Navigating the Intersection of Agronomic Research and Economic Implications

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Agronomics x Economics

• ‘ultimate purpose is to provide management guidelines to the producer’
• ‘Ideally, by applying sound economic theory to data from agronomic experiments’


“We are neither hunters nor gatherers. We are economists.”
A Hypothetical: Crop Scientist Asks for Stats and Econ Help.....at the 11th hr

Why didn’t you ask me that at the beginning of the study??!

New York Times – Morgan Schweitzer
In Crop Production Systems There Are No Magic Bullets........
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.


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

<table>
<thead>
<tr>
<th>Effect / Level</th>
<th>heads</th>
<th>KWT</th>
<th>plants</th>
<th>Protein</th>
<th>TWT</th>
<th>yield</th>
<th>biomass</th>
<th>broadlfwt</th>
<th>grassywt</th>
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<tr>
<td>(no. plant⁻¹)</td>
<td>(mg)</td>
<td>(no. m⁻²)</td>
<td>(%)</td>
<td>(kg hL⁻¹)</td>
<td>(Mg ha⁻¹)</td>
<td>(kg ha⁻¹)</td>
<td>(kg ha⁻¹)</td>
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<tr>
<td>T*Ce-LDR</td>
<td>1.56</td>
<td>39.4</td>
<td>209</td>
<td>9.45</td>
<td>69.5</td>
<td>3.49</td>
<td>976</td>
<td>50.5</td>
<td>54.0</td>
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<tr>
<td>T*C-MDR</td>
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<td>41.0</td>
<td>217</td>
<td>9.67</td>
<td>69.7</td>
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<td>TT-LDR</td>
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<td>CT*P-HDR</td>
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<td>224</td>
<td>9.74</td>
<td>69.6</td>
<td>3.94</td>
<td>1077</td>
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<td>11</td>
<td>0.27</td>
<td>0.3</td>
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<td>71</td>
<td>34.3</td>
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<td>(Variance estimate)</td>
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<tr>
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<td>1</td>
<td>7</td>
<td>0</td>
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<td>1</td>
<td>1</td>
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<td>5.3 Mg ha(^{-1})</td>
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<tr>
<td>CT*P-HDR</td>
<td>2.14</td>
<td>5.90</td>
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<td>T*C-MDR</td>
<td>2.09</td>
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<td>T*Ce-LDR</td>
<td>1.96</td>
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<td>T*P-MDR</td>
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<td>T*inP-MDR</td>
<td>1.93</td>
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<tr>
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<tr>
<td>LSD(_{0.05})</td>
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</table>
### Does Canola Respond Similarly to Rotational Diversity?

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

Canola-Triticale 2 Yr Rotation

Canola-Trit-Field Pea 3 Yr Rotation
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?

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

†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

Canola area (%)

Year


Total HR

Glyphosate-HR

Glufosinate-HR

Imidazolinone-HR

Bromoxynil-HR
Comparison of RR system with conventional herbicide regimes

Weed Biomass (kg/ha)

Glyx2  136
Glyx1  296
Cadillac*  410
Poast+Muster  1182
Fall Edge  1393

*Fall Edge+Poast+Muster+Lontrel

O’Donovan et al. 2006
Economic Impact of RR system with conventional herbicide regimes

Net Return ($/ha)

Glyx1  $354  Glyx2  $321  Fall Edge  $286  Poast+Muster  $245  Cadillac*  $165

*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.......!

NEW STUDY
ROUNDUP HERBICIDE DAMAGES SPERM

Roundup altered rats' testicular function after only 8 days of exposure at a concentration of only 0.5%, similar to levels found in water after agricultural spraying. The study found no difference in sperm concentration, viability and mobility, but there was an increase in abnormal sperm formation measured 2, 3, and 4 months after this short exposure.

www.facebook.com/gmofreeusa  www.gmofreeusa.org  Tatto/gmofreecanadagroup
## Amount of active ingredient associated with different herbicide regimes

<table>
<thead>
<tr>
<th>Herbicide regime</th>
<th>Active ingredient g/hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Cadillac</td>
<td>2,482</td>
</tr>
<tr>
<td>Fall Edge + 2,4-D</td>
<td>1,660</td>
</tr>
<tr>
<td>**Glyphosate pre-seed + twice in-crop</td>
<td>1,350</td>
</tr>
<tr>
<td>**Glyphosate pre-seed + once in-crop</td>
<td>900</td>
</tr>
<tr>
<td>*Poast+Muster+Lontrel (in-crop) + fall Edge</td>
<td></td>
</tr>
<tr>
<td>**Roundup Ready system</td>
<td></td>
</tr>
</tbody>
</table>

*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

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)

52% of all hectares handweeded
US$72.69/ha (max = US$370/ha)

2011 Photo: Jason Norsworthy
University of Arkansas

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/insecticide (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

Grain Yield (Mg ha\(^{-1}\))
Coefficient of Variation (%)
## Does It Pay? Average for 20 Pan-Prairie Site-Yrs 2011-12.

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


‡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

Most sustainable?  Most Profitable??

Grain Yield (Mg ha⁻¹)

Coefficient of Variation (%)

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
RADIANT 300 seeds/m²

RADIANT 450 seeds/m²

RADIANT 600 seeds/m²

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

Gross return ($/ha) less seed input costs

$574
$577
$564
$576
$548
$540
$624
$607
$609
$655
$655
$632

Gross return ($/ha) less seed input costs

**Grain Yield (Mg ha⁻¹)**

<table>
<thead>
<tr>
<th></th>
<th>AC Avonlea</th>
<th>AC Lillian</th>
<th>1:1 Blend of CDC Go: AC Lillian</th>
<th>CDC Go</th>
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</thead>
<tbody>
<tr>
<td>Sowing Density</td>
<td>150</td>
<td>250</td>
<td>350</td>
<td>450</td>
</tr>
<tr>
<td>Variety</td>
<td>b†</td>
<td>ab</td>
<td>ab</td>
<td>a</td>
</tr>
</tbody>
</table>

† LSmeans within variety not sharing the same letter are significantly different (Fisher’s Protected LSD₀.₀₅). Error bars are the standard error for the least square mean of the variety x sowing density density interaction.

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

![Graph showing yield versus total weed biomass](image)

Grain Yield (kg ha\(^{-1}\))

Why Should Winter Wheat Be Such a Tough Sell??
Prairie Canada Winter Wheat (‘000 Ac.)

How do we get to 3 or even 5 million acres of winter wheat in Prairies??

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

- **Eggs**: Mid-June to mid-July (3% of life out of host environment)
- **Feeding larva**: Late-June to mid-August
- **Overwintering larva**: Mid-Aug to mid-May
- **Pupa**:
~ 5 M hectares of wheat in sawfly region
~ $ 10 - 150 M annual losses ($450M incl USA)
#1 Economic Production Constraint for Wheat in Montana


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

Pith Expression (1 = hollow; 5 = solid)

Sowing Density

100 seeds/m²
300 seeds/m²
500 seeds/m²

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

Stem Cutting (% stems cut)

Rate of Banded N (kg N ha⁻¹)
Micro trt: 90 kg N ha⁻¹ + 10x the recommended rate of micronutrient blend
Economic Analysis – Profitability vs. Best Mgmt for WSS

Scenario if N costs are 50% greater

Most Profitable System w/o WSS Damage

Best system for WSS Mgmt

NetReturn ($ ha⁻¹)

Nitrogen Rate (kg N ha⁻¹)

NetReturn ($ ha⁻¹)

Nitrogen Rate (kg N ha⁻¹)
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!

Think it Through!

Be Brave and Bold

Shape your policy position wisely!
Thank-you, AAEA!

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