Soil Testing for Soil Health

Rick Haney PhD, USDA-ARS, Temple, TX

Natures Way

- Grows a skin for living systems
- Cycles nutrients
- Diverse, no monoculture
- Seeks balance
- Sustainable
- R & D experience
- Plant root network

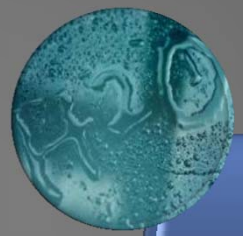
How we do it

- Strip off the soil's skin
- Destroy organic matter
- Increase erosion

- Increase inputs
- Waste water
- Disrupt root network

What can we do?

Increase Organic Matter



Increase Water Conservation

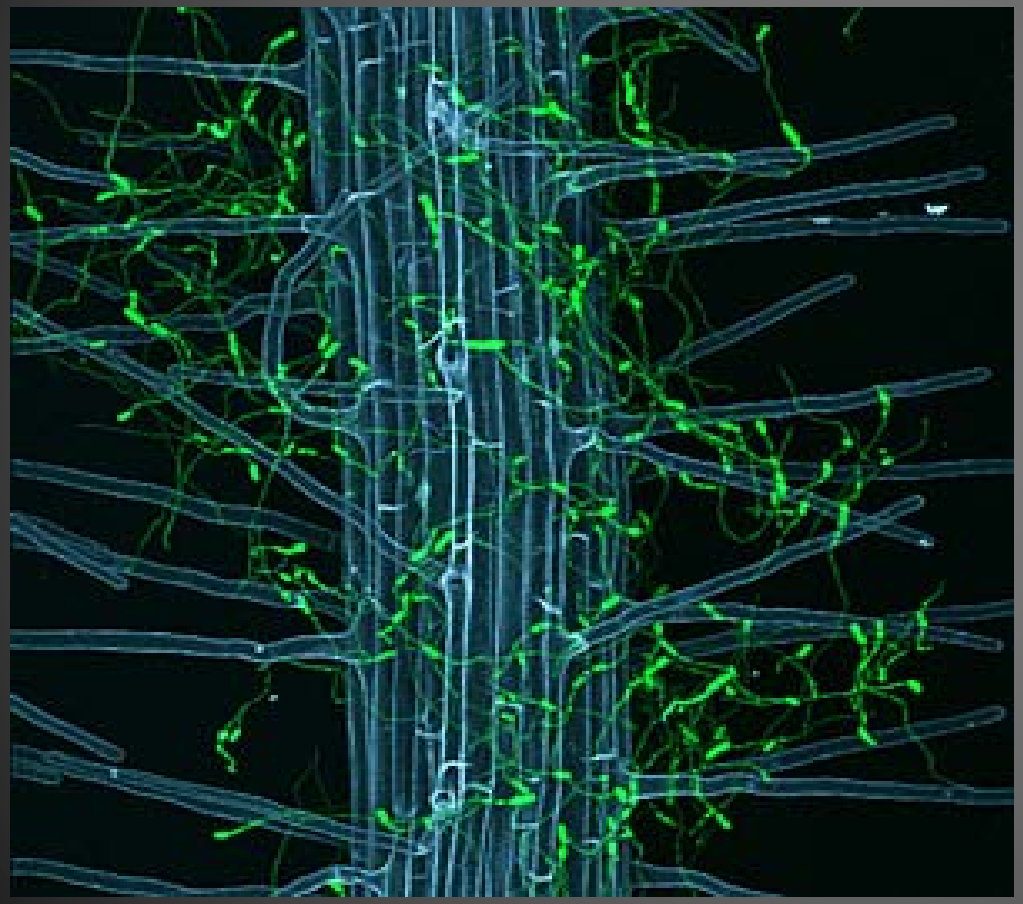
Increase Nutrient Cycling

No Till

Cover Crops

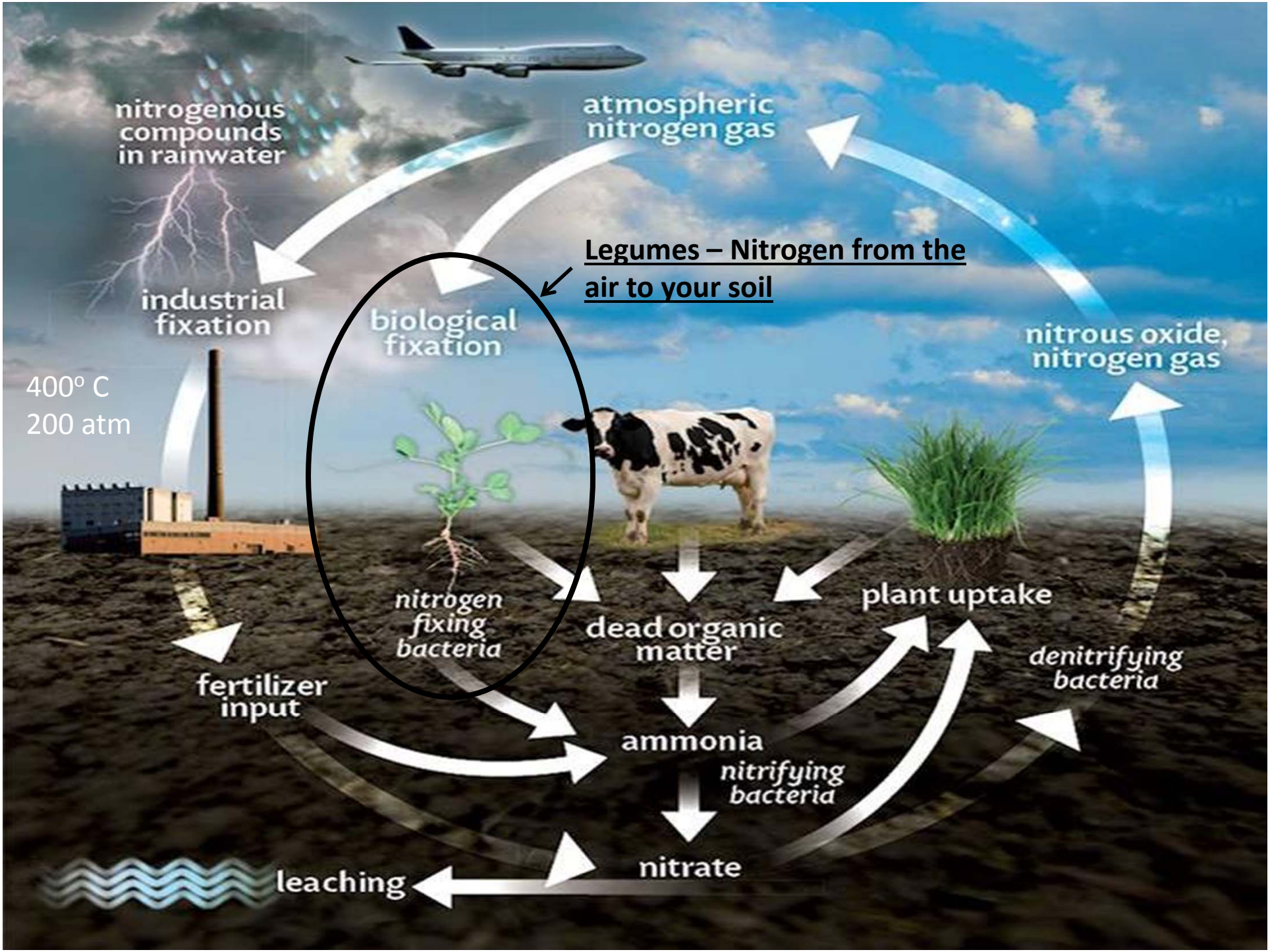
Cover Crops

Feed Diversity below ground with roots



8-Way Cover Crop Seed Mix 5% each

Whistler Winter Peas - white blossom
Common Vetch
Greenfix Chickling Vetch
Lentil Seed
Annual Rye Grass - KB Royal
Hybrid Pearl Millet
Winter Triticale
Mancan Buckwheat
Micro Noc Organic Inoculant



Legumes – Nitrogen from the air to your soil

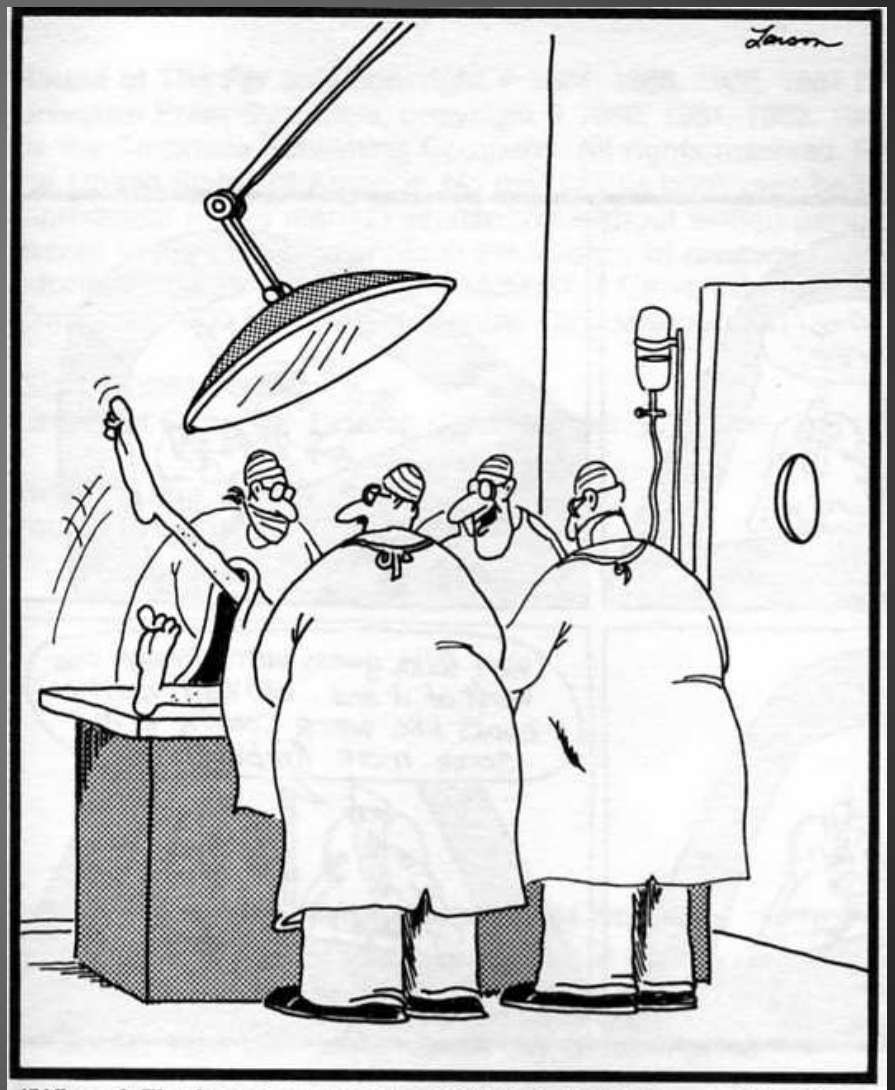
Traditional Soil Testing Methods

Where's the soil biology?

Soil Health Tool

Measure soil health by asking our soil the following questions:

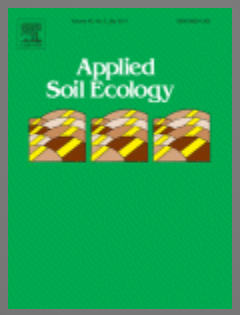
- What is your condition?
- Are you in balance?
- What can we do to help?

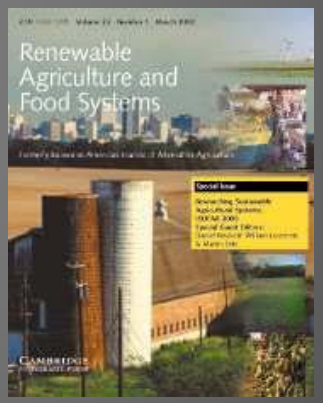


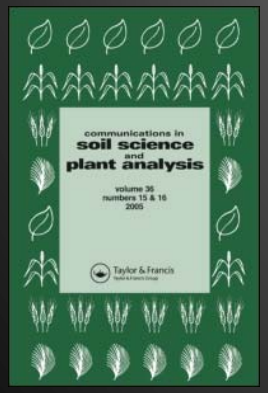
"Whoa! *That* was a good one! Try it, Hobbs — just poke his brain right where my finger is."

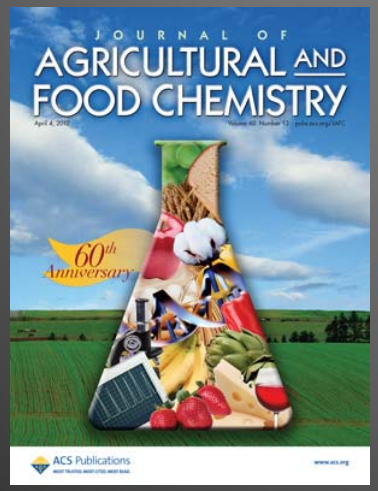
2000-2011

- There are at least 18 peer reviewed journal articles by Haney and others to support the science behind these soil analysis tests.







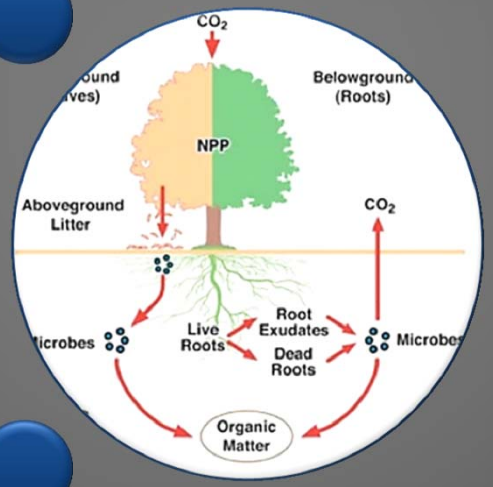


New Soil Testing Methods

Soil N, P, K

Soil Organic N and P

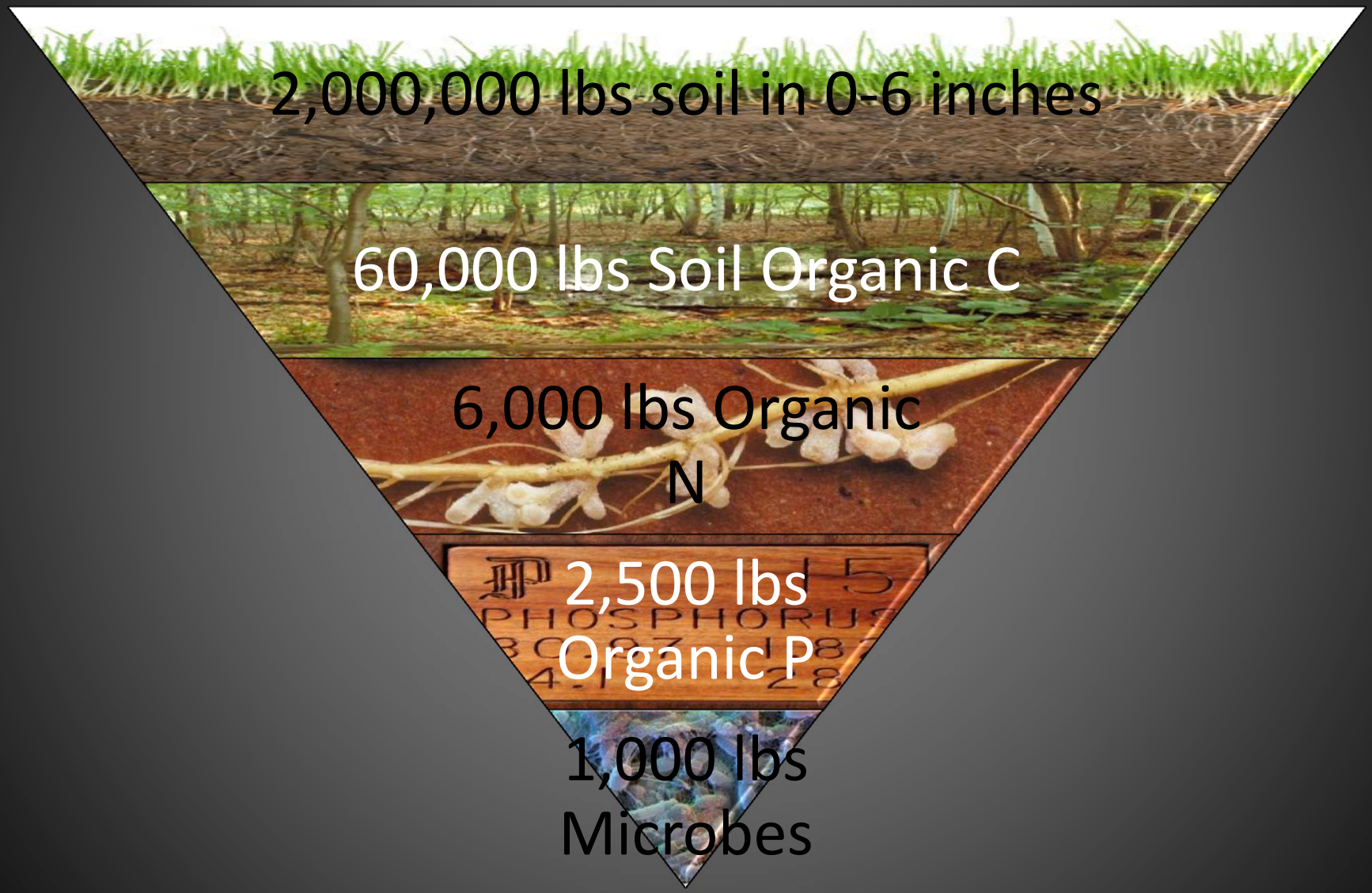
Microbial Activity



Water Extractable C

C:N balance

Microbial Activity – Per Acre



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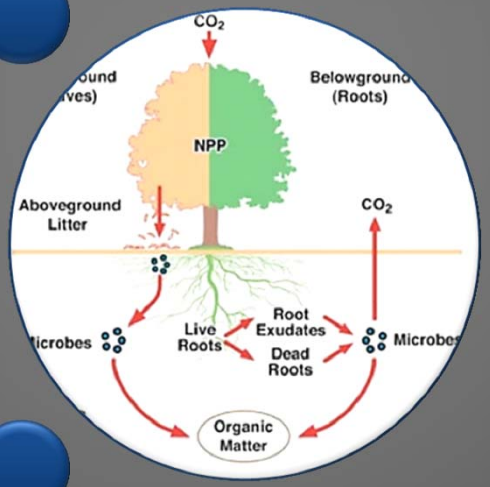
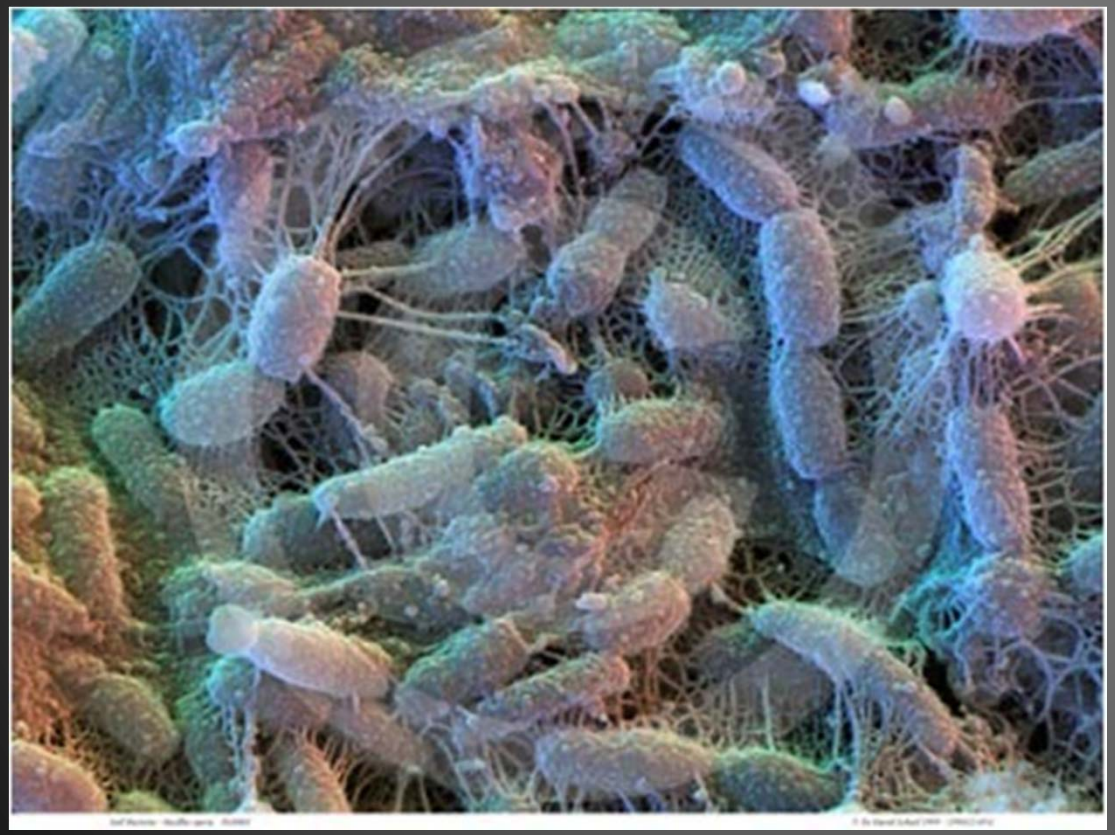


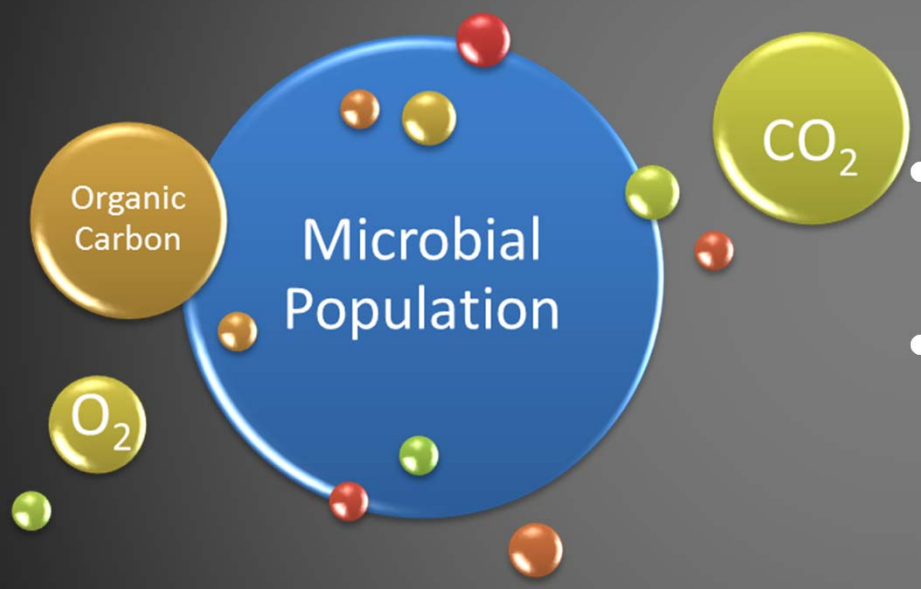
Water Extractable C

C:N balance

Microbial Activity - Soil bacteria and fungi



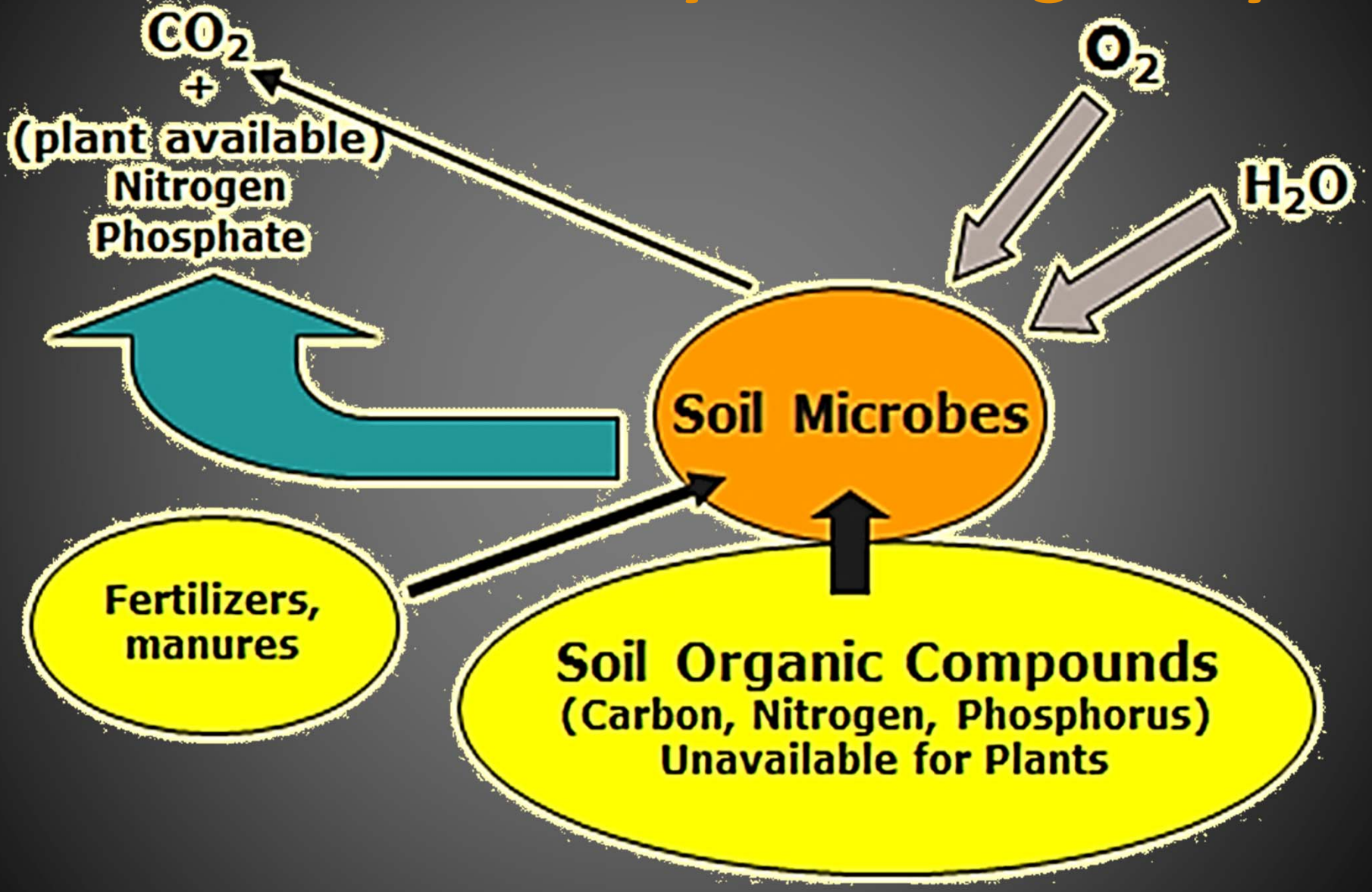
An Incredibly Complex Living System



- Soil microbes require **organic carbon** compounds for **growth and energy**
- Soil microbes take in O_2 and release CO_2
- This CO_2 release is coupled with **energy production, nutrient cycling and microbial growth**

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

Microbial Activity - A Living Body

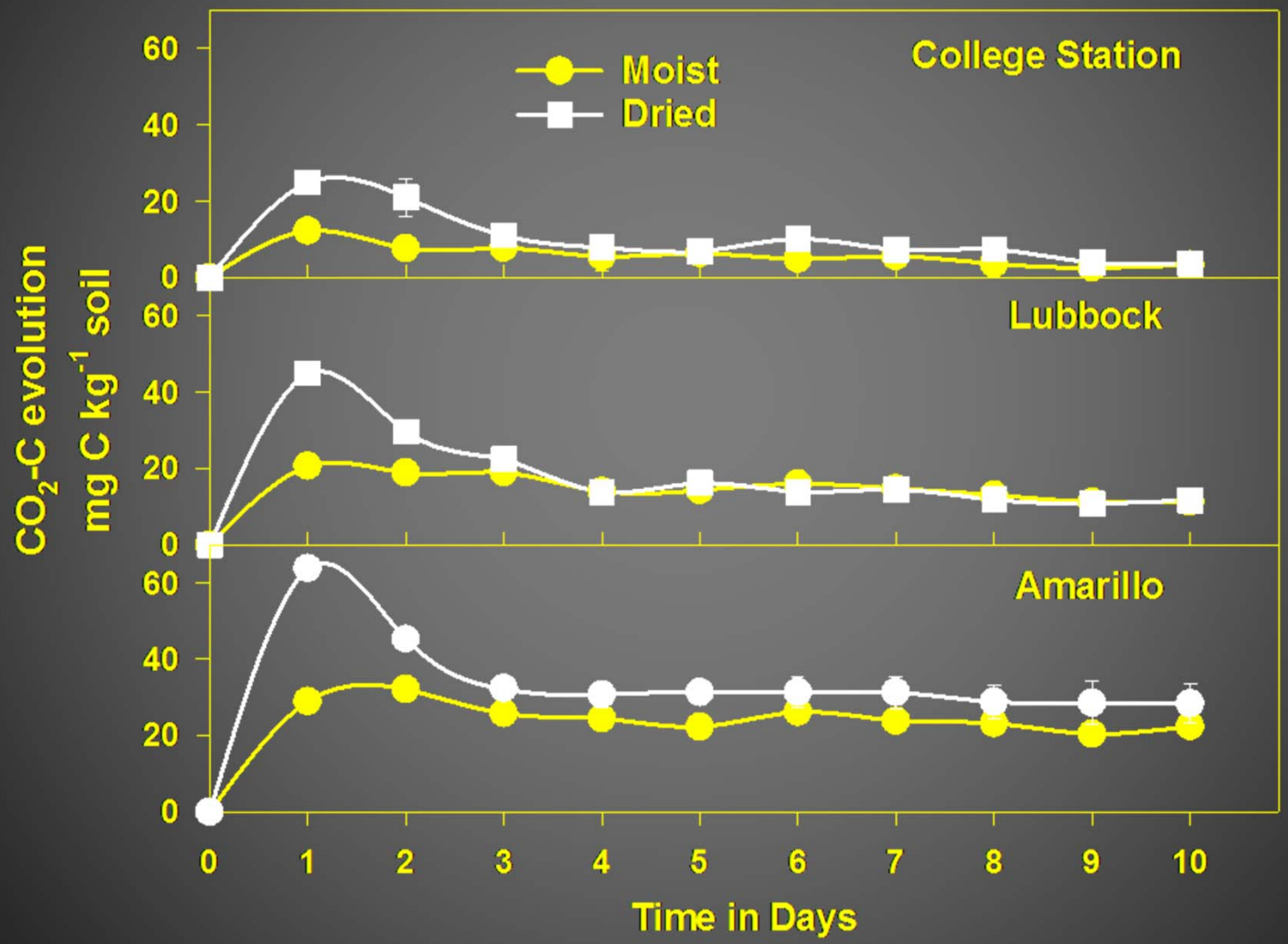


Soil Microbial Activity (respiration)

Solvita 1-day CO_2-C

Soil Microbial Activity Test
with Digital Reader

Research History - 1994



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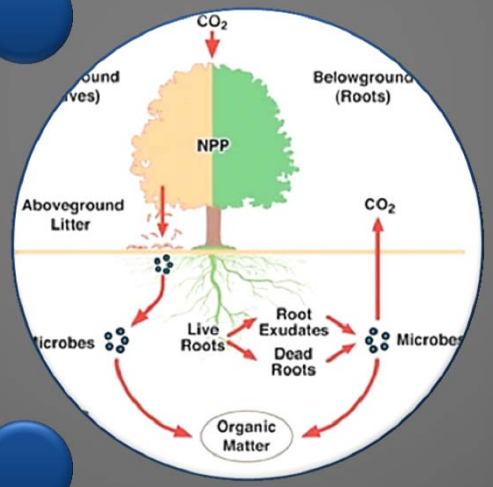
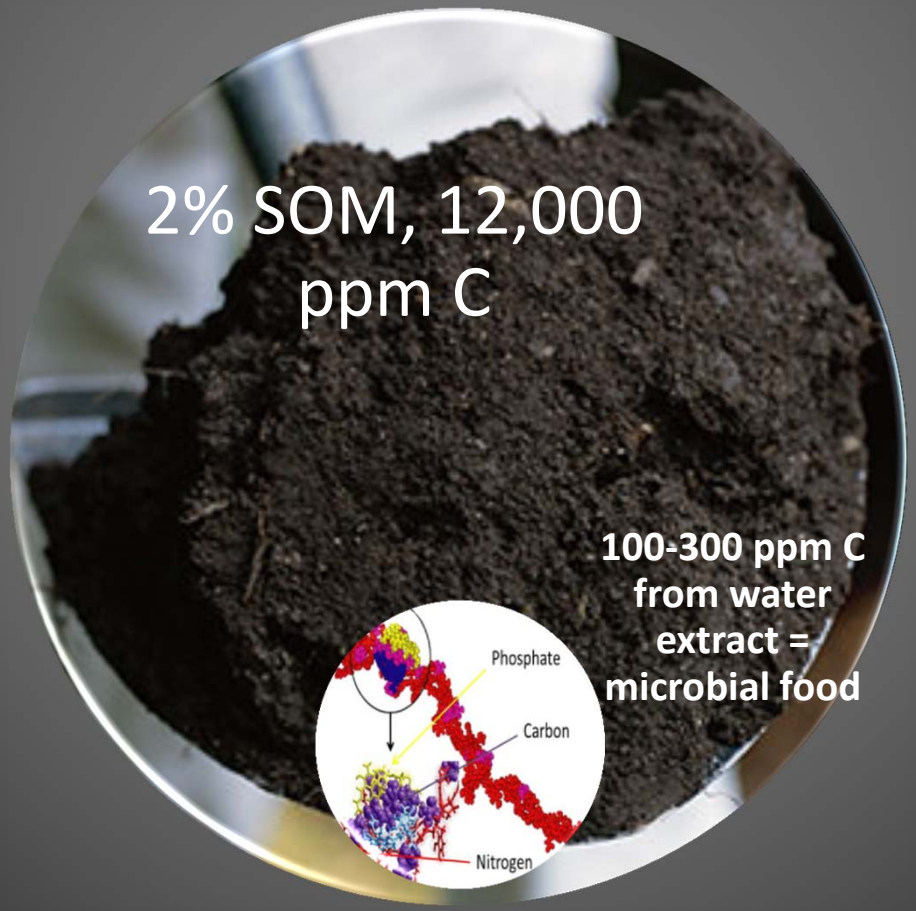
Microbial Activity

Water Extractable C

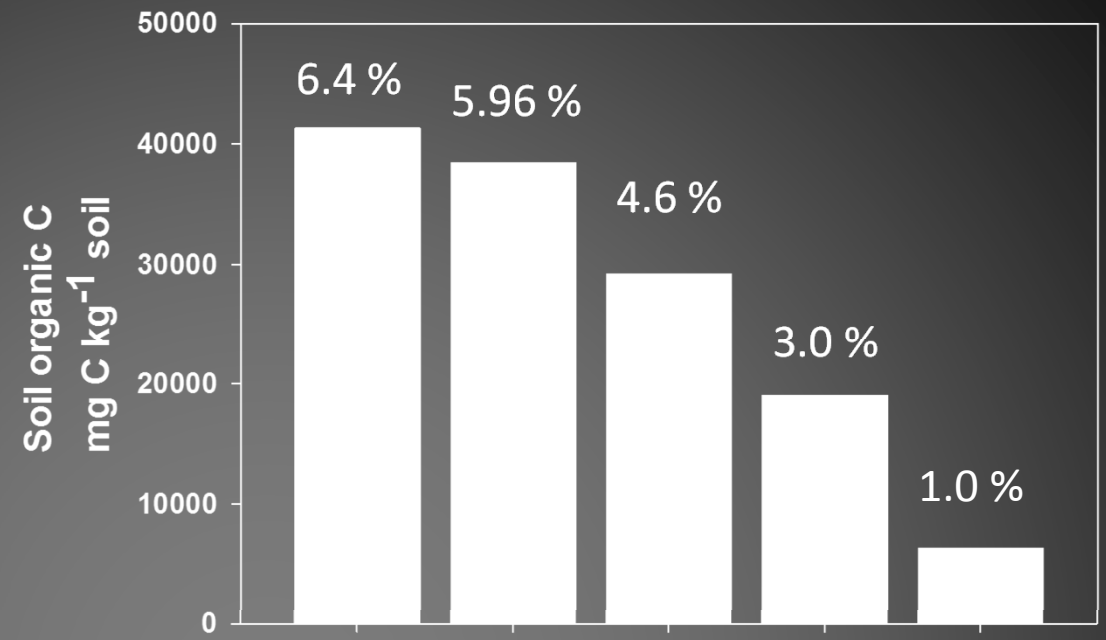
C:N balance



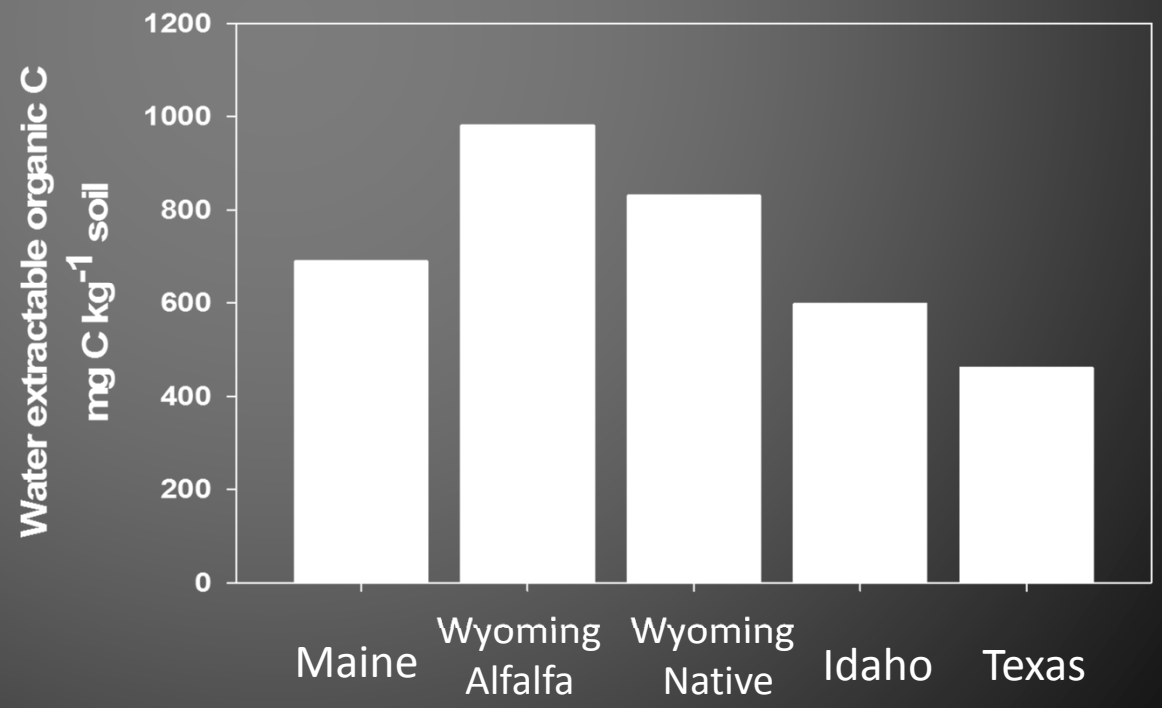
Water Extractable Organic Carbon is food for soil microbes.



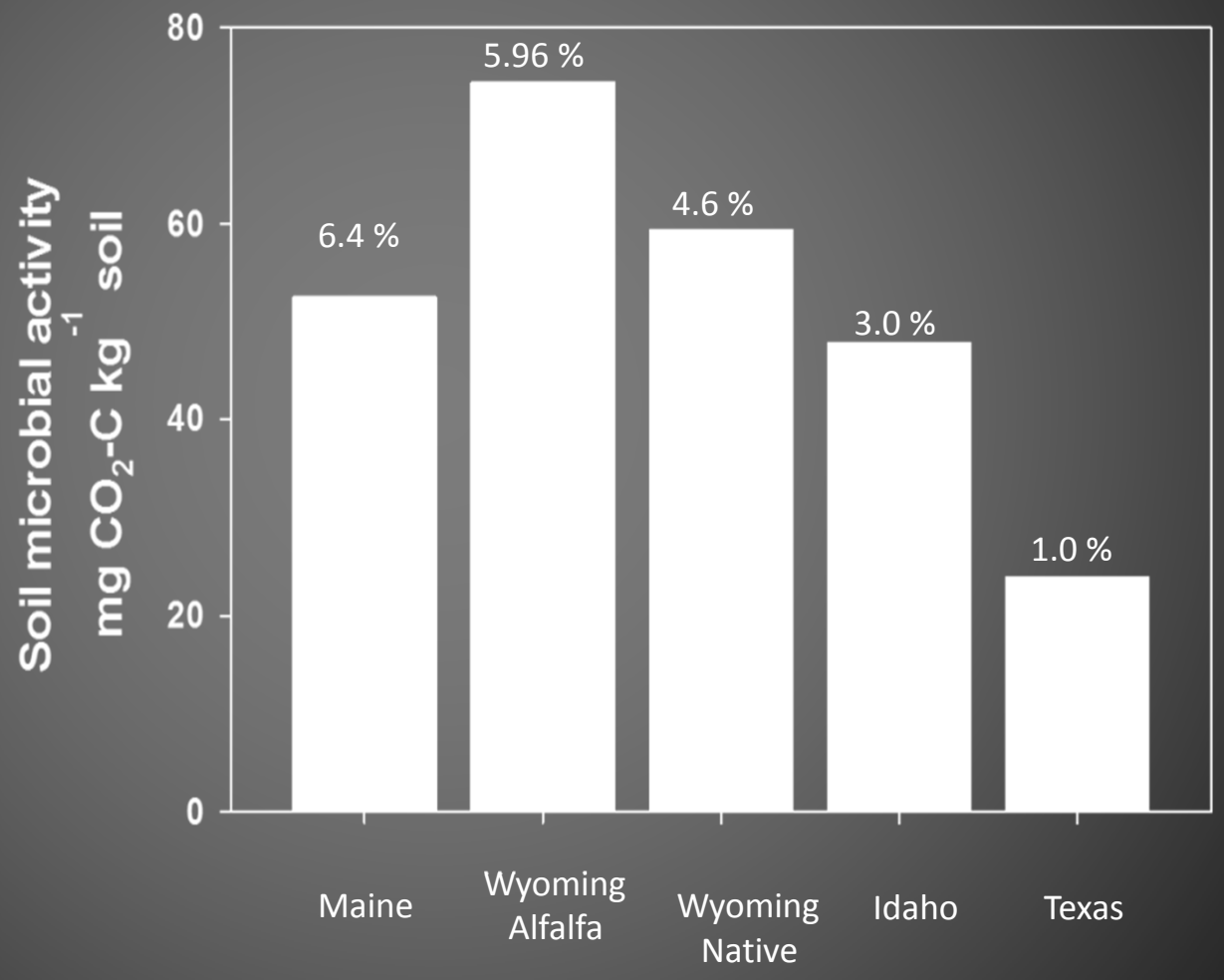
Soil Organic C
(%OM)



Water Extractable
Organic C



Soil Microbial Activity



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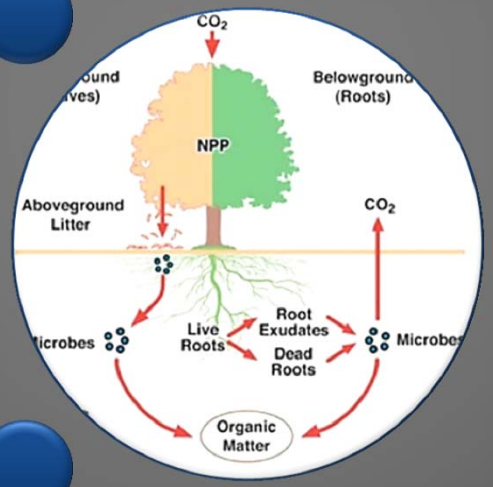
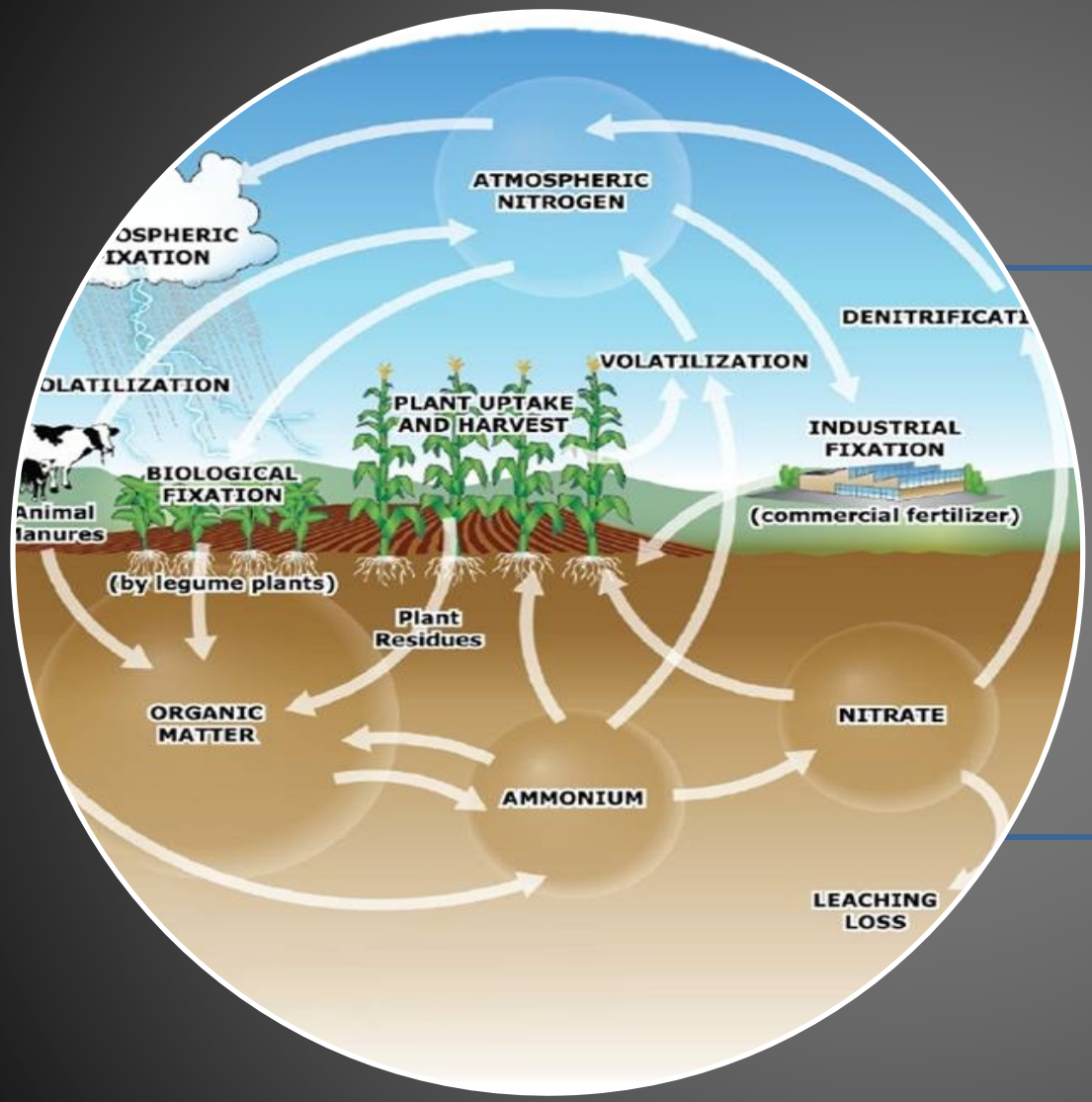
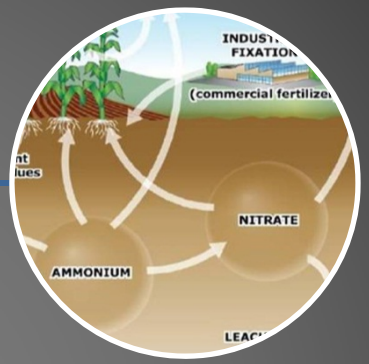


Water Extractable C

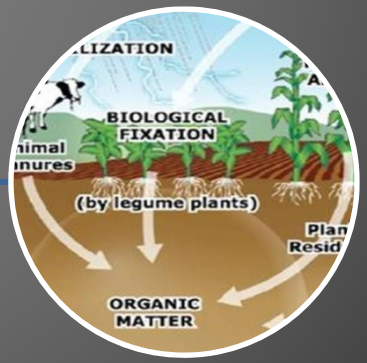
C:N balance

Soil-water total N (Pool 1)





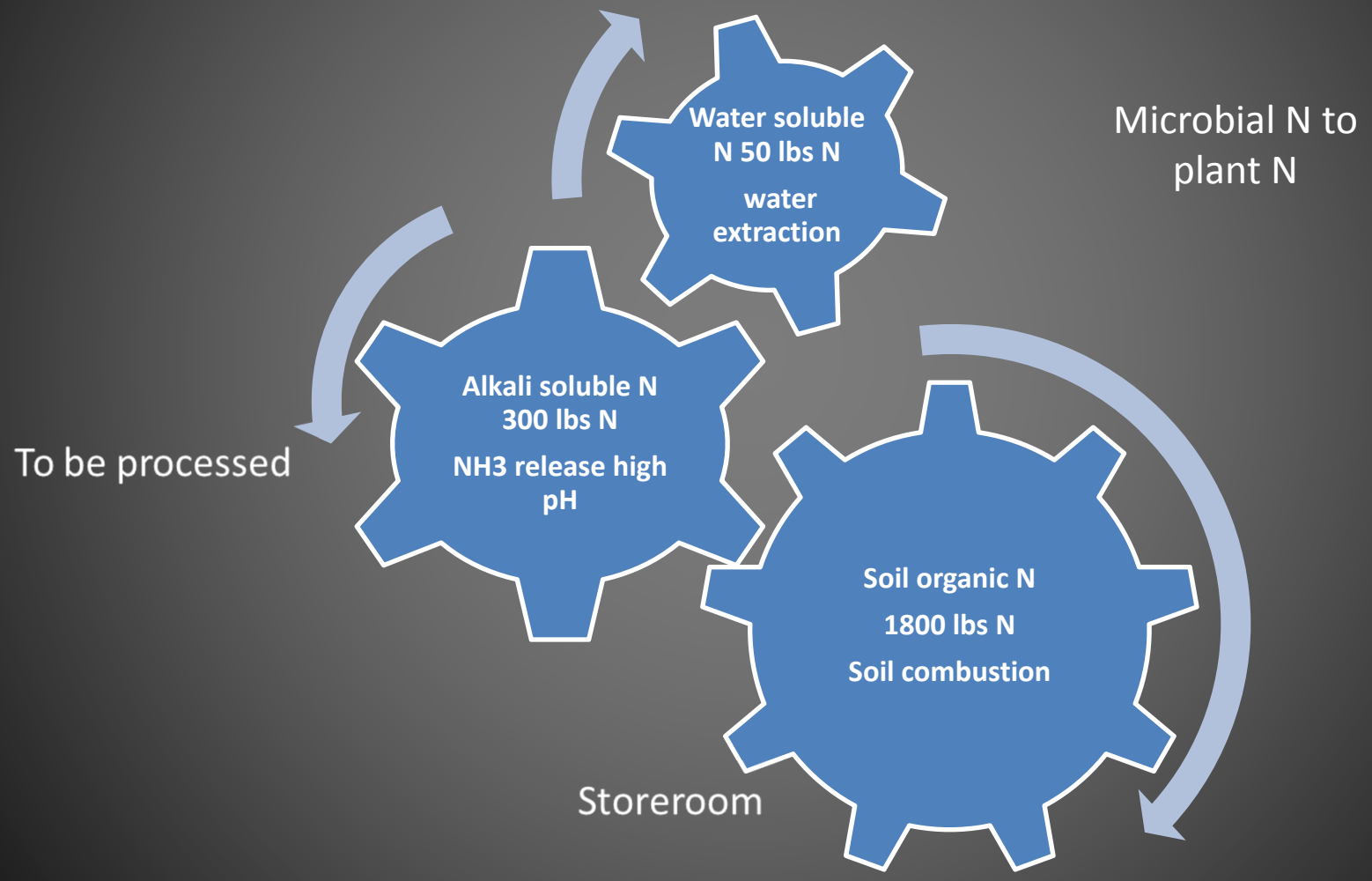
Soil – water inorganic N (Pool 2)



Soil-water organic N (Pool 3)

Source: The International Plant Institute

Soil Nitrogen Pools



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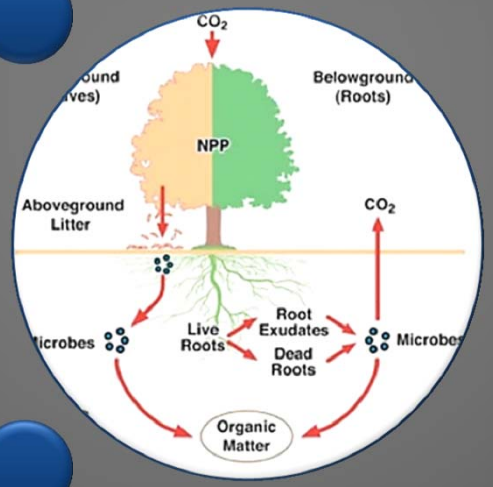
Microbial Activity

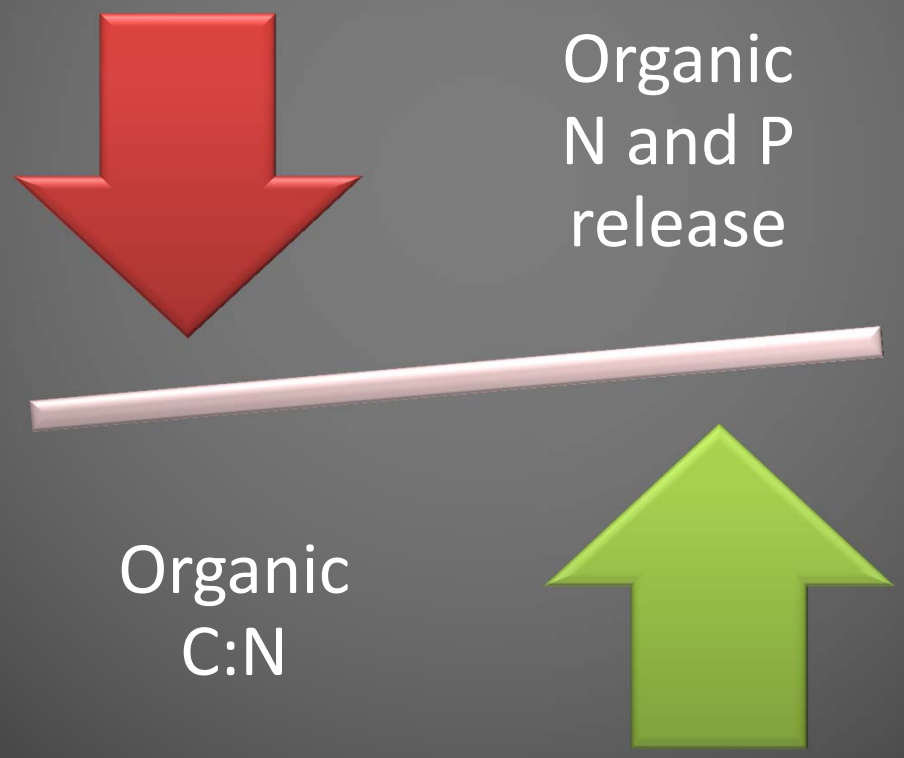


Water Extractable C

C:N balance

C:N Balance

- $\mathrm{C:N} = Organic\ C \div Organic\ N$
- Water extractable C:N ratio more sensitive because this is the amount of C and N the soil microbes use.
- Ratio usually between 8:1 and 15:1



New Soil Testing Methods

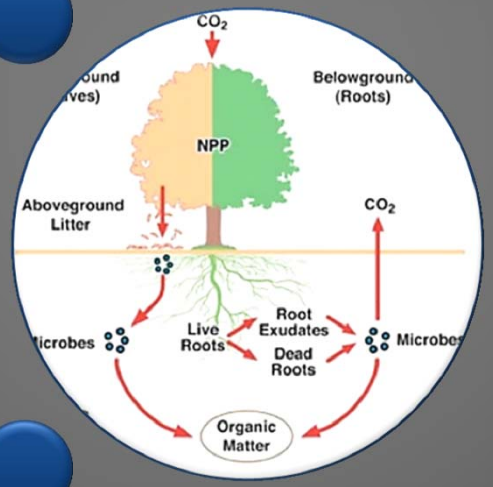
Soil N, P, K

Soil Organic N and P

Microbial Activity

Water Extractable C

C:N balance

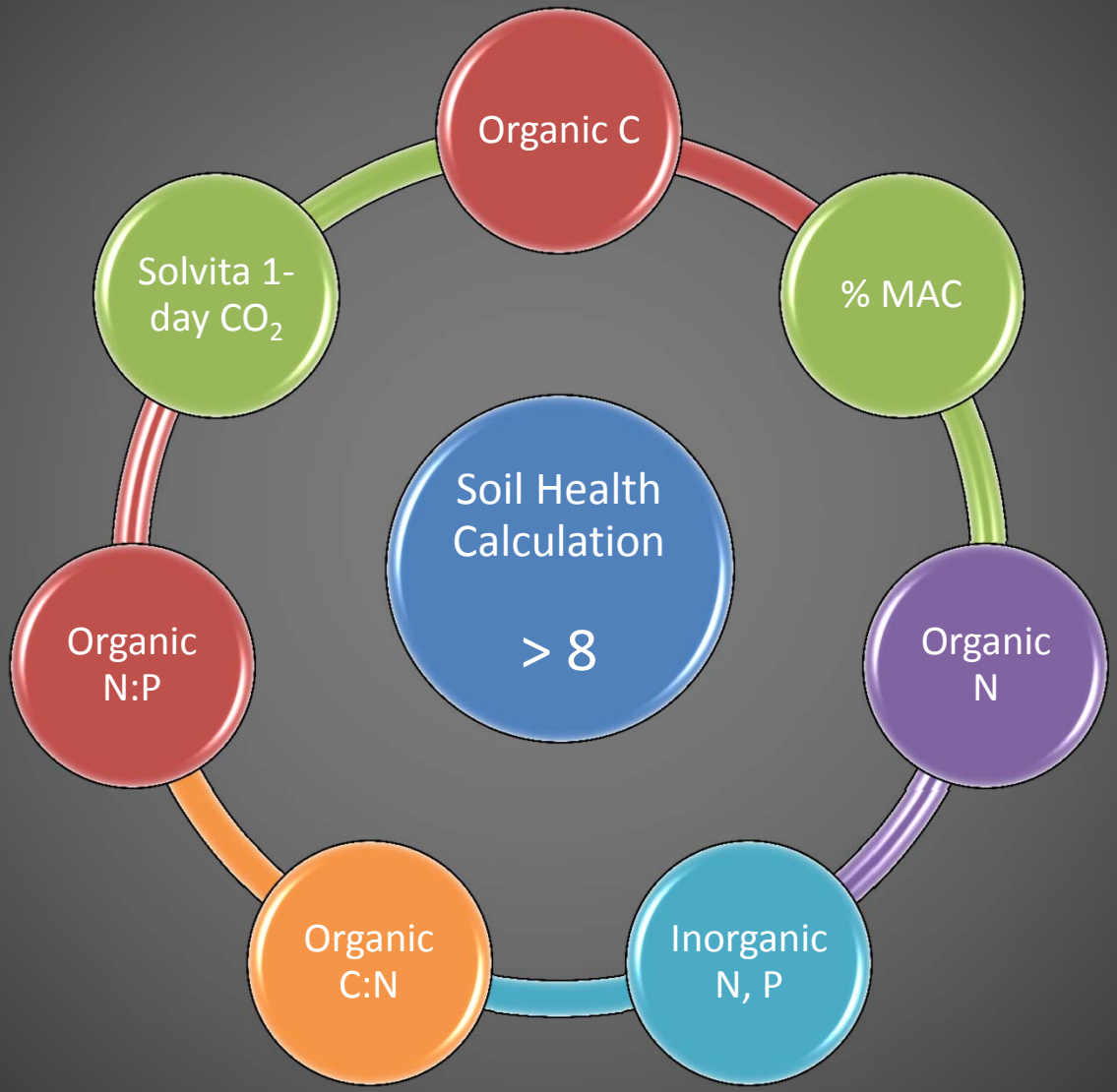


Soil Health Calculation

Soil Health Calculation

- **Soil Health Calculation –Overall health of your soil system.**
- **Combines several independent measurements of your soil's biological and chemical properties.**
- **A soil health calculation number can vary from 1 to over 50.**
- **This number is about where your soil is now and will allow you to gauge the effects of your management practices over the years.**
- **Used to calculate cover crop input**

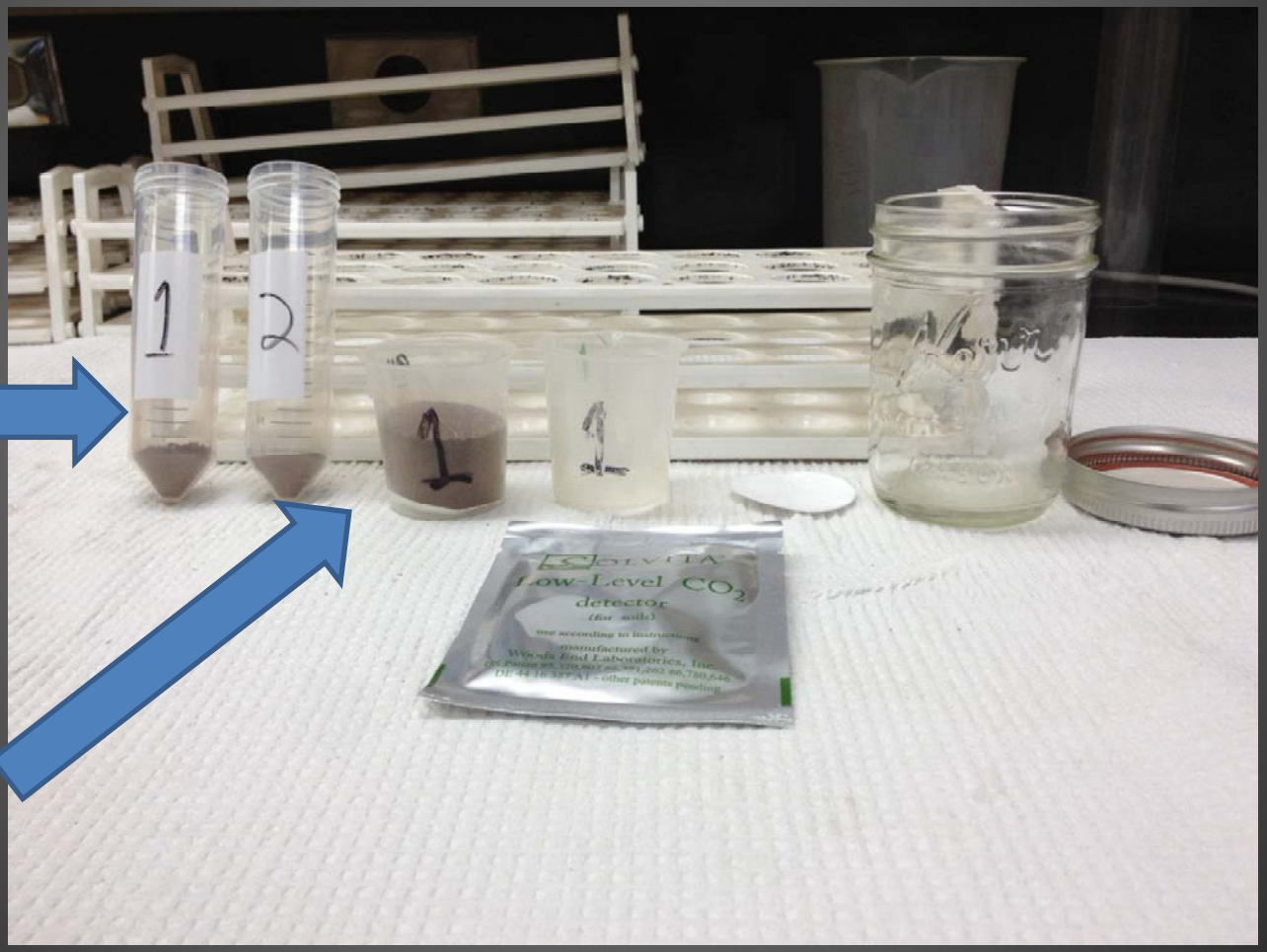
Soil Test Integration



Sample Analysis

4 grams each

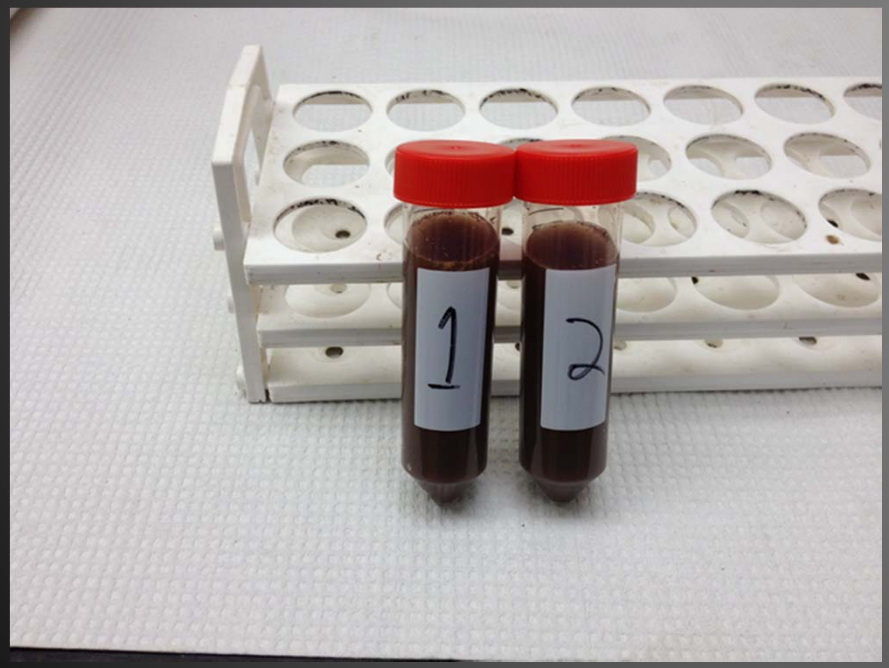
40 grams



Soil Extraction

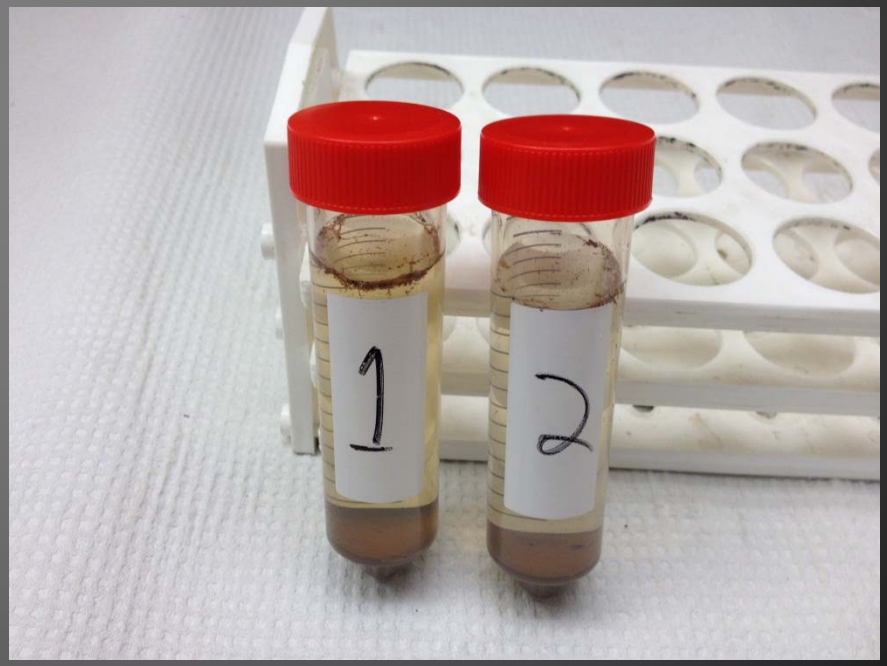
After shaking for 10 minutes

4 grams soil 40 mls (1) H3A, (2) water



After 5 minute centrifuge

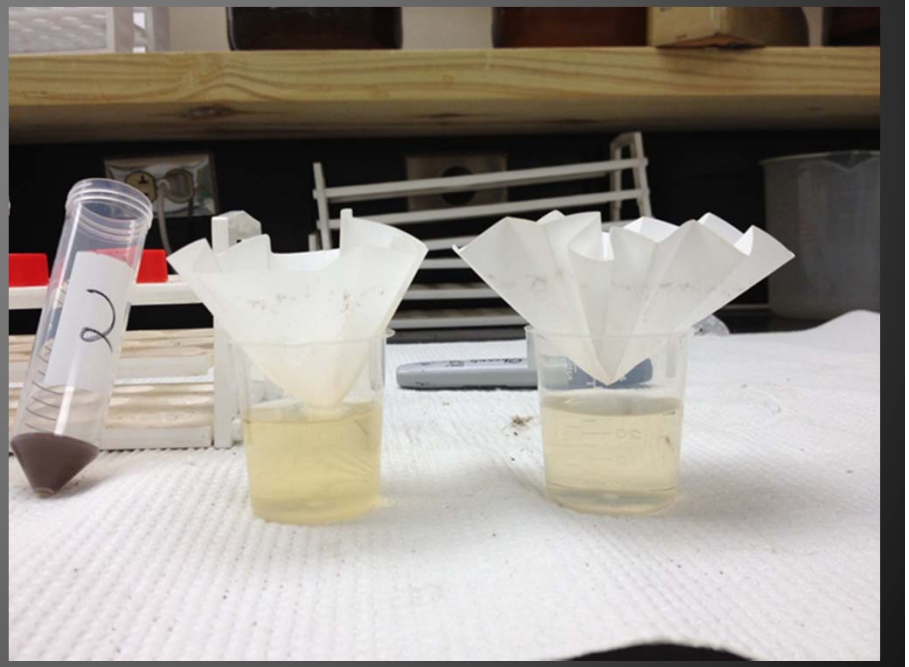
(1) H3A (2) water



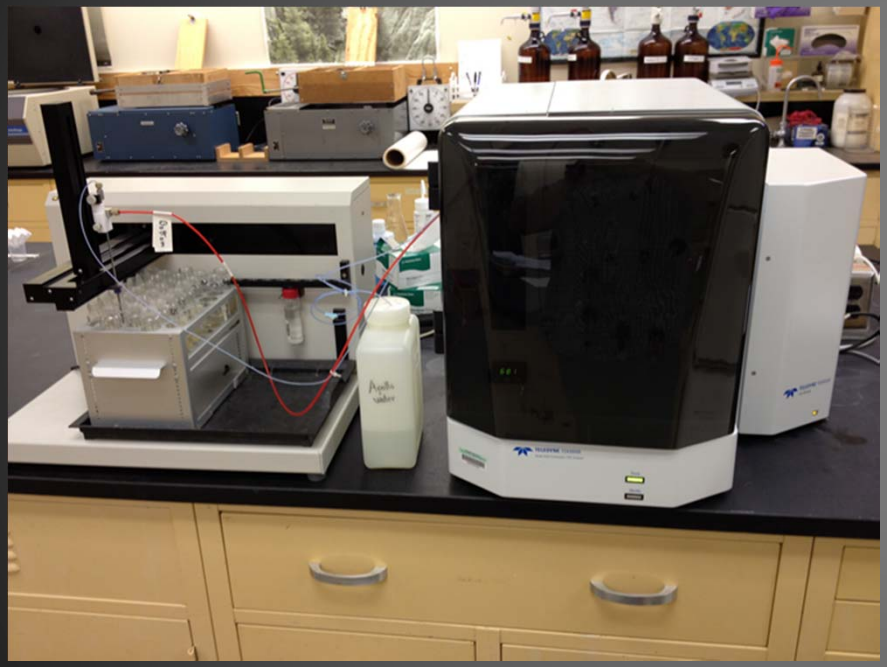
Soil Extractant Filtration

After Centrifugation

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

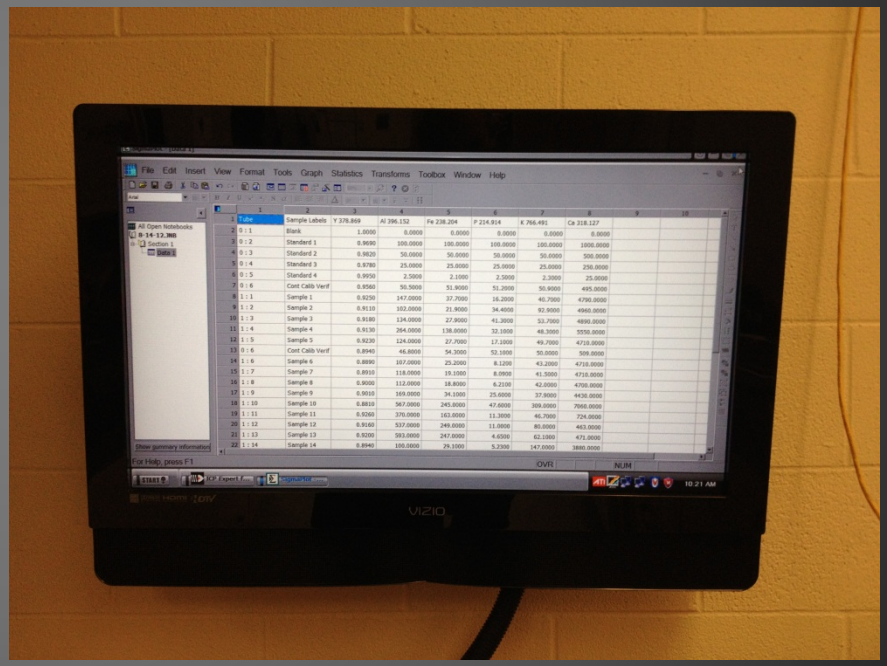


Organic C and Total N from Water Extract



Inorganic N and P
H3A and Water

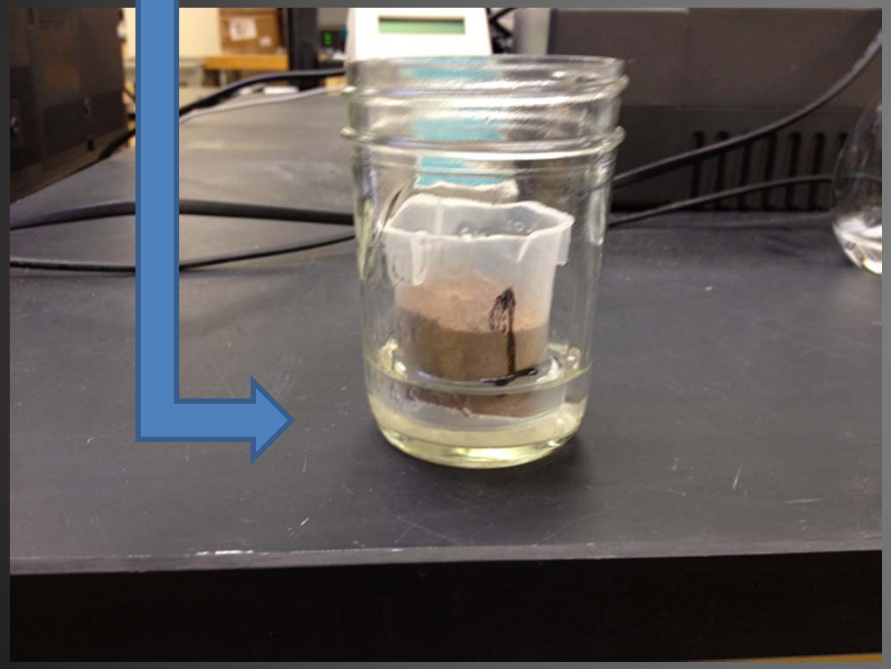
ICP Elemental Ca, P, K, Fe, Al
H3A

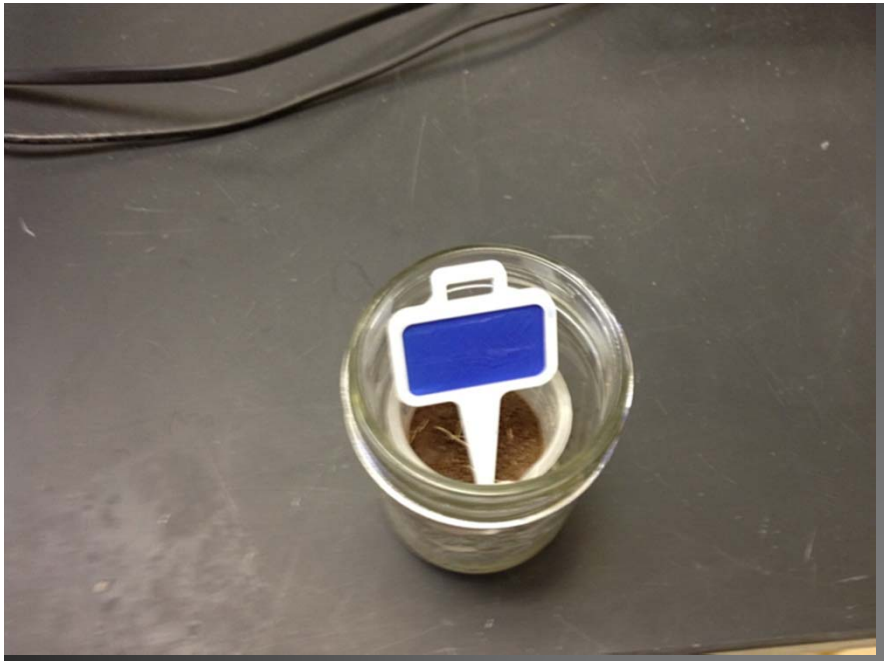


Solvita Soil Microbial Activity

25 ml water

Capillary action rewets soil to field capacity





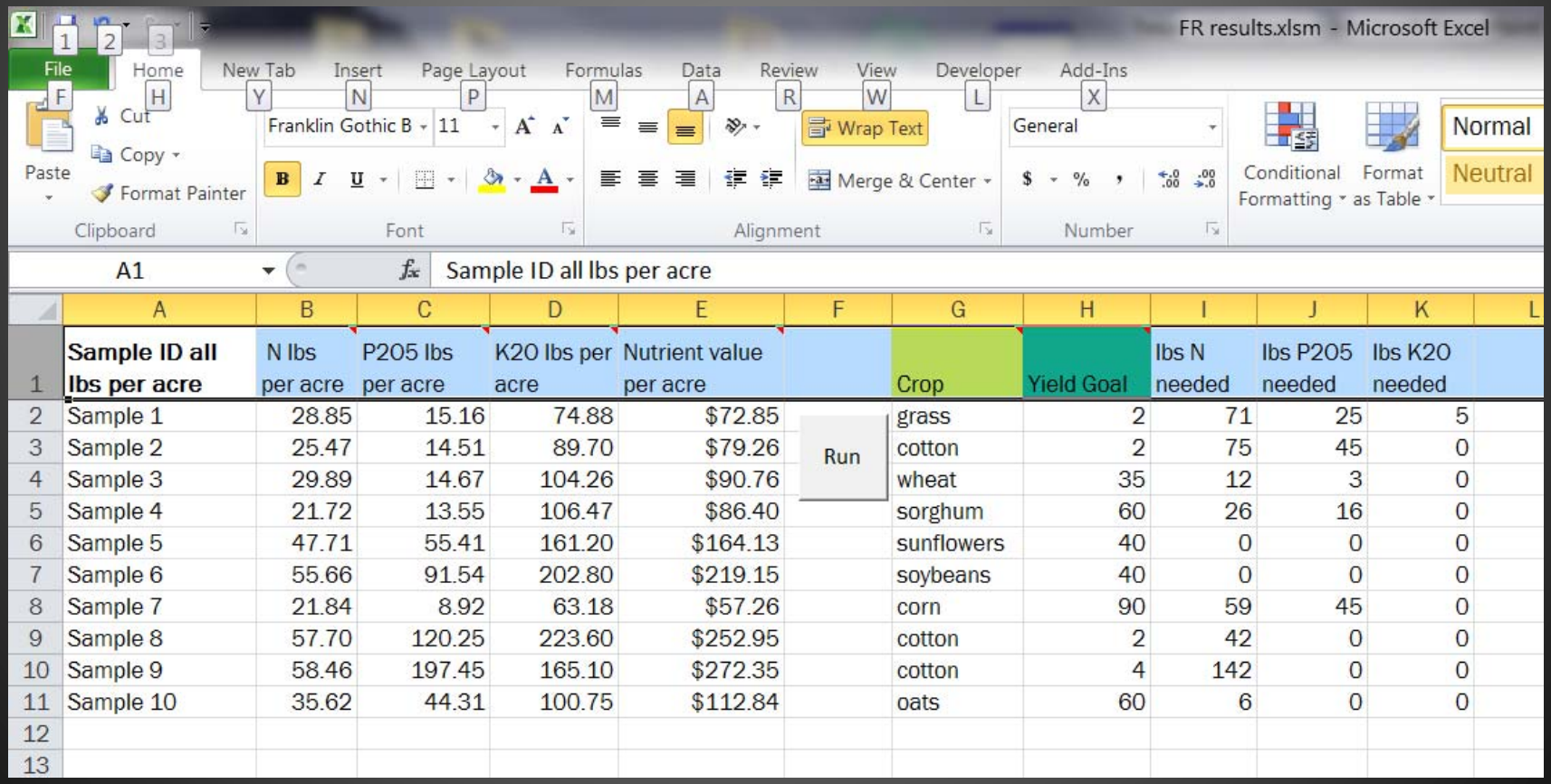
SOLVITA
CO2 HIGH
CO2 LOW
NH3
ALT
Woods End Laboratories
READ

Soil Health Tool - Results

- Results are displayed in an Excel file with 4 tabs:
  - Plant available NPK
  - Soil Health
  - Nitrogen pools
  - Phosphate pools
- Analysis explanation sheet
- Explanations for the values in each column

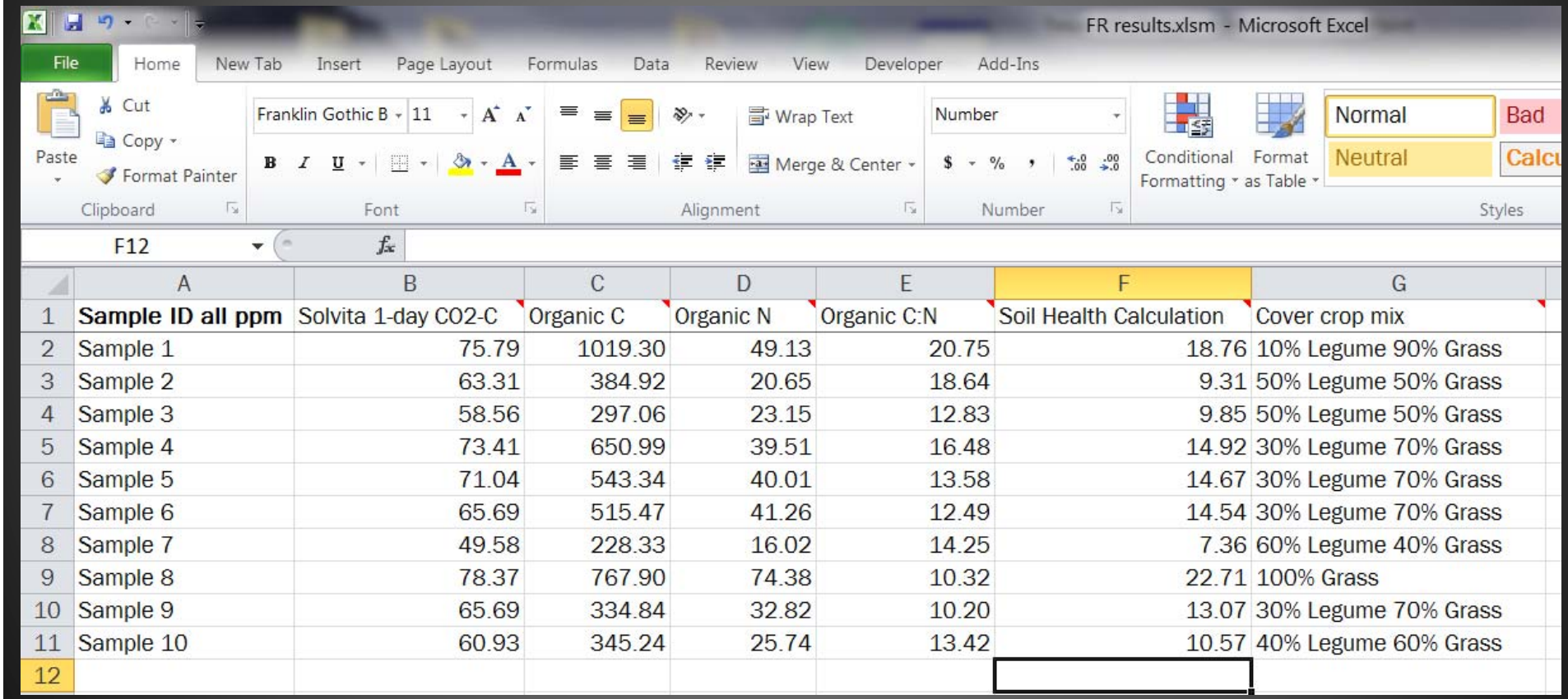
Tab 1 - NPK

- **Nitrogen: (Inorganic and Organic N) soil microbes provide N**
- **Phosphate: (Inorganic and Organic P) soil microbes provide P. Converted to P2O5**
- **Potassium converted to K2O**
- **Nutrient value per acre: Current fertilizer prices multiplied by the nutrients present in your soil. This is the value of your current soil nutrients in dollars per acre.**



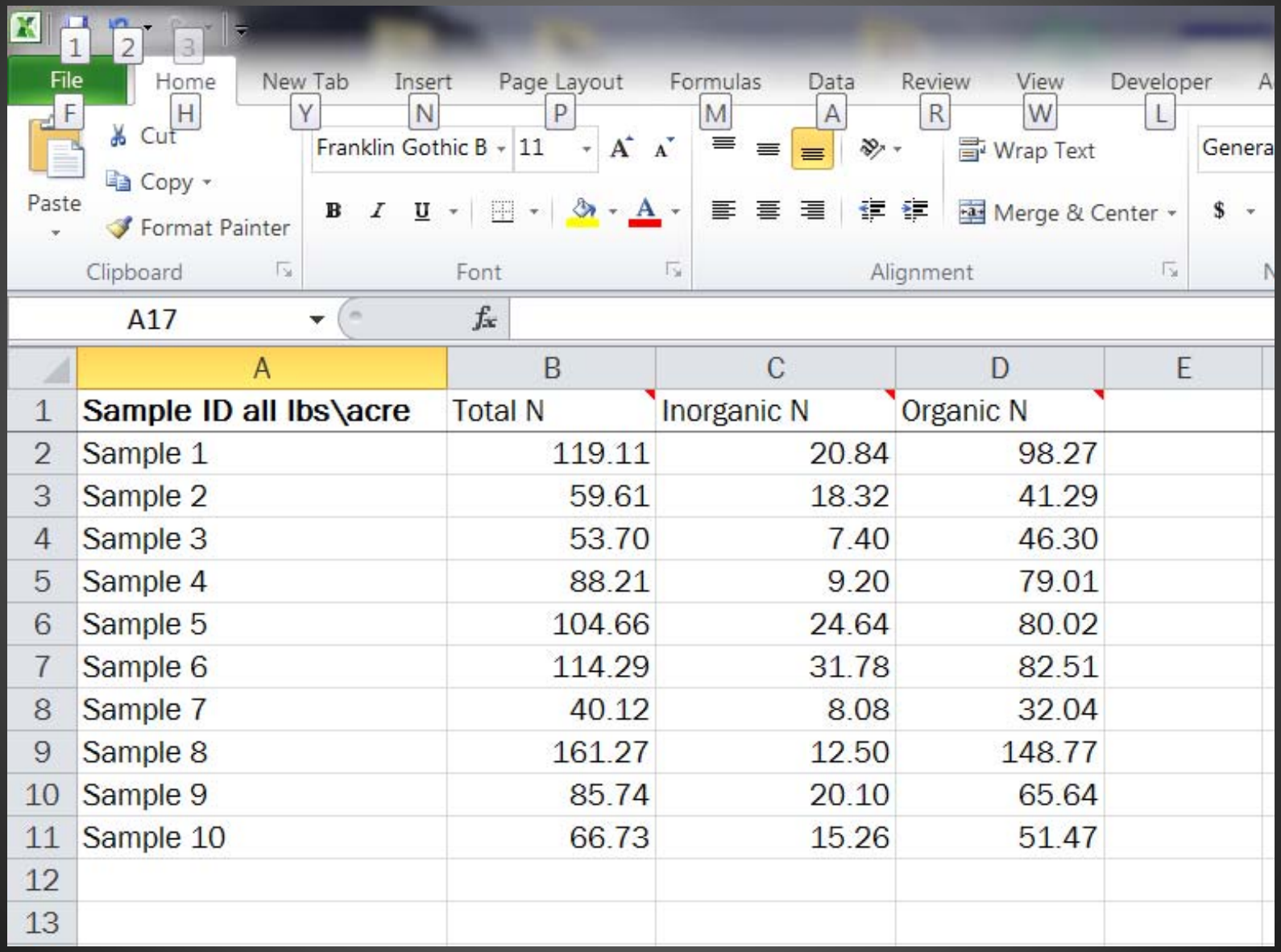
	A	B	C	D	E	F	G	H	I	J	K	L
1	Sample ID all lbs per acre	N lbs per acre	P2O5 lbs per acre	K2O lbs per acre	Nutrient value per acre		Crop	Yield Goal	lbs N needed	lbs P2O5 needed	lbs K2O needed	
2	Sample 1	28.85	15.16	74.88	$72.85		grass	2	71	25	5	
3	Sample 2	25.47	14.51	89.70	$79.26		cotton	2	75	45	0	
4	Sample 3	29.89	14.67	104.26	$90.76		wheat	35	12	3	0	
5	Sample 4	21.72	13.55	106.47	$86.40		sorghum	60	26	16	0	
6	Sample 5	47.71	55.41	161.20	$164.13		sunflowers	40	0	0	0	
7	Sample 6	55.66	91.54	202.80	$219.15		soybeans	40	0	0	0	
8	Sample 7	21.84	8.92	63.18	$57.26		corn	90	59	45	0	
9	Sample 8	57.70	120.25	223.60	$252.95		cotton	2	42	0	0	
10	Sample 9	58.46	197.45	165.10	$272.35		cotton	4	142	0	0	
11	Sample 10	35.62	44.31	100.75	$112.84		oats	60	6	0	0	
12												
13												

Tab 2 - Soil Health



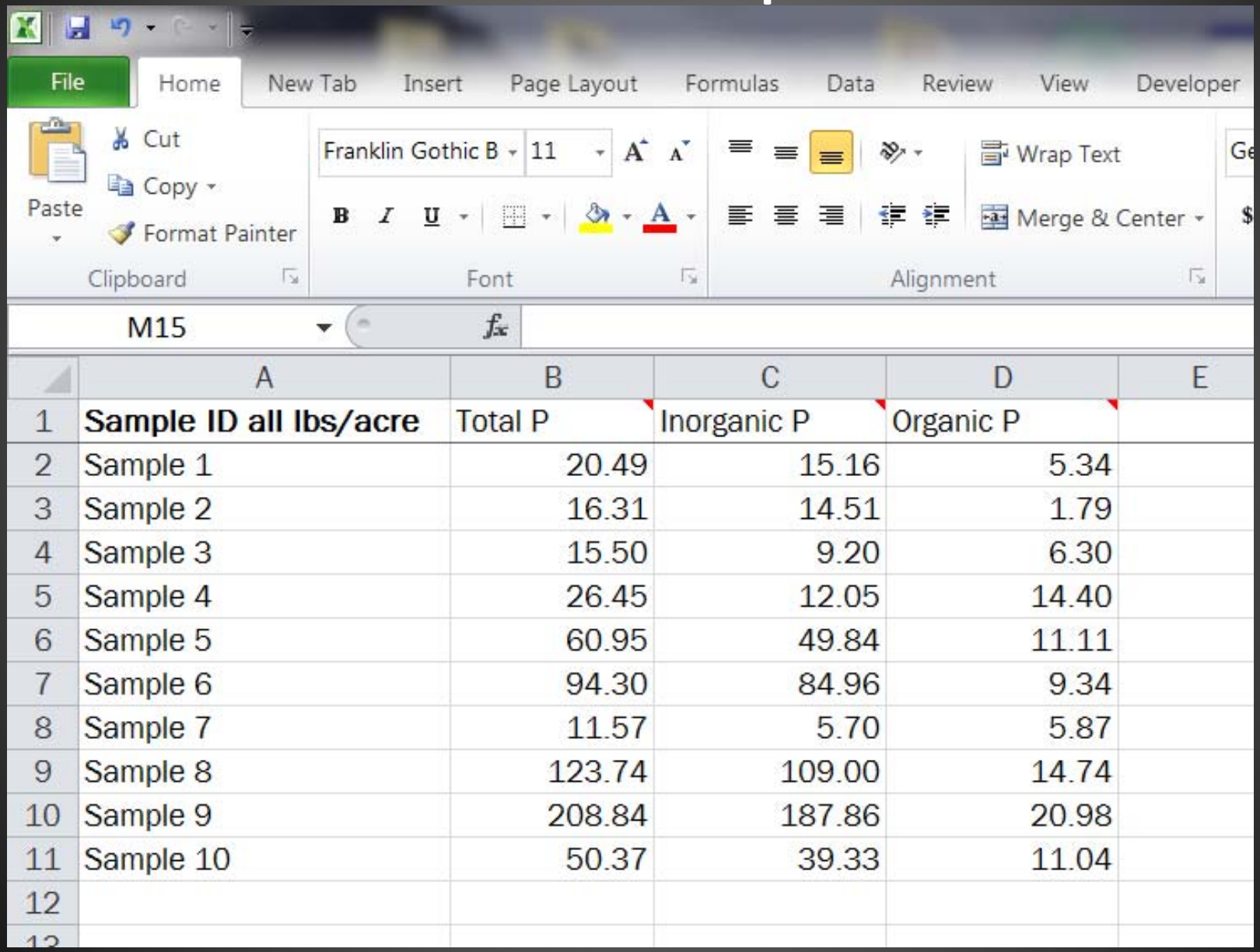
	A	B	C	D	E	F	G
1	**Sample ID all ppm**	Solvita 1-day CO2-C	Organic C	Organic N	Organic C:N	Soil Health Calculation	Cover crop mix
2	Sample 1	75.79	1019.30	49.13	20.75	18.76	10% Legume 90% Grass
3	Sample 2	63.31	384.92	20.65	18.64	9.31	50% Legume 50% Grass
4	Sample 3	58.56	297.06	23.15	12.83	9.85	50% Legume 50% Grass
5	Sample 4	73.41	650.99	39.51	16.48	14.92	30% Legume 70% Grass
6	Sample 5	71.04	543.34	40.01	13.58	14.67	30% Legume 70% Grass
7	Sample 6	65.69	515.47	41.26	12.49	14.54	30% Legume 70% Grass
8	Sample 7	49.58	228.33	16.02	14.25	7.36	60% Legume 40% Grass
9	Sample 8	78.37	767.90	74.38	10.32	22.71	100% Grass
10	Sample 9	65.69	334.84	32.82	10.20	13.07	30% Legume 70% Grass
11	Sample 10	60.93	345.24	25.74	13.42	10.57	40% Legume 60% Grass
12							

Tab 3 - Nitrogen



	A	B	C	D	E
1	**Sample ID all lbs\acre**	Total N	Inorganic N	Organic N	
2	Sample 1	119.11	20.84	98.27	
3	Sample 2	59.61	18.32	41.29	
4	Sample 3	53.70	7.40	46.30	
5	Sample 4	88.21	9.20	79.01	
6	Sample 5	104.66	24.64	80.02	
7	Sample 6	114.29	31.78	82.51	
8	Sample 7	40.12	8.08	32.04	
9	Sample 8	161.27	12.50	148.77	
10	Sample 9	85.74	20.10	65.64	
11	Sample 10	66.73	15.26	51.47	
12					
13					

Tab 4 - Phosphate



	A	B	C	D	E
1	**Sample ID all lbs/acre**	Total P	Inorganic P	Organic P	
2	Sample 1	20.49	15.16	5.34	
3	Sample 2	16.31	14.51	1.79	
4	Sample 3	15.50	9.20	6.30	
5	Sample 4	26.45	12.05	14.40	
6	Sample 5	60.95	49.84	11.11	
7	Sample 6	94.30	84.96	9.34	
8	Sample 7	11.57	5.70	5.87	
9	Sample 8	123.74	109.00	14.74	
10	Sample 9	208.84	187.86	20.98	
11	Sample 10	50.37	39.33	11.04	
12					

Soil Nutrient Assessment Program

SNAP Home | Optional Details | About

Field Information

State: Texas

County: Bell

Crop: Corn

Field Area (Acres): 1000

Yield Goal: 100

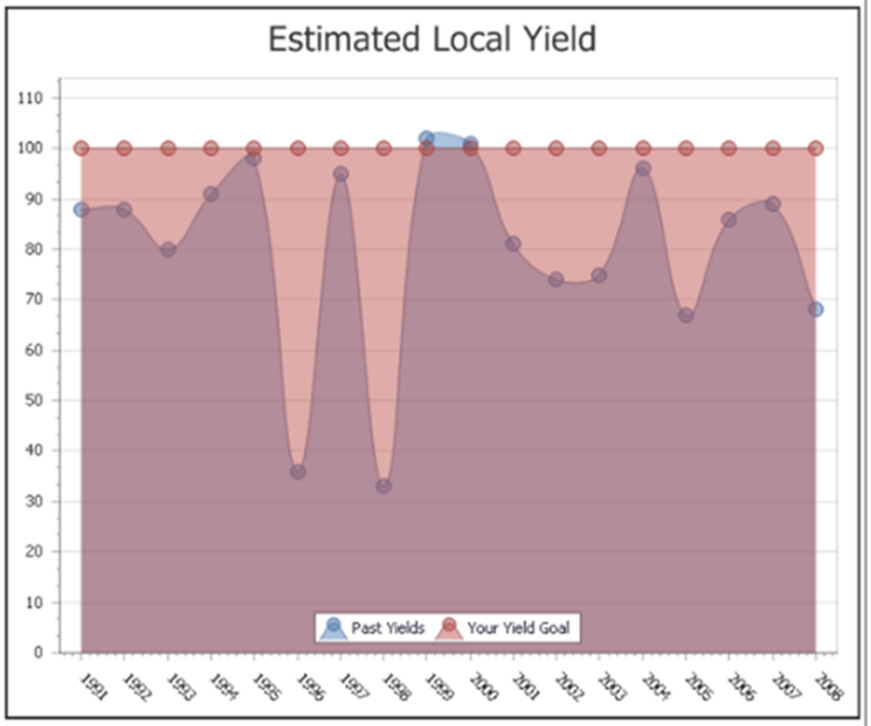
Soil Test Results

Nitrogen (lb N/acre): 25

Phosphate (lb P2O5/acre): 20

Potassium (lb K2O/acre): 50

Update



Results

-	N	P2O5	K	Cost/Acre	Total Cost
Crop Requirements	100.0	50.0	50.0	$110.00	$110000
Soil Test Based Requirements	75.0	30.0	0.0	$63.00	$63000

Chance of Success %

Soil Nutrient Assessment Program

SNAP Home | Optional Details | About

Field Information

State: Texas

County: Bell

Crop: Corn

Field Area (Acres): 1000

Yield Goal: 80

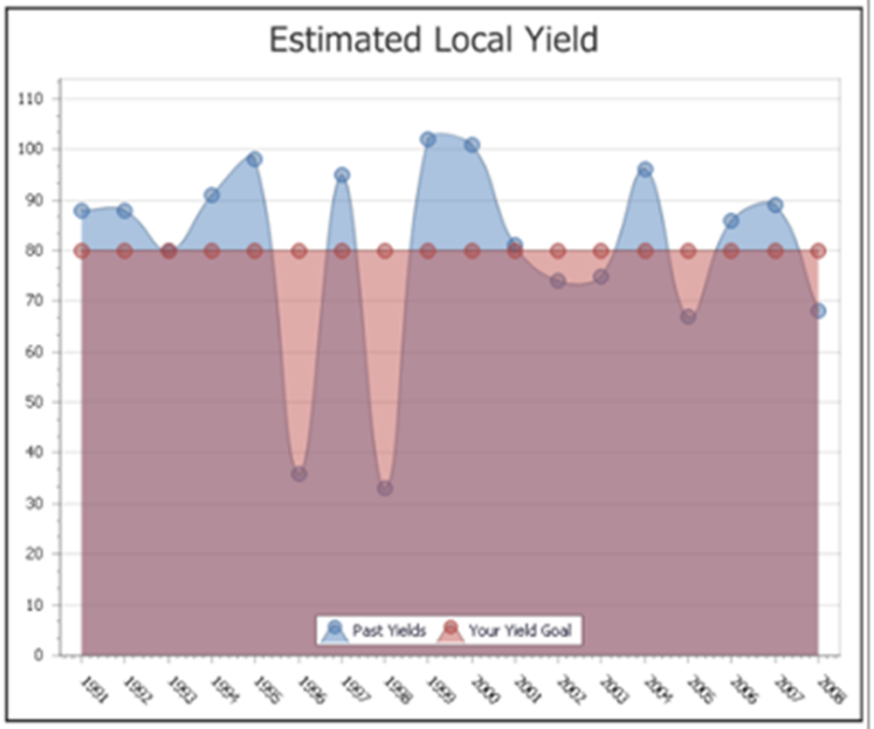
Soil Test Results

Nitrogen (lb N/acre): 25

Phosphate (lb P2O5/acre): 20

Potassium (lb K2O/acre): 50

Update



Results

-	N	P2O5	K	Cost/Acre	Total Cost
Crop Requirements	80.0	40.0	40.0	$88.00	$88000
Soil Test Based Requirements	55.0	20.0	0	$44.50	$44500

Chance of Success %

Future Soil Test Results could have a Graphic Interface

Work with the system
Create balance
Be sustainable
Conserve water
Recycle nutrients

USDA-ARS

Temple, Texas - Soil research lab

We are striving, through research and education, to deliver a soil testing package that can be readily adopted by any soil testing lab to further our understanding of soil biology and increase the efficiency of our fertilizer use while protecting our natural resources.

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

Rick Haney
Soil Scientist
USDA – ARS
Grassland, Soil & Water Research Laboratory
808 E. Blackland Road
Temple, TX 76502
(254) 770-6503
rick.haney@ars.usda.gov

Rick Haney (53) and daughter, Maggie (2)

Background: Worked for Farmers and Ranchers off and on from 1975-2000, as well as a mechanic, apartment manager and maintenance, furniture upholstery

BS: Southwestern Oklahoma State University, Biology/Chemistry, 1993

MS: Texas A&M University, Soil Microbial Ecology, 1997

PhD: Texas A&M University, Soil Chemistry, 2001

Texas A&M University, Post Doc Herbicide Chemistry, 2001 - 2002

USDA-ARS Research Scientist 2002-present

Crop Nutrient Requirements

Crops	Unit	Nutrients Required		
		Nitrogen	Phosphate P_2O_5	Potassium K_2O
Corn	lbs per bushel	**1.00**	**0.50**	**0.50**
Wheat	lbs per bushel	**1.20**	**0.50**	**0.50**
Sorghum	lbs per bushel	**0.80**	**0.50**	**0.50**
Oats	lbs per bushel	**0.70**	**0.40**	**0.30**
Soybeans*	lbs per bushel	**3.00**	**1.00**	**1.40**
Sunflowers	lbs per bushel	**0.70**	**0.40**	**0.30**
Cotton	lbs per bale	**50**	**30**	**20**
Warm season grasses	lbs per ton	**50**	**20**	**40**

Sources used: Ortho fertilizer Dallas, Texas: Potash and Phosphate Institute: North Carolina State University: Iowa State University: University of Nebraska: Oklahoma State University: Kansas State University.
* The majority of N is fixed by the plant. No N fertilization is needed if the seeds are inoculated.

Fertilizer Required – Soil Test Analysis = Fertilizer neede d

Yield goal (bu\ac or lbs per bale\ton) multiplied by **nutrients required** minus **soil test analysis** = lbs\ac fertilizer needed

Background: Worked for Farmers and Ranchers off and on from 1975-2000, as well as a mechanic, apartment manager and maintenance, furniture upholstery

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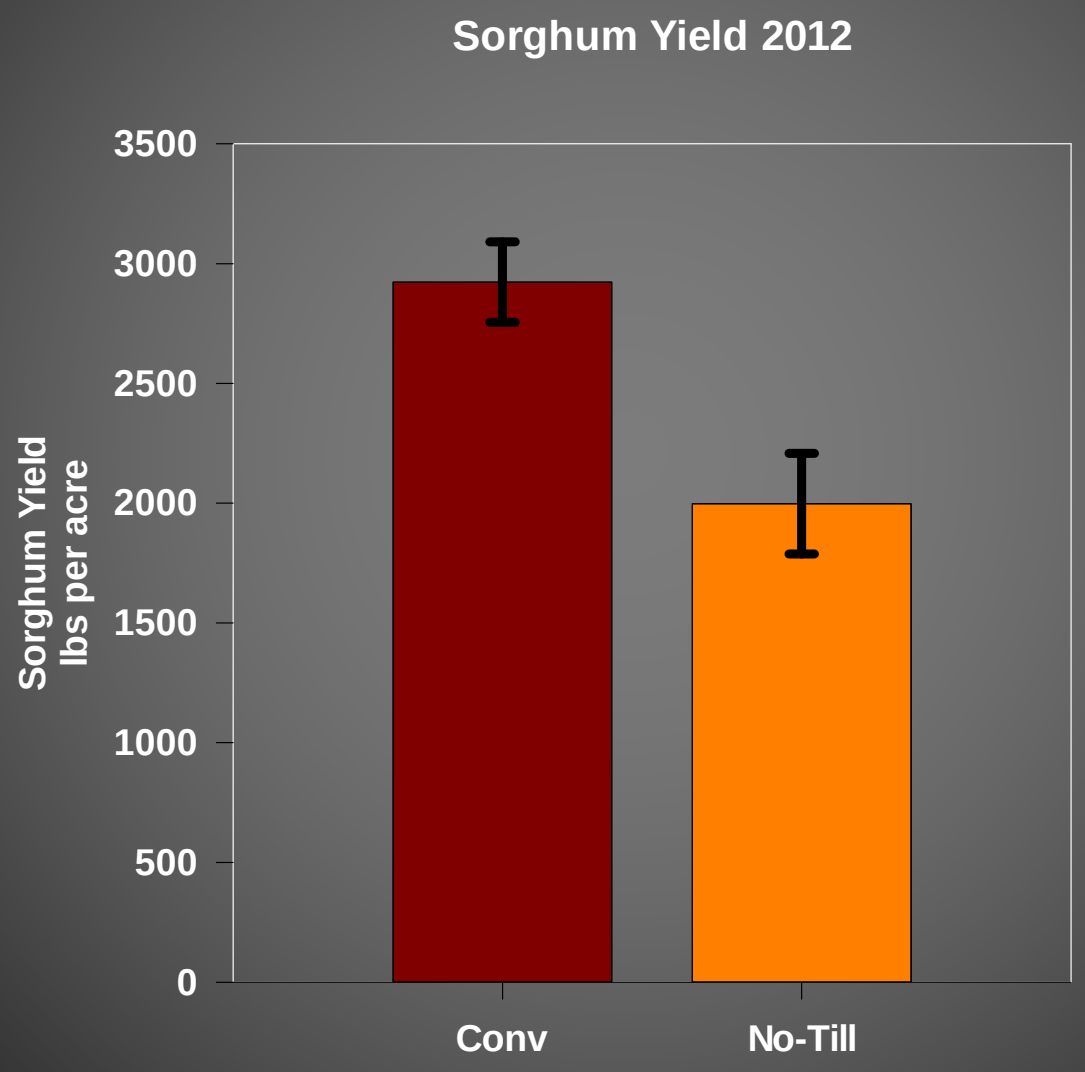
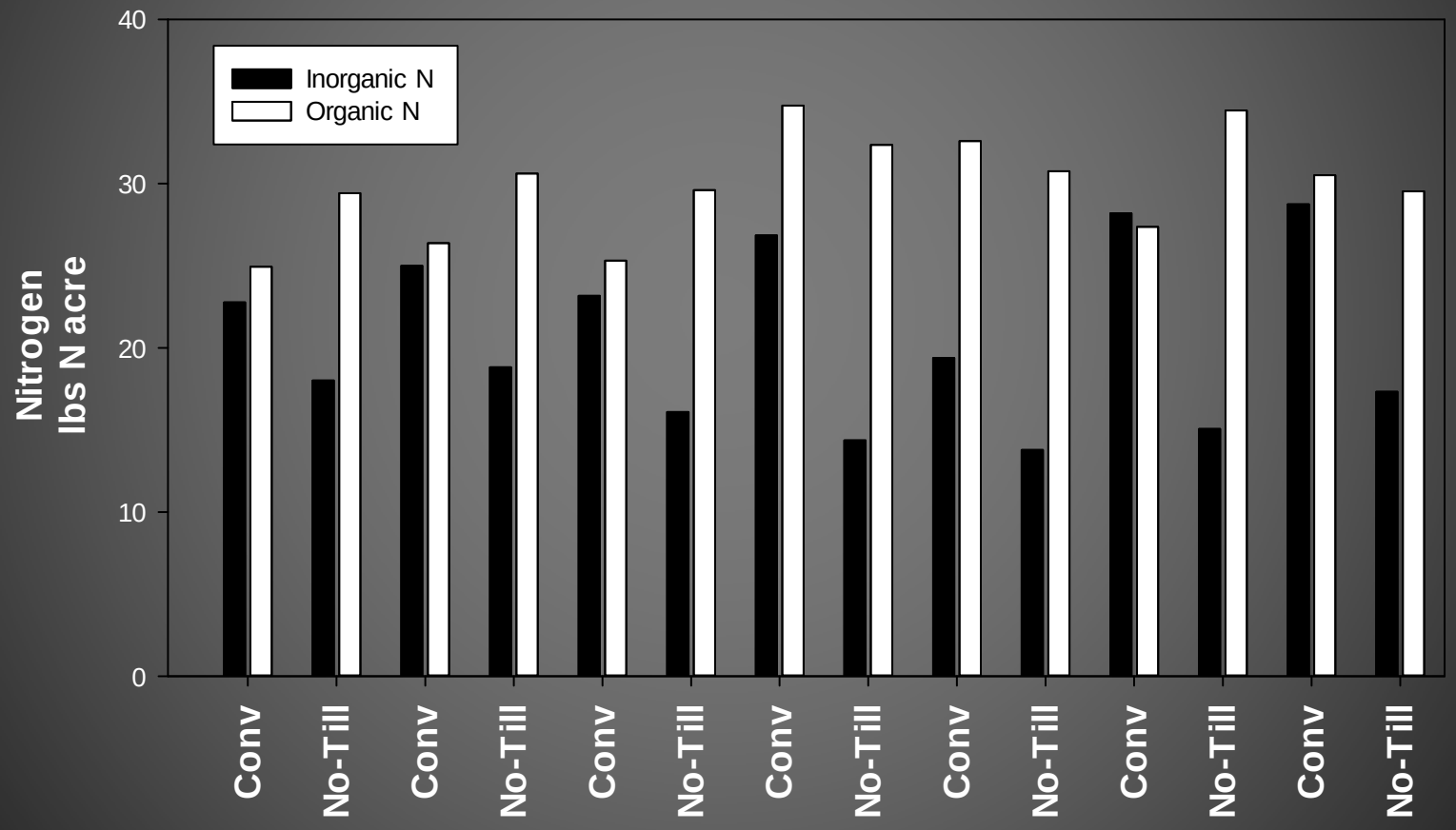
USDA-ARS Research Scientist 2002-present

No-till vs. Tilled with Cover Crops

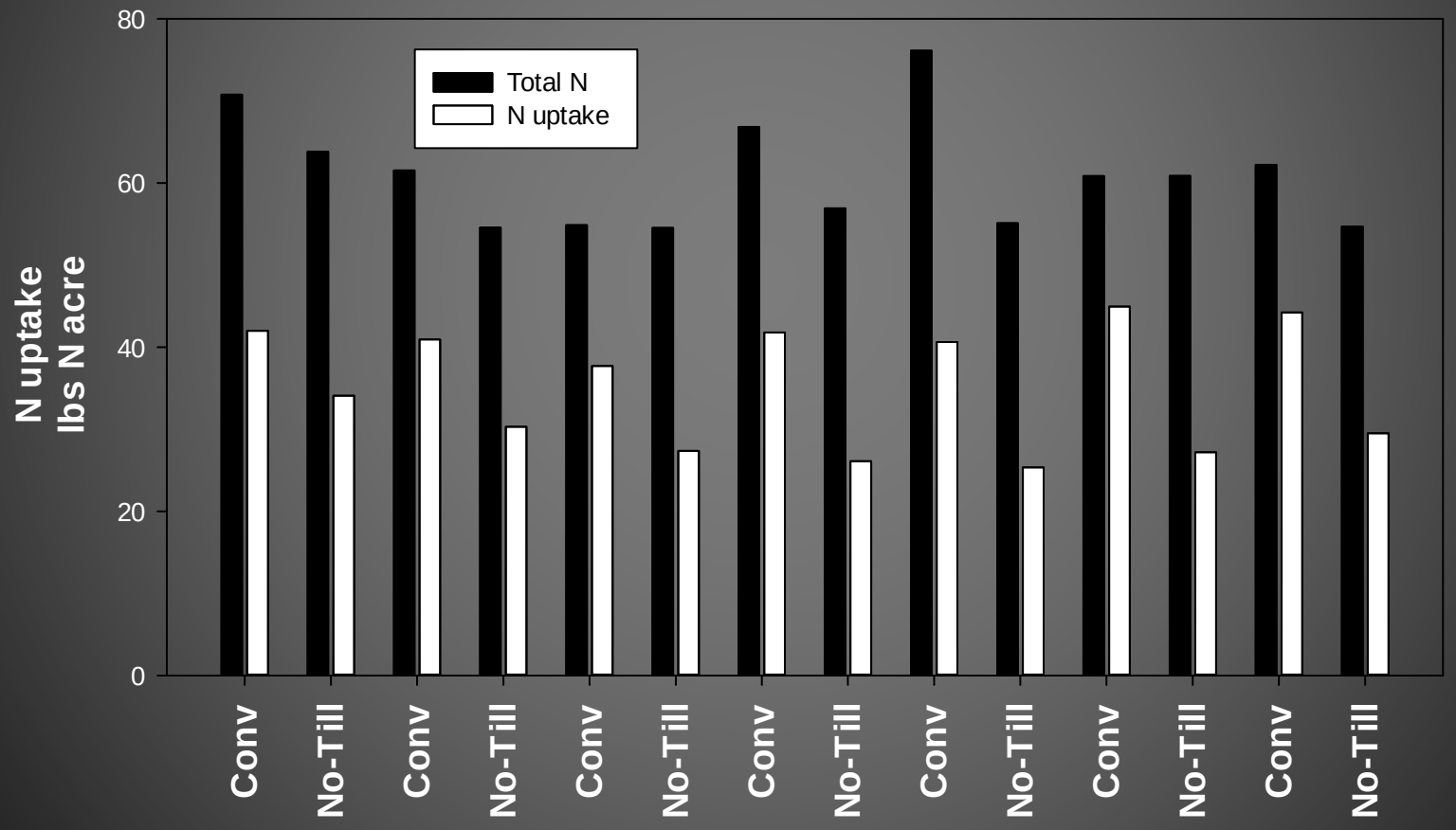
Mean of 7 reps, 6.3-3.7 acre each, total of 69 acres



Inorganic N vs. Organic N

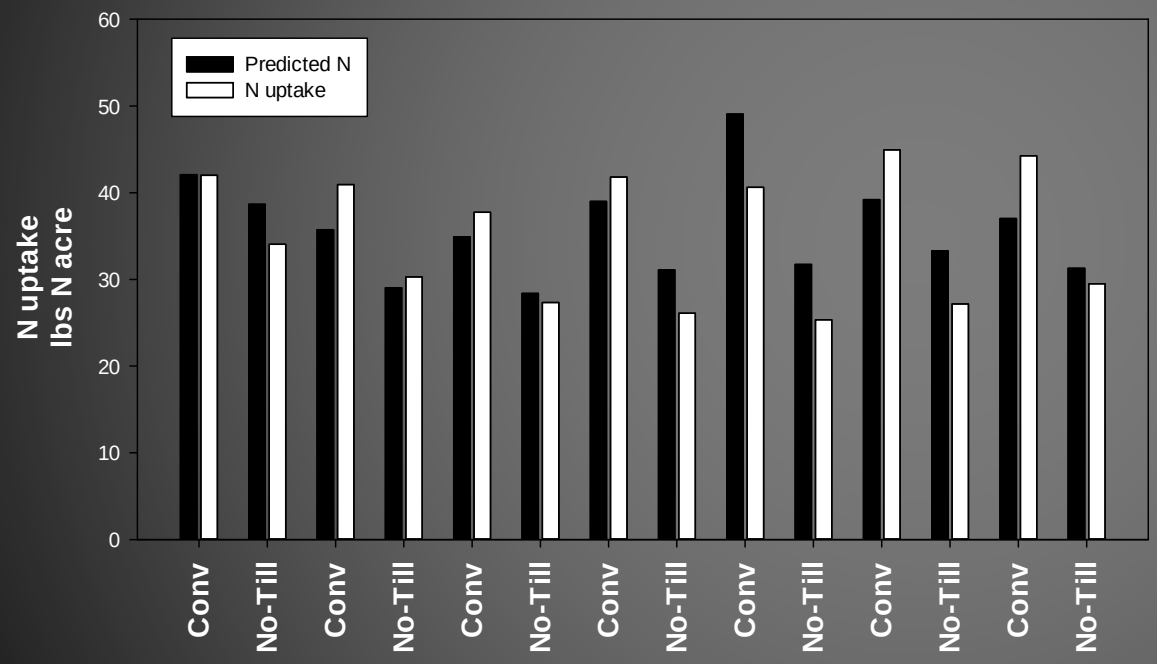


Total N vs. N uptake

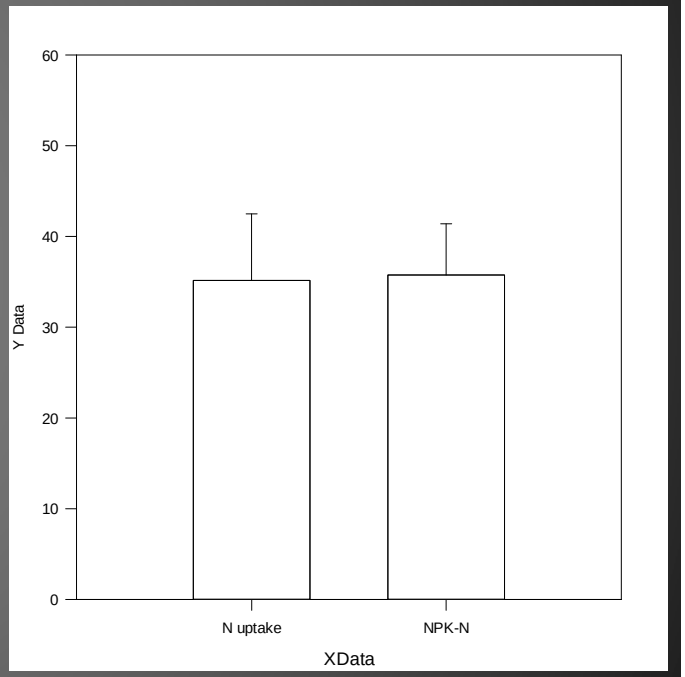


Soil test N vs. N uptake

Individual Fields



Average of Results



Cover Seed

Weigh wagon

Planting mixed species cover crops
40 lbs seed per acre

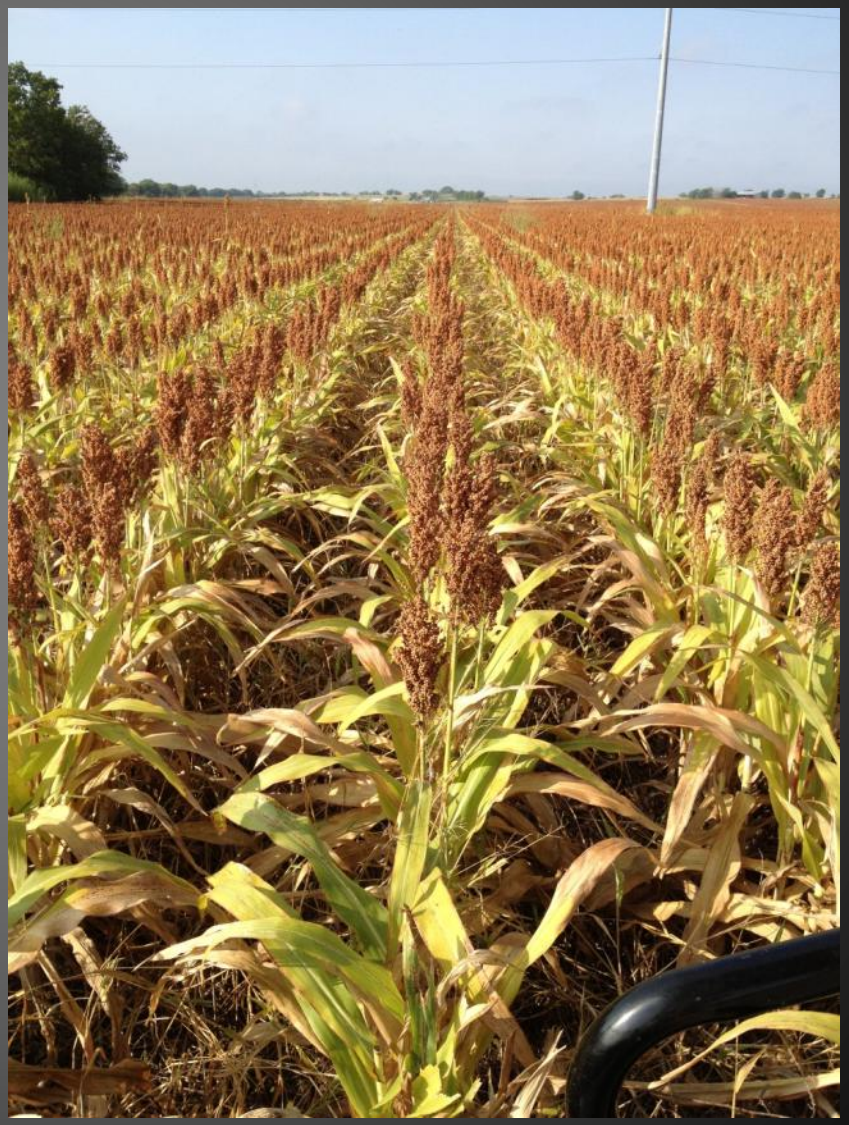
No-Till Equipment

Tillage Tools

Without Cover Crop

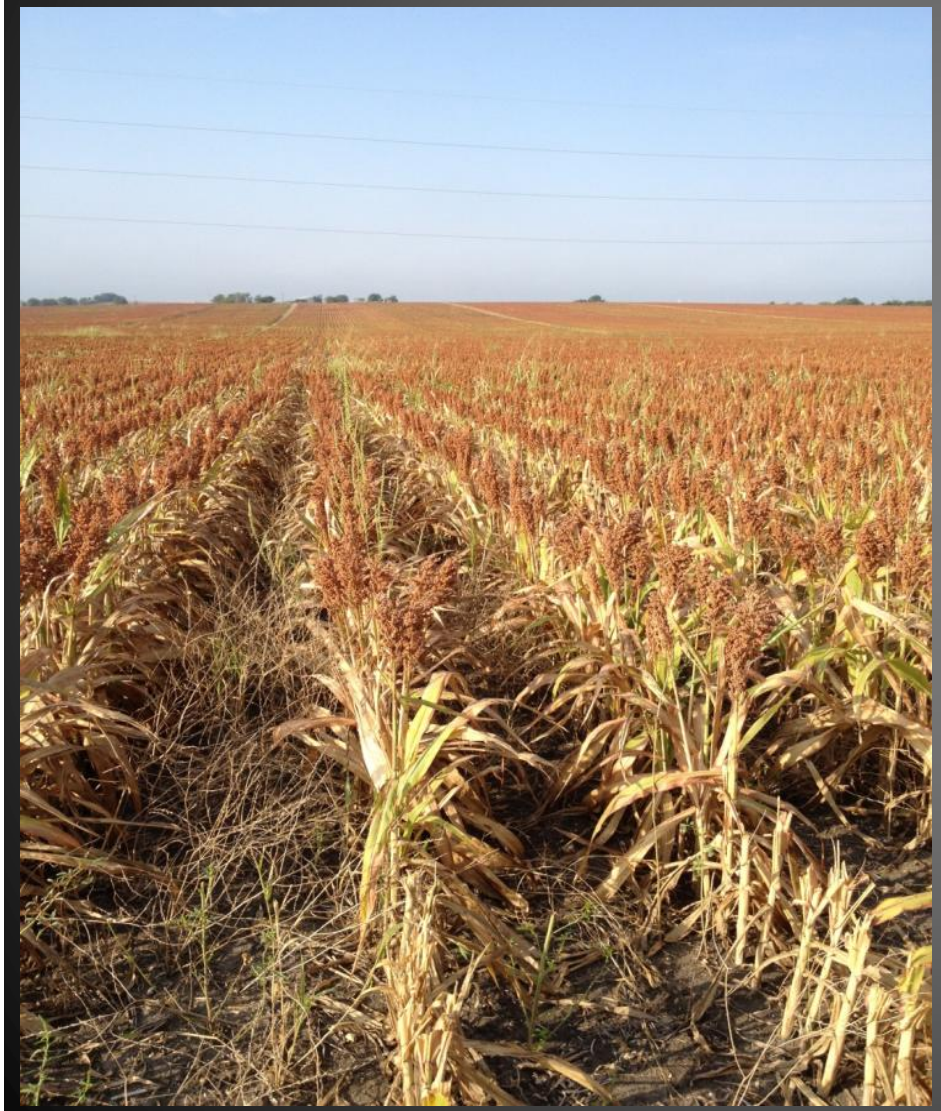
Conventional - till

No-till

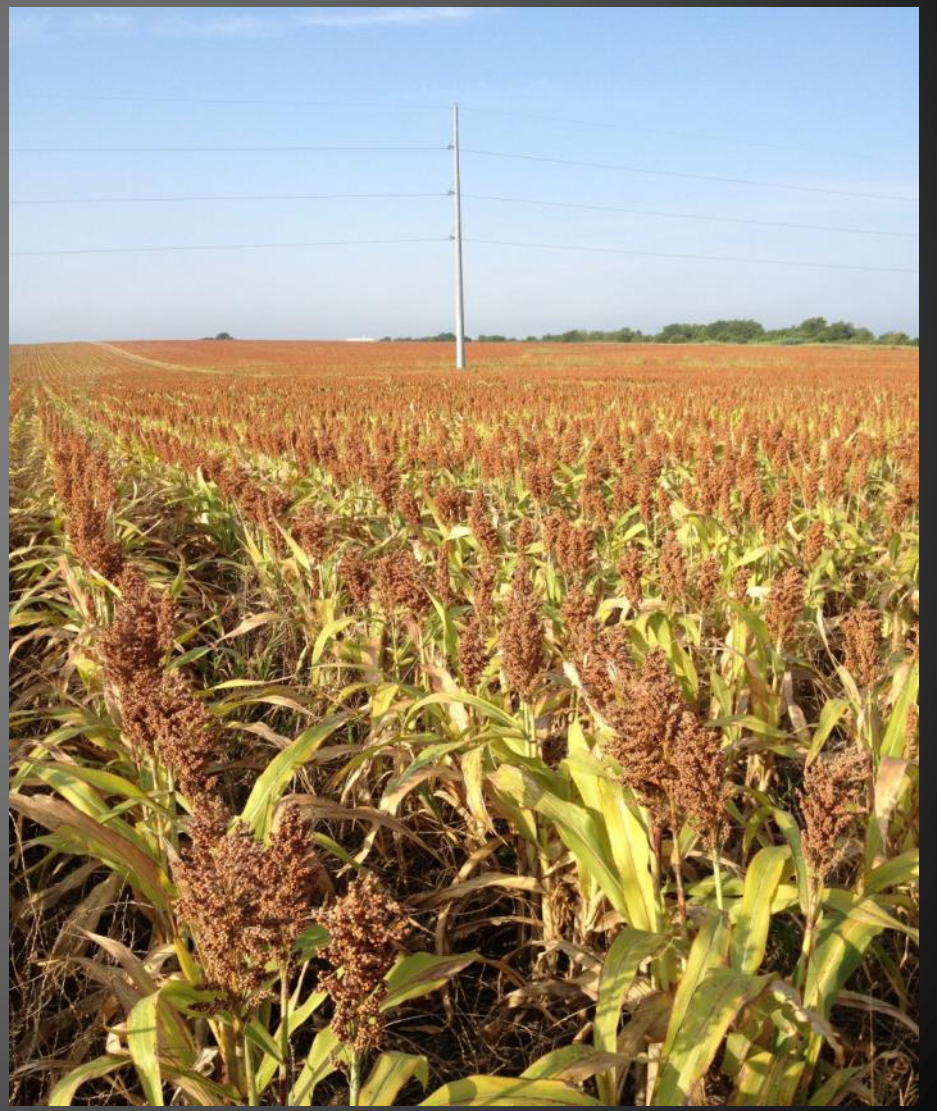


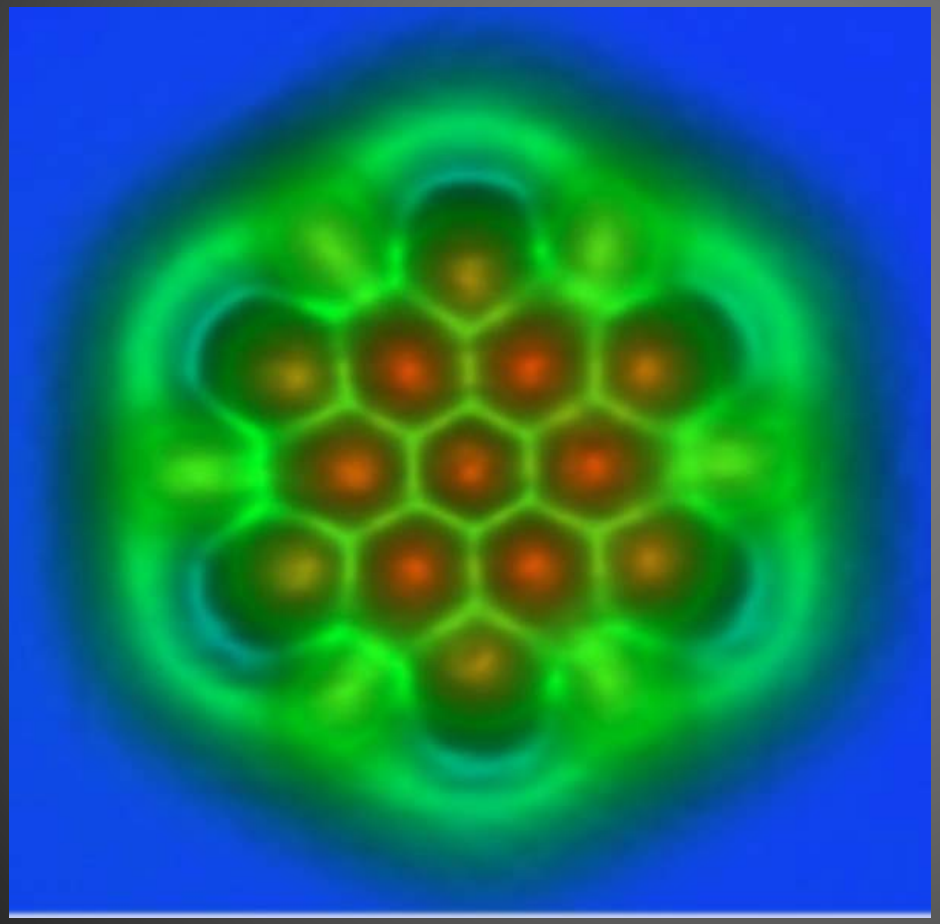
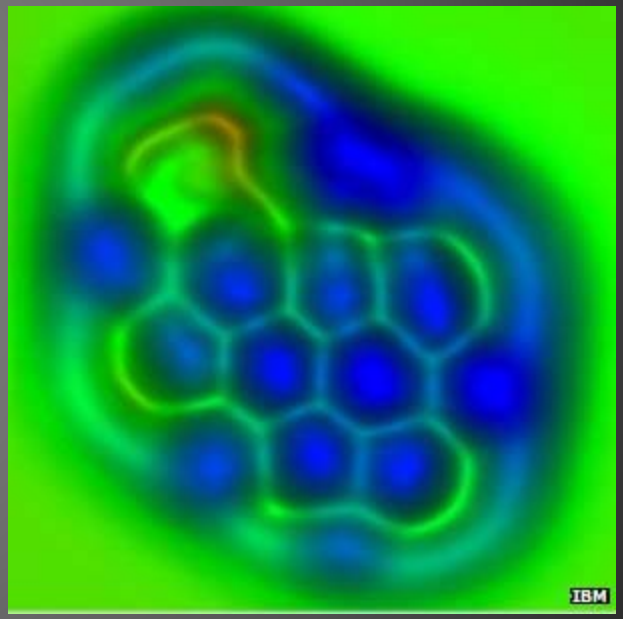
With Cover Crop

Conventional - till



No-till



Perspective of Scale
13 billion light years to <1 micron

Atomic Force Microscopy image of a nanographene molecule, the resolution is so high that for the first time, we can see the individual bonds between atoms, shown here as green lines.