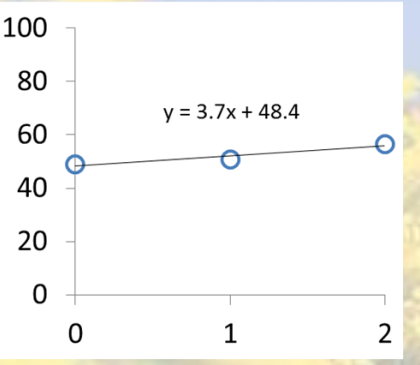
2012
Y5



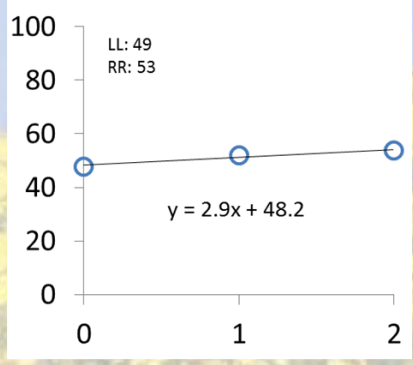
2013
Y6



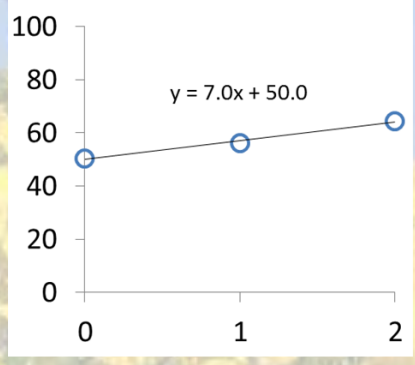
2014
Y7



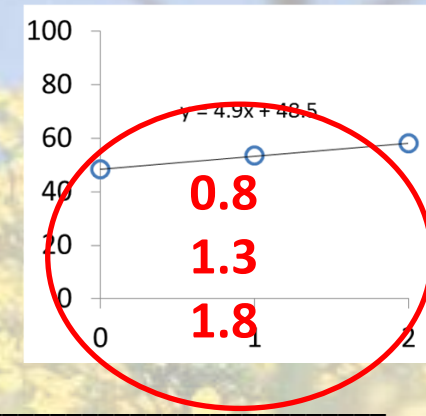
2015
Y8



2016
Y9



ALL
Years



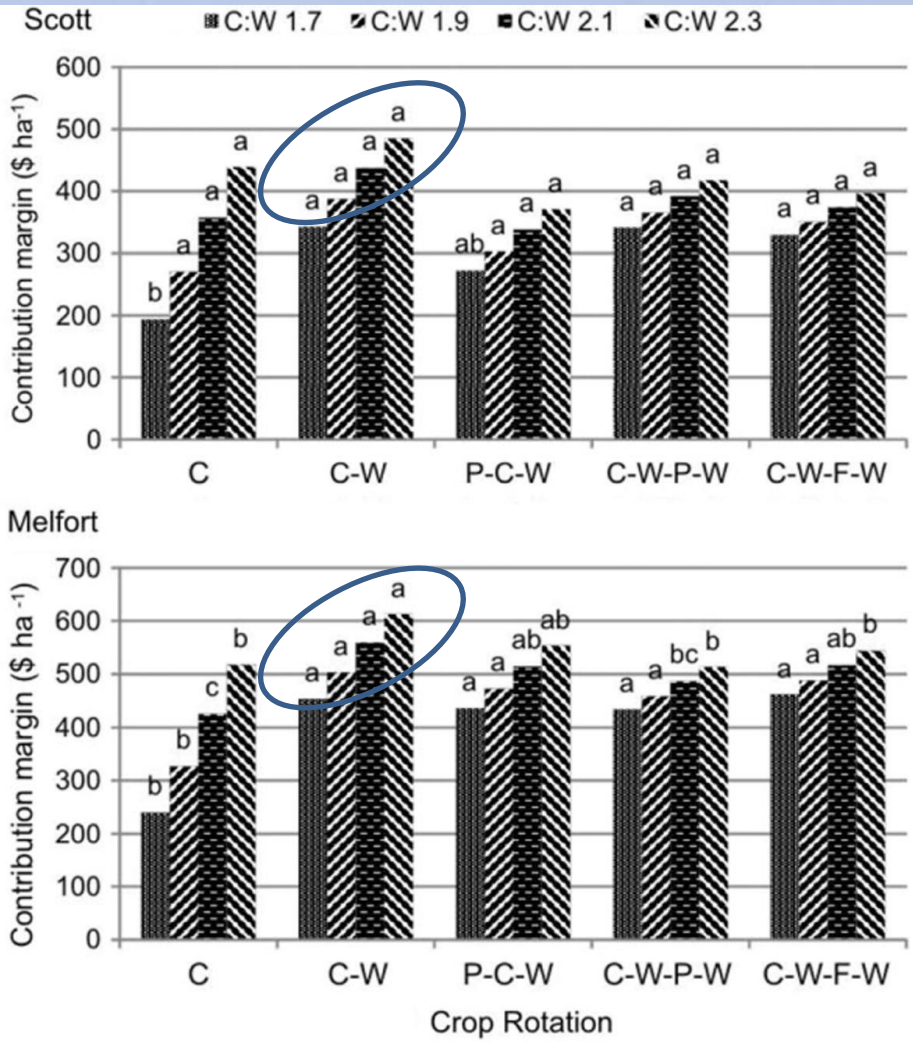
Years between canola crops

Economics for hybrid canola rotations
(Smith et al., Can. J. Plant Sci. 2013)

Current ratio 2:1

Revenue – **variable costs**

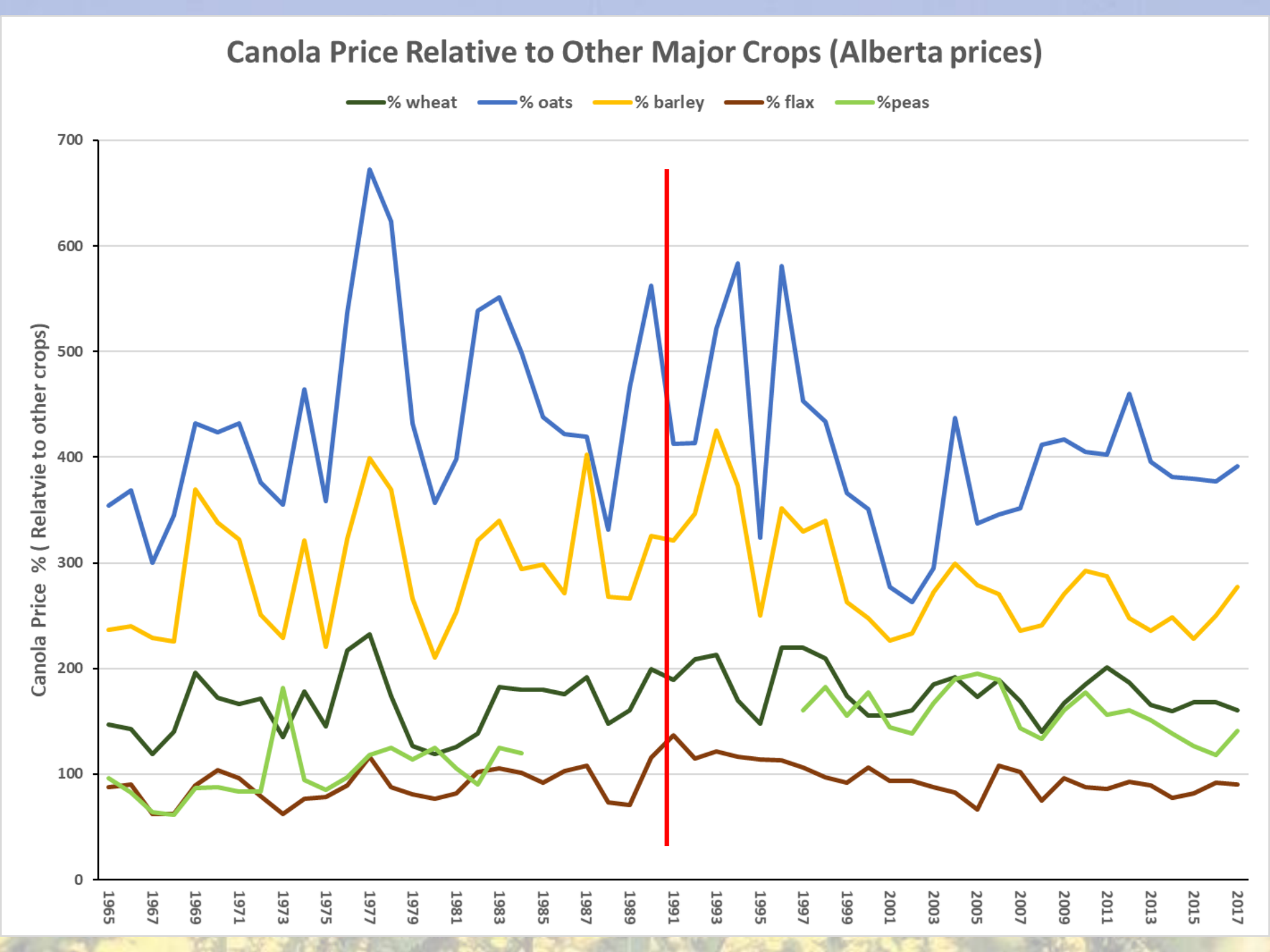
Canola 150 seeds/m^2 6.7 to 8.2 kg/ha @$25/kg



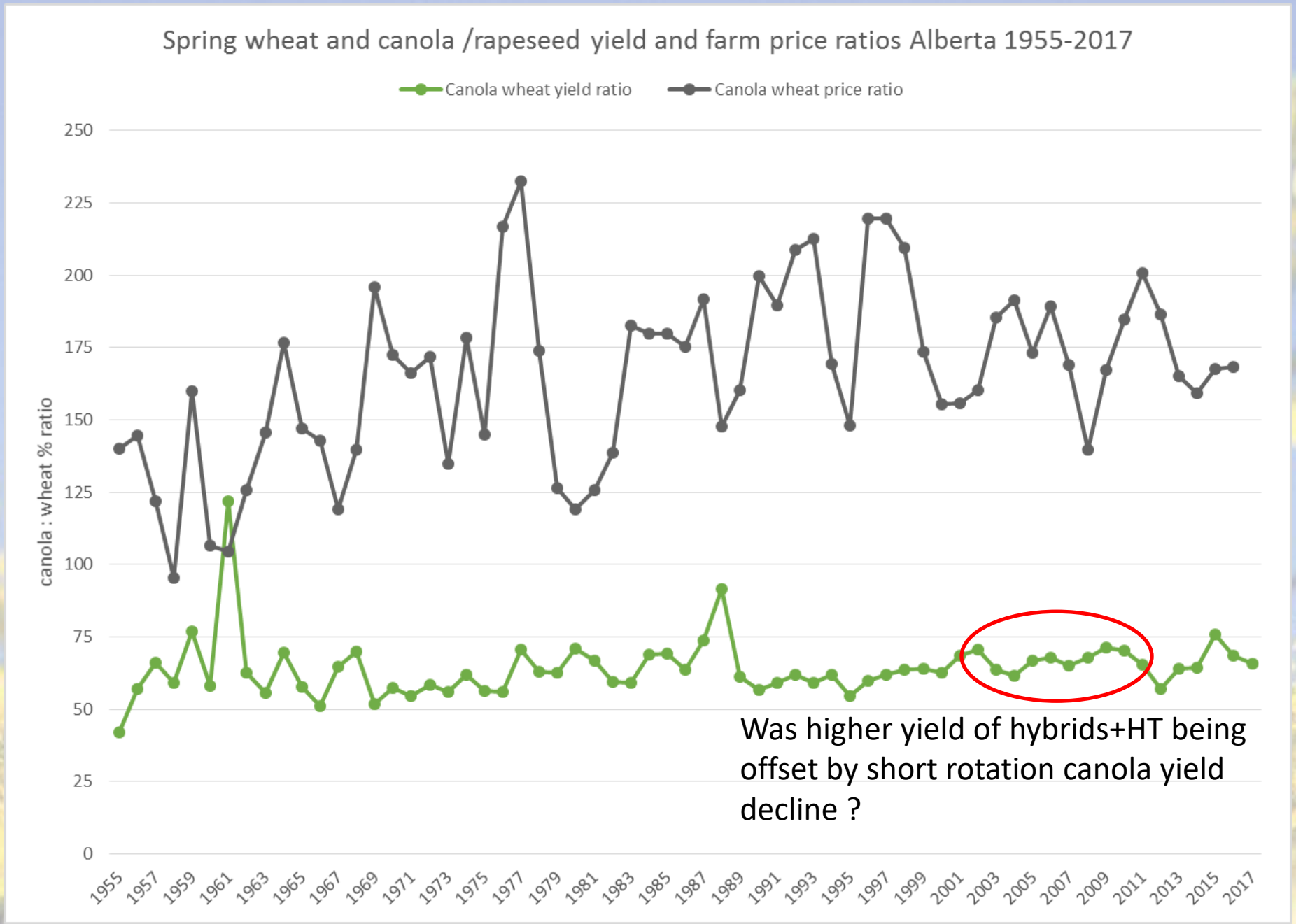
Based on hybrid yields of last 4 year rotation only

Doesn't consider relative prices to peas or flax

Fig. 1. Contribution margin for five hybrid canola rotations without fungicide control, and for four ratios of canola to wheat prices (C:W) at Scott and Melfort, Saskatchewan, Canada. Letters above the bars indicate significant differences among the five crop rotations by each of the four wheat:canola price ratios.


Canola Price Relative to Other Major Crops (Alberta prices)
% wheat
% oats
% barley
% flax
%peas
Canola Price % (Relatvie to other crops)
700
600
500
400
300
200
100
0
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017

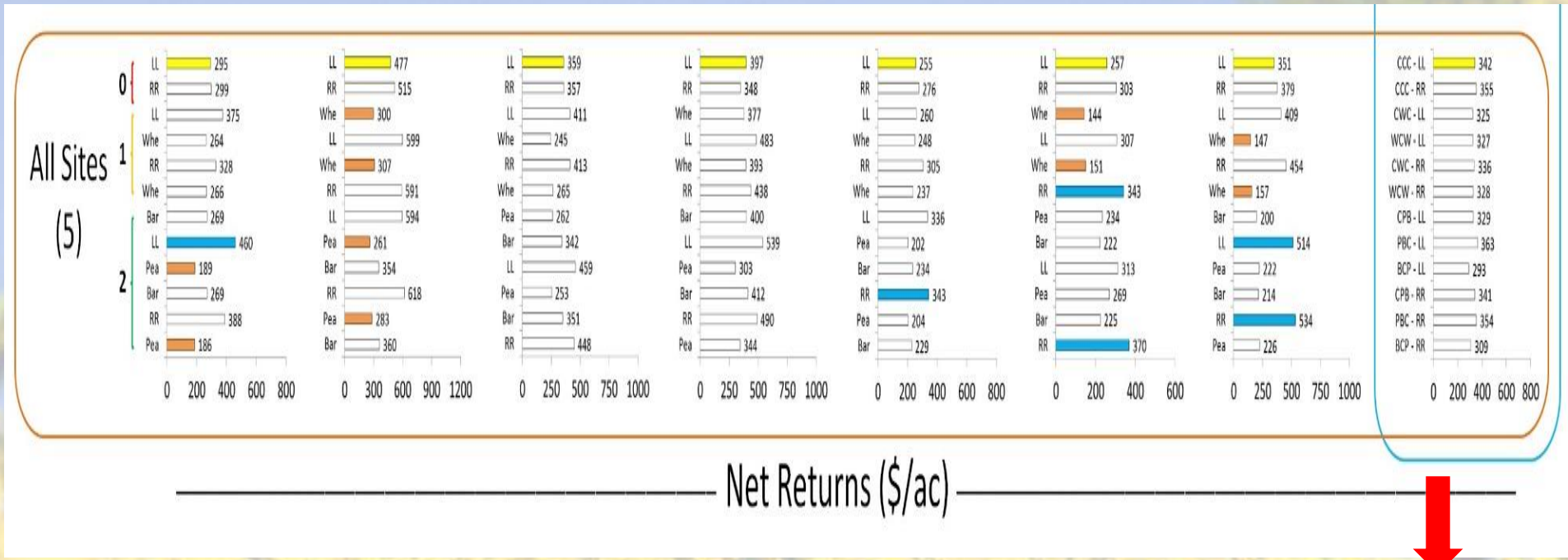
Making sense of trends



Economics- net returns

Using actual yields and average crop price each year

Costs using provincial estimates per crop and soil zone



Different views of farmers and scientists

Confirmation bias

Different Subjective Views on Each Side of the Fence

Very difficult to quantify economic value for farm decision making

Short rotations with few crops are simpler to manage

Short rotations increase risk of pesticide resistance or erosion of genetic resistance

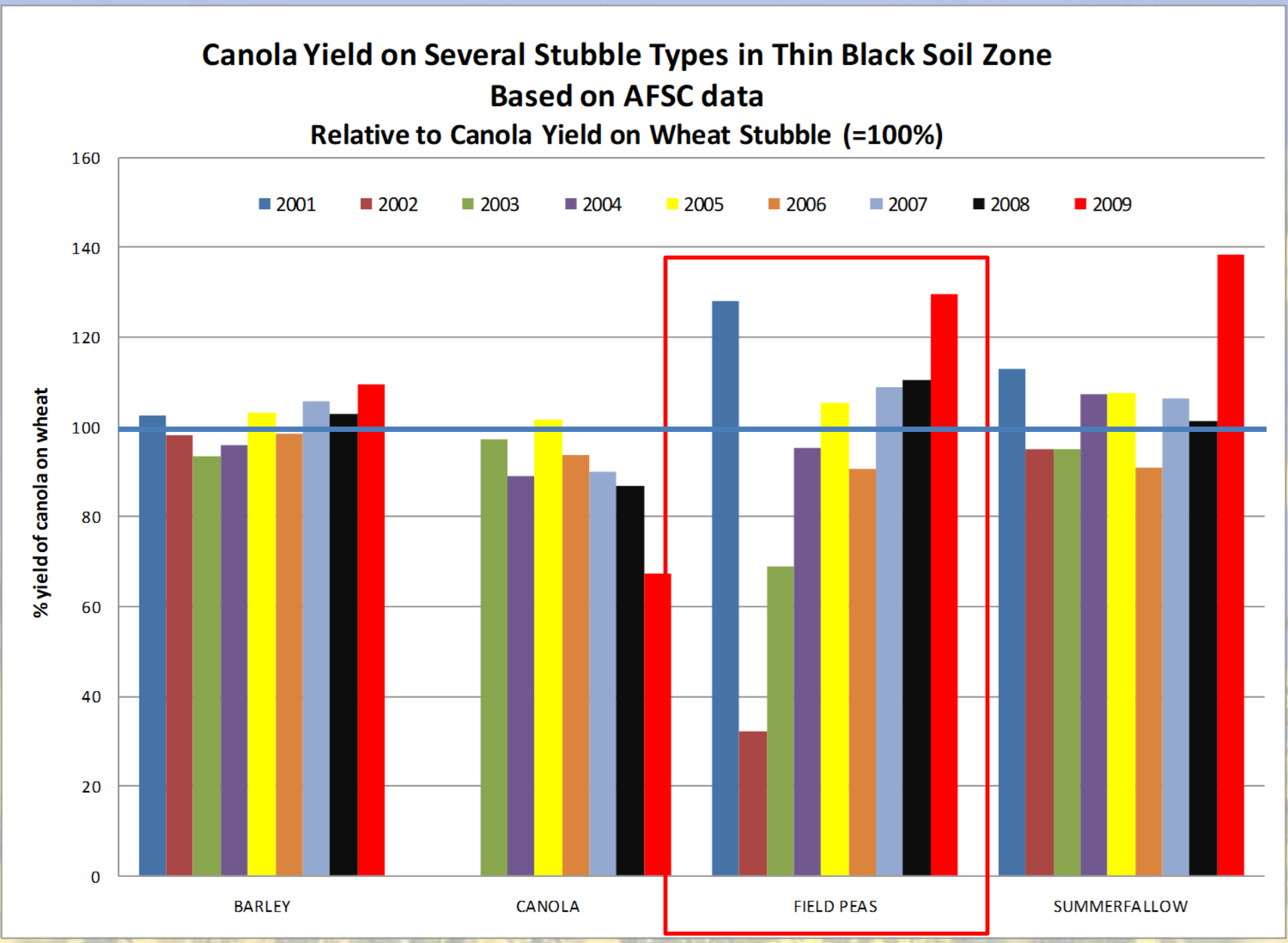
Khakbazan et al. Agron J. 2014 (O'Donovan et al. 2014)

Table 7. The effect of preceding crops established in 2009 on net revenue gain or loss of canola (C), barley (B), canola–barley (C–B) and preceding crop–canola–barley (P–C–B) compared to preceding crop wheat at seven locations in the western Canada from 2009 to 2011. P values for differences from wheat are in parentheses.

	Gain or loss of net revenue compared to preceding crop wheat†					
	Preceding crops					
Location	Wheat	Canola	Faba bean	Faba bean GRM	Lentil	Pea
	C (2010, $ ha^{-1})					
Brandon	371	−127 (0.004)	27 (ns)	156 (<0.001)	59 (ns)	83 (0.032)
Beaverlodge	223	−78 (0.037)	6 (ns)	262 (<0.001)	70 (0.061)	63 (0.091)
Indian Head	−41	−17 (ns)	5 (ns)	301 (<0.001)	228 (<0.001)	77 (0.059)
Lacombe	940	−286 (<0.001)	48 (ns)	311(<0.001)	–	–
Lethbridge	486	−256 (<0.001)	−98 (0.072)	262 (<0.001)	20 (ns)	68 (ns)
Scott	190	12 (ns)	47 ns	257 (<0.001)	80 (0.064)	68 (ns)
Swift Current	269	−10 (ns)	122 (<0.001)	114 (<0.001)	99 (0.002)	101 (0.002)
Average‡	348	−109 (−31%)	22 (6%)	238 (68%)	93 (27%)	77 (22%)
	P (2011, $ ha^{-1})					

Canola seed rates 150/m² and large seed led to an average seed rate of 10 kg/ha (9 lb/ac) and @$23.15/kg = $230/ha ($93/ac)

Typical seeding rate now ~ 5 kg/ha so the canola seed cost is unrealistic and well beyond economic threshold


Canola Yield on Several Stubble Types in Thin Black Soil Zone
Based on AFSC data
Relative to Canola Yield on Wheat Stubble (=100%)
% yield of canola on wheat
160
140
120
100
80
60
40
20
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
BARLEY
CANOLA
FIELD PEAS
SUMMERFALLOW

Khakbazan economics - yields

- seeding canola after pea resulted in 10% higher yield compared to after wheat
- canola after canola reduced yield by 8% compared to after wheat

Table 2: Relative Yield response (per cent of 2008-2012 average) of Manitoba crops sown on previous crops (stubble >120 acre)

	Crop Planted									
Previous Crop	**Winter Wheat**	**Spring Wheat**	**Barley**	**Oat**	**Canola**	**Flax**	**Field Pea**	**Soybean**	**Sunflower**	**Grain Corn**
Winter Wheat	78	74	106	100	97	107	107	101	97	87
Spring Wheat	86	85	98	101	104	104	103	103	101	100
Barley	83	89	84	93	100	96	101	100	97	99
Oat	76	90	86	82	92	95	97	99	100	93
Canola	104	102	103	104	85	88	92	101	95	95
Flax	102	98	110	97	104	73	101	96	98	NSD
Field Pea	NSD	100	104	98	104	124	NSD	NSD	NSD	NSD
Soybean	NSD	106	106	105	98	100	NSD	95	92	103
Sunflower	NSD	99	102	96	NSD	NSD	NSD	99	88	99
Grain Corn	NSD	NSD	101	106	104	NSD	NSD	107	112	87
Yield (bu/ac)	*65*	*47*	*62*	*95*	*34*	*20*		*32*	*1521lb*	*95*

Anastasia Kubinec, 2014 Yield Manitoba

Can We Recover Some of Short Rotation Yield Loss with Management

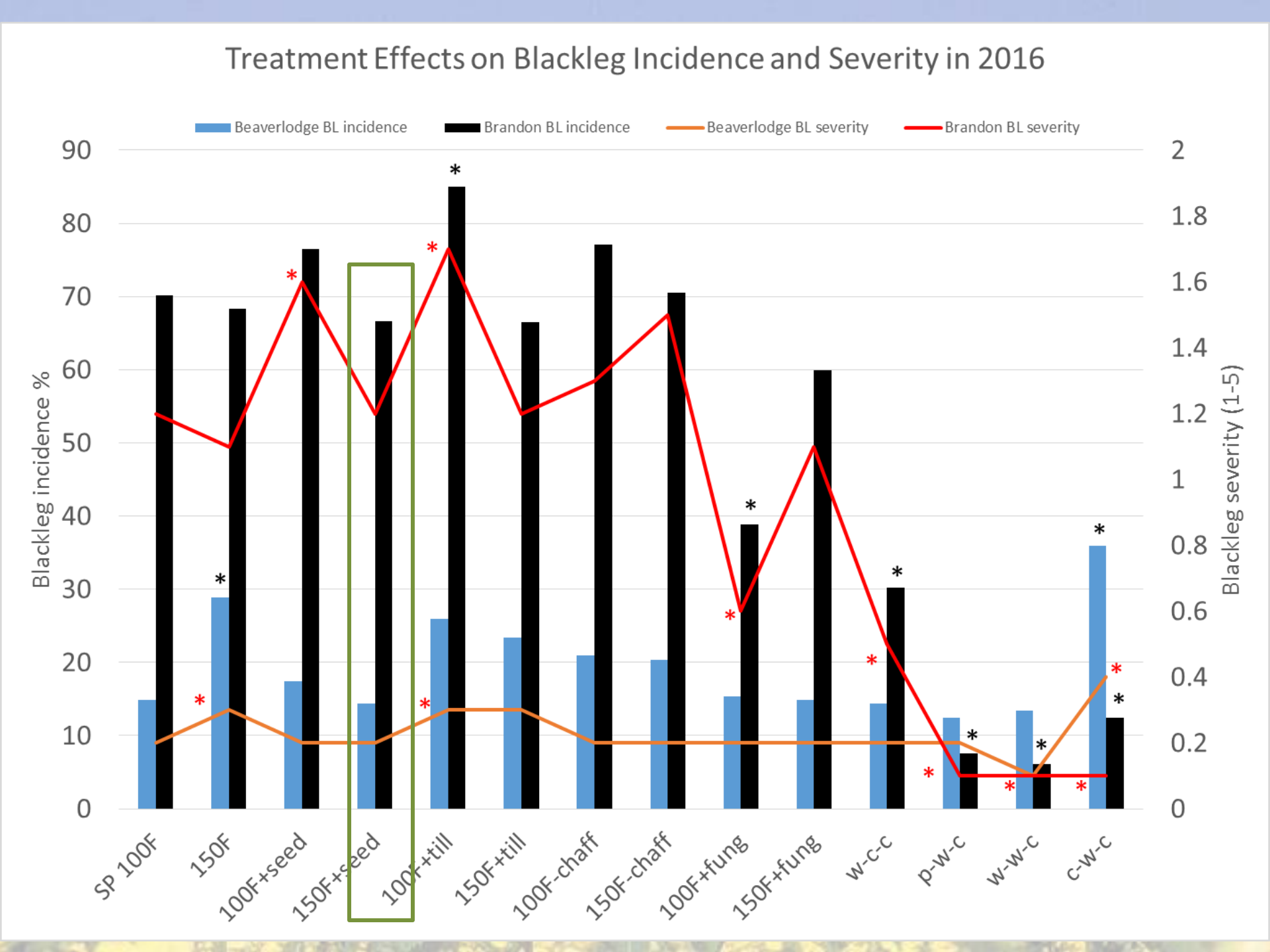
Harker et al. CJPS 2018

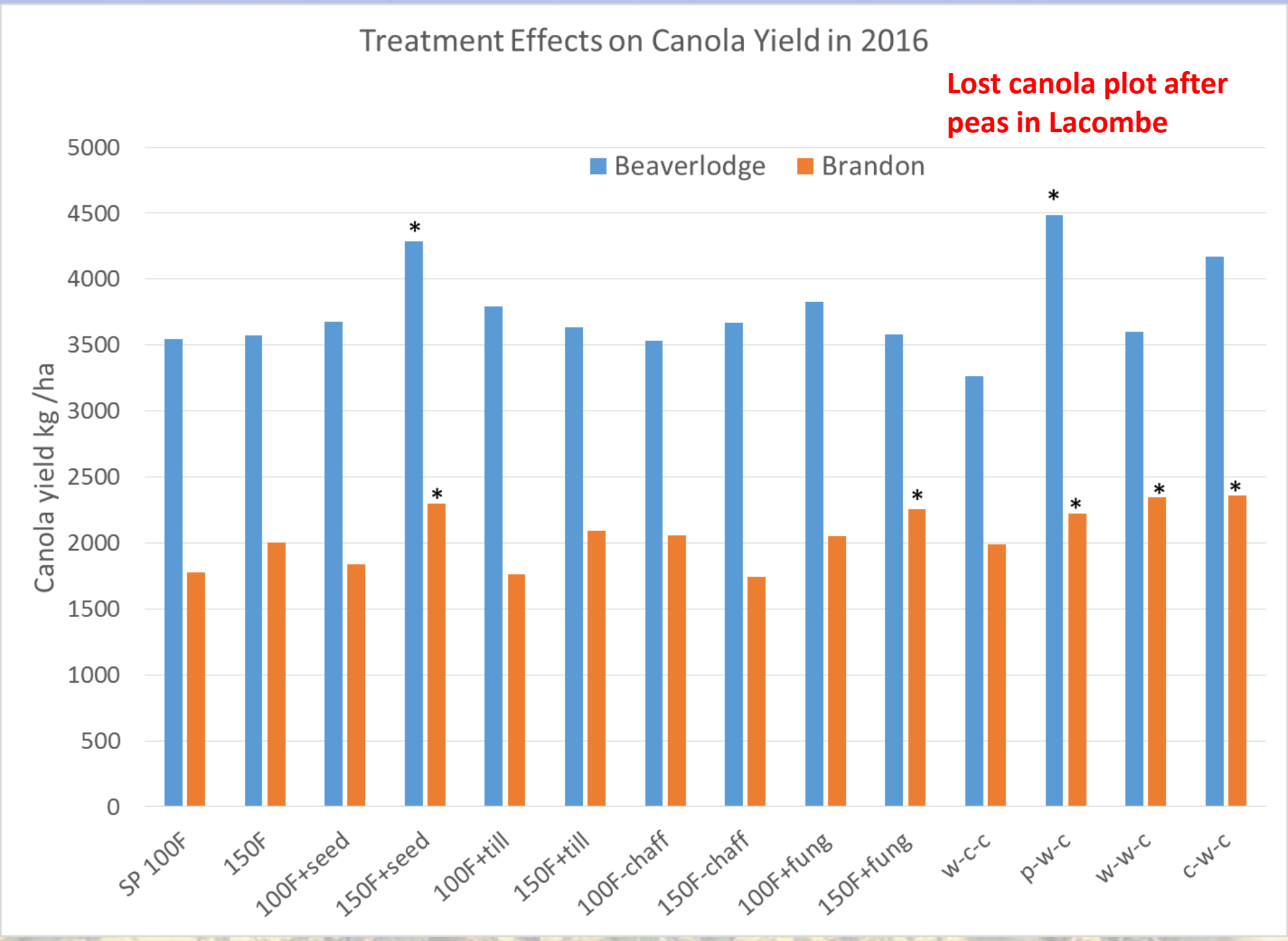
Treatment Description*

1. 100% NPKS
2. 150% NPKS (extra N as ESN in all higher fertility treatments)
3. 100% NPKS + Higher seeding rate (150 seeds/m^2)
4. 150% NPKS + Higher seeding rate (150 seeds/m^2)
5. 100% NPKS + Tillage (spike in the fall and cultivate & harrow in spring for seedbed preparation)
6. 150% NPKS + Tillage (spike in the fall and cultivate & harrow in spring for seedbed preparation)
7. 100% NPKS + Chaff removal (2014 before seeding, 2014 to 2016 at harvest) (autoallelopathy)
8. 150% NPKS + Chaff removal (2014 before seeding, 2014 to 2016 at harvest) (autoallelopathy)
9. 100% NPKS + Headline at 4 leaf stage (0.16 L/ac) – AgCellence & Blackleg suppression
10. 150% NPKS + Headline at 4 leaf stage (0.16 L/ac) – AgCellence & Blackleg suppression
11. Same as 1st 2 cycles (W-C-C rotation with no enhanced inputs)
12. Same as 1st 2 cycles (P-W-C rotation with no enhanced inputs)
13. Same as 1st 2 cycles (W-W-C rotation with no enhanced inputs)
14. New rotation (C-W-C with no enhanced inputs)

*Herbicides, fungicides and insecticides would be applied to all treatments as needed

150% NPKS - If soil test indicates 0 P, K, or S for the 100% NPKS trts,
add 15 lbs/ac of P_2O_5, 15 K_2O, and/or 10 S for 150% trt


Treatment Effects on Blackleg Incidence and Severity in 2016
Beaverlodge BL incidence
Brandon BL incidence
Beaverlodge BL severity
Brandon BL severity
Blackleg incidence %
Blackleg severity (1-5)
0
10
20
30
40
50
60
70
80
90
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
SP 100F
150F
100F+seed
150F+seed
100F+till
150F+till
100F-chaff
150F-chaff
100F+fung
150F+fung
w-c-c
p-w-c
w-w-c
c-w-c


Treatment Effects on Canola Yield in 2016
Lost canola plot after peas in Lacombe
Beaverlodge
Brandon
Canola yield kg /ha
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
SP 100F
150F
100F+seed
150F+seed
100F+till
150F+till
100F-chaff
150F-chaff
100F+fung
150F+fung
w-c-c
p-w-c
w-w-c
c-w-c

Are More Answers Waiting Belowground?

- Lay et al. (2018) Canola Root–Associated Microbiomes in the Canadian Prairies. Front. Microbiol. 9:1188
- In 2014, sampled 5 plots from Harker et al. 2018
  - canola 100% seed (100/m^2) and recommended fertilizer rates (Can_RE)
  - canola fertilized at 150% (Can_HF)
  - canola seeded at 150% of the recommended rate (Can_HD)
  - wheat after canola
  - pea following canola
- Root and rhizosphere soil samples were collected the last week of July and root / rhizosphere microbiomes were analyzed

Net Effect of Enemies vs Allies

- plant-growth-promoting rhizobacteria were present in canola's core microbiome and correlated with canola yield
  - Amycolatopsis sp., Serratia proteamaculans, Pedobacter sp., Arthrobacter sp., Stenotrophomonas sp., Fusarium merismoides, and Fusicolla sp.
- The fungal parasite *Olpidium brassicae* was dominant in the continuous canola and the only fungal species in canola core root microbiome
  - Unlike UK studies (Hilton et al. 2013) it was not negatively correlated with yield
  - **Its relative abundance in canola roots was greatly reduced in plots with higher seeding rate while Stenotrophomonas sp. increased**

Summary

- Good data is needed for rotation decisions including yields, economics, pest impacts
  - Subjective reasons and risk perspectives for / against short rotation are hard to quantify in economic value

- small plot rotation research has limitations
  - Pest differences between rotations may be underestimated
  - Economic analyses are problematic
  - Omitting plot failures from analysis underestimates risks
  - Rotation yield benefits can't be accurately attributed to pest differences between treatments due to many unmeasured rotation factors

- Short rotation canola more profitable when canola prices much better than cereals and pulses
  - BUT there seems to be something more than economics that appeals to growers
- We still don’t fully understand the rotation yield benefit but new scientific methods may fill in the knowledge gaps