# Unlocking the Secrets of Soil Biology to Improve Soil Health

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## **4 Cornerstones of Soil Health**



- 1. Little or No Soil Disturbance
- 2. Diverse Crop Rotations and Multi-species Cover Crop Mixtures
- 3. Living Roots Growing Most of the Year
- 4. Year Round Residue on Soil Surface
- 5. Livestock

## Mimic Nature





#### **Evaluate How Your Soil System is Functioning**

All parameters are important ; typically we focus on physical and chemical- but Biology is King!



### The Soil Food Web Working Toward A Higher Quality No-till The "Below Ground" Players...





#### • Bacteria-

Decomposer of simple carbon chains (low carbon residue). Little bag of fertilizer. One bacterium can produce 5 billion offspring in 12 hours (food available). Feed on root exudates.

Soil Biology Primer

### The Soil Food Web Working Toward A Higher Quality No-till The "Below Ground" Players...



#### Fungi-

Saprophytic-primary decomposer of complex carbon chains (high carbon chains).

*Mycorrhizal*-transports nutrients.

Little bag of fertilizer.

Forms the soils glue (glomalin) along with the plant roots exudates.

Soil Biology Primer

Sections of fungal hyphae in <u>no-till soil</u> with cover crop (Fayette County, IA)



#### No-till w/ cover crop,1:10 dilution (100X)

No-till w/ cover crop, 1:10 dilution (400X)

This <u>conventional tillage soil</u> in Fayette Co. exhibited 8-10 times less fungi than the no-till soil w/ cover crop.

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Glomalin is naturally brown. A laboratory procedure reveals glomalin on hypae and soil aggregates as the bright green material shown here.





Dr. Kris Nichols – Microbiologist - USDA ARS



### The Soil Food Web Working Toward A Higher Quality No-till The "Below Ground" Players...



#### Protozoa-

Mineralize nutrients by eating the little guys (fungi and bacteria).

Consumes an average of 10,000 bacteria per day. Amoebae – large Ciliates – medium Flagellates - small

Soil Biology Primer



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#### Nematodes-

Mineralize nutrients by eating the little guys (fungi and bacteria). Taxi for the bacteria & fungi. Locate food by temperature. Types: Herbivore, Bacterivores, Fungivores, and Predator. Large in size, compacted soil restricts their travel.

Soil Biology Primer





Video of nematode at 400x magnification (1:10 soil-to-water solution)

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### The Soil Food Web Working Toward A Higher Quality No-till The "Below Ground" Players...



## Actinomycetes-

Source of antibiotics: tetracycline, neomycin, streptomycin.

Controls bacteria in the soil and in humans.

Convert dinitrogen gas to ammonia.

Decompose SOM.

Cure compost.

Soil Biology Primer

## What Do They Weigh?

- Bacteria
- Fungi
- Protozoa
- Nematodes

2,000 - 2,500 Lbs/Ac 2,200 - 2800 Kilograms/Hectare

1,000 - 15,000 Lbs/Ac 1,200 – 17,000 Kilograms/Hectare

20 - 300 Lbs/Ac

10 - 300 Lbs/Ac 13 – 340 Kilograms/Hectare

Microbes in Humans

3 lbs/Person

#### Source:

 The Nature and Properties of Soils Brady and Weil, Fourteenth Edition.
 Soil Biology Primer.
 National Geographic, Nathan Wolfe, January 2013.





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#### Nitrogen Oxygen Hydrogen Carbon ole

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Key

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1. Lightning "fixes" nitrogen by gen (N<sub>2</sub>) with wate (H<sub>2</sub>O), to form nitric acid (HNO<sub>3</sub>), which falls to the ground with rain and is absorbed by the soil.

2. Animals take in nitrogen by consuming plants and other animals

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 Microorganisms release nitrogen rich compounds, including ammonia, from decaying plants and animals. Animal waste also contains nitrogen rich compounds such as urea.

2 6 PGP magazine/March 2005

 Some bacteria in the soil are "denitrifiers." They use nitrites and nitrates for energy, producing nitrous oxide (N<sub>2</sub>O) or free nitrogen (N<sub>2</sub>), which is released back into the atmosphere ON CREET CO

5. Nitrogen in the form of fertilizer (here, anhydrous ammonia) can be added to the nitrogen cycle.

4. Ammonia becomes ammonia ions when

mixed with water.

6. Bacteria in the roots of legumes, such as beans, peas and alfalfa, use the hydrogen in ammonia for energy, releasing nitrogen 

9. Plants, including corn, absorb nitrogen from the soil in the form of nitrate and ammonium ions and use them with the products of photosynthesis to create other nore-complex molecules, such as the nucleotide bases that are a part of DNA. The young corn plant uses these new molecules to fuel stalk and leaf growth.

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Nucleotide: Adenime

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10. Nitrogen is an essential element for the creation of amino acids, the building blocks of all proteins. As the plant matures, the percentage of nitrogen used for growth gradually decreases. The amino acids and proteins begin to go instead into reproduction, then into ear development. As the growing season advances, com takes in less and less nitrogen through the roots. However, the plant mobilizes nitrogen stores in the stalk and leaves to continue feeding ear development.

11. Excess nitrates can leach from the soil. These nitrates can reduce ground water quality. Managing nitrogen application levels is critical both for providing sufficient nutrients for crop growth and for avoiding potential environmental concerns:

7. Other bacteria in the soil change nitrite ions to

nitrate ions.

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Nitrous med

PGP magnzine/Marol 20

## Nitrogen



- Current labs
- 1. NO3-N
- 2. 2 M KCl (1965)
- 3. None



- Soil Health Tool
- 1. NH4-N
- 2. NO3-N
- 3. WETN
- 4. Solvita
- 5. Org N
- 6. Org C:N
- 7. MAC WEON
- 8. N min
- 9. Water

## Soil Health



#### Current labs

- 1. Permanganate: active carbon (not what soil microbes "see", they see water soluble carbon)
- 2. Organic matter (the house, not the food)
- 3. Anaerobic 7 day Nmin (40 C, anaerobic, not what happens in the field, can't measure N immobilization)

## • Soil Health Tool

- 1. Solvita (microbial respiration/activity)
- 2. Water soluble Organic C (microbial food)
- 3. Water soluble Organic N
- 4. Org C:N
- 5. Soil health score
- 6. Cover crop suggestion

# Traditional Soil Testing Methods

Soil N, P, K

# Soil pH, CEC

Recommendations

# % Organic matter



Where's the soil biology?

## Lab Chemistry



- Sulfuric acid
- Hydrochloric acid
- Nitric acid
- Acetic acid
- Phosphoric acid
- KCl
- Ammonium acetate
- Diethylene triamine pentaacetic acid
- Ethylenediaminetetraacetic acid
- Ammonium nitrate

- Water
- Naturally occurring organic acids (H3A)

# Soil Microbial Activity (respiration)

# Solvita 1-day CO<sub>2</sub>-C

#### Soil Microbial Activity Test with Digital Reader





## Soil Biology is a Complex Integrated Living System



 Organic carbon in water drives the system

 Soil microbes take in O<sub>2</sub> and release CO<sub>2</sub>

Soil microorganisms have been in R&D for millions of years.

Soil Organic Matter is the "House" microbes livers in, Water Extractable Organic Carbon is the "Food" they eat.



2% SOM, 12,000 ppm C





#### Water extractable total N



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## We have been missing half of the



Water Extractable Total Nitrogen Average of 6227 soil samples



2M KCl 1965 Bremer

"If plants could not take up organic compounds herbicides would not work" Liz Haney 2013 Plants eat: Inorganic N And Organic N from soil organic matter

## Balance in your Soil-water extract



- C: N = Organic C ÷ Organic N
- High C:N >20 :1 calculates no N and P mineralization
- As C:N is lowered N and P mineralization increases but is dependent on soil microbial activity



## Nutrient Cycling Carbon/Nitrogen Ratios

- Soil Microorganisms, Bacteria \*
- SOM, Mollisol Ap horizon \*
- Rotted barnyard manure \*
- Mature Alfalfa Hay \*
- Protozoa \*\*
- Corn Stover \*
- Wheat Straw \*
- Newspaper \*
- Deciduous Wood \*\*

Source:

\*The Nature and Properties of Soils, fourteenth Edition. DR. Nyle C. Brady and DR. Ray R. Weil

\*\* DR. Elaine R. Ingham, Soil Food Web

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## Soil Health Calculation

- Overall health of your soil system.
- Combines several independent measurements of your soil's biological and chemical properties.
- Varies from 1 to 30.
- Track the effects of your management practices over the years.
- Used to calculate cover crop input









## Soil Test Integration

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## Soil Health Tool - Results

Excel file via email
Plant available NPK and fertilizer calculator
Soil Health
Nitrogen
Phosphate
Explanation sheet pdf

## YouTube Video



Soil Health Principles – Rick Haney

<u>http://www.youtube.com/watch?v=qQ3tI-KwgEE</u>