MSU-Bozeman
Cover Crop Research

NPARL Focus Group Meeting

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Today’s objectives

- Summarize past cover crop research findings of the MSU Cropping Systems group
- Present results from recent and ongoing MSU cover crop studies
MSU single species cover crop research since 1999 has found higher grain yields and/or protein after cover crops when:

1. Seeding winter legumes (vs spring legumes)
2. Seeding spring cover crops early (vs late)
3. Terminating at first bloom (vs pod)
4. Tilling cover crop (vs spraying)

Why?

More N fixed (1)
More time for soil water to be recharged and N to become released from residue (1, 2, 3)
Faster N release and fewer N losses (4)
Questions still to be answered

- Do cover crop mixtures improve yield, protein, and soil health more than single species?
- Do yield and soil health benefits increase with number of cover crop cycles?
Study 1: Cover crop cocktails, one 2-year cycle, four site years

- Objective: Determine effects of “functional groups” within mixed cover crops on yield and soil health
- 2 sites in Triangle (Dutton and Conrad), 2 sites in Gallatin Valley (Amsterdam and Bozeman)
- 2\textsuperscript{nd} cc cycle at Conrad and Amsterdam was completed in 2014 (but no soil data yet)
- Full field component as well
### Study Sites

![Map of Montana showing study sites: Amsterdam, Conrad, Dutton, Bozeman.]

- **3 on-farm conventional**
- **1 university land**
- **3 yr minimum no-till**

### Methods

<table>
<thead>
<tr>
<th>Year</th>
<th>Amsterdam, Conrad</th>
<th>Bozeman, Dutton</th>
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</thead>
<tbody>
<tr>
<td>2012</td>
<td>cover crop</td>
<td>--</td>
</tr>
<tr>
<td>2013</td>
<td>wheat</td>
<td>cover crop</td>
</tr>
<tr>
<td>2014</td>
<td>cover crop</td>
<td>wheat</td>
</tr>
<tr>
<td>2015</td>
<td>wheat</td>
<td>cover crop</td>
</tr>
</tbody>
</table>
Plant Functional Groups & Species

**Nitrogen Fixers**
- Spring Pea: *Pisum sativum*
- Lentil: *Lens culinaris*
- Common Vetch: *Vicia sativa*

**Fibrous Root**
- Oats: *Avena sativa*
- Proso millet: *Panicum miliaceum*
- Italian Ryegrass: *Lolium multiflorum*

**Tap Root**
- Safflower: *Carthamus tinctorius*
- Purple Top Turnip: *Brassica rapa*

**Brassica**
- Daikon radish: *Raphanus sativus*
- Winter Canola: *Brassica napus*
- Camelina: *Camelina sativa*
Fallow

Pea

Full (8 species)

Nitrogen Fixers

Fibrous Roots

Tap Roots

Brassicas

Minus Nitrogen Fixers

Minus Fibrous Roots

Minus Tap Roots

Minus Brassicas (no turnip)

All photos: Steve Spence; Amsterdam, 14 June 2012
2013 Cover Crop Biomass

Bozeman  \( p<0.001 \)

Dutton  \( p=0.81 \)

6 species mixes had higher yield than 2 species mixes when sites combined (\( p=0.03 \))
Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)

Averaged over 0, 60, 120 lb N/acre

Spring Wheat Yield (bu/acre)

Fallow | Pea | N fixer | Brass | Fibr root | Tap root | No brass | No fibr | No N fix | No tap | All 8 spp

Housman et al., unpub. data, Dutton

Cover Crop Mix

2 Species

6 Species
Percent legume and termination timing affects plant available N (PAN)

Take home: Legume % less than 50 can result in low available N esp if terminated late

Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)

Housman et al., unpub. data, Dutton

Cover Crop Mix
Spring wheat yield at Dutton vs previous year total biomass (cc + weed)

What about soil health?

y = -7.25x + 46.4
R² = 0.72

Housman, Tallman, et al., unpub data, Dutton

What about soil health?
Microbial Biomass

Preliminary Results

![Graph showing microbial biomass](image)
Large soil temperature differences among treatments

Most soils were cooler under cover crop than under fallow (and fibrous cc) for over a month. Benefit?

Crops terminated on 7/11
## Summary after first full rotation

<table>
<thead>
<tr>
<th></th>
<th>Amsterdam</th>
<th>Conrad</th>
<th>Dutton</th>
<th>Bozeman</th>
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</thead>
<tbody>
<tr>
<td><strong>CC Biomass</strong></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
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<tr>
<td><strong>Biomass C:N</strong></td>
<td>8 spec&gt;Pea</td>
<td>ns</td>
<td>8 spec&gt;Pea</td>
<td>ns</td>
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<tr>
<td><strong>Microbial Biomass</strong></td>
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<td>ns</td>
<td>CCrop&gt;fallow</td>
<td>CCrop&gt;fallow</td>
</tr>
<tr>
<td><strong>PMN</strong></td>
<td>CCrop&gt;fallow</td>
<td>Pea&gt;MFR</td>
<td>CCrop&gt;fallow</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Olsen P</strong></td>
<td>ns</td>
<td>ns</td>
<td>Not analyzed</td>
<td>Not analyzed</td>
</tr>
<tr>
<td><strong>Max daily temp</strong></td>
<td>--</td>
<td>--</td>
<td>fallow&gt;CCrop</td>
<td>fallow&gt;CCrop</td>
</tr>
<tr>
<td><strong>Penetration resistance</strong>*</td>
<td>ns</td>
<td>Pea&gt;MFR</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

*ns – no significant difference between 8 species (full mix) and pea

* - penetration resistance less for fallow than CCs at Dutton and Conrad, likely due to higher water content, not less compaction so only CCs compared.*
Study 1: Take home messages on yield and soil quality

- After one cycle, spring wheat grain yields higher after pea and N fixers than most other mixes.
- Higher cover crop biomass correlated with lower spring wheat yield, likely b/c of more water and N use.
- Relatively few soil health differences; not unexpected given only one cycle.
Study 2: Eight-year, plot study

- Objective: Determine long-term effects of legume-containing rotations vs. fallow on subsequent wheat mainly in no-till.
- ~16 inch annual precip. (4 miles west of Bozeman)
Study 2. Experimental Design

- Unique feature is deep, uniform silt loam soil and relatively abundant winter precip. to recharge soils
- Focus here on no-till pea forage/legume cover crop-wheat vs. fallow-wheat
- Pea forage grown in 2003, 05, 07 and pea CC grown in 2009, terminated at full pod
- Spring or winter wheat planted in even years. 2010 was wettest of wheat years, 2012 record drought.
- 2 N rates: Full (3 lb available N/bu) and ½ N
Study 2: 8 year plot study, Grain yield in 8th year (2010)

@ 12% moist
Study 2: 8 year plot study, Grain protein in 8th year

Pea cover crop after 4 CC-wheat rotations saved 124 lb N/ac compared to fallow.
Study 2 Economics (2009 – 2012)

4 yr Average Discounted Present Value of Net Returns ($/ac)

Miller et al. (in press)
Study 2: Take home messages

- In the first 3 cycles, wheat grain yield was not higher after legume than after fallow.
- After 4 two-year cycles, wheat grain yield and protein were higher after legume CC than after fallow.
- Higher than normal precipitation in 2010 likely 1) increased release of available N from an increased organic N pool, and 2) made N limiting to growth.
- Over 100 lb N/ac was saved in 2010 following legume cover crop compared to fallow!
- Economic returns were more stable with cover crop (less dependent on N rate)
Conclusions

- In short term (1 CC-cycle studies), grain yield and protein are generally equal or less than after fallow.
- Early termination (by ~ first pea bloom) is key to preventing yield and protein losses.
- In short term studies, there does not appear to be yield or soil quality advantages of multiple species mixes over pea.
- In long term (4+ cycles), yield, protein, and net revenue can be higher after cover crops than fallow, especially at low N rates, likely from more available N.
- Cover crop value to soil health, subsequent crops, and possibly land value is expected to increase over time.
Acknowledgments

- USDA – AFRI
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- Jeff Holmes
Questions?

For additional information on soil fertility topics including information on cover crops, see http://landresources.montana.edu/soilfertility