Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Canada

Achieving Sustainable Wheat Production Through Agronomy

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Points to Ponder

- **Agronomy Critical for Achieving Sustainable Wheat Production**
  - **Conservation Ag: → A transformative innovation**
    - A platform for sustainable wheat production and crop diversity
  - **Exploiting Yield**
    - Yield Gap
    - Diversity
    - Break Crops
  - **Case Studies of G x E x M Integration**
    - FHB
  - **Looking Ahead**
    - **Wheat Initiative**

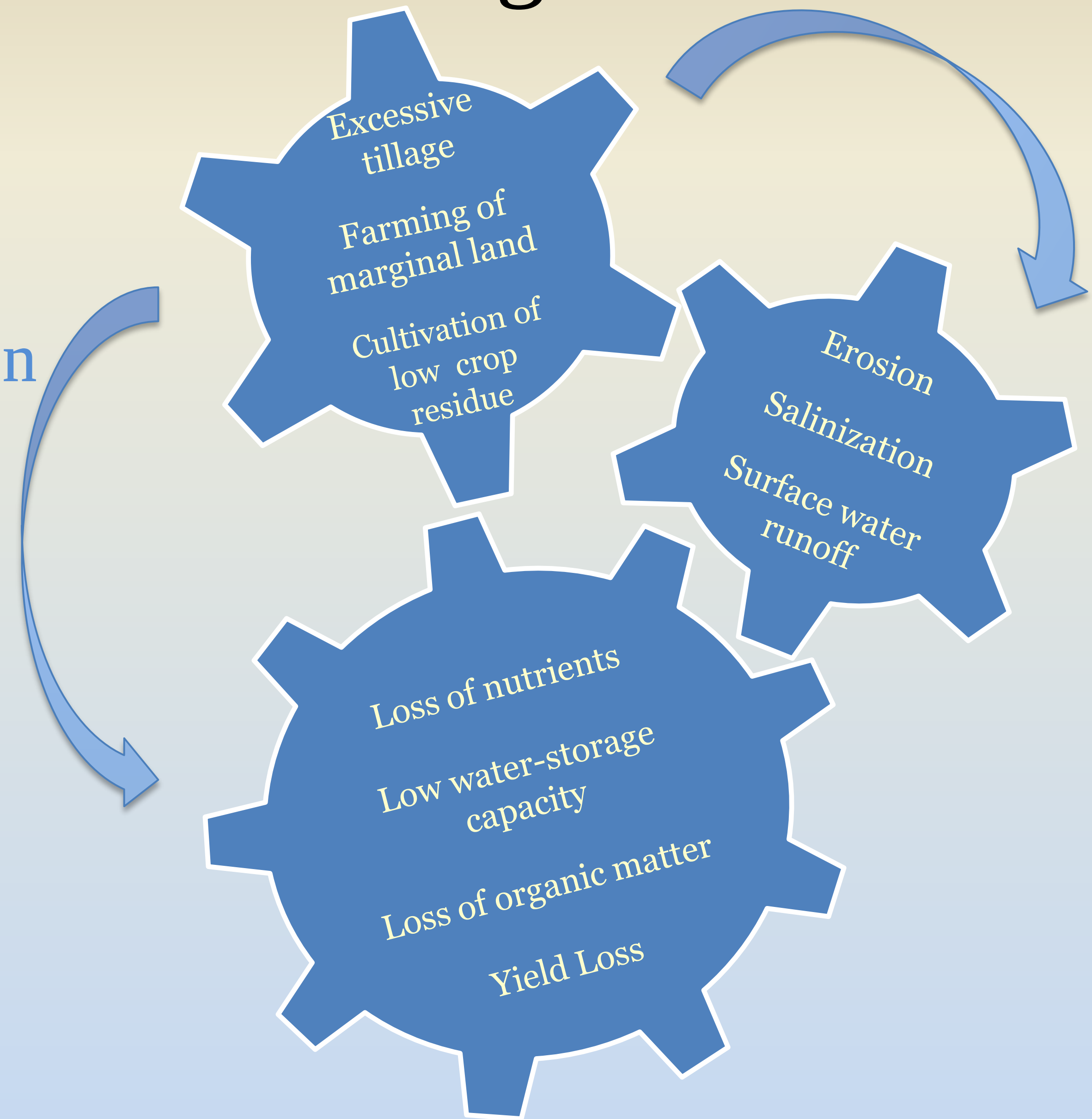
Agronomists' Impacts on Conservation Agriculture

Changing Canadian Prairies' Landscape:
The Evolution of No-Till

Agronomists' Impacts on Conservation Agriculture

Issue

Soils Degradation in the Prairies



Agronomists' Impacts on Conservation Agriculture

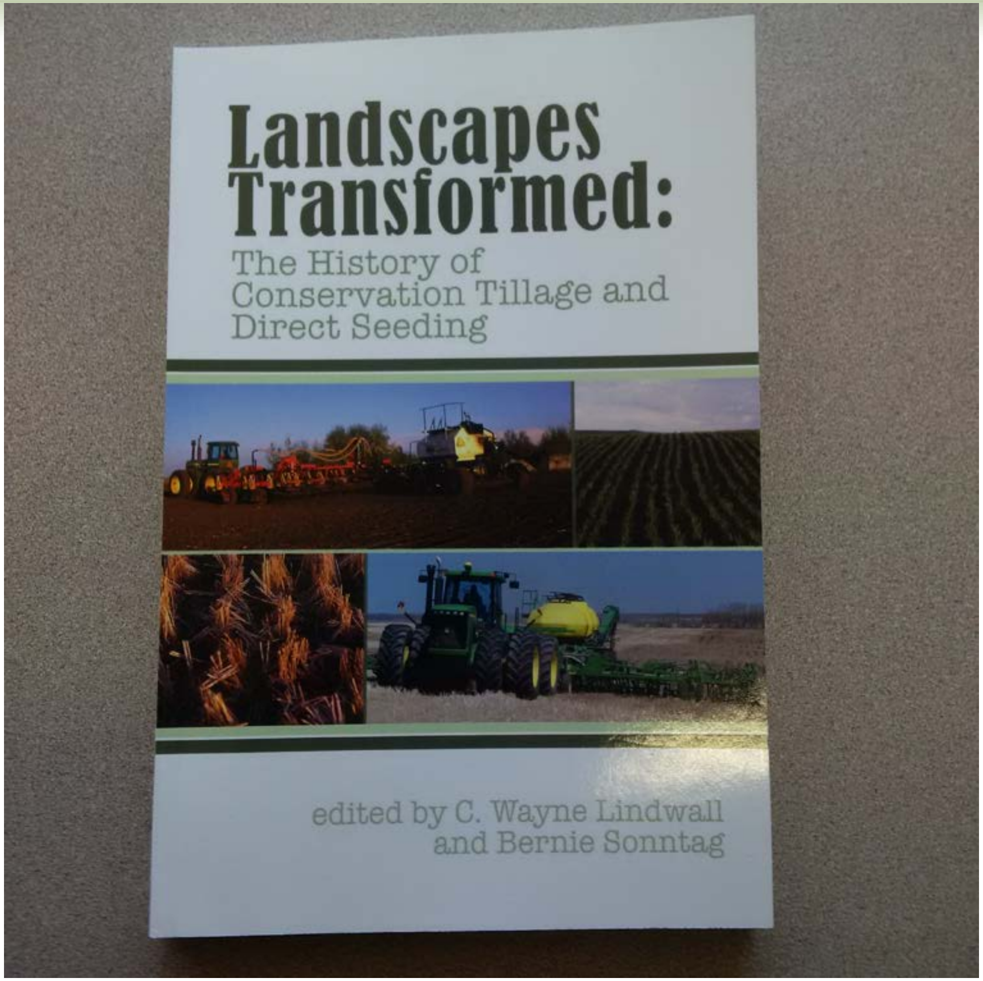
Solution

New Agricultural Practices

- New Cropping Systems
- No-Till
- Integrated Pest Manageme nt
- Adapted Cultivars/ Hybrids
- New Crop Rotations

Impacts on Canadian Agriculture

- Market diversification
- Infrastructure development



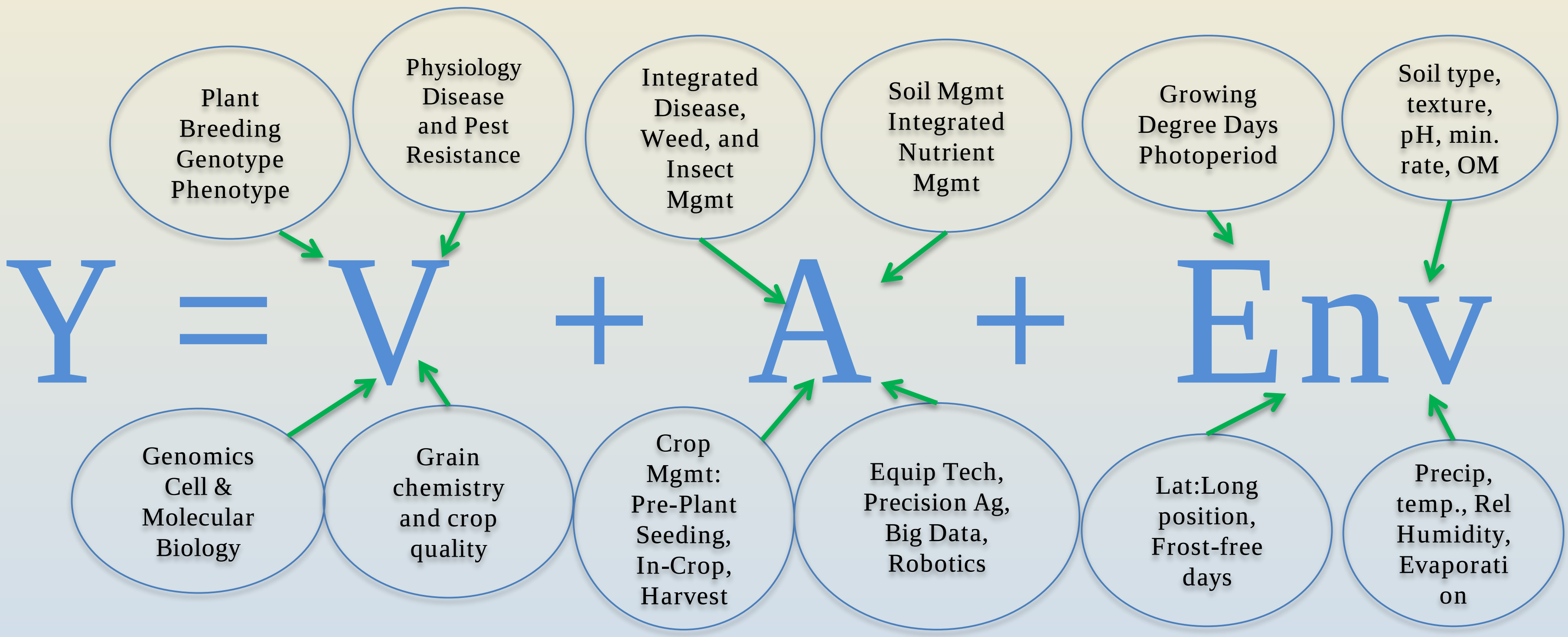
- Agronomists
- Engineers
- Farmers
- Extension Specialists
- Weed Scientists
- Economists

- *identified and resolved the key issues that prevented widespread adoption of conservation agriculture. Stu Brandt*

Exploiting Yield

- Contributions to Yield and the Yield Gap

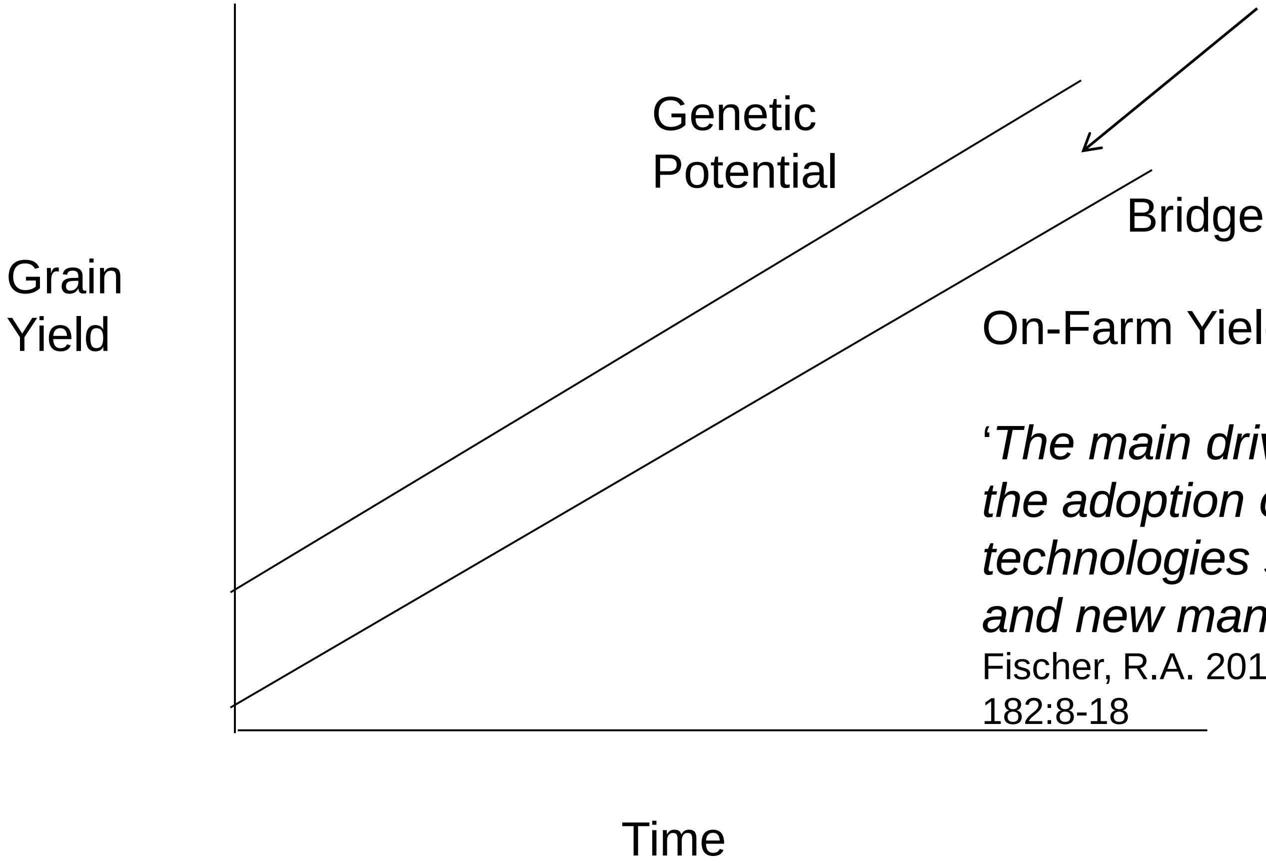
Contributions to
Yield = Variety + Agronomy + Environment



Beres et al. 2017. Integrated Crop Management of Wheat Chapter 28. In Langridge, P, . (ed). Achieving Sustainable Wheat Production. Burleigh Dodds, Oxfordshire, UK. In Press

The Yield Gap

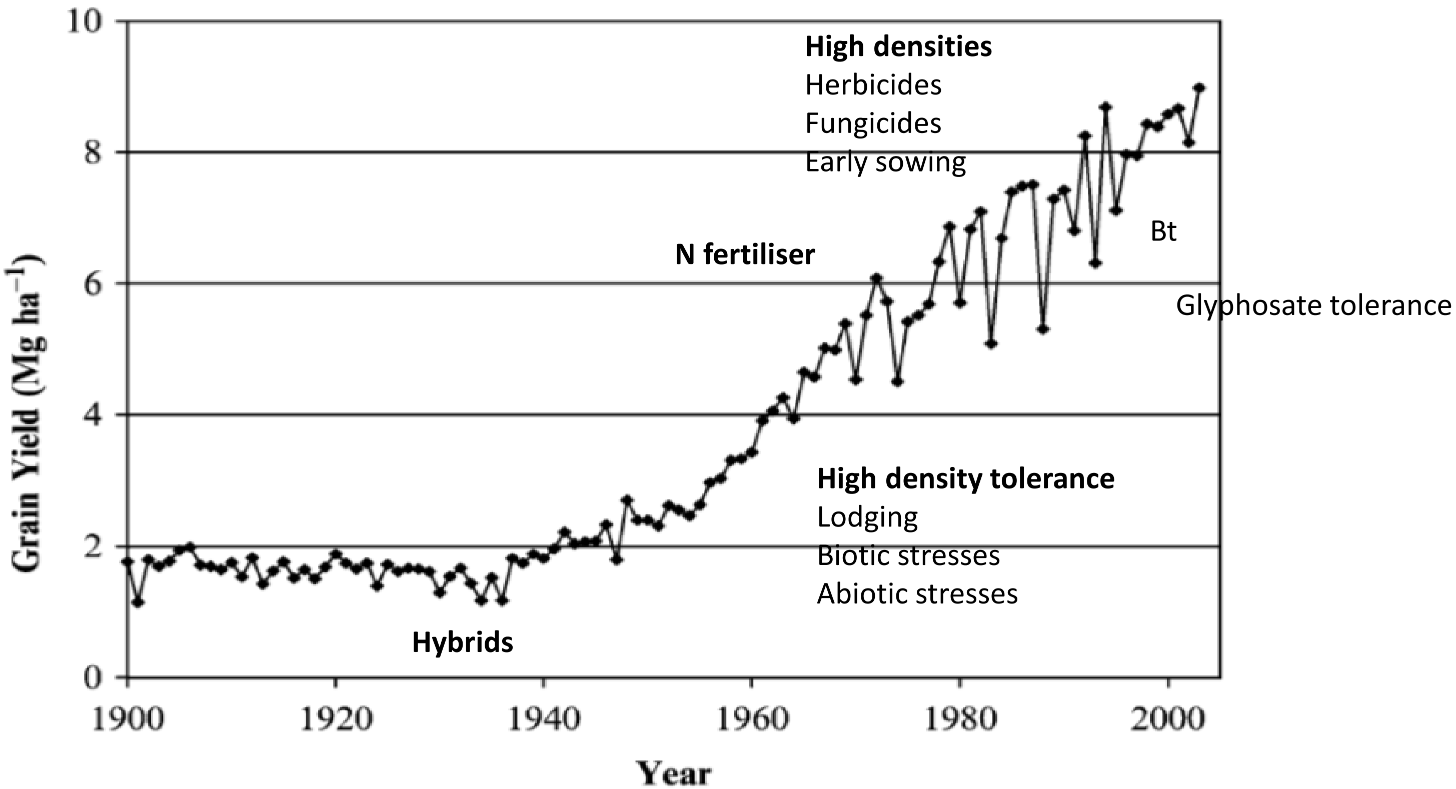
How Big is the Exploitable and Attainable Yield Gap?



'*The main drivers of FY progress is the adoption of steadily improving technologies such as new varieties, and new management methods.*'
Fischer, R.A. 2015. Field Crops Research. 182:8-18

The gap that exists between genetic potential and grain yield achieved at the farm gate. (Beres et al. 2017. Integrated Crop Management of Wheat Chapter 28. In Langridge, P, . (ed). Achieving Sustainable Wheat Production. Burleigh Dodds, Oxfordshire, UK.) In Press

US Maize – a modern agricultural revolution..



"On average, about 50% of the increase is due to management and 50% to breeding. The two tools interact so closely that neither of them could have produced such progress alone."

Duvick (2005) Genetic Progress In Yield of United States Maize (Zea mays L.). Maydica 50: 193-202

Slide courtesy of Dr. John Kirkegaard

Exploiting Yield

- Cropping diversity and break crops research

Break Crops

- Based on >900 comparisons of wheat growing after a break crop with wheat after wheat
- Crops studied: oats, field peas, mustard, faba bean, canola, flax, lentils, chickpeas, lupins
- Range of mean yield response = 0.5 $t\ ha^{-1}$ after oats to 1.2 $t\ ha^{-1}$ after grain legumes.
- oats < canola = mustard = flax < field peas = faba beans = chickpeas = lentils = lupins

- *J. F. AngusA, J. A. Kirkegaard, J. R. Hunt, M. H. Ryan, L. Ohlander,*
- *and M. B. Peoples Crop & Pasture Science, 2015, 66, 523–552*

Rotational Diversity Effects in a Cereal-Based Cropping System

Fully-phased rotational study with 13 crop phases x 4 replicates

Plot Size: 24’ x 50’ or 7.4m x 15.24m

Seeding Rates: Triticale: 400 seeds m^{-2}

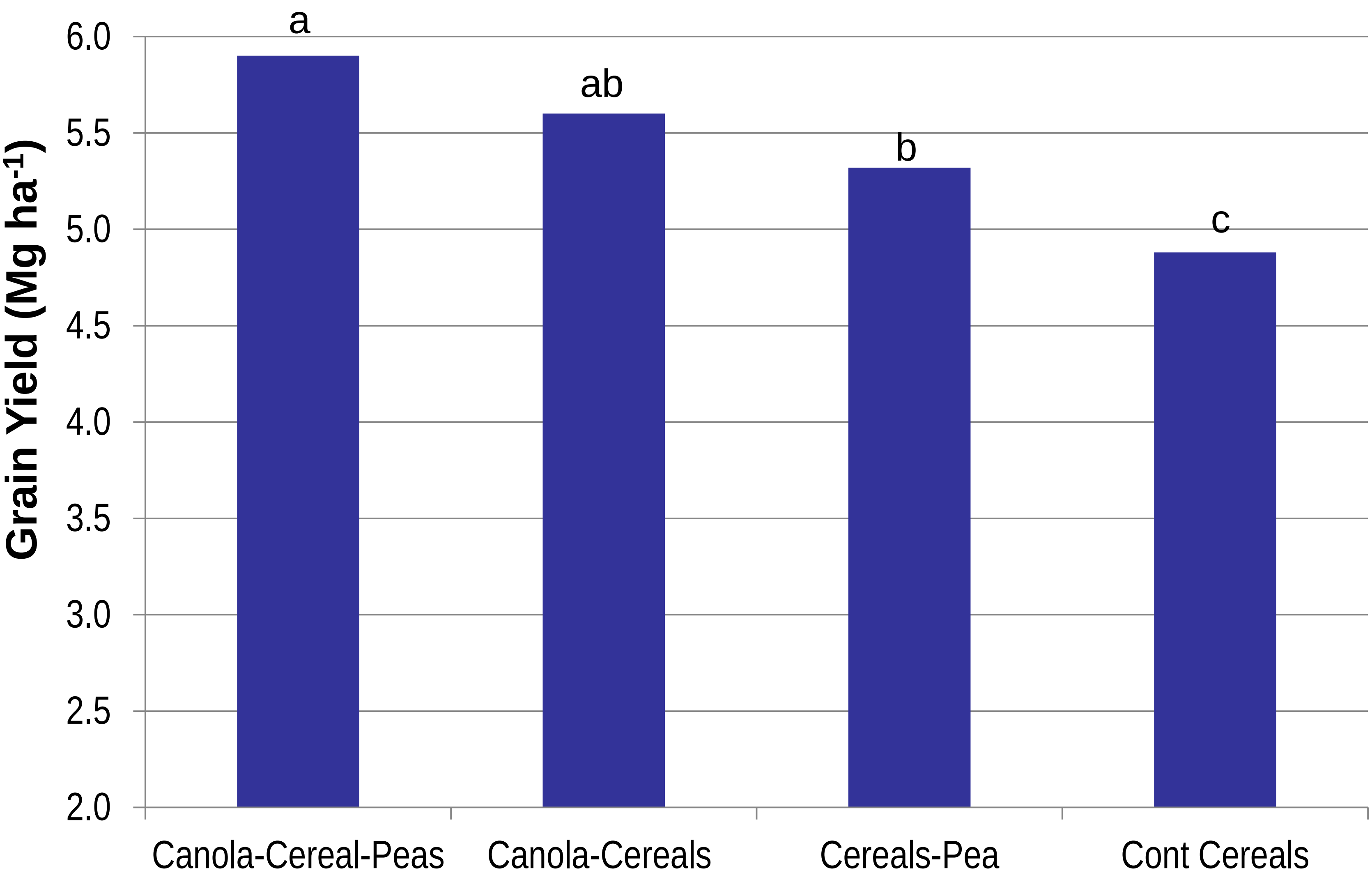
Wheat: 400 seeds m^{-2}

Peas: 100 seeds m^{-2}

Canola: 150 seeds m^{-2}

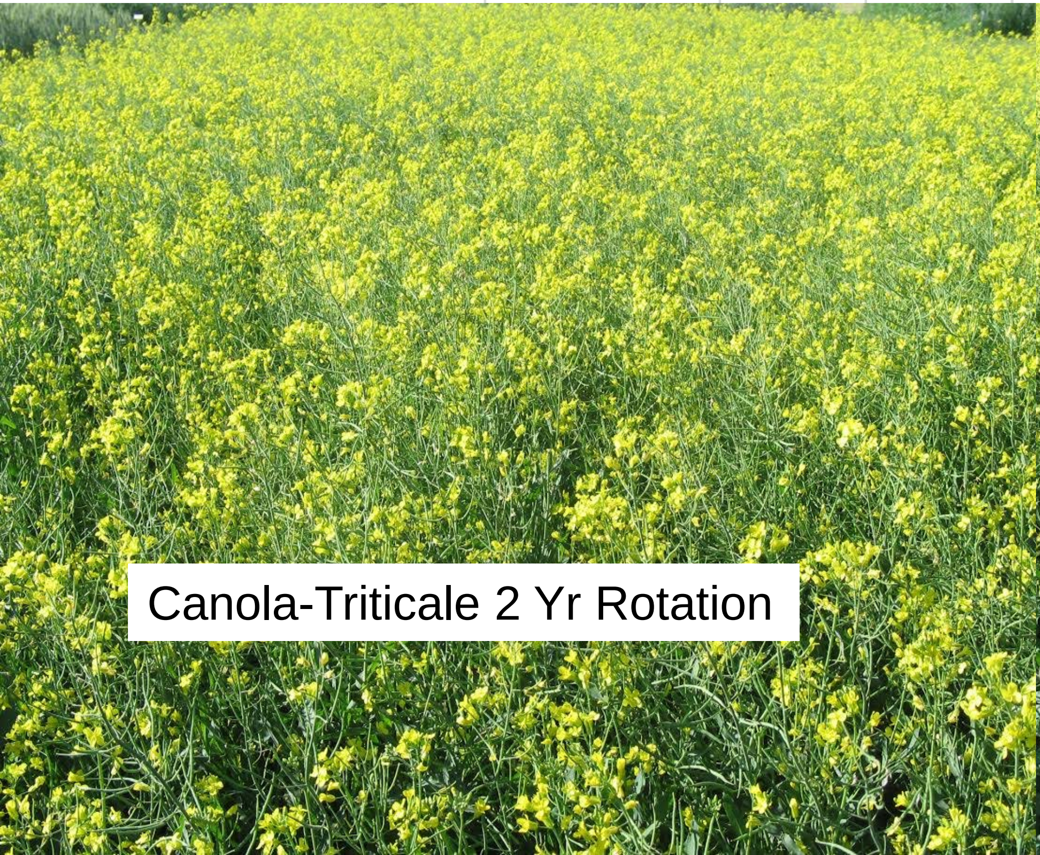
Intercrop: reduce both components to 60% of rate stated above.

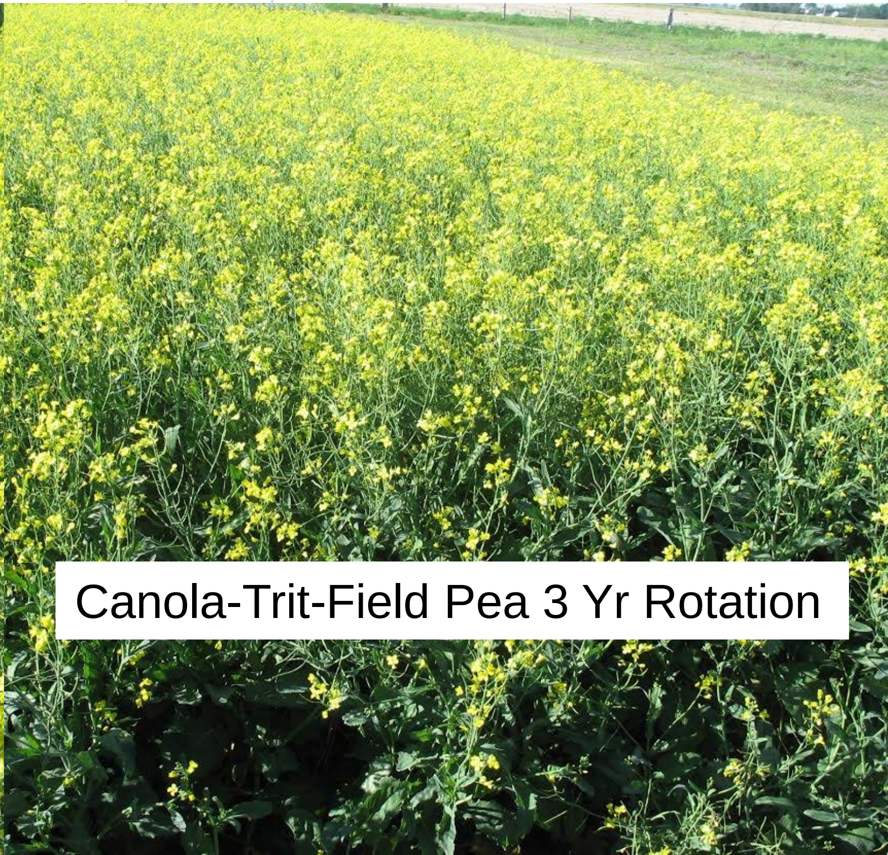
Rotational diversity effects on cereal grain yield. 2008 – 2014. 23 Pan-Prairie Site-Yrs



Does Canola Respond Similarly to Rotational Diversity?

Effect / Level	Plants	Protein	TWT	Yield
	(P value)			
Treatment	0.629	0.077	0.152	0.921
	(no. m-2)	(%)	(kg hL-1)	(Mg ha-1)
C*TP-HDR	87	14.4	63.9	1.68
TC*-MDR	85	13.8	64.1	1.67
LSD0.05	9	0.7	0.5	0.90
Site	1927	3.83	2.97	0.713





Rotational Effects on Soil Microbial Activity

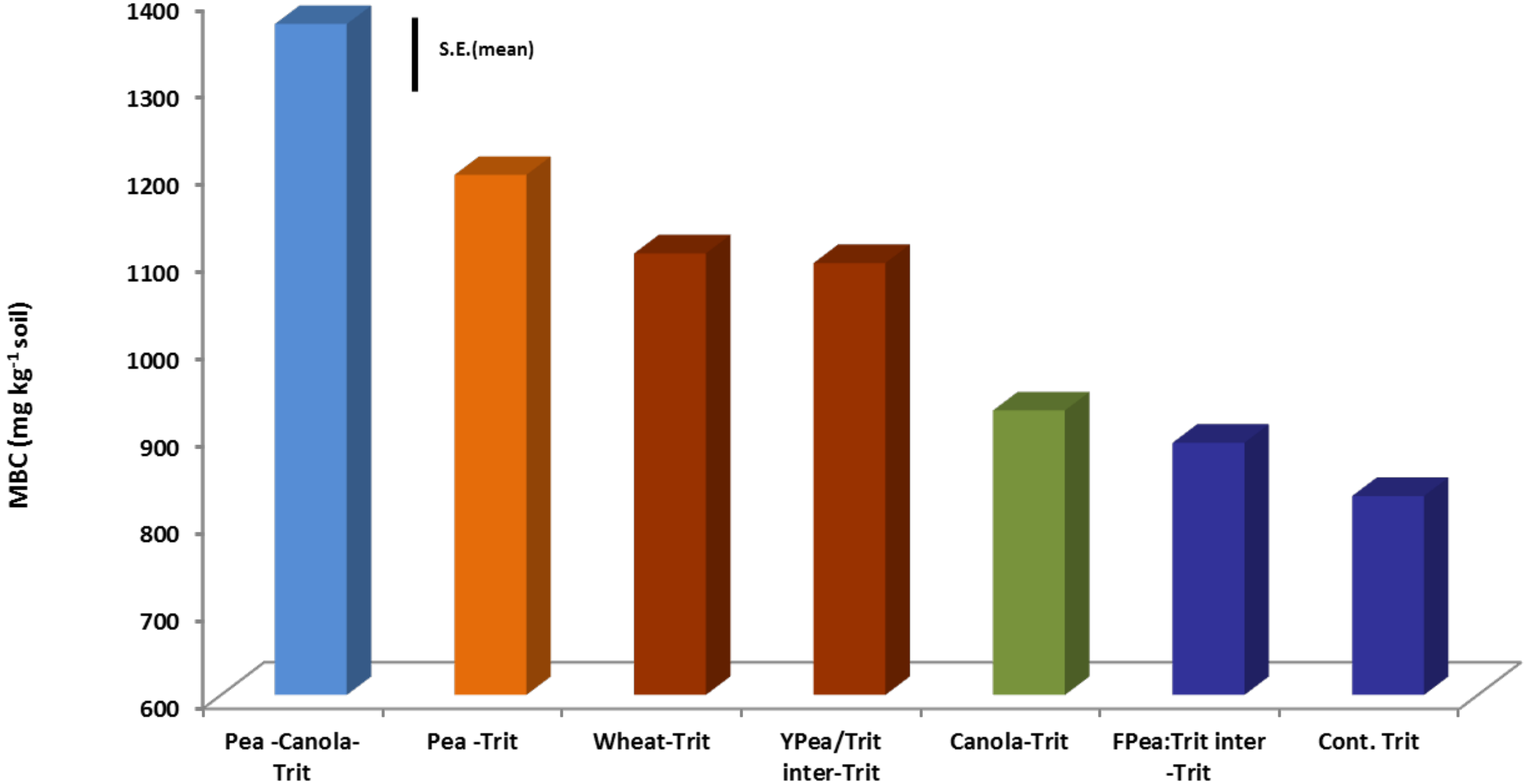


Fig. 1. Microbial Biomass C (MBC) in Triticale Rhizosphere. Swift Current, 2012.

Is Diversity A Profitable Cropping Systems Strategy?

Rotation	Can-Trit-Peas	Trit-Can	Trit-Peas	Trit-SWS	Cont. Trit
Production Environment	High Diversity	Medium Diversity	Medium Diversity	Low Diversity	Low Diversity
Low Production Environment	$-311 Net Returns ($/ha)	$-274	$-247	$-329	$-201
Low-Med Prod Environment	$31	$48	$1	$-123	$0
Med-High Prod Env.	$670	$629	$531	$458	$465
Average over all site means	$111	$92	$142	$23	$138

†Costs and revenue derived from 'Crop Planning Guide 2015', Ministry of Agriculture of Saskatchewan

GxExM Case Study - FHB

The role of genetics, growth habit and cultural practices in the mitigation of FHB

- 1. Factor 1 - Fungicide Treatments: (4)

  a) Check – untreated seed

  b) Seed Treatment: to control Fusarium, Cochliobolus and seed borne fungi (Septoria, smuts and bunts), eg. CruzerMax with Proseed

  c) Foliar Fungicide – In-crop foliar eg. Prosario

  d) Seed- and Foliar-applied treatments

- 2. Factor 2 - Genetics and Growth Habit (4):

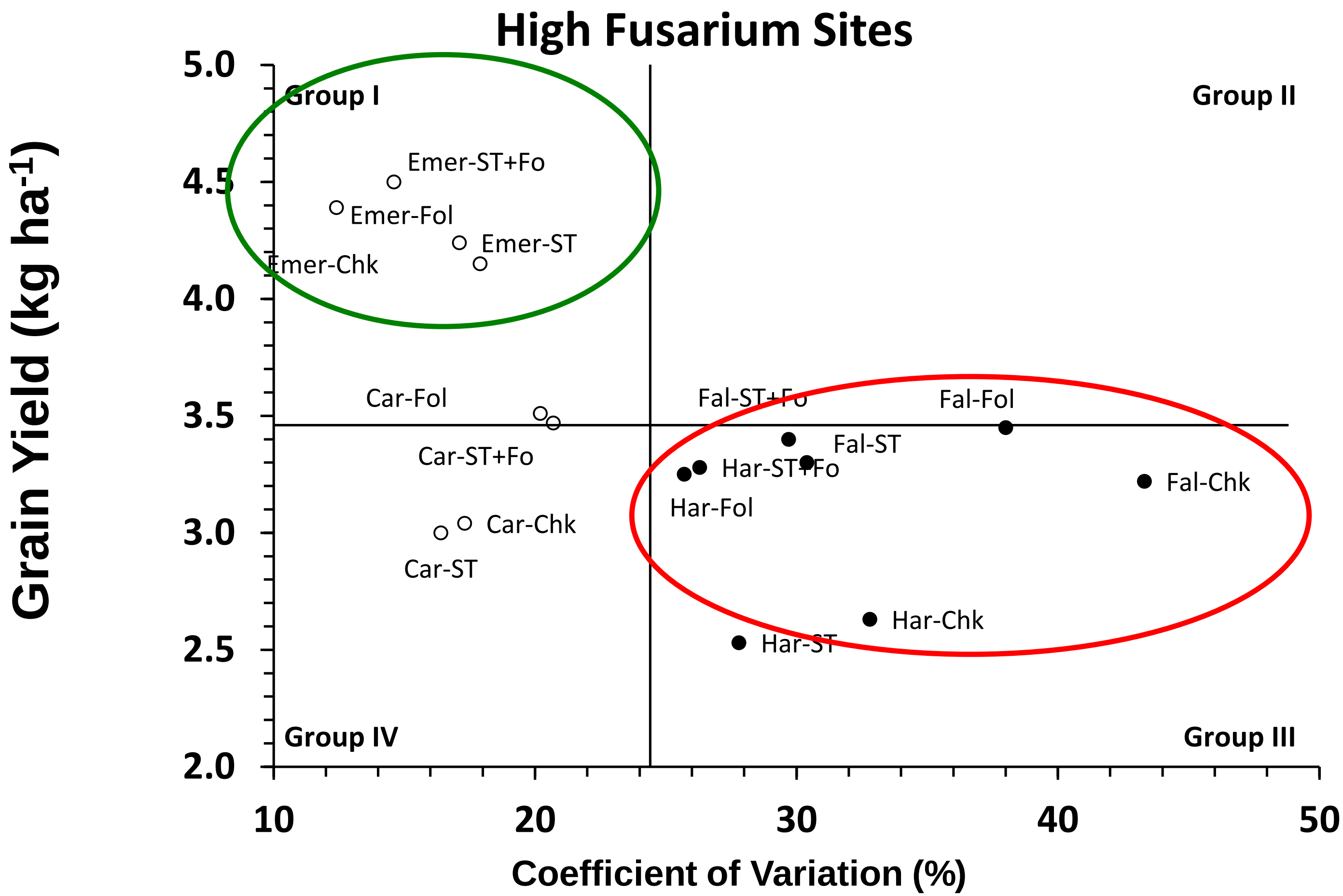
  a) W454 (Emerson) – Good *Fusarium* tolerance – CWRW

  b) CDC Falcon – Very poor tolerance to *Fusarium* - CWRW

  c) Carberry – Good *Fusarium* tolerance - CWRS

  d) Harvest - Very poor tolerance to *Fusarium* - CWRS

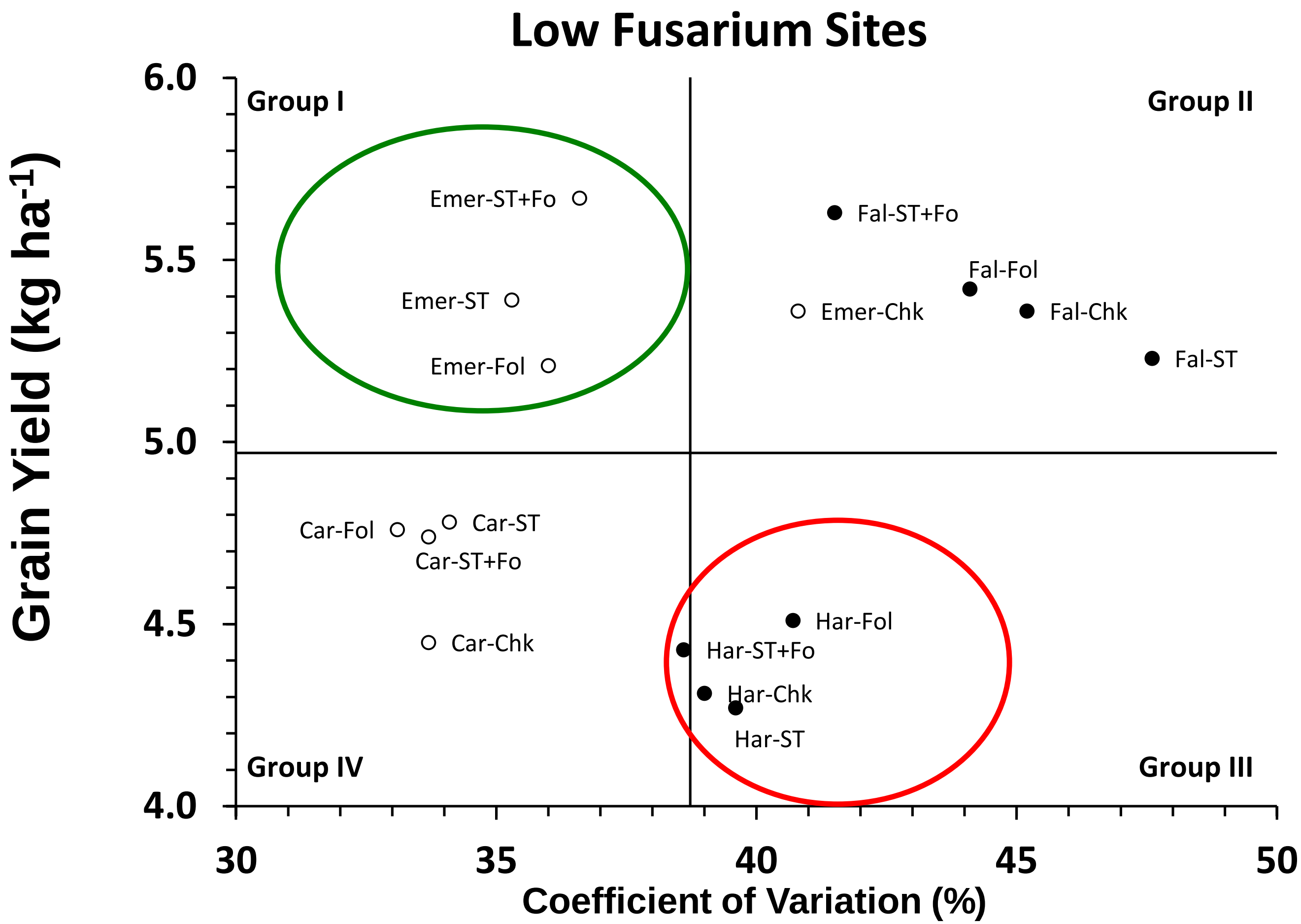
Ye, Z., Brûlé-Babel, A. L., Graf, R. J., Mohr, R., and Beres, B. L. 2016. The role of genetics, growth habit, and cultural practices in the mitigation of Fusarium head blight CJPS *In Press*



Group I: High mean, low variability (optimal)
Group II: High mean, high variability
Group III: Low mean, high variability (poor)
Group IV: Low mean, low variability

Emer=Emerson; Fal=CDC Falcon; Car=Carberry; Har=Harvest
Sd=Cruiser Maxx Seed Trt; Fol=In-crop Foliar Prosaro; Sd+Fo=Both

Ye, Z., Brûlé-Babel, A. L., Graf, R. J., Mohr, R., and Beres, B. L. 2016. The role of genetics, growth habit, and cultural practices in the mitigation of Fusarium head blight CJPS *In Press*



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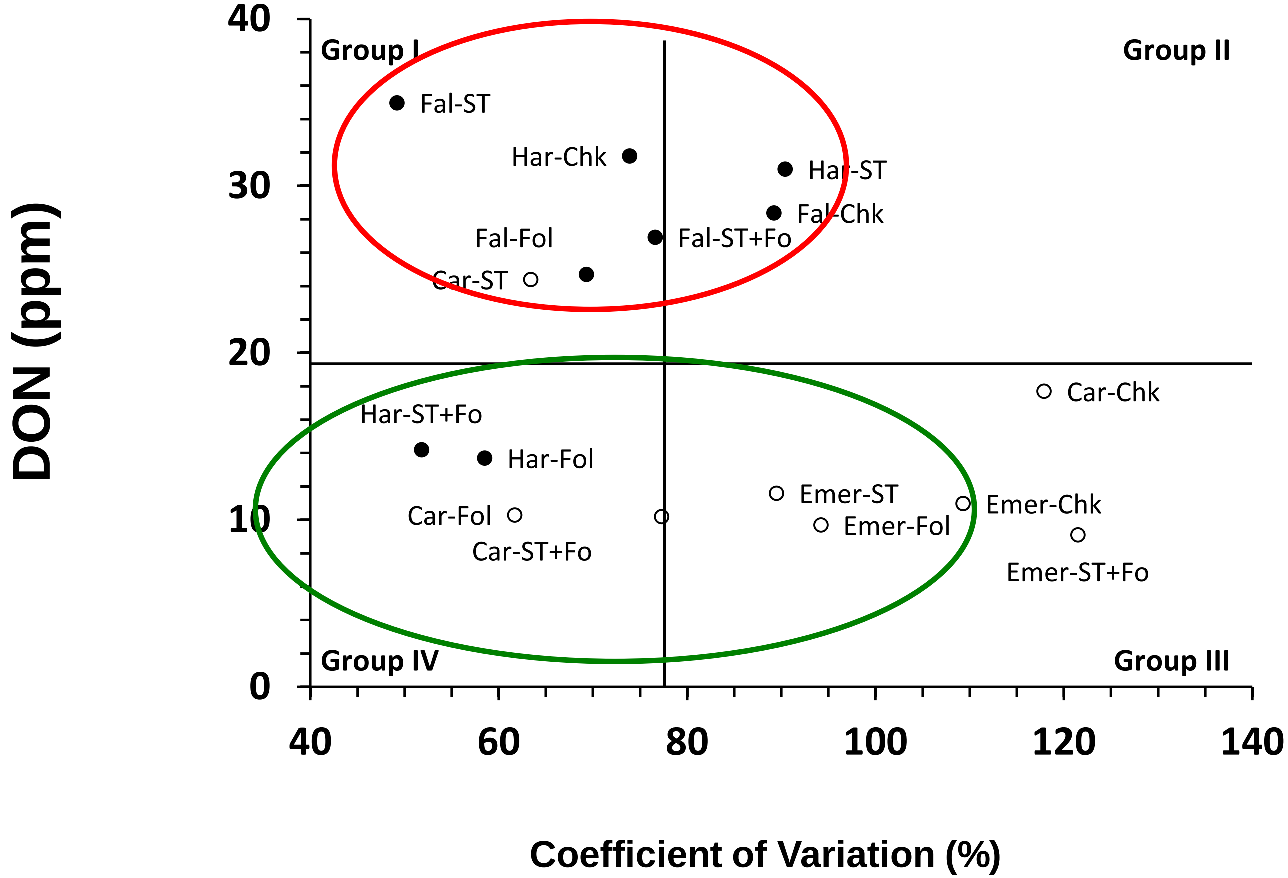

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Grade Retention in High FHB Zones with Seed Trt and Foliar Fungicide

Grade	g1	g2	g3	feed	common salvage
DON Level		**(ppm)**			
Carberry		1.2	1.1	2.3	10.8
CDC Falcon	0.5	0.8	3.8	7.0	27.8
Emerson	0.5		2.2	7.9	13.9
Harvest		1.3	1.9	3.1	14.2
No. observations for DON value					
Carberry		2	2	5	11
CDC Falcon	3	1	2	2	12
Emerson	4		4	2	10
Harvest		1	2	5	12
Obs totals by grade classification	7	4	10	14	45

Grade Retention in High FHB Zones with Seed Trt Only (7 site-years)

Grade	g1	g2	g3	feed	common salvage
DON Level		**(ppm)**			
Carberry			2.0	2.2	22.6
CDC Falcon	0.3	0.2	3.2	8.9	32.8
Emerson	0.7		2.6	8.5	15.1
Harvest		2.5	3.3	3.9	30.8
No. observations for DON value					
Carberry			3	5	12
CDC Falcon	2	1	3	2	12
Emerson	5		3	1	10
Harvest		1	1	5	13
Obs totals by grade classification	7	2	10	13	47

Fungicide Efficacy with Cultivar (High Disease Pressure)

Fungicide	Glenn (MR-I)			Roblin (S)		
	FHB Index	FDK	DON	FHB Index	FDK	DON
Prosaro	93.6	55.6	73.1	12.3	-4.3	-20.4
Proline	97.9	67.5	69.9	21.9	11.3	13.6
Folicur	90.2	51.0	64.3	22.8	-2.4	23.6
Caramba	95.7	57.9	70.3	6.8	-6.8	10.0

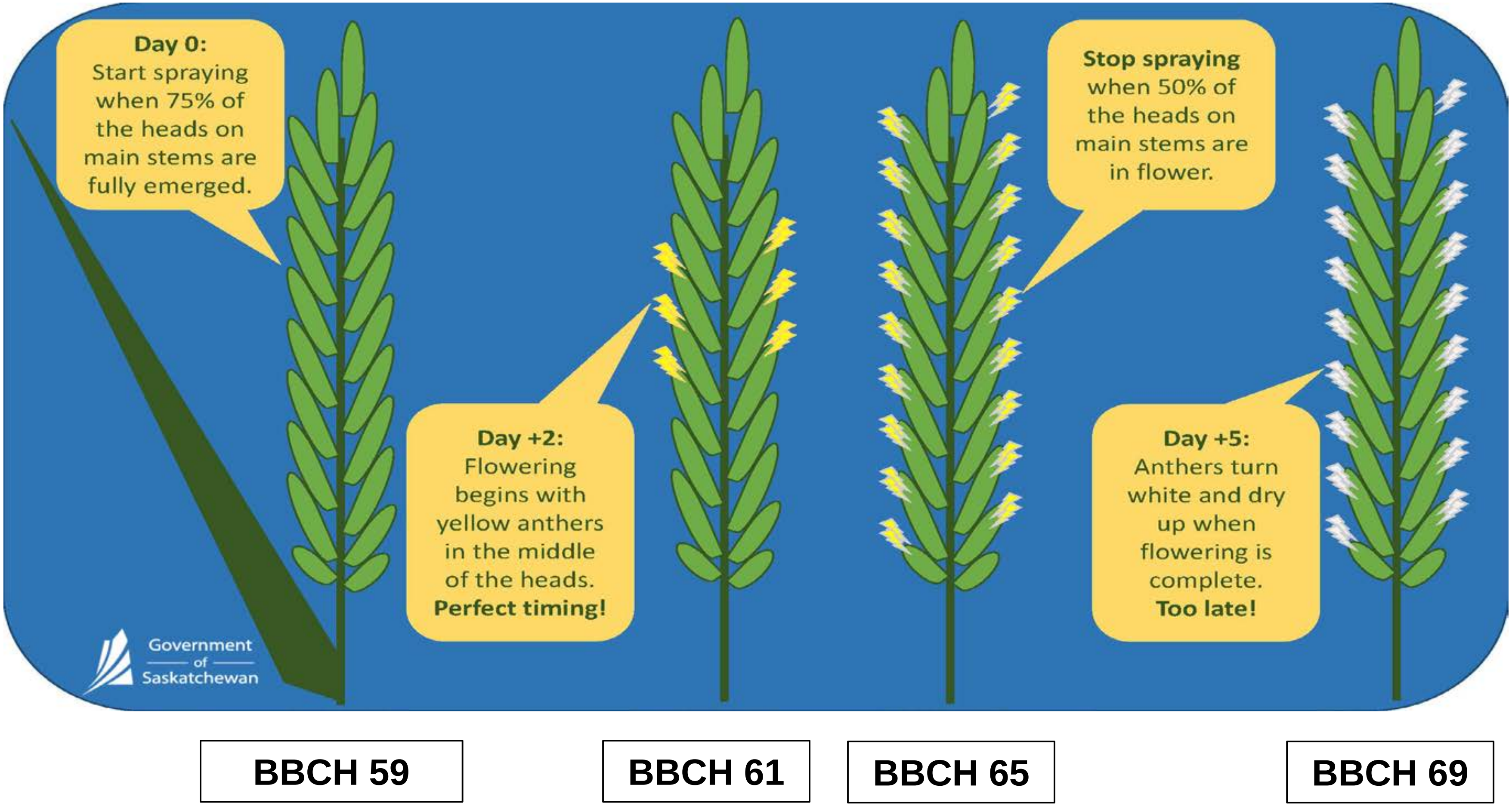
Amarasinghe 2011

% reduction in FHB index, FDK

and DON highest with more resistant cultivar

Application timing: anthesis for FHB

http://www.saskwheatcommission.com/producer-info/fusarium-risk-assessment-map/



BBCH growth stage scale; Lancashire et al. 1991, Ann. Appl. Biol. 119: 561-601.

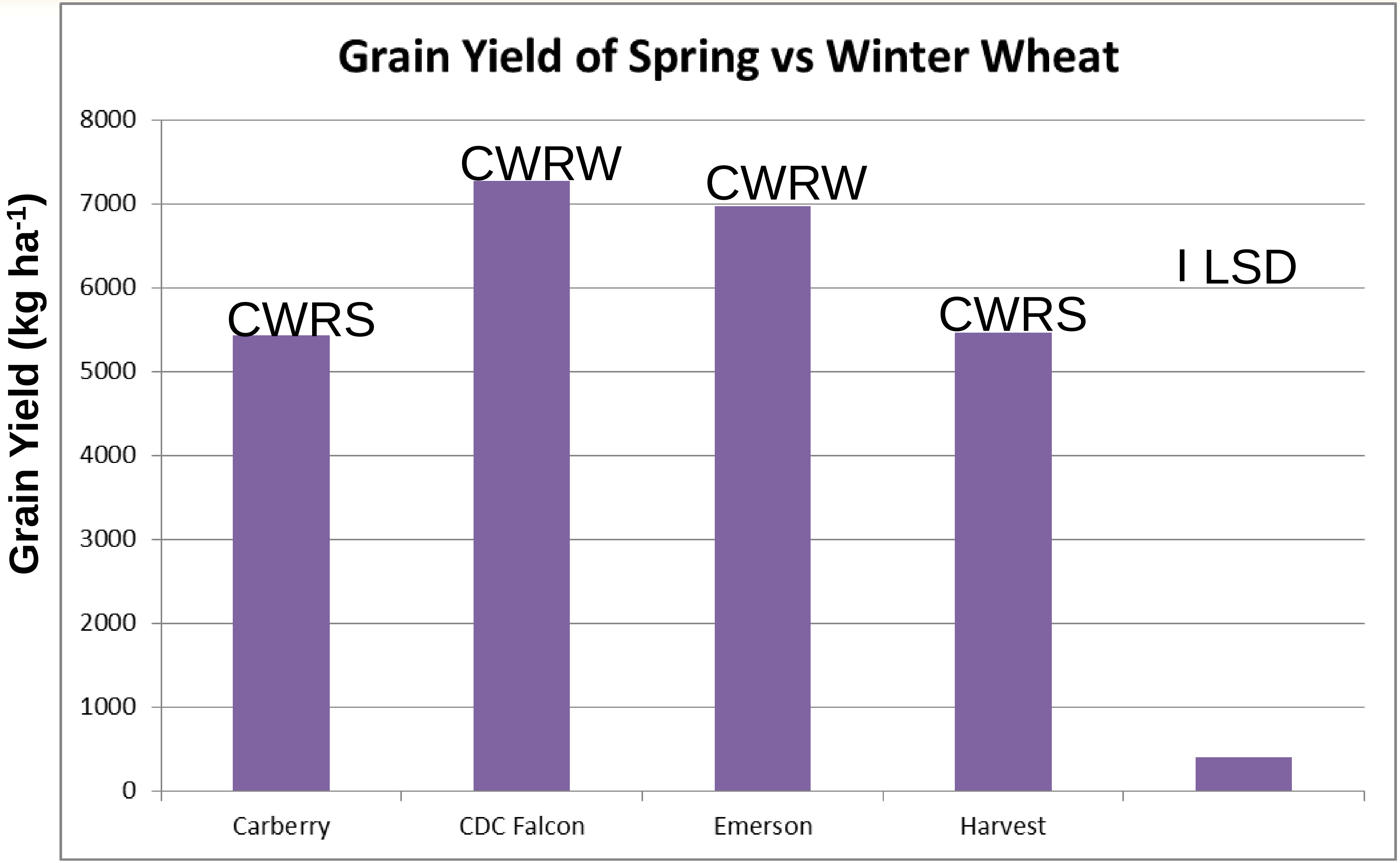
Source: Dr. Randy Kutcher, U of S, SK

Effect of the timing of fungicide on FHB severity, FDK and mycotoxins

Yoshida et al. 2012

Treatment	FHB severity	FDK (%)	DON+NIV (µg/g)
Unsprayed check	44	14.2	8.9
Anthesis (A)	8	7.2	4.5
10 DAA	33	12.7	8.2
20 DAA	32	8.1	4.2
30 DAA	32	13.2	8.6
A + 10 days	5	3.7	2.5
A + 20 days	7	2.4	1.4
A + 30 days	10	6.4	3.9

Why Should Winter Wheat Be Such a Tough Sell ????



Why Grow Winter Wheat?

- Promotes conservation tillage practices
- 15 to 25% higher yield than spring wheat
- Improved water utilization pattern
- Lower fuel costs due to fewer field operations
- Better competitor with annual weeds so herbicides are often not required.
- No wild oat herbicide reduces selection pressure for herbicide resistance
- High yield + reduced herbicide = higher net return

Source: Dr. Rob Graf, AAFC-Lethbridge

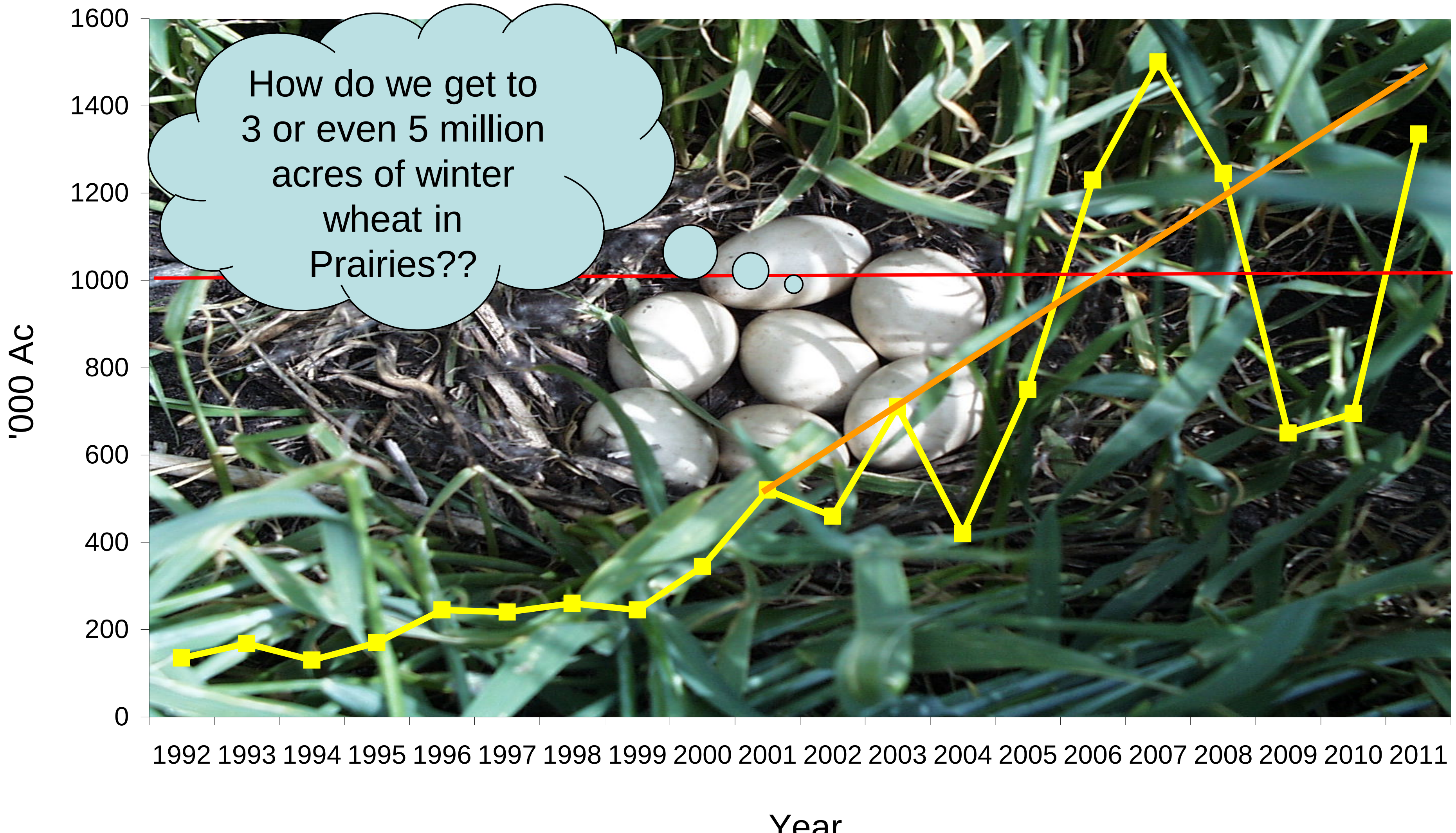
Why Grow Winter Wheat?

- Early marketing calls provide better cash flow
- Reduced risk of Fusarium head blight
- Avoids wheat midge damage (early heading)
- Less disturbance to wildlife
- Avoids seeding problems during late, wet springs
- Earlier harvest than spring wheat, which is particularly valuable in short season areas
- Higher average grades than spring wheat
- Displacement of workload, allowing longer annual use of farm machinery

Source: Dr. Rob Graf, AAFC-Lethbridge

Prairie Canada Winter Wheat ('000 Ac.)

source: Stats Canada

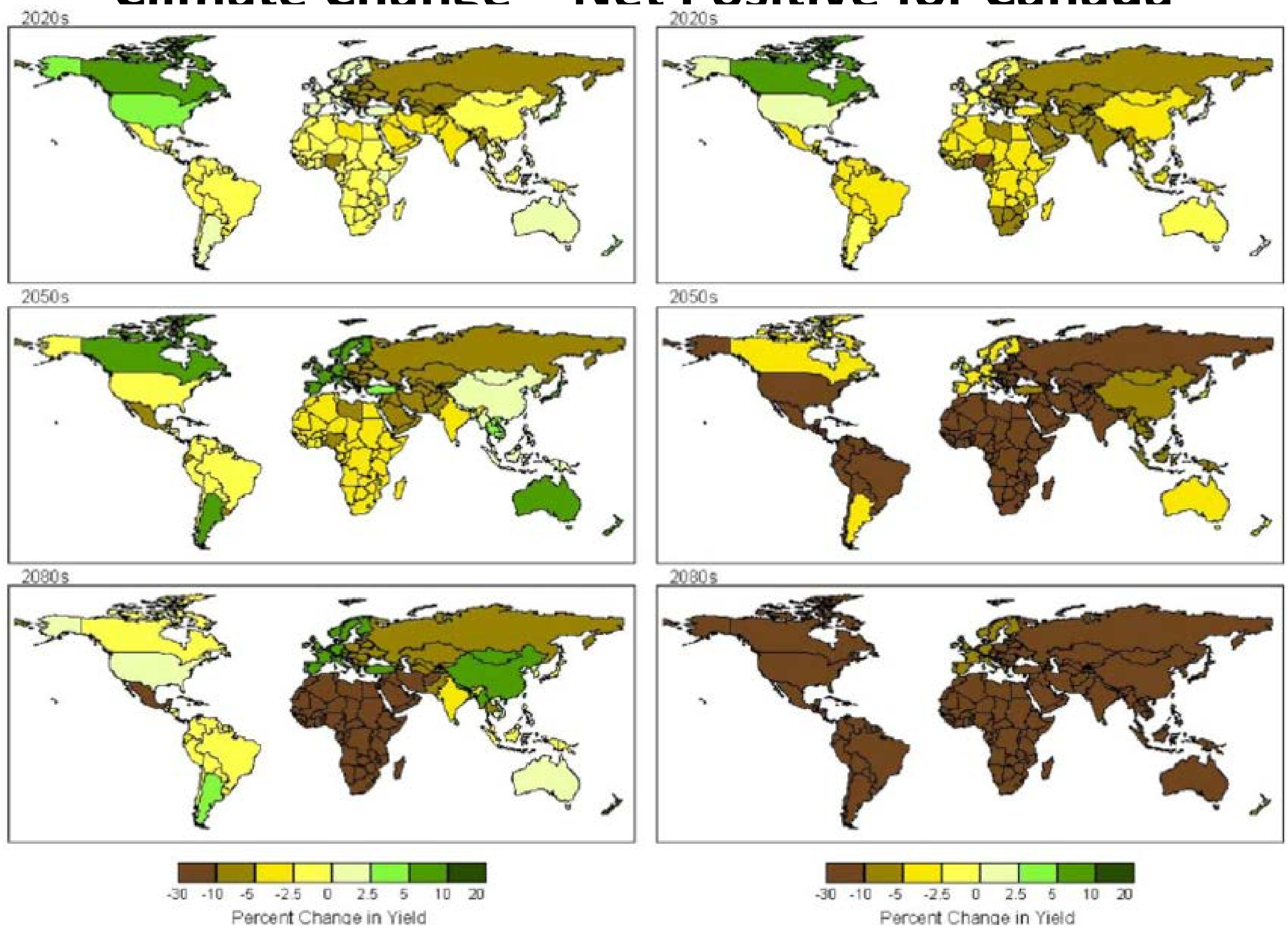


Winter wheat is an eco-friendly crop providing nesting habitat to ducks

Source: Paul Thoroughgood, Duck’s Unlimited Canada

Background for Planting Early or Switching Growth Phase to WW

Climate Change = Net Positive for Canada



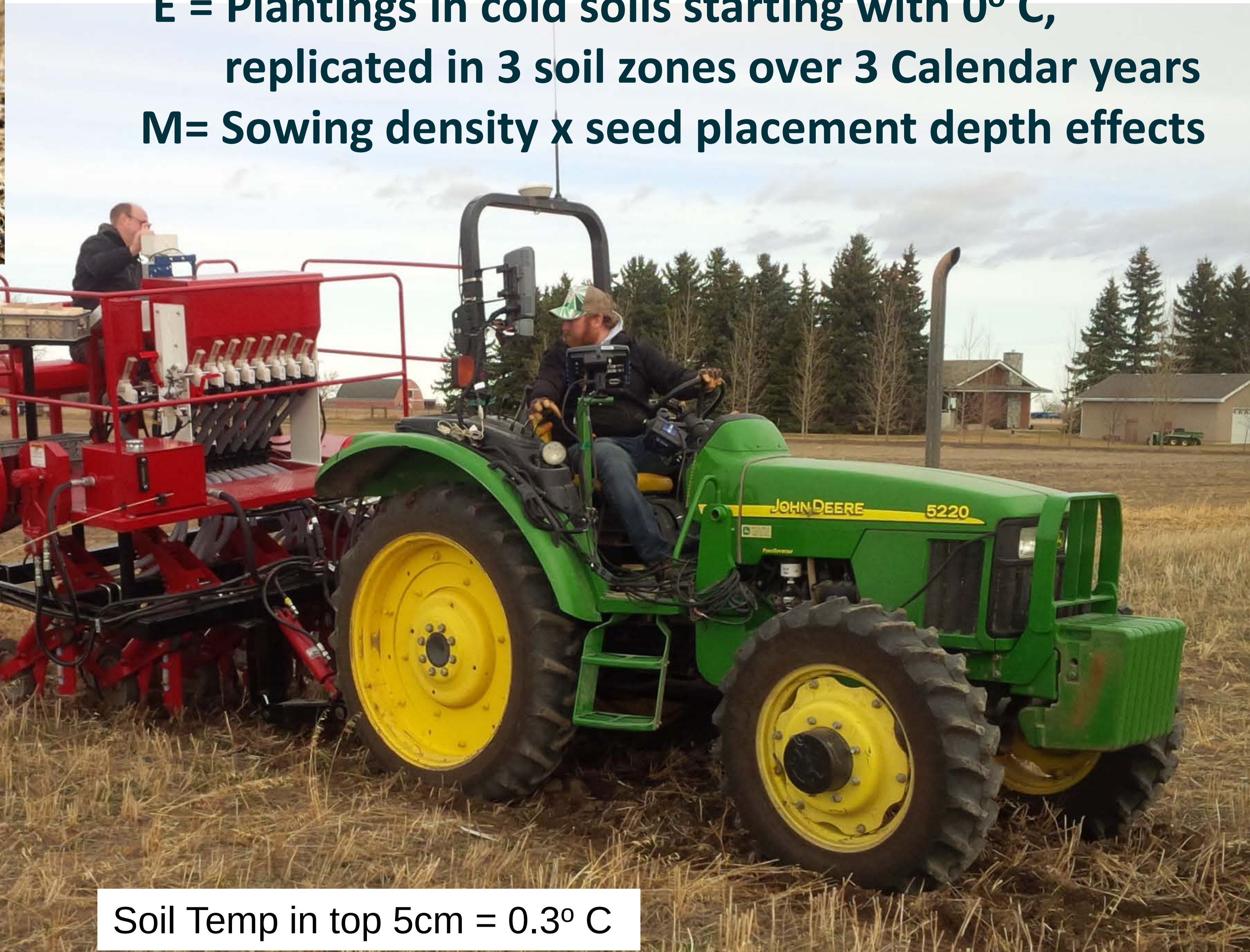
Potential changes (%) in national cereal yields to 2080 compared to 1990, under the HadCM3 SRES A1F1 with and without CO2. Source: (Parry et al. 2004)

Feb 16th 2016 – Planting Cold Tolerant Wheat Study

G = Cold tolerant spring wheat lines

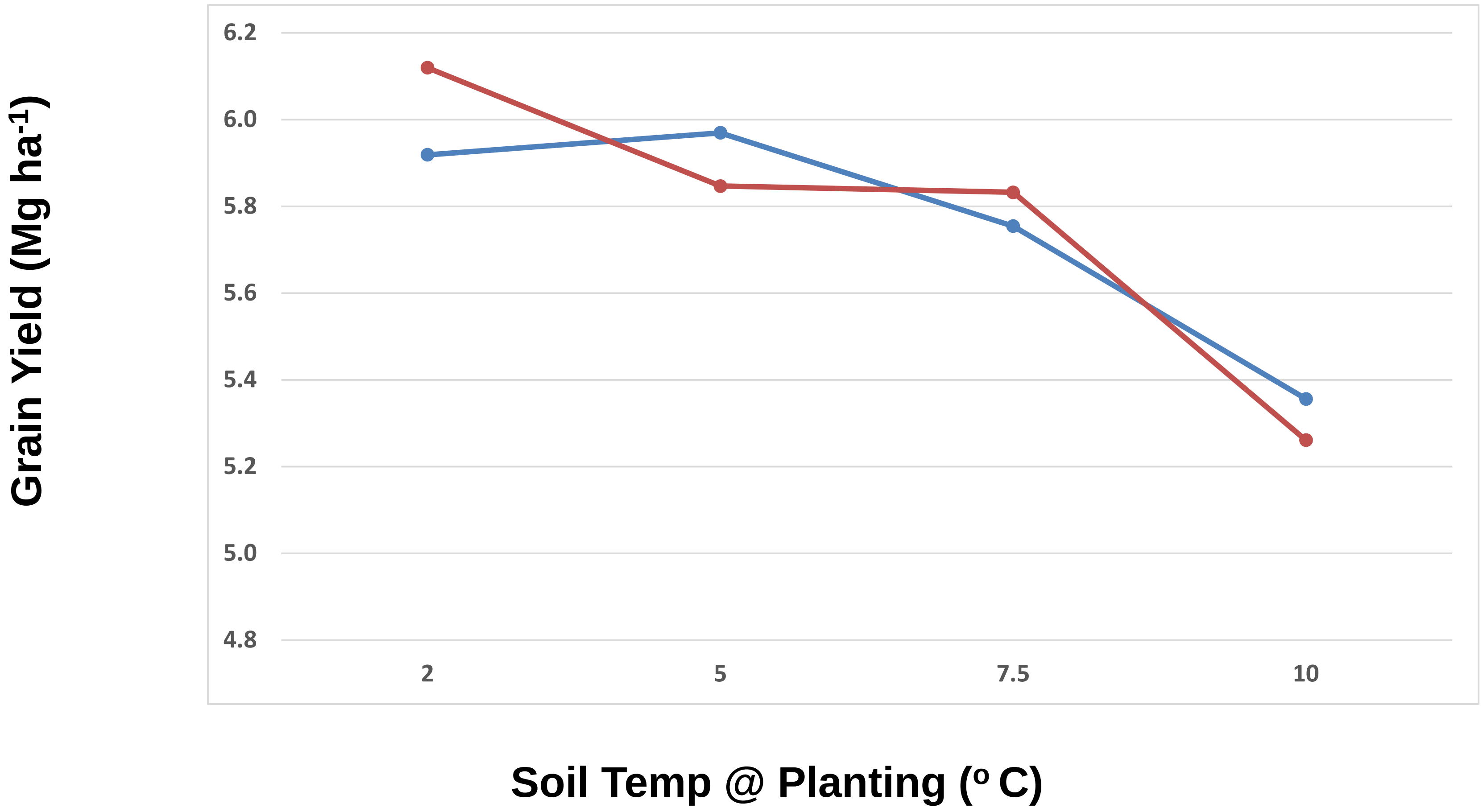
E = Plantings in cold soils starting with 0º C, replicated in 3 soil zones over 3 Calendar years

M= Sowing density x seed placement depth effects



Soil Temp in top 5cm = 0.3º C

Preliminary Results



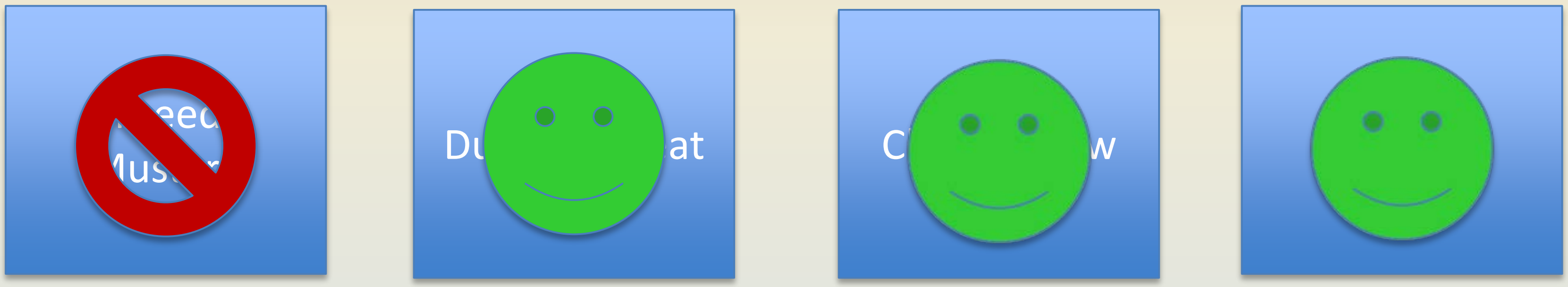
Spring wheat grain yield response to soil temperature at planting, averaged over cold tolerance & conventional trait lines.
Blue line = 2.5 cm sowing depth; red line = 5cm sowing depth.

GxExM Case Study

GxExM Case Study

GxExM Case Study

- Farmer Rotation near Oyen, SK
  - Appears to follow the 1 in 4 Rule for disease mitigation



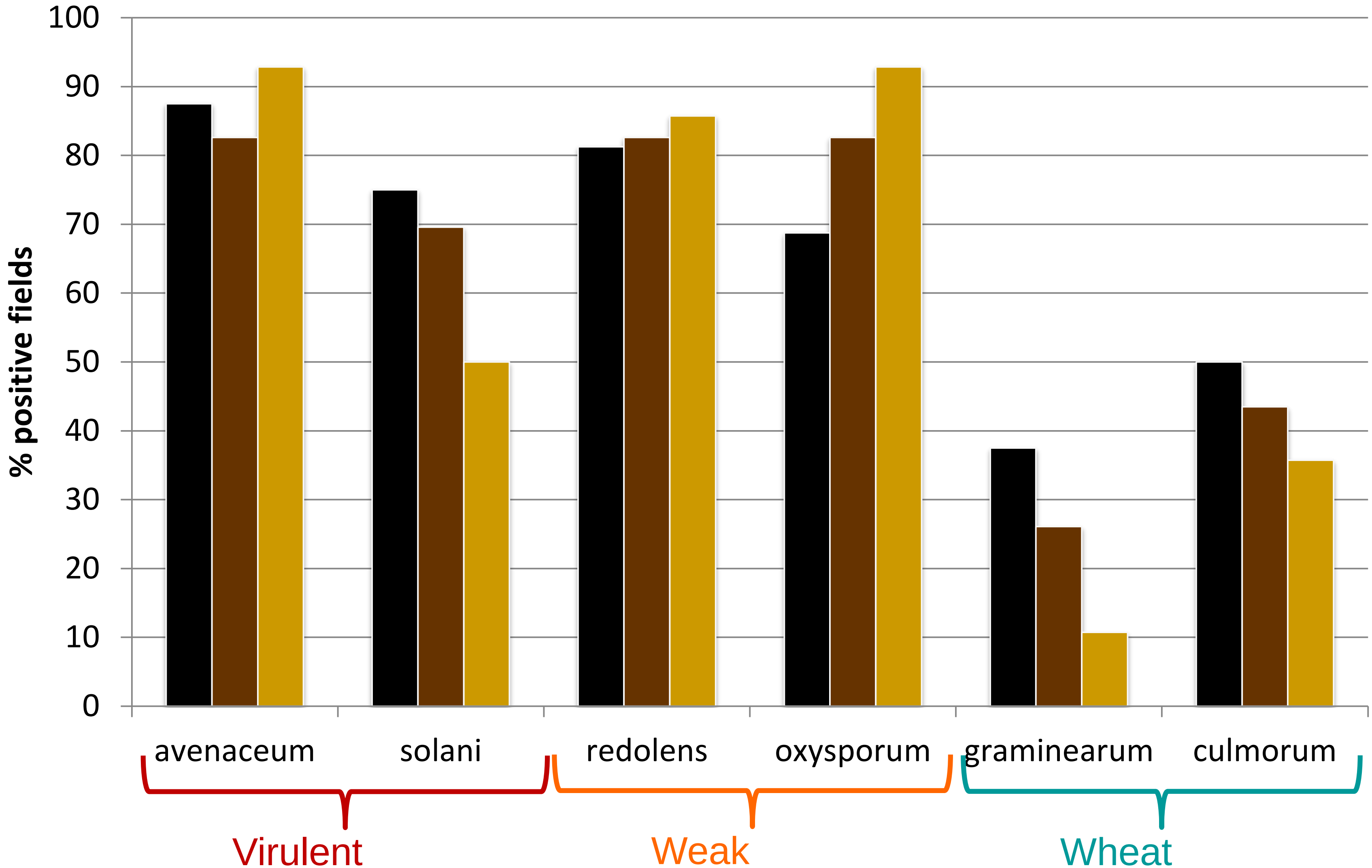
- Which phase is not a host for FHB?

- *Non-Host*

- *Host*

- May explain no notable FHB for years then high infestation in 2016

Fusarium spp. on pea roots in Saskatchewan



Dr. Syama Chatterton, AAFC - Lethbridge

GxExM Case Study

- Chem Fallow phase is an issue due to repeated glyphosate >>>>> roots of intact dead weeds are colonized by FHB

Fernandez, M.R., R.P. Zentner, P. Basnyat, D. Gehl, F. Selles, and D. Huber. 2009. Glyphosate associations with cereal diseases caused by Fusarium spp. in the Canadian Prairies. European Journal of Agronomy 31:133-143.

Kawate, M.K., S.G. Colwell, A.G. Ogg Jr, and J.M. Kraft. 1997. Effect of glyphosate-treated henbit (Lamium amplexicaule) and downy brome (Bromus tectorum) on Fusarium solani f. sp. pisi and Pythium ultimum. Weed science 45:739-743.

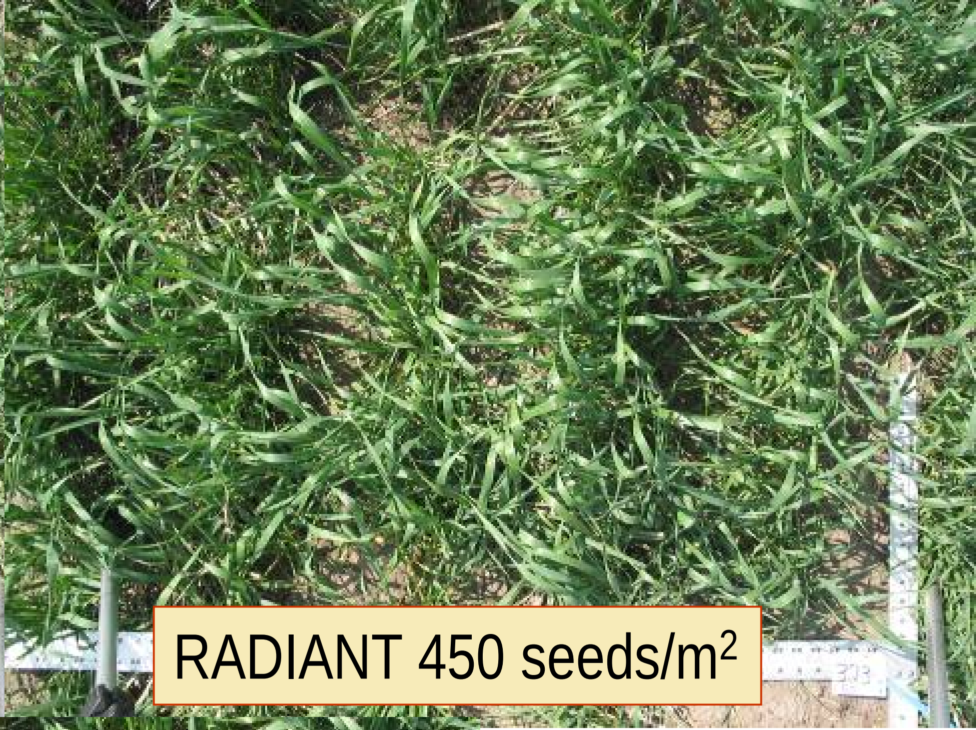
Rahe, J.E., C.A. Lévesque, and G.S. Johal. 1990. Synergistic role of soil fungi in the herbicidal efficacy of glyphosate, p. 260-275, In R. E. Hoagland, ed. Biological weed control mircobes and microbial produts as herbicides. Symposium, 9-14 April, 1989. American Chemical Society, Washington D.C.

Other FHB Mgmt Components

- Crop Uniformity
  - Seed treatments
  - Seeding rates
- Does tillage control FHB?
- Harvest Management

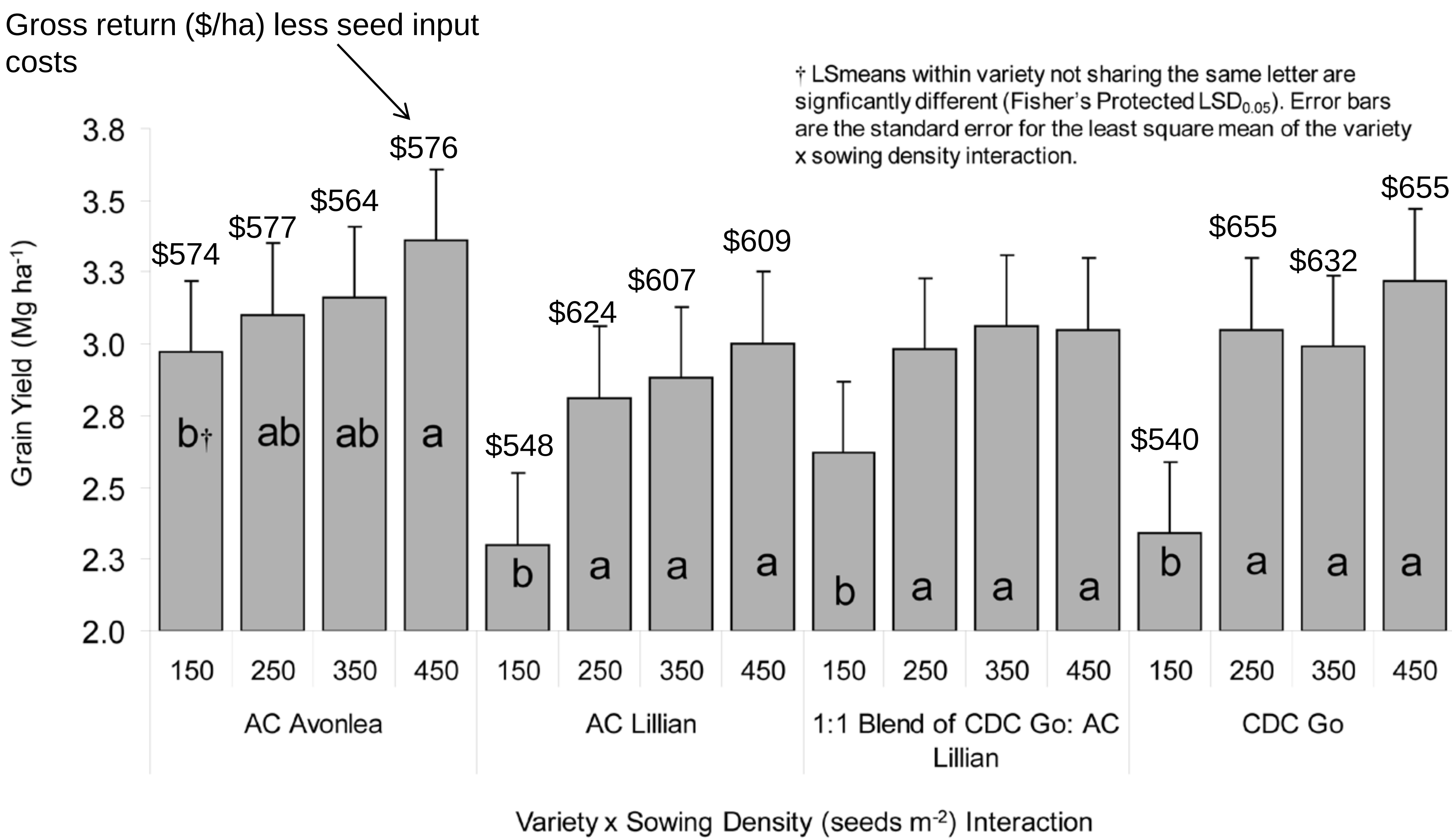
Fig. 1. Weak agronomic system of low sowing density and light seed with no seed treatment (left photo) or with dual fungicide/insecticide ('Raxil WW') (right photo).

Fig. 2. Strong agronomic system of high sowing density and heavy seed with no seed treatment (left photo) or with dual fungicide/insecticide ('Raxil WW') (right photo). Beres et al. Agron J. 2016



Source: Beres et al. Agronomy Journal **102**:649-657

Influence of Seeding Rate on Yield of CWRS and CWAD Planted on Wheat Stubble in Coalhurst & Nobleford, Alberta



Beres, B.L., H.A. Cárcamo, R-C Yang, and D.M. Spaner. 2011. Integration of variety selection and sowing density to manage wheat stem sawfly in durum and hard red spring wheat. Agronomy Journal 103: 1755-1764.

Influence of kwt on seed volume requirements for spatial density planting

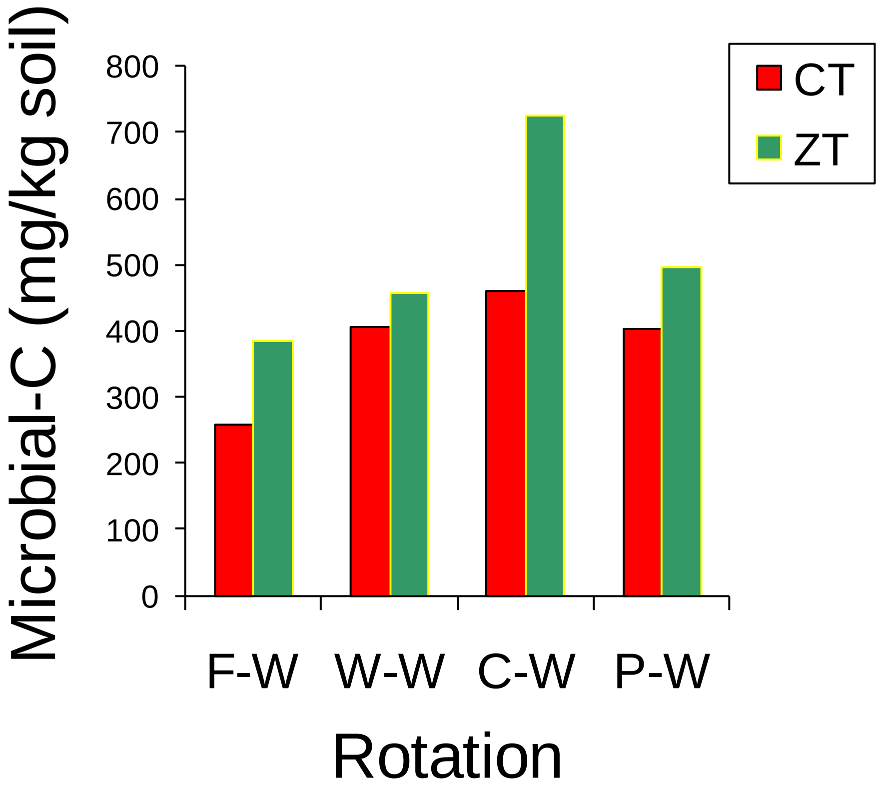
Seed Rate	AC Avonlea (44g kwt)	AC Lillian (32.8g kwt)
200 seeds/m^2	1.3 bu/ac	1.0 bu/ac
300 seeds/m^2	2.0 bu/ac	1.5 bu/ac
400 seeds/m^2	2.6 bu/ac	2.0 bu/ac
500 seeds/m^2	3.3 bu/ac	2.5 bu/ac
600 seeds/m^2	3.9 bu/ac	3.0 bu/ac

Tillage?

- Tillage to destroy plant residue
  - Significantly reduces F. avenaceum
  - Tillage effects not significantly different than no-till for F. graminearum

Fernandez, M.R., R.P. Zentner, P. Basnyat, D. Gehl, F. Selles, and D. Huber. 2009. Glyphosate associations with cereal diseases caused by Fusarium spp. in the Canadian Prairies. European Journal of Agronomy 31:133-143.

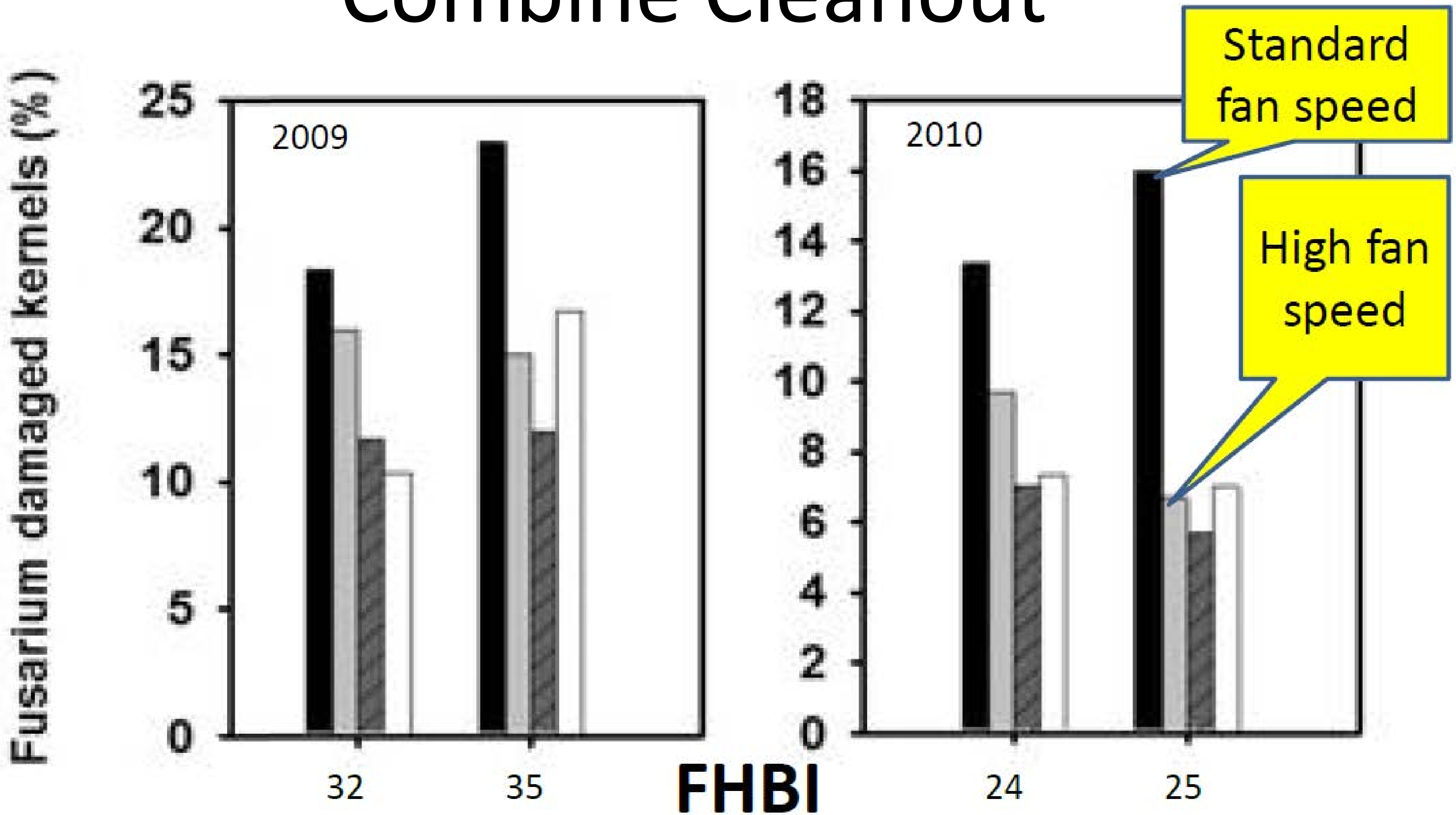
No-till increases microbial biomass



- Greater microbial biomass under ZT than under CT.
- Highest biomass in wheat following red clover and lowest biomass in wheat following summer fallow

Lupwayi et al. 1998

Combine Cleanout



Ohio State Univ.

Modified from Salgado et al. 2011. Plant Dis. 95:1448-1457.

Managing Crop Residue and FDK's

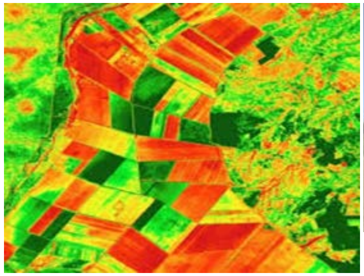
Harrington Seed Destructor for Managing Weed Resistance…..and FHB????

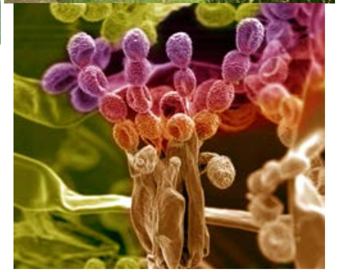
Source: https://dl.sciencesocieties.org/publications/cns/articles/46/2/4

Looking Ahead

Integrating Innovative Tools

- Smart Farming Technologies
- Big Data
- Biotechnology
- Microbiomes and the Biologicals Bloom
- Exploiting hybrid wheat yield/traits





What does the Future Hold?

Partnerships is key in moving forward

- ✓ Coordination and collaboration is important in order to eliminate duplication and build on each others' work
- ✓ Multidisciplinary collaboration (Scientists, field agronomists, sales representatives, agronomic consultants, etc.)
- ✓ Many players:
  - Producers
  - Governments
  - Industry
  - Consumers
  - Scientists

An international research partnership for wheat improvement

OECD workshop, Paris

Hélène Lucas, February 26, 2016

Key Points for an Agronomy EWG

- Road Map for Implementation

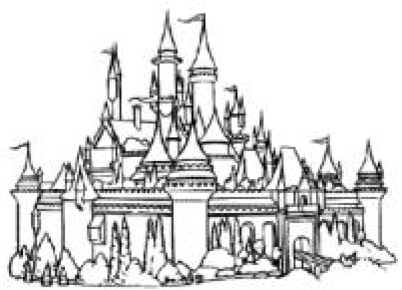
Agronomy Plots. AAFC-Lethbridge, AB CANADA

Call For Agronomy EWG 'Experts'

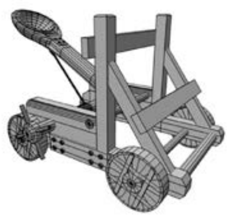
- **Who should join the Agronomy EWG?**
  - **Agronomists, soil & crop scientists**
  - **Cross-disciplines**: IPM scientists (weed, pathology, entomology); Physiologists; crop modellers/remote sensing/digital agriculture (big data) scientists; wheat breeders; economists; statisticians
  - **Others**: social scientists, policy analysts, stakeholders

The bad old days....

G x E

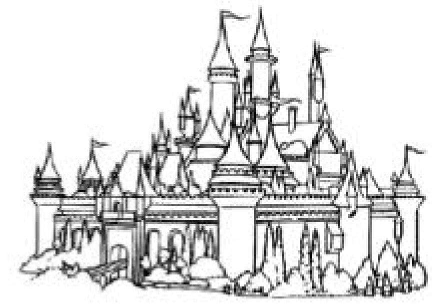


Molecular biology
Plant cell biology
Crop physiology



Genetics
Plant breeding
Seed developers

E x M

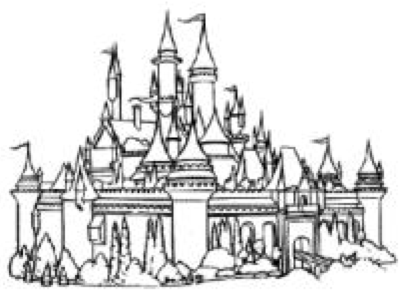


Farmers
Consultants
Input resellers

Agronomy
Farming systems

Slide courtesy of Dr. John Kirkegaard

A better way....



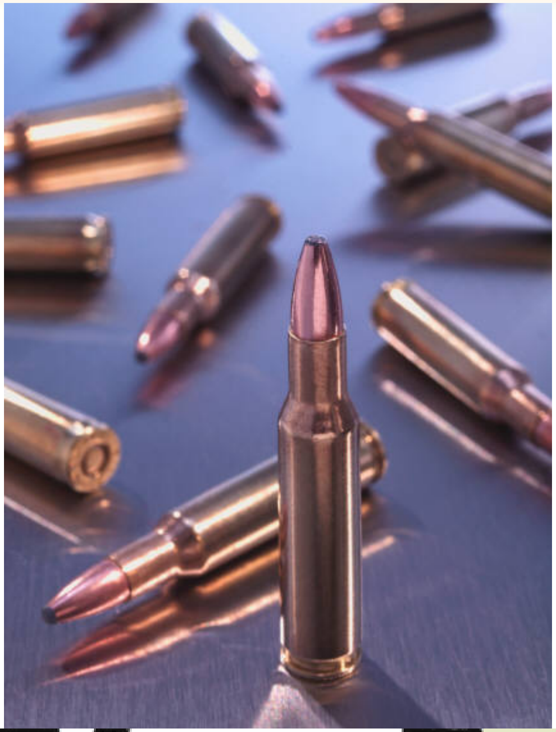
G x E x M

Molecular biology
Plant cell biology
Crop physiology

Farmers
Consultants
Input resellers

- *Not which has delivered more, but how to identify best synergies*
- *What traits will suit the systems of the future (not just the climate)?*
- *What systems are needed to capitalise on new traits?*

In Crop Production Systems There Are No Magic Bullets……..



You'll be shooting blanks by a reliance on a single cultivar or singular management strategy

Design your rotation and couple the best genetics with a complex set of mgmt components

My thanks to:

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