COVER CROPS AND SOIL HEALTH

MABA

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MSU Soil Fertility Extension
Today’s goals

• Present cover crop management considerations

• Discuss single vs mixed species cover crop effects on
  ▪ Nitrogen availability
  ▪ Soil organic matter
  ▪ Soil quality parameters
  ▪ Following crop yield and protein
  ▪ Economics
The Summerfallow Challenge

PROS:
Soil moisture recharge
N benefit

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
What we have found with MT CC research trials
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)
Our MT studies confirmed early Saskatchewan studies that termination timing is key, when water is limiting. Haying cover crop at early bloom produced higher sp. wheat yields the following year than harvesting pea when water or N limiting (Miller et al 2006).
Effect of lentil and pea cover crop on spring wheat yield & protein – plot studies

Take home:
• Early-terminated spring cover crop did not hurt wheat yield or protein.
• Pea cover crop only increased yield at low N rates when tilled.
• Pea increased grain protein at all N rates and both NT and T.
• Lentil cover crop did not benefit yield or protein (likely N contribution too low)
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

- Full N
- 1/2 N

Cropping system:
- NTF
- PW grain
- PW hay
- PW cover

Wheat grain yield (bu/acre, 2016)
14-Year Plot Study: Grain protein in 14\textsuperscript{th} year (2016)

Wheat grain protein (\%, 2016)

- Full N
- 1/2 N

Cropping system

NTF, PW grain, PW hay, PW cover
Questions?

On to economics of single species
cover crops
Economics: 14-year Plot Study (2009-2012)

2010 was a wheat year, and had very wet spring

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
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
4-yr Net Returns – Big Sandy (Sandy Clay Loam, 1.4% OM)

Flat protein premiums

Steep protein premiums

Miller and Jones unpub data
4-yr Net Returns – Dutton (Clay loam to Clay, 3% OM)

Average protein premiums
Take home: In short to long term studies, in different regions in Montana, pea - wheat returns far more profit than cover crop - wheat, when cover crop sprayed out.

Questions?

On to cover crops
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?

SOM often is included in both lists
SOM after 10 years of cropping systems (2012)

Engel, in press, MSU Post Farm
1. Does increased crop diversity improve soil health?
   - Microbial biomass
   - Soil enzyme activity
   - Soil temperature
   - Aggregate stability
   - Compaction

2. Does increased diversity increase subsequent grain yield?
   - Soil water, nitrate, and Olsen P
   - Mycorrhizal colonization
   - Potentially mineralizable nitrogen
Plant functional groups — planted individually and in groups

Nitrogen Fixers
- Spring Pea
- Lentil

Increase nitrogen

Add soil carbon

Fibrous Root
- Oats
- Proso millet

Reduce compaction, move nutrients upward

Tap Root
- Purple top turnip
- Safflower

Rapid ground cover, high biomass, potential disease control

Brassica
- Daikon radish
- Winter canola
Experimental Design

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
- NF, TR, BC
- NF, FR, BC
- NF, FR, TR
Cover Crop Biomass – depends on moisture

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Biomass (ton/acre)</th>
</tr>
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<tbody>
<tr>
<td>Amsterdam</td>
<td>2012</td>
<td>0.4</td>
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<tr>
<td>Conrad</td>
<td>2012</td>
<td>0.2</td>
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Biomass is not strongly related to # of species

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Soil quality summary after second full rotation – among pea, 8 species mix, and fallow

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<thead>
<tr>
<th></th>
<th>Amsterdam</th>
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<th>Dutton</th>
<th>Bozeman</th>
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<tbody>
<tr>
<td><strong>Microbial Biomass</strong></td>
<td>CC&gt;fallow</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td><strong>Microbial Enzymes (5)</strong></td>
<td>CC&gt;fallow</td>
<td>NS</td>
<td>NS</td>
<td>CC&gt;fallow</td>
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<tr>
<td><strong>PMN</strong></td>
<td>CC&gt;fallow</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td><strong>Olsen P</strong></td>
<td>NS</td>
<td>NS</td>
<td>na</td>
<td>na</td>
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<tr>
<td><strong>Temp at 2”</strong></td>
<td>CC&lt;fallow</td>
<td>CC&lt;fallow</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>Aggregate stability</strong></td>
<td>NS</td>
<td>NS</td>
<td>na</td>
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</table>

NS – no significant difference (95% confidence) among treatments, na – not available

The number of species in Ccrop mix did not matter much
Questions?

On to wheat yields after mixed species cover crops
Wheat grain yield after 2 cycles

- Fallow
- Pea
- Full CCMix

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

Averaged over 0, 60, 120 lb N/acre
Spring wheat yield at Dutton vs previous year total biomass (cc + weed)

\[
SW \text{ yield} = (-7.25 \times CC\text{biomass}) + 46.4
\]

\[R^2 = 0.72\]

Housman, Tallman, et al., unpub data, Dutton
Spring wheat grain yield was lower after CC than fallow in four of six field-scale studies, and protein results were mixed.

High water use from late termination (full pod or even later) was likely cause of yield differences.

Low N release because of low amount of legume likely caused difference with our plot studies.
Percent legume and termination timing affects plant available N (PAN)

Our field studies ≈ <50% legume

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

Willamette Valley, Oregon
Sullivan and Andrews, 2012
Summary

• Cover crops can’t compete economically with pea grain-wheat
• It takes time to change soil quality
• Higher number of species in mix doesn’t appear to consistently improve yield, protein, or soil quality. Good result – allows flexibility. Base selection on seed cost, biomass produced, specific soil health goals, etc.
• IF your client is growing cover crops, encourage early termination (by first pea bloom) and >50% legume in seed mix.
Thank you for funding the MSU studies:

**QUESTIONS?**

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

Montana Fertilizer Advisory Committee