Doubling Down with Diversified, Integrated Cropping Systems

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- General trend of durum production
- Choice of cropping systems
- Management options for soil N
- Productivity vs environ. footprints
- Strip cropping possibility?
Historical changes of durum varieties on the Canadian prairie

(SCIC, 2014)
Seeded acres of durum wheat in Saskatchewan

Year

2001 2003 2005 2007 2009 2011 2013

acres

0 2000000 4000000 6000000 8000000 1000000 1200000 1400000 1600000 1800000 2000000

Summerfallow  Stubble

Seeded acres of durum wheat in Saskatchewan
Grain yield of durum wheat in the recent 14 years

89.6 kg/ha/year

Y = 89.6X – 1983
R² = 0.596
Choice of Cropping Systems for Durum

Conventional wheat monoculture

Pulse-intensified systems

Diversified systems
Growing $\text{N}_2$-fixing pulses in rotation prior to durum wheat.
Direct-seeding pulses in standing wheat stubble in rotation
Variable cost of growing crops in 2015

(SMA 2014)
Net incomes of various 4-yr rotations

(Gan et al. 2016)
Nitrogen Cycling

- Precipitation
- Nitrification
- Nitrites \((\text{NO}_2^-)\)
- Nitrification
- Nitrates \((\text{NO}_3^-)\)
- Denitrification
- Mineralization
- Ammonium \((\text{NH}_4^+)\)
- Fertilizers
- Gaseous losses \((\text{N}_2 & \text{N}_2\text{O})\)
- Nodules
- Lightning fixation
- Rhizobium fixation
- SOM

78%
Available Soil-N at Spring Seeding

Soil mineral N  
(kg N ha\(^{-1}\))

- **Deschp**
- **Kabchp**
- **Drybean**
- **Gmpea**
- **Yelpea**
- **Fababean**
- **Fallow**
- **Cfrdlen**
- **Lggnlen**
- **Redlen**
- **Smgnlen**
- **Barley**

Crops grown in previous year

- **Left-N in the 0-120 cm soil layers**
- **Increased N in the 0-30 cm depth**
- **Increased N in the 30-60 depth**

**P < 0.01**
Soil residual N after 4-years of rotations (in the 0-120 cm depth)

Pulse frequency

- 3 pulses
- 2 pulses
- 1 pulse
- 0 pulse

Rotation effect: $P = 0.010$
Wheat grain yield, N use, and NUE in the different rotation systems

(Wheat grain yield)

<table>
<thead>
<tr>
<th>System</th>
<th>Dry</th>
<th>Normal</th>
<th>Wet</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg ha⁻¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ContW</td>
<td>1352</td>
<td>2104</td>
<td>2205</td>
<td>1887</td>
</tr>
<tr>
<td>LentW</td>
<td>1033</td>
<td>2234</td>
<td>2474</td>
<td>1913</td>
</tr>
<tr>
<td>SEM</td>
<td>205</td>
<td>196</td>
<td>208</td>
<td>125</td>
</tr>
</tbody>
</table>

(NUE 46%)

(N use 32%)

(Wheat grain yield, N use, and NUE in the different rotation systems (Gan et al., 2015))
Soil C changes during the 25-yr (1985-2009) in different cropping systems

(Campbell et al. 2011)
GHG emissions (top) and carbon sequestered to soil (bottom) in different cropping systems (1985-2009)

(Gan et al. 2014)
Carbon footprints of different cropping systems

<table>
<thead>
<tr>
<th>Cropping systems</th>
<th>Year1 - year2 - year3</th>
<th>% decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse-pulse-durum</td>
<td></td>
<td>-34.8</td>
</tr>
<tr>
<td>Pulse-oilseed-durum</td>
<td></td>
<td>-22.5</td>
</tr>
<tr>
<td>Pulse-cereal-durum</td>
<td></td>
<td>-21.2</td>
</tr>
<tr>
<td>Oilseed-pulse-durum</td>
<td></td>
<td>-28.8</td>
</tr>
<tr>
<td>Oilseed-oilseed-durum</td>
<td></td>
<td>-23.6</td>
</tr>
<tr>
<td>Oilseed-cereal-durum</td>
<td></td>
<td>-17.1</td>
</tr>
<tr>
<td>Cereal-pulse-durum</td>
<td></td>
<td>-20.3</td>
</tr>
<tr>
<td>Cereal-oilseed-durum</td>
<td></td>
<td>-10.2</td>
</tr>
<tr>
<td>Cereal-cereal-durum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
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</tr>
</tbody>
</table>

Carbon footprint (kg CO$_2$e kg$^{-1}$ of grain)

(Gan et al. 2011)
Integrated Cropping Systems allows to:

- Increase crop productivity
- Improve N use efficiency
- Increase SOC
- Reduce carbon footprint
- Improve soil health
- Enhance long-term sustainability

Gan et al. (2014) *Nature Communications* 5:5012, doi:10.1038/ncomms6012;
Corn – pea strip cropping

- 6-rows of pea in 80 cm strip
- 2-rows of corn in 80 cm strip
Corn – pea strip cropping

3-rows of corn in 80 cm strip

4-rows of pea in 80 cm strip
Corn – soybean strip cropping

4-rows of soybean in 80 cm strip

2-rows of corn in 80 cm strip
Wheat – corn strip cropping

- 6-rows of wheat in 80 cm strip
- 2-rows of corn in 80 cm strip
Wheat – corn strip cropping

- 6-rows of wheat in 80 cm strip
- 2-rows of corn in 80 cm strip

Wheat grain-fulling stage
Corn is grown under plastic film
Film cover helps reduce soil evaporation during the entire growing season.

Weeds are blocked under the plastic film cover physically.
Grain yield (t ha\(^{-1}\))

- Maize - wheat: 27%
- Maize - rape: 41%
- Maize - pea: 42%
- Soybean - wheat: 5%
- Rape: Late-sown
- Pea: Early-sown
- Wheat
- Soybean
- Maize

***Land Equivalent Ratio: 1.21 to 1.43***

(Chai et al. 2013, 2014, 2016)
Research support

AAFC Cluster

SASKATCHEWAN pulse Growers

Western Grains Research Foundation

Growing Forward

WESERN AG INNOVATIONS

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Agriculture et Agroalimentaire Canada

canola council of Canada

NSERC

Barilla

canola council of Canada
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Ahmad Taheri
Walid Ellouze
Navid Bazghaleh
Mulan Dai
Zakir Hossain
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