How Cover Crops Build Soil Health
Part 1 (Slides 1 – 47)

North Valley Organics (Minor Morgan, Albuquerque, NM)

Close up of Cover Crops growing between vegetable rows at Minor’s Organic Farm

Soil Health & Assessments Training in NM

Rudy Garcia
USDA-NRCS Regional Soil Health Specialist (NM, CO, UT, AZ)

NOTE: this presentation is about how cover crops help to build soil health. Many NRCS Soil Health Specialists/Conservationists, Producers, University Specialists, Ag Consultants and other Soil Health Partners have shared their work on how cover crops build soil health and increase productivity. Many thanks to all of you.
How Cover Crops Build Soil Health

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

(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

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

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

Other Benefits: Clean Air, Clean Water, Healthy & Nutritious Plants, and much more.
Nurture Nature with System Synergies

Cover Crops increase soil organic matter and improve Soil Health.

(1) Cover Crops Add Organic Matter:

- Cover Crops increase soil organic matter and improve Soil Health.
- No Tillage: Minimum carbon loss
- Cover Crops: Maximum carbon input

Carbon management

Sustainability

No Tillage

Cover Crops

Carbon management

Sustainability

No-Till, Low Diversity

Located in Close Proximity (Same Soil Type)

No Till, High Diversity, ZERO Synthetics, Livestock

Ref.: Ray Archuleta

Dr. Don Reicosky
ARS, Morris, MN
(1) Cover Crops **Add** Organic Matter:

Taking the soil from this ... To this in 3 to 5 years with an Soil Health Mgt. System

*Organic Matter makes the soil darker and richer looking.*

**Increase Soil Organic Matter**

- Contributes directly to nutrient cycling, nutrient availability, nutrient holding capacity, and water holding capacity.
- Plays a significant role in the formation of water stable aggregates which affects infiltration, aeration, drainage and bulk density.
- Provides carbon and energy for soil organisms that are essential for maintaining a healthy soil.

*Carbon is a “keystone” in nutrient cycling!*

Soil carbon is the “Keystone” for all soil physical, chemical and biological processes and properties.
Plan on Diversity

- What crop types do you lack?
  - Cool season grass
  - Warm season grass
  - Cool season broadleaf
  - Warm season broadleaf
- Multi-species always better
  - Remember nature!
- Soil foodweb does better on diverse diet

Cover Crop Role in Diversity

1. Allow you to look at cropping periods rather than years
2. Can be used to accelerate rejuvenating soil health
3. Getting 4 to 6 weeks of growth is adequate to get the “rotation” effect!
4. Will increase soil biological diversity “Diversity above= diversity below”
Diversity in root systems = diversity in soil biota

Healthy Soil

Approximately 2/3 Of Your OM Increase Will Come From Roots!

Healthy Soil

Diverse Plants = Diverse Soil Food Web
= Healthy Soil, when implementing a Soil Health Mgt. System

(2) Cover Crops Add Plant Diversity:

- Providing quality habitat for soil microorganisms should be the goal of producers interested in improving soil health.
- Soil is a biological system that functions only as well as the organisms that inhabit it.
If **Soil Health** is the goal, **Crop Diversity** cannot be ignored or overstated.

Plants were created to grow in diverse ecosystems.

**Resilience** comes from **Diversity**.

Balanced “diet” for soil biology.

Balance: because even good things (legumes, brassicas) when not used in moderated balance can be harmful.

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**(2) Cover Crops Add Plant Diversity:**

**Why Build Diversity?**

**Diversity conduit for energy and nutrients.**

Diversity increases other soil activities:

- Microbial community biomass
- Microbial composition (more species)
- Respiration
- Fungal abundance
- N mineralization rates (fast, medium and slow)

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**Increase Biodiversity**

- Addition of different functional groups into an existing rotation (i.e. warm season grass, cool season grass, warm season broadleaf, cool season broadleaf)
- Adding diversity of plant species helps feed the biological life in the soil improving soil health
(3) Cover Crops Enhance Mycorrhizae numbers:

Fungal hyphae binding soil particles together into aggregates.

Although mycorrhizae don’t make humus, it is difficult to start the humification Process without them. They bring large quantities of soluble Carbon into the soil from plant roots, which feeds the microbes involved in the complex process.

Photo: Jill Clapperton

Hyphae of arbuscular mycorrhizae fungi grow beyond nutrient depleted zones found around roots and root hairs.

Ref.: Does glomalin hold your farm together?

Dr. Kris Nichols

Soil Humus Formations:
1) Photosynthesis
2) Resynthesis
3) Exudation
4) Humification

Dr. Christine Jones
(3) Cover Crops **Enhance** Mycorrhizae numbers:

**Soil Food Web Benefits:**
Symbiosis- Mycorrhizae

- Myco (fungus)- rhiza (root)
- Plant uses 5-30% of energy (C) from photosynthesis to ‘feed’ fungi
- Fungi increase adsorptive surface area 10x or more of plant roots
- Increase nutrient uptake especially P, N, Zn
- Suppresses pests and disease
- Builds soil aggregates

Above: USDA-ARS research microbiologist Wendy Taheri found that arbuscular mycorrhizal spores were sparse from a **tilled farm field**, but abundant in an **undisturbed prairie** soil.
Plant species differ in abilities to acquire nutrients

- Exudation of P mobilizing carboxylates (brassicas)
- Fe- and other micronutrient (Zn) chelating phytosiderophores (depends on pH/legumes)
- Mycorrhizas or other symbionts
- Combination of all the above

(3) Cover Crops Enhance Mycorrhizae numbers:

A microscopic view of an arbuscular mycorrhizal fungus growing on a corn root. The round bodies are spores, and the threadlike filaments are hyphae. The substance coating them is glomalin, revealed by a green dye tagged to an antibody against glomalin.

*Credit: Photo by Sara Wright*
Soil Food Web Benefits: Formation & Stabilization of Aggregates

- Chemical interactions
  - Polysaccharides (sugars) released by bacteria act like glues to bind particles
  - Glycoproteins (glomalin-related soil proteins and other proteins) act like glues

How do soil aggregates form?

Glycoproteins on soil aggregates
Dr. Nichols, USDA-ARS

Bacteria (ovals) with ‘sticky’ polysaccharides (red arrows)

SEM photo source: Eickhorst, Thilo & Tippkoetter, Rolf
Micropedology – The hidden world of soils, University of Bremen, Germany. [Link to source]
Soil Food Web Benefits: Formation & Stabilization of Aggregates

- Physical interactions
  - Plant roots enmesh soil particles
  - Earthworms (casts) and termites (mounds)
  - Soil fungi and some Actinobacteria produce filaments that physically enmesh soil particles together

How do soil aggregates form?

Stabilization of soil structure by actinomycete (bacterial) filaments

Net-like fungal mycelia stabilize micro-aggregates

Soil image with worm: Aaron Roth, NRCS-OR
(4) Cover Crops build Aggregates:

The maintenance of a high degree of aggregation is one of the most important goals of soil management. (Ref.: The Nature and Properties of Soils, 14 Edition revised. Chapter 4)

Soil aggregation and carbon sequestration are tightly correlated with the abundance of arbuscular mycorrhizal fungi: results from long-term field experiments

Gail W. T. Wilson,1* Charles W. Rice,2 Matthias C. Rillig,3 Adam Springer4 and David C. Hartnett5

Cover Crops build Aggregates:

Healthy soils are held together by soil glues, or glomalin, that are produced by fungi. Soils rich in soil biota hold together, while soils devoid of soil life fall apart and form a layer of sediment in the bottom of the jar. Pictured above, the soil on the left is from a field that has been managed using no-till for several years. The soil on the right is from a conventionally-tilled field.

Crumbly soils (left) have more pores and channels than cloddy soils (right). Pores and channels allow air and water to move into the soil.

Rhizosphere...where roots meet soil

Zone of concentrated biological activity adjacent to the root.
- Bacteria
- Fungi
- Protozoa
- Nematodes
- Microarthropods
- Earthworms

Ref.: Jon Stika, ND
Cover Crops Increase Earthworms:

Earthworms consuming cover crops and making healthy soil

Earthworm Population On The Cover Crop Side 3X Greater Than Non Cover Crop Side.

Earthworms in Temple, TX
Earthworms

Cover Crops Increase Earthworms:

- Earthworms bury litter, shred organic matter, & stimulate microbial decomposition.

Earthworms

- Poor soils contain 250,000 earthworms per acre while good soils contain 1,750,000 per acre.
- 1 or less per shovel indicates poor soil health.
- 10 or more per shovel indicates good soil health.
- Burrowing through lubricated tunnels forces air in and out of soil.
- Earthworm casts contain 11% of the humus, 7X the nitrogen, 11X the phosphorus, 9X the potash, than surrounding soil.

Figure 1. Effect of tillage and crop on earthworm number/m²
CT = conventional till, NT = no-till; W = wheat, C = corn, S = soybean
Adapted from Hubbard, et al. 1999.

Ref.: NRCS Soil Quality Indicators

Earthworms bury litter, shred organic matter, & stimulate microbial decomposition.
(6) Cover Crops Add lasting residue/cover:

Crop Residues are needed to protect the soil surface and to feed the soil organisms.

- Prevents soil particle detachment by wind and water
- Reduces raindrop impact
- Prevents crusting

Raindrop impact destroys soil aggregates and disperses soil particles...

Creating soil crusts
Cover crops added to a cash crop rotation can help manage nitrogen and crop residue cover in a cropping sequence.

A low C:N ratio cover crop containing legumes (pea, lentil, cowpea, soybean, sunn hemp, or clovers) and/or brassicas (turnip, radish, canola, rape, or mustard) can follow a high C:N ratio crop such as corn or wheat, to help those residues decompose, allowing nutrients to become available to the next crop.

Similarly, a high C:N ratio cover crop that might include corn, sorghum, sunflower, or millet can provide soil cover after a low residue, low C:N ratio crop such as pea or soybean, yet decompose during the next growing season to make nutrients available to the following crop.

Understanding carbon to nitrogen ratios of crop residues and other material applied to the soil is important to manage soil cover and crop nutrient cycling.

### Additional lasting residue/cover:

**Rye**
- High C:N
- Ties up N
- Compounds problem following another high C:N crop

**Hairy Vetch**
- Low C:N
- Release lots of N
- Decomposes Fast

**Rye & Hairy Vetch Mix**
- Balance C:N ratio
- Control decomposition
- Ideal cover crop mix
(6) Cover Crops Add lasting residue/cover:

Brown’s Ranch (Same Field)

June 16, 2009
Corn planted into previous years’ cover crop residue

Photo are from Gab Brown’s farm in ND and demonstrate how quickly residue can breakdown when soils are healthy.

July 1, 2009 (Rapid residue decomposition)

High Carbon Cover Crops
- Armor the soil
- Increase soil OM
- Capture & recycle nutrients (slower release)
- Manage soil moisture
- Moderate soil temperature

Low Carbon Cover Crops
- N fixation (legumes)
- Scavenge N (quick release)
- Help break down high carbon residues

Residue should be broken down and incorporated into the soil profile in a healthy soil!

Residue is thought to be a good indicator of soil health, lots of residue equals healthy soils, but this is only looking at the erosion aspect. Residue shouldn’t stick around for multiple years, if so than there is something not functioning in the soil, poor microbial action.
(6) Cover Crops Add lasting residue/cover:

**Crop Residue Treasure or Trash?**

- **Treasure**
  - Erosion control
  - Nutrients
  - Organic matter and soil quality
  - Soil moisture conservation
  - Weed control

- **Trash**
  - Seeding issues
  - Crop issues

**The Detritusphere:**
- Protects the agratusphere and the porosphere from the sun, wind and rain
- Lowers temperature and evaporation
- Provides habitat and food for soil organisms
- Enhances biogeochemical nutrient cycling
- Builds soil structure and nutrient reserves

**FIGURE 6.** Residue cover – relative soil loss relationship. With 30% residue cover, soil loss is reduced 70%.

Soil mites such as this *Ametrop* species process crop residues into soil organic matter (Jill Clapperton)
Cover Crops Suppress Weeds:

- Adequate lignin content (boot stage)
- Moisture use considerations
- Lack of growing season?
- Same direction as planting
- Weed control by mulching

- A healthy stand of cover crops can out-compete weeds for light and nutrients.
- The mulching effect of some types of cover crops can reduce weed pressure.
- Some types of cover crops produce chemical exudates that can inhibit weed growth.
- In addition to controlling weeds cover crops can help break pest cycles
- Terminate cover crop before they produce viable seed
- Cover crops can become weeds if not properly managed
- Site preparation: Early weed control is essential
Cover Crops Suppress Weeds:

- Buckwheat:
  - Covered the ground within 15 days after planting (DAP).
- Pearl millet:
  - Substantial biomass by 42 DAP
  - Crowded out most weeds.

Weed Control: The more diversity in the rotation, the easier it is to control weeds. Cover crops compete with weeds and crop residue serves to suppress establishment of the weeds.
(8) Cover Crops Increase Infiltration of Water:

What Tillage does to the Soil:
- Destroys aggregates
- Exposes organic matter to decomposition
- Compacts the soil
- Damages soil fungi
- Reduces habitat for the Soil Food Web
- Disrupts soil pore continuity
- Increases salinity at the soil surface
- Plants weed seeds

Rainfall Simulator Demonstration

Runoff & Erosion Results

Tillage disrupts ecosystems processes

Infiltration Results
This picture shows two fields, one on each side of a fence, in Brookings County, SD. The soil was saturated from a series of rain events.

Hours after a storm left almost another inch of rain, water in the no-till field was able to infiltrate into the soil.

By contrast, the adjacent field under conventional tillage was still ponded, and had runoff that moved tons of topsoil off the field.

Ref.: Ray the Soil Guy

(8) Cover Crops **Increase** Infiltration of Water:
(9) Cover Crops Reduce Soil Erosion:

Cover Crops build aggregates and protect the soil from wind and water erosion.

Do you have “Crumbly” Soil?

Agricultural soils do not have a water erosion/runoff problem, they have a water infiltration problem.

Ref.: Ray the Soil Guy

Jan 12, 2014

April 14, 1935
(10) Cover Crops **Minimize & Reduce** Soil Compaction:

- **Which answer to compaction?**

  - Roots run laterally on top of a compacted layer

  - Soil Compaction – soil pit in conventional tilled field, roots growing sideways

  - Soil Compaction – high bulk density

  - Use as needed to remediate compaction
In areas of limited soil moisture, terminate growth of the cover crop sufficiently early to conserve soil moisture for the subsequent crop. Cover crops established for moisture conservation shall be left on the soil surface.

SOIL CARBON is the key driver for the nutritional status of plants – and therefore the mineral density in animals and people.

For every 1% that you increase SOM, waterholding capacity increases 20,000-25,000 gallons per acre.

Dr. Christine Jones
Cover Crops used to Manage Soil Moisture:

Reduce Evaporation with cover

- Crop residue improves infiltration and reduces soil evaporation. Maintaining adequate residue cover takes the “E” out of ET.
- A study in Kansas found that leaving crop residue in place resulted in a savings of 3.5” of soil water. That is equivalent to an extra 40 bu/ac dryland corn or an irrigation savings of $25 to $35 per acre.

Cover Crop in Rainfall and/or irrigation:

- Increases infiltration
- Reduces Evaporation
- Removes Excess Moisture (In areas of potential excess soil moisture, allow the cover crop to grow as long as possible to maximize soil moisture removal)
- Terminate while cover crop is vegetative (before peak water use occurs)
- Six weeks of growth to achieve “rotation effect”

When moisture becomes limiting in a dryland period the mycorrhizal plant utilizes the water stored in root cell vesicles.

Taking crop residues away from the fields will compromise agricultural sustainability.
Cover Crops used to Manage Soil Moisture:

Ref.: Adam Daugherty, NRCS District Conservationist in TN
Cover Crops used to Manage Soil Moisture:

**Competition or Collaboration?**

- **Stress Gradient Hypothesis** (Bertness and Callaway, TREE, vol. 9, no. 5, 1994)
  - As environmental stress increases, plants in a community collaborate rather than compete.
  - Diverse cover crop mixes are more productive under good or bad conditions.

Images:
- Turnip cover crop, July 2006 Bismarck, ND
- Radish cover crop
- Six specie cover crop July 2006 Bismarck, ND, 1.8” growing season precip to date
Cover crops Capture & Recycle Nutrients:

Nitrogen Storage Tank

- Cover crops such as wheat, rye, oats and sorghum-sudangrass which establish quickly and have fibrous roots systems are ideal for scavenging excess nitrates from the soil profile (i.e., they decrease nutrient loss).
- Brassicas such as oilseed radish and turnips are also good scavengers although they establish more slowly and will winter kill.
- Growing deep rooted cover crops may help redistribute micro-nutrients in the soil profile and make them more available for the subsequent crop.
- Use deep-rooted species to maximize nutrient recovery.

Give it least 3 to 5 years for diversity to repair the soil before it is starts to increase nutrient cycling...

Soil biological processes are responsible for supplying approximately 75% of the plant available nitrogen and 65% of the available phosphorus in the soil. Like all organisms, those inhabiting your soil need food & a favorable environment. Adequate organic matter content, ample aeration, moderate moisture, neutral pH, and warm temperatures all favor increased microbial activity.

Cover crops can reduce nutrient losses

- Nitrate leaching in the fall is a concern.
- Non-legume cover crops help reducing nitrate leaching by taking-up the extra N
  - Cereal rye
  - Wheat
  - Barley
  - Oats
  - Ryegrass
(12) Cover Crops Capture & Recycle Nutrients:

Soil Health Management System (Managing SOM)

Grass is mowed several times during the growing season (residues are left on the surface to decompose & recycle back to the soil)

Bare Surface (poor nutrient cycling)

(Orchard with a cover: soil has an “Optimal” Bio-Geo-Chemical Nutrient Cycle)
(12) Cover Crops Capture & Recycle Nutrients:

- 90% N,P,K eaten is returned to soil.

- ~75% of N and K in Urine

- ~75% of P in Manure

Impact of Manure and Urine recycling
Cover Crops create the Optimal environment for Soil Organisms to cycle nutrients efficiently.

Factors affecting Nutrient Cycling & Soil Health:
- Temperature
- Oxygen
- Soil Moisture
- Soluble Organic Carbon
- C:N ratio
- Salinity
- pH
- Predation
- Nutrients
- Competition

(12) Cover Crops Capture & Recycle Nutrients:

Cover Crops minimize the Optimal environment for Soil Organisms to cycle nutrients efficiently.

Oxygen (O₂ gas in macro pores)
Carbon Dioxide (CO₂ gas in macro pores)

Dissolved Oxygen & Carbon Dioxide

Mineralization ↔ Immobilization

Soluble Nutrients (e.g., OC, ON, OP, NH₄⁺, NO₃⁻, other: K⁺, Ca₂⁺, etc.)

(Microorganisms are Sub-Aquatic Organisms)

Microaggregate Consisting of Clay, silt, humus, particulate organic matter, very fine sand, precipitated minerals, microorganisms & other organic compounds.

O₂ CO₂
Dung Beetles move fecal material down up to 18 inches.

Soil eaten by earthworms with organic matter is deposited on the soil surface as castings.

April 29, 2014 evaluating soil of the cover crop field: Worms underneath decomposing cow pie. 165 worms per cubic foot. 7.2 million worms per acre. (Ref.: Marlon Winger)

Dung Beetles having lunch.
(13) Cover Crops Add Nitrogen (Legume):

- **Legumes are Symbiotic with Ryzobium & AMF, important in pastures to drive the carbon and nutrient cycles.**
- **AMF bring in Zn, P, Moly, and Fe needed for nodulation (Much more efficient system).**
- **Legumes add the most plant-available N if terminated when about 30% of the crop is in bloom.**

**Promote Biological N-fixation**

- Legumes can fix atmospheric N through a symbiotic relationship between the plant and Rhizobium.
- Growing legume cover crops can supply additional N for the subsequent crop providing that a majority of the above ground biomass is returned to the soil.
- **Considerations:**
  - Works best when N is limiting
  - Legumes need to be properly inoculated

### Legumes- Biological N fixation

<table>
<thead>
<tr>
<th>Legume</th>
<th>N fixed lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>195</td>
</tr>
<tr>
<td>Red clover</td>
<td>115</td>
</tr>
<tr>
<td>Cowpea</td>
<td>90</td>
</tr>
<tr>
<td>Pea</td>
<td>63</td>
</tr>
<tr>
<td>Common bean</td>
<td>41</td>
</tr>
</tbody>
</table>

[www.sare.org](http://www.sare.org)
(13) Cover Crops Add Nitrogen (Legume):
Sesbania Nodulation, Fall 2011

Key issues to focus on in water limited environment:
- Water requirements of the cover crop - is the demand high or low?
- Drought tolerance of the cover crop - does the cover crop tolerate dry spells and to what extent?
- Is the cover crop easy to manage - watch out for tendency to become weeds

Drier Climates
- Delayed termination of a winter cover crop – may result in moisture deficiency for main summer crop.
- Kill the cover crop before it removes too much soil water.

Putting it all together
- Cover crops are an important component of sustainable crop production.
- Multiple benefits of cover crops.
- Specific functions.
- Things to consider while selecting a cover crop.
- Integration of cover crops into cropping systems.
- Management challenges.
- Potential cover crops for the region.

Ref.: Dr. Kulbhushan Grover, NMSU

Soil Aggregate Stability with Cover Crops

Grover et al., 2009
It is important to recognize that the ability to fix nitrogen is not limited to bacteria associated with legumes. Chlorophyll is part of a protein complex - hence wherever you see green plants - there will also be an association with nitrogen-fixing bacteria or archaea.

In addition to nitrogen-fixing bacteria and archaea, mycorrhizal fungi are also vitally important to the N-fixing process. **Although mycorrhizal fungi do not fix nitrogen, they transfer energy, in the form of liquid carbon (Jones 2008) to associative nitrogen fixers.** They also transport biologically fixed nitrogen to plants in organic form, for example, as amino acids, including glycine, arginine, chitosan and glutamine (Leake *et al.* 2004, Whiteside *et al.* 2009).

**The acquisition and transfer of organic nitrogen by mycorrhizal fungi is highly energy efficient.** This pathway closes the nitrogen loop, reducing nitrification, denitrification, volatilization and leaching. Additionally, the storage of nitrogen in the organic form prevents soil acidification.

**Fig.1.** Cross section of a plant root showing the thread-like hyphae of mycorrhizal fungi. **Mycorrhiza deliver sunlight energy packaged as liquid carbon to a vast array of soil microbes involved in plant nutrition and disease suppression.** Organic nitrogen, phosphorus, sulphur, potassium, calcium, magnesium, iron and essential trace elements such as zinc, manganese and copper are returned to plant hosts in exchange for carbon. **Nutrient transfers are inhibited when high rates of inorganic nitrogen and/or inorganic phosphorus are applied.** Photo Jill Clapperton.
(15) Cover Crops Attract Beneficial Insects:

Build it... they will come!

162,000 weed seeds/ 1 sq. meter of a farm field. 137,000 to 161,000 predators per acre of corn canopy.

Approximately 10 percent of weed seeds are eaten per day by Millipedes, Small crickets, Isopods, Field Crickets an Carabid Beetles.

Jan 9, 2015. Dr. Jonathan Lundgren SD ARS/USDA.
(15) Cover Crops Attract Beneficial Insects:

Plant Diversity = Beneficial Insect Diversity

Cape Town, South Africa
100 Plants & Animals
24 Hours - Grassland

Costa Rica
150 Plants & Animals
24 Hours - Forest

Iowa Corn Field
8 Plants & Animals
24 Hours
(16) Cover Crops are used for Disease Mgmt./Suppression:

Healthy Soil: Provides Optimal Predator-Prey conditions and for managing pest/disease problems

- Cover Crops Provide food or habitat for natural enemies of pests
- Cover crops may be selected that release biofumigation compounds that inhibit soil-borne plant pests and pathogens
- Species can be selected to serve as trap crops to divert pests from production crops
- Mycorrhizae suppresses pests and diseases
- Cover Crops break pest cycles
- Avoid cover crop species that harbor or carry over potentially damaging diseases or insects
- Use an Integrated Pest Management (IPM) Plan

The Soil Food Web (SFW) is a complex association of organisms responsible for breaking down crop residues and cycling plant-available nutrients in the soil.
Cover Crops are used for Disease Mgmt./Suppression:

What Do Soil Organisms Do In Soil?

**Organic Matter Dynamics**
- Shred, mix, fragment residues
- Decompose residues
- Release nutrients
- Sequester C

**Soil Structure**
- Form & stabilize aggregates
- Create biopores
- Influence H₂O, gas exchange

**Nutrient Cycling**
- Transform, store, release C, N, P, S and micronutrients
- Solubilize nutrients from soil minerals (e.g. P)
- Fix atmospheric N₂ → NH₄⁺

**Plant Protection**
- Biocontrol to suppress pathogens and disease

**Plant Growth**
- Release biochemicals that stimulate plants
- Symbiosis

**Detoxify Pollutants**
- Agrichemical sources
- Industrial sources

Photo credit: Aaron Roth, NRCS-OR; Slide design: Jen Moore Kucera, NRCS-SHD
Cover Crops are used for Disease Mgmt./Suppression:

Soil Food Web Benefits: Population Control (Predation)

- Nematode trapping fungi
- Predation: Mite consuming springtail and a nematode
- Predation: Protozoa consume billions of bacteria; some consume fungi
Use plant species that enhance forage opportunities for pollinators by using diverse legumes and other forbs.

Pollinators: Flowering plants that support pollinators also support beneficial predatory & parasitic insects.

Beneficial Insectary: Many of the nectar sipping & pest-eating insects that are attracted to flower pollen will also pollinate your fruit and vegetable crops & increase your yields.
Cover Crops help support Wildlife:

Wildlife winter food & shelter

Diversity

Soil temp. 68F

Provide food and cover for wildlife habitat management.
(19) Cover Crops catch Snow:

Cows digging through snow to balance diet
Planting/Seeding Cover Crops:

Get 4 Things Right

1. The Right Species
2. The Right Inoculants
3. The Right Seeding Rates
4. The Right Seeding Time

- Select plants from all functional groups (diversity).
- Select at least two plant species within each functional group to provide some redundancy and insurance against failure of one species.

Considerations for successful cover crop planning

- Economics (yields, cost of establishment, soil improvement)
- Establishment of next cash crop
- Residue management (cash crop) before and after cover crop emergence
- Timing and species (adequate growing season)
- Site and moisture conditions
- Seeding method/seed-soil contact (broadcast vs. drilling; adequate equipment)
- Crop rotation (diversity)
- Herbicide carryover (i.e., Label restrictions on herbicide use)
- Site preparation: Early weed control is essential

OTHER Cover Crop Planning/Management Considerations:

- Become a “committed” student and a observer
- Be Patient: Do not go cold turkey.....
- Find a mentor or community of believers of this type of holistic thought and planning process
- At least a two year break between crop types
- Plant the opposite crop type for your cover crop rotation

Cover Crop Seed Mix