Cover Crop Research Results

CPMS Bozeman

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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
The Summerfallow Challenge

**PROS:**
- Soil moisture recharge
- N benefit

**CONS:**
- Loss of organic matter
- Increased soil erosion
- Decreased soil structure
- Decreased water holding capacity
- Increased saline seeps
- Increased N leaching
- Decreased soil biological activity

Photo: Susan Tallman
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)
Plot Study No-till and Till: Three 2-year cycles

- **Objective:** Determine effects of legume species and tillage on subsequent spring wheat.
- ~14 inch annual precip. (central Gallatin Valley, MT)
- Field had been no-till for several years
Plot Study No-till and Till: Design

3 Crop Treatments:  
- Spring Pea Manure  
- Spring Lentil Manure  
- Fallow

X

4 Tillage Treatments:  
- No-Till (NT)  
- No-Till, Till (NTT)  
- Till (T)  
- Till, No-Till (TNT)

- Green manures terminated at first flower  
- Spring wheat planted at 4 N rates following year
Plot Study No-till and Till: Spring wheat yield & protein
Early-terminated spring cover crops did not hurt subsequent spring wheat grain yield or protein compared to fallow.

Higher N fixation by pea often produced higher subsequent spring wheat yield and/or protein.
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)
8-year Plot Study: 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
Legume or fallow year

Wheat year
8 Year Plot Study: Grain yield in 8th year (2010)

Grain yield (bu/ac) @ 12% moist

- Fallow
- Green Manure

Full N Rate
- a

Half N Rate
- b
- a
8 Year Plot Study:
Grain protein in 8\textsuperscript{th} year

Pea cover crop after 4 CC-wheat rotations saved \textbf{124 lb N/ac} compared to fallow.
8-year Plot Study: Economics (2009-2012)

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

Miller et al. (in press)
8-year Plot Study: 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)
Questions still to be answered

- Do cover crop mixtures improve yield, protein, and soil health more than single species?
- Do certain types of species increase soil health more than others?
- Do yield and soil health benefits increase with number of cover crop cycles?
Cover Crop Cocktails Plot Study: One to two 2-year cycles, four site years

- **Objective:** Determine effects of “functional groups” within mixed cover crops on yield and soil health (microbial respiration, soil enzyme activity, soil temperature, potentially mineralizable N, mycorrhizal colonization)

- 2 sites in Triangle (Dutton and Conrad), 2 sites in Gallatin Valley (Amsterdam and Bozeman)

- 2\(^{nd}\) cc cycle at Conrad and Amsterdam was completed in 2014 (preliminary soil data only to date)

- Full field component as well
Cover Crop Cocktails Plot Study: Study sites

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<thead>
<tr>
<th>Year</th>
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3 on-farm conventional
1 university land
3-yr minimum no-till

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Plant functional groups & species

**Nitrogen Fixers**
- Spring Pea
  - *Pisum sativum*
- Lentil
  - *Lens culinaris*

**Fibrous Root**
- Oats
  - *Avena sativa*
- Proso millet
  - *Panicum miliaceum*

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

**Brassica**
- Daikon radish
  - *Raphanus sativus*
- Winter Canola
  - *Brassica napus*

**Camelina**
- *Camelina sativa*
All photos: Steve Spence; Amsterdam, 14 June 2012
2012 Cover Crop Biomass

Amsterdam 2012
0.4 ton/acre

Conrad 2012
0.2 ton/acre

Photo: Steve Spence

Photo: Evette Allison

Photo: Steve Spence
2013 Cover Crop Biomass

Bozeman
1.7 ton/acre

Dutton
1.2 ton/acre
Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)

Housman et al., unpub. data, Dutton
Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)

Housman et al., unpub. data, Dutton
Spring wheat yield at Dutton vs previous year total biomass (cc + weed)

SW yield = (-7.25*CCbiomass) + 46.41

R² = 0.72

weeds in fallow

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

What about soil health?
Microbial Biomass

Preliminary Results

Microbial Biomass

ug CO₂ g soil⁻¹ hr⁻¹

Site

Amsterdam Conrad Dutton Bozeman

Treatment
FULL PEA SF MFR

a b ab a *
Potentially Mineralizable Nitrogen

Tallman, Housman, et al., 2014
Soil temperature at 2” deep much higher under fallow than cover crops

Cover crops terminated on 5 July

Soils were cooler under cover crop than fallow for over a month.

Benefit?

Jones, Miller, et al. unpublished
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<td>Biomass C:N</td>
<td>8 spec&gt;Pea</td>
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<td>8 spec&gt;Pea</td>
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<tr>
<td>Microbial Biomass</td>
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<td>CCrop&gt;fallow</td>
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<tr>
<td>PMN</td>
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<td>Pea&gt;MFR</td>
<td>CCrop&gt;fallow</td>
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<tr>
<td>Max daily temp</td>
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<td>fallow&gt;CCrop</td>
<td>fallow&gt;CCrop</td>
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<tr>
<td>Penetration resistance*</td>
<td>ns</td>
<td>Pea&gt;MFR</td>
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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.
Cover Crop Cocktails Plot Study: 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.
Cover Crop Cocktail Farm Study (2012 – 2013)

- 3 sites (Gallatin Valley and two in Triangle)
- Cover crops selected by growers and/or NRCS
- Growing season length somewhat on long side:
  - Site 1 (Gallatin Valley): May 29 – Aug 29
  - Site 2 (Triangle): Apr 12 – July 1
  - Site 3 (Triangle): May 5 – July 20
Cover Crop Cocktails Farm Study: Spring wheat yield after mixed CC, Gallatin Valley

Why was protein so much lower after mixed cover crops?
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

Willamette Valley, Oregon
Sullivan and Andrews, 2012
Cover Crop Cocktail Farm Study: Spring wheat yield after mixed CC, Golden Triangle
Yield and protein less after mixed cover crops on farmers’ fields, likely due to late termination and high water & N use
Cover Crop Cocktails Farm Study: Take home messages on yield and protein

- Spring wheat grain yield was lower after CC than fallow in two of three field-scale studies.
- Spring wheat grain protein was lower after CC than after fallow in all 3 studies.
- High water use from late termination was likely cause of yield differences.
- Low N availability from late termination & low legume % was likely cause of protein differences.
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
- USDA – WSARE
- NRCS – CIG
- Montana Fertilizer Advisory Committee
- Montana Wheat and Barley Committee
- Numerous landowners
- Ann McCauley
- Jeff Holmes
- Anton Bekkerman
- Mac Burgess
Questions?

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