Tonight’s host and co-host

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Cover Crops

Winter Soil Fertility Series: Week 7

Feb 17, 2021

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Photo by K. Olson-Rutz
Today’s goals

- Present cover crop management considerations
- Discuss cover crop effects on
  - Following crop yield, protein, and profit
  - Soil quality parameters, including SOM and N availability
- Answer the question: does cover crop diversity matter? (to soil quality, or cash crop yield and protein)
The Summerfallow Challenge

PROS:
Soil moisture recharge
N benefit
More consistent yields

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

Alternatives?
• No-Till
• Cover crops
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 covers early (vs late)
3. Terminating at first bloom (vs pod)
4. Tilling covers (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)
Our MT studies confirmed early Saskatchewan studies that termination timing is key, when water is limiting. Haying covers at early bloom produced higher sp. wheat yields the following year than harvesting pea when water or N limiting (Miller et al 2006).
Generally spring soil water and wheat yields are lower following covers than fallow

Soil water to 3’ depth; covers terminated at first flower, full-bloom, or pod stage.
14-year Plot Study: east of Bozeman

- Long-term effects of no-till pea grain, forage, or cover crop-wheat vs. fallow-wheat
- ~16” annual precip on deep soils & ability to recharge soils
- Pea terminated at full pod
- 2 N rates: Full (3 lb available N/bu) and ½ N
14-Year Plot Study:
Winter wheat grain yield in 14th year

Wheat grain yield (bu/acre, 2016)

Full N  1/2 N

Cropping system

NTF  PW grain  PW hay  PW cover
14-Year Plot Study:
Grain protein in 14\textsuperscript{th} year (2016)
Wheat protein is generally higher after cover than fallow

Questions?

On to economics of single species covers
Economics: 14-year Plot Study (2009-2012)
2010 was a wheat year, and had very wet spring

Note consistency of profit for Green Manures (GM)

Miller et al., 2015
Economics: 14-year Plot Study (2013-2016) 
dry years

Take home:
1) Pea grown for grain followed by winter wheat was big net revenue winner.
2) Full N rate best choice

$/acre summed 2013 to 2016

- Full N high discount
- Full N low discount
- 1/2 N low discount
- 1/2 N high discount

Crop system:
- NTF
- PW grain
- PW hay
- PW cover
14-year Plot Study: Take home messages

- Wheat grain yield and protein benefits take time
  - 3 - 4 CC cycles in high moisture years
  - 6 CC cycles with dry years
- Economic returns were more stable with cover crop (less dependent on N rate) and much higher with pea-grain than cover crop
- How do results compare in locations outside Gallatin Valley?
Average winter wheat yield, protein, annual net return after lentil green manure or grain (2005-2010)

Chen et al., 2012, Moccasin, MT, dryland, notill, shallow soil (18”), plot study

Grn manure > grain

Grn manure > grain

Grain > grn manure

Chen et al., 2012, Moccasin, MT, dryland, notill, shallow soil (18”), plot study
Take home: In short to long term studies, in different regions in Montana, pulse - wheat returns more profit than pulse cover crop - wheat, when cover crop sprayed out.

Questions?

On to covers
and soil health
Soil Quality vs Soil Health

**Soil Quality** = properties that change little, if at all, with land use management practices

- Texture
- pH
- Cation Exchange Capacity

**Soil Health** = dynamic properties which may be subjective to measure

- Aggregation
- Microbial activity
- Tilth
- Nutrient availability
- Water holding capacity
- Compaction

Which is more likely to be influenced by cover crops?

SON and SOM often included in both lists
Covers lower daily soil temperature (4 pm at 2” deep), which should benefit microbes (and more)

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

Covers lower daily soil temperature (4 pm at 2” deep), which should benefit microbes (and more)
Legume covers increase microbial populations

Agrees with MT study: pea or mixed cover generally greater microbial biomass than fallow (Tallman 2014, Housman 2016, D’Agati unpub data).

Biederbeck et al. 2005, 6 yrs of rotations, SK. Organisms in top 4”, sampled after wheat phase in Oct, 15 months after cover crop termination.
Infiltration rates were 7-FOLD higher after 18 years of recrop than after fallow at Bozeman (2020)

Fouts and Jones unpub data
Soil enzyme activity greater after 18 years of recrop than after fallow at Bozeman (2020)

**Diagram:**

- **Geometric mean (µg p-nitrophenol/g soil/hour)**

**Rotation with wheat**

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Geometric Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Till F</td>
<td>400 c</td>
</tr>
<tr>
<td>F</td>
<td>500 bc</td>
</tr>
<tr>
<td>W</td>
<td>600 ab</td>
</tr>
<tr>
<td>Pgrain</td>
<td>700 ab</td>
</tr>
<tr>
<td>Phay</td>
<td>800 abc</td>
</tr>
<tr>
<td>Pcover</td>
<td>900 ab</td>
</tr>
<tr>
<td>CRP/Pg</td>
<td>1000 a</td>
</tr>
</tbody>
</table>

Fouts and Zabinski, unpub data
Pea cover produced higher SOM than tilled fallow but lower than CRP

SOM in top foot after 14 years of cropping systems at 2 N rates near Bozeman, MT (2016)

Ewing et al unpub data
N from legumes

• Legume covers release more N more quickly than legume grain (pulse)

• N benefit depends on species, how long grown, how often grown, growing and decomposing conditions

• Legumes should be >40% of cover to provide plant available N (PAN), especially if terminated late

Sullivan and Andrews 2016, OR
Plant available N **AMOUNT** from plant residue

Depends on residue N concentration

- Leafy green: high N concentration = more PAN
- Mature plant: lower N concentration, N used by microbes and not available for crop

Oregon State University Extension Predicting Plant Available N EM9235
Estimating Plant-available Nitrogen Release from Cover Crops PNW636
N release from above ground plant material for many years

Cover biomass cut at full bloom
Lupwayi and Soon 2016, AB
If want to maximize N fixation in pulse cover crops, need adequate S (and P and K)

Higher N fix = less N fertilizer = reduced risk of soil acidification. See Feb 10 session

Lentil, 16” rainfall zone
N budget method
Jones unpub data 2020
Questions?

On to mixed species cover crops
1. Does increased crop diversity improve soil health?
   - Microbial biomass
   - Soil enzyme activity
   - Soil temperature
   - Aggregate stability
   - Compaction
   - Soil water, nitrate, and Olsen P
   - Mycorrhizal colonization
   - Potentially mineralizable nitrogen
   - Soil organic matter

2. Does increased diversity increase subsequent grain yield?
Plant functional groups — planted individually and in groups

- **Nitrogen fixers**
  - Spring Pea
  - Lentil

  ➢ *Increase N*

- **Tap Root**
  - Purple top turnip
  - Safflower

  ➢ *Reduce compaction, move nutrients upward*

- **Fibrous Root**
  - Oats
  - Proso millet

  ➢ *Add soil carbon*

- **Brassicas**
  - Daikon radish
  - Winter canola

  ➢ *Rapid ground cover, high biomass, potential disease control*
11 treatments

The big three
- Summer Fallow (SF)
- Pea-only Legume Green Manure (PEA)
- Cover Crop Mixture -8-spp/4-functional group (CCM)

Single functional group treatments (2-species)
- Nitrogen Fixers (NF)
- Fibrous Roots (FR)
- Taproots (TR)
- Brassicas (BC)

Three functional group treatments (6-species)
- FR, TR, BC (Minus NF)
- NF, TR, BC (Minus FR)
- NF, FR, BC (Minus TR)
- NF, FR, TR (Minus BR)

Study design: 2 sites, 12 and 14” rainfall zones
Cover Crop Biomass – depends on moisture

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Biomass (ton/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam</td>
<td>2012</td>
<td>0.4</td>
</tr>
<tr>
<td>Conrad</td>
<td>2012</td>
<td>0.2</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>2014</td>
<td>1.4</td>
</tr>
<tr>
<td>Conrad</td>
<td>2014</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Biomass was not strongly related to # of species.
Soil organic matter vs biomass

N rate did not affect SOM in top 4” at either site.

Take home: Select covers that produce high biomass OVER THE ROTATION if want to build SOM.
Microbial biomass (SIR):

<table>
<thead>
<tr>
<th></th>
<th>Conrad</th>
<th>Amsterdam</th>
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<tbody>
<tr>
<td>Fallow</td>
<td>B</td>
<td>b</td>
</tr>
<tr>
<td>Full mix cover</td>
<td>A</td>
<td>ab</td>
</tr>
<tr>
<td>Pea cover</td>
<td>A</td>
<td>a</td>
</tr>
</tbody>
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Rotation with wheat
Questions?

On to wheat yield and protein after mixed species cover crops
Spring wheat protein after 4 rotations (2019)

D’Agati et al. 2020
Summary

• Cover crops can’t compete economically with pea grain-wheat (unless perhaps covers are grazed)
• It takes time to change soil quality
• Higher number of species in mix doesn’t consistently improve yield, protein, or soil quality. Good result – allows flexibility. Base selection on seed cost, biomass produced, specific soil health goals, etc.
• To maximize N and water availability following covers:
  ▪ Early termination (by first pea bloom)
  ▪ >50% legume in seed mix

Thank you to our MSU funding sources
Thank you!

Questions?

This presentation and more information on soil fertility is available at http://landresources.montana.edu/soilfertility

Please take a few minutes to evaluate this seminar series by completing the short survey; link provided in chat box soon.