Navigating the Intersection of Agronomic Research and Economic Implications

Brian L. Beres, Ph.D., P.Ag.
Research Scientist - Agronomy
AAFC – Lethbridge, Alberta
brian.beres@agr.gc.ca

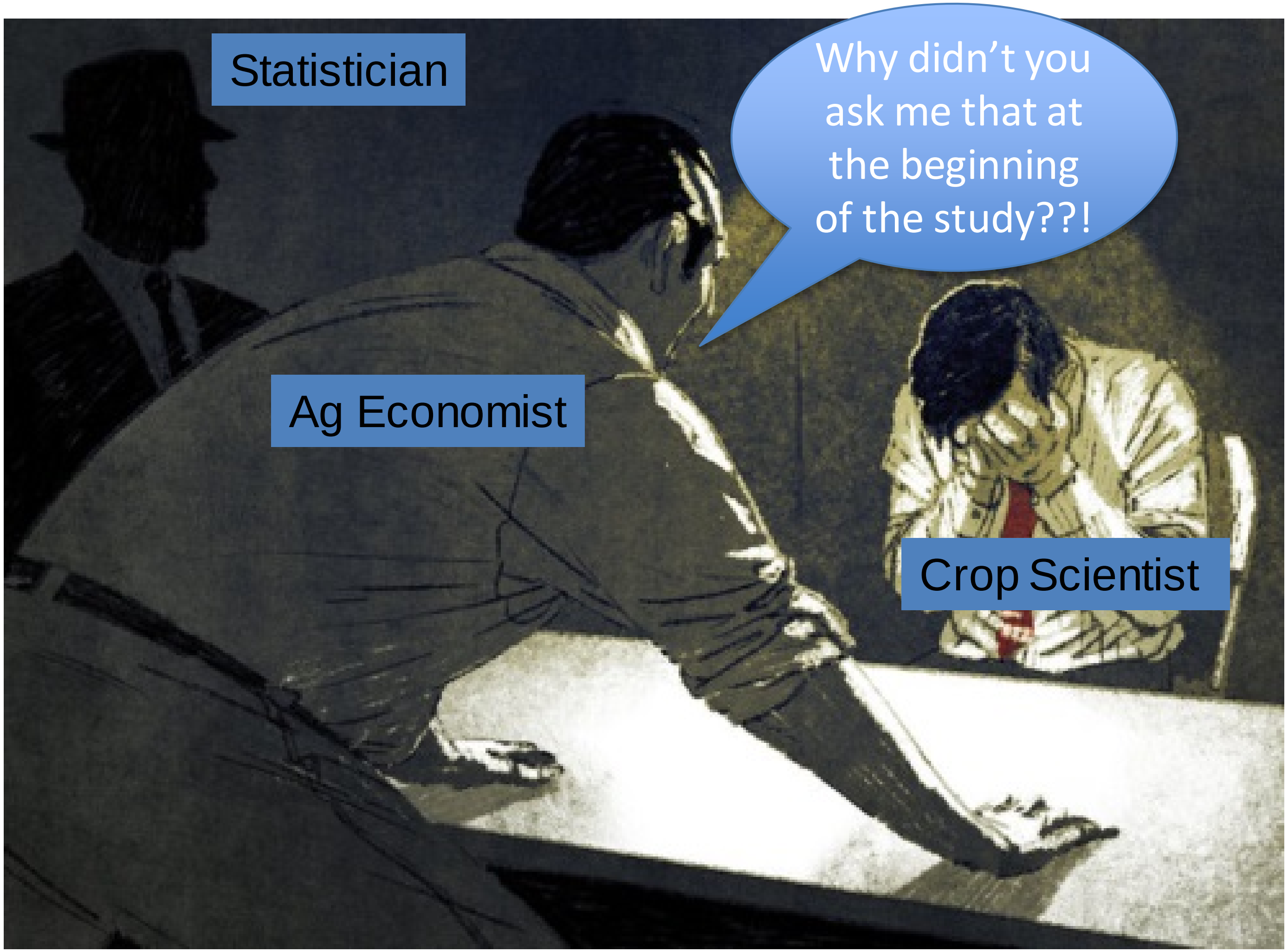
April 30, 2015

Agronomics x Economics

- ‘ultimate purpose is to provide management guidelines to the producer’
- ‘Ideally, by applying sound economic theory to <u>data from agronomic experiments</u>’

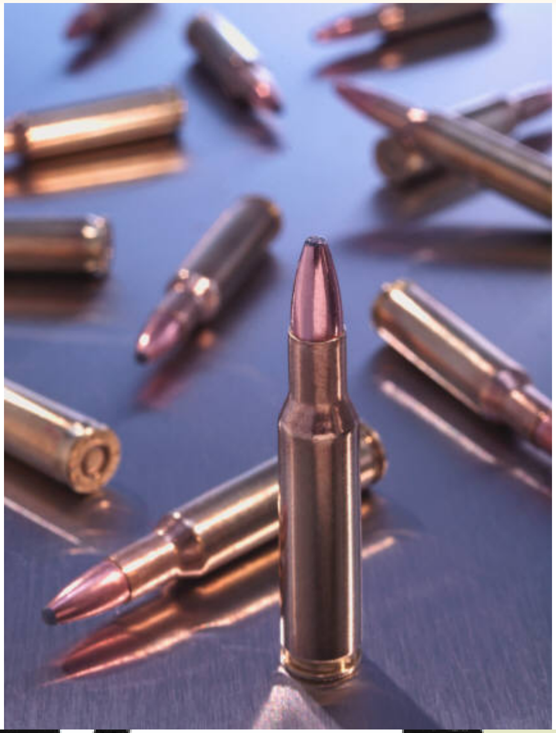
David Bullock and Don Bullock. 2000. From Agronomic Research to Farm Management Guidelines: A Primer on the Economics of Information and Precision Technology. Precision Agriculture 2: 71-101

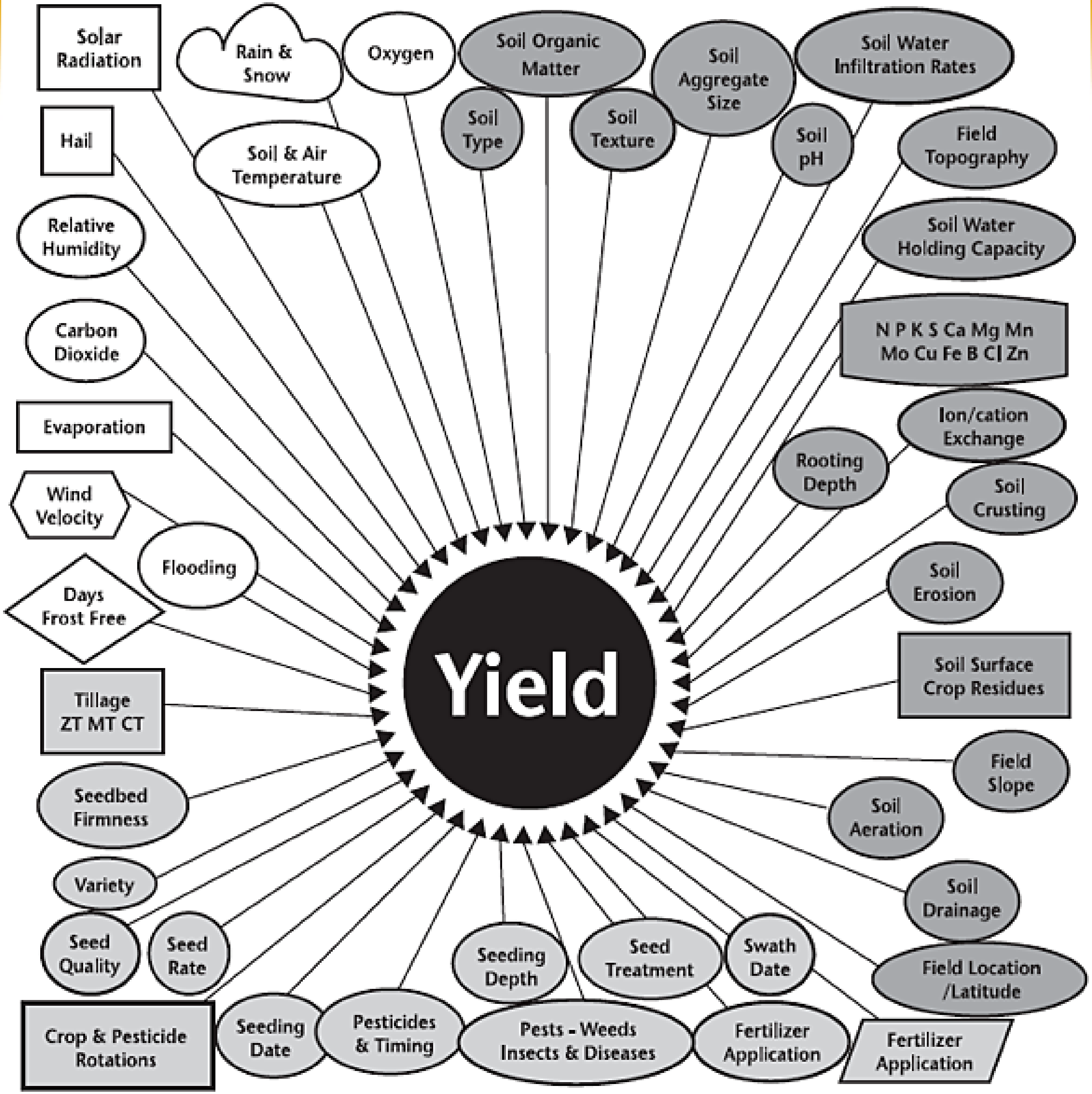
A Hypothetical: Crop Scientist Asks for Stats and Econ Help.....at the 11th hr



New York Times – Morgan Schweitzer

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





Solar Radiation
Rain & Snow
Oxygen
Soil Organic Matter
Soil Aggregate Size
Soil Water Infiltration Rates
Hail
Soil & Air Temperature
Soil Type
Soil Texture
Soil pH
Field Topography
Relative Humidity
Soil Water Holding Capacity
Carbon Dioxide
N P K S Ca Mg Mn Mo Cu Fe B Cl Zn
Evaporation
Ion/cation Exchange
Rooting Depth
Wind Velocity
Soil Crusting
Flooding
Days Frost Free
Soil Erosion
Yield
Tillage ZT MT CT
Soil Surface Crop Residues
Field Slope
Seedbed Firmness
Soil Aeration
Variety
Soil Drainage
Seed Quality
Seed Rate
Seeding Depth
Seed Treatment
Swath Date
Field Location /Latitude
Crop & Pesticide Rotations
Seeding Date
Pesticides & Timing
Pests - Weeds Insects & Diseases
Fertilizer Application
Fertilizer Application

Theme and sub-themes

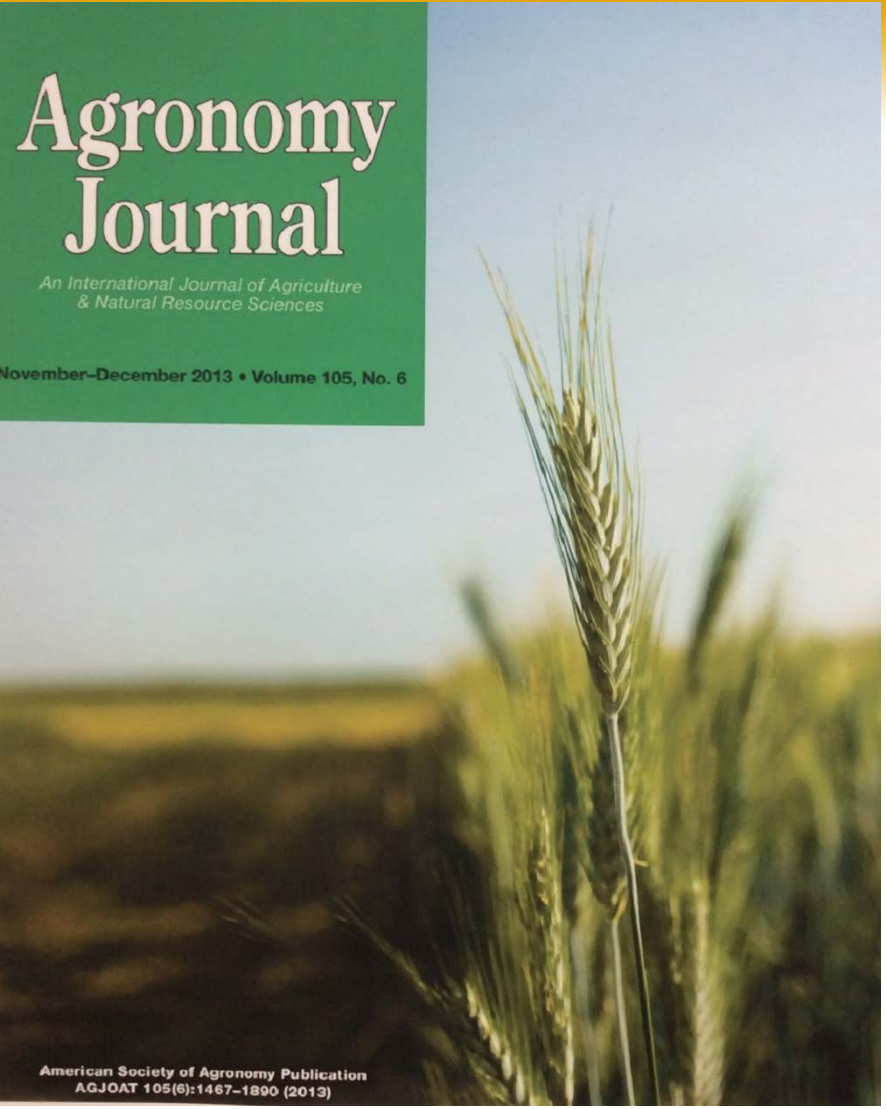
- Agronomic and Economic impacts of cropping systems research
  - Crop rotations
  - Adoption of herbicide tolerant canola
  - Seed treatments
  - Seeding rates

Theme and sub-themes

- Agronomic and Economic impacts of cropping systems research
  - Crop rotations

Why Triticale (circa 2005)? Production Challenges For Triticale

- Maturity
  - Perception that triticales have significantly higher growing degree-day requirements than wheat
- Ergot
  - Major Concern for Farmers and Ethanol Plants i.e. toxins in DDG's
  - Perception/Reality that triticales would 'pollute' farm land with ergot
- Fusarium
  - A serious disease pest of all cereal crops
- Yield Performance
  - Perception: No yield improvement in triticale in last decade
- Ethanol:Perception: poor starch and high viscosity = low ethanol with triticale.



Agronomics:

We conclude that ***triticale would be superior to CPS and CWRS wheat and similar to CWSWS*** *in many agronomic traits desired by ethanol fermentation plants and is superior for biomass production.*

Ethanol Production:

Ethanol fermentation plants could therefore ***increase efficiency by replacing CPS wheat feedstocks with select triticales*** *and potentially improve the consistency of production by using select triticales in regions where CWSWS wheats are less stable.*

Beres, B.L., Pozniak, Eudes, F., Graf, R.J., Randhawa, H.S., Salmon, D.F., McLeod, G.J., Dion, Y., Irvine, R.B., Voldeng, H.D., Martin, R.A., Pageau, D., Comeau, A., DePauw, R.M., Phelps, S.M., and Spaner, D.M. 2013. A Canadian ethanol feedstock study to benchmark the relative performance of triticale – Part I: Agronomics. Agronomy Journal 105: 1695-1706

Beres, B.L., Pozniak, C.J., Bressler, D., Gibreel, A., Eudes, F., Graf, R.J., Randhawa, H.S., Salmon, D.F., McLeod, G.J., Dion, Y., Irvine, R.B., Voldeng, H.D., Martin, R.A., Pageau, D., Comeau, A., DePauw, R.M., Phelps, S.M., and Spaner, D.M.. 2013. A Canadian ethanol feedstock study to benchmark the relative performance of triticale – Part II: Grain quality and ethanol production. Agronomy Journal 105: 1707-1720.

Test 404 – Rotational Diversity Effects in a Triticale-Based Cropping System

- Questions around a modern triticale-based cropping system
  - Should the goal be isolation (disease or GM trait considerations) or full integration?

- Hypotheses:
  - 1) Rotational diversity improves cereal phases of cropping system
  - 2) Rotational diversity for a cereal-based cropping system improves soil health.
  - 3) A diverse cropping system can be profitable.

Six Rotational Sequences

1. **Low diversity rotation** - (bioethanol focus) rotation – **continuous triticale (TT-LDR)**
2. **Low diversity rotation** - (bioethanol focus) rotation – continuous cereal crop phases: triticale-soft white spring wheat (**T*Ce-LDR)**

3. **Moderate diversity rotation** - (bioethanol with peas to add N back to the system) – triticale-field peas (**T*P-MDR)**

4. **Moderate diversity rotation** (bioethanol and biodiesel focus) - **triticale-canola (T*C-MDR)**

5. **High diversity rotation** (bioethanol and biodiesel focus with peas to add N back to the system) – field pea-canola-triticale (**CT*P-HDR)**

6. **Moderate diversity rotation** - **intercrop:** 1:1 blend of peas with pea cultivar **split** as follows: 1)**Field Pea**: CDC Golden – later maturity for increased harvest compatibility with triticale:triticale, and 2) **Forage pea**: Meadow - triticale to test single harvest feasibility – triticale **(T*inP-MDR)**

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.

ANOVA Results for Triticale Phase Responses in Prairie Sites

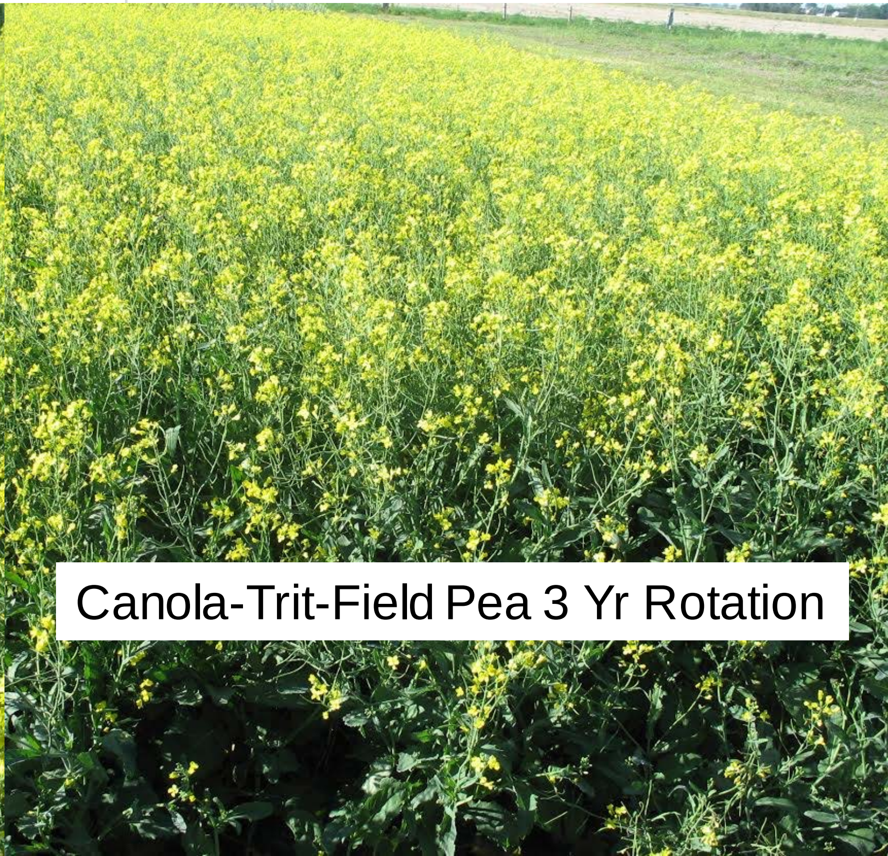
Effect / Level	heads	KWT	plants	Protein	TWT	yield	biomass	broadlfwt	grassywt
	(P value)								
Treatment	0.621	**< 0.001**	0.225	**0.029**	**0.020**	**< 0.001**	**0.003**	0.162	0.715
	Means								
	(no. plant^{-1})	(mg)	(no. m^{-2})	(%)	(kg hL^{-1})	(Mg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})
T*Ce-LDR	1.56	39.4	209	9.45	69.5	3.49	976	50.5	54.0
T*C-MDR	1.59	41.0	217	9.67	69.7	3.79	1018	62.2	60.4
T*P-MDR	1.53	41.1	217	9.83	69.6	3.57	1013	83.8	56.1
TT-LDR	1.56	40.0	219	9.54	69.4	3.45	936	44.4	61.8
CT*P-HDR	1.50	40.9	224	9.74	69.6	3.94	1077	40.6	39.8
T*inP-MDR	1.56	40.3	218	9.84	69.1	3.47	948	66.4	55.6
LSD0.05	0.11	0.8	11	0.27	0.3	0.25	71	34.3	29.7
	(Variance estimate)								
Site	0.207	31.0	7539	0.88	22.0	1.86	337792	11106	607
Site x Treatment	0	0.5	63	0.07	0.0	0.09	3153	81	229
	0	2	1	7	0	4	1	1	**27**

Sensitivity Analysis for Triticale Yield in Low and High Production Environments

	Site mean	
Rotation	**2.0 Mg ha^{-1}**	**5.3 Mg ha^{-1}**
CT*P-HDR	**2.14**	**5.90**
T*C-MDR	**2.09**	**5.60**
T*Ce-LDR	**1.96**	**5.02**
T*P-MDR	**1.92**	**5.32**
T*inP-MDR	**1.93**	**5.03**
TT-LDR	**1.97**	**4.88**
$LSD_{0.05}$	**0.28**	**0.38**

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

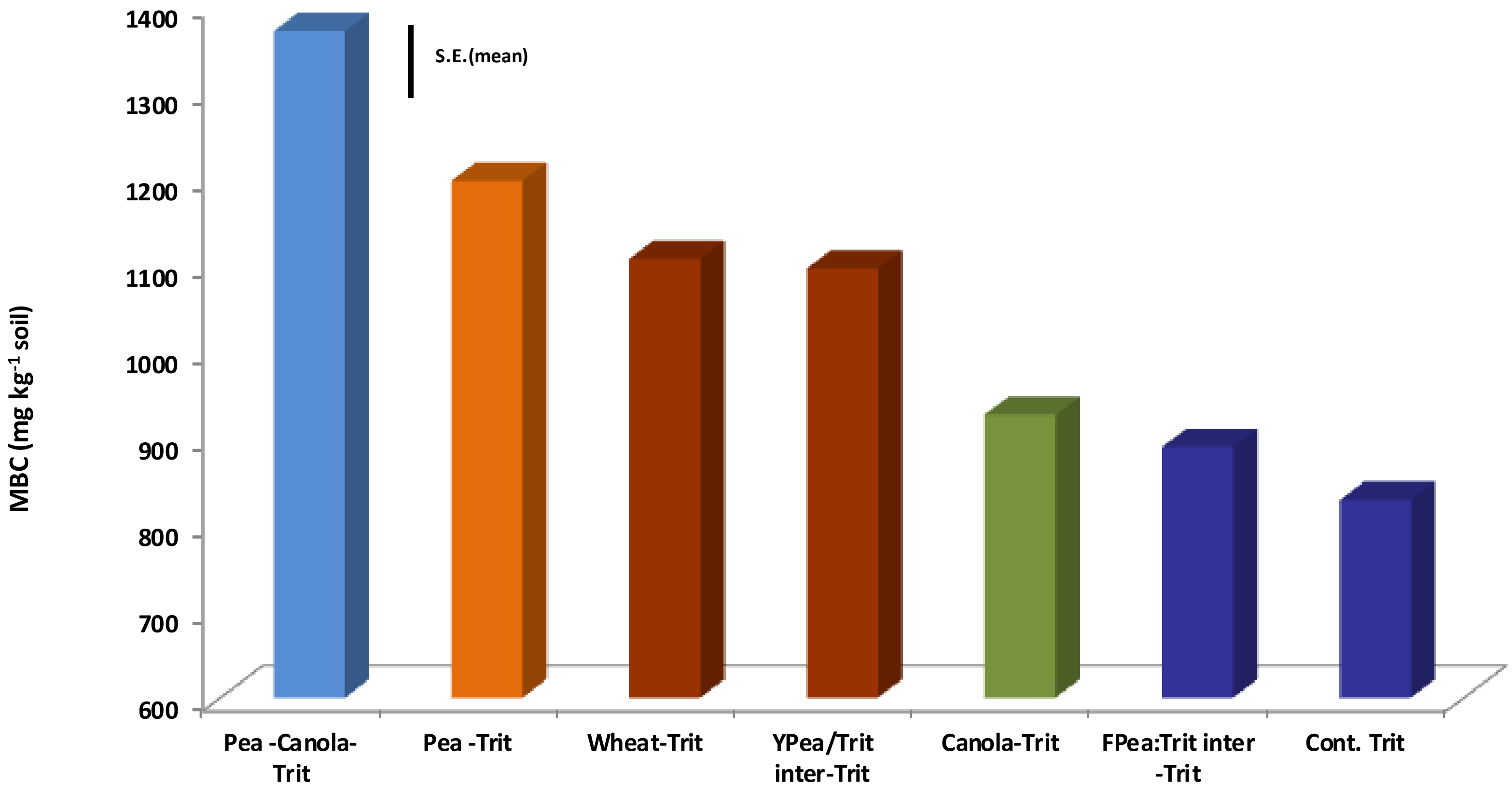


Fig. 1. Microbial Biomass C (MBC) in Triticale Rhizosphere. Swift Current, 2012.

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

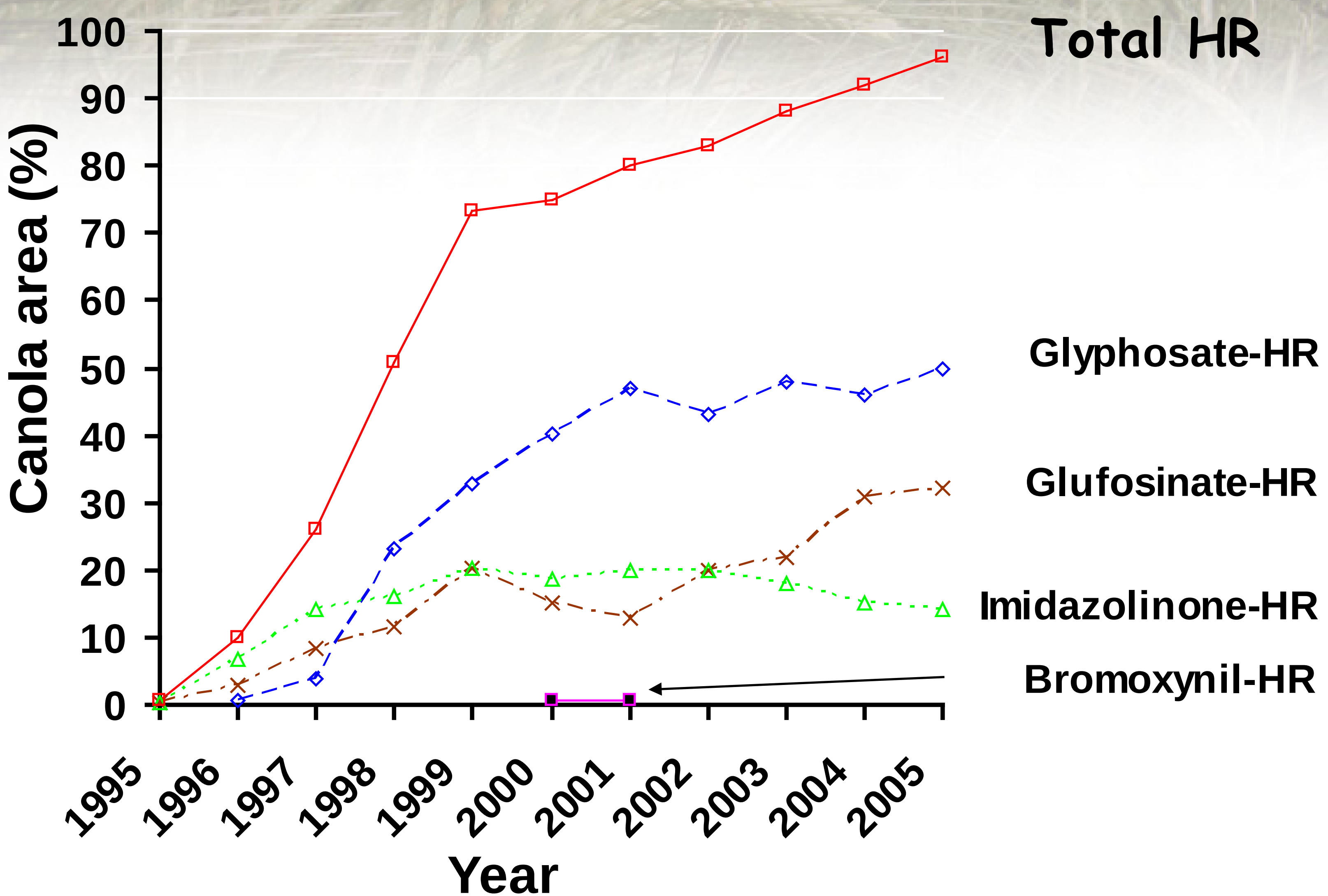
†Costs and revenue derived from 'Crop Planning Guide 2015', Ministry of Agriculture of Saskatchewan

Theme and sub-themes

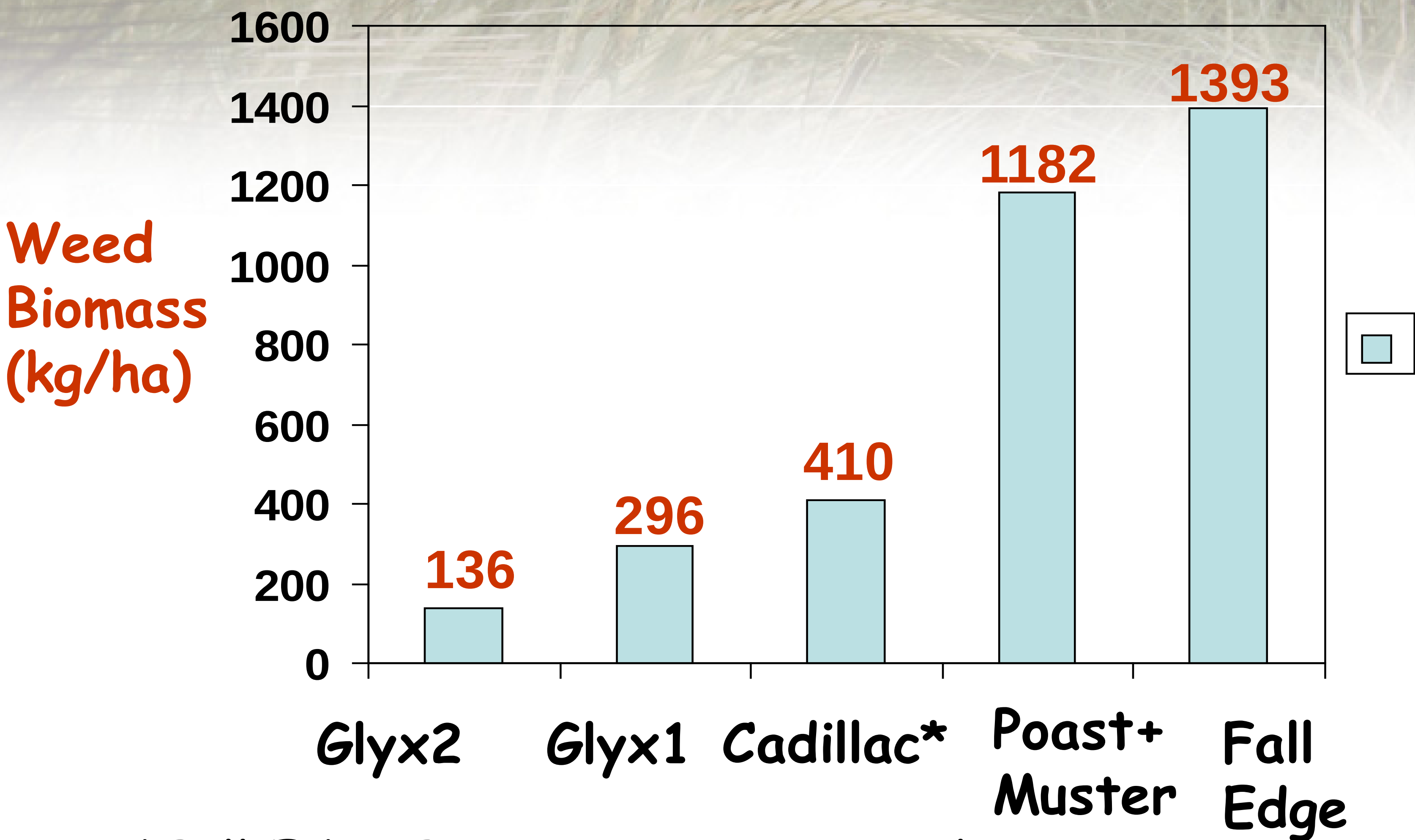
- Agronomic and Economic impacts of cropping systems research
  - Adoption of herbicide tolerant canola

Slides courtesy of Dr. John O’Donovan AAFC - Lacombe

Herbicide resistant (HR) canola adoption in western Canada



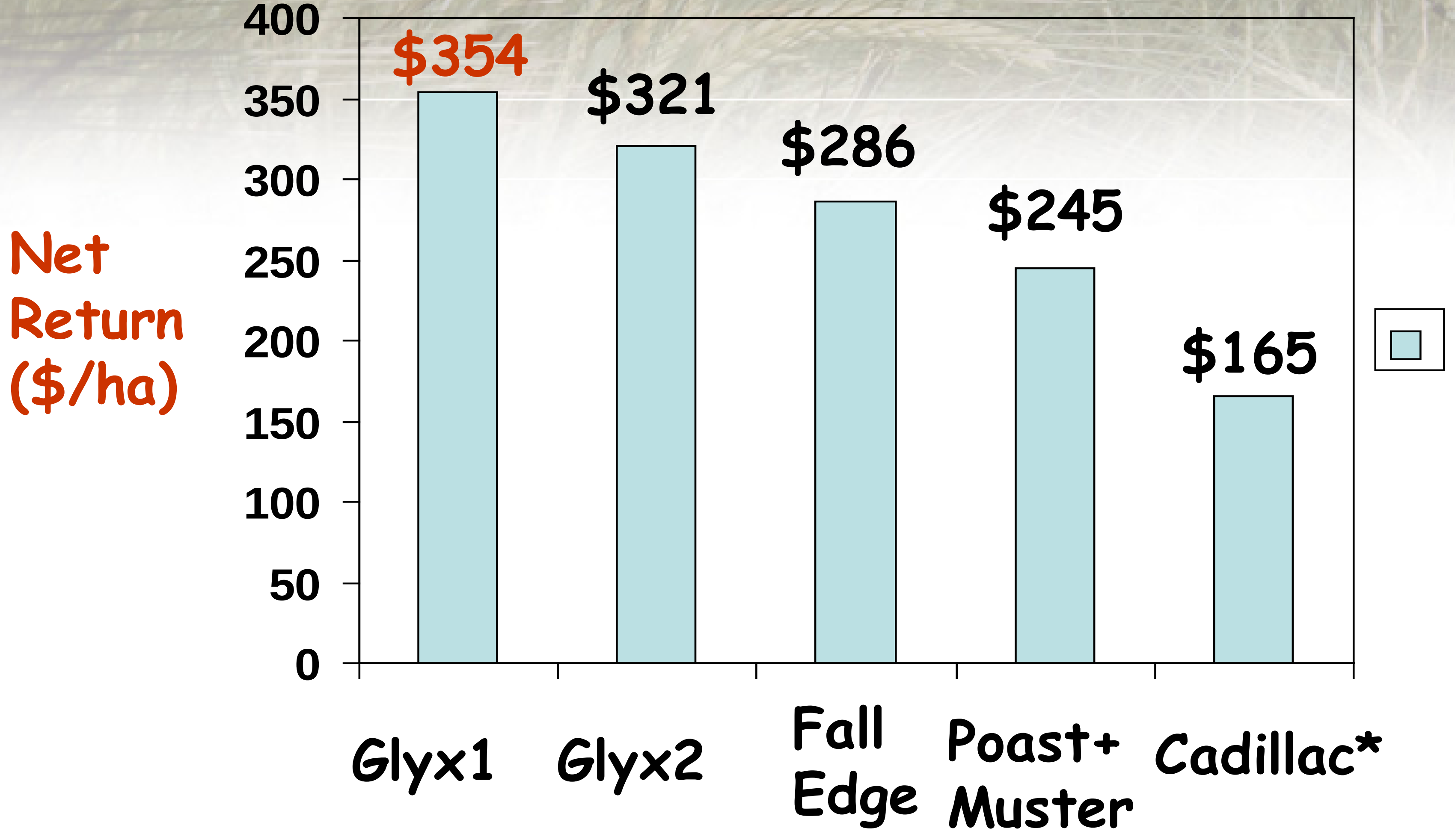
Comparison of RR system with conventional herbicide regimes



*Fall Edge+Poast+Muster+Lontrel

O'Donovan et al. 2006

Economic Impact of RR system with conventional herbicide regimes



*Poast+Muster+Lontrel (in-crop) + fall Edge

O'Donovan et al. 2006

Thankfully, I'm not a rat and I don't go swimming in groundwater for 8 days at a time…….!

Amount of active ingredient associated with different herbicide regimes

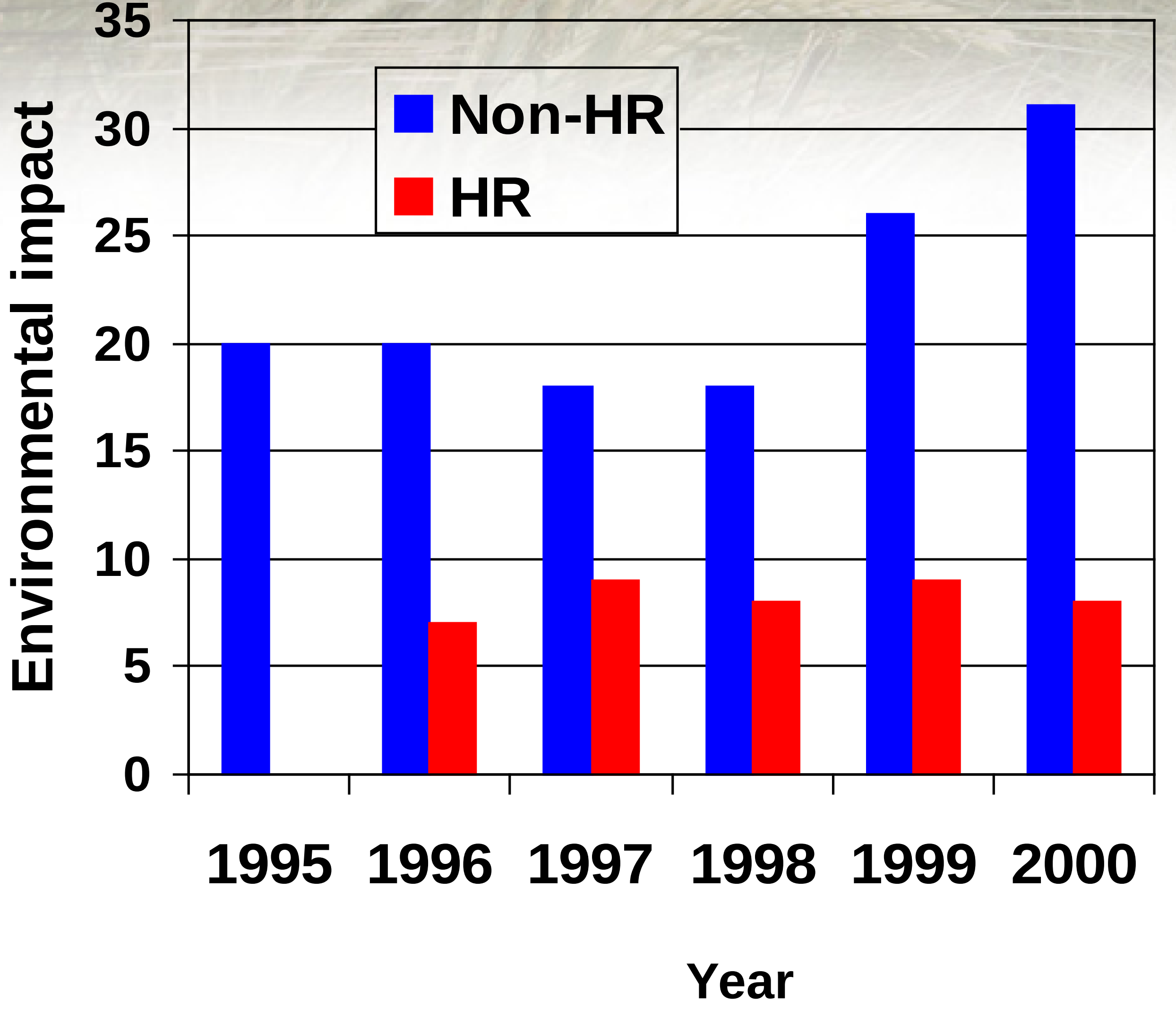
Herbicide regime	Active ingredient g/hectare
*Cadillac	2,482
Fall Edge + 2,4-D	1,660
**Glyphosate pre-seed + twice in-crop	1,350
**Glyphosate pre-seed + once in-crop	900

*Poast+Muster+Lontrel (in-crop) + fall Edge

**Roundup Ready system

O'Donovan et al. 2006

Environmental impact of herbicide use in HR canola



Brimner et al. 2005

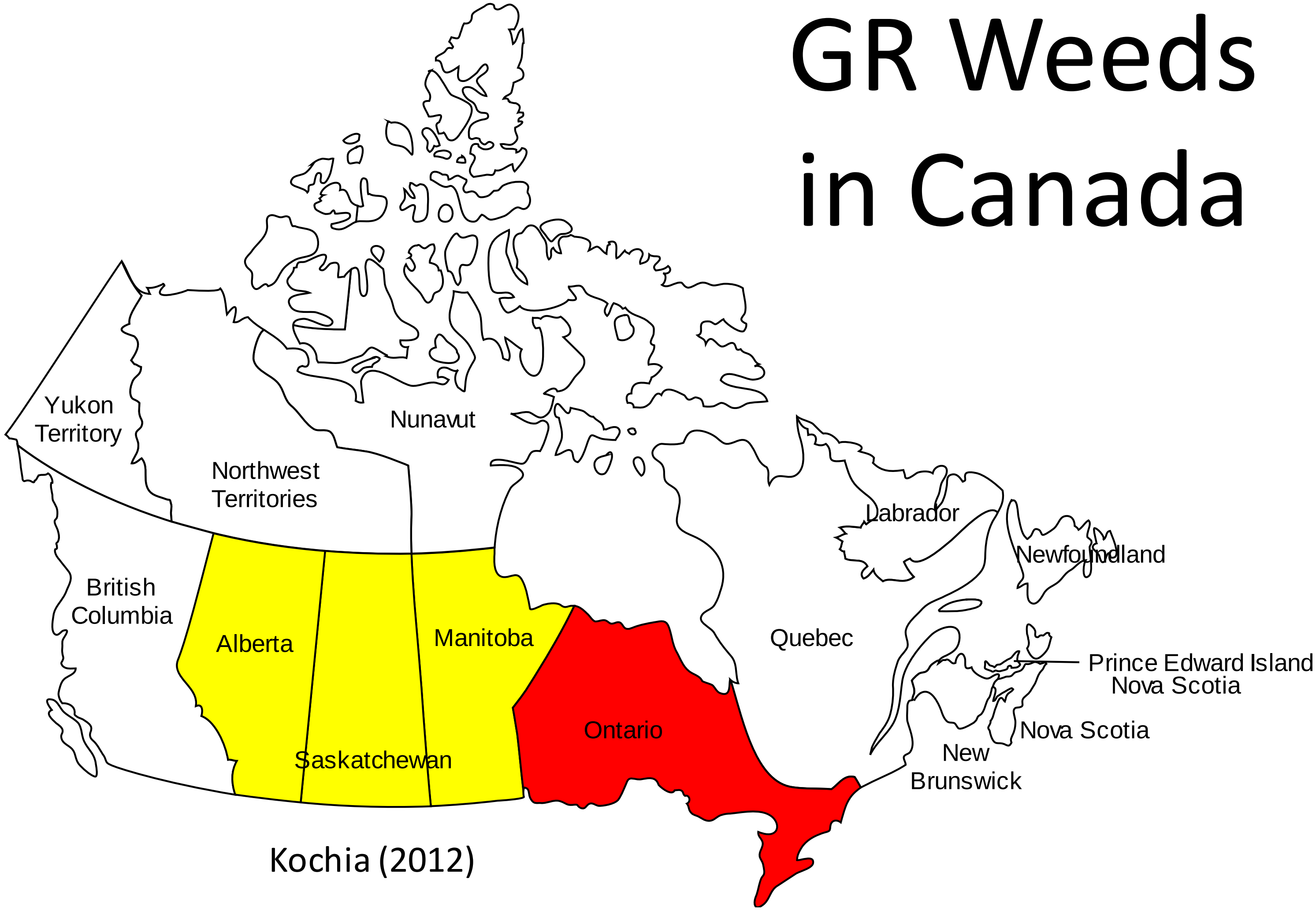
Weed resistance to glyphosate – when sound agronomy succumbs to the magic bullet

- 1996 - *Lolium rigidum* - Rigid Ryegrass
  - ✓ Australia, USA, South Africa
- 1997 - *Eleusine indica* – Goosegrass
  - ✓ Malaysia
- 2000 - *Conyza canadensis* – Horseweed
  - ✓ USA many States)
- 2001 - *Lolium multiflorum* - Italian Ryegrass
  - ✓ Chile, Brazil, USA
- 2003 - *Plantago lanceolata* - Buckhorn Plantain
  - ✓ South Africa
- 2003 - *Conyza bonariensis* - Hairy Fleabane
  - ✓ South Africa, Spain, Brazil, USA
- 2004 - *Ambrosia artemisiifolia* - Common Ragweed
  - ✓ USA (several states)
- 2004 – *Ambrosia trifida* – Giant ragweed
  - ✓ Indiana, Kansas
- 2005 - *Amaranthus palmeri* - Palmer Amaranth
  - ✓ USA (Georgia)
- 2005 – *Sorghum halepense* - Johnsongrass
  - ✓ Argentina
- 2005 – *Amaranthus rudis* – Common waterhemp
  - ✓ Illinois, Kansas
- 2006 – *Euphorbia heterophylla* – Wild poinsetta
  - ✓ Brazil
- 2007 – *Echinochloa colona* – Junglerice
  - ✓ Australia

First case of suspected glyphosate resistance in Canada – Giant ragweed in RR soybean

Source: Heap. 2008. www.weedscience.org

GR Weeds in Canada



Kochia (2012)

Giant ragweed (2008)

Canada fleabane (2011)

Common ragweed (2012)

Waterhemp (2014)

Slide courtesy of Dr. Neil Harker AAFC-Lacombe

Economic Impacts of Glyphosate Resistant Weeds
"New" Weed Tool in Arkansas (Hoe)

Slide courtesy of Dr. Neil Harker AAFC-Lacombe

Theme and sub-themes

- Agronomic and Economic impacts of cropping systems research
  - Seed Treatments

Background

- What are the bottlenecks preventing wider adoption of winter wheat?
  - Poor stand establishment leading to less than ideal yield – Spring wheat growers will grow spring wheat after ‘train wrecks’ but a new winter wheat grower may never plant a fall cereal again if he/she experiences a crop failure
- Anecdotal reports disagreed over the potential of seed treatments to improve stands emergence and establishment, crop vigor, and yield
- Hypotheses:
  - 1) seed treatments can improve crop competitiveness of winter wheat and responses may differ between active ingredients
  - 2) Applications of foliar fungicides in fall will improve crop health, vigor and competitiveness

Expt 211. Winter wheat response to seed treatment and fall fungicide applications.

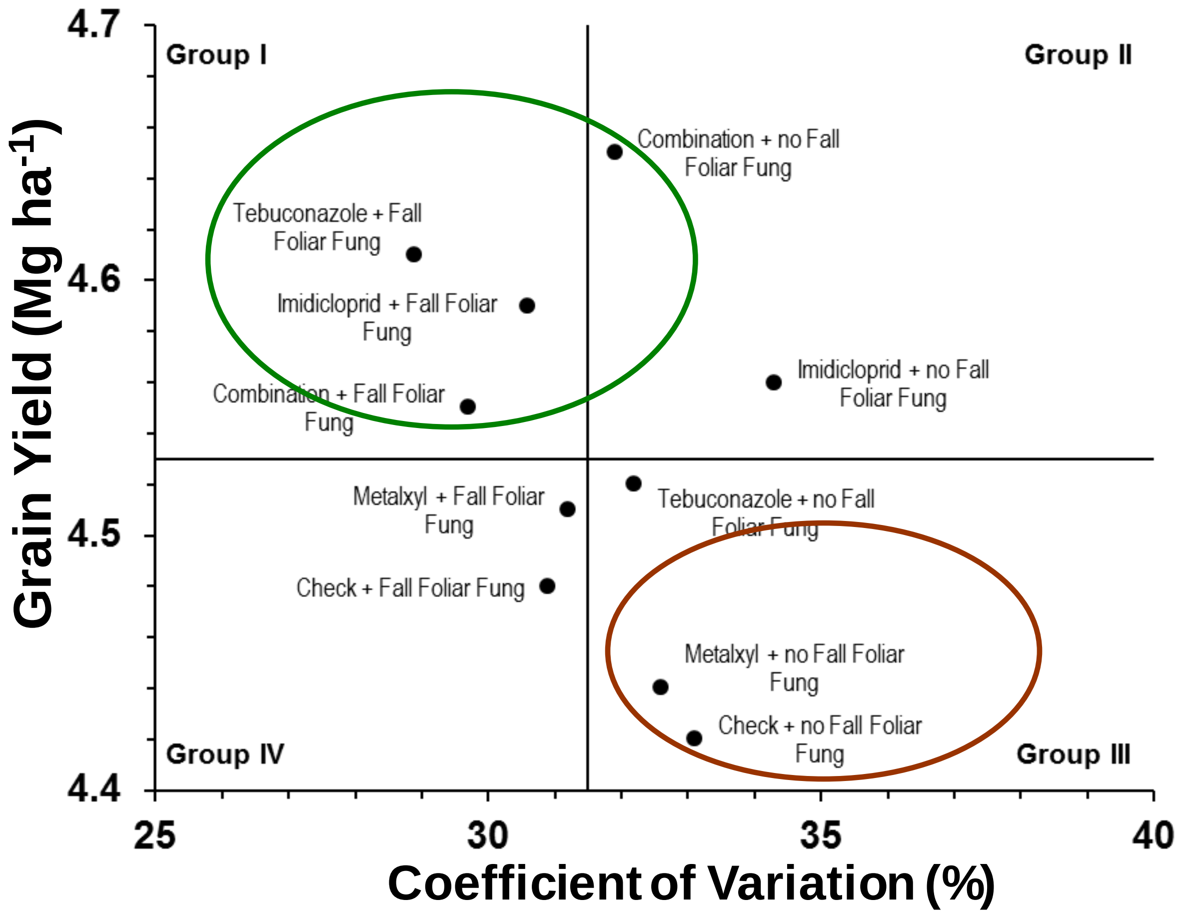
- Locations: Lethbridge (irrigated; rainfed clay loam and silty clay sites), Medicine Hat, Beaverlodge and Lacombe, AB; Scott, Melfort, Canora, and Indian Head, SK; and Brandon, MB
- Treatments:
- Seed Treatments: (5)
  - a) Check – untreated seed
  - b) Fungicide 1 – to control Fusarium, Cochliobolus and seed borne fungi (Septoria, smuts and bunts) - **tebuconazole** (Raxil 250).
  - c) Fungicide 2 – to control Pythium only - **metalxyl (Allegience)**
  - d) Insecticide – to determine insect damage only, such as wireworms – will be **imidicloprid** (Stress Shield™).
  - e) Combination product of fungicide and insecticide (Raxil WW™) with **tebuconazole, metalxyl and imidicloprid**.
- Fall Foliar Treatments (2):
  - a) Check (no fungicide)
  - b) **prothioconazole** (Proline™) applied at 3-4 leaf stage in mid-October

Effects of Dual Seed Treatment on Winter Wheat

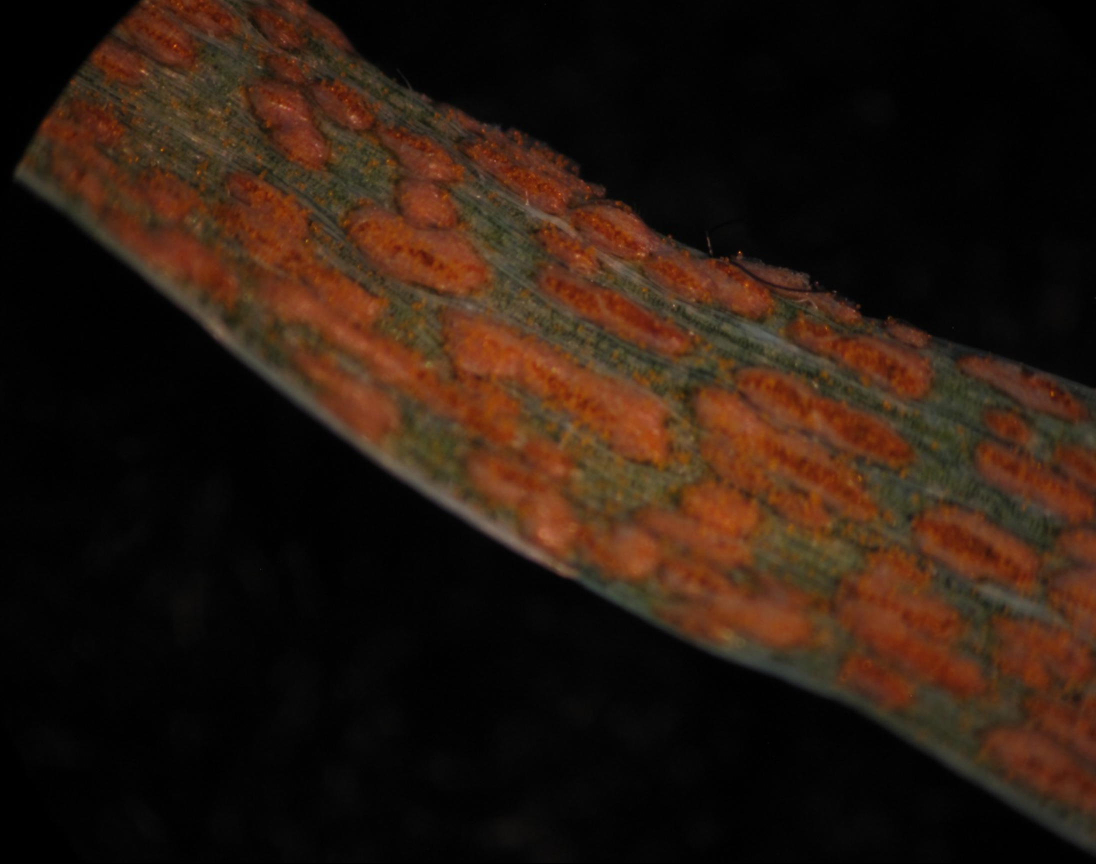
Fig. 1. Control treatment of winter wheat (cv. CDC Buteo) - no seed treatments applied (Lethbridge, AB Canada, 2011).

Fig. 2. Winter wheat (cv. CDC Buteo) treated with dual fungicide/insecticde (Lethbridge, AB Canada, 2011).

Winter Wheat Yield Responses to Seed Treatment and Fall Foliar Fungicide – Based on 20 Pan-Prairie Site-Yrs 2011-12



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



Source: Randy Kutcher – AAFC Melfort
cv. CDC Buteo

Source: Mike Gretzinger – SARA Lethbridge
cv. CDC Buteo

Does It Pay? Average for 20 Pan-Prairie Site-Yrs 2011-12.

Treatment	Seed Costs ($/ha)	Grain Yield (t/ha)	Econ Return @ 11% ($/ha) †	Econ Return @12% ($/ha)	Econ Return @ 13.5% ($/ha)
Control	127	4.42	$1022	$1040	$1128
Control with Proline	155	4.52	$1020	$1038	$1129
Raxil WW	145	4.62	$1056	$1075	$1167
Raxil WW with Proline ‡	173	4.61	$1026	$1044	$1136

†Prices based on final Farmer Payments reported by the Canadian Wheat Board
http://cwb.ca/_uploads/documents/1112payments/2011-12_tonnes.pdf
‡Addition of fall-applied foliar prothioconazole (Proline) at sites with stripe rust further improved net returns to those reported above.

Expt 221. Winter wheat response to seed size, density and seed-applied fungicide/insecticide treatments.

- Locations: Lethbridge (irrigated; and rainfed clay loam and silty clay sites), Medicine Hat, Beaverlodge and Lacombe, AB; Scott, Melfort, Indian Head, and Canora, SK; and Brandon, MB
- Experimental design: Four replicate randomized complete block with a factorial arrangement of treatments.

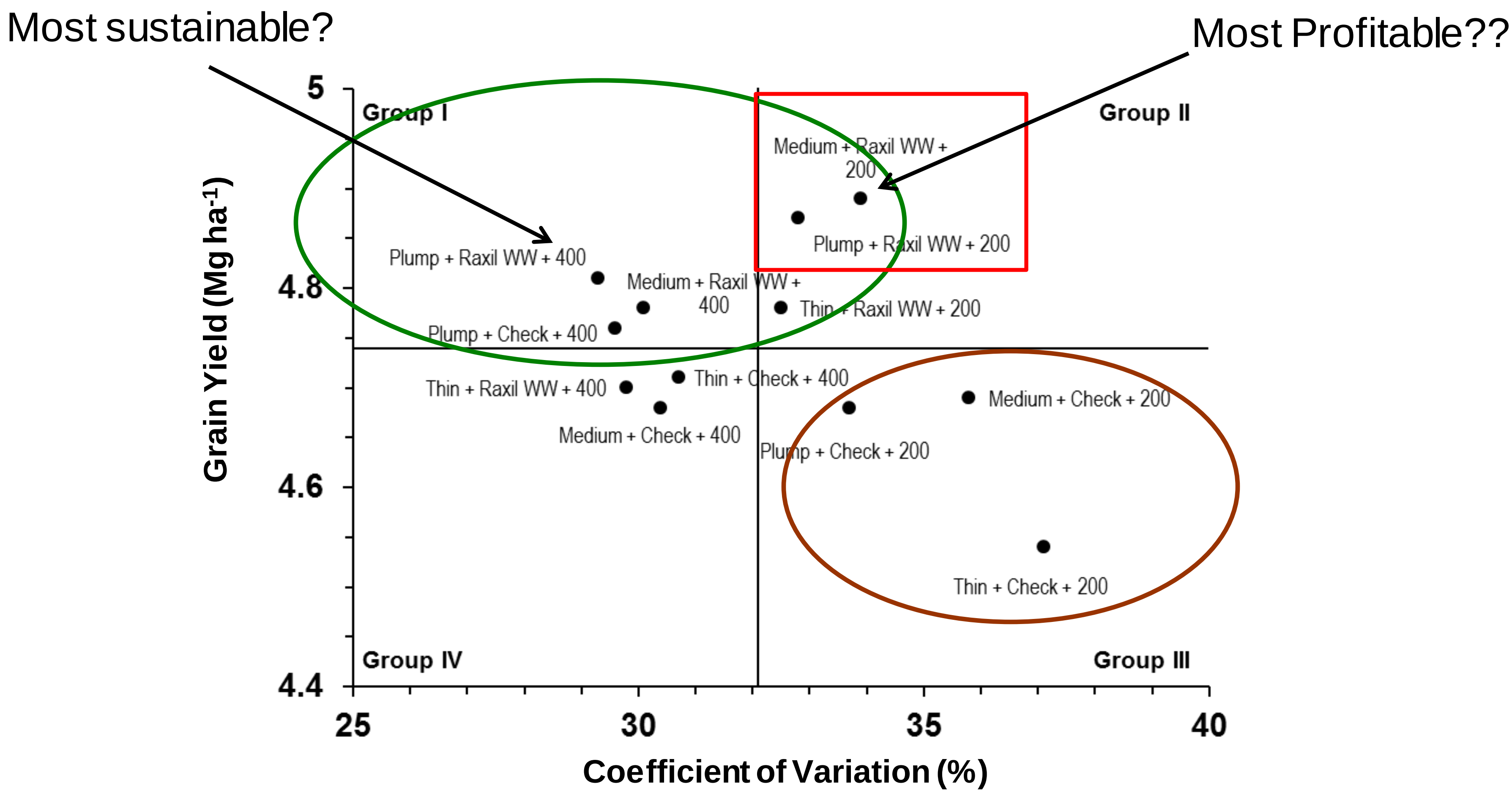
Treatments:

- 1. Seeding Rate (2):
  - a) 200 seeds m^{-2}
  - b) 400 seeds m^{-2}
- 2. Seed Size (3):
  - a) Light
  - b) Moderate (bulk seed not sized)
  - c) Heavy
- 3. Seed treatment (2):
  - a) Check
  - b) Dual Fungicide/Insecticide (Raxil WW™)

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).

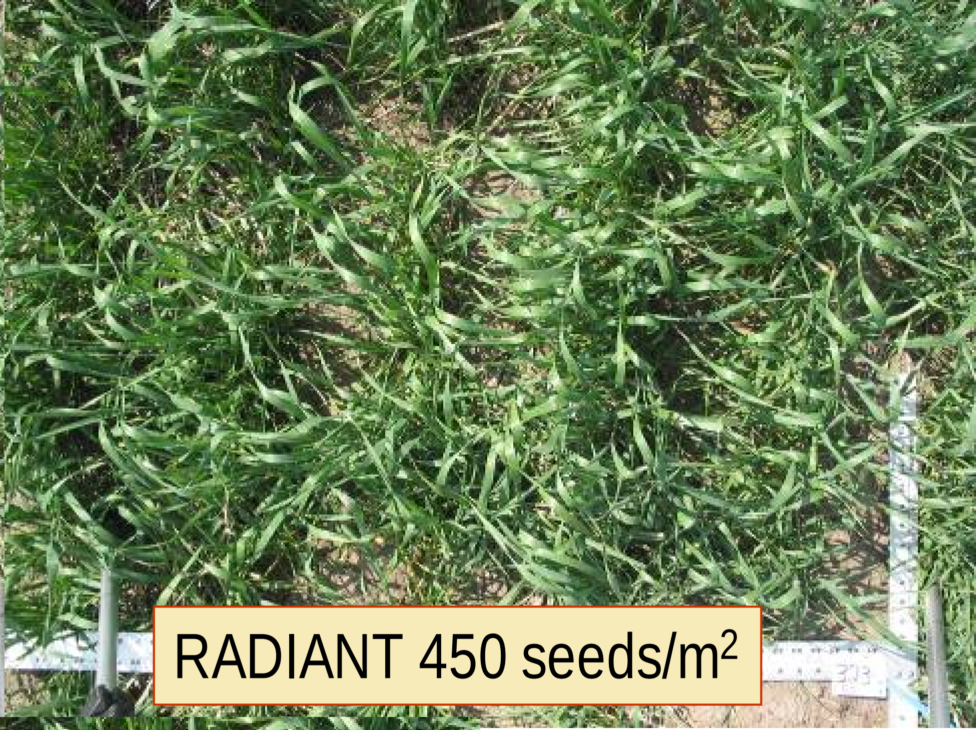
Winter Wheat Yield Responses to Seed Size x Seed Treatment x Sowing Density – Based on 20 Pan-Prairie Site-Yrs 2011-12



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

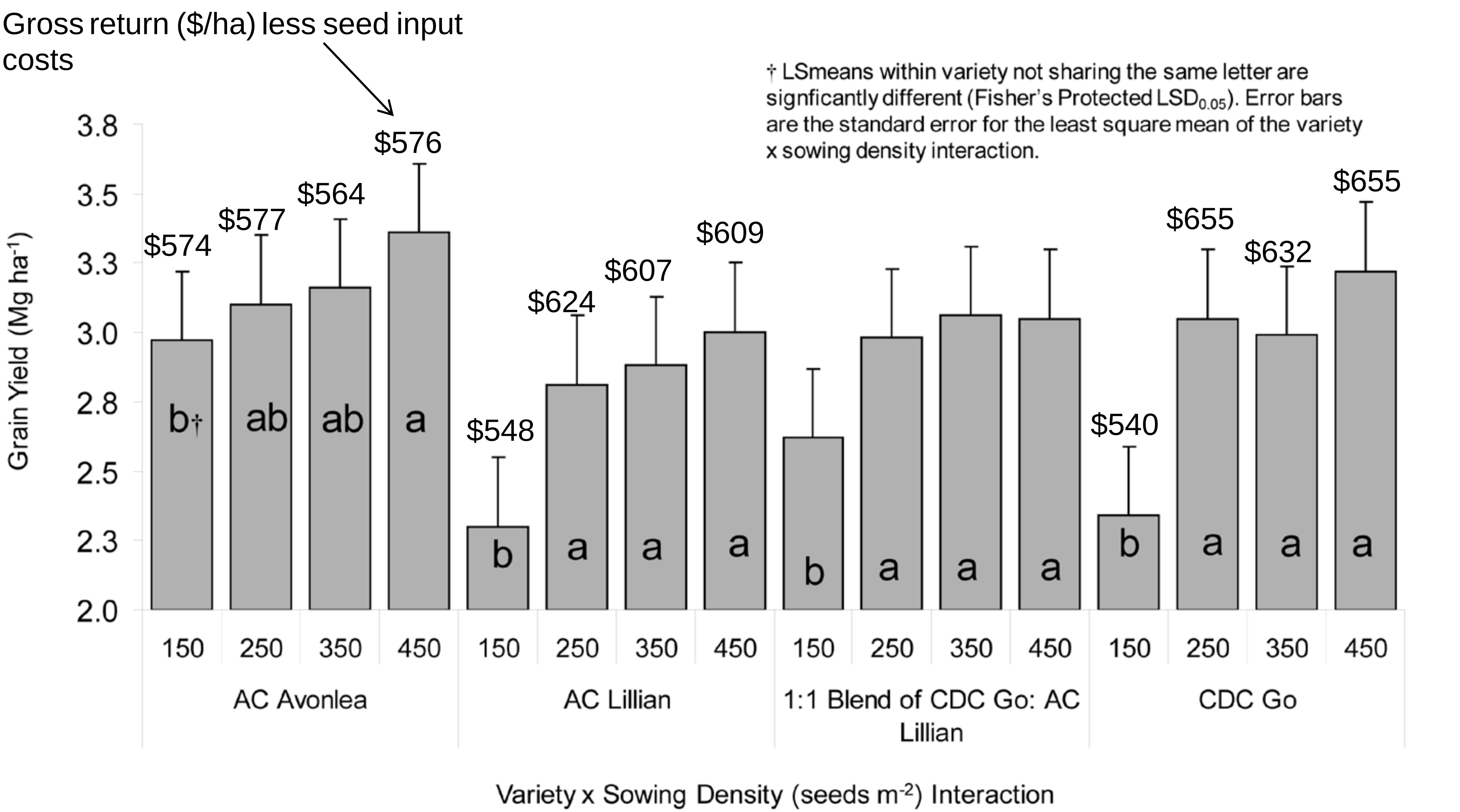
Theme and sub-themes

- Agronomic and Economic impacts of cropping systems research
  - Seeding and nitrogen rates



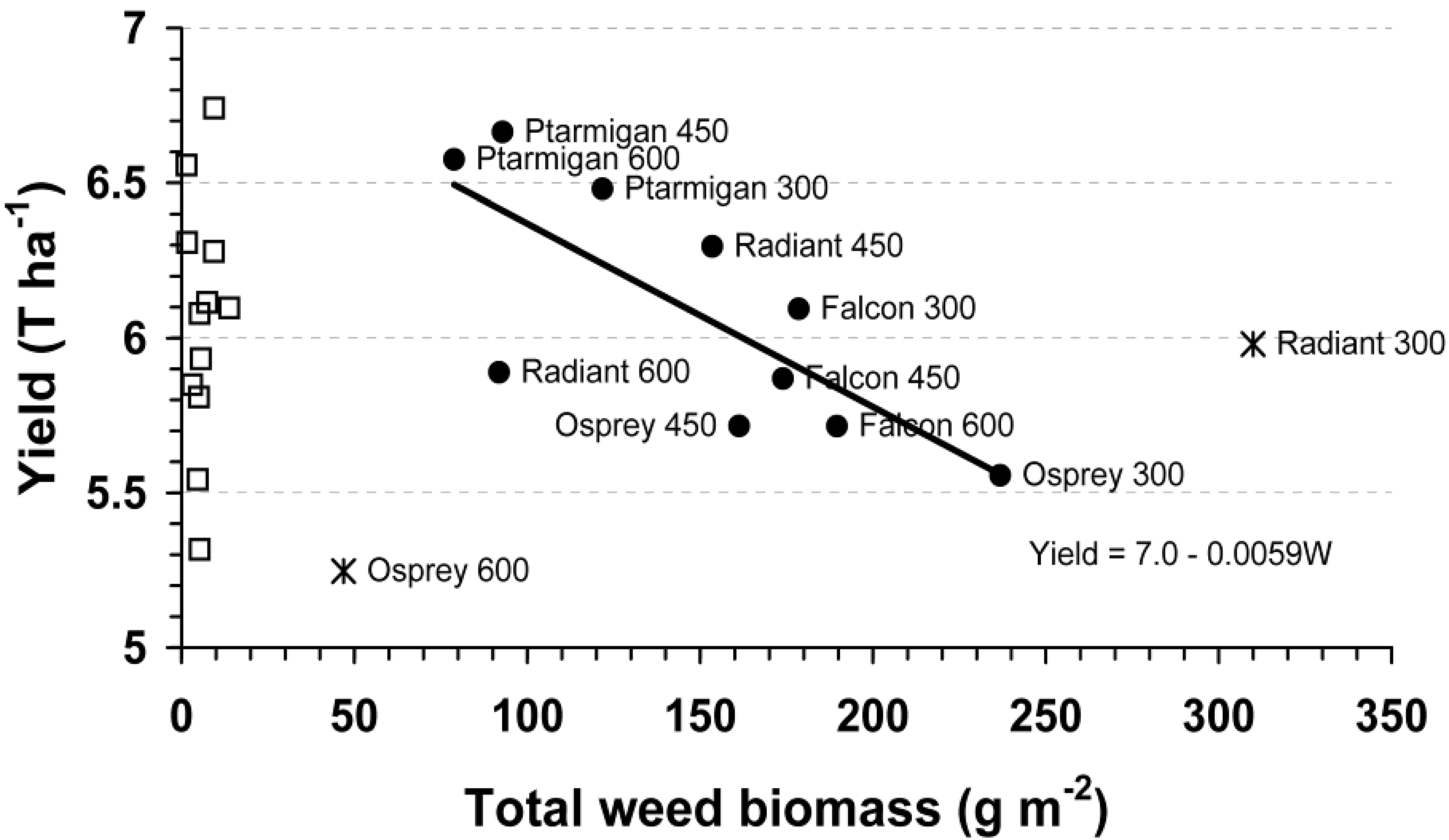
Source: Beres et al. Agronomy Journal **102**:649-657

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



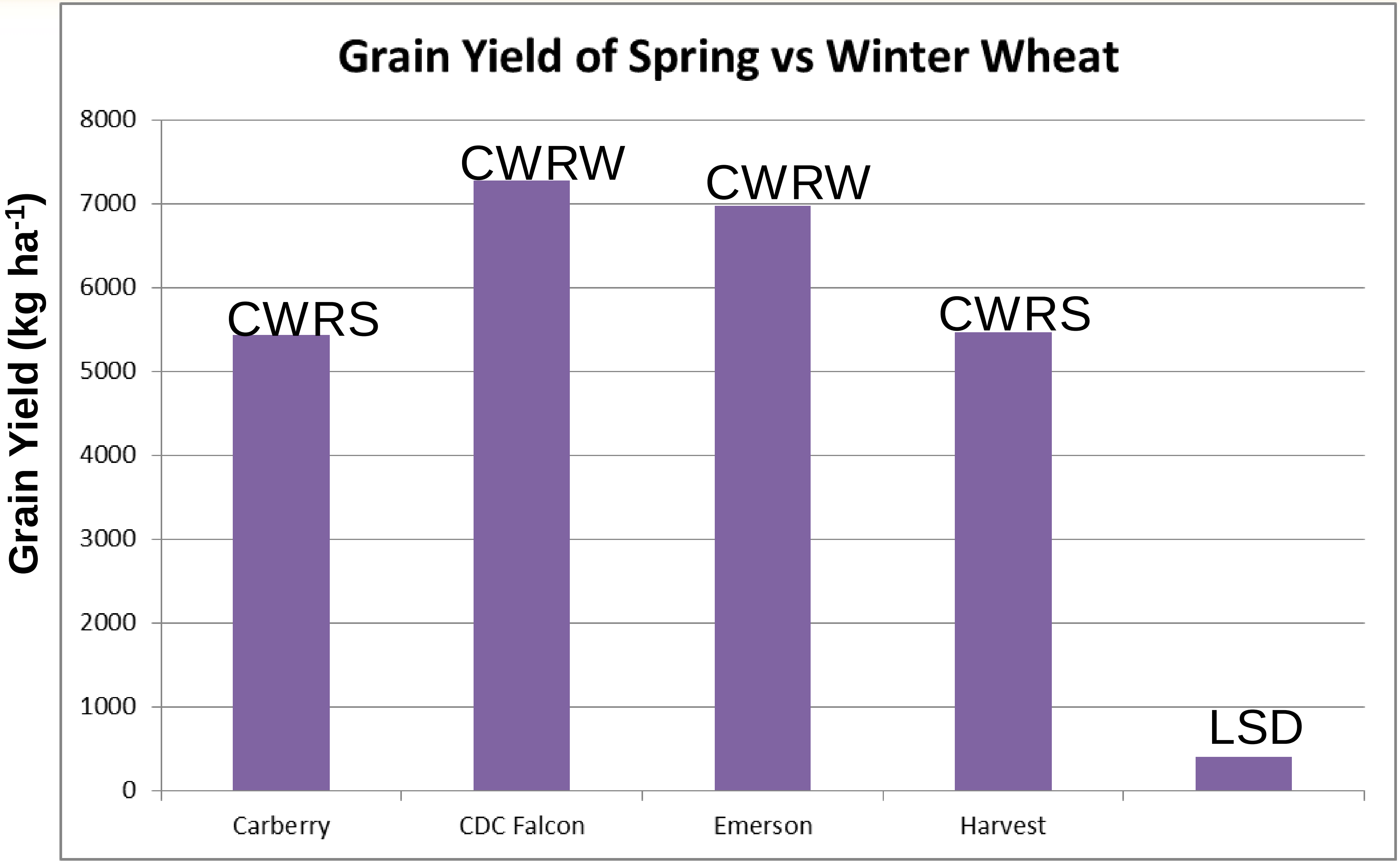
Beres, B.L., H.A. Cárcamo, R-C Yang, and D.M. Spaner. 2011. Integration of variety selection and sowing density to manage wheat stem sawfly in durum and hard red spring wheat. Agronomy Journal 103: 1755-1764.

What is the economic impact of a reduced weed seedbank??



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

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



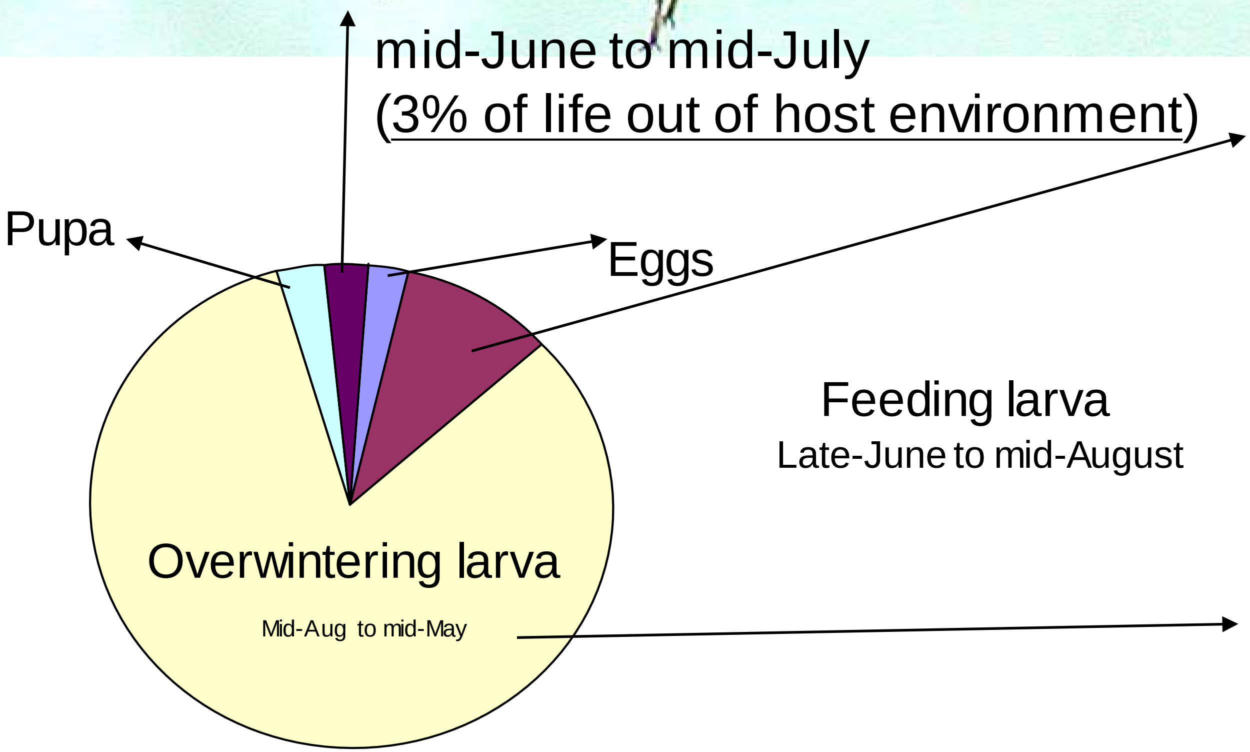
Based on grain yield from 2 sites in southern AB and Rosebank, MB

Prairie Canada Winter Wheat ('000 Ac.)

source: Stats Canada

Winter wheat is an eco-friendly crop providing nesting habitat to ducks – **what are ecosystem services worth??**

Source: Paul Thoroughgood, Duck's Unlimited Canada



Wheat Stem Sawfly Life Cycle

~ 5 M hectares of wheat in sawfly region
~ $ 10 -150 M annual losses ($450M incl USA)
#1 Economic Production Constraint for Wheat in Montana

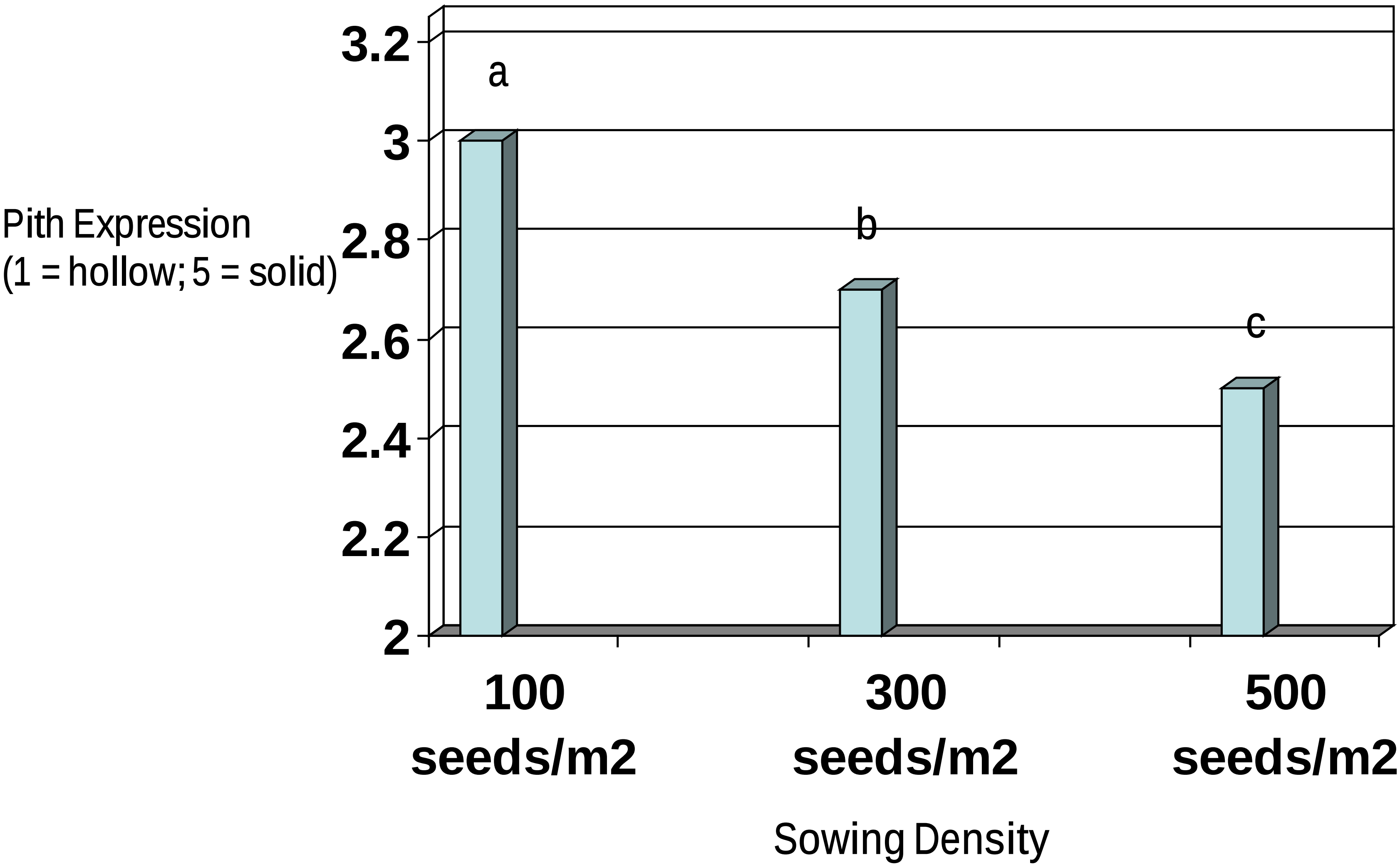
Beres, B. L., Cárcamo, H. A. and Byers, J. R. 2007. Effect of wheat stem sawfly damage on yield and quality of selected Canadian spring wheat. Journal of Economic Entomology 100(1):79-87#1 Economic Production Constraint for Wheat in Montana

Beres, B. L., Dosdall, L. M., Weaver, D. K., Spaner, D. M. and Cárcamo, H. A. 2011. The biology and integrated management of wheat stem sawfly, Cephus cinctus (Hymenoptera: Cephidae), and the need for continuing research. Canadian Entomologist 143:105-125.

Resistant Varieties Are Not A ‘Magic Bullet’ Solution!!

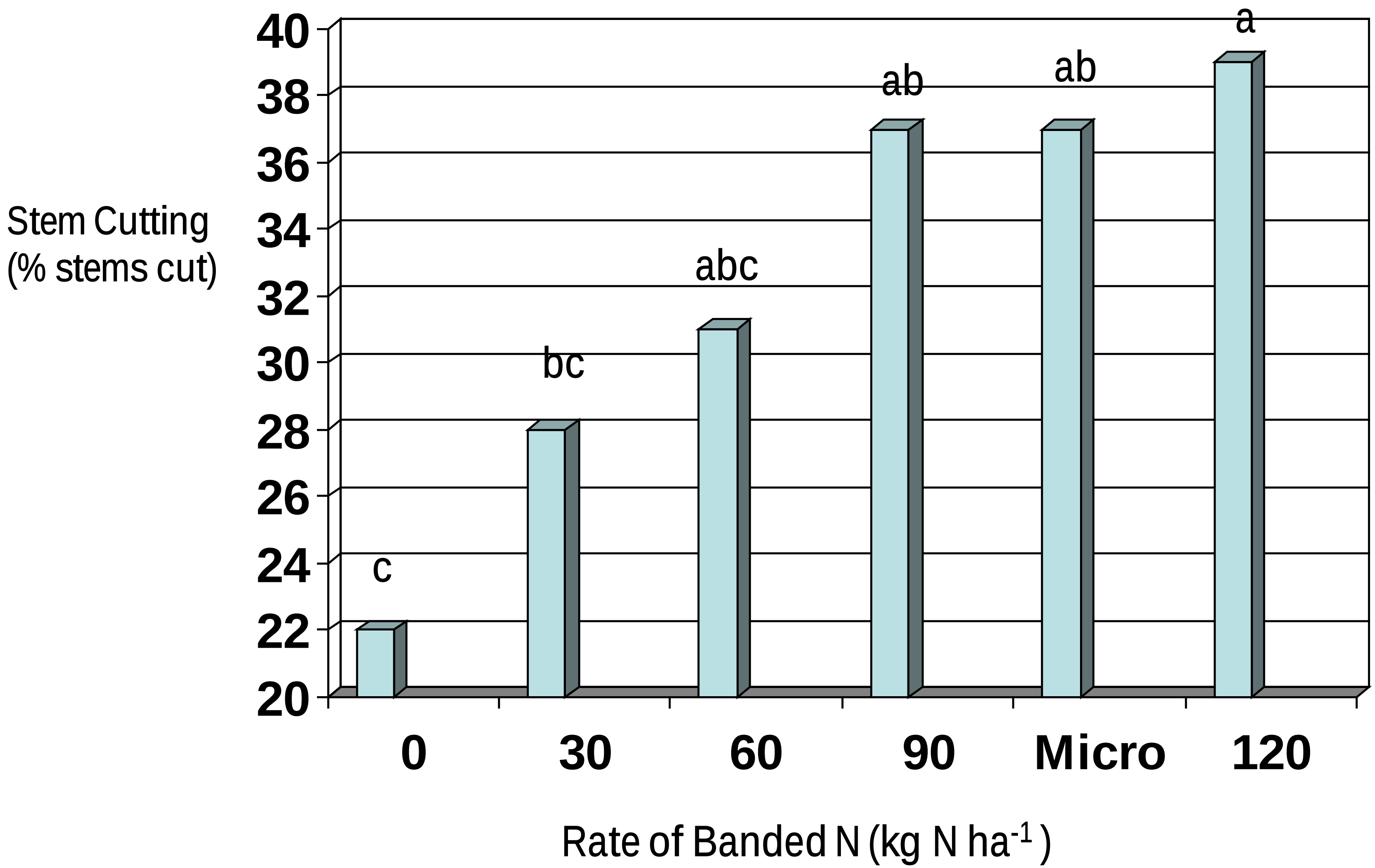
Precipitation-related weather influences genes controlling pith expression.
(Solid-stemmed wheat cv Lillian near Esk, SK in 2006)

Seeding Rate Influences Pith Expression in Solid-Stemmed Hard Red Spring Wheat Cultivars



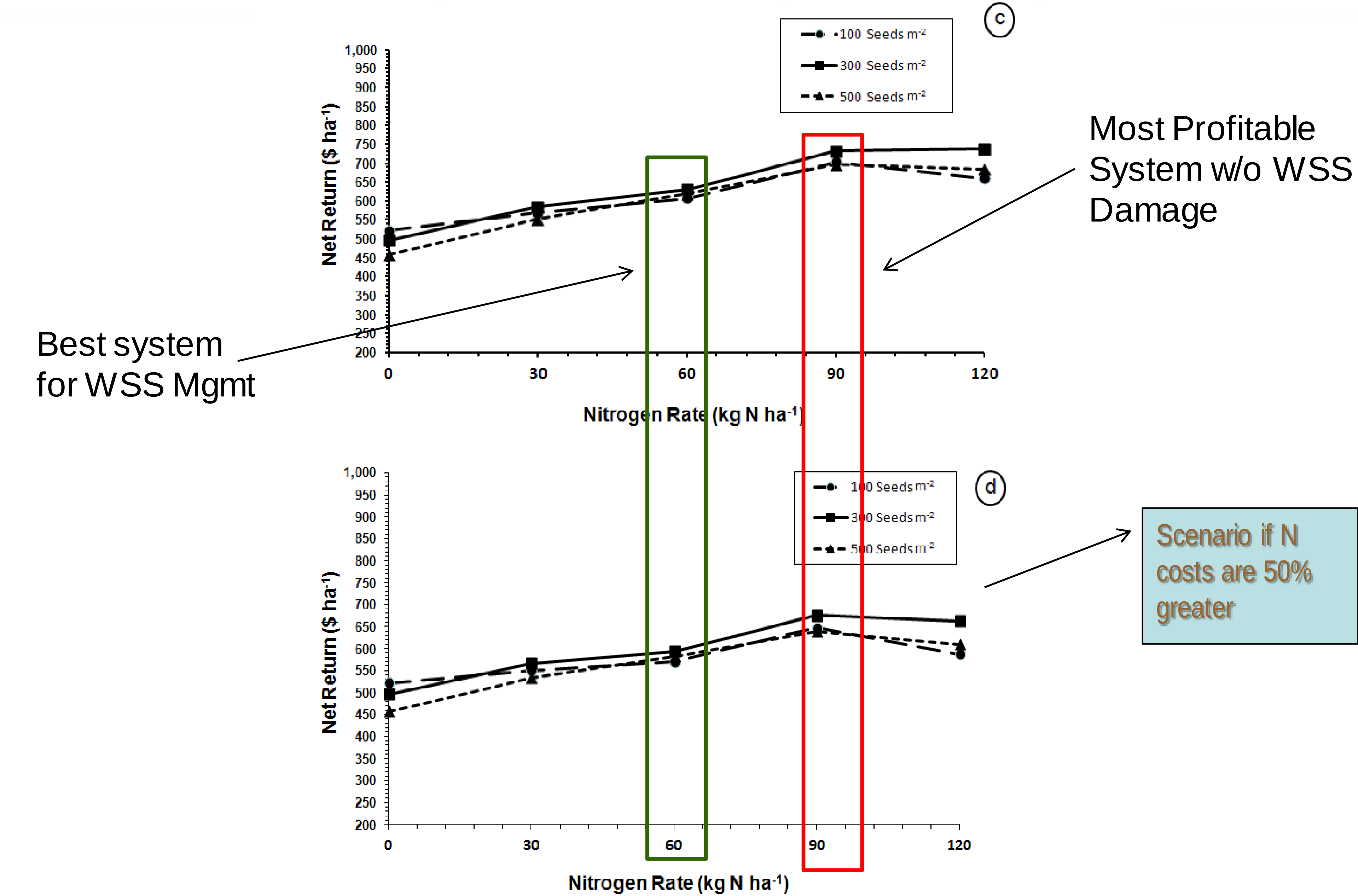
No Effects From N Fertilizer or Micronutrient Blends Observed.

Nitrogen Rate Influences Stem Cutting Damage by Wheat Stem Sawfly in Solid-Stemmed Hard Red Spring Wheat Cultivars



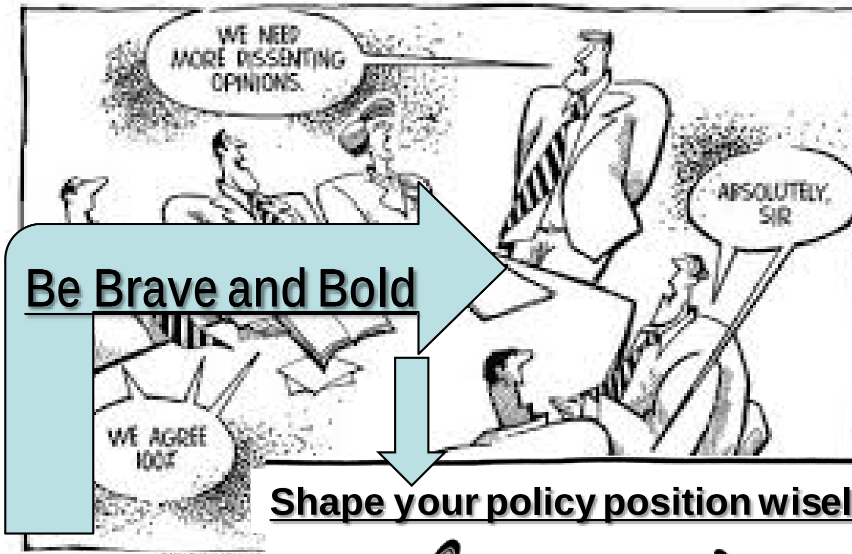
Micro trt: 90 kg N ha-1+ 10x the recommended rate of micronutrient blend

Economic Analysis – Profitability vs. Best Mgmt for WSS



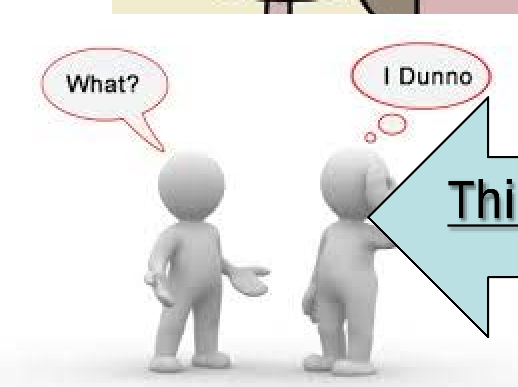
Final Thoughts

- Agronomic data is complex & multi-dimensional – avoid the tendency to simplify it for the sake of quick and easy conclusions or prescriptions.
- Ag Economists often have the final word on research outcomes so tread lightly but fearlessly!

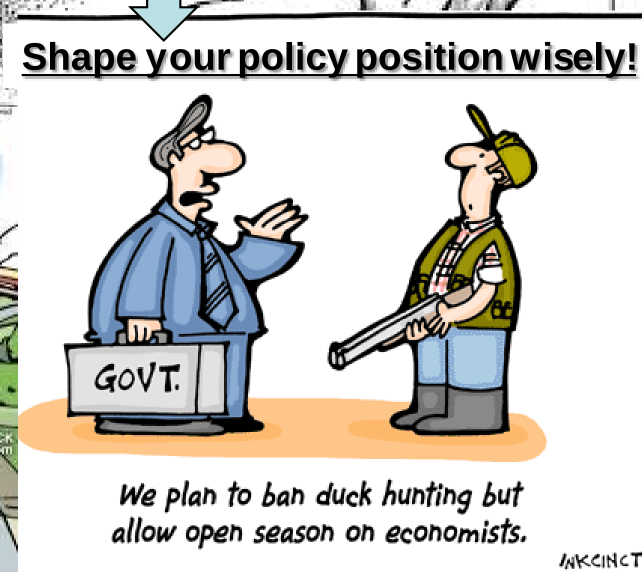


Be Brave and Bold

Shape your policy position wisely!



Think it Through!



Thank-you, AAEA!

- Dr. Dan LeRoy – University of Lethbridge
- Dr. Elwin Smith – AAFC-Lethbridge
- Mr. Jose Barbieri – AAFC-Lethbridge