Cover Crops

“If you’re trying to make your soil healthier, You shouldn’t see it very often”

Marlon Winger
USDA-NRCS, National Soil Health Division
MT, WY & ID
Is it a Cover Crop or Biological Primer?

- Cover Crops have been used mainly to provide cover to protect from forms of erosion.
- Soil health innovators realize that cover crops are more than that and see that they are biological primers that jump start the revitalization of the degraded soil ecosystem.
How Cover Crops Build Soil Health

(1) Add Organic Matter
(2) Add Plant Diversity
(3) Enhance Mycorrhizal numbers
(4) Build Aggregates
(5) Increase Earthworms
(6) Add Lasting Residue/Cover
(7) Suppress Weeds
(8) Increase Infiltration of Water
(9) Reduce Erosion
(10) Minimize & Reduce Soil Compaction
(11) Manage Soil Moisture
(12) Capture & Recycle Nutrients (decrease nutrient loss)
(13) Add Nitrogen (Legumes)
(14) Add Nitrogen (Associative Nitrogen Fixers)
(15) Attract Beneficial Insects
(16) Disease Mgt./Suppression
(17) Enhance Pollinators
(18) Support Wildlife
(19) Catch Snow

Cover Crop Cocktail/Biological Primer (Photo: Jay Fuhrer, ND)

Sunflower 1 lb
Soybean 15 lbs
Cowpea 10 lbs
Turnip 1 lb
Radish 2 lbs
Proso Millet 3 lbs
Pearl Millet 3 lbs
Corn 1 lb
Squash 1 lb
Canola 1 lb

Other Benefits: Clean Air, Clean Water, Healthy & Nutritious Plants, and much more.
A Biological Primer is a diverse cover crop mix that enhances the life and function of the soil. (G. Brown)

W. Jones
Genesee, ID

B. McIntyre
Caldwell, ID
“And then, this morning, I suddenly noticed she didn’t look so good.”
Conclusions:

“Soil borne diseases are most damaging when soil conditions are poor as a result of inadequate drainage, poor soil structure, low organic matter, low soil fertility, and high soil compaction”.

Impact of soil health management practices on soilborne pathogens, nematodes and root diseases of vegetable crops
Several mechanisms to explain increased resistance or tolerance to soil-borne pathogens

- Increased nutrient uptake – More vigorous plants
- Competitive exclusion of pathogens
- Changes in root exudation
- Enhanced P uptake may inhibit spore germination and infection
- Promote microbial shifts that could influence plant health
- Lignification of root cells that limit penetration of pathogens

Nature’s Way:

- No mechanical disturbance
- Armor on the soil surface
- Cycles water
- Living plant-root networks
- Nutrient cycling via biology
- Thousands of years of R & D
NASA CO₂

Youtube video
2nd most important biological process = Nitrogen fixation

What is the most important biological process?
Mid west,
Rolling multi species cover crops and planting the same day

Photosynthesis 360
Answer 4 Main Questions when planning cover crops

1. What Are The Goals/Concerns?
2. What Are The Environmentals?
3. What Is The Timeframe?
4. What Is The Budget?
Why should farmers try cover crops?

Agricultural Benefits

• Soil structure, compaction, porosity (physical properties)
• Erosion and runoff reduction (HELC)
• Nitrogen fixation by legume cover crops
• Soil water management
• Soil health – biological life
• Supplemental grazing
• Improve organic matter
• Nitrogen capture/cycling
• Additional lasting residue/cover
• Weed suppression/disease cycle
• Attract beneficial insects/pollinators

Source: http://www2.mcdaniel.edu/Biology/eco/soil/soils1.htm

Photo: M. Winger, Radish holes
What are your environmentals?

1. Rainfall or irrigation
2. Evapo-Transpiration (ET)
3. Growing season
4. Soil type and condition
5. Seeding method
6. Previous crop and next crop
7. Previous herbicides
Considerations for successful cover crop planning

- Site preparation/Early weed control is essential
- Herbicide carryover and label restrictions
- Timing and species (adequate growing season)
- Crop rotation/diversity
- Seeding method seed-soil contact (broadcast vs. drilling, adequate equipment)
- Seed size/seeding depth
- Site and moisture conditions
- Residue management (cash crop) before and after cover crop emergence
- Moisture management (cover benefits, water use)
- Nutrient cycling considerations (C:N ratio, living root)
- Weed, insect and disease management
- Termination method/timing – know before you plant how your are going to terminate
- Establishment of next cash crop
- Economics (yield impacts, cost of establishment, soil improvement,
  – (“can we afford not to use a cover crop” J. Fuhrer, 2016)
Tex Creek, Wildlife mgmt area,
Idaho Dept of Fish & Game  Idaho Falls, Id
13 way cover crop mix – Great plains no-till drill
Improve forage diversity for wildlife
Biomass Production
Annual Cropping Systems

Missed opportunities for resource assimilation and dry matter production

Dry matter production or resource loss (mass / time)

Spring | Summer | Autumn | Winter

Annual grain crop

Winter cover crop

Additional opportunities for resource losses

after A.H. Heggenstaller

A. H. Heggenstaller, University of Alberta
McIntyre Farms: 2013
Caldwell, ID
Cover crop mix: Radish, Turnip, Sudan grass, Millet, Buckwheat, Oats, Soybean, Rape, vol wheat
Planted: 8/10/2013. Grazed beginning on 10-17-13,
End grazed: Dec 17, 2013; grazed for 61 days
No till drilled cover crop mix into winter wheat stubble
Clipped 13,684 lbs DM/ ac
23.1 % DM
300 head of wild mother cows on 3 acres per day
Stock density: ~106,000 lbs / acre
Previous crop: winter wheat
Planned crop:
2014  grain corn -274 bu /ac Idaho no- till record
2015 spring peas
April 29, 2014 evaluating soil of the cover crop field: Worms underneath decomposing cow pie. Brad McIntyre farm. Caldwell Id. 165 worms per cubic foot. = 7.2 million worms per acre.
Soil Solutions 1:21 min
## Measuring Soil Health – Haney Test

<table>
<thead>
<tr>
<th>Field</th>
<th>2014</th>
<th>2016</th>
<th>Soil Health Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 ac pivot 0702c</td>
<td>18.5, 202.7, 17.0, 11.9, 5.6</td>
<td>70 ac pivot 72.4, 254.3, 26.8, 9.5, 12.5</td>
<td></td>
</tr>
<tr>
<td>6 ac 0703c</td>
<td>11.6, 215.0, 17.8, 12.0, 5.1</td>
<td>6 ac 60.1, 248.5, 32.0, 7.8, 11.7</td>
<td></td>
</tr>
</tbody>
</table>

Gaining Knowledge and Humility!

McIntyre brothers and Ray Archuleta
## Measuring Soil Health – Haney Test

C. Williams, Grace, ID

Hay field results – Carbon poor

<table>
<thead>
<tr>
<th>Year</th>
<th>1-day CO2-C</th>
<th>Organic C</th>
<th>Organic N</th>
<th>Organic C:N</th>
<th>Soil Health Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>52.7</td>
<td>288.1</td>
<td>33.7</td>
<td>8.6</td>
<td>12.4</td>
</tr>
<tr>
<td>2015</td>
<td>40.8</td>
<td>217.6</td>
<td>30.7</td>
<td>7.1</td>
<td>9.3</td>
</tr>
<tr>
<td>2016</td>
<td>43.1</td>
<td>75.0</td>
<td>11.9</td>
<td>6.3</td>
<td>6.3</td>
</tr>
</tbody>
</table>
# Measuring Soil Health

## Haney Test

<table>
<thead>
<tr>
<th>Sample</th>
<th>Solvita CO2 ppm C (respiration)</th>
<th>Organic C (food)</th>
<th>Organic N</th>
<th>Soil Health Index</th>
<th>AL ppm</th>
<th>Fe ppm</th>
<th>Ca ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>No till /CC</td>
<td>151</td>
<td>347</td>
<td>10.9</td>
<td>20.6</td>
<td>190</td>
<td>109</td>
<td>254</td>
</tr>
<tr>
<td>Tillage /Fallow</td>
<td>13</td>
<td>160</td>
<td>7.1</td>
<td>5.1</td>
<td>844</td>
<td>418</td>
<td>191</td>
</tr>
</tbody>
</table>
1. If *Soil Health* is the goal, *Crop Diversity* cannot be ignored or overstated
2. Plants were created to grow in diverse ecosystems
3. *Resilience* comes from *Diversity*
4. Balanced “diet” for soil biology
5. Balance: because even good things (legumes, brassicas) when not used in moderated balance can be harmful
More types of seeds more stable is the mix
Gabe Brown talks about Biological Primers (cover crops)
6 way mix: wheat, turnip, radish, soybean, cowpea, sudan grass

Planted: July 25, 2012
2 producers go to National no till mtg

1,260 acres corn silage planted no till

1,260 acres fall triticale planted no till into silage residue

New pivot planted 5 way warm season mix, then no tilled fall triticale

Oct 31, 2012
Nurture Nature with System Synergies

No Tillage
Minimum carbon loss

Cover Crops
Maximum carbon input

Carbon management

Sustainability

Dr. Don Reicosky
Cover Crops
Designing for what you don’t have!

Resource Concerns

- Provide crop diversity
- Provide soil surface armor (erosion)
- Build soil aggregates
- Improve the water cycle
- Integrated Pest Management
- Build soil organic matter
- Nutrient cycling
- Air Quality
- Enhance pollinators /predators
- Adjust carbon/nitrogen ratios
- Wildlife winter food & shelter
- Livestock integration
- Nitrogen fixation
What are your goals/resource concerns?

Generally speaking....

1. The more specific your goals/concerns, the less diverse your mixes will typically be.

2. The tighter your planting windows, the fewer species will work and thus the less diverse your mixes will be.

3. Minimum of 6 to 8 weeks of growth necessary to achieve most benefits.
What is your timeframe?

1. Spring - fallow ground or prior to a spring crop
   (chemical/mechanical termination)
   (Check crop insurance implications!)
2. Early Summer - Right after wheat harvest
   (frost or chemical/mech. termination)
3. Late Summer – Delay after wheat harvest
   (frost termination)
4. Fall - After fall crops
   (frost termination or over-wintering)
Get 4 Things Right

1. The Right Species
2. The Right Inoculants
3. The Right Seeding Rates
4. The Right Seeding Time
Cover Crop Termination Methods

- Frost termination
- Crimper / Roller (mature enough to kink the stem)
- Herbicide burn down
- Grazing
- Shredding
- Organic methods (propane flame)
- Combination of methods
Cover Crop Tips

• Use species that are adaptable to your environment
• Adjust species composition to season of use
• Diversity (speeds up biological time)
• Be aware of herbicide residuals
• Check with crop insurance eligibility
• Don’t use a species in the mix if you are planning to seed it in that field next year
• If grass finishing, do not allow any grains to set seed
• “It can’t grow in the bin, when in doubt seed it”! (G. Brown)
Diversify!

- Hard to improve Soil Health if there is no diversity of crop types.
- Need to add species diversity.

Grace, Id 2014
8 way cover mix
Diversity in Root Systems

- Diversity in root systems = diversity in soil biota
Soil Moisture Management

• Increase infiltration
• Reduce evaporation (take E out of ET)
• Remove excess moisture
• Terminate while cover crop is vegetative (before peak water use occurs)
• Six weeks of growth to achieve “rotation effect”
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*
Cool Season Grasses

- Annual Ryegrass
- Cereal Rye
- Barley
- Oats
- Winter Wheat
- Triticale

Spring Oats planted on August 1

Cereal Rye

[Images of grasses and a person holding grass]

Oats & cowpeas
Warm Season Grasses

- Pearl Millet
- Sorghum-Sudan grass
- Forage Sorghum

Brown rib sorghum - sudan grass

Pearl Millet
Cool Season Broadleaf

- Oilseed Radish
- Turnip
- Kale and Collards

Impact Forage Collard
Warm Season Broadleaves

- Buckwheat (no longer can use due to allergic reactions to buckwheat flour)
- Safflower
- Sunflower
Cool Season Legumes

• Hairy Vetch - Crimson Clover - Winter Pea
Warm Season Legumes

- Cowpea
- Soybean
- Sunnhemp
- Chickpea
- Mungbean
Do you know your cover crops?

- Cool Season Grasses?
- Warm Season Grasses?
- Cool Season Broadleaf's (legumes, brassicas)?
- Warm Season Broadleaf (legumes, non-legumes)?
- Perennial, Biannual, Annual?
- Tap root?
- Fibrous root?
- C:N Ratios?
- Growing season for each group/species (frost sensitivity)?
- Diversity?
- Moisture Use?
- Other Considerations?
Why Build Diversity????

Diversity conduit for energy and nutrients.
Suppress Weeds
Spring 2008 Weed Suppression (ND)
Cover Crop Herbicide Restrictions

- Forage and grain (food chain)
  - Herbicide must be labeled for all crops
  - Rotation/plant back restrictions
  - Forage restrictions (grazing, haying)
- Cover only (soil building or erosion)
  - At your own risk (some labels lack info)
  - Review labels/experience
  - Climate & soils (biological activity)
Read Herbicide Labels Thoroughly

• “Cover crops for soil building or erosion control may be planted any time, but do not graze or harvest for food or feed. Stand reductions may occur in some areas”. Ex. (Prefix Label)

• Nathan to add another common herbicide label and add picture
# Cover Crop Periodic Table

## Cool Season Plants

<table>
<thead>
<tr>
<th>Grass</th>
<th>Broadleaf Plants</th>
<th>Legumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oat (wk)</td>
<td>Arugula</td>
<td></td>
</tr>
<tr>
<td>Ryegrass</td>
<td>Flax (wk)</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>Rape / Kale¹</td>
<td>Turnip¹</td>
</tr>
<tr>
<td>Cereal rye</td>
<td>Phacelia (wk)</td>
<td>Radish</td>
</tr>
<tr>
<td>Triticale</td>
<td>Canola / Mustards¹</td>
<td>Beet</td>
</tr>
<tr>
<td>Forage Oat (wk)</td>
<td>Ethiopian Cabbage (wk)¹</td>
<td>Tyfon¹ (wk)</td>
</tr>
</tbody>
</table>

## Warm Season Plants

<table>
<thead>
<tr>
<th>Grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearl Millet (wk)</td>
</tr>
<tr>
<td>Safflower (wk)</td>
</tr>
<tr>
<td>Foxtail Millet (wk)</td>
</tr>
<tr>
<td>Buckwheat⁴ (wk)</td>
</tr>
<tr>
<td>Proso Millet (wk)</td>
</tr>
</tbody>
</table>

**Legumes**

- Winter Field Pea²
- Chickling vetch² (wk)
- Red clover
- Balansa clover
- Mung Bean (wk)
- Amaranth (wk)
- Forage Pea²
- Crimson clover
- Foxtail Millet (wk)
- Sunflower (wk)
- Sudan grass³ (wk)
- Chicory
- Grain Sorghum³ (wk)
- Sun Hemp (wk)
- Flower mix
- Corn³ (wk)

**(wk) = winter killed**

*See footnotes on back side*

---

USDA is an equal opportunity provider and employer.
USDA – ARS
Cover Crop Chart
C:.../crop issues/cover crops/ ARS
Cover crop chart
<table>
<thead>
<tr>
<th>Species</th>
<th>Crude Protein</th>
<th>RFV</th>
<th>TDN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Ryegrass - Top/half</td>
<td>15.67%</td>
<td>110.81</td>
<td>61.88%</td>
</tr>
<tr>
<td>Annual Ryegrass - Bottom/half</td>
<td>8.02%</td>
<td>109.05</td>
<td>60.12%</td>
</tr>
<tr>
<td>Cowpea - Top/half</td>
<td>14.79%</td>
<td>218.90</td>
<td>69.38%</td>
</tr>
<tr>
<td>Cowpea - Bottom/half</td>
<td>4.35%</td>
<td>103.72</td>
<td>58.94%</td>
</tr>
<tr>
<td>Hairy Vetch - Top/half</td>
<td>14.75%</td>
<td>126.74</td>
<td>60.78%</td>
</tr>
<tr>
<td>Hairy Vetch - Bottom/half</td>
<td>6.07%</td>
<td>85.59</td>
<td>52.08%</td>
</tr>
<tr>
<td>Pearl Millet - Top/half</td>
<td>9.77%</td>
<td>83.95</td>
<td>59.18%</td>
</tr>
<tr>
<td>Pearl Millet - Bottom/half</td>
<td>1.77%</td>
<td>86.91</td>
<td>57.79%</td>
</tr>
<tr>
<td>Radish - Top/half</td>
<td>10.74%</td>
<td>105.20</td>
<td>56.08%</td>
</tr>
<tr>
<td>Radish - Bottom/half</td>
<td>6.54%</td>
<td>75.30</td>
<td>48.09%</td>
</tr>
<tr>
<td>Soybean - Top/half</td>
<td>17.90%</td>
<td>190.15</td>
<td>67.95%</td>
</tr>
<tr>
<td>Soybean - Bottom/half</td>
<td>11.76%</td>
<td>114.08</td>
<td>59.10%</td>
</tr>
<tr>
<td>Sudan - Top/half</td>
<td>7.83%</td>
<td>83.93</td>
<td>58.21%</td>
</tr>
<tr>
<td>Sudan - Bottom/half</td>
<td>7.52%</td>
<td>84.78</td>
<td>57.56%</td>
</tr>
<tr>
<td>Sunflower - Top/half</td>
<td>10.38%</td>
<td>193.66</td>
<td>65.57%</td>
</tr>
<tr>
<td>Sunflower - Bottom/half</td>
<td>6.06%</td>
<td>123.83</td>
<td>58.30%</td>
</tr>
<tr>
<td>Sweet clover - Top/half</td>
<td>24.53%</td>
<td>228.51</td>
<td>72.25%</td>
</tr>
<tr>
<td>Sweet clover - Bottom/half</td>
<td>12.62%</td>
<td>97.47</td>
<td>55.15%</td>
</tr>
<tr>
<td>Cool Season Cover Crop Mix (fall seeded)</td>
<td>26.79%</td>
<td>208.43</td>
<td>71.32%</td>
</tr>
</tbody>
</table>
## Biological Primer mixes

Example

cool & warm season

<table>
<thead>
<tr>
<th>Cool Season Early Cover crop</th>
<th>Seed rate PLS/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barely</td>
<td>8</td>
</tr>
<tr>
<td>Oat</td>
<td>5</td>
</tr>
<tr>
<td>Lentil or Vetch</td>
<td>2</td>
</tr>
<tr>
<td>Pea</td>
<td>15</td>
</tr>
<tr>
<td>Clover, Crimson</td>
<td>1</td>
</tr>
<tr>
<td>Radish</td>
<td>1</td>
</tr>
<tr>
<td>Canola or Rape</td>
<td>1</td>
</tr>
<tr>
<td>Turnip</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>34 Lbs</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Warm Season cover Crop</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearl Millet</td>
<td>3</td>
</tr>
<tr>
<td>Sudangrass</td>
<td>4</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>3</td>
</tr>
<tr>
<td>Safflower</td>
<td>2</td>
</tr>
<tr>
<td>Radish</td>
<td>1</td>
</tr>
<tr>
<td>Turnip</td>
<td>1</td>
</tr>
<tr>
<td>Canola</td>
<td>1</td>
</tr>
<tr>
<td>Spring Lentil</td>
<td>2</td>
</tr>
<tr>
<td>Pea</td>
<td>15</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>33 lbs</strong></td>
</tr>
</tbody>
</table>
2014 Cover Crop Mix: (J. Fuhrer 2016)

warm season or cool season

- #/acre: Species
- 5: Super sweetsorg / sudan
- 5: BMR grazing corn
- 3: Soybean
- 1: Cowpea
- 1: Mung bean
- 2: Forage collards
- 1: Hunter turnips
- 1: Wildlife grain sorghum
- 1: German millet
- 1: Berseem Clover, Crimson Clover, Arrowleaf Clover
- 1: Sunflower
- 1: Buckwheat, Oats, Safflower

Total 23#  Cost $27.00/ acre
What could this producer do to improve this learning experience
Terminating Covers and planting in one pass
Spreading Rye Cover Crop Mix Last Fall (2011)
Terminating cover crop, spraying and rolling in one pass
Rye Grows in Spring and corn is planted with no-till drill
Cover Crop Planning Tools

- Cover crop Calculators:
  - PNW cover crop calculator
  - Midwest Cover Crop Council http://www.mccc.msu.edu/index.htm
- NRCS cover crop practice standard / Job sheets
- Green Cover seed in Nebraska
- LG college Extension Bulletin: G4161 Cover Crops in Missouri
- Sustainable Agriculture Research & Education (SARE)
  - Online Book and Topic Room on Cover Crops
- Cover Crops for Sustainable Crop Rotation and Soil Health and the SARE cover crops topic room at http://www.sare.org/Learning-Center/Topic-Rooms/Cover-Crops
Winter graze starts at 32.38