Soil Health and NPK

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USDA-ARS Temple Texas 2012

How it's tested: Soil NPK

- Treat the soil as a non-living non-integrated system
- Focus on physical and chemical
- Ignore the biological
- Extract soil with chemistry that soil never sees
- Measure the house and not the food

How can we test it?

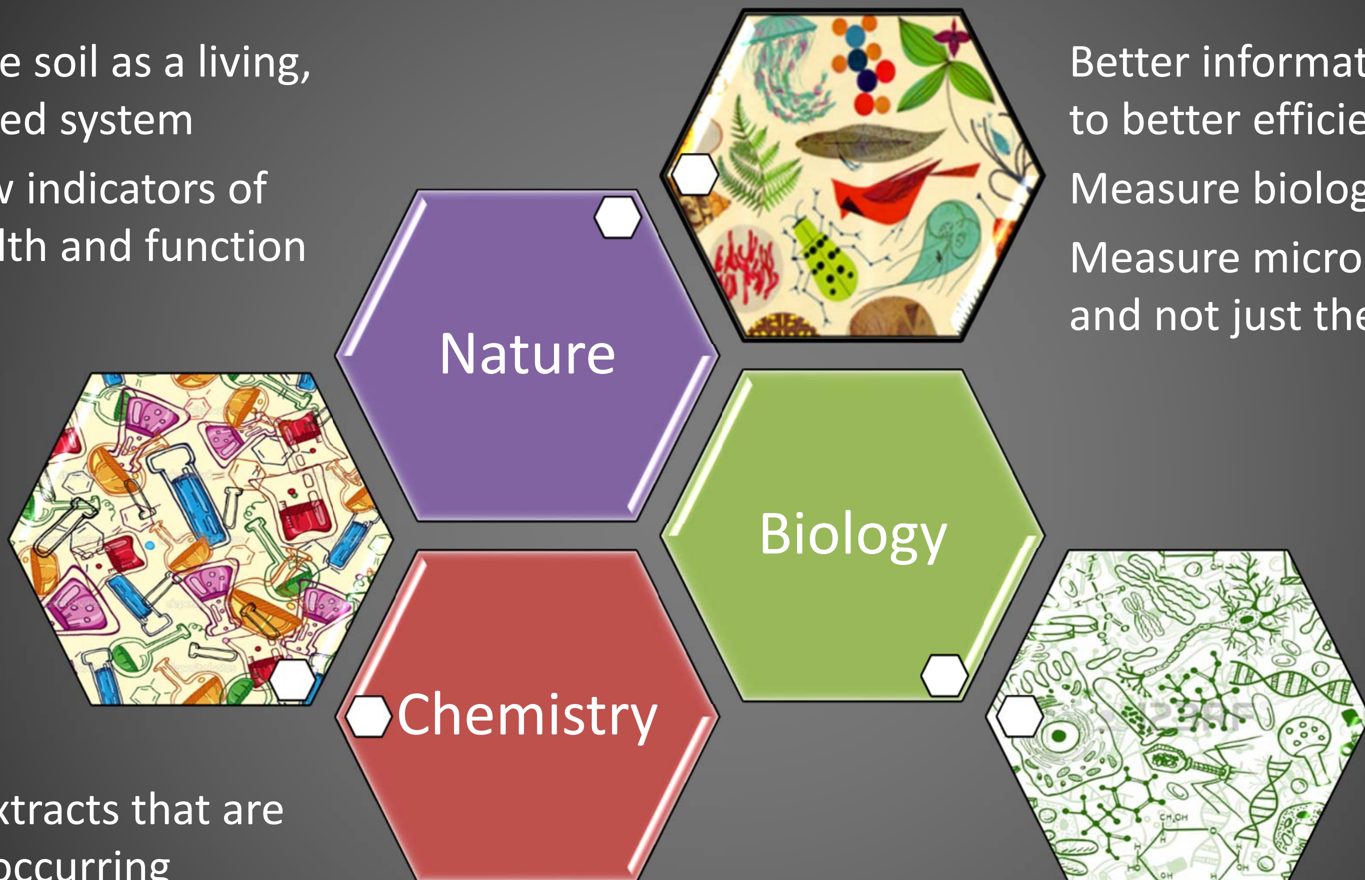
Treat the soil as a living, integrated system

Use new indicators of soil health and function

Better information leads to better efficiency

Measure biological activity

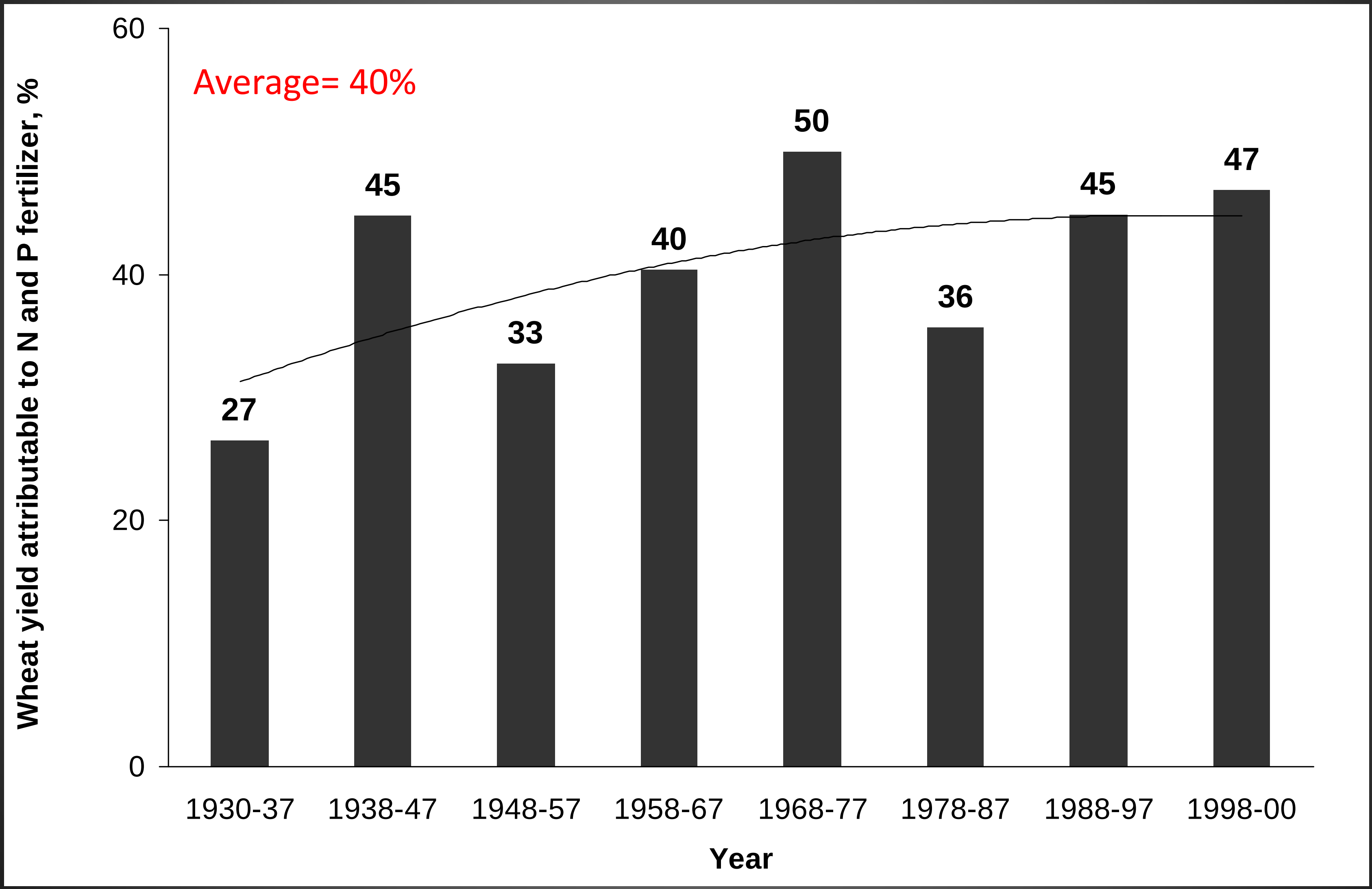
Measure microbial food and not just the house



Use soil extracts that are naturally occurring

Integrate the data to form a more compete picture of biology and chemistry

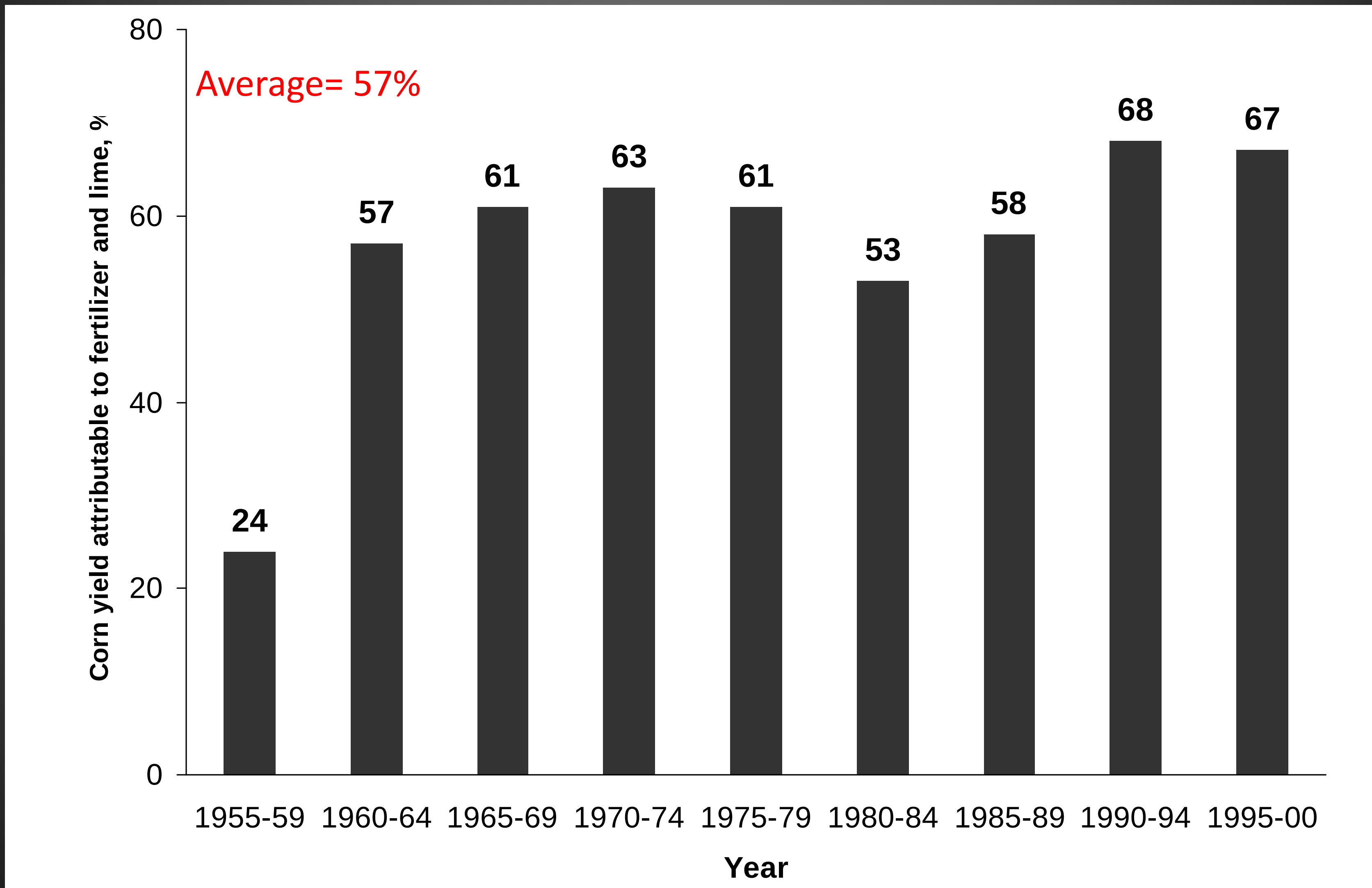
Wheat yield attributable to fertilizer: 1930-2000 Magruder plots (OSU)



Upward trend due to depletion of native N and P through crop removal.

Source: IPNI.net

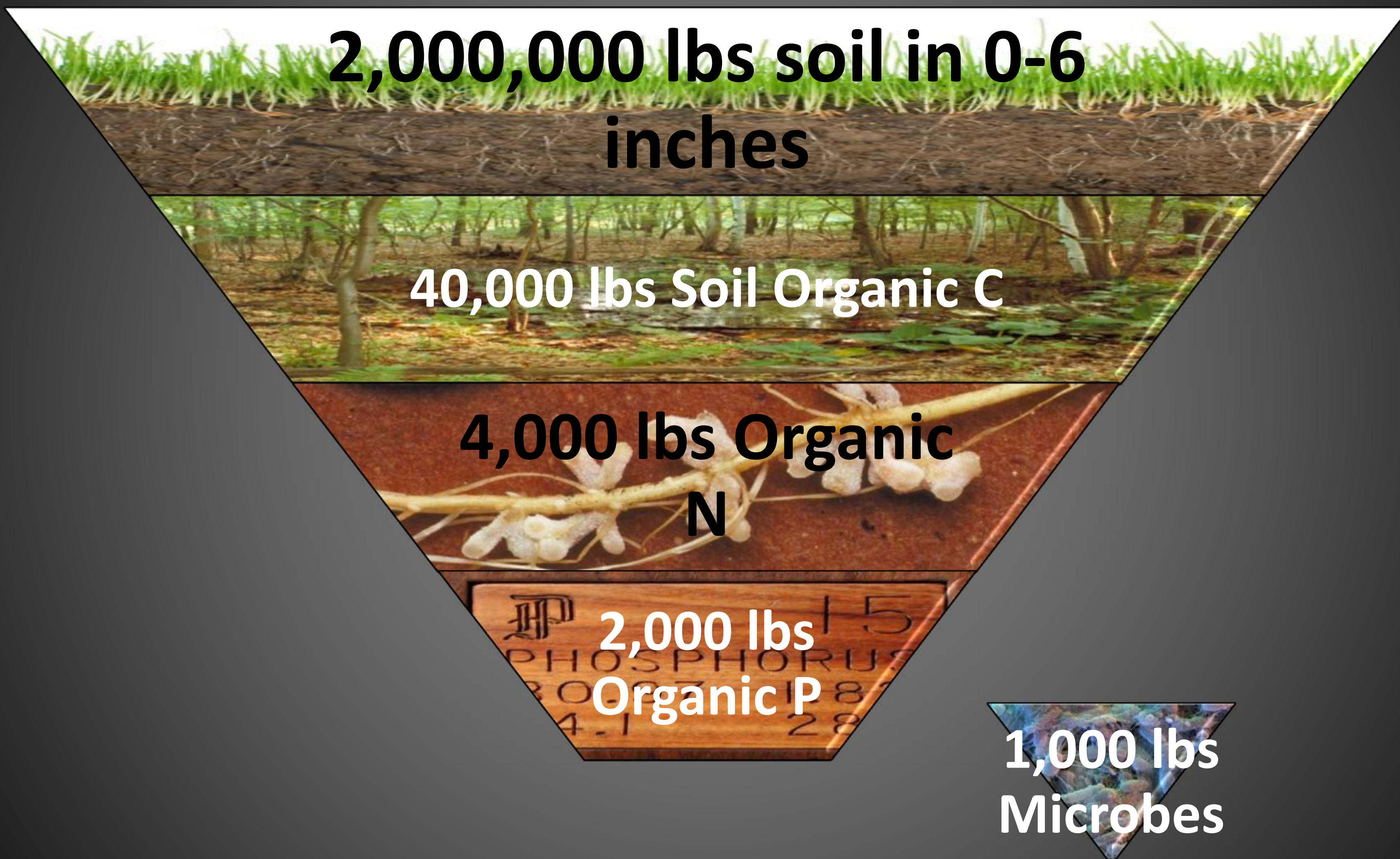
Corn yield attributable to fertilizer and lime: 1955-2000
Morrow plots (U. of Illinois)



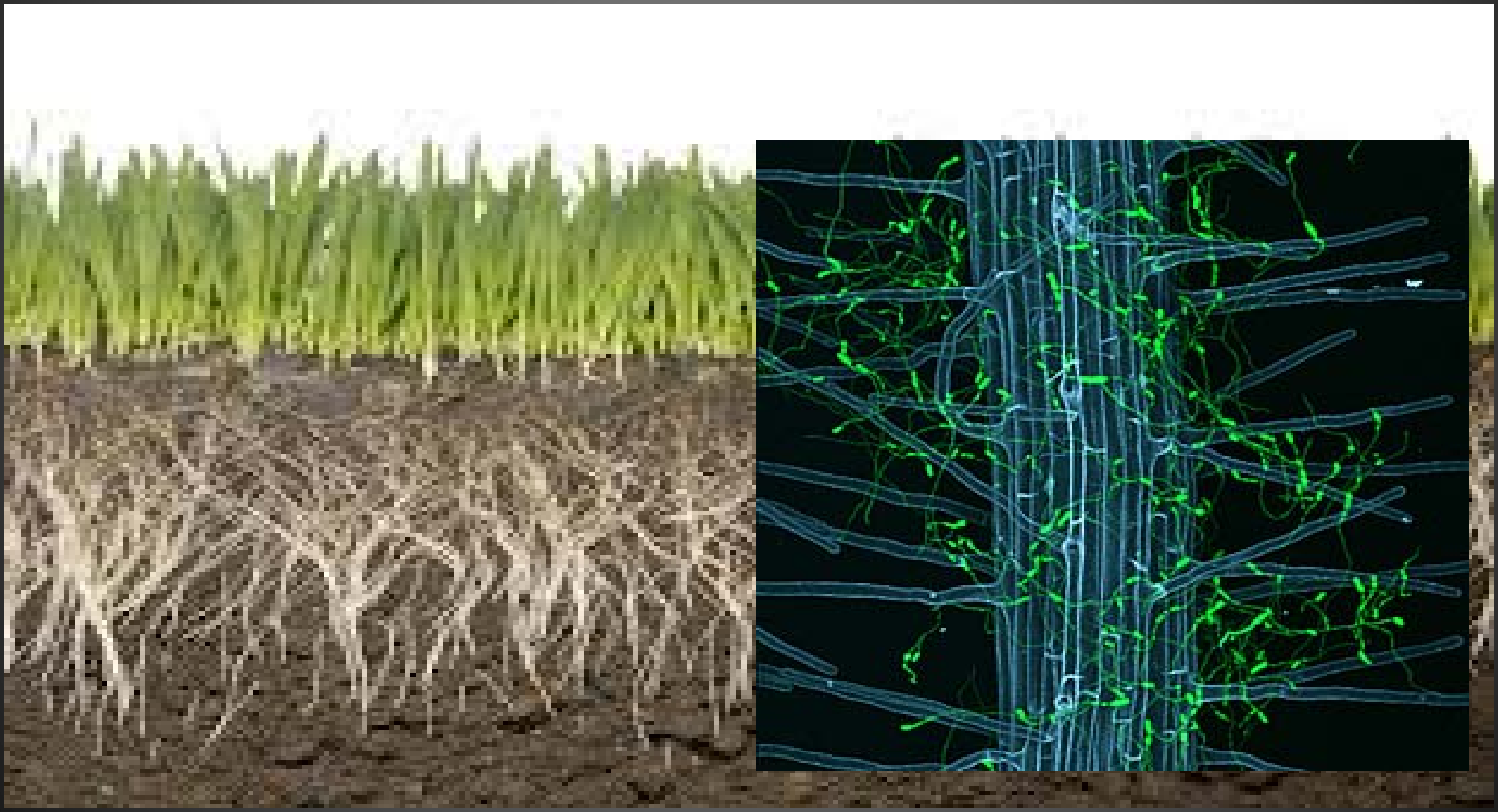
Outlier in 1956 reduced average for 1955-59.

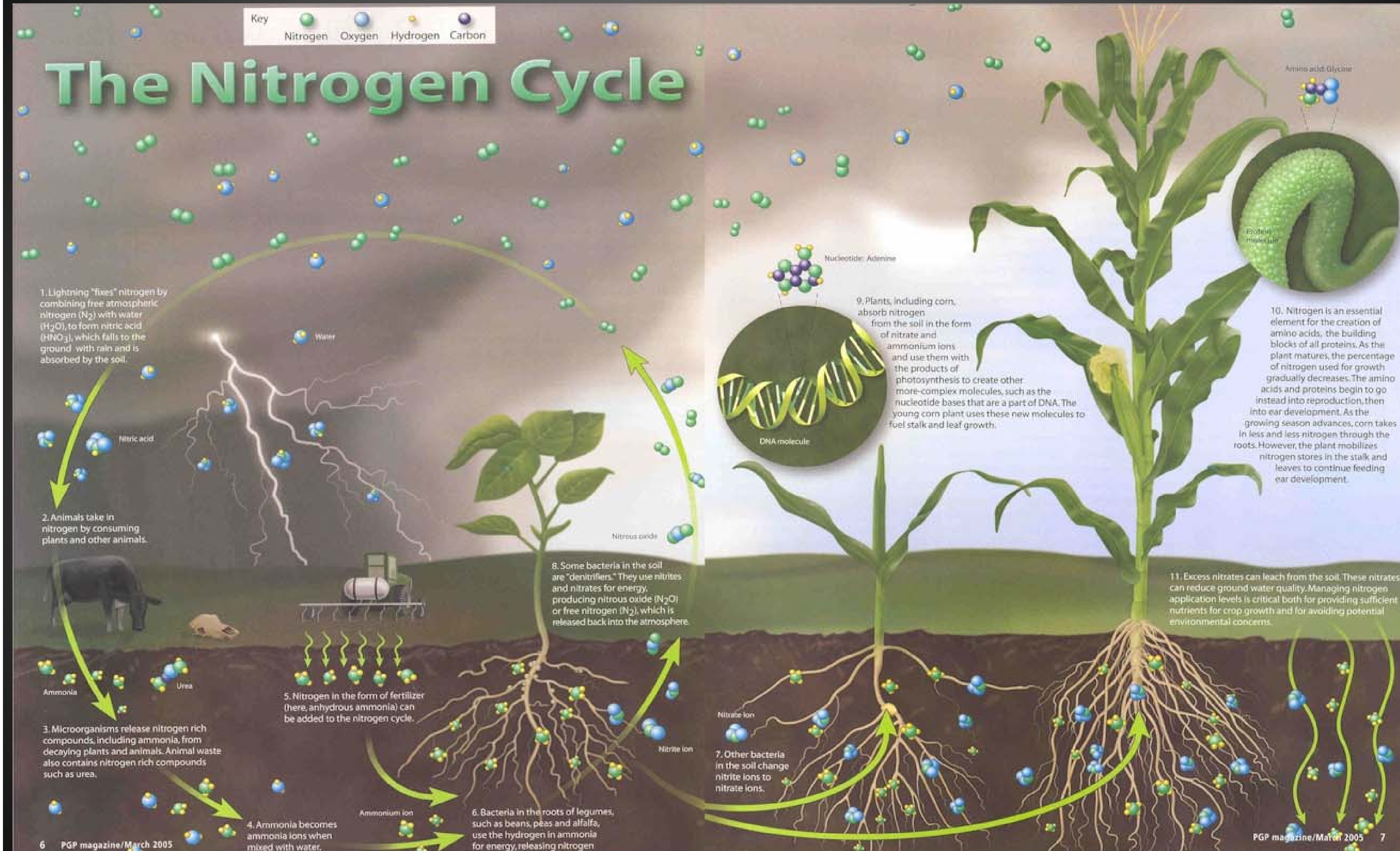
Source: IPNI.net

We can Unlock the Secrets in the Soil



We can GROW microbial and organic chemical diversity with plant roots (Plants fix dirt)





Key
Nitrogen
Oxygen
Hydrogen
Carbon
The Nitrogen Cycle
1. Lightning "fixes" nitrogen by combining free atmospheric nitrogen (N_2) with water (H_2O), to form nitric acid (HNO_3), which falls to the ground with rain and is absorbed by the soil.
Water
Nitric acid
2. Animals take in nitrogen by consuming plants and other animals.
Ammonia
Urea
3. Microorganisms release nitrogen rich compounds, including ammonia, from decaying plants and animals. Animal waste also contains nitrogen rich compounds such as urea.
4. Ammonia becomes ammonia ions when mixed with water.
Ammonium ion
5. Nitrogen in the form of fertilizer (here, anhydrous ammonia) can be added to the nitrogen cycle.
6. Bacteria in the roots of legumes, such as beans, peas and alfalfa, use the hydrogen in ammonia for energy, releasing nitrogen
Nitrous oxide
8. Some bacteria in the soil are "denitrifiers." They use nitrites and nitrates for energy, producing nitrous oxide (N_2O) or free nitrogen (N_2), which is released back into the atmosphere.
Nitrite ion
Nitrate ion
7. Other bacteria in the soil change nitrite ions to nitrate ions.
Nucleotide: Adenine
DNA molecule
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 more-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.
Amino acid: Glycine
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, corn 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.
6 PGP magazine/March 2005
PGP magazine/March 2005 7

Nitrogen

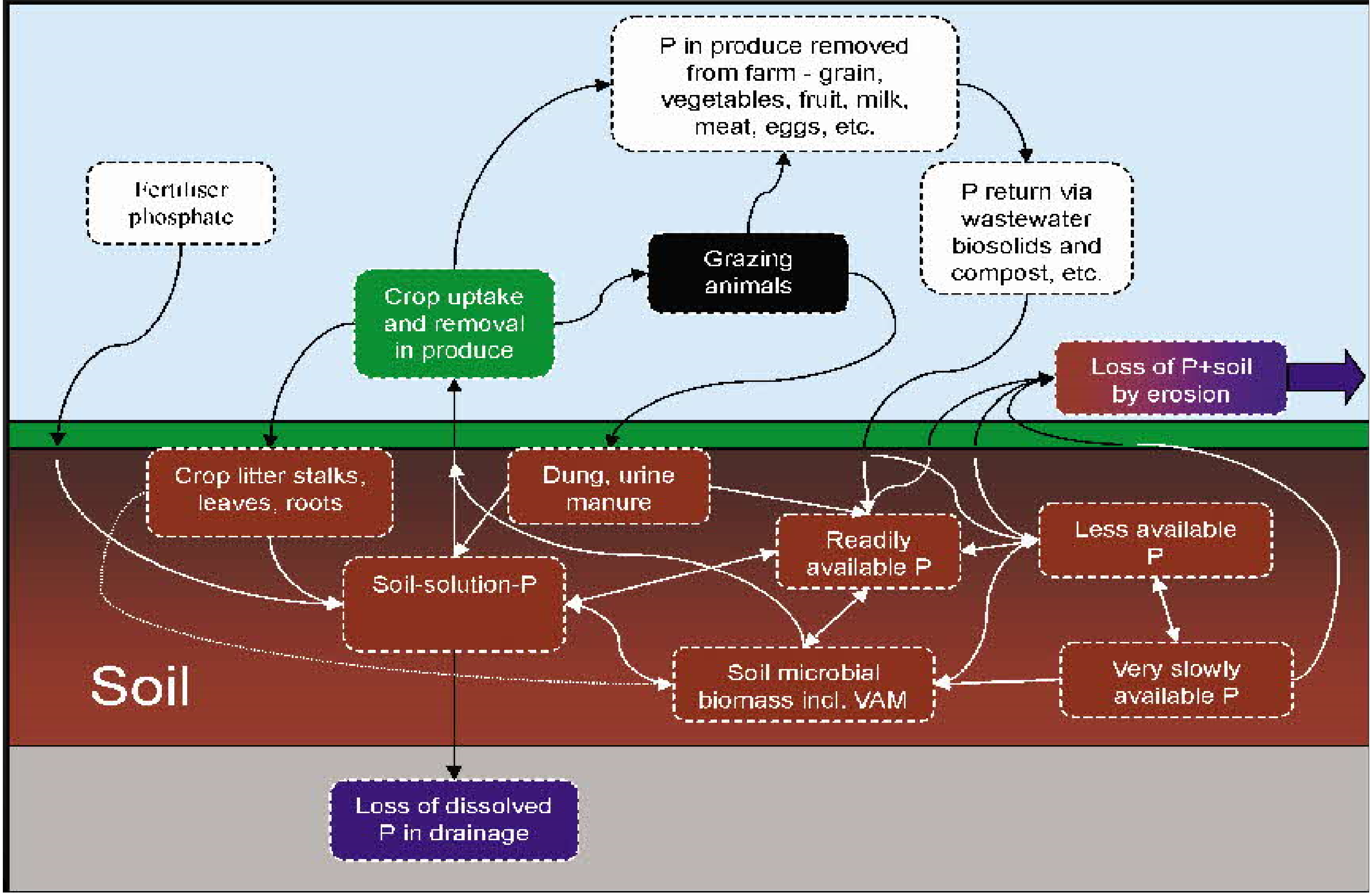
- **Current labs**

1. NO3-N
2. 2 M KCl (1965)

- **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

Phosphate Cycle



Phosphate

- **Current labs**

1. ICP P or PO4-P using 7 different extractants

- **Soil Health**

1. ICP P
2. PO4-P
3. H3A (mimics plant root exudates)
4. Solvita
5. Org C:N
6. P min
7. % water P/ H3A P
8. % P/ FeAl
9. Ca/FeAl

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

% Organic matter

Recommendations

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)

History

1896

Oxidation of Organic Compounds

1919

Gainey stated that CO_2, NH_4^+ and NO_3^- formation are parallel processes and of a biological nature

1924

Lebedjantzev noticed that soil, which had been dried and rewetted, was more fertile than field moist soil

1934

Corbet stated that, "for purposes of agriculture it would be preferable to evaluate microbial activity rather than the total population"

"CO_2 evolution was a more pertinent estimation of microbial concentrations than that of plate counting"

1935

Vandecaveye and Allen: a sequence of microbial groups involved in organic matter decomposition

CO_2 evolution was greatest the first day after rewetting dried soil

1944
Bodily showed that CO_2 evolution was closely correlated with fluctuations in the numbers of bacteria

1956
Stevenson showed that the flush of C and N from rewetting dried soil was due to biological activity and not chemical action

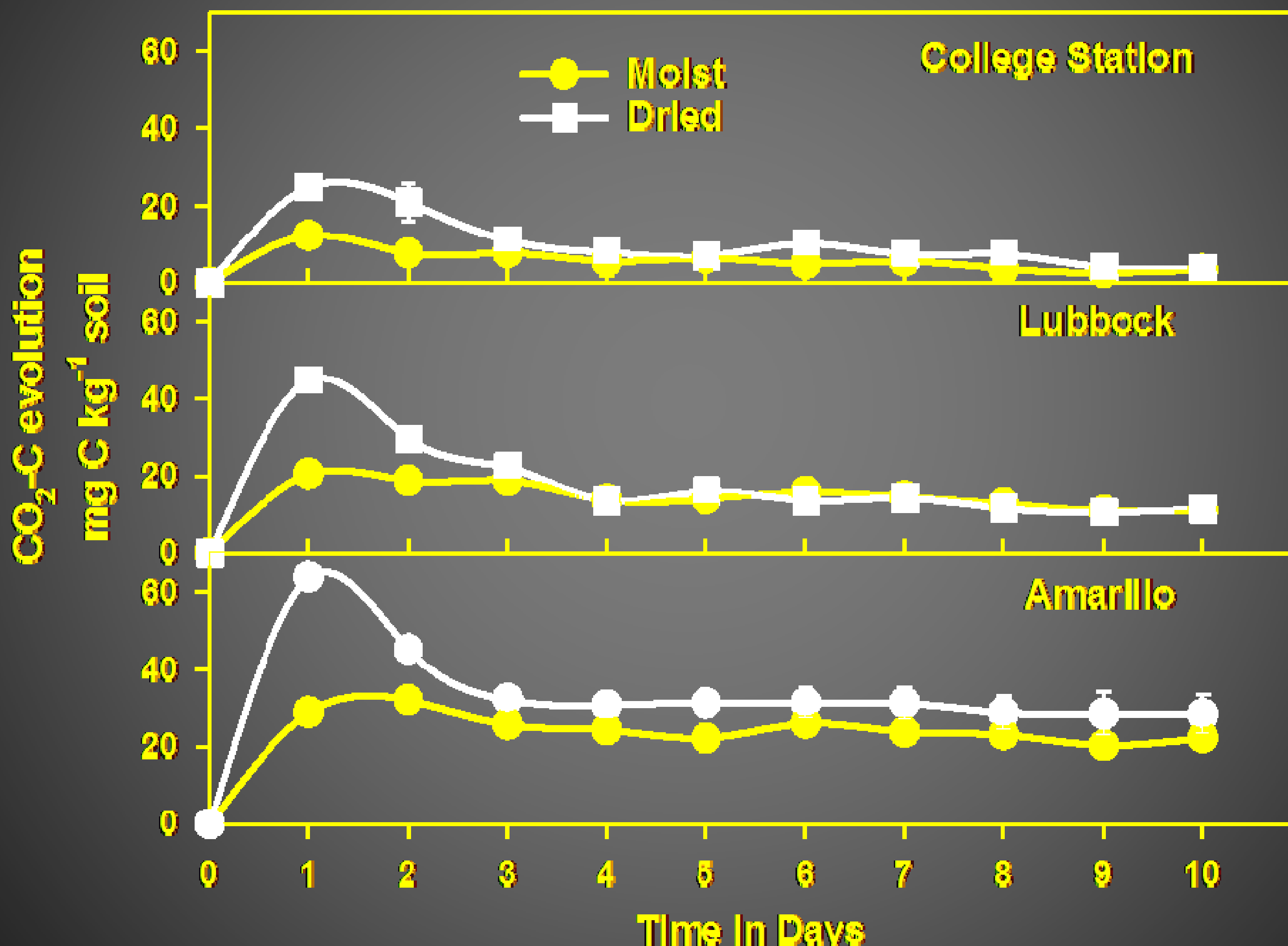
1958
Birch stated that spores are very resistant to drying and when rewetted, soil followed a uniform flush of CO_2

1959
Birch: Successive drying and rewetting resulted in a flush of C and N which was repetitive and also occurred in the field.

1960
Birch: Laboratory results underestimate field conditions

1970 and beyond: Change focus from CO_2 evolution to soil microbial biomass C (SMBC)

Research History - 1994



Soil Microbial Activity (respiration)

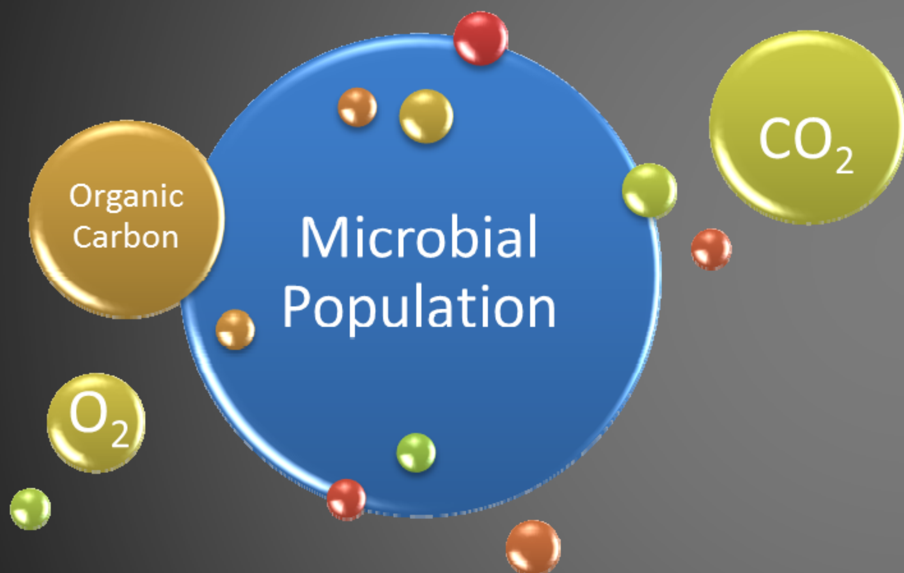
Soil Health Tool

Measure soil health by **asking** our soil the right questions:

- What is your condition?
- Are you in balance?
- What can we do to help?

"Whoa! *That* was a good one! Try it, Hobbs — just poke his brain right where my finger is."

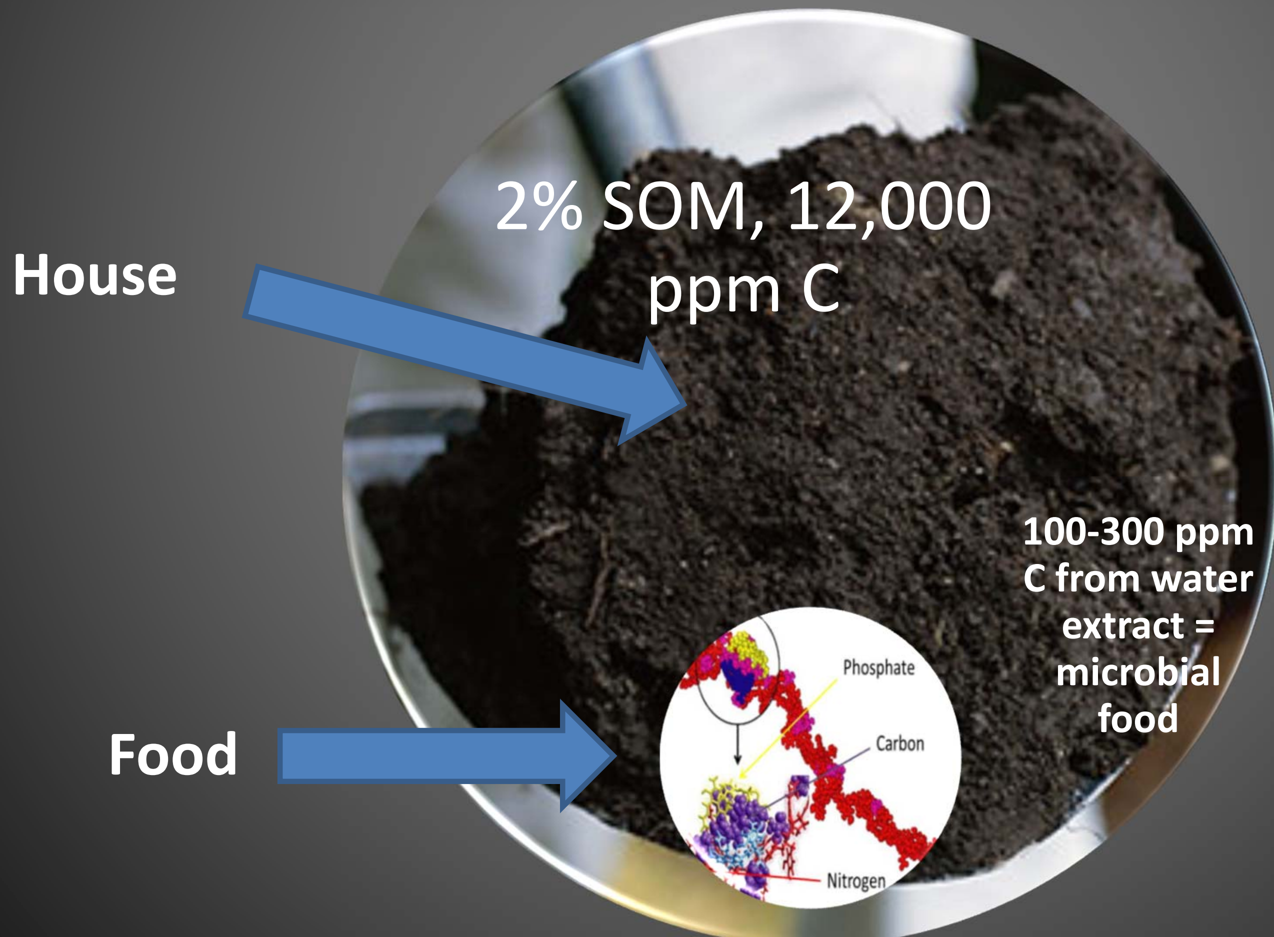
Soil Biology is a Complex Integrated Living System

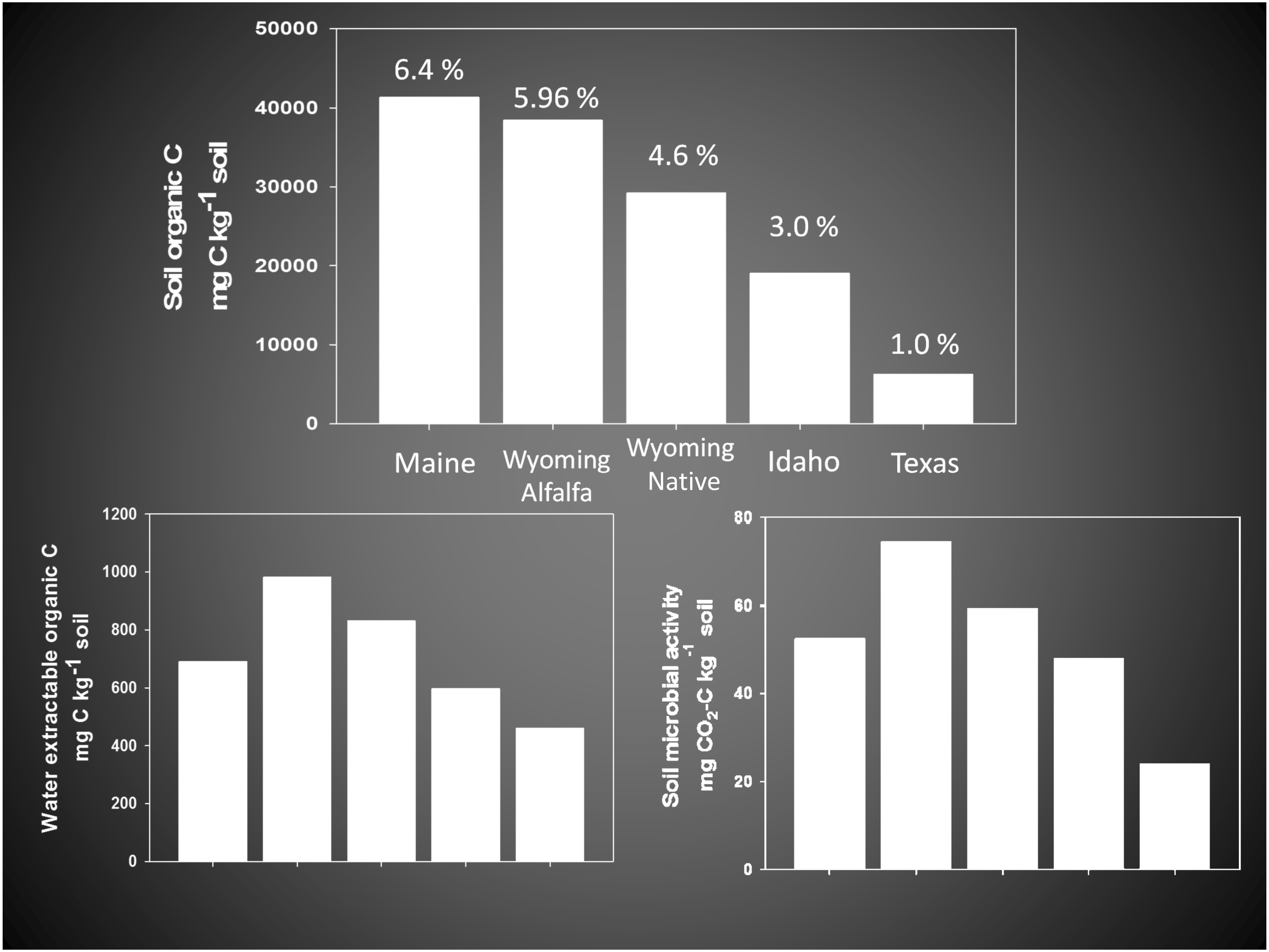


- **Organic carbon in water drives the system**
- Soil microbes take in O_2 and release CO_2

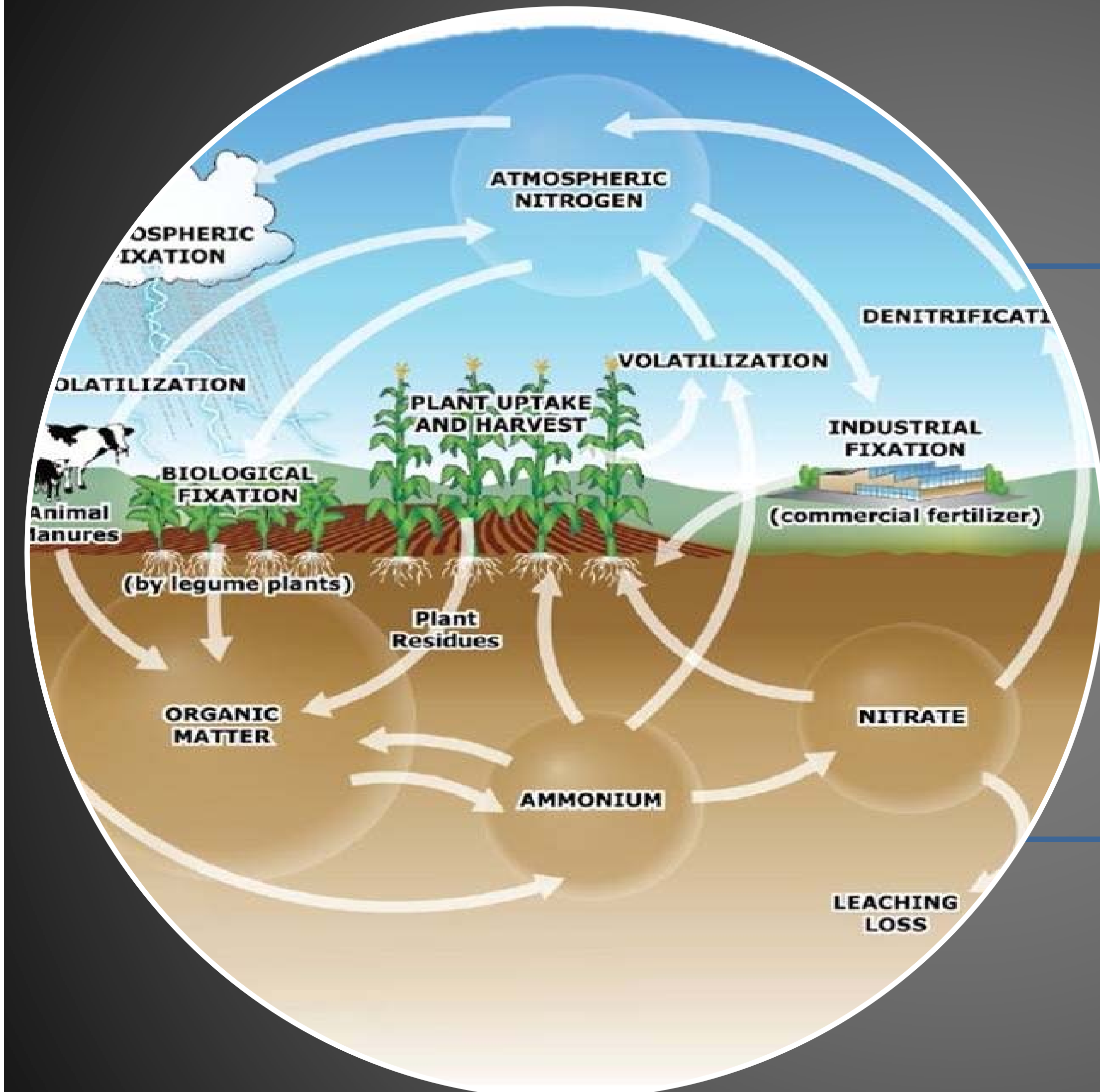
Soil microorganisms have been in R&D for millions of years.

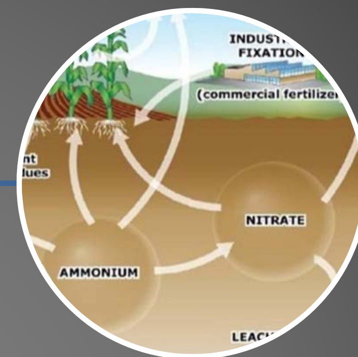
Soil Organic Matter is the "House" microbes live in, Water Extractable Organic Carbon is the "**Food**" they eat.



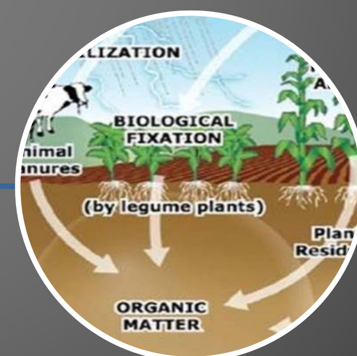

Soil organic C
mg C kg-1 soil
50000
40000
30000
20000
10000
0
6.4 %
5.96 %
4.6 %
3.0 %
1.0 %
Maine
Wyoming Alfalfa
Wyoming Native
Idaho
Texas
Water extractable organic C
mg C kg-1 soil
1200
1000
800
600
400
200
0
Soil microbial activity
mg CO2-C kg-1 soil
80
60
40
20
0

Water extractable total N





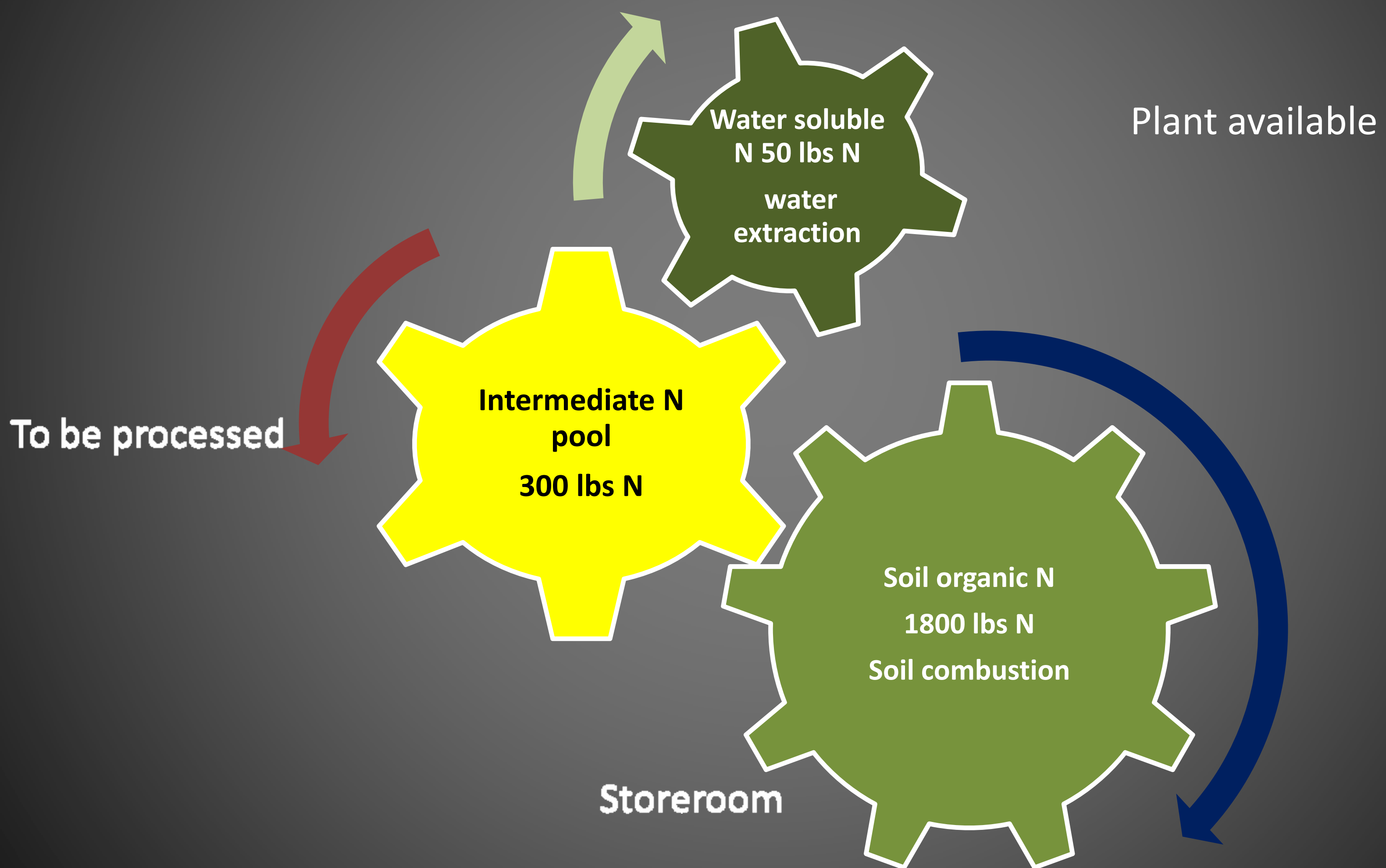
Water extractable Inorganic N



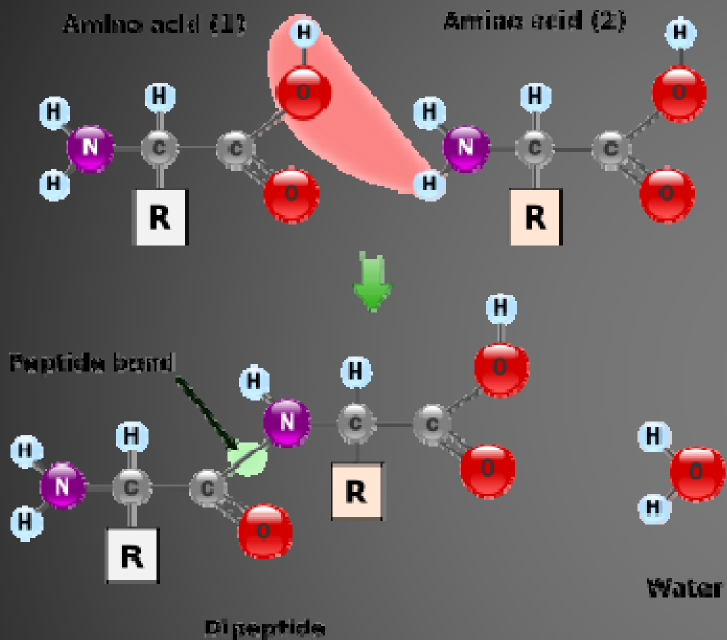
Water extractable Organic N

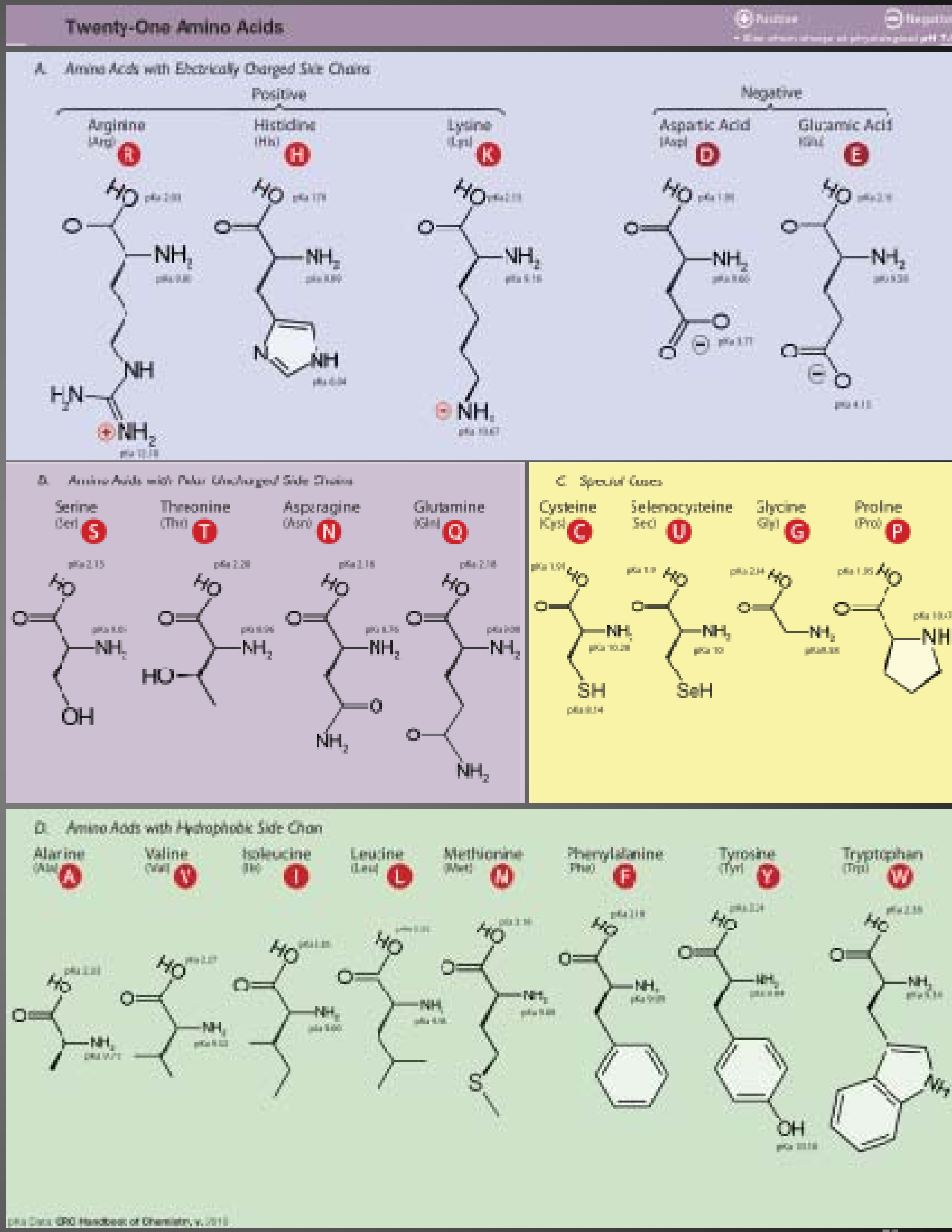
Source: The International Plant Institute

Soil Nitrogen Pools



Nitrogen



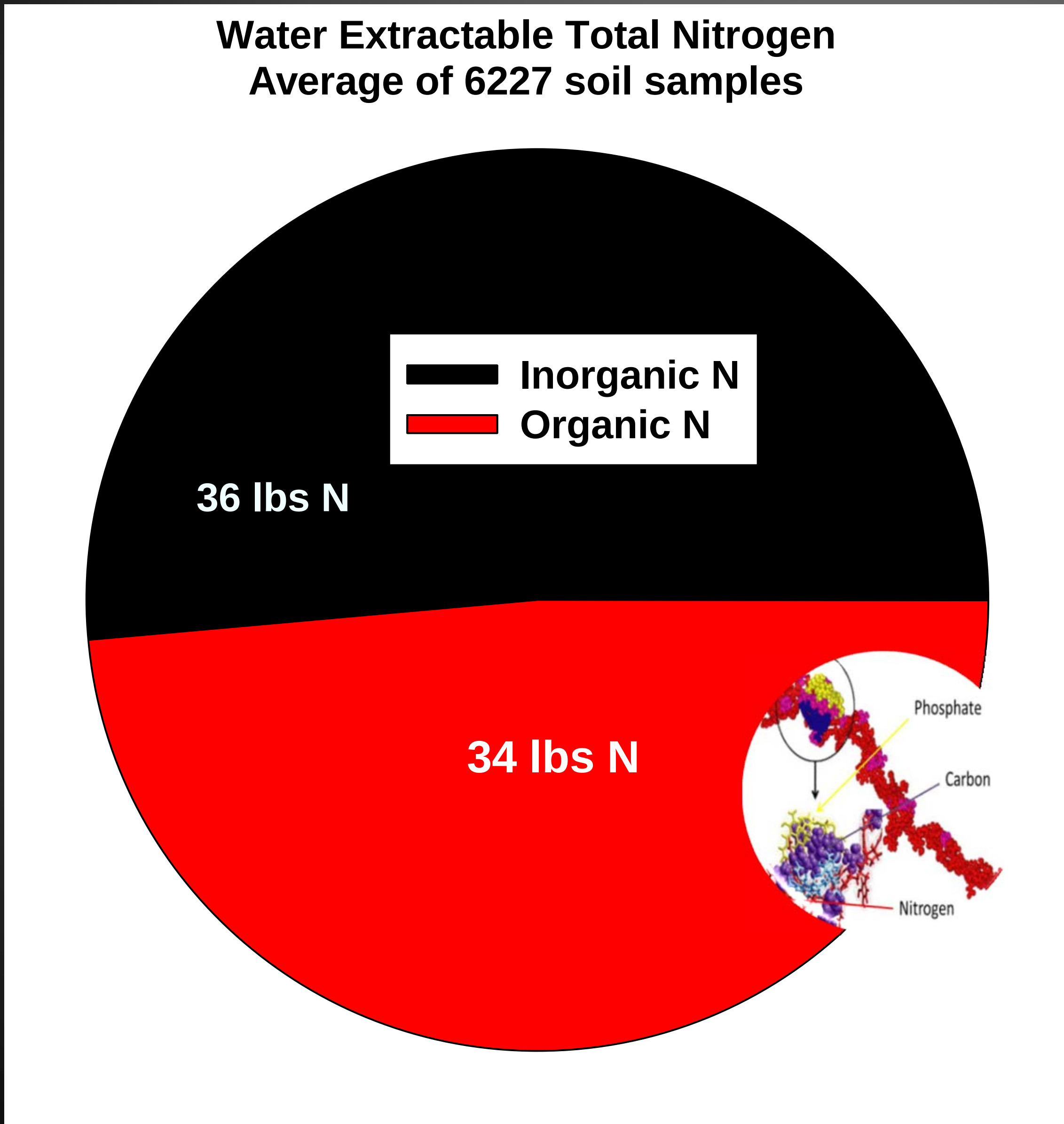


Organic N: amino acids

Exudation of proteases by plant roots

Inorganic N: NO3-N, NH4-N

We have been missing half of the N



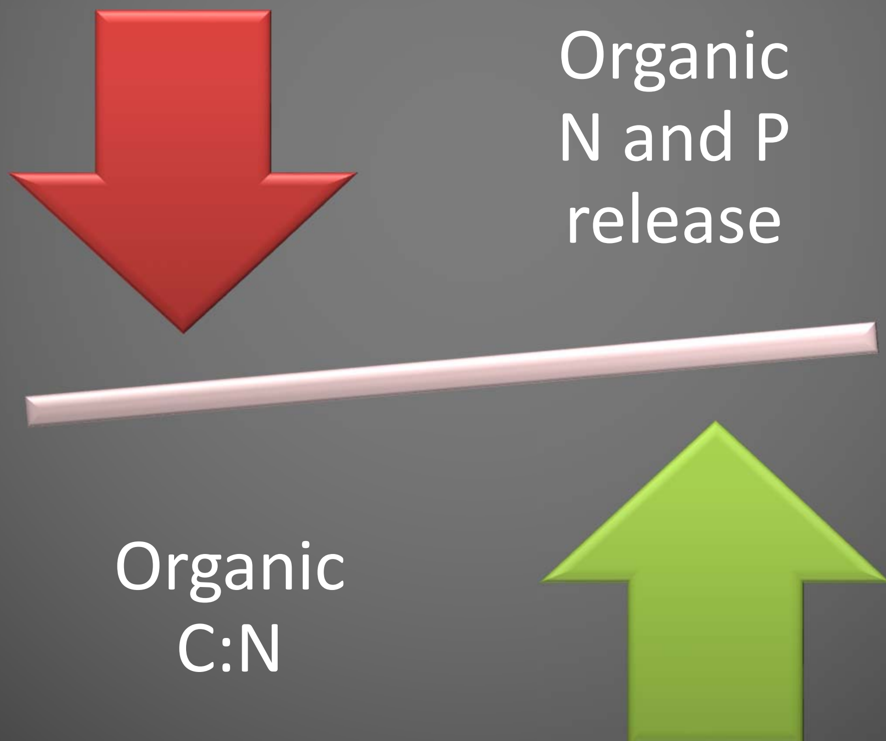
2M KCl 1965 Bremer

"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

- $\mathrm{C:N} = Organic\ C \div Organic\ N$
- 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



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**

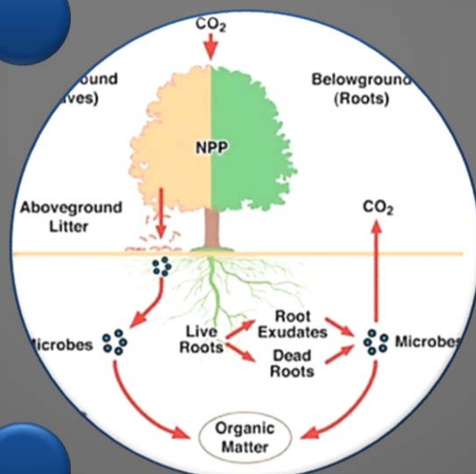
New Soil Testing Methods

soil testing in nature's image

Soil N, P, K

Soil Organic N and P

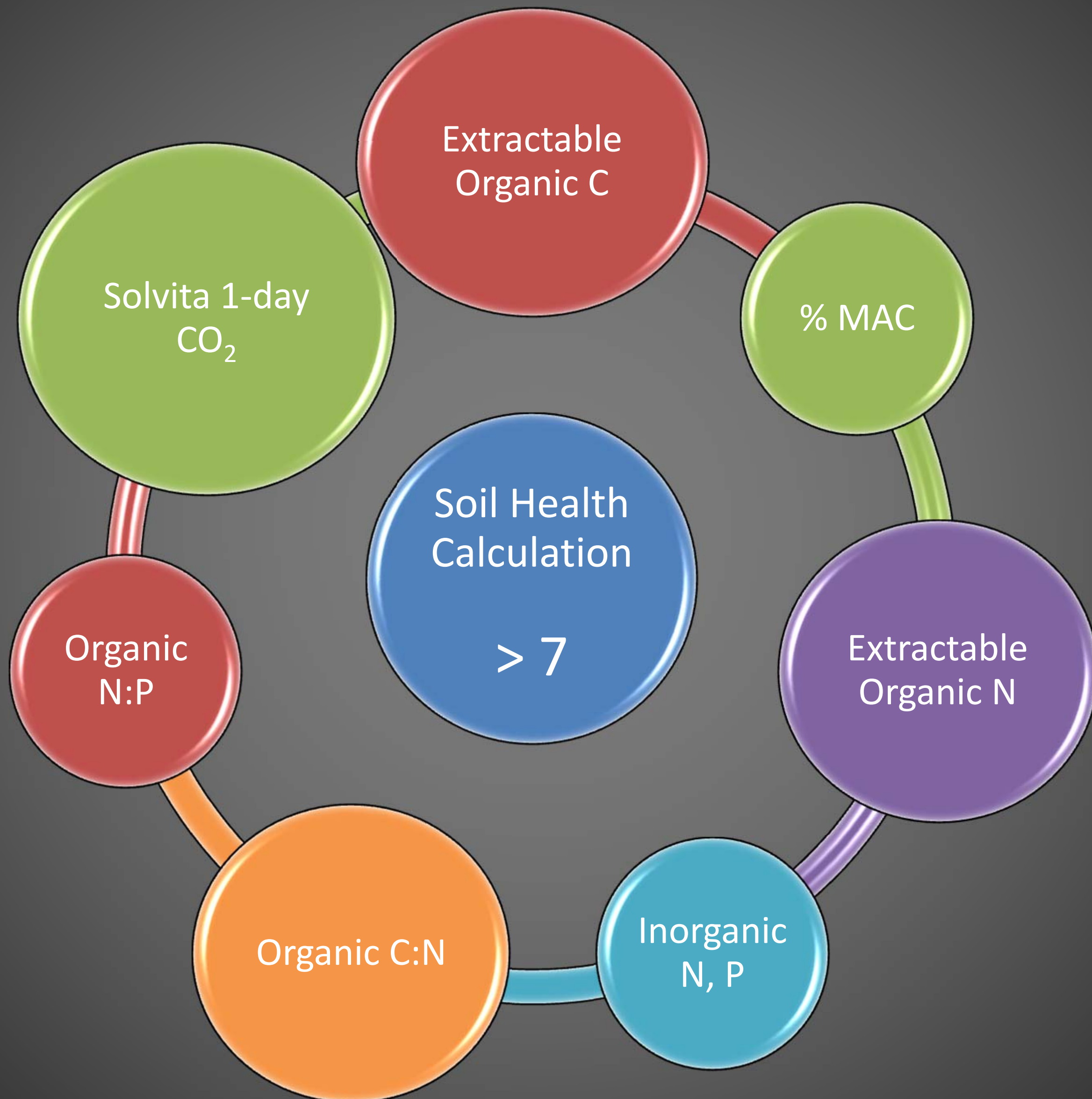
Microbial Activity



Water Extractable C

C:N balance

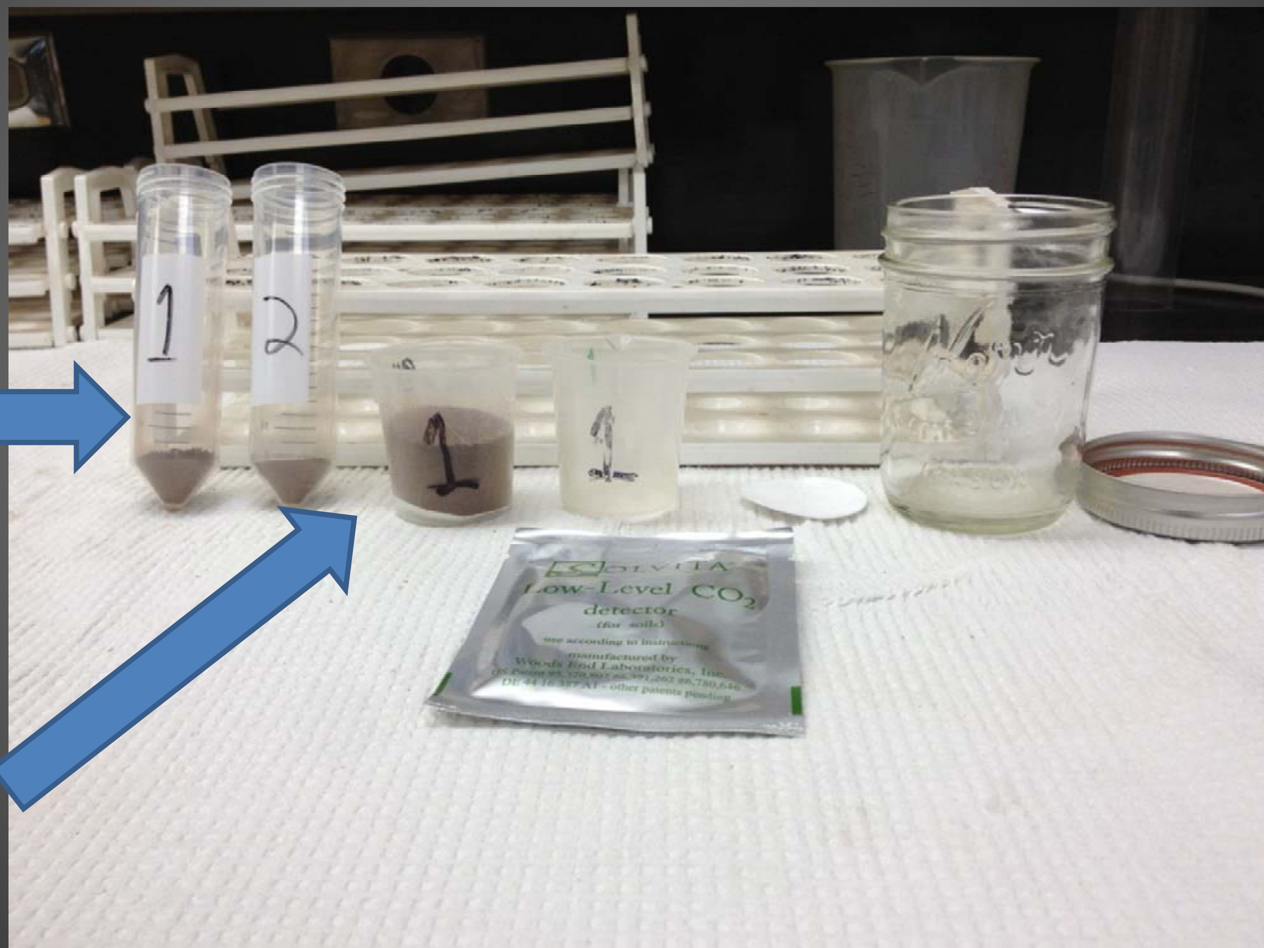
Soil Test Integration



Sample Analysis

4 grams each

40 grams



Soil Extraction H3A and Water

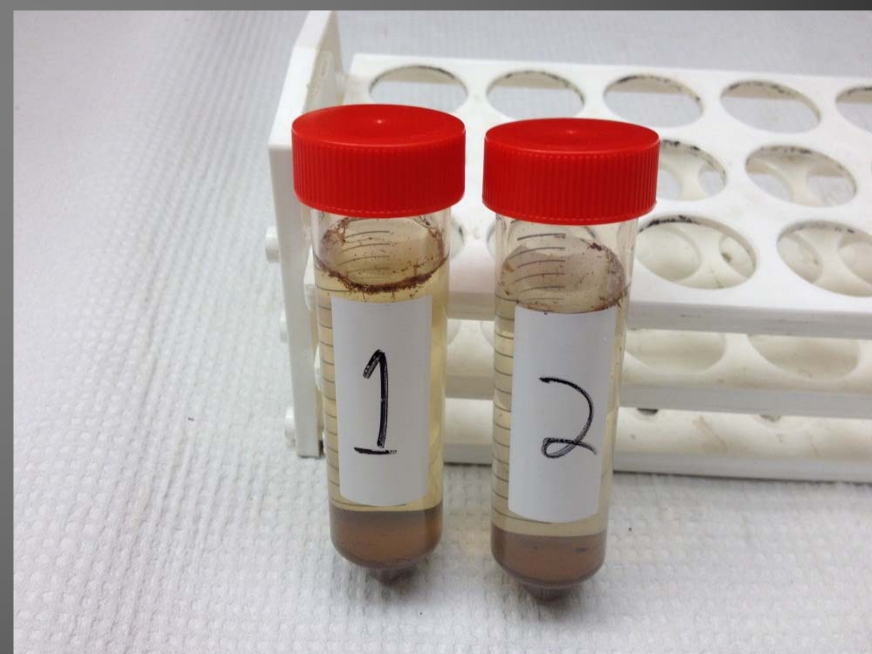
What does the plant root really see?

- **WATER and a complex mixture of plant root exudates along with microbial derived enzymes and nutrients**
- **The below ground root system flows with elegance and complexity**
- **We extract soil with highly disruptive acidic or alkali solutions and call it "plant available"**

Soil Extraction

After shaking for 10 minutes
4 grams soil 40 mls (1) H3A, (2) water

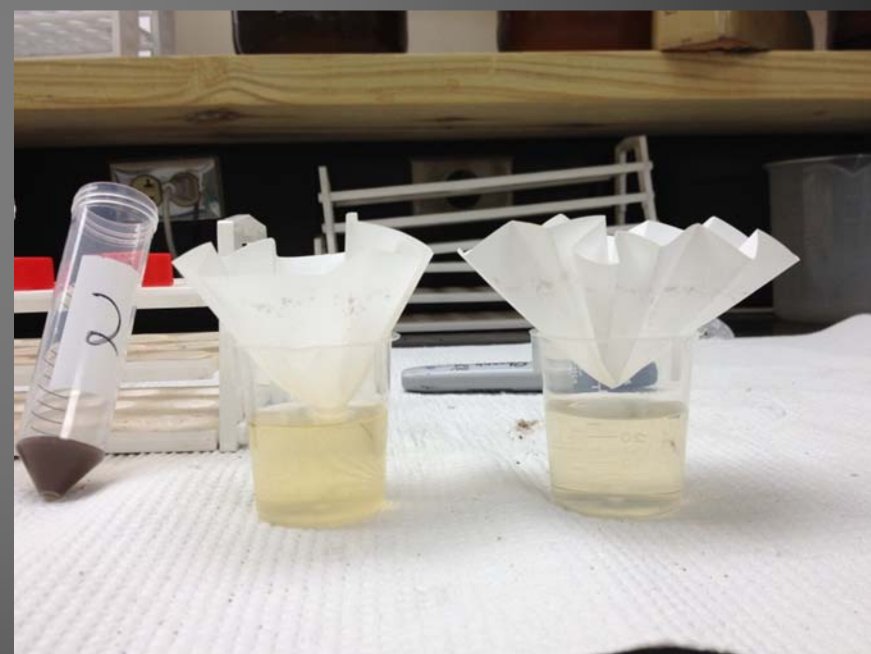
After 5 minute centrifuge
(1) H3A (2) water



Soil Extractant Filtration

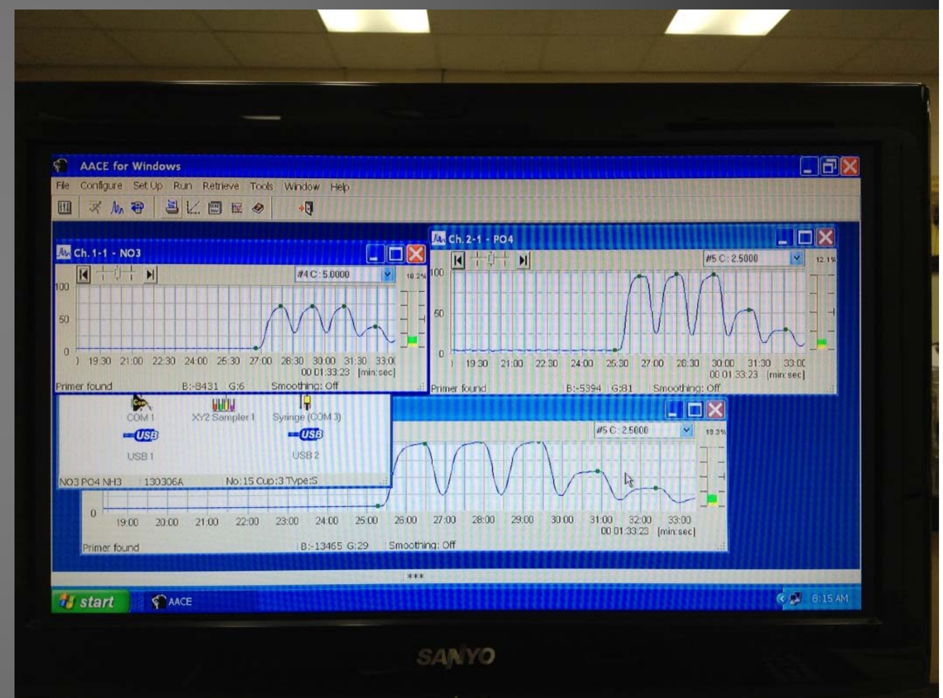
After Centrifugation

Filtration: Whatman 2V pleated filter paper (8 micron)

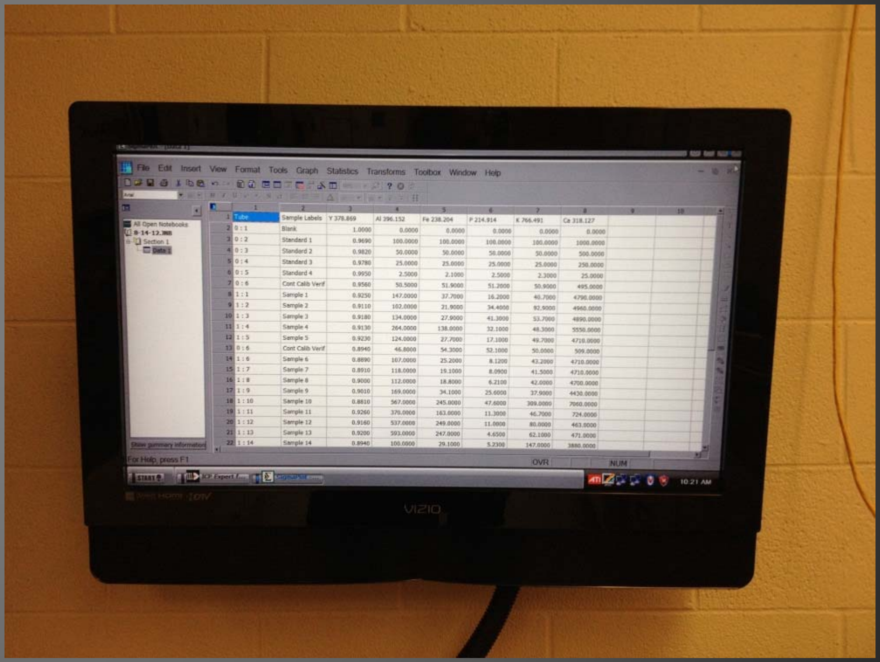


Organic C and Total N from Water Extract

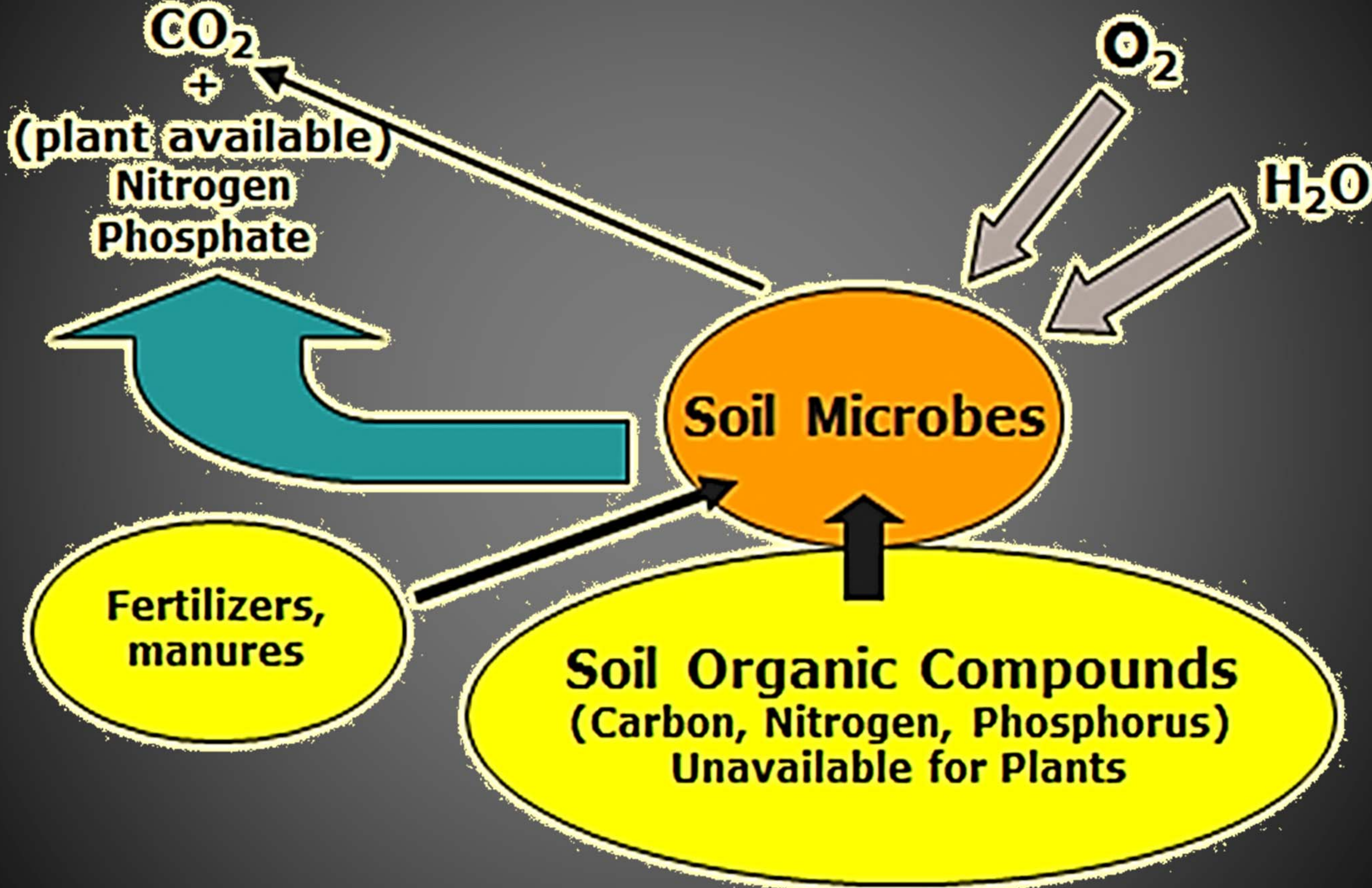
Inorganic N and P
H3A and Water



ICP Elemental Ca, P, K, Fe, Al H3A



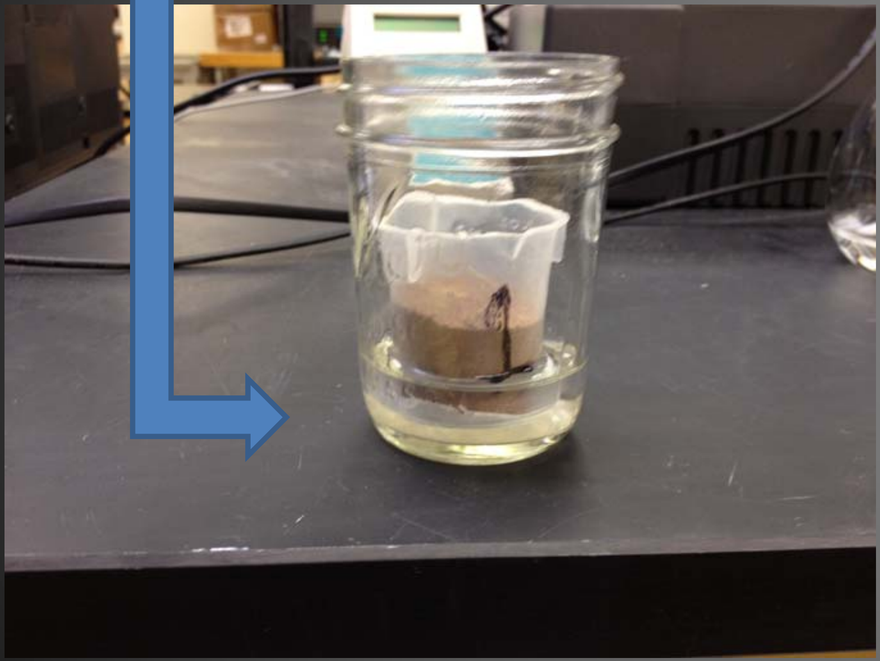
Microbial Activity - A Living Body

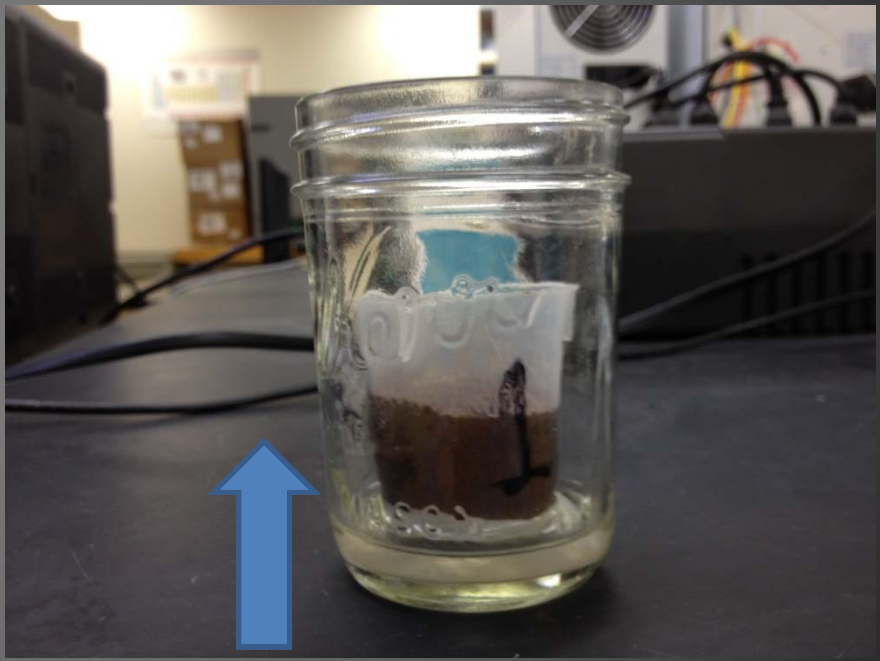


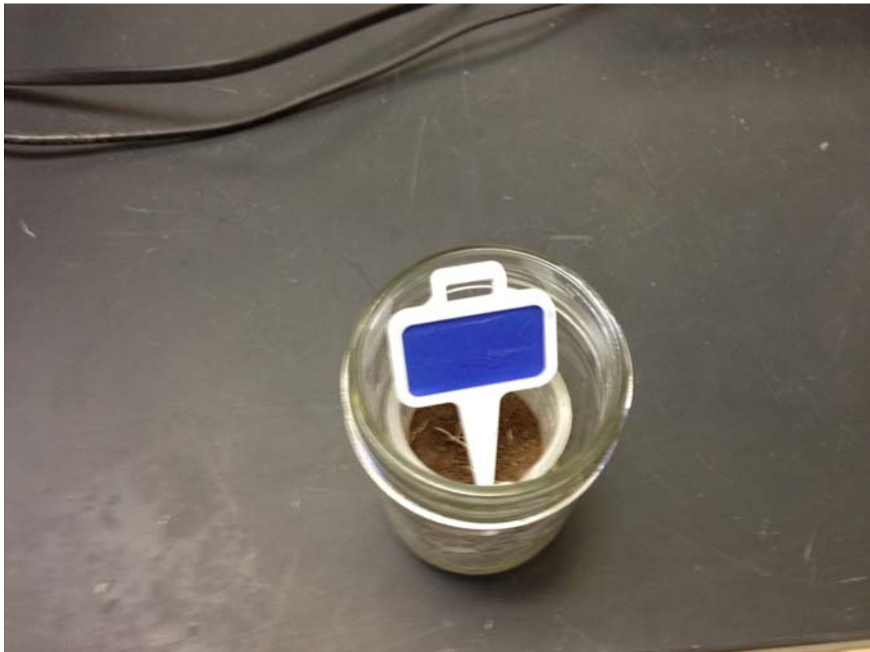
Solvita Soil Microbial Activity

25 ml water

Capillary action rewets soil to field capacity





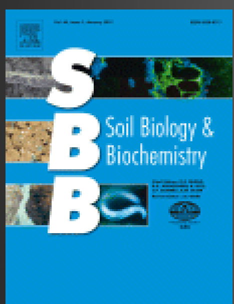


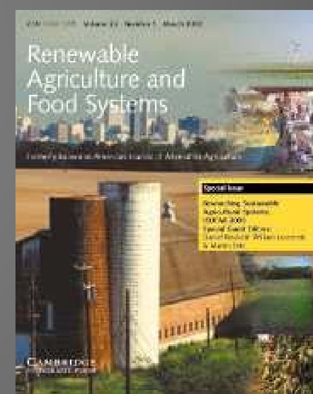


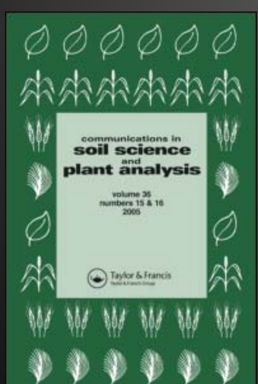
SOLVITA
NH3
ALT
Woods End Laboratories
READ

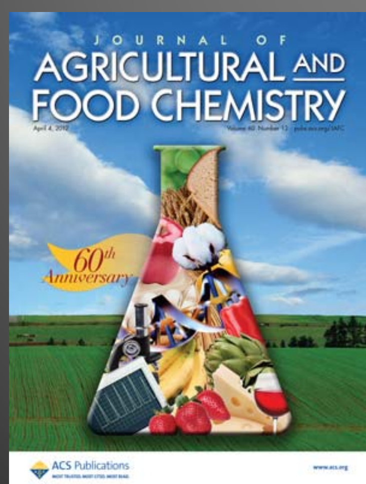
1996-2013

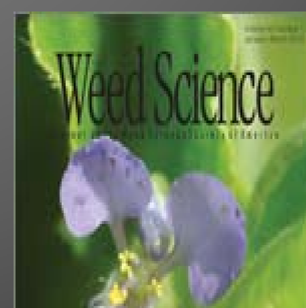
- There are over 20 peer reviewed journal articles by Haney and others to support the science behind these soil analysis tests.

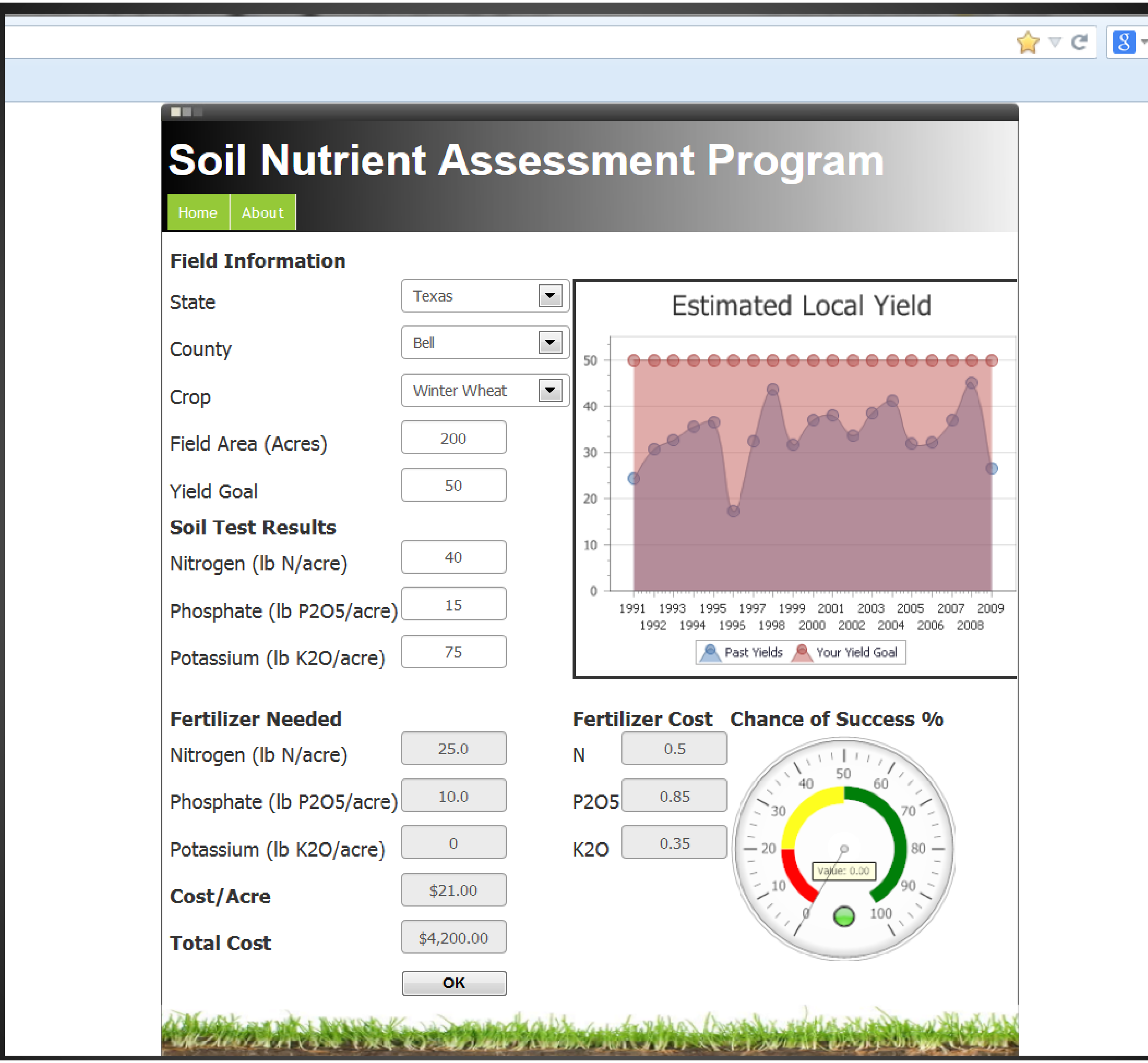








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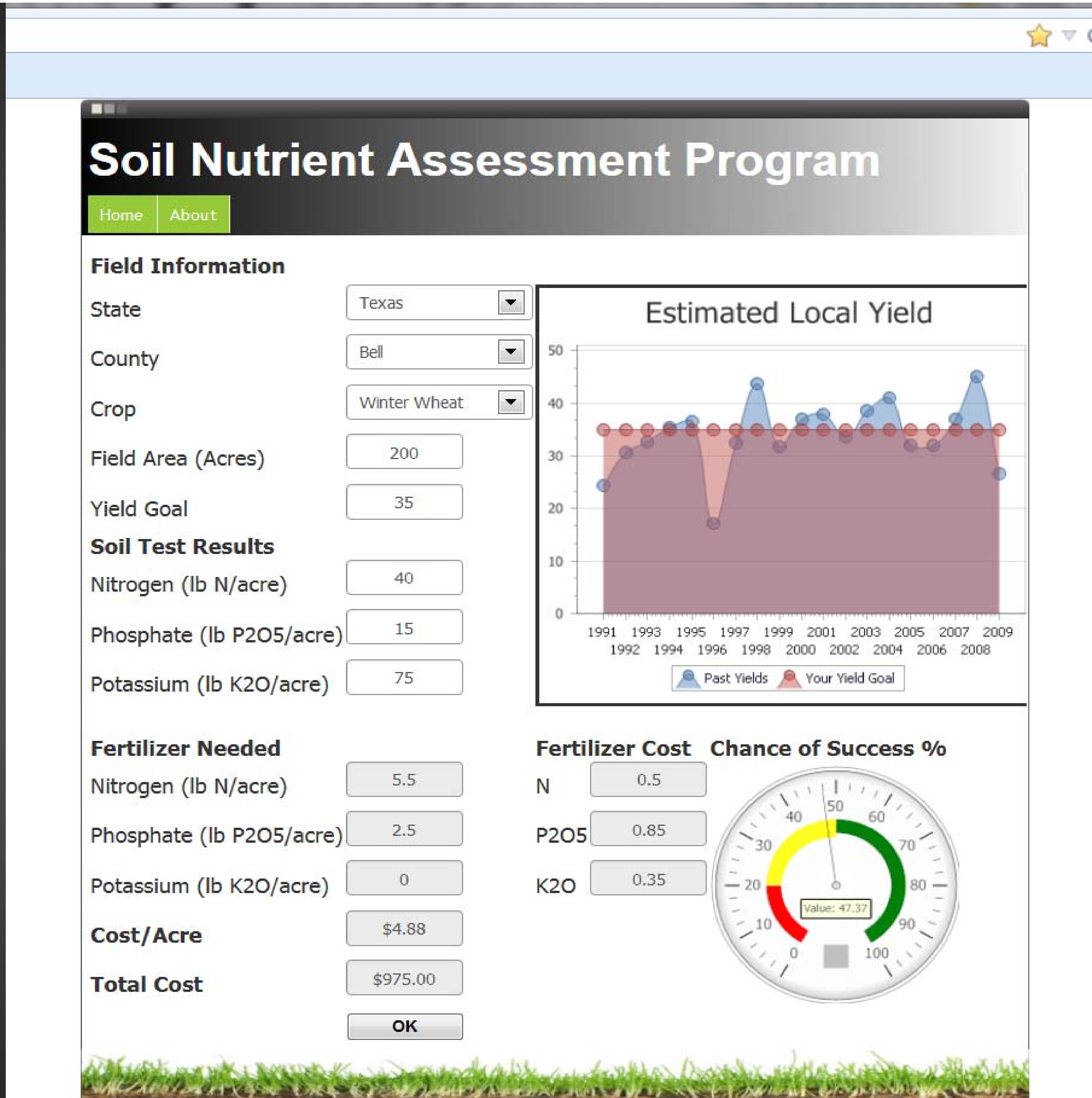
Home
About
Field Information
State
Texas
County
Bell
Crop
Winter Wheat
Field Area (Acres)
200
Yield Goal
50
Soil Test Results
Nitrogen (lb N/acre)
40
Phosphate (lb P2O5/acre)
15
Potassium (lb K2O/acre)
75
Estimated Local Yield
0 10 20 30 40 50
1991 1993 1995 1997 1999 2001 2003 2005 2007 2009
1992 1994 1996 1998 2000 2002 2004 2006 2008
Past Yields
Your Yield Goal
Fertilizer Needed
Nitrogen (lb N/acre)
25.0
Phosphate (lb P2O5/acre)
10.0
Potassium (lb K2O/acre)
0
Cost/Acre
$21.00
Total Cost
$4,200.00
OK
Fertilizer Cost
N
0.5
P2O5
0.85
K2O
0.35
Chance of Success %
0 10 20 30 40 50 60 70 80 90 100
Value: 0.00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40
30
20
10
0
1991 1993 1995 1997 1999 2001 2003 2005 2007 2009
1992 1994 1996 1998 2000 2002 2004 2006 2008
Past Yields
Your Yield Goal
Fertilizer Needed
Nitrogen (lb N/acre)
5.5
Phosphate (lb P2O5/acre)
2.5
Potassium (lb K2O/acre)
0
Cost/Acre
$4.88
Total Cost
$975.00
OK
Fertilizer Cost
N
0.5
P2O5
0.85
K2O
0.35
Chance of Success %
0
10
20
30
40
50
60
70
80
90
100
Value: 47.37

Soil Health Tool - Results

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

Buddy (ARS) and Chris (NRCS)

http://research.brc.tamus.edu/snap/

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