Effects of Mixed Species Cover Crops on Soil Health

First Year Results

Annie Young-Mathews
Corvallis, Oregon Plant Materials Center

CONNECT 2014
Thursday, May 1, 2014
Soil Health Questions

• Does increasing seeding rates of cover crop mixes increase dry matter yield, N accumulation, weed control, and cover?
• Does increasing the diversity of cover crop seed mixes improve soil health as measured by changes in soil dynamic properties and biological assessments over time?

National Soil Health Study

• Three year study (2012-2015) at 7 locations nation wide
• Collaboration among the USDA-NRCS National Soil Health and Sustainability Team, Plant Materials Program, & National Technology Support Centers
Soil Health Study Locations

Plant Materials Centers:
- Brookville, FL
- Beltsville, MD
- Elsberry, MO
- Bismarck, ND
- Lockeford, CA
- Corvallis, OR
- Pullman, WA
Treatments

**Seeding Rate**
- 20 seeds ft\(^{-2}\)
- 40 seeds ft\(^{-2}\)
- 60 seeds ft\(^{-2}\)

**Seeding Mixes**
- 2 species (legume, grass)
- 4 species (2 legumes, grass, brassica)
- 6 species (2 legumes, 2 grasses, 2 brassicas)
## Corvallis PMC Cover Crop Mixes

<table>
<thead>
<tr>
<th>Mix</th>
<th>Grasses</th>
<th>Legumes</th>
<th>Brassicas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-species</td>
<td>50% cereal rye</td>
<td>50% crimson clover</td>
<td>-</td>
</tr>
<tr>
<td>4-species</td>
<td>45% cereal rye</td>
<td>22.5% crimson clover, 22.5% hairy vetch</td>
<td>10% ‘Soil Buster’ radish</td>
</tr>
<tr>
<td>6-species</td>
<td>22.5% cereal rye, 22.5% ‘Walken’ oats</td>
<td>22.5% crimson clover, 22.5% hairy vetch</td>
<td>5% ‘Soil Buster’ radish, 5% ‘Shogoin’ turnips</td>
</tr>
</tbody>
</table>
Data Collection

**Plant Data**
- Percent live canopy cover
- Dry matter yield
- Plant height over the growing season
- Functional group composition at termination
- Nitrogen content of aboveground biomass

**Soil Data**
- Soil moisture
- Soil temperature
- Bulk density
- Biological assessment
- Soil dynamic properties
- Resistance
Effect of Seeding Rate on Percent Cover Over Time

Days After Planting

Seed ft\(^2\)
- 20
- 40
- 60
- Control

Percent Cover

Oregon
Effect of Seeding Rate on Percent Cover

60 seeds ft$^{-2}$

30 DAP

62 DAP

97 DAP

20 seeds ft$^{-2}$

6-species mix
Effects of Seeding Rate & Mix on Weed Cover
Aboveground Biomass at Cover Crop Termination

termination date May 9, 2013

Seeding Rate (seed ft$^2$)

- 20 seeds ft$^2$
- 40 seeds ft$^2$
- 60 seeds ft$^2$
- control

Ib acre$^{-1}$

- 2,000
- 4,000
- 6,000
- 8,000
- 10,000

Oregon
## Cover Crop Biomass Composition

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% N in Dry Matter</th>
<th>Grasses</th>
<th>Legumes</th>
<th>Brassicas</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-species</td>
<td>1.4 b</td>
<td>63% a</td>
<td>27% b</td>
<td>0% b</td>
<td>10% a</td>
</tr>
<tr>
<td>4-species</td>
<td>2.2 a</td>
<td>28% b</td>
<td>44% a</td>
<td>24% a</td>
<td>4% b</td>
</tr>
<tr>
<td>6-species</td>
<td>2.3 a</td>
<td>29% b</td>
<td>44% a</td>
<td>24% a</td>
<td>3% b</td>
</tr>
<tr>
<td>20 seeds/ft²</td>
<td>2.0 a</td>
<td>37% a</td>
<td>38% a</td>
<td>16% a</td>
<td>9% a</td>
</tr>
<tr>
<td>40 seeds/ft²</td>
<td>1.9 a</td>
<td>40% a</td>
<td>38% a</td>
<td>18% a</td>
<td>4% b</td>
</tr>
<tr>
<td>60 seeds/ft²</td>
<td>1.9 a</td>
<td>43% a</td>
<td>38% a</td>
<td>15% a</td>
<td>4% b</td>
</tr>
<tr>
<td>Control</td>
<td>1.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100%</td>
</tr>
</tbody>
</table>
Soil Moisture at Cover Crop Termination

Termination date May 9, 2013
Corn planted June 3, 2013

<table>
<thead>
<tr>
<th>Seeding Rate (seed ft⁻²)</th>
<th>Gravimetric Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>40</td>
<td>22</td>
</tr>
<tr>
<td>60</td>
<td>22</td>
</tr>
<tr>
<td>Control</td>
<td>16</td>
</tr>
</tbody>
</table>
Soil Temperature at Cover Crop Termination

- Termination date: May 9, 2013
- Corn planted: June 3, 2013
- Seeding Rate (seed ft\(^2\))
  - 2 species, 60 seeds ft\(^2\)
  - 6 species, 60 seeds ft\(^2\)
  - Control
Sweet Corn Production

9 Aug. 2013 (60 DAP)

6-species, 60 seeds ft⁻²

2-species, 60 seeds ft⁻²

Control
Effects of Seeding Rate & Mix on Corn Yields

Cover Crop Mixes and Seeding Rates (seeds/ft²)

- Control
- 2 species
- 4 species
- 6 species

Sweet Corn Yield (tons/acre)

- 0
- 20
- 40
- 60
- 20
- 40
- 60
- 20
- 40
- 60

C, BC, AB
Soil Characterization

- **MLRA**: 2 -- Willamette and Puget Sound Valleys
- **Map Unit**: 169 -- Willamette silt loam, 0 to 3 percent slopes
- **Soil Name as Described/Sampled**: Willamette
- **Classification**: Fine-silty, mixed, superactive, mesic Pachic Ultic Argixerolls

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-12</td>
<td>Ap1</td>
</tr>
<tr>
<td>12-33</td>
<td>Ap2</td>
</tr>
<tr>
<td>33-61</td>
<td>BA</td>
</tr>
<tr>
<td>61-76</td>
<td>2Bt1</td>
</tr>
<tr>
<td>76-97</td>
<td>2Bt2</td>
</tr>
<tr>
<td>97-125</td>
<td>3BCT1</td>
</tr>
<tr>
<td>125-160</td>
<td>3BCT2</td>
</tr>
</tbody>
</table>
Baseline Soil Physical & Chemical Parameters

- USDA-NRCS Kellogg Soil Survey Laboratory, Lincoln, NE
- October 2012 prior to cover crop planting; will be repeated yearly prior to cover crop planting (except particle size analysis)

<table>
<thead>
<tr>
<th>Soil Depth</th>
<th>Clay</th>
<th>Silt</th>
<th>Sand</th>
<th>pH</th>
<th>Total C</th>
<th>Total N</th>
<th>Total S</th>
<th>C:N ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2&quot;</td>
<td>24.6%</td>
<td>68.7%</td>
<td>6.7%</td>
<td>5.4</td>
<td>1.8%</td>
<td>0.15%</td>
<td>0.003%</td>
<td>12</td>
</tr>
<tr>
<td>2-6&quot;</td>
<td>24.4%</td>
<td>68.8%</td>
<td>6.7%</td>
<td>5.5</td>
<td>1.8%</td>
<td>0.14%</td>
<td>0.003%</td>
<td>13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Depth</th>
<th>CEC</th>
<th>Ca</th>
<th>K</th>
<th>Mg</th>
<th>Base Sat</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2&quot;</td>
<td>18.1</td>
<td>11.6</td>
<td>0.7</td>
<td>1.1</td>
<td>74%</td>
</tr>
<tr>
<td>2-6&quot;</td>
<td>18.2</td>
<td>11.3</td>
<td>0.7</td>
<td>1.1</td>
<td>72%</td>
</tr>
</tbody>
</table>
Soil Physical Condition

Soil Compaction Testing

Soil Resistance (psi)

0-6” depth
6-12” depth
12-18” depth

Oct-12
Nov-12
Dec-12
Jan-13
Feb-13
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Soil Physical Condition

**Bulk Density**

- Bulk density is an indicator of how well plant roots are able to extend into the soil.
- For fine-silty soils:
  - Ideal $<1.30 \text{ g/cm}^3$
  - Restriction initiation $1.54 \text{ g/cm}^3$
  - Root-limiting $>1.65 \text{ g/cm}^3$

<table>
<thead>
<tr>
<th>Depth</th>
<th>Oct-12</th>
<th>Sep-13</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2&quot; depth</td>
<td>1.23</td>
<td>1.36</td>
</tr>
<tr>
<td>2-6&quot; depth</td>
<td>1.21</td>
<td>1.36</td>
</tr>
</tbody>
</table>
Soil Health Tool – “Green Chemistry”

- Soil Health Tool (SHT) developed by Dr. Rick Haney, USDA-ARS
- “Green chemistry” soil analysis methods:
  - Soil microbial activity indicator (Solvita 1-day CO$_2$-C)
  - Soil water extract (nature’s solvent)
  - H$_3$A, a weakly buffered soil extractant that mimics organic acids produced by living plant roots to temporarily change the soil pH thereby increasing nutrient availability.
- SHT is currently available from 3 commercial laboratories (and hopefully more soon):
  - Woods End Laboratories (Mt Vernon, ME)
  - Ward Laboratories (Kearney, NE)
  - Brookside Laboratories (New Bremen, OH)
Soil Health Tool – “Green Chemistry”

Water-Extractable Organic Nutrients

**Carbon**

**Nitrogen**

<table>
<thead>
<tr>
<th>Month</th>
<th>Organic C (ppm)</th>
<th>Organic N (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct-12</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>Dec-12</td>
<td>120</td>
<td>14</td>
</tr>
<tr>
<td>Feb-13</td>
<td>140</td>
<td>18</td>
</tr>
<tr>
<td>Apr-13</td>
<td>160</td>
<td>20</td>
</tr>
<tr>
<td>Jun-13</td>
<td>180</td>
<td>20</td>
</tr>
<tr>
<td>Aug-13</td>
<td>200</td>
<td>20</td>
</tr>
</tbody>
</table>
Soil Health Tool – “Green Chemistry”

Water-Extractable Organic C:N

Solvita 1-day CO$_2$-C

Soil Organic C:N ratio

1-day CO$_2$-C (ppm)
Soil Health Tool – “Green Chemistry”

**Soil Health Calculation**

- This number is calculated as 1-day CO$_2$ divided by the organic C:N ratio plus a weighted organic C and organic N addition.
- Represents the overall health of your soil system.
- Varies from 0 to over 50, good to see above 7.
- Should increase over time if the soil is being managed sustainably.
Soil Health Tool – “Green Chemistry”

**Plant Available Nutrients**

- Values include the inorganic NH$_4$-N, NO$_3$-N, K$_2$O, and PO$_4$-P; the amount of N and P that the soil microbes will provide based on your soil microbial activity (Solvita 1-day CO$_2$-C) and the organic C:N ratio of the water extract.
Summary of Year 1 Observations

The observations for:

- Total percent cover,
- Weed cover,
- Aboveground biomass,
- Nitrogen content of biomass,

did not show many significant differences between seeding at 40 or 60 seeds/ft\(^2\); differences were greater between the 20 and 40 seeds/ft\(^2\) rates for some parameters.

If these trends continues, we may be able to reduce seeding rates and therefore establishment costs without losing any of the cover crops benefits.
# Cover Crop Seed Mix Costs

<table>
<thead>
<tr>
<th>Cover Crop Mix</th>
<th>Seeding Rate (seeds/ft²)</th>
<th>Seed Cost (per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-species</td>
<td>20</td>
<td>$12.78</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>$25.57</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>$38.35</td>
</tr>
<tr>
<td>4-species</td>
<td>20</td>
<td>$31.20</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>$62.39</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>$93.59</td>
</tr>
<tr>
<td>6-species</td>
<td>20</td>
<td>$34.41</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>$68.82</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>$103.24</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
<td>$0.00</td>
</tr>
</tbody>
</table>
Slug Predation

- Extensive slug damage in no-till sweet corn and 2nd year no-till cover crop
- Surface residue provides the ideal humid habitat for slugs to feed and breed
- Recommended methods of slug control are deep & frequent tillage, biocontrols (birds, nematodes, ground beetles), and slug bait

**High Cost of Slug Baits**

- Deadline® metaldehyde bait @ 10-40 lbs/acre costs $18.50 to $74.00 per acre
- Organic-certified Sluggo® iron phosphate bait @ 24-44 lbs/acre costs $51.50 to $94.40 per acre
Questions Data May Help Explain

Plant

1. How do seeding rates affect weed density?

2. How do seeding rates affect the species composition of the cover crops?

3. Do the functional groups seeded persist until cover crop termination?

4. Will the seeding rates and seed mixes provide adequate cover and biomass?
Soil

1. How do the seed mixes affect soil health parameters?

2. How do the seeding rates affect soil health parameters?

3. How does the species composition of the cover crop at termination affect soil health parameters?

4. When are improvements in soil health measurable?

5. Will soil moisture and soil temperature change as the study continues?

6. Is there a correlation between species richness and soil health?
Thanks to Our National Cooperators

Dr. Rick Haney
USDA Agricultural Research Service
Grassland Soil and Water Research Laboratory
Temple, Texas

Dr. Steven Mirsky
USDA Agricultural Research Service
Sustainable Agricultural Systems Laboratory
Beltsville, Maryland

USDA Natural Resources Conservation Service
Kellogg Soil Survey Laboratory
Lincoln, Nebraska
Thanks to Our Local Cooperators

Teresa Matteson
Benton Soil & Water Conservation District
Corvallis, Oregon

Fran Lacroix
Benton SWCD Intern/OSU Student
Corvallis, Oregon
Questions?

Annie Young-Mathews  
USDA-NRCS Corvallis Plant Materials Center  
3415 NE Granger Ave.  
Corvallis, OR 97330  
(541) 757-4812 ext. 106  
anna.young-mathews@or.usda.gov


USDA is an equal opportunity provider and employer