Rotational Diversity Effects in a Cereal-Based Cropping System.

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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.
Canadian Triticale Biorefinery Initiative (CTBI) 2008-2012 – Agronomy Objectives

- Biosafety Assessment
- Novel Germplasm
- Benchmark triticale to wheat for ethanol.
- Cropping Systems
Benchmarking Triticale Against Wheat
Benchmarkeding starch performance of triticale in w. Canada

- Triticale would provide **improved gross margins to the grower** in the 12 – 15% range at a delivered price of $105 per tonne vs. less than 8% for wheat at $110 per tonne.

- **No apparent disadvantage** to using triticale as a source of starch for ethanol production.

- **Triticale is a lower cost feedstock** for an industrial ethanol plant - $10 per tonne lower price than feed wheat.

- Therefore, A switch to Triticale = improved margins for the crop producer, and **equivalent ethanol plant operating margins to corn**

- **Assumptions based solely on starch data………..**

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 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.
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.
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.
<table>
<thead>
<tr>
<th>Effect / Level</th>
<th>heads (P value)</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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<tbody>
<tr>
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<td>&lt; 0.001</td>
<td>0.225</td>
<td>0.029</td>
<td>0.020</td>
<td>&lt; 0.001</td>
<td>0.003</td>
<td>0.162</td>
<td>0.715</td>
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**Means**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>(no. plant⁻¹)</th>
<th>(mg)</th>
<th>(no. m⁻²)</th>
<th>(%)</th>
<th>(kg hL⁻¹)</th>
<th>(Mg ha⁻¹)</th>
<th>(kg ha⁻¹)</th>
<th>(kg ha⁻¹)</th>
<th>(kg ha⁻¹)</th>
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<tbody>
<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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<td>T*C-MDR</td>
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<td>3.57</td>
<td>1013</td>
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<td>3.45</td>
<td>936</td>
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<td>71</td>
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**(Variance estimate)**

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<td>1</td>
<td>7</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>27</td>
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Triticale Grain Yield Responses to Rotational Diversity – Based on 23 Pan-Prairie Site-Yrs 2008-14

- 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 (%)

10 15 20 25
Triticale Biomass Yield Responses to Rotational Diversity – Based on 23 Pan-Prairie Site-Yrs 2008-14

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

Coefficient of Variation (%)

Biomass Yield (kg ha⁻¹)
## Sensitivity Analysis for Triticale Yield in Low and High Production Environments

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Site mean</th>
<th>2.0 Mg ha(^{-1})</th>
<th>5.3 Mg ha(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT*P-HDR</td>
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<td>2.14</td>
<td>5.90</td>
</tr>
<tr>
<td>T*C-MDR</td>
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<td>2.09</td>
<td>5.60</td>
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<tr>
<td>T*Ce-LDR</td>
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<tr>
<td>T*P-MDR</td>
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<td>1.92</td>
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<td>T*inP-MDR</td>
<td></td>
<td>1.93</td>
<td>5.03</td>
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<tr>
<td>TT-LDR</td>
<td></td>
<td>1.97</td>
<td>4.88</td>
</tr>
<tr>
<td>LSD(_{0.05})</td>
<td></td>
<td>0.28</td>
<td>0.38</td>
</tr>
</tbody>
</table>
Similar findings in Canola-Wheat

Scenario A
- High water availability
- High input
- High disease

Yield (t ha\(^{-1}\))

Applied N (kg ha\(^{-1}\))

Canola-Wheat
Peas-Wheat
Cont. Wheat

# Does Canola Respond Similarly to Rotational Diversity?

<table>
<thead>
<tr>
<th>Effect / Level</th>
<th>Plants (P value)</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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<tr>
<td>(no. m⁻²)</td>
<td>(%)</td>
<td>(kg hL⁻¹)</td>
<td>(Mg ha⁻¹)</td>
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<tr>
<td>C*TP-HDR</td>
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<td>14.4</td>
<td>63.9</td>
<td>1.68</td>
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<tr>
<td>TC*-MDR</td>
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<td>13.8</td>
<td>64.1</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>
</tr>
</tbody>
</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.
β-glucosidase enzyme activity in triticale rhizosphere

Fig. 2. β-glucosidase enzyme activity in triticale rhizosphere at the Lethbridge irrigated rotation in 2013
Do Trends Change Over Time?

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

Years After Study Initiation
Conclusions

- Triticale grain and biomass increases with rotational diversity. Similar results in barley and wheat.

- If isolation was desired (ergot contamination, GM traits, etc.), continuous triticale would be \(~17\%\) less productive.

- Peas improved proxies for soil health but aboveground benefits to triticale yield components not as notable

- Canola grain yield not responsive to cropping sequences.
  - Removing canola from the rotation caused a yield drag in cereals.

- Medium (6+ yrs) to long term studies are needed to observe rotational effects on rhizosphere
Co-Authors by Institution

- Agriculture and Agri-Food Canada:
  - Lethbridge, AB: Newton Z. Lupwayi, Francis J. Larney, Benjamin Ellert and Elwin Smith
  - Lacombe, AB: Thomas Kelly Turkington; Scott, SK: Eric Johnson
  - Normandin, QC: Denis Pageau

- CEROM - Saint-Mathieu-de-Beloeil, QC:
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