Managing Cover Crops from Selection to Termination

Gene Hardee, Agronomist
NRCS/East National Technology Support Center
Why Grow Cover Crops?

- Soil Management
- Water Management
- Pest Management
- Nutrient Management
- Energy Management (Economic Benefit)
Cover Crop
- purpose -
NRCS Conservation Practice Standard

- Reduce erosion from wind & water
- Increase Soil Organic Matter
- Increase biodiversity
- Capture and recycle or redistribute nutrients
- Promote biological nitrogen fixation & reduce energy use
- Suppress weeds
- Manage soil moisture & temperature
- Minimize & reduce soil compaction
“Reducing Erosion from Wind and Water”:

Erosion Processes

# Detachment
# Transport

Sheet and Rill Erosion  Wind Erosion
Steve Groff Farm, Lancaster, PA
- 14.8” of rain in 4 days
- two fields 100 feet apart
- Gully 4’ 4” deep in neighbor’s conventionally tilled field
“Increasing Soil Organic Matter”:

Crop residues

Crop residues
Cover Crops
Animal manure

20 years of similar tillage intensity and C inputs but contrasting types of organic inputs
Building & Maintaining Soil Organic Matter (Humus)

• OM is relatively stable in the soil but inherently about 5% is mineralized annually.

• Soil disturbance significantly increases mineralization of humus.

• It takes about 10 lbs of organic material to produce one pound of humus. Large quantity of biomass is needed.

• Approximately 65% of the carbon in organic material is given off as carbon dioxide due to microbial respiration.

• The C: N ratio of humus is typically around 10:1.

• If adequate nitrogen is not available, additional carbon will be released to the atmosphere.

• Bodies of Bacteria and fungi have C:N ratios of 4:1 - 10:1.

• Soil bacteria and fungi will take up N from the soil to decay high carbon organic material.

Glomalin & similar glues – key to soil aggregate stability
Example Soil Analysis Report Format

<table>
<thead>
<tr>
<th>SAMPLE NUMBER</th>
<th>LAB NUMBER</th>
<th>ORGANIC MATTER %</th>
<th>ENR</th>
<th>PHOSPHORUS</th>
<th>POTASSIUM</th>
<th>MAGNESIUM</th>
<th>CALCIUM</th>
<th>SODIUM</th>
<th>COMputed</th>
<th>pH</th>
<th>BUFFER INDEX</th>
<th>Cation Exchange CEC</th>
<th>PERCENT BASE SATURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>meg/100g</td>
<td>% K</td>
</tr>
</tbody>
</table>

- Approximately 20 lbs. of Nitrogen for each percent of soil organic matter.

Soil Organic Matter % and ENR

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

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REPORT NUMBER
A

SEND TO:

DATE OF REPORT:

GROWER:

SAMPLES SUBMITTED BY:
B

REPORT

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SOIL ANALYSIS REPORT

<table>
<thead>
<tr>
<th>SAMPLE NUMBER</th>
<th>NITRATE</th>
<th>SULFUR</th>
<th>ZINC</th>
<th>MANGANESE</th>
<th>IRON</th>
<th>COPPER</th>
<th>BORON</th>
<th>EXCESS LIME RATE</th>
<th>SOLUBLE SALTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NO₃⁻</td>
<td>ppm NO₃</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>mmhos/cm</td>
</tr>
<tr>
<td></td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
</tr>
</tbody>
</table>

(SEE EXPLANATION ON BACK)

REPORT

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CODE TO RATING: VERY LOW (V-L), LOW (L), MEDIUM (M), HIGH (H), VERY HIGH (V-H)
ENR: ESTIMATED NITROGEN RELEASE
MULTIPLY THE RESULTS IN ppm BY 4.5 TO CONVERT TO LBS PER ACRE P-Y
MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS PER ACRE K-NO₃
MOST SOILS WEIGH TWO (2) MILLION POUNDS (DRY WEIGHT) FOR AN ACRE OF SOIL 623 INCHES DEEP

REMARKS

E

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

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“Increasing Biodiversity”:

• Increase in number and species of soil microbes

• Increase in mycorrhizal fungi.

• Increase in beneficial insects.
Impact of cover crops on soybean cyst nematodes

<table>
<thead>
<tr>
<th>Site</th>
<th>Bare</th>
<th>Cereal Rye</th>
<th>Ryegrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7533</td>
<td>717*</td>
<td>117**</td>
</tr>
<tr>
<td>2</td>
<td>3650</td>
<td>320*</td>
<td>0**</td>
</tr>
<tr>
<td>3</td>
<td>1559</td>
<td>722*</td>
<td>386*</td>
</tr>
<tr>
<td>4</td>
<td>1202</td>
<td>390*</td>
<td>279*</td>
</tr>
</tbody>
</table>

* Significant .05 ** Significant .01

M Plumer

2 years /3 replications
It’s ALL About the Roots

Conventional tillage corn roots
3-7”

VS

No-till corn roots in ARG macroprores
23-27”

Jim Hoorman, OSU
“Capturing and Recycling or Redistributing Nutrients”:

Average annual flow-weighted nitrate-N concentration of drainage water for 2002-2005

- Control
- Rye Cover Crop

<table>
<thead>
<tr>
<th>Year</th>
<th>Control</th>
<th>Rye Cover Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>19.1</td>
<td>5.8</td>
</tr>
<tr>
<td>2003</td>
<td>24.7</td>
<td>11.8</td>
</tr>
<tr>
<td>2004</td>
<td>19.8</td>
<td>9.3</td>
</tr>
<tr>
<td>2005</td>
<td>21.6</td>
<td>8.0</td>
</tr>
<tr>
<td>Avg.</td>
<td>21.3</td>
<td>8.7</td>
</tr>
</tbody>
</table>

Kaspar et al. J. Environ. Qual. 36:1503-1511
Nitrogen capture in fall 2003 at Wye

- The taproot accounts for a major part of radish biomass and N uptake.
Ability of radishes to capture soil N in fall

- Control
- Forage radish
- Oliseed Radish

Soil Depth, cm

Nitrate-N, mg/kg

2003 nitrogen

2002 nitrogen?

Hayden Fall '03

ns

*ns

**ns
Brassicas appear to be particularly adept at solubilizing P.

**Soil Test P**
Silt loam at Wye, fall 2003
Means for top 18 inches

Biological pumping + organic acid root exudates

Third year of cover crop treatments in a corn-soybean rotation
### Examples of Nitrogen Provided by Legumes at Full Biomass

<table>
<thead>
<tr>
<th>Legume</th>
<th>Range of Nitrogen Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berseem Clover</td>
<td>100 – 200 lbs./ac.</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>100 – 150 lbs./ac.</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>70 – 150 lbs./ac.</td>
</tr>
<tr>
<td>Hairy Vetch</td>
<td>120 - 180 lbs./ac.</td>
</tr>
<tr>
<td>Red Clover</td>
<td>70 – 150 lbs/ac.</td>
</tr>
<tr>
<td>Sweet Clover</td>
<td>100 – 200 lbs./ac.</td>
</tr>
<tr>
<td>Winter Peas</td>
<td>100 – 160 lbs. ac.</td>
</tr>
</tbody>
</table>

*Managing Cover Crops Profitably*
Determination of Nitrogen Content in Cover Crops

- Laboratory analysis
- On-farm trials
- Rough estimates from published tables
- Computation using values from feeds texts.
Contributions of Cover Crops to Weed Management

- Allelopathic Effects
- Suppression by Residue Cover
- Competition with Weeds During Non-Crop Periods

> “Suppressing Weeds”
Crops with Demonstrated Allelopathic Effects

- Rye (cereal)
- Sudangrass
- Sorghum x sudangrass Hybrids
- Sweet Clover (Yellow Blossom)
- Sunflowers
- Black Mustard
- White Mustard
- Rapeseed
- Hairy Vetch
- Wheat
- Other Examples: Little Bluestem, Black Walnut, Some Oak Species.

Problem: May also affect some crops.
Weed suppression in no-till corn by sub clover (background is conventional tillage, no cover)
No-till no-herbicide broccoli transplanted into rolled foxtail millet (Ron Morse)

Weed control lasts longer after rolling than after mowing.
Palmer Amaranth
Soil Temperature (1” below surface)
Approximately 2 PM on July 13, 2011
Soil temperature taken in row middles

Conventional tilled -> 104°
No tilled -> 85°
Soil temperature fluctuations are reduced as residue cover increases.

- Lower maximum temperatures improve crop growth in hot areas.

Soil temperature (°F) at 1" Londrina, Brazil (23°S)

Time of the day (h)

Derpsch et al. 1986
Disk No Cover

CT = 119 tons/6 years
89% lost in 3 rain events (June 97, June 2000 and Sept 2000)

Disk Cover

CT = 119 tons/6 years
89% lost in 3 rain events (June 97, June 2000 and Sept 2000)

No Tillage No Cover

NT = 7.1 tons/6 years
3.8%-6.2% slopes

No Tillage Cover

NT = 7.1 tons/6 years
3.8%-6.2% slopes

JSWC C.W. Raczkowski 2009
Reduction in Runoff with Cover Crops

“Minimizing & Reducing Soil Compaction”:

Insufficient Residue = Soil Crusts (no-till won’t work with bare soil)
# Bulk density (g/cm³)

**all no-tilled 9+ years**

<table>
<thead>
<tr>
<th>Depth (in)</th>
<th>Ryegrass cover crop</th>
<th>No cover crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>10”</td>
<td>1.49*</td>
<td>1.66</td>
</tr>
<tr>
<td>16”</td>
<td>1.58</td>
<td>1.54</td>
</tr>
<tr>
<td>24”</td>
<td>1.48*</td>
<td>1.65</td>
</tr>
</tbody>
</table>

M Plumer

* sig. .05
Soil Compaction:

Compaction in the subsurface layer is a major soil resource concern on some Coastal Plain soils.
Soybean Roots Following the Channels Made by the Preceding Canola Crop
Which solution would you use?
Considerations in Management of Cover Crops

- Selection of Species
- Time of Planting
- Seeding Rate
- Seeding Method
- Fertilization (?)
- Termination of Cover Crops
Management of Cover Crops

SARE-Managing Cover Crops Profitably

Managing Cover Crops Profitably

THIRD EDITION
What to Plant?

- Triticale
- Yellow pea
- Sunn hemp
- Austrian winterpea
- Annual ryegrass
- Hairy vetch
- Tillage radish
- Pearl millet
- Phacelia
- Iron-clay Cowpea
Considerations in Selection of Species

- Primary purpose of the cover crop
- Additional benefits
- Season (cool season or warm season)
- Suitability for the soils and other site conditions
- Fast germination and emergence
- Competitiveness
- Tolerance of herbicide carryover
Considerations in Selection of Species

- Time of nutrient release
- Impact on specific pest pressures
- Potential of species becoming a weed pest
- Herbicide carryover
- Termination method
- Cost
Residual Herbicide Carryover - Brassicas

Herbicides Used on Wheat and/or Barley

- Ally - (34)
- Ally Extra - (22)
- Amber - Bioassay
- Beyond - (18)
- ClearMax - (18)
- Curtail M - (5)
- Everest - (9)
- Glean - (9)
- GoldSky - (9)
- Huskie - (9)
- Maverick - Bioassay
- Olympus - (22) Bioassay

# of Months between application and seeding a Brasica = (#)

- PowerFlex - (9)
- Rimfire - (10)
- Silverado - (10)
- Starane - (4)
- WideMatch - (4)
- Wolverine - (9)
# Cover Crop Options for the Southeast

<table>
<thead>
<tr>
<th>Cool Season</th>
<th>Warm Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td>Grasses</td>
</tr>
<tr>
<td>Cereal Rye</td>
<td>Cereal Rye</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>Crimson Clover</td>
</tr>
<tr>
<td>Brassicas</td>
<td>Brassicas</td>
</tr>
<tr>
<td>Wheat</td>
<td>Wheat</td>
</tr>
<tr>
<td>Hairy and common Vetch</td>
<td>Hairy and common Vetch</td>
</tr>
<tr>
<td>Winter Peas</td>
<td>Winter Peas</td>
</tr>
<tr>
<td>White Clover</td>
<td>White Clover</td>
</tr>
<tr>
<td>Triticale</td>
<td>Triticale</td>
</tr>
<tr>
<td>Subterranean clover</td>
<td>Subterranean clover</td>
</tr>
<tr>
<td>Berseem Clover</td>
<td>Berseem Clover</td>
</tr>
<tr>
<td>Sweet Clover</td>
<td>Sweet Clover</td>
</tr>
<tr>
<td>Sorghum x Sudan</td>
<td>Sorghum x Sudan</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>Cowpeas</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>Buckwheat</td>
</tr>
<tr>
<td>Pearl Millet</td>
<td>Pearl Millet</td>
</tr>
<tr>
<td>Forage soybeans</td>
<td>Forage soybeans</td>
</tr>
<tr>
<td>Sunflower</td>
<td>Sunflower</td>
</tr>
<tr>
<td>Browntop Millet</td>
<td>Browntop Millet</td>
</tr>
<tr>
<td>Tropical Sunn Hemp</td>
<td>Tropical Sunn Hemp</td>
</tr>
<tr>
<td>Hemp</td>
<td>Hemp</td>
</tr>
<tr>
<td>Forage soybeans</td>
<td>Forage soybeans</td>
</tr>
<tr>
<td>Sunflower</td>
<td>Sunflower</td>
</tr>
<tr>
<td>Proso Millet</td>
<td>Proso Millet</td>
</tr>
<tr>
<td>Velvet Bean</td>
<td>Velvet Bean</td>
</tr>
<tr>
<td>Fava Beans</td>
<td>Fava Beans</td>
</tr>
</tbody>
</table>
Cover Crop Mixtures

- Provide Multiple Benefits
- Can provide synergistic Effects
- Provide opportunity to maximize biomass
- Enhance the ecosystem and add diversity to soil biology.
Cover Crop Mixtures

Mixture of cereal rye, hairy vetch, and field peas as a winter cover crop

Stripped cover crops of rye and a clover mix in Georgia for beneficial insect habitat
Be Cautious Promoting Unproven Exotics

Rely on the Choices among the Natives of the Area and Proven Introductions

Showy Crotalaria and Striped Crotalaria were introduced and heavily used across the Southeast in the 1950s.

These species became noxious weeds throughout the area.

In addition to being very persistent due to the longevity of the seeds, the plants also are toxic to livestock and poultry.
Time of Planting

• Early Planting of cool season cover crops typically is essential for development of needed biomass prior to planting of early spring crops.

• If seeding warm season cover crops following summer harvest, ensure that time before frost is adequate to allow the desired growth.

• Plant following or in front of rainfall events or irrigation to ensure adequate soil moisture for germination.

• Are there pest related factors that limit the timely planting needed for cover crop use, e.g. hessian fly on wheat?
Determining Appropriate Seeding Rates

• Seeding rates for Monocultures:
  - University/Extension recommendations
  - NRCS Technical Guidance Documents
  - http://www.ces.ncsu.edu/depts/hort/hil/hil-37.html
  - Producer Experience

• Seeding Rates for Mixtures
  - Rule of Thumb:
    monoculture seeding rate/( no. of species in the mixture + 1)
    Blend the species at the determined rate for the seeding mix
    (Dr. Charles White, Penn State University)
  - Adjustments based on specific species in the mixture, priority
    purposes of the cover crop, and site conditions.
Early April 2009

Rye 40 lbs
Crimson Clover 12 lbs
Vetch 25 lbs
## Species Composition

<table>
<thead>
<tr>
<th>sample</th>
<th>crop</th>
<th>lbs/acre</th>
<th>% of mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>vetch</td>
<td>498</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>clover</td>
<td>3774</td>
<td>52</td>
</tr>
<tr>
<td>1</td>
<td>rye</td>
<td>2951</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7223</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>vetch</td>
<td>232</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>clover</td>
<td>729</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>rye</td>
<td>2515</td>
<td>72</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3476</td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{Average} \frac{\text{lbs}}{\text{ac}} = 5350 \]
## Example of Seeding Mixture Computations

<table>
<thead>
<tr>
<th>No.</th>
<th>Species</th>
<th>Monoculture Rate</th>
<th>Formula</th>
<th>Approximate Amount in Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rye (Cereal)</td>
<td>100 lbs./ac.</td>
<td>100/(7+1)</td>
<td>12.5 lbs./ac.</td>
</tr>
<tr>
<td>2</td>
<td>Ryegrass</td>
<td>25 lbs./ac.</td>
<td>25/(7+1)</td>
<td>3.15 lbs./ac.</td>
</tr>
<tr>
<td>3</td>
<td>Winter Peas</td>
<td>75 lbs./ac.</td>
<td>75/(7+1)</td>
<td>9.4 lbs./ac.</td>
</tr>
<tr>
<td>4</td>
<td>Crimson Clover</td>
<td>20 lbs./ac.</td>
<td>20/(7+1)</td>
<td>2.5 lbs./ac.</td>
</tr>
<tr>
<td>5</td>
<td>Hairy Vetch</td>
<td>25 lbs./ac.</td>
<td>25/(7+1)</td>
<td>3.15 lbs./ac.</td>
</tr>
<tr>
<td>6</td>
<td>Forage Radish</td>
<td>10 lbs./ac.</td>
<td>100/(7+1)</td>
<td>1.25 lbs./ac.</td>
</tr>
<tr>
<td>7</td>
<td>Turnips</td>
<td>5 lbs./ac.</td>
<td>100/(7+1)</td>
<td>0.5 lbs./ac.</td>
</tr>
</tbody>
</table>
Seeding Method

• Incorporating (broadcasting/disking, etc.)
• Broadcasting/Cultipacking
• Broadcasting (spin spreader, etc.)
• Aerial Seeding
• Drilling
Aerial seeding cover crops into standing crops

- Cereal Rye 1.5 – 2.0 bu / acre
- Turnips 3.0 lb / acre
- Millet 1.5 lb / acre
- Wheat 1.0 – 2.0 bu / acre
- Soybeans 2 bu / acre
Considerations Relating to Proper Planting

- Depth of seed placement
- Coverage of the seeds
- Settling of smaller seeds
- Carriers to improve seed flow and distribution
- Competition, existing
- Inoculation of legumes
Considerations for Application of Fertilizers to Cover Crops

- Soil fertility
- Residual nutrients from the previous crop
- Increased window for application of animal manures.
- Early root development
- Increased biomass production
Terminating Cover Crops

- Incorporation
- Flat Sweeps
- Mowing

- Winterkill
- Herbicides
- Rolling/crimping
Plowing cover crops into soil minimizes contribution to soil organic matter and does not maintain protective surface cover.

Tillage burns up soil organic matter and speeds organic N mineralization and nitrification.

Herbicides for termination are not compatible with organic rules.

Mowing is relatively slow which may limit its use on larger operations.

Rolled cover crops provide greater suppression of weeds than mowed or standing cover crops.

Cover must be near physiological maturity for effective termination by rolling only.
Undercutter (Nancy Creamer, NC State)
GA farmer, Lamar Black, rolls a 2 meter tall rye cover crop prior to planting corn or cotton. The resulting mulch suppresses weeds, conserves water, and lowers peak soil temperature.
American Rollers, Roll-choppers, and Roll crimpers
Options for rolling cover crops

Rodale design

Cultimulcher
3 Bales Per Acre
Percent kill of summer cover crops in North Carolina (Creamer and Dabney, 2002, Am J. Alt. Ag. 17:32-40)

<table>
<thead>
<tr>
<th>Cover crop</th>
<th>Growth stage</th>
<th>Mow</th>
<th>Undercut</th>
<th>Roll (smooth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea</td>
<td>Vegetative</td>
<td>98</td>
<td>85</td>
<td>5</td>
</tr>
<tr>
<td>Soybean</td>
<td>Early bloom</td>
<td>100</td>
<td>99</td>
<td>12</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>Mature</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pearl Millet</td>
<td>Heading</td>
<td>0</td>
<td>73</td>
<td>18</td>
</tr>
<tr>
<td>German Millet</td>
<td>Green Seed</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Sorghum-sudangrass</td>
<td>Mature</td>
<td>0</td>
<td>89</td>
<td>25</td>
</tr>
</tbody>
</table>