Pulses in Rotation: 101 and Beyond

CARC Research Update
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LR = Land Resources and Environmental Sciences
AE = Ag Economics and Economics
Outline

1. 101 Review of pulses in dryland rotations.
2. Long-term pulse effects in no-till systems.
3. Future challenges – what role to pulses have to play?
4. Fun with pulses! – chickpea-flax intercrop?
101 Review

i. Pulse crop adaptation to dryland regions
ii. Nitrogen vs non-N rotational benefits – Can you make a N credit disappear?
iii. Time lags with N benefits?
Pulse crops evolved in semiarid regions

- Association with rhizobium so don’t need root system to scavenge nitrate-N

Photo – J. Holmes
Discussion about pulse adaptation?
Could pulse crops be grown in the Brown soil zone of Sask? … and would we see rotational benefits of wetter areas? - tillage x crop rotation study southwest Sask (Doug Derksen)
Yield of Wheat Recrop  
SwftCrnt&Congress, 1993-97 (Miller)

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Lentil</th>
<th>Pea</th>
<th>Chickpea</th>
<th>Sunflower</th>
<th>Mustard</th>
<th>Stubble</th>
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<td>Yield</td>
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23% avg yield increase on pulse stubble!

Grain Protein  
SwftCrnt&Congress, 1993-97 (Miller)

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<td>Protein</td>
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+ protein boost!
N vs Non-N Rotational Benefit

Beckie and Brandt 1997

Can you make a N credit disappear?

Barley Yield (bu/ac)

Nitrogen (lb/ac)
N Credits in Crop Diversity Rotation Study at Bozeman
Winter Wheat - Yield

Even though a 20-lb pea N credit was assumed.

28% greater on pea stubble

bu/ac

2001 2002 2003 2010HN 2010LN Average

stubble
- canola
- pea
N Credits in Two Rotation Studies at Bozeman
Spring Wheat - Yield

Even though a 20-lb pea N credit was assumed, 22% greater on pea stubble.
Nitrogen cycling time lag? - Bozeman

... but at daughter studies in northern Montana, was no lag observed.

[Graph showing change in soil N supply over time; pea hay (Sys 6) vs chem fallow (Sys 2)]

Despite taking a 36-lb N credit for pea hay

2012 = record drought
Discussion about N cycling/credits?
2. Long-term effects of pulses in rotation

i. 14-yr study Bozeman
   - Economics
   - Soil carbon and other soil attributes

ii. 6-yr ‘daughter’ studies at Dutton and Big Sandy
Long-term Sites

- Bozeman – deep silt loam
  - begun 2003
- Big Sandy – loam
- Dutton – clay loam
  - 2011 – 2016

Funding mainly by Montana Fertilizer Advisory Committee
### Table 1. Recent crop rotation in nine cropping systems in GGRS study begun at Bozeman in 2003.

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<tbody>
<tr>
<td>1) Fallow-Wheat (Till)</td>
<td>Fallow</td>
<td>Spring Wheat</td>
<td>Fallow</td>
<td>Winter Wheat</td>
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<tr>
<td>2) Fallow-Wheat (NT)</td>
<td>Fallow</td>
<td>Spring Wheat</td>
<td>Fallow</td>
<td>Winter Wheat</td>
</tr>
<tr>
<td>3) Continuous Wheat</td>
<td>Spring Wheat</td>
<td>Spring Wheat</td>
<td>Winter Wheat</td>
<td>Winter Wheat</td>
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<tr>
<td>4) Oilseed-Wheat</td>
<td>Flax</td>
<td>Spring Wheat</td>
<td>Winter Canola</td>
<td>Winter Wheat</td>
</tr>
<tr>
<td>5) Pea(seed)-Wheat</td>
<td>Spring Pea</td>
<td>Spring Wheat</td>
<td>Winter Pea</td>
<td>Winter Wheat</td>
</tr>
<tr>
<td>6) Pea(hay)-Wheat</td>
<td>Spring Pea (Hay)</td>
<td>Spring Wheat</td>
<td>Winter Pea (Hay)</td>
<td>Winter Wheat</td>
</tr>
<tr>
<td>9) ex-CRP/alfalfa: Pea(seed)-Wheat</td>
<td>Spring Pea</td>
<td>Spring Wheat</td>
<td>Winter Pea</td>
<td>Winter Wheat</td>
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</tbody>
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Systems 1-7 and 9 all split into Full and Half recommended N
2013-16 Net Returns to Land and Management (excl. insurance)

Messages:
1. Chem fallow > Till fallow
2. Pea-wheat best
3. Pea fallow ~ fallow
4. 4-yr hangover from CRP (alfalfa?)
Soil carbon measured Fall 2016 after 14 yr – Stephanie Ewing

1) Ex-CRP plot differentiating AFTER conversion back to annual cropping

2) N rate associating positively with SOC gain

3) All annual grain systems equal

4) Pea hay/manure systems = chem fallow

![Bar graph showing soil organic carbon measurements for different cropping systems. The cropping systems include Fall-W, F-W, W-W, P_{1}O-W, P_{2}W, P_{3}W, P_{4}W, and CRP.](image)
2016 Results - Dutton

Winter wheat Protein - Dutton 2016

Pea supplying greater N
6-yr Summed Net Returns per Acre

Pea – Wheat system best returns
Pea manure – not so much
Apr 7, 2017

0 N applied; June 29, 2017

June 29, 2017

Full N rate; June 29, 2017

0.9” rainfall event June 12-14 Rescued this crop; Biggest wheat kernels we’ve ever harvested

3.0 inches Apr - July
1. Amazing yields for 3.0” of rain!!!
2. Pea brown manure similar to Pulse for grain; less N responsive
Cumulative Net Returns 2012-17

Pulse-wheat system most profitable; Pea brown manure least

With steep protein discounts, it pays to fertilize aggressively
Apparent Nitrogen Fertilizer Recovery – 6 yr (Clain Jones)

Notable:

NFR much higher than reported nationwide and globally in literature (33 – 50%). Precip.

Leg Grain consistently produced higher profits, higher NFR, and lower leaching than Fallow. Win – win - win
Discussion about long-term aspects?
Future challenges – role of pulses?

1. Glyphosate-resistant kochia
2. Soil acidification

Things that weren’t even on our minds when study begun.

**Agronomics:**
CRP hangover. Organic hangover.

**Soils:**
Biology, other measures of soil Q
Seed zone acidity!
Pulses likely to be a help or a hindrance? What do you think?
14-yr of N fertilization reduced top 4” pH on dryland cropping west of Bozeman

Silt loam

Engel, Ewing, Miller, unpub data
Some dryland crop rotations reduced top 4” soil pH more than others

Silt loam

Engel, Ewing, Miller, unpub data
6-yr N fertilization reduce soil pH (0-3") west of Big Sandy

Alternate year was always winter wheat; Jones and Miller unpub data

100 lb N/acre
~0.15 pH units

why faster rate?

sandy clay loam

Fallow-WW
LegGrain-WW
Spwht-WW
PeaGM-WW

N Fertilization Rate

0N 3 lb avail N/bu
No Discussion please!
4. Fun with Pulses!

Chickpea-flax Intercrop
- Increased weed competition/over-yielding
- Ascochyta blight help
- Seeding/harvesting challenges

meh
Ooh, interesting!
Fun with Pulses: Chickpea-Flax Intercrop...

Intercropping chickpea and flax to manage disease (Ascochyta blight) – Interesting option for organic farming (seed late to avoid Pythium seed rot; likely helps with weeds).

Flax was competitive with chickpea (fix with optimal seed ratios, row orientation, or sowing timing?)

Harvesting WAS a major challenge for us with small plot combine (actually so was seeding).

2:1 Seed Rows

Malta, MT
June 25, 2018

2:1 Seed Rows
Malta, MT
June 25, 2018

June 26
Bozeman
1x rate chickpea
1/2x rate flax

Aug 16
Sep 7
No-till sown 22 d earlier but had lots of prick lettuce
OGRT was seeded as planned
OT flax component was sown too deep
Lost ~ 150 lb/ac chickpea in two of three (probably harvest losses in swath)

But we lost 160 – 470 lb/ac flax due to insufficient threshing!
<table>
<thead>
<tr>
<th>Intercrop Treatment</th>
<th>Lb/ac (12% moist)</th>
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<tbody>
<tr>
<td>C100N0</td>
<td>3000</td>
</tr>
<tr>
<td>CAWP5050N0</td>
<td>2000</td>
</tr>
<tr>
<td>CFlax5050N0</td>
<td>1000</td>
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Disease results from conventional trial at Post Farm.
Discussion?