USDA-ARS Temple Texas 2012

Soil Testing

Traditional NPK

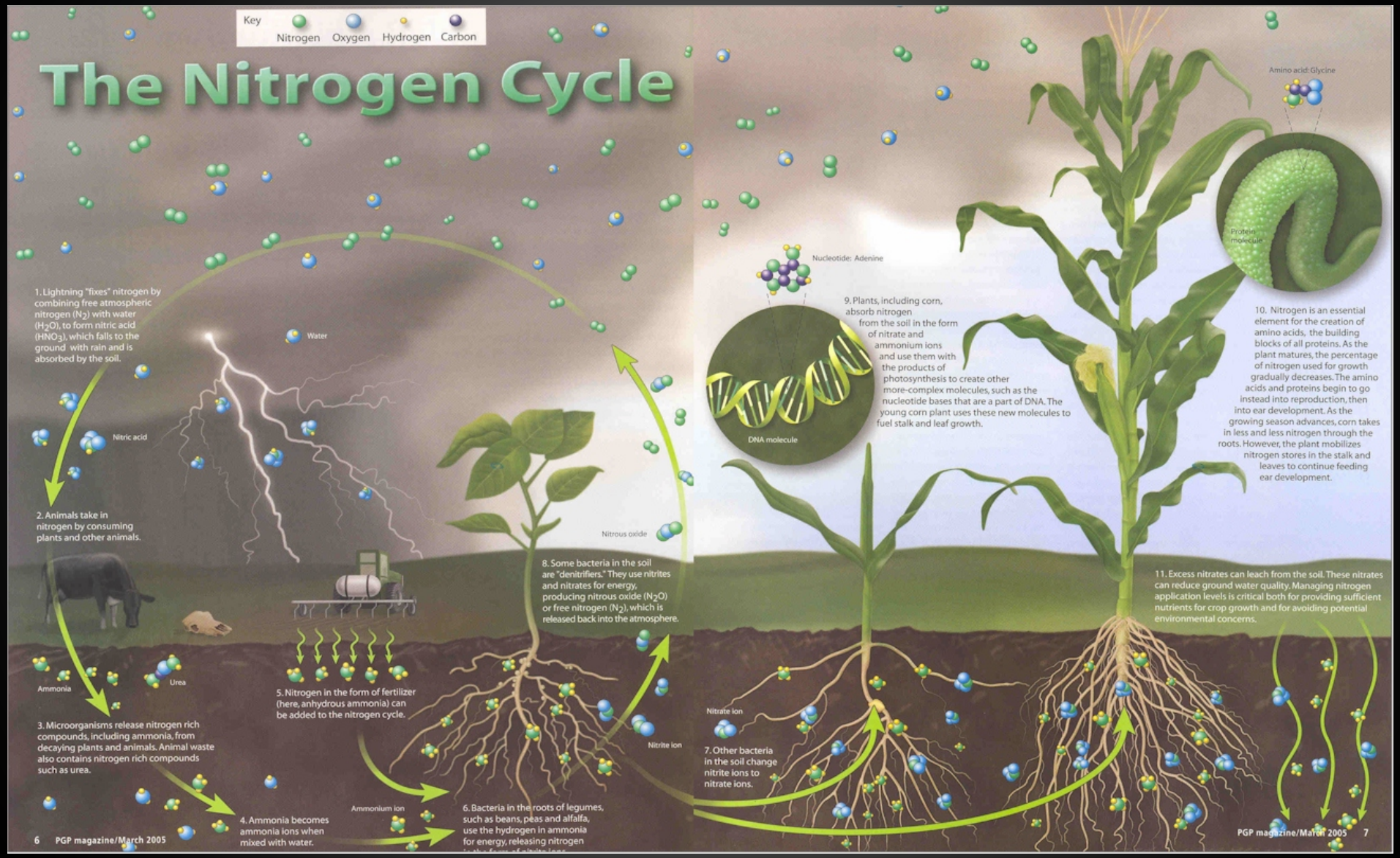
- Soil is not simply a chemical system
- Soil chemistry is much easier to measure than soil biology
- Due to a lack of technology and innovation we have largely ignored soil biology
- We now have both the technology and innovation we need to improve soil testing

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

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)


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
Protein molecule
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.

Nitrogen

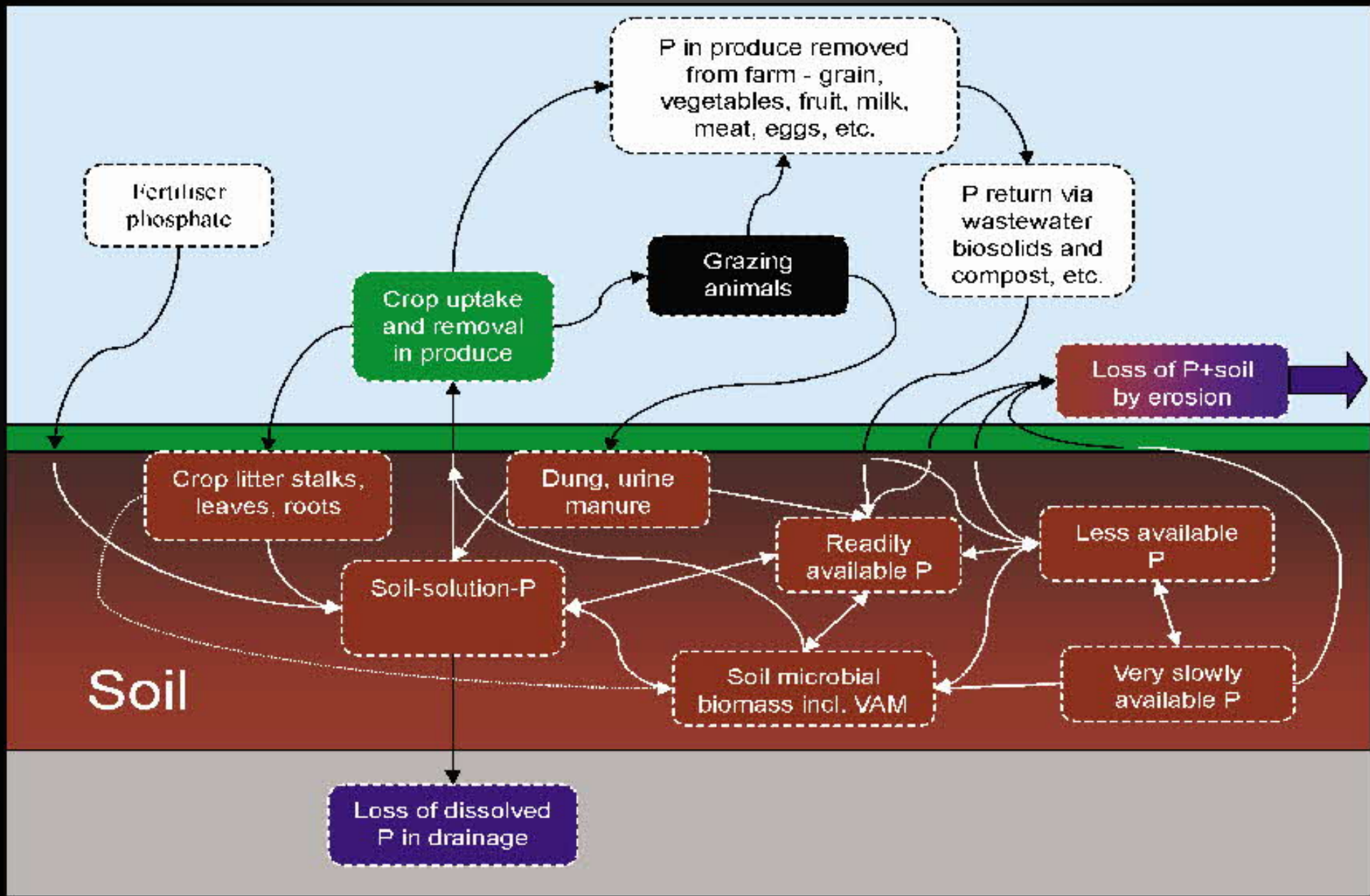
- **Current labs**

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

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**

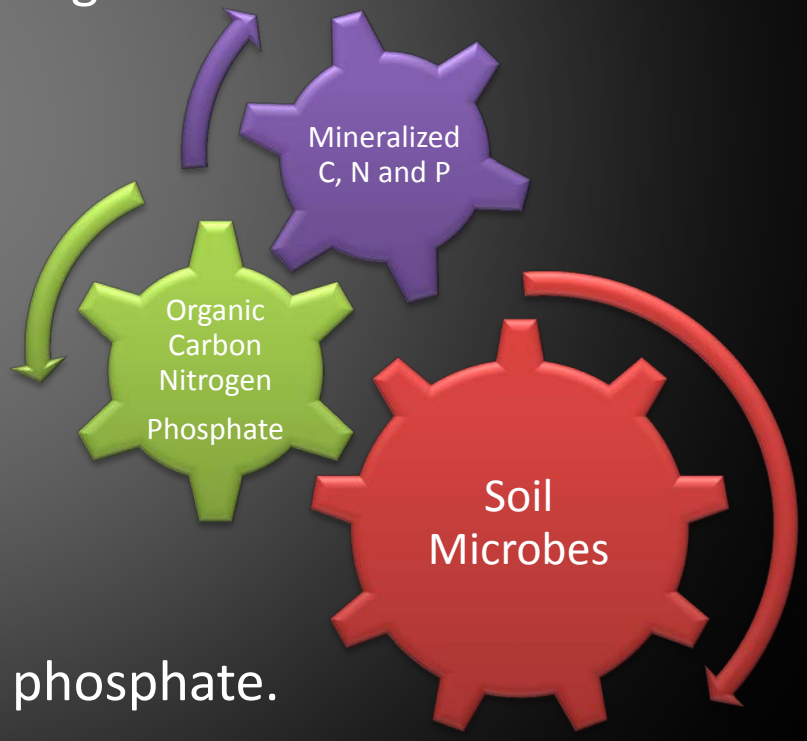
1. Solvita (microbial respiration/activity)
2. Water soluble Organic C (microbial food)
3. Water soluble Organic N
4. Org C:N
5. Soil health score
6. Cover crop suggestion

Soil Health Methods

The SHT relies on information gleaned from newly developed soil-testing methods geared towards soil microbial activity and the readily available substrate that they act upon. In other words, we assess the soil as a doctor might assess a living being, using many measurements of health viewed collectively to attain an overall picture of soil vigor.

The measurements include:

- water extractable organic C (WEOC)
- water extractable nitrogen (WEN)
- water extractable organic N (WEON)
- C: N ratio of the two
- 1-day CO_2-C microbial activity test
- inorganic N and P and K
- H3A extractable aluminum, iron, and phosphate.

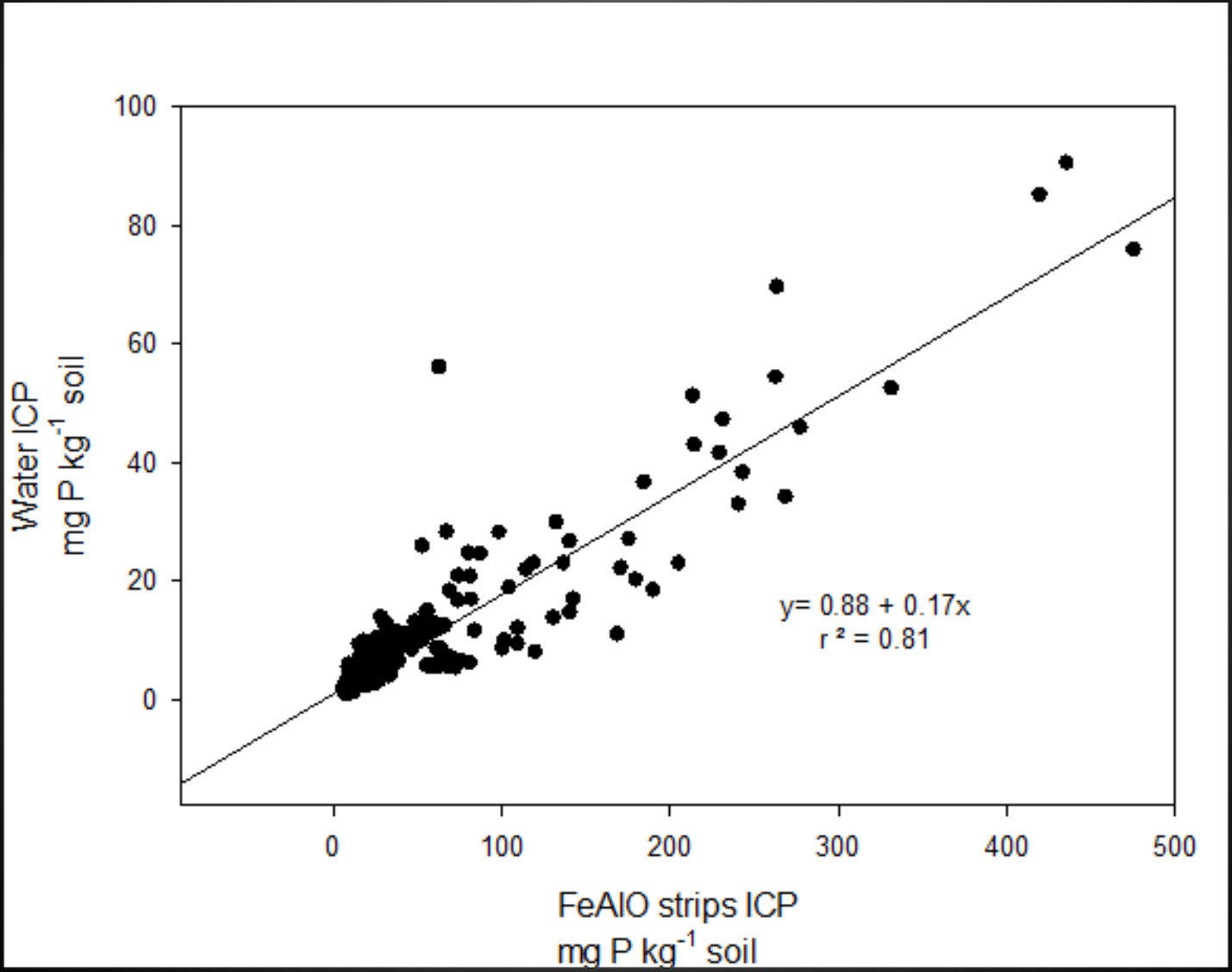


Soil Extraction H3A and Water

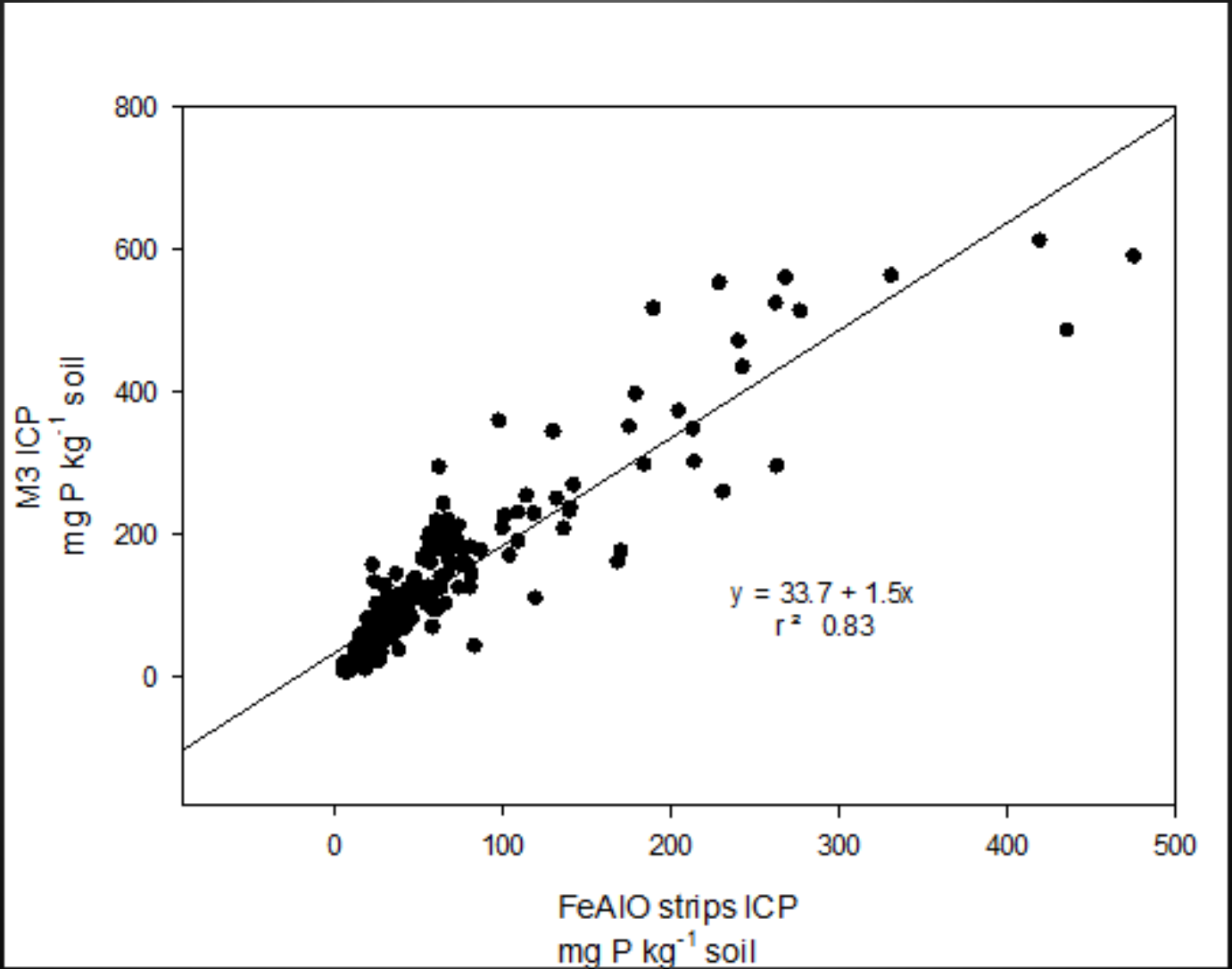
What does the plant root really see?

- **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"**

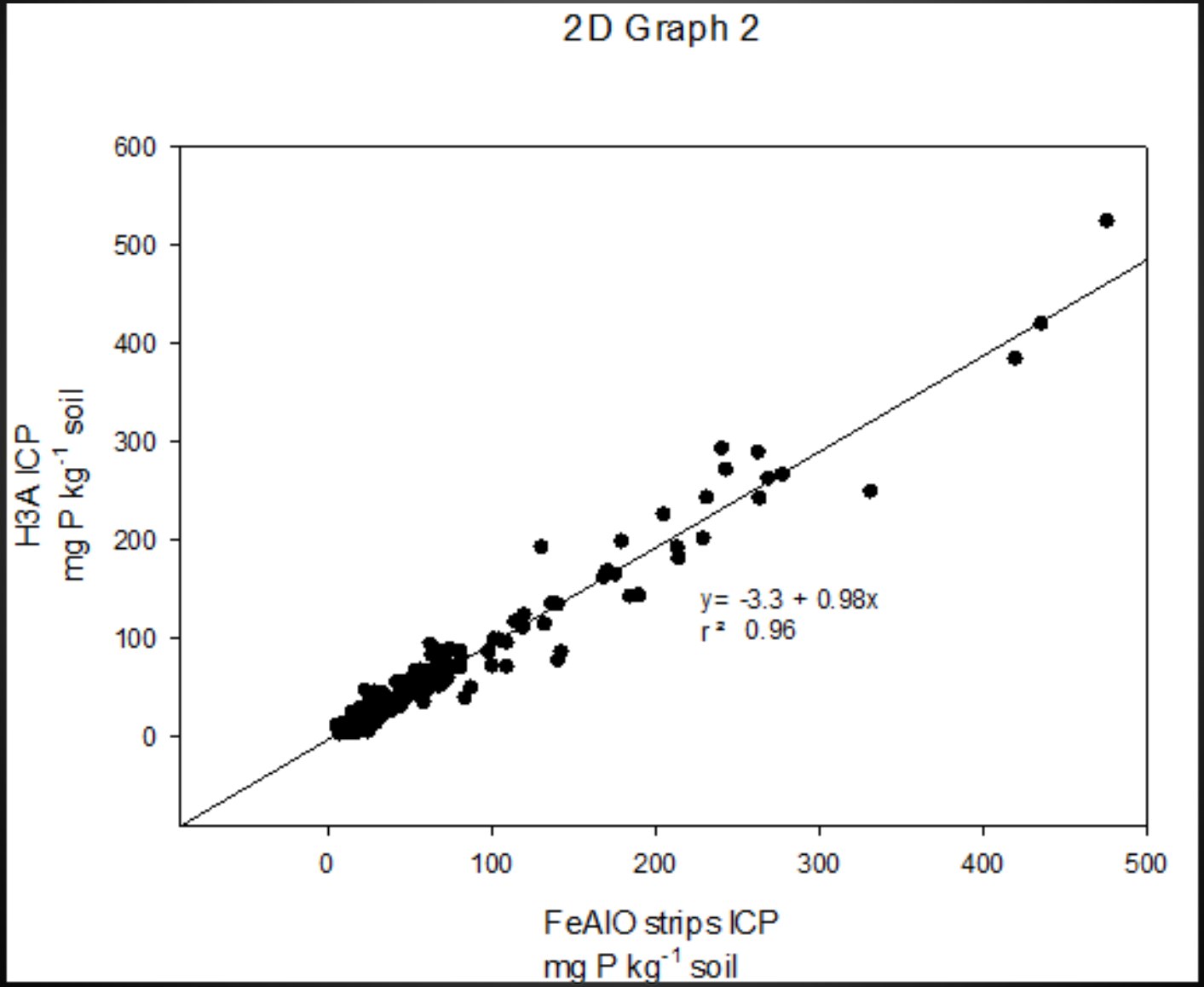
Water extract



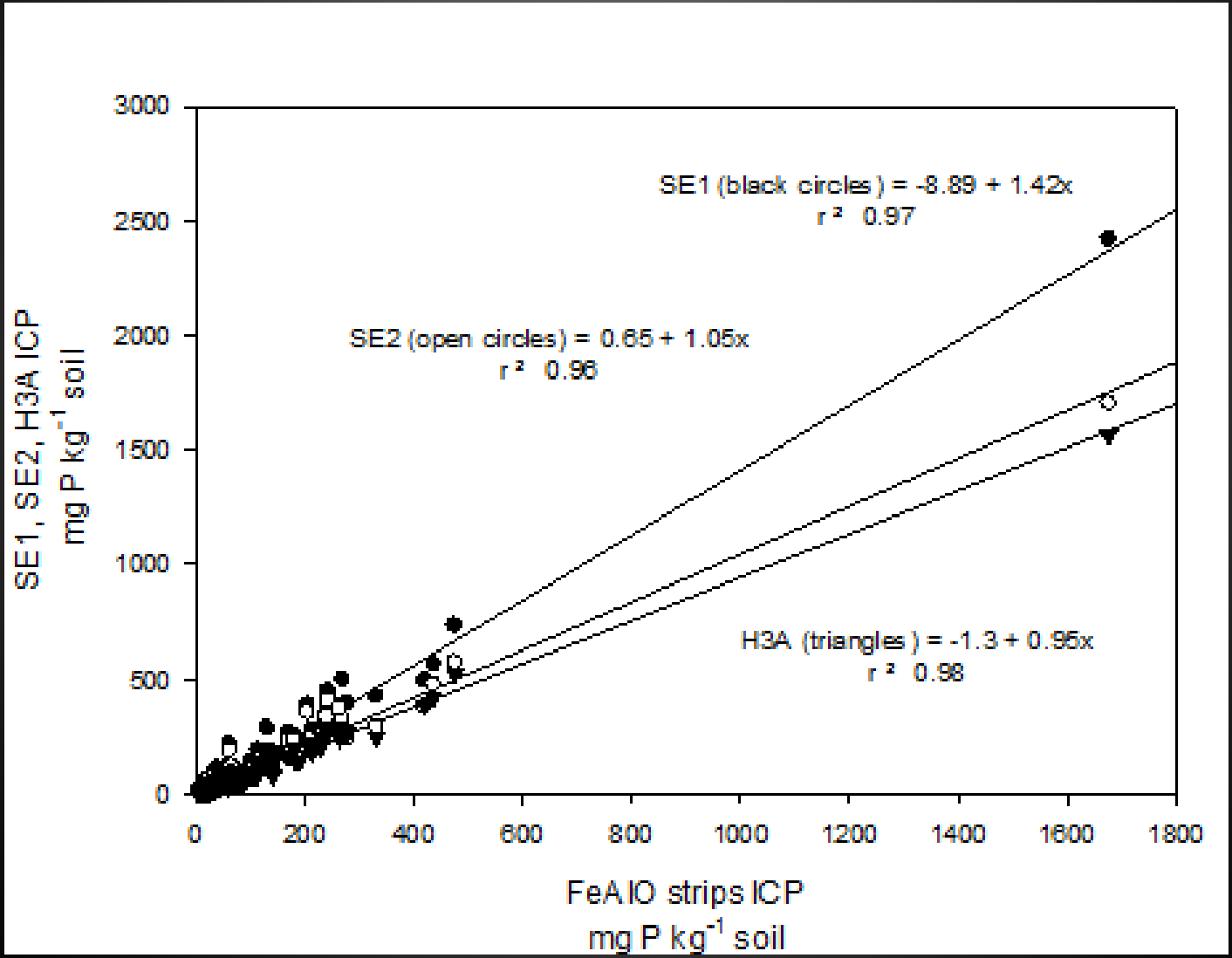
Mehlich 3


800
600
400
200
0
M3 ICP
mg P kg-1 soil
y = 33.7 + 1.5x
r² 0.83
0
100
200
300
400
500
FeAlO strips ICP
mg P kg-1 soil

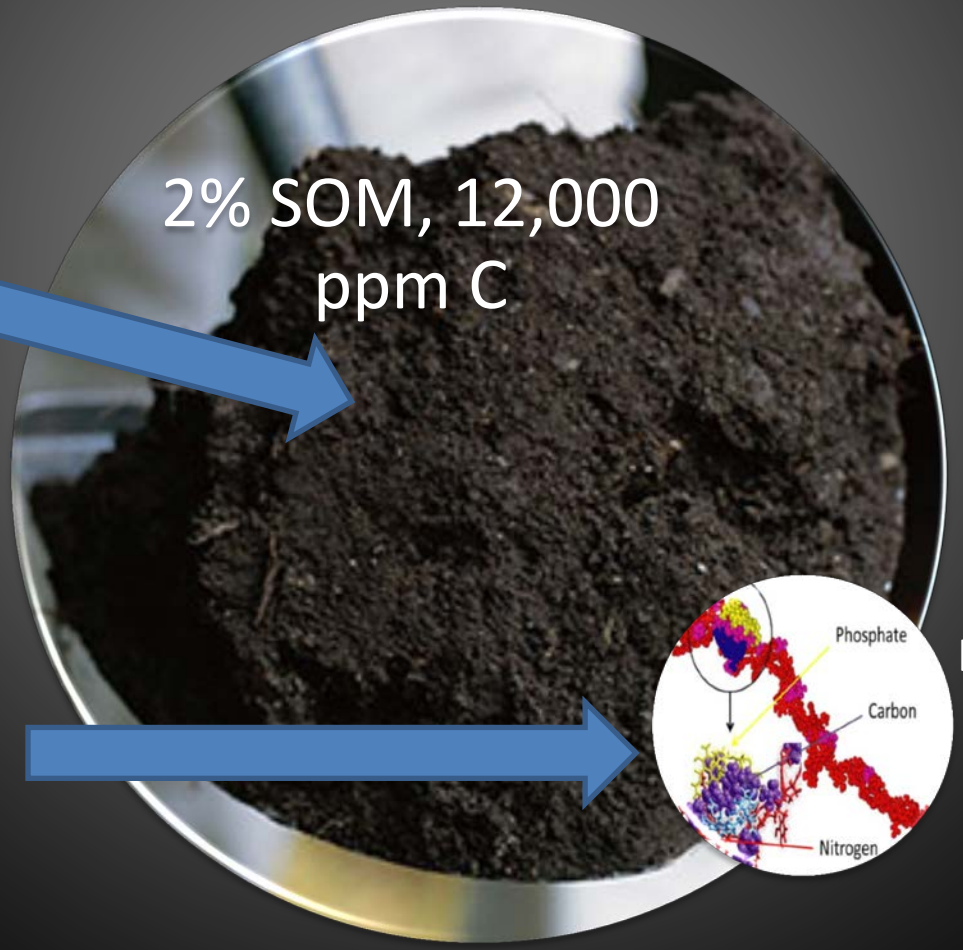
H3A


2D Graph 2
600
500
400
300
200
100
0
H3A ICP
mg P kg-1 soil
y= -3.3 + 0.98x
r² 0.96
0
100
200
300
400
500
FeAlO strips ICP
mg P kg-1 soil

H3A soil extractant



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



% ORGANIC MATTER IN SOIL

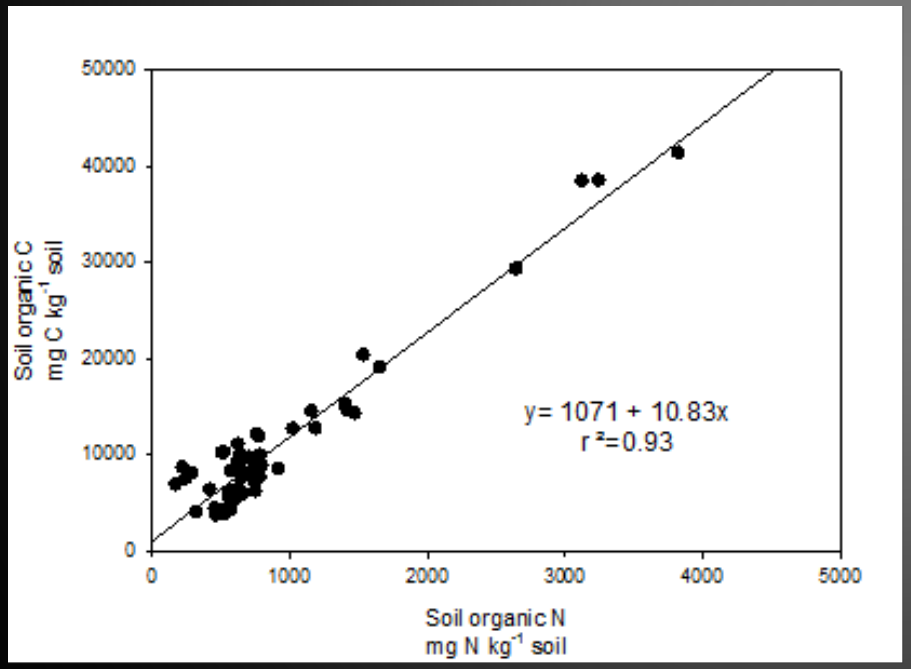
3.5% OM = 20,000 ppm C

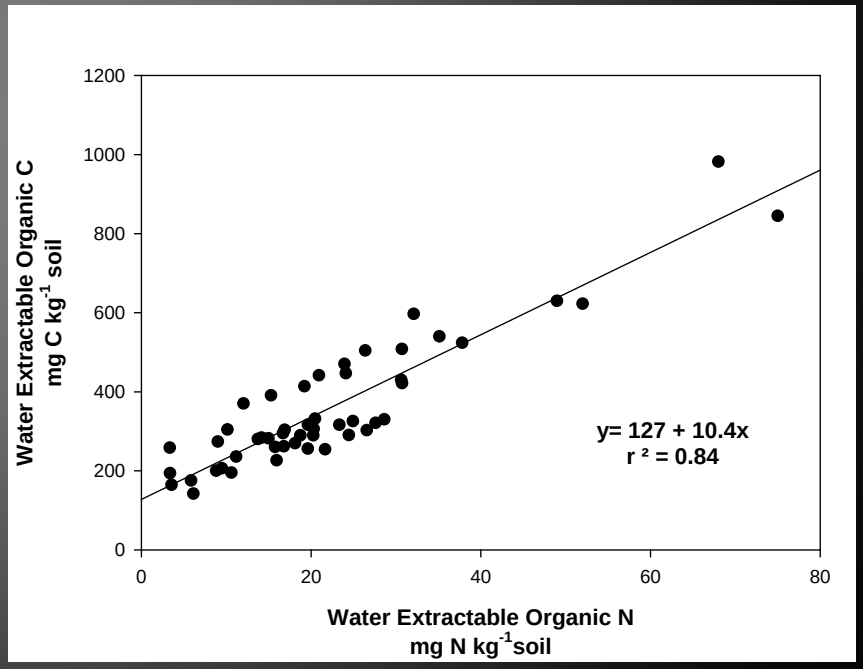
PPM CARBON IN WATER

WEOC range 60-1000 ppm C

Soil Organic C vs. Water Extractable Organic C

A soil with 2 % soil organic matter (SOM) would have 12,000 ppm C. When we analyze the water extract from the same soil, that number could be from 100-300 ppm C. The organic C in the soil water extract reflects the carbon in your soil that is highly related to the microbial activity. % SOM is about the quantity of organic C, water extractable organic C is about quality.



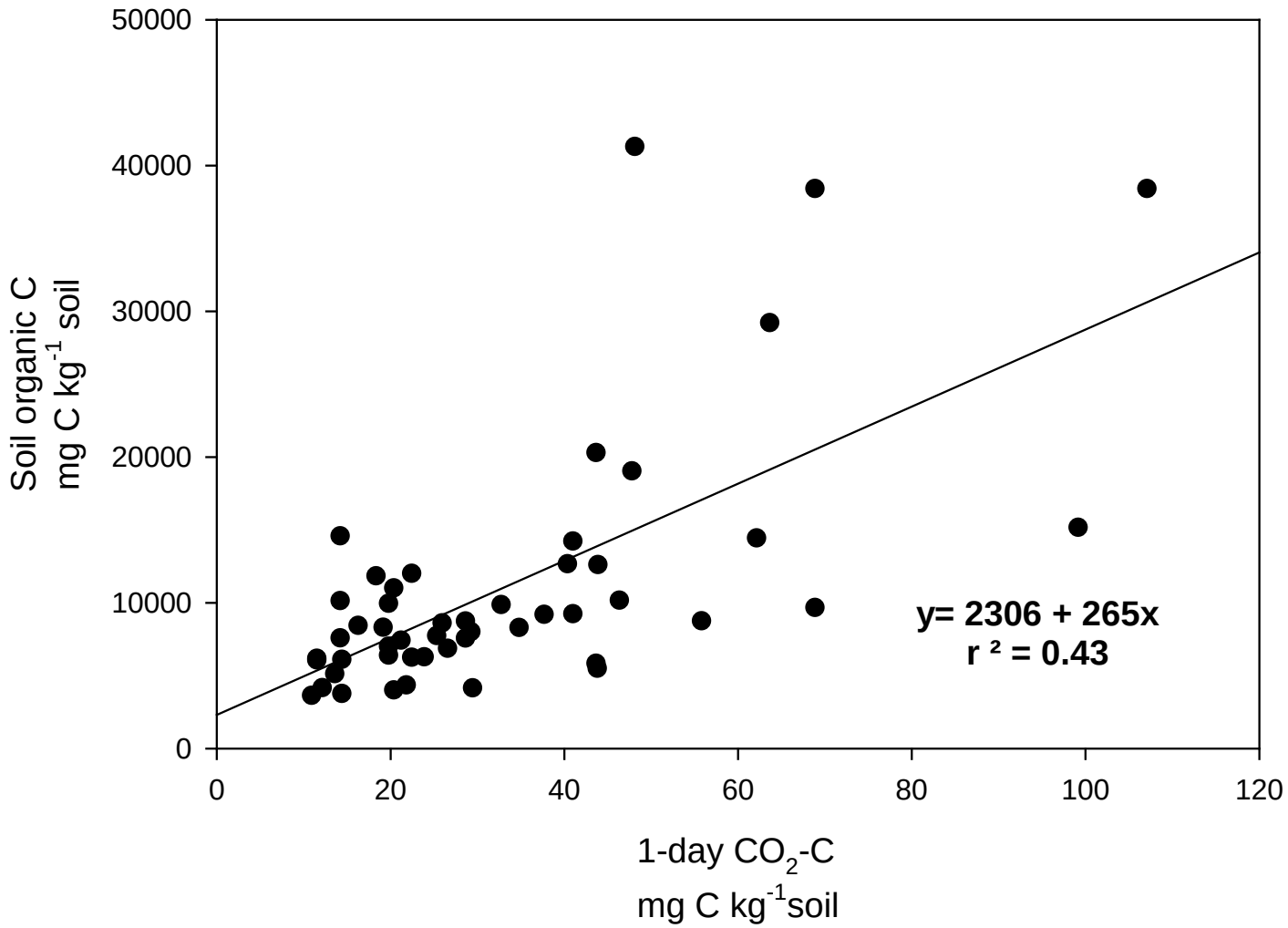


ON AVERAGE, 4% OF THE SOIL ORGANIC C IS IN THE WATER EXTRACT,
AND 2.9% OF THE SOIL ORGANIC N IS IN THE WATER EXTRACT

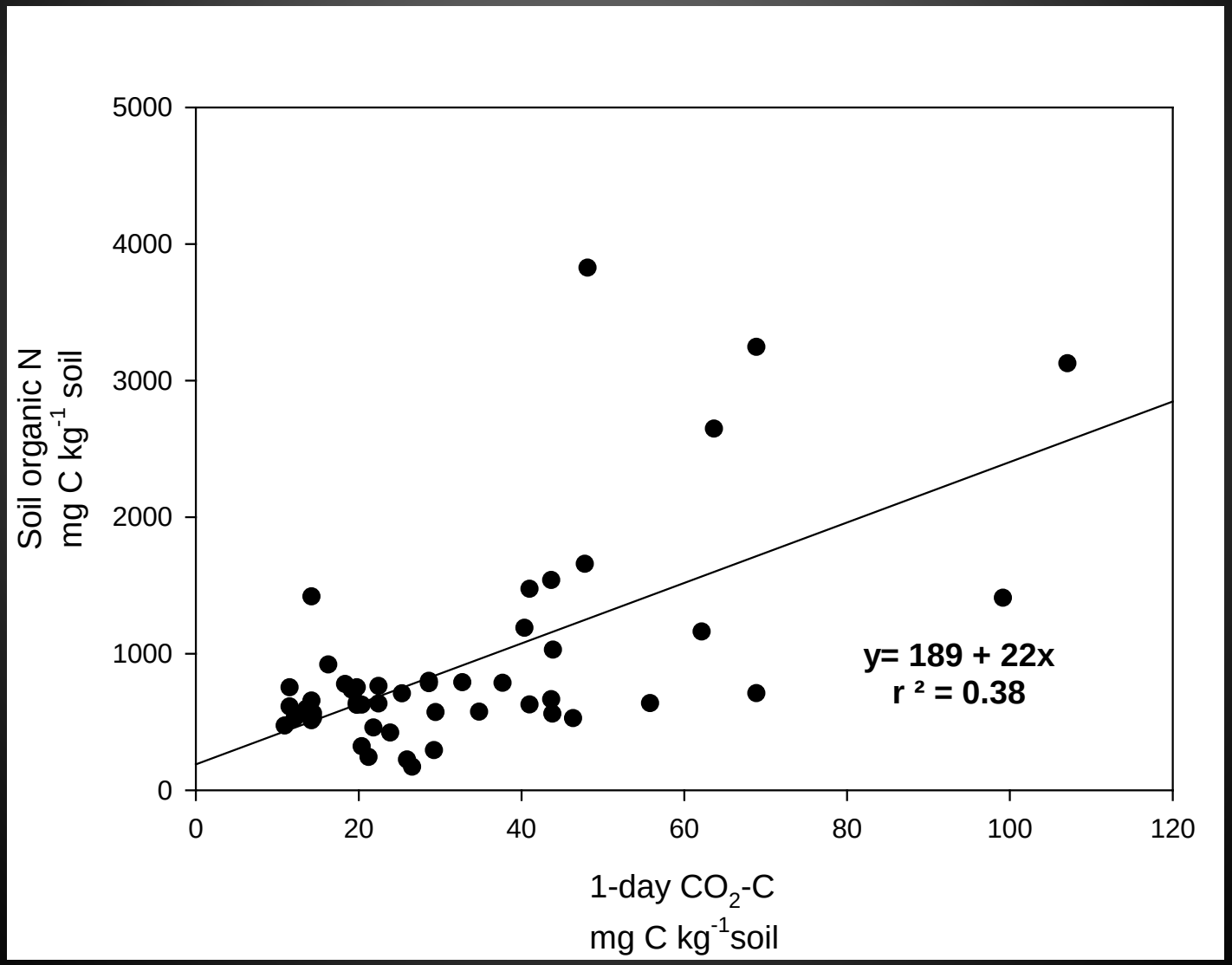
OF THE CARBON, ONLY 8% IS BEING MINERALIZED BY THE SOIL MICROBES IN 24 HRS. WHICH IS 0.34% OF THE SOC

SO LESS THAN 1% OF THE TOTAL SOIL ORGANIC C IS IN PLAY BY THE SOIL MICROBES UNDER OPTIMUM CONDITIONS

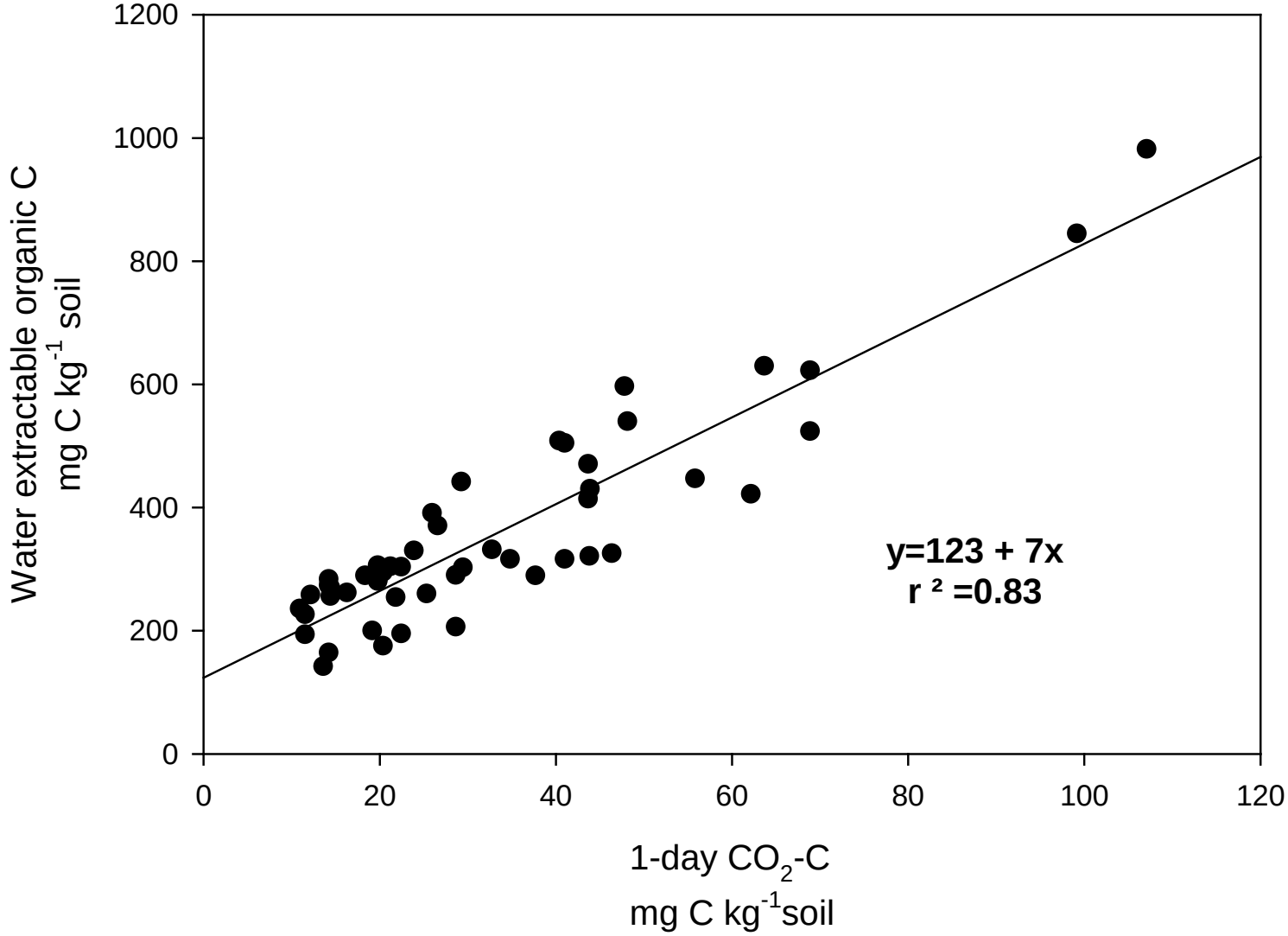
Microbial activity vs. SOC



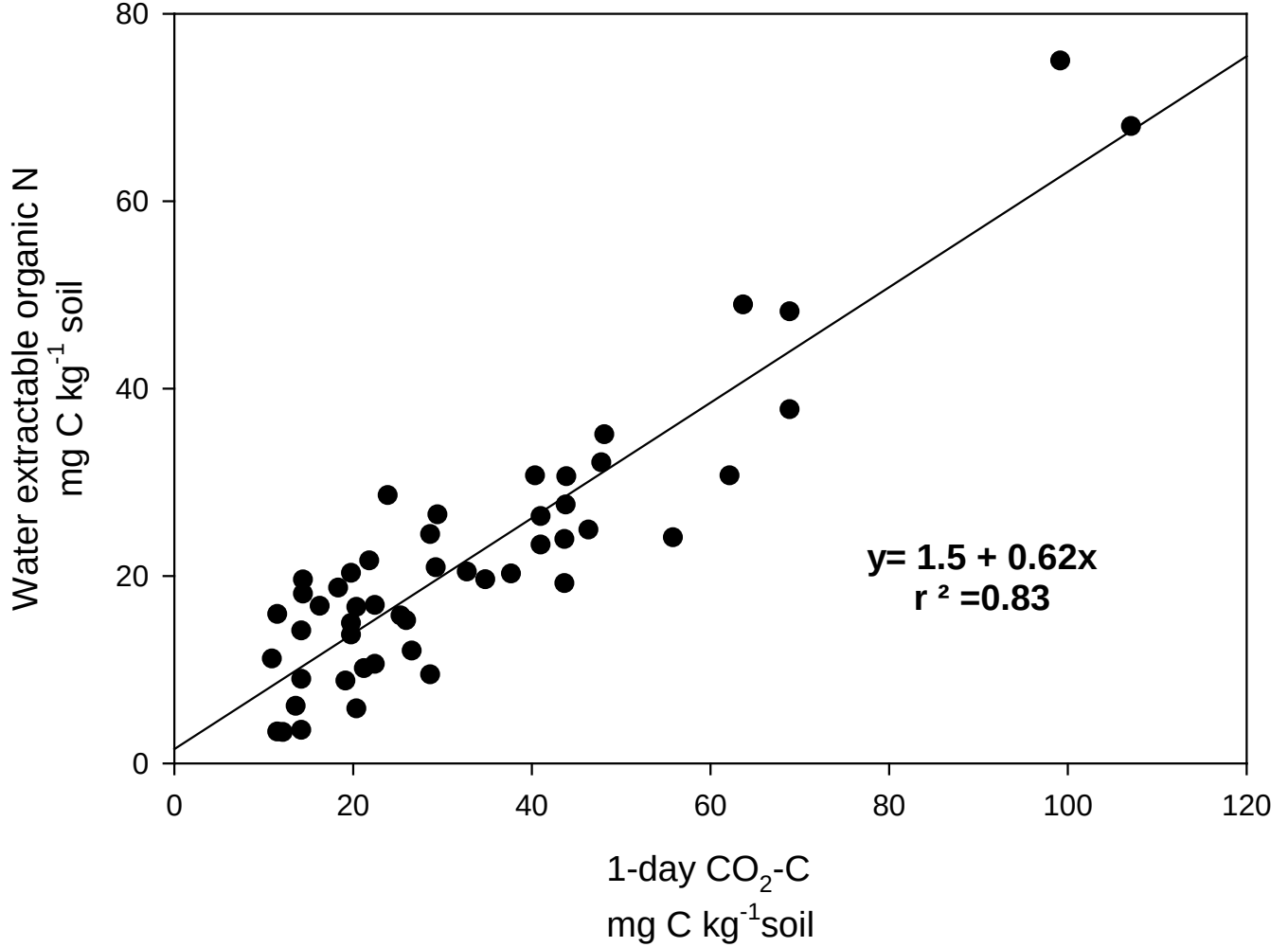
Microbial activity vs. SON



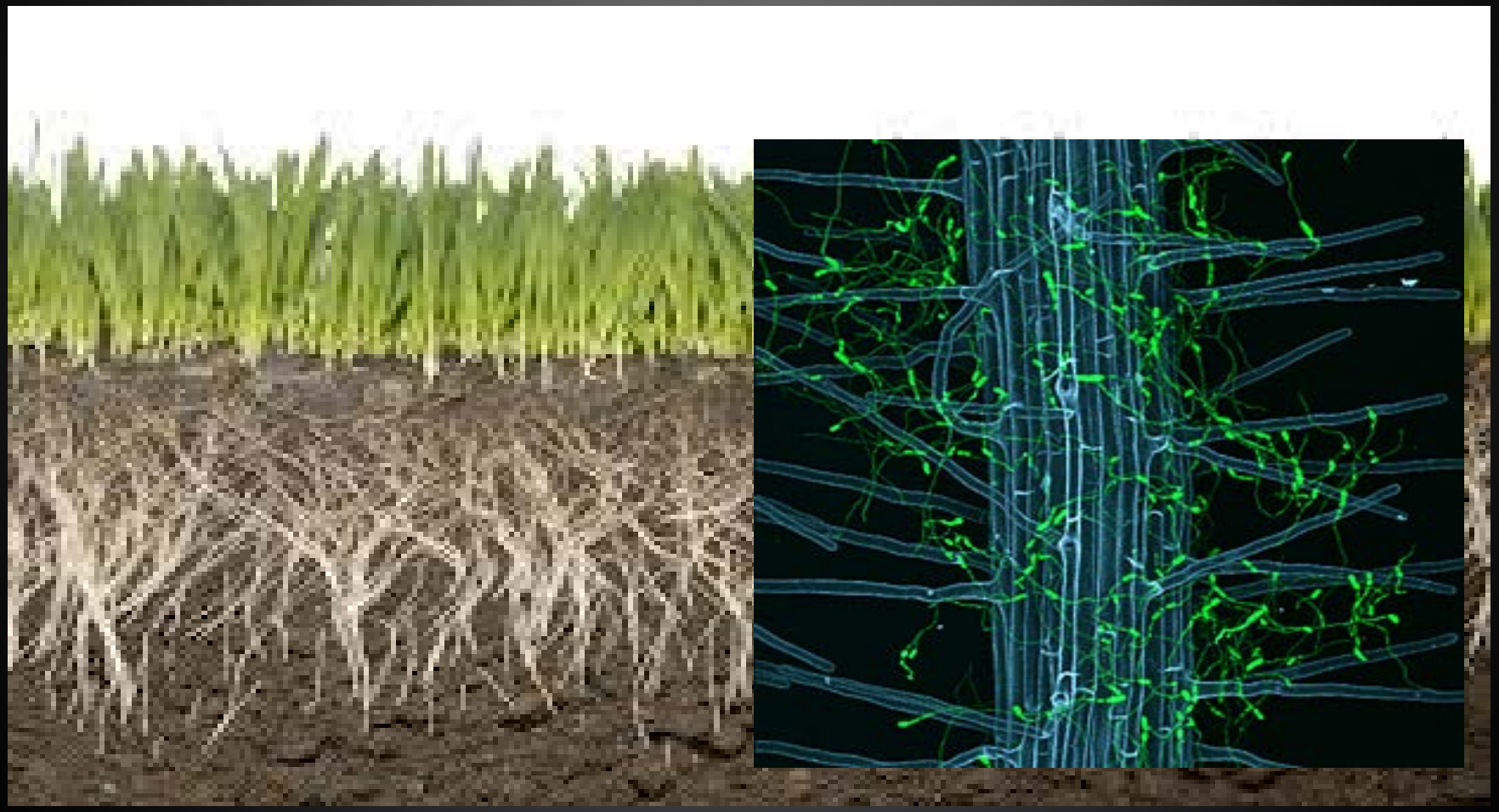
Microbial activity vs. WEOC



Microbial activity vs. WEON



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



History

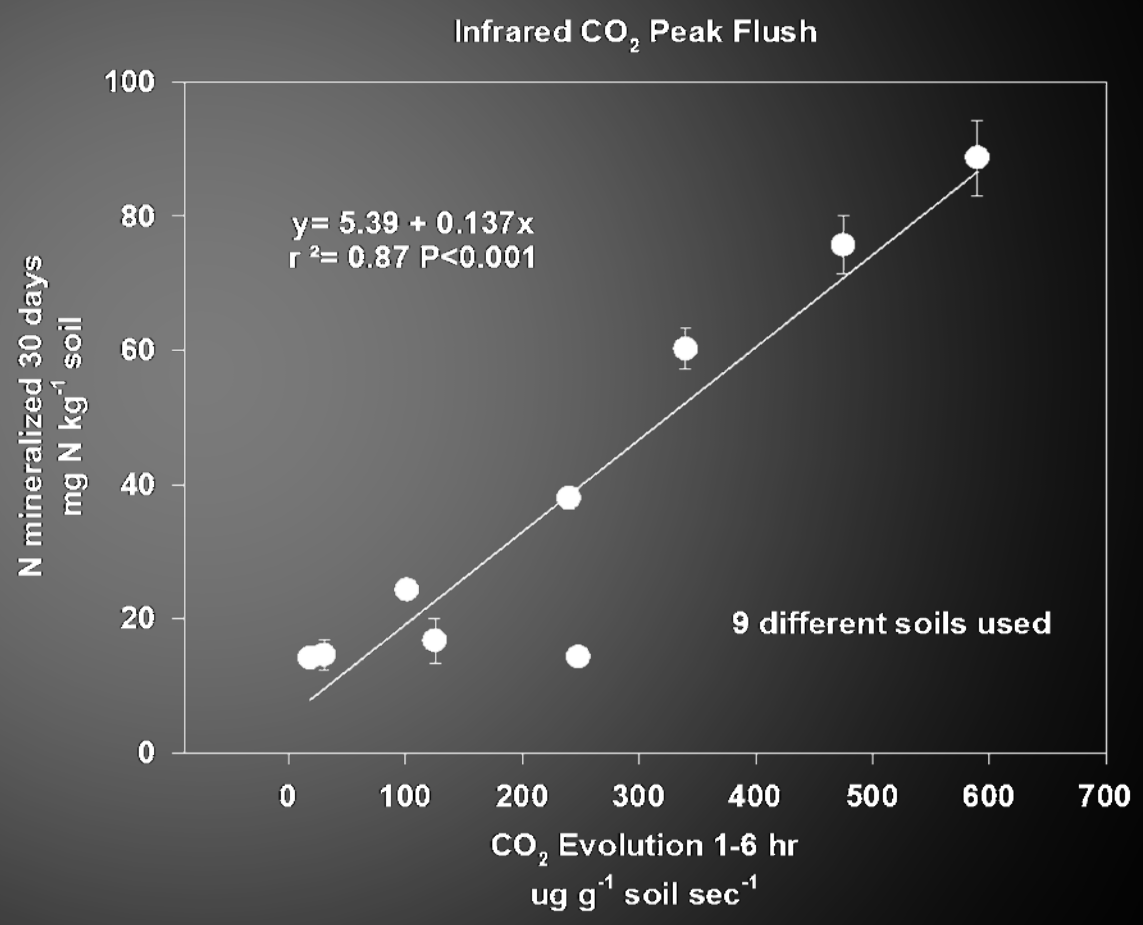
1896	1919	1924	1934	1935
Oxidation of Organic Compounds	Gainey stated that CO_2, NH_4^+ and NO_3^- formation are parallel processes and of a biological nature	Lebedjantzev noticed that soil, which had been dried and rewetted, was more fertile than field moist soil	Corbet stated that, "for purposes of 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"	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	1956	1958	1959	1960
Bodily showed that CO_2 evolution was closely correlated with fluctuations in the numbers of bacteria	Stevenson showed that the flush of C and N from rewetting dried soil was due to biological activity and not chemical action	Birch stated that spores are very resistant to drying and when rewetted, soil followed a uniform flush of CO_2	Birch: Successive drying and rewetting resulted in a flush of C and N which was repetitive and also occurred in the field.	Birch: Laboratory results underestimate field conditions

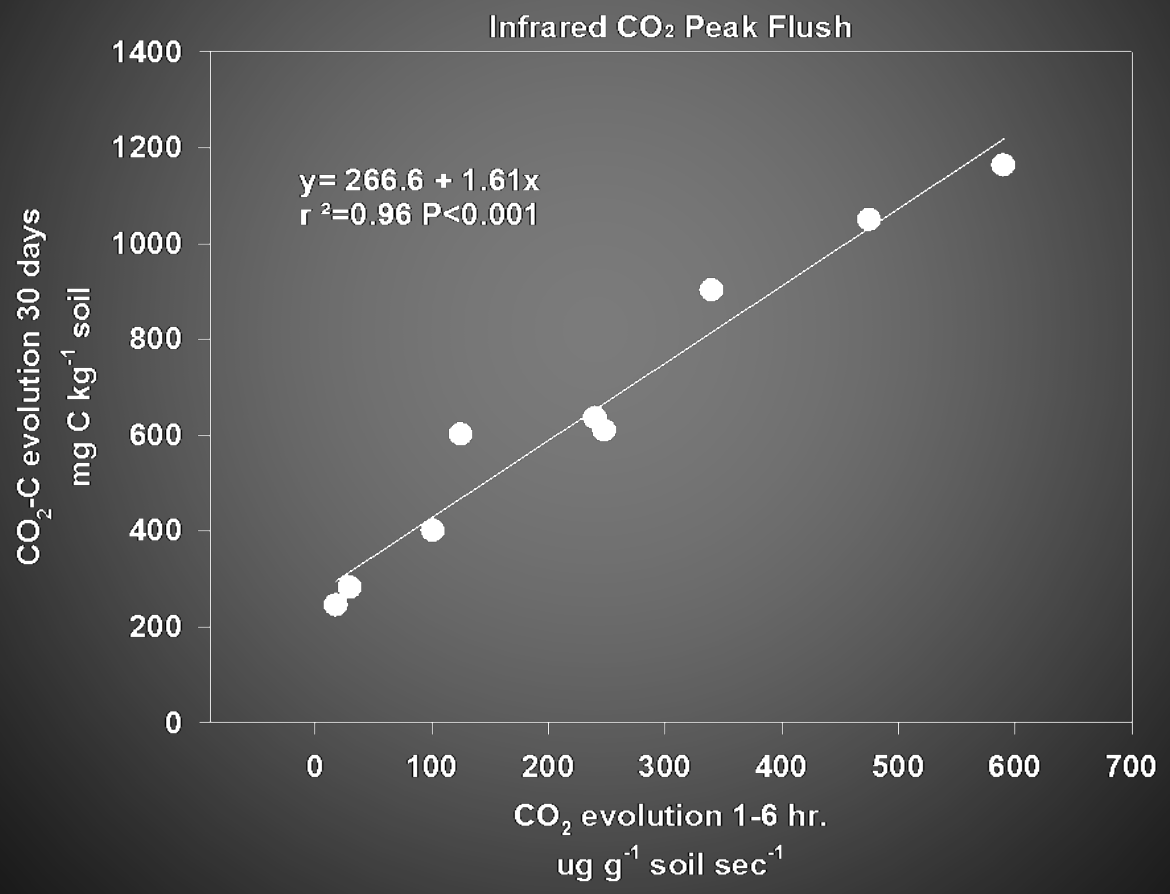
1970 and beyond: Change focus from CO_2 evolution to soil microbial biomass C (SMBC)

Research History 1995

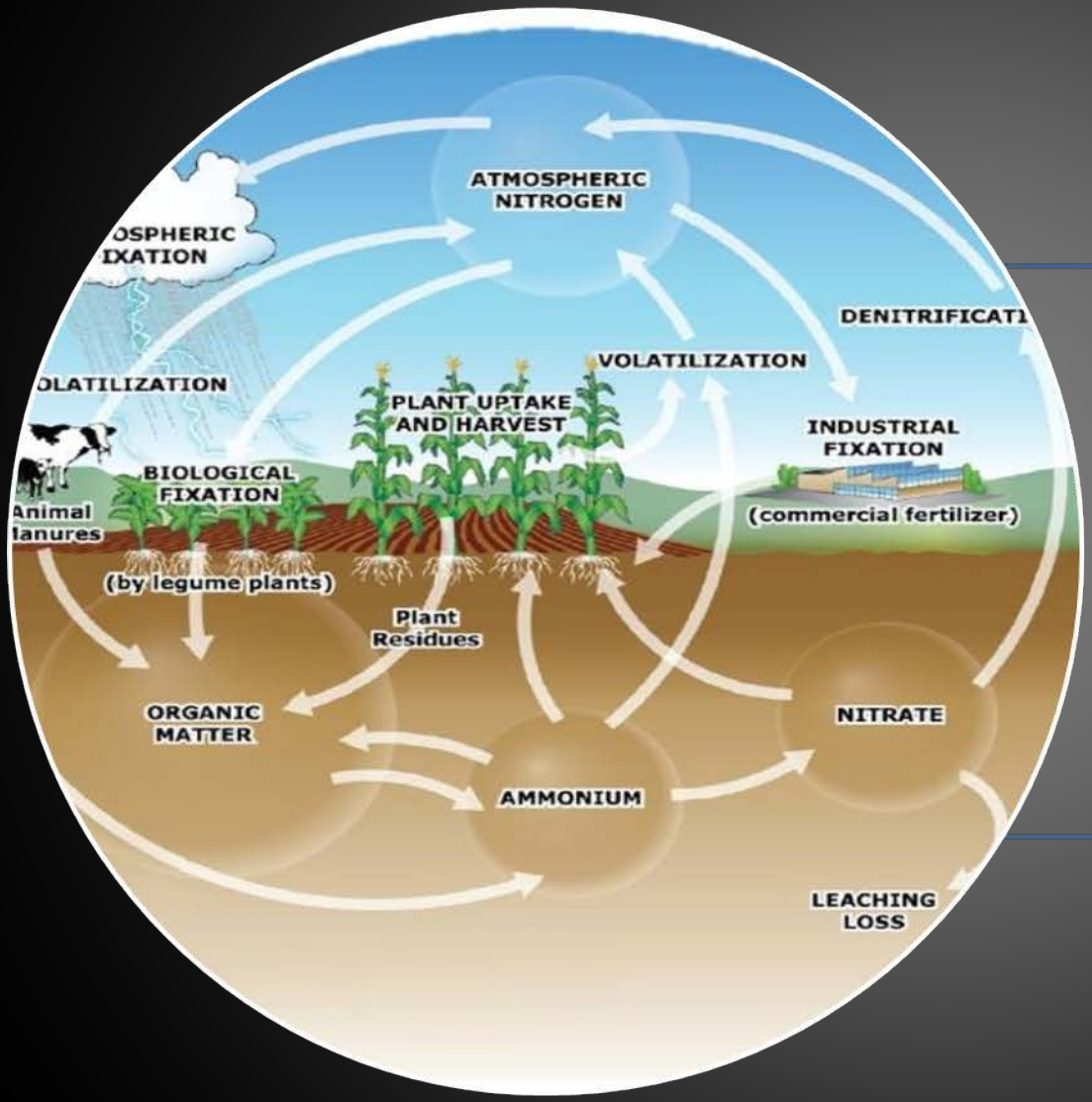
- 1995: Haney's first attempt at publishing using a technique involving drying and rewetting soil and recording the flush of CO_2 in 1 day to estimate N mineralization is rejected (finally published in 2000).
- It's deemed "too simplistic" by reviewers in spite of the data presented.
- Haney becomes emotionally disturbed.

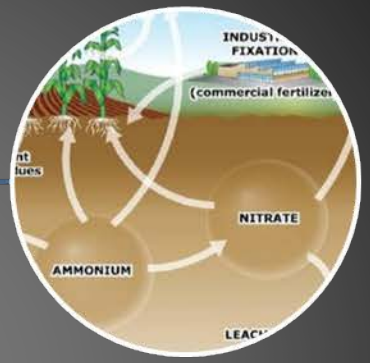


CO_2 vs. 30 day CO_2

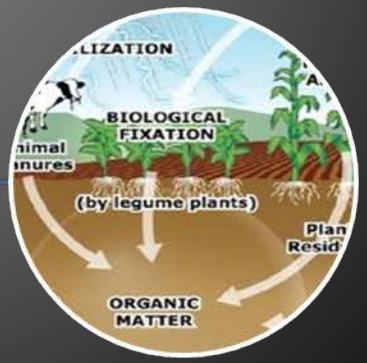


Soil Nitrogen





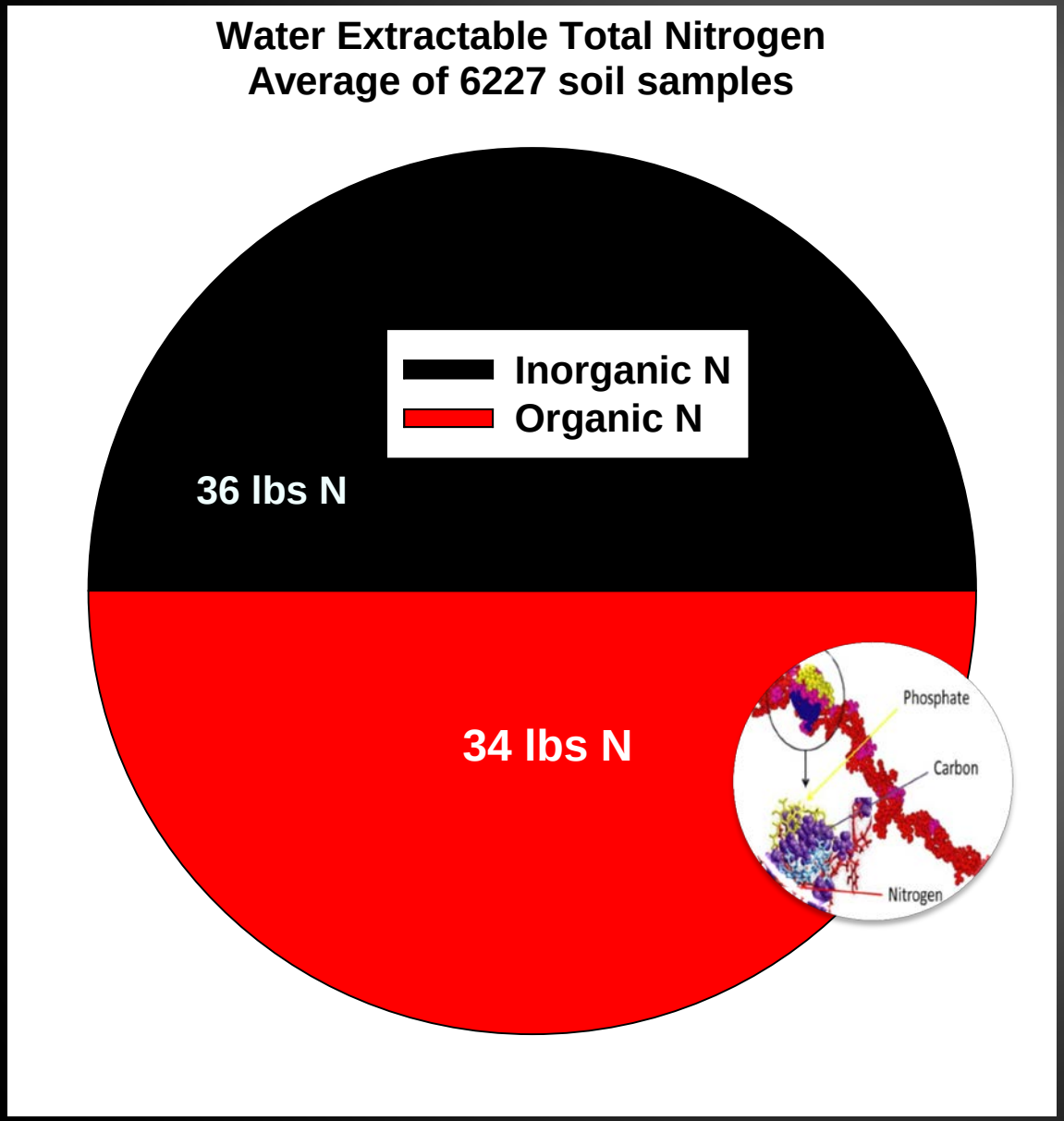
Water extractable Inorganic N



Water extractable Organic N

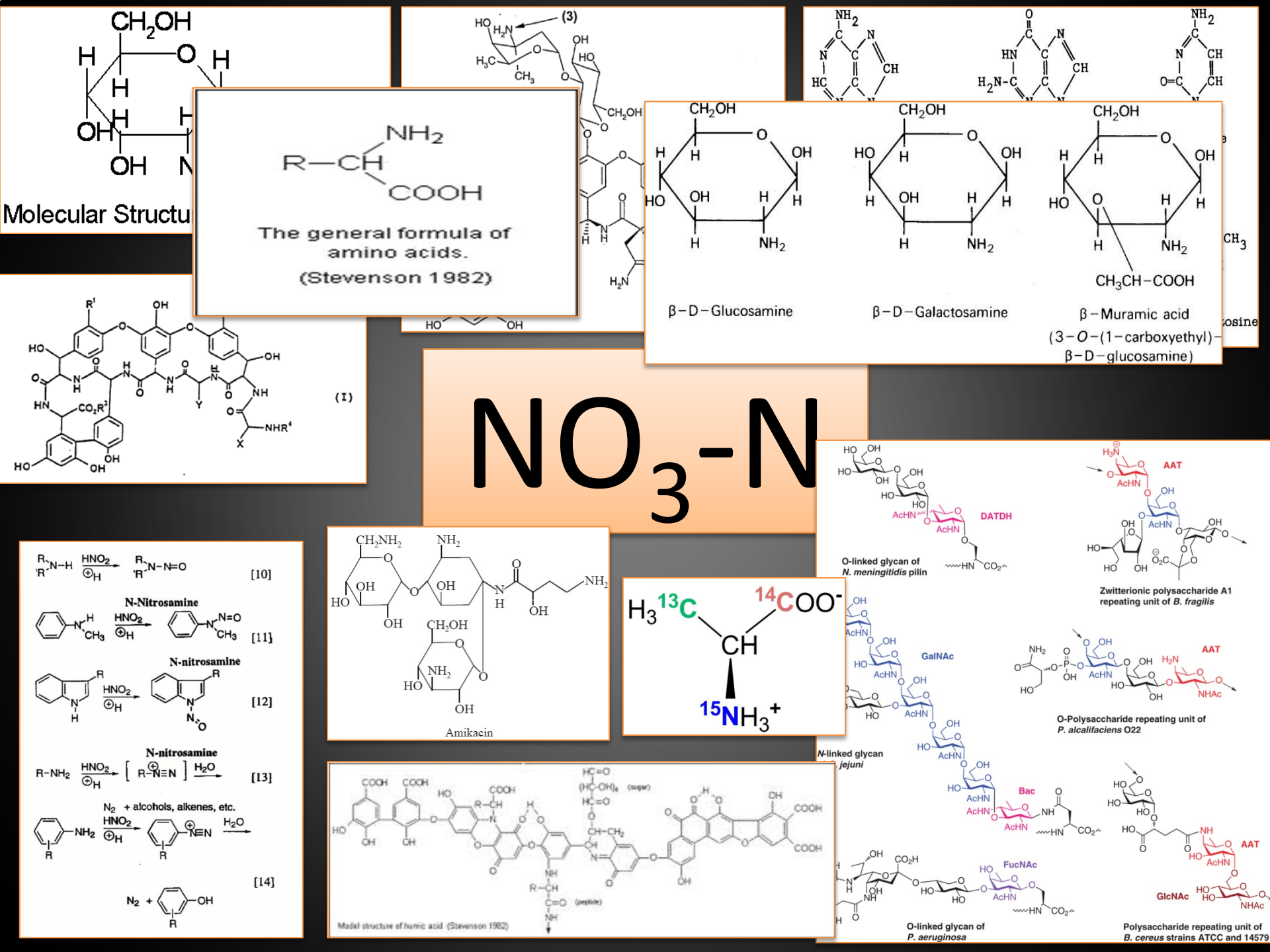
Since 1965* we have been missing half of the N

*2M KCl 1965 Bremer

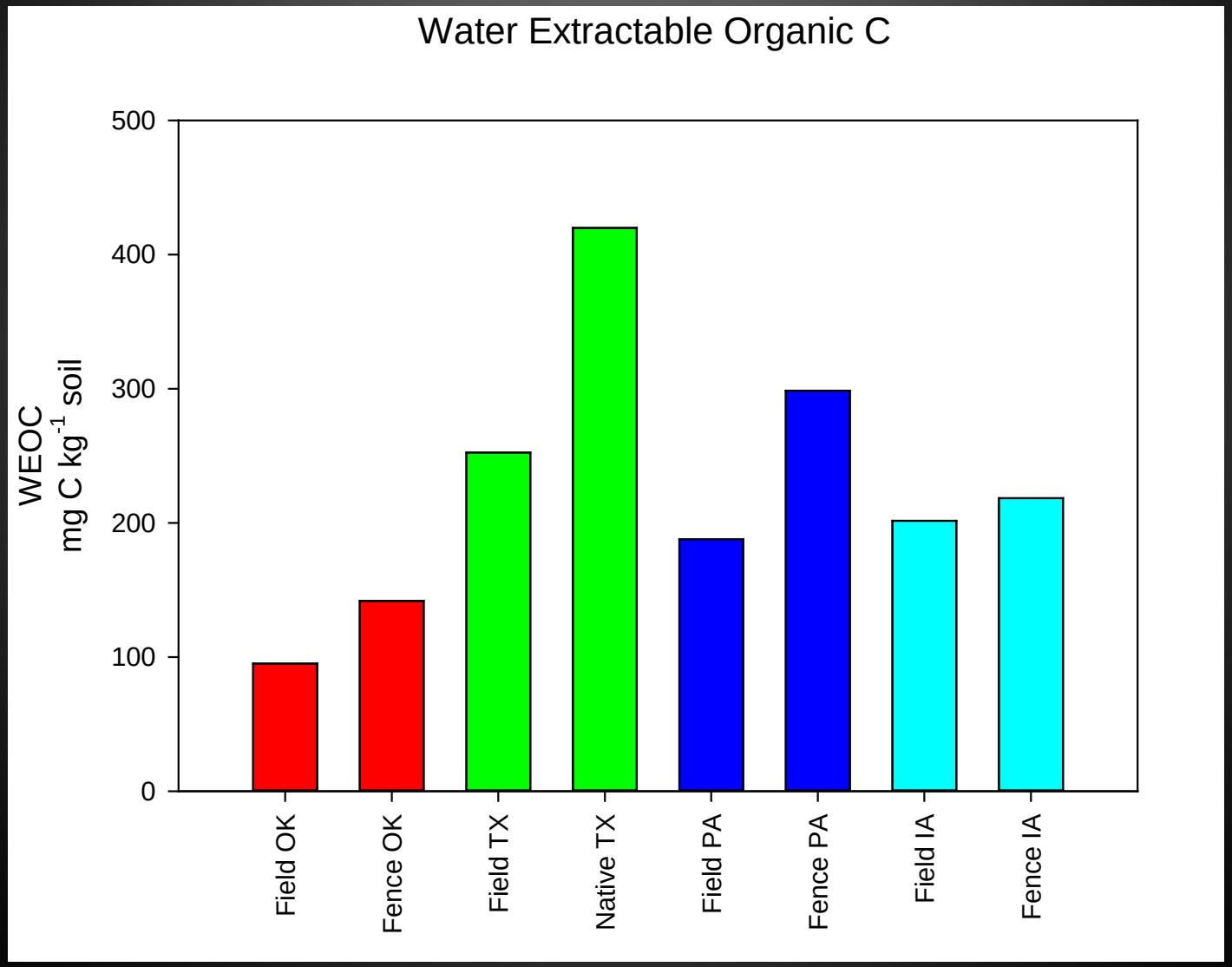


"If plants could not take up organic compounds herbicides would not work"

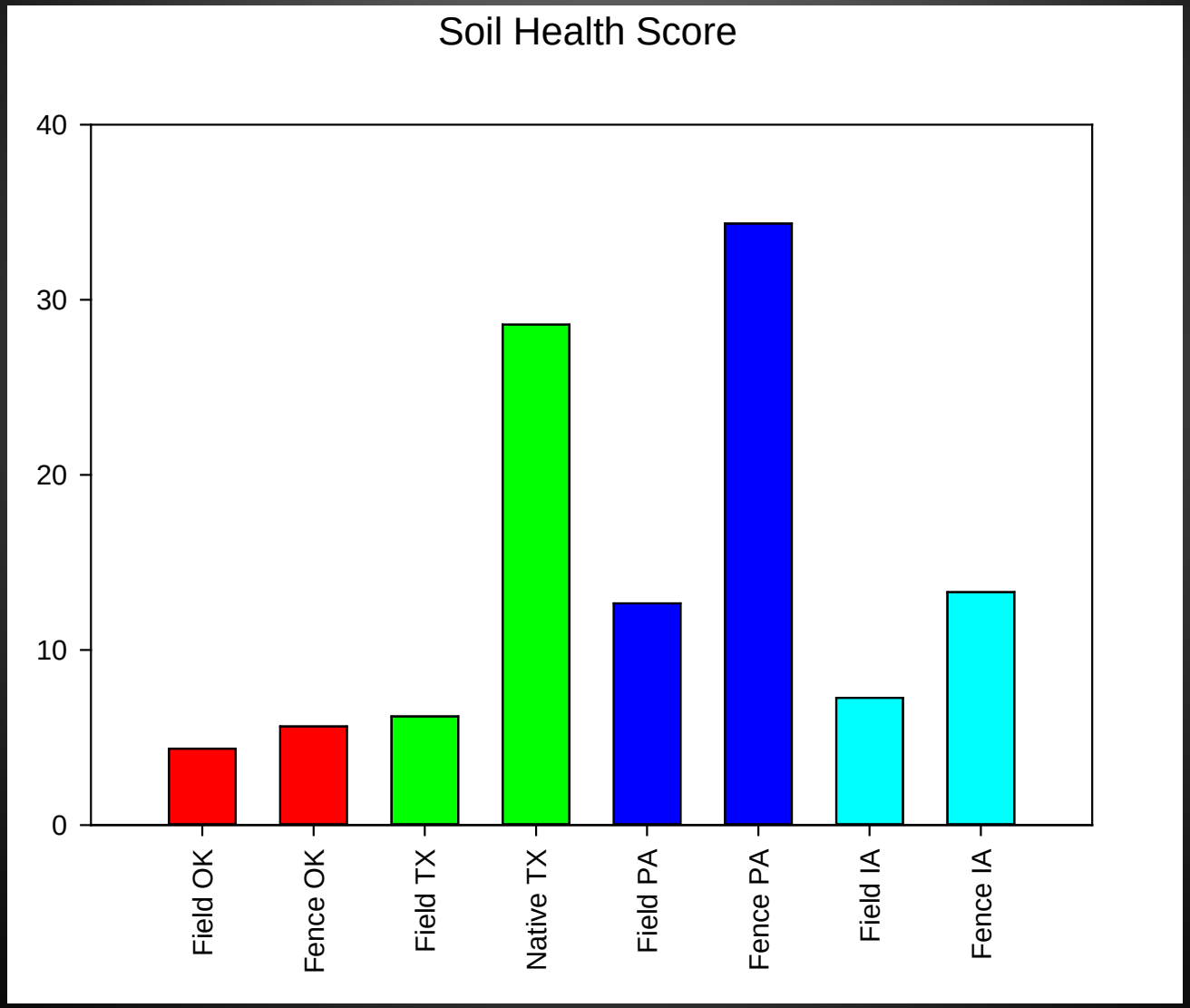
Plants eat: Inorganic N
And Organic N from soil organic matter


Molecular Structu
The general formula of amino acids.
(Stevenson 1982)
β-D-Glucosamine
β-D-Galactosamine
β-Muramic acid
(3-O-(1-carboxyethyl)-β-D-glucosamine)
NO3-N
N-Nitrosamine
N-nitrosamine
N-nitrosamine
N2 + alcohols, alkenes, etc.
Amikacin
Model structure of humic acid (Stevenson 1982)
O-linked glycan of N. meningitidis pilin
Zwitterionic polysaccharide A1 repeating unit of B. fragilis
N-linked glycan jejuni
O-Polysaccharide repeating unit of P. alcalifaciens O22
O-linked glycan of P. aeruginosa
Polysaccharide repeating unit of B. cereus strains ATCC and 14579

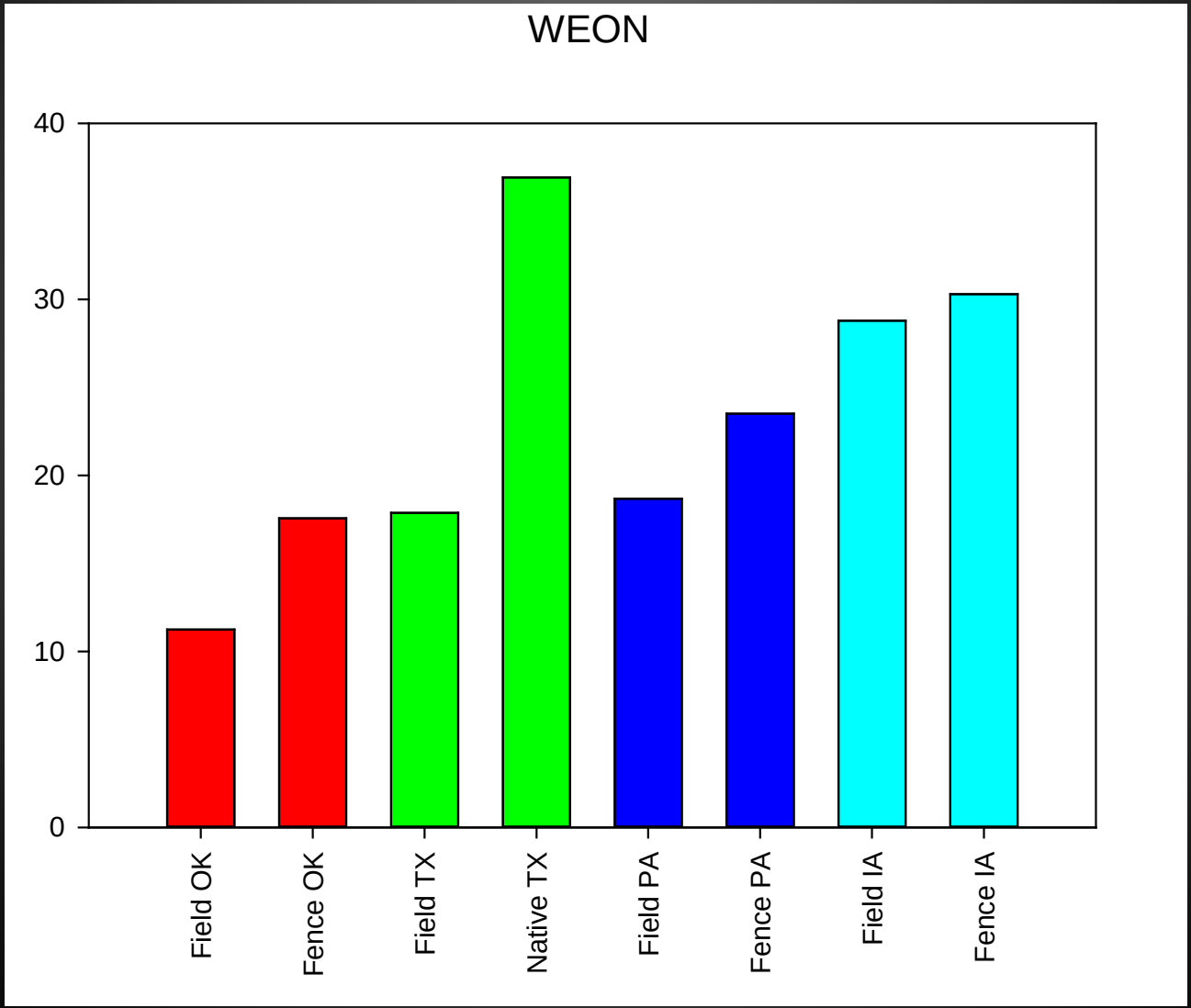
Field vs. Fence



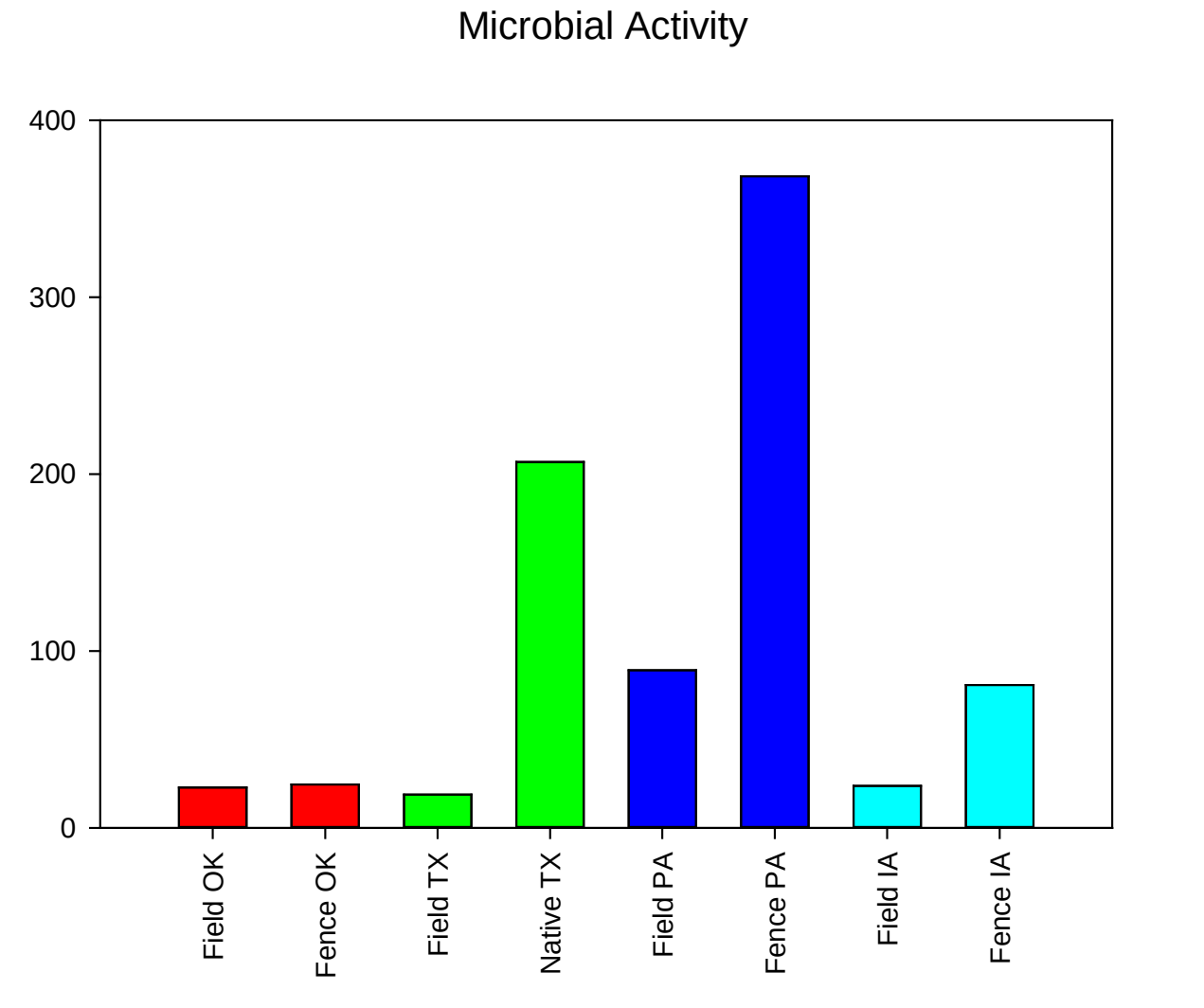
Field vs. Fence



Water Extractable Organic N



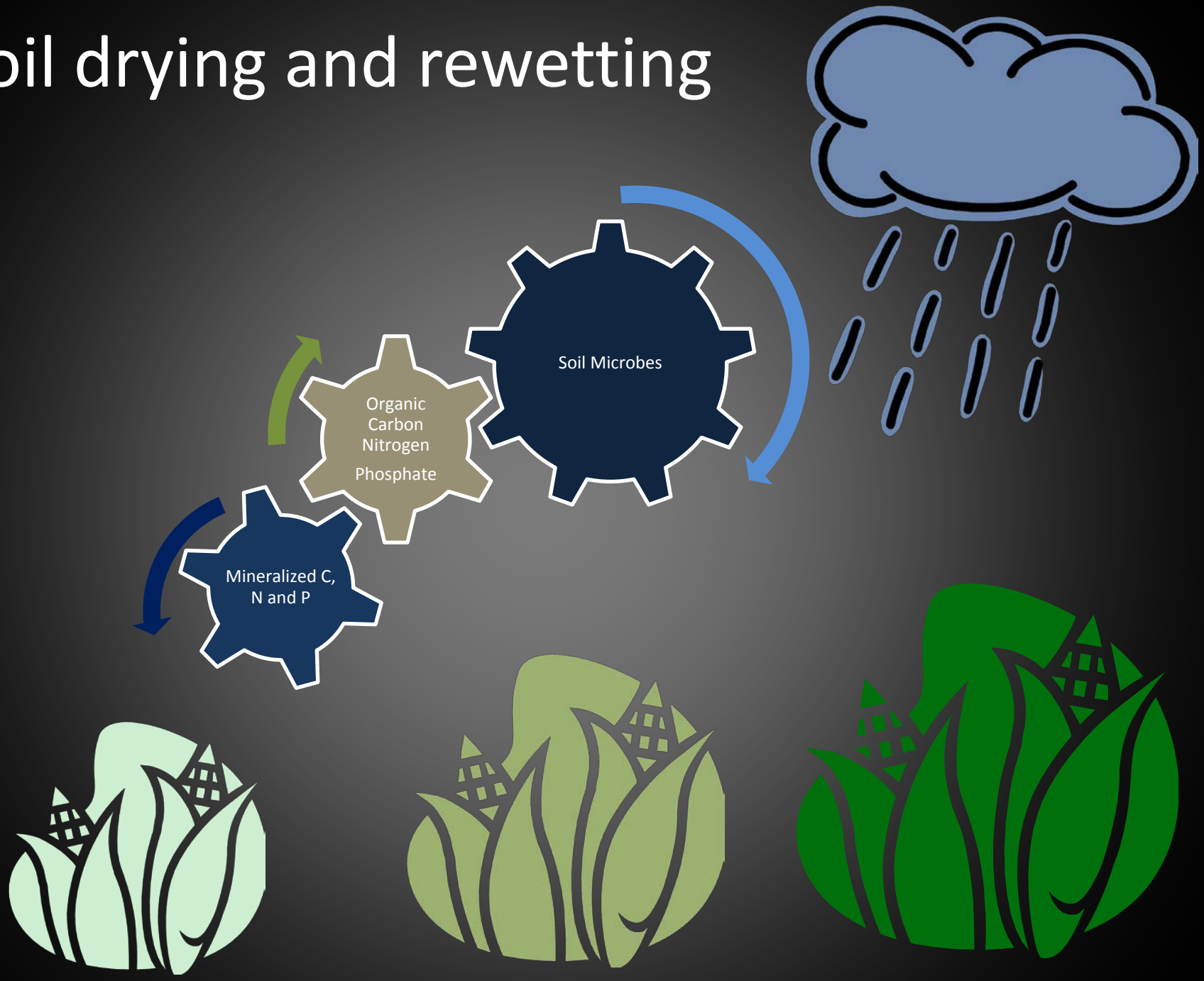
Microbial Activity

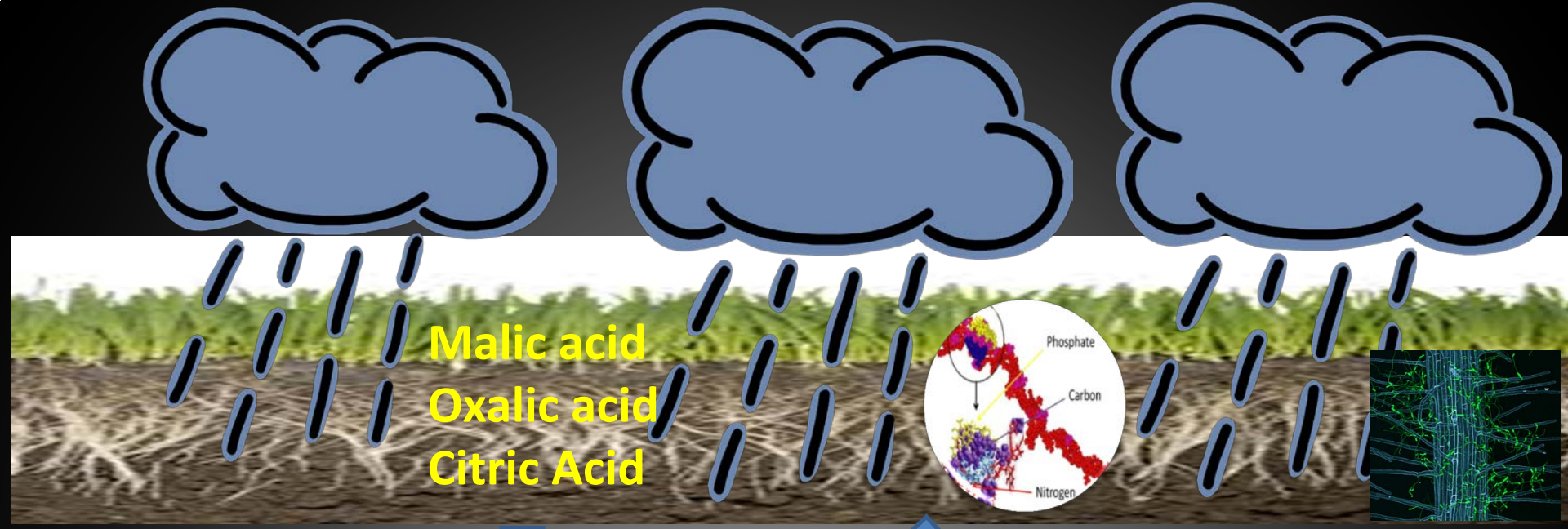


Soil drying and rewetting

- **We need to mimic natural systems in the lab**
- **Plants turn greener after it rains due to the release of N and P, not just the water**
- **The majority of nutrient cycling is due to the drying/rewetting effect**
- **Laboratory analysis does not account for this process**

Soil drying and rewetting





Total P
Inorganic P
Organic P

Phosphate
Potassium
Calcium
Iron
Aluminum

WEN

NH_4-N NO_3-N

WEON

WEOC

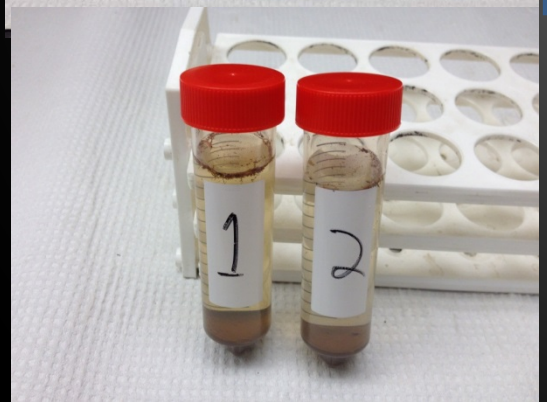
1 day CO_2-C

%P/Al+Fe
Ca/ Al+Fe

Soil Health Calculation

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

Filtration



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

1 day CO_2-C

20 ml water, 40 grams soil

Capillary action rewets soil to field capacity

WEOC
WEN

Water

NH4-N
PO4-P
NO3-N

H3A

P
K
Ca
Fe
Al

Soil Respiration 1 day CO_2-C D/R

2014 Corrected NF.xlsm - Microsoft Excel

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Paste | Cut | Copy | Format Painter | Clipboard | Calibri | 11 | Font | Wrap Text | Merge & Center | Alignment | General | Number | Conditional Formatting | Format as Table | Normal 2 | Normal 2 2 | Normal 3 | Normal_Raw ... | Normal_Raw ... | Normal | Styles

A1 | Sample ID

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Lab ID	one day C	WEOC	WEN	NO3 H3A	NO3 water	PO4 H3A	PO4 water	NH4 H3A	NH4 water	Al H3A	Fe H3A	P H3A	K H3A	Ca H3A
3507	IN-2141-C	17	137	24	9	9	11	0	0	1	475	322	47	91	369
3508	IN-2142-C	9	132	31	15	15	12	0	0	1	662	385	47	87	369
3509	IN-2143-C	10	134	30	14	15	7	0	0	1	636	389	36	91	418
3510	IN-2144-C	18	157	39	21	22	6	0	0	1	626	386	32	113	394
3511	IN-2145-C	21	128	28	14	14	10	0	1	1	560	349	42	106	393
3512	IN-2146-C	23	144	32	15	15	9	0	1	1	508	332	40	100	350
3513	IN-2147-C	17	140	41	21	23	8	0	0	1	440	289	39	90	345
3514	IN-2148-C	22	143	39	20	22	10	0	0	1	501	328	43	92	373
3515	IN-2149-C	18	160	30	12	12	13	0	1	1	533	350	53	94	424
3516	MO-2150-C	19	215	33	10	10	12	0	1	1	486	356	48	81	589
3517	MO-2151-C	17	225	30	8	8	11	0	1	1	692	401	43	84	484
3518	MO-2152-C	28	164	37	17	18	23	0	1	1	294	201	44	106	370
3519	OK-2153-R	23	267	34	4	5	10	3	9	2	65	80	17	79	2424
3520	OK-2154-R	42	147	21	3	2	8	3	2	0	195	127	16	73	39
3521	OK-2155-R	20	241	30	2	2	17	3	1	0	357	171	22	120	227
3522	OK-2156-R	18	141	23	4	4	14	5	1	0	116	81	22	129	174
3523	OK-2157-R	68	306	42	8	8	9	3	2	0	347	263	17	114	101
3524	OK-2158-R	144	313	38	4	4	33	4	2	0	152	109	37	60	611
3525	OK-2159-R	16	195	42	17	18	19	2	4	2	91	51	25	123	1287
3526	OK-2160-R	9	137	19	5	5	16	2	4	1	53	17	21	51	1535
3527	OK-2161-R	26	200	29	8	8	34	3	3	1	211	145	41	147	837
3528	OK-2162-R	14	182	23	5	5	29	3	2	1	70	30	35	60	1041
3529	OK-2163-R	59	204	25	3	3	25	2	3	0	355	208	36	120	141
3530	OK-2164-R	43	152	18	2	2	11	1	3	0	468	277	19	116	155
3531	OK-2165-R	12	169	27	11	11	7	2	1	0	52	1	10	64	2929
3532	OK-2166-R	103	216	55	28	28	33	5	4	0	593	288	42	134	117
3533	OK-2167-R	33	157	28	15	12	19	4	1	1	337	262	29	132	74
3534	OK-2168-R	147	184	32	13	12	19	4	0	1	361	267	28	133	68
3535	OK-2169-R	49	188	32	10	10	51	9	1	1	480	236	55	145	151
3536	OK-2170-R	185	221	152	109	116	77	10	23	16	542	320	80	219	163

Raw data | Calculations | NPK

Ready

Microsoft Visual Basic for Applications - 2014 Corrected NF.xlsm - [Module1 (Code)]

File Edit View Insert Format Debug Run Tools Add-Ins Window Help

Ln 2, Col 1

Project - VBAProject

- VBAProject (2014 Corrected N
  - Microsoft Excel Objects
    - Sheet1 (Raw data)
    - Sheet2 (Calculations)
    - Sheet3 (NPK)
    - ThisWorkbook
  - Modules
    - Module1
- VBAProject (2014 Soil Health T
  - Microsoft Excel Objects
    - Sheet1 (NPK)
    - Sheet2 (GraphIt)
    - ThisWorkbook
  - Modules
- VBAProject (Sigmaplot.xla)
- VBAProject (spRemove.xla)

(General) | Calculate

```
Sub Calculate()
' main subroutine
Application.Calculation = xlCalculationManual
' read raw data to arrays
' count line for array dim
Dim count As Integer ' number of samples
Sheets("Raw data").Select
Range("a1").Select
For count = 1 To 9000
    If Cells(count, 1) = Empty Or Cells(count, 1) = "" Then count = count - 1: Exit For
Next count
' set arrays must use fixed array for some stupid reason dynamic fails
Dim Sample_ID(9000) As String
Dim Lab_ID(9000) As String
Dim one_day_C(9000) As Single
Dim WEOC(9000) As Single
Dim WEN(9000) As Single
Dim NO3_H3A(9000) As Single
Dim NO3_water(9000) As Single
Dim PO4_H3A(9000) As Single
Dim PO4_water(9000) As Single
Dim NH4_H3A(9000) As Single
Dim NH4_water(9000) As Single
Dim Al_H3A(9000) As Single
Dim Fe_H3A(9000) As Single
Dim P_H3A(9000) As Single
Dim K_H3A(9000) As Single
Dim Ca_H3A(9000) As Single


' populate arrays
Dim a As Integer ' counter
For a = 2 To count
    Sample_ID(a) = Cells(a, 1)
    Lab_ID(a) = Cells(a, 2)
    one_day_C(a) = Cells(a, 3)
    WEOC(a) = Cells(a, 4)
    WEN(a) = Cells(a, 5)
    NO3_H3A(a) = Cells(a, 6)
    NO3_water(a) = Cells(a, 7)
    PO4_H3A(a) = Cells(a, 8)
    PO4_water(a) = Cells(a, 9)
    NH4_H3A(a) = Cells(a, 10)
    NH4_water(a) = Cells(a, 11)
    Al_H3A(a) = Cells(a, 12)
    Fe_H3A(a) = Cells(a, 13)
```

2014 Corrected NF.xlsm - Microsoft Excel

File | Home | New Tab | Insert | Page Layout | Formulas | Data | Review | View | Developer | Add-Ins

Paste | Cut | Copy | Format Painter | Clipboard | Calibri | 11 | Font | Wrap Text | Merge & Center | Alignment | General | Number | Conditional Formatting | Format as Table | Normal 2 | Normal 2 2 | Normal 3 | Normal_Raw ... | Normal_Raw ... | Normal | Styles | Insert | Delete | Format | Cells | AutoSum | Fill | Clear

S5005

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Lab ID	In N H3A	In N water	WEON	WEOC:N	Nmin	Pmin	MAC	SHC	Soil Input	MAC*WEON*8	H3A Organic P	H3A-P	H3A-PO4	MAC*Org P
3507	IN-2141-C	8.88	9.66	14.64	9.36	14.40	3.50	0.13	4.56	60% Legume 40% Grass	14.77	36.35	47.05	10.69	4.58
3508	IN-2142-C	15.08	16.26	14.49	9.09	8.00	1.94	0.07	3.70	60% Legume 40% Grass	8.18	34.86	46.89	12.03	2.46
3509	IN-2143-C	14.48	15.57	14.12	9.52	8.21	2.01	0.07	3.76	60% Legume 40% Grass	8.44	28.88	36.36	7.48	2.16
3510	IN-2144-C	21.24	23.34	15.45	10.18	13.31	3.30	0.11	4.89	60% Legume 40% Grass	13.90	26.04	31.92	5.88	2.93
3511	IN-2145-C	14.33	15.02	13.07	9.82	13.07	3.99	0.16	4.65	60% Legume 40% Grass	16.79	31.44	41.83	10.39	5.05
3512	IN-2146-C	15.63	16.18	15.76	9.12	15.76	4.86	0.16	5.35	50% Legume 50% Grass	20.52	31.07	40.10	9.03	5.06
3513	IN-2147-C	20.90	23.49	17.74	7.89	16.42	3.87	0.12	4.84	60% Legume 40% Grass	16.90	31.08	39.10	8.02	3.70
3514	IN-2148-C	20.17	23.31	15.41	9.29	15.41	4.58	0.16	5.22	50% Legume 50% Grass	19.32	33.68	43.40	9.72	5.28
3515	IN-2149-C	12.78	13.70	16.16	9.91	13.93	3.43	0.11	5.01	50% Legume 50% Grass	14.44	40.50	53.37	12.87	4.52
3516	MO-2150-C	10.24	10.92	22.00	9.79	15.01	3.69	0.09	6.25	50% Legume 50% Grass	15.52	36.16	48.45	12.29	3.19
3517	MO-2151-C	8.47	9.71	19.87	11.31	11.22	2.85	0.08	5.97	50% Legume 50% Grass	12.30	31.94	43.06	11.12	2.47
3518	MO-2152-C	17.89	18.82	18.45	8.89	18.45	5.92	0.17	6.27	50% Legume 50% Grass	25.09	20.99	43.75	22.76	3.57
3519	OK-2153-R	13.06	7.78	25.87	10.31	16.80	4.17	0.09	7.53	50% Legume 50% Grass	17.62	7.43	17.46	10.03	0.63
3520	OK-2154-R	4.72	2.56	18.28	8.03	18.28	7.95	0.29	7.49	50% Legume 50% Grass	36.57	7.95	15.90	7.95	2.27
3521	OK-2155-R	3.45	2.19	27.50	8.75	18.17	4.36	0.08	7.19	50% Legume 50% Grass	18.56	5.23	22.43	17.20	0.44
3522	OK-2156-R	5.67	4.61	18.67	7.56	18.26	4.27	0.13	5.07	50% Legume 50% Grass	18.93	7.89	21.97	14.08	1.00
3523	OK-2157-R	10.04	8.25	34.24	8.94	34.24	7.61	0.22	13.27	40% Legume 60% Grass	60.73	7.61	16.87	9.26	1.69
3524	OK-2158-R	5.80	4.39	33.87	9.25	33.87	4.45	0.46	20.89	20% Legume 80% Grass	67.74	4.45	37.31	32.86	2.04
3525	OK-2159-R	20.44	19.56	22.02	8.83	14.09	3.39	0.08	5.74	50% Legume 50% Grass	14.39	6.13	25.45	19.32	0.50
3526	OK-2160-R	8.37	5.55	13.85	9.91	6.82	1.68	0.06	3.64	60% Legume 40% Grass	7.07	4.41	20.71	16.30	0.28
3527	OK-2161-R	11.01	9.09	19.62	10.20	19.62	4.88	0.13	6.59	50% Legume 50% Grass	20.57	7.19	41.14	33.95	0.94
3528	OK-2162-R	7.49	5.85	17.57	10.34	10.68	2.66	0.08	5.02	50% Legume 50% Grass	11.22	5.24	34.65	29.41	0.42
3529	OK-2163-R	5.18	2.67	22.12	9.22	22.12	11.53	0.29	10.20	40% Legume 60% Grass	44.24	11.53	36.33	24.80	3.36
3530	OK-2164-R	4.69	2.08	16.17	9.37	16.17	8.28	0.29	7.45	50% Legume 50% Grass	32.34	8.28	18.85	10.58	2.36
3531	OK-2165-R	12.19	11.34	16.14	10.47	9.04	2.25	0.07	4.55	60% Legume 40% Grass	9.54	3.23	10.41	7.18	0.24
3532	OK-2166-R	31.41	28.60	26.04	8.31	26.04	8.90	0.48	15.05	30% Legume 70% Grass	52.08	8.90	41.64	32.74	4.23
3533	OK-2167-R	15.81	12.63	15.56	10.08	15.56	6.22	0.21	6.42	50% Legume 50% Grass	26.19	9.87	29.32	19.46	2.08
3534	OK-2168-R	12.68	12.75	18.91	9.71	18.91	9.06	0.80	18.48	30% Legume 70% Grass	37.82	9.06	28.16	19.10	7.28
3535	OK-2169-R	10.62	10.56	21.50	8.76	21.50	4.77	0.26	8.90	50% Legume 50% Grass	42.99	4.77	55.28	50.50	1.23
3536	OK-2170-R	132.66	132.51	19.90	11.10	19.90	2.99	0.84	20.83	10% Legume 90% Grass	39.81	2.99	79.80	76.81	2.50

Raw data | Calculations | NPK

Ready

Microsoft Visual Basic for Applications - 2014 Corrected NF.xlsm - [Module1 (Code)]

File Edit View Insert Format Debug Run Tools Add-Ins Window Help

Ln 19, Col 30

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- VBAProject (spRemove.xla)

(General) | Calculate

```
    End If


    WEON(a) = WEN(a) - In_N_water(a)


    WEOC_N(a) = WEOC(a) / WEON(a)


    Pct_MAC(a) = one_day_C(a) / WEOC(a)

    'Nmin
     Nmin(a) = (one_day_C(a) * ((-0.068 * WEOC_N(a)) + (0.00095 * WEOC_N(a) ^ 2) + 0.97)) * 2
    If Nmin(a) <= 0 Then Nmin(a) = 0
    If WEOC_N(a) > 30 Then Nmin(a) = 0
    ' pmin
    Pmin(a) = one_day_C(a) * (-0.02 * WEOC_N(a) + 0.39)
    If Pmin(a) <= 0 Then Pmin(a) = 0
    If Pmin(a) > H3A_org_P(a) Then Pmin(a) = H3A_org_P(a)

    If Nmin(a) > WEON(a) Then Nmin(a) = WEON(a)

    SHC(a) = (one_day_C(a) / 10) + WEOC(a) / 100 + WEON(a) / 10
    If one_day_C(a) > 150 Then SHC(a) = (one_day_C(a) / WEOC_N(a)) + WEOC(a) / 100 + WEON(a) / 10
    If one_day_C(a) > 150 And WEOC_N(a) < 10 Then SHC(a) = (one_day_C(a) / 10) + WEOC(a) / 100 + WEON(a) / 10


    MAC_WEON(a) = (WEON(a) * Pct_MAC(a)) * 8
    If MAC_WEON(a) > WEON(a) * 2 Then MAC_WEON(a) = WEON(a) * 2

    MAC_H3A_org_P(a) = Pct_MAC(a) * H3A_org_P(a)
    If MAC_H3A_org_P(a) > H3A_org_P(a) Then MAC_H3A_org_P(a) = H3A_org_P(a)





    ' Trigger

    If SHC(a) > 0 And SHC(a) < 2.5 Then Soil_Input(a) = "70% Legume 30% Grass"

    If SHC(a) > 2.5 And SHC(a) < 5 Then Soil_Input(a) = "60% Legume 40% Grass"

    If SHC(a) > 5 And SHC(a) < 10 Then Soil_Input(a) = "50% Legume 50% Grass"
```

Microsoft Visual Basic for Applications - 2014 Corrected NF.xlsm - [Module1 (Code)]

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Ln 122, Col 45

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- VBAProject (spRemove.xla)

(General) | Calculate

```
    Next a

Sheets("npk").Select
Range("A2:U5000").ClearContents
Range("A2").Select
For a = 2 To count
    Cells(a, 1) = Sample_ID(a)
    Cells(a, 2) = Lab_ID(a)
    Cells(a, 3) = NH4_water(a) * 2 + NO3_water(a) * 1.4 + MAC_WEON(a)
    Cells(a, 4) = PO4_H3A(a) * 2.3 + Pmin(a) * 2.3
    Cells(a, 5) = K_H3A(a) * 1.2
    Cells(a, 6) = Cells(a, 3) * 0.6 + Cells(a, 4) * 0.85 + Cells(a, 5) * 0.45
    Cells(a, 13) = ((NO3_water(a) * 2)) * 0.7
    Cells(a, 14) = Cells(a, 3) - Cells(a, 13)
    Cells(a, 15) = Cells(a, 14) * 0.7
    Cells(a, 17) = one_day_C(a)
    Cells(a, 18) = WEOC(a)
    Cells(a, 19) = WEON(a)
    Cells(a, 20) = WEOC_N(a)
    Cells(a, 21) = SHC(a)
    Cells(a, 22) = Soil_Input(a)
    Cells(a, 23) = WEN(a) * 2
    Cells(a, 24) = In_N_water(a) * 2
    Cells(a, 25) = Cells(a, 23) - Cells(a, 24)
    Cells(a, 26) = P_H3A(a) * 2.3
    Cells(a, 27) = PO4_H3A(a) * 2.3
    Cells(a, 28) = Cells(a, 26) - Cells(a, 27)
    Cells(a, 30) = Al_H3A(a)
    Cells(a, 31) = Fe_H3A(a)
    Cells(a, 32) = Ca_H3A(a)
    Cells(a, 34) = MAC_WEON(a)
    If Cells(a, 34) > Cells(a, 25) Then Cells(a, 34) = Cells(a, 25)
    Cells(a, 35) = Cells(a, 19) * 2 - Cells(a, 34)
    Cells(a, 36) = Pmin(a) * 2.3
    If Cells(a, 36) < 0 Then Cells(a, 36) = 0
    Cells(a, 37) = Cells(a, 26) - Cells(a, 27) - Pmin(a) * 2.3
    Cells(a, 38) = P_H3A(a) / (Al_H3A(a) + Fe_H3A(a)) * 100
    Cells(a, 39) = Ca_H3A(a) / (Al_H3A(a) + Fe_H3A(a))
    Cells(a, 41) = Cells(a, 21)
    Cells(a, 42) = Cells(a, 15)
```

2014 Soil Health Tool results2.xlsm - Microsoft Excel

	C	D	E	F	G	H	I	J	K	L	M	N	O
1	N lbs per acre	P205 lbs per acre	K20 lbs per acre	Nutrient value per acre		Crop	Yield Goal	lbs N needed	lbs P205 needed	lbs K20 needed	NO3-N Only lbs per acre 70%	Additional N lbs per acre	$ nitrogen saved per acre
2	71.7	59.3	40.9	$111.8	Run	corn	200	118	41	29	11.6	60.1	$42.1
3	77.5	60.5	61.6	$125.7		corn	200	113	39	8	10.7	66.8	$46.8
4	31.8	47.8	26.1	$71.5		corn	200	158	52	44	15.8	16.0	$11.2
5	51.5	31.2	29.1	$70.5		corn	200	138	69	41	9.0	42.5	$29.7
6	71.7	74.1	92.3	$147.5		corn	200	118	26	0	26.2	45.6	$31.9
7	53.8	51.5	52.0	$99.4		corn	200	136	49	18	10.3	43.5	$30.5
8	27.3	175.6	176.1	$244.9		corn	200	163	0	0	11.5	15.8	$11.1
9	30.4	97.3	176.6	$180.4		corn	200	160	3	0	5.3	25.1	$17.6

NPK GraphIt

Ready

Microsoft Visual Basic for Applications - 2014 Soil Health Tool results2.xlsm - [Module1 (Code)]

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Ln 2, Col 1

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  - Modules
    - Module1
    - Module2
- VBAProject (Sigmaplot.xla)
- VBAProject (spRemove.xla)

(General) | run

```
Sub run()
' update fert rec
Dim myflag As Boolean
Dim N_Needed, P_Needed, K_Needed, YG As Single ' rec
Range("h2").Select

10: If ActiveCell.Offset([0], [-7]).Value = "" Then Exit Sub
' verify yield goal
If IsNumeric(ActiveCell.Offset([0], [1]).Value) = False Or ActiveCell.Offset([0], [1]).Value = "" Then
    ActiveCell.Offset([0], [1]).Style = "bad"
    MsgBox ("Yield goal missing")
    Exit Sub
Else
    ActiveCell.Offset([0], [1]).Style = "Normal"
End If

YG = ActiveCell.Offset([0], [1]).Value
' select crop
myflag = False


If UCase(ActiveCell.Value) = "CORN" Then
    N_Needed = YG * 0.95
    P_Needed = YG * 0.5
    K_Needed = YG * 0.35
    myflag = True
End If

If UCase(ActiveCell.Value) = "WHEAT" Then
    N_Needed = YG * 1.5
    P_Needed = YG * 0.5
    K_Needed = YG * 0.4
    myflag = True
End If

If UCase(ActiveCell.Value) = "OATS" Then
    N_Needed = YG * 0.7
    P_Needed = YG * 0.4
    K_Needed = YG * 0.3
    myflag = True
End If


If UCase(ActiveCell.Value) = "SORGHUM" Then
    N_Needed = YG * 0.8
    P_Needed = YG * 0.5
```

2014 Soil Health Tool results2.xlsm - Microsoft Excel

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Zoom | 100% | Zoom to Selection | Zoom

New Window | Arrange All | Freeze Panes | Split | Hide | Unhide | View Side by Side | Synchronous Scrolling | Reset Window Position | Save Workspace | Switch Windows | Window

Macros | Macros

C17

	Q	R	S	T	U	V	W	X	Y
1	1-day CO2-C	Organic C	Organic N	Organic C:N	Soil Health Calculation	Cover crop mix	**Total Nitrogen lbs\acre**	Inorganic N	Organic N
2	63.4	273.3	32.3	8.5	12.3	40% Legume 60% Grass	81.4	16.7	64.6
3	238.6	345.4	33.3	10.4	29.8	20% Legume 80% Grass	82.1	15.5	66.6
4	16.2	212.4	26.0	8.2	6.3	50% Legume 50% Grass	74.7	22.7	51.9
5	45.3	193.2	22.6	8.5	8.7	50% Legume 50% Grass	58.2	13.0	45.3
6	54.3	231.4	24.1	9.6	10.2	40% Legume 60% Grass	85.9	37.6	48.2
7	49.3	271.2	29.7	9.1	10.6	40% Legume 60% Grass	74.4	14.9	59.5
8	17.5	130.4	13.8	9.4	4.4	60% Legume 40% Grass	45.0	17.4	27.6
9	27.5	179.5	19.6	9.2	6.5	50% Legume 50% Grass	47.8	8.6	39.2

NPK | GraphIt

Ready

2014 Soil Health Tool results2.xlsm - Microsoft Excel

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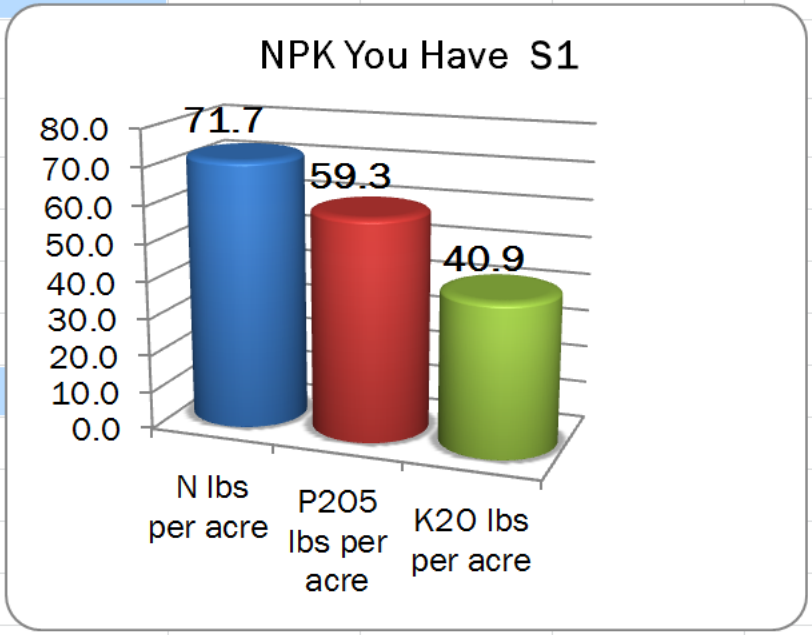
Ruler | Formula Bar | Gridlines | Headings | Show

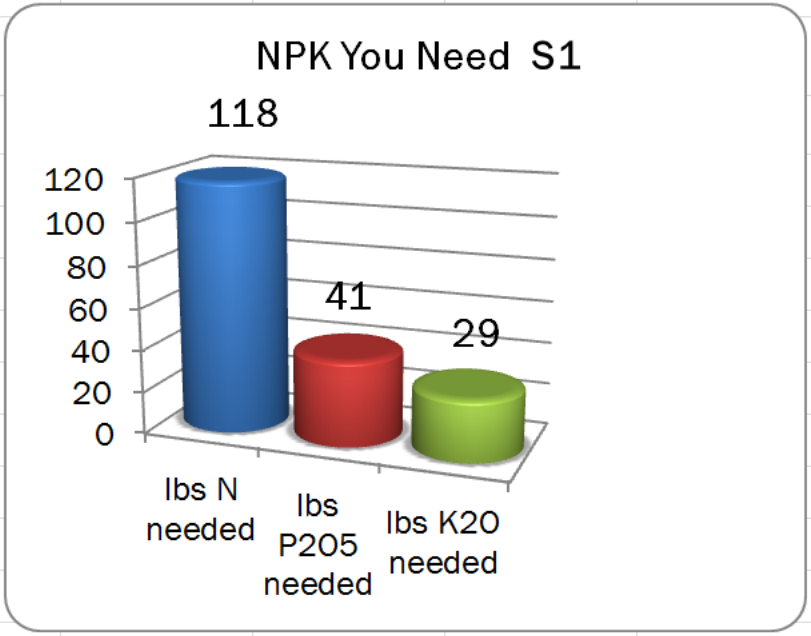
Zoom | 100% | Zoom to Selection | Zoom

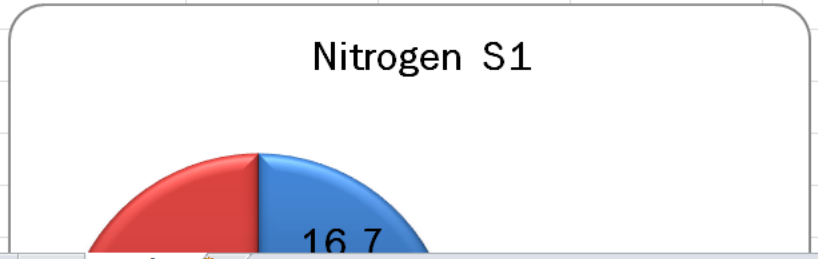
New Window | Arrange All | Freeze Panes | Split | Hide | Unhide | View Side by Side | Synchronous Scrolling | Reset Window Position | Save Workspace | Switch Windows | Window

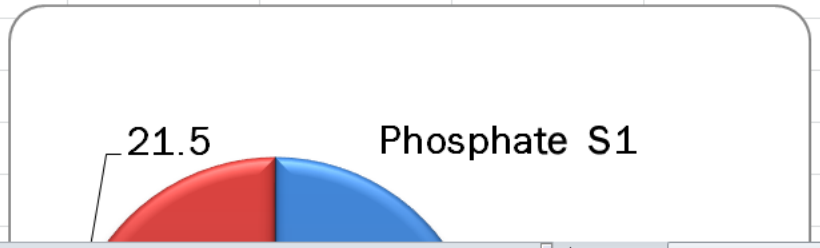
Macros | Macros

B8









NPK | GraphIt

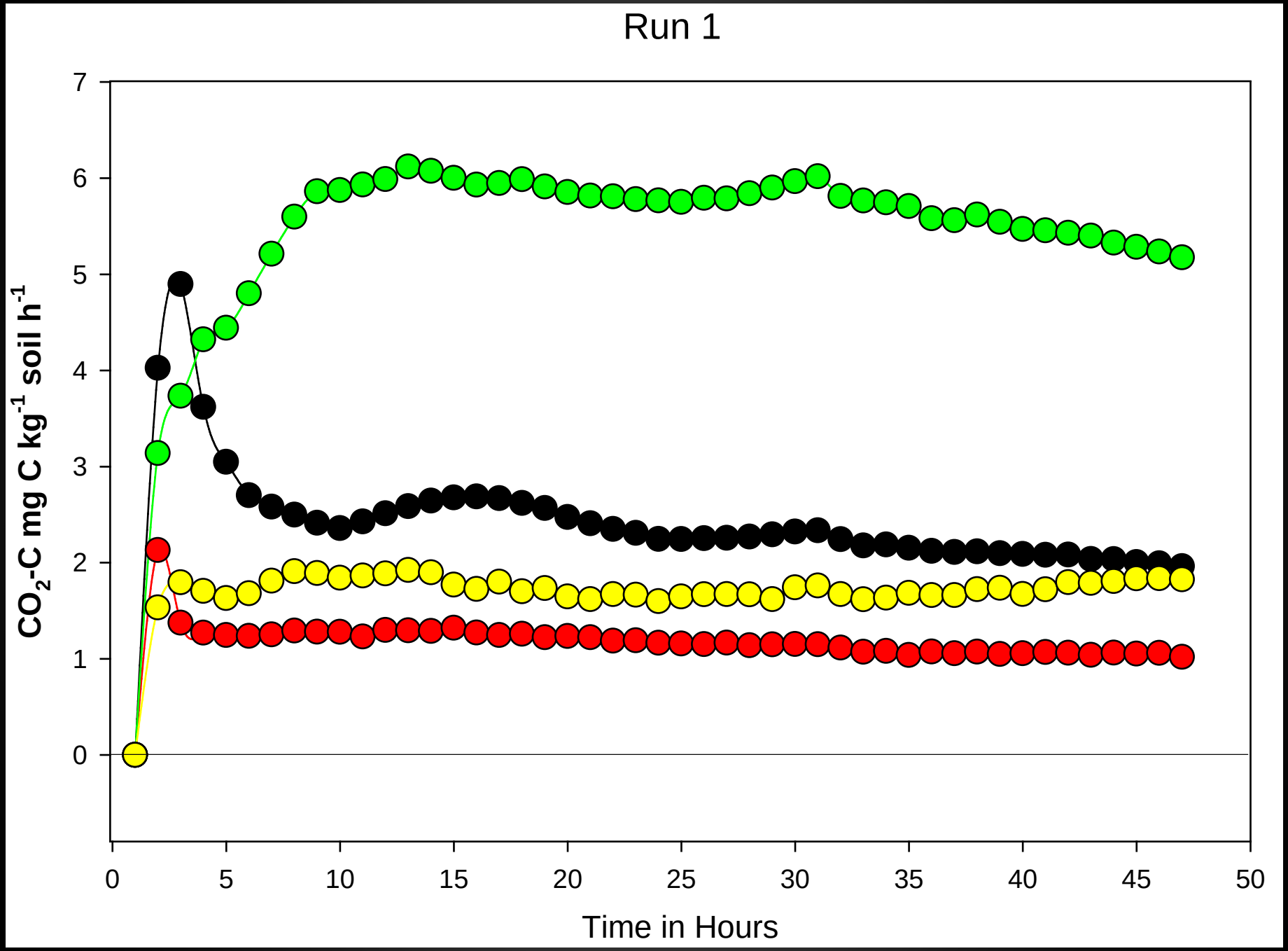
Ready

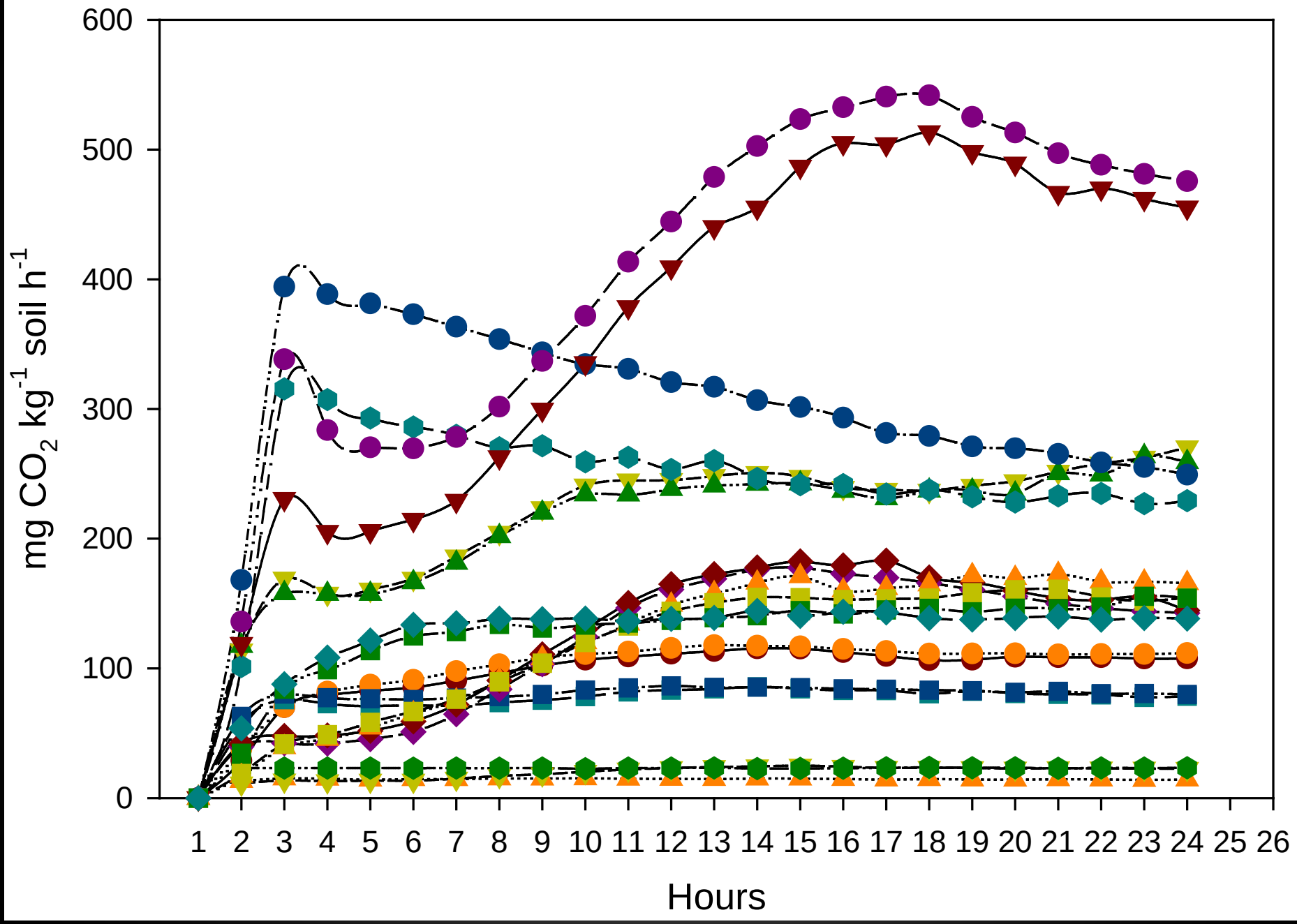
Site	Solvita 1-day CO2-C	Organic C	Organic N	Organic C:N	Soil Health Calculation	Cover crop mix
0-2 inch	128.89	378.37	33.54	11.28	18.56	20% Legume 80% Grass
0-6 inch	71.63	313.24	28.78	10.88	12.59	40% Legume 60% Grass
2 tons tilled	60.93	345.24	25.74	13.42	10.57	50% Legume 50% Grass
4 tons tilled	71.04	543.34	40.01	13.58	14.67	40% Legume 60% Grass
6 tons pasture	75.79	826.20	51.76	15.96	18.19	20% Legume 80% Grass
ND Producer	86.25	750.74	69.68	10.77	22.48	10% Legume 90% Grass
Temple 2007	32.73	117.53	12.40	9.48	5.87	70% Legume 30% Grass
Temple 2013	51.40	170.50	15.49	10.99	7.99	60% Legume 40% Grass
PMC	5.40	54.26	2.77	19.57	1.10	90% Legume 10% Grass

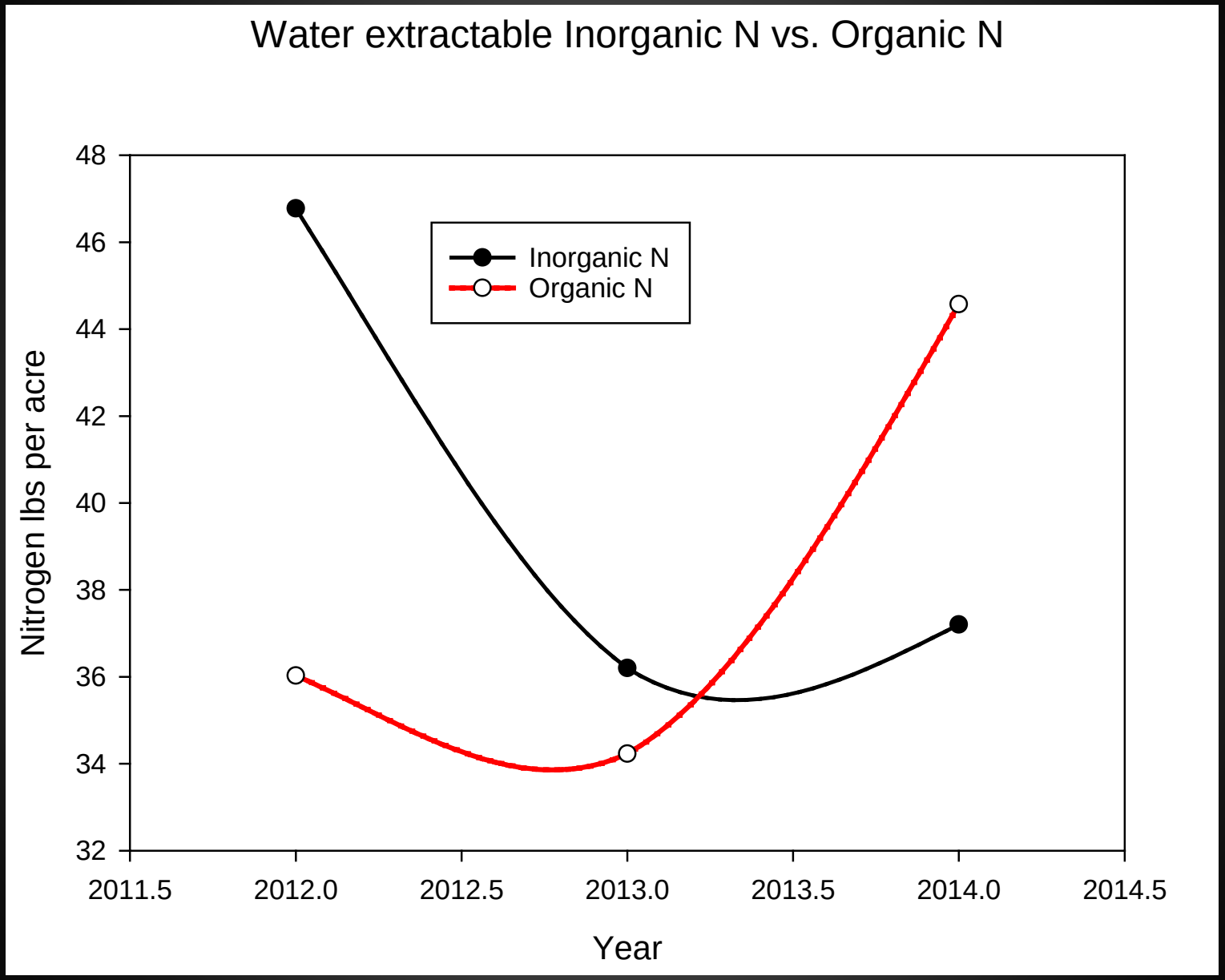
Buddy (ARS) and Chris (NRCS)

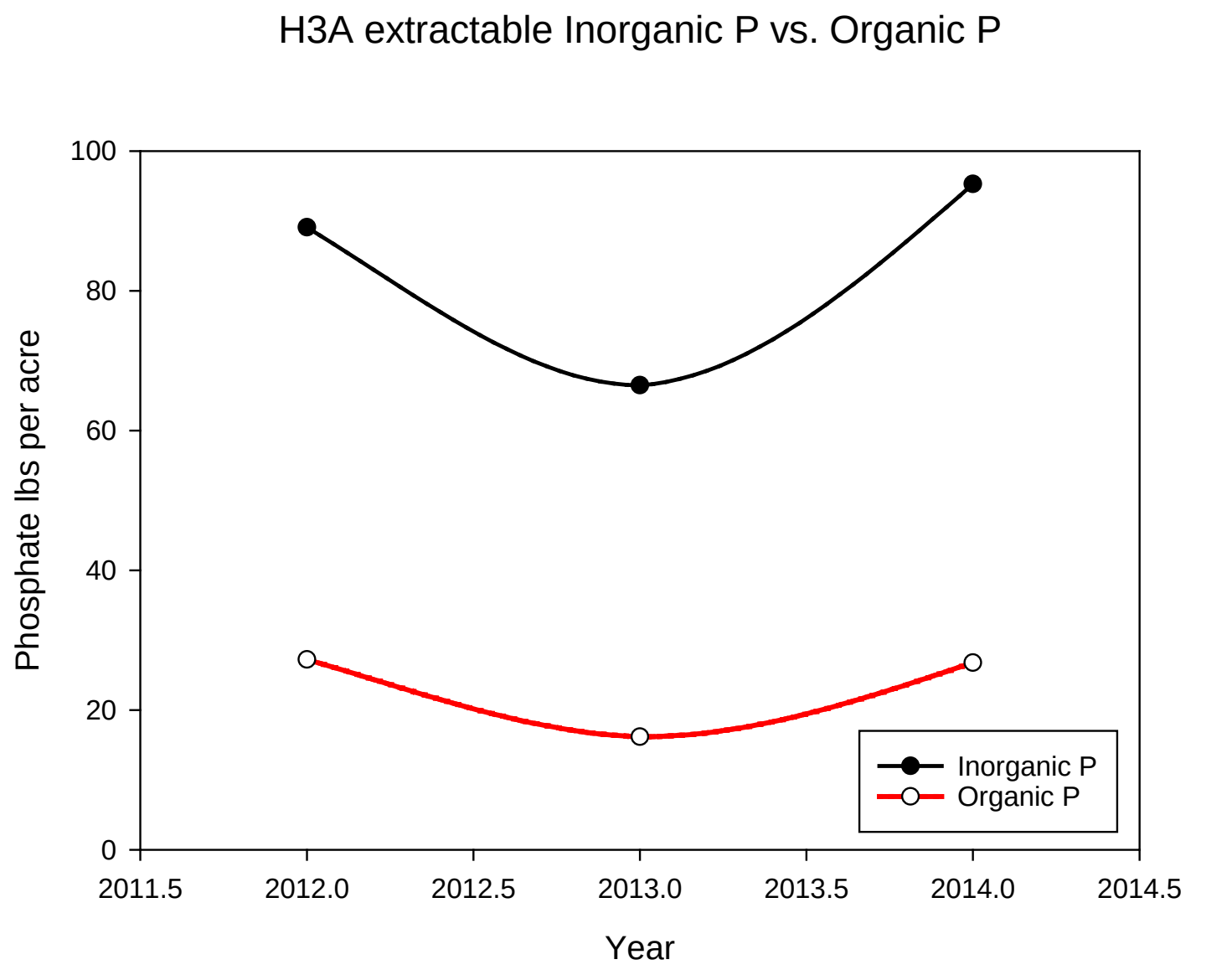
An Explanation for Texas A&M's Offensive Approach Against UL-Monroe
Rubbermaid
Commercial Products

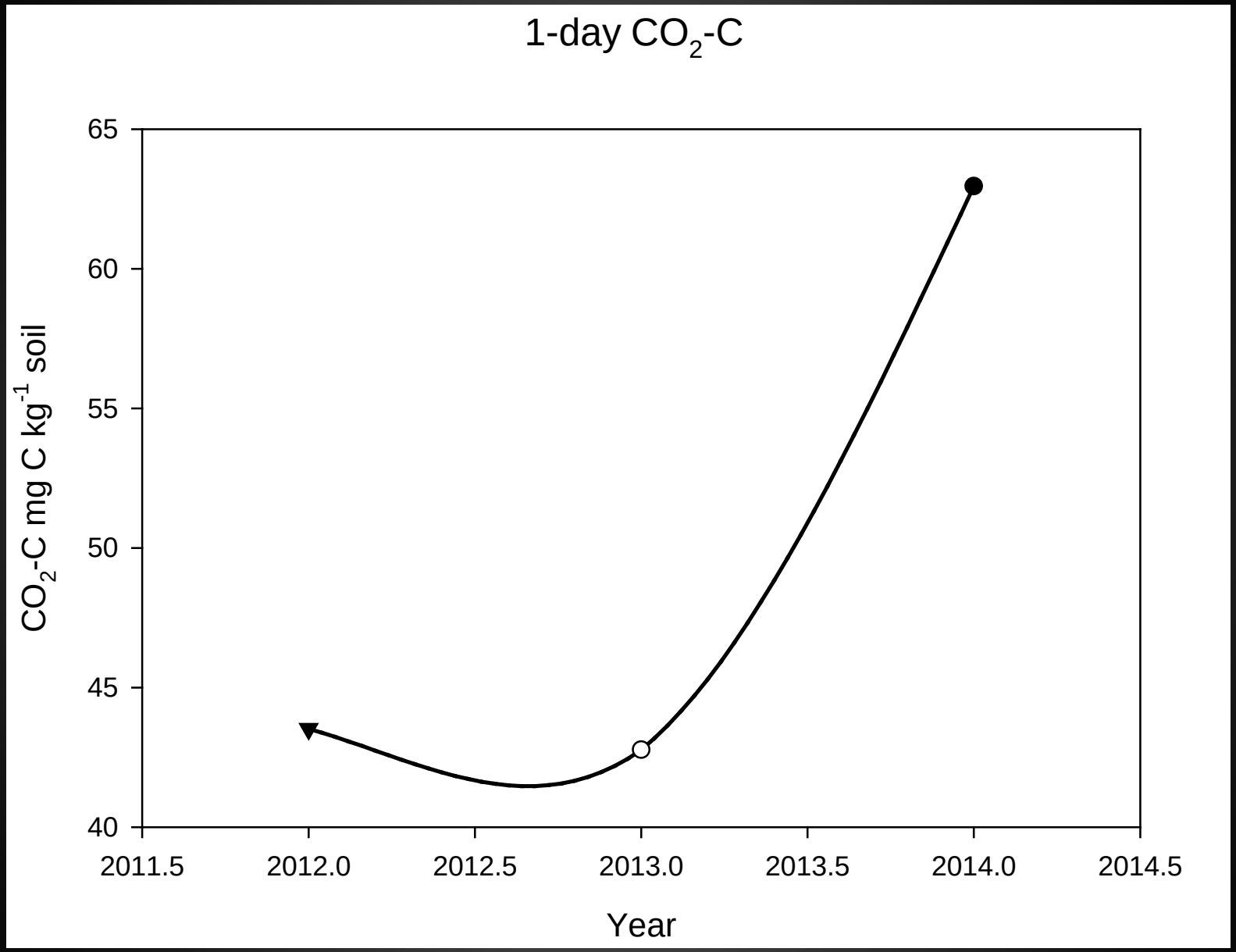
DESSICANT TUBES
SQUARE BOTTLES
CORROSIVE

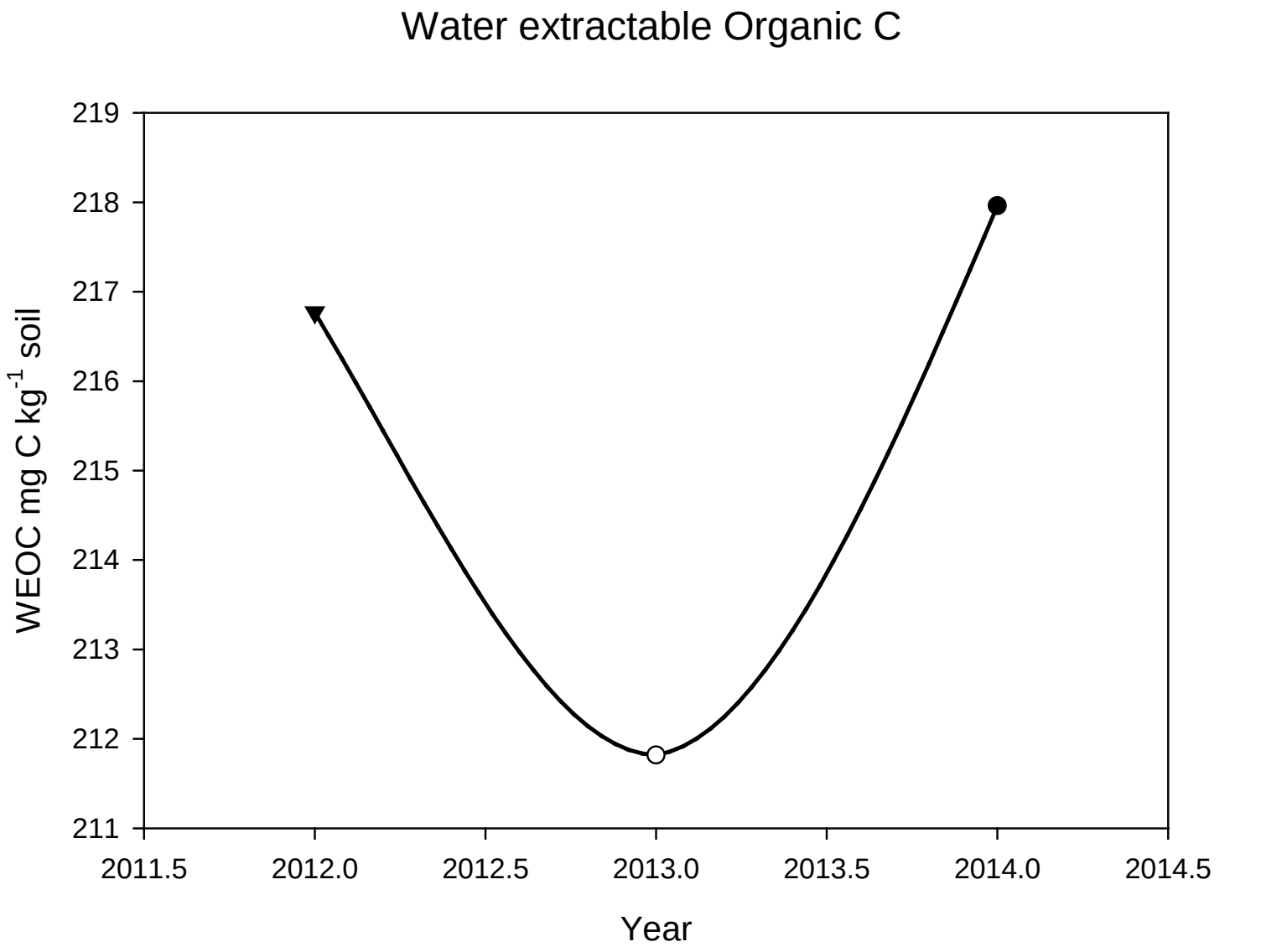

Run 1
7
6
5
4
3
2
1
0
CO_2-C mg C kg^{-1} soil h^{-1}
0
5
10
15
20
25
30
35
40
45
50
Time in Hours


600
500
400
300
200
100
0
mg CO_2 kg^{-1} soil h^{-1}
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Hours


Water extractable Inorganic N vs. Organic N
Inorganic N
Organic N
Nitrogen lbs per acre
48
46
44
42
40
38
36
34
32
2011.5
2012.0
2012.5
2013.0
2013.5
2014.0
2014.5
Year


H3A extractable Inorganic P vs. Organic P
Phosphate lbs per acre
100
80
60
40
20
0
2011.5
2012.0
2012.5
2013.0
2013.5
2014.0
2014.5
Year
Inorganic P
Organic P


1-day CO_2-C
65
60
55
50
45
40
CO_2-C mg C kg^{-1} soil
2011.5
2012.0
2012.5
2013.0
2013.5
2014.0
2014.5
Year


Water extractable Organic C
WEOC mg C kg-1 soil
219
218
217
216
215
214
213
212
211
2011.5
2012.0
2012.5
2013.0
2013.5
2014.0
2014.5
Year

The End

Soil Health Nutrient Tool Project

David Lamm

National Soil Health & Sustainability Team, Leader

Soil Health What is It?

- The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans
  - Nutrient cycling
  - Water (infiltration & availability)
  - Filtering and Buffering
  - Physical Stability and Support
  - Habitat for Biodiversity

Challenges to NRCS

- How does improved nutrient cycling impact Nutrient Management (590)
- What's the "Quality Criteria" for a Soil Health Management System
- How do you develop and justify a multi-species cover crop mix
- Is there a simplified tool to give a soil health rating

Project Objectives

- Improve Soil Health by enhancing understanding:
  - chemical/biological soil test
  - Improved soil function
  - Impact on fertilizer efficiency
- Identify impact of cover crops and CC mixes on soil health and verify recommendations
- Evaluate different soil management systems
- Develop a national database
  - Soil test results
  - Management systems
  - By state

Accomplishments & Deliverables

- National database
- Estimate of potential savings on fertilizer
- NRCS Tech Note on Soil Health Nutrient Tool
- Training for 2 years for NRCS employees
- Answer countless inquires about the test

What is NRCS helping to do?

- Not validating the science behind the test
- Validate soil health assessments and nutrient recommendations using SHNT
- Evaluate changes in soil health and available nutrients as participating producer implement a SHMS
- Assess the economic and environmental benefits resulting from improved soil health and accurate nutrient assessment
- Provide research and education to farmers and ranchers through NRCS field personnel

NRCS Role

- NRCS identify a project contact person within the state
- Identify 10-20 farmers and/or ranchers
  - selecting a variety of cropping system and management types.
  - They do not all need have been implementing soil health management activities
- Explain project
- Assist in completing data collection forms
- Review of sampling results
- Next Steps & Questions

Farmer/Rancher Role

- Farmers provide soil samples on a yearly basis,
  - 1 samples per cropland management system and 1 sample per year for grazing systems will be provided each year
  - Samples will be pulled from the same fields each year following standard soil sampling protocol
  - Participants will agree to remain in program for a minimum of 5 years
  - Include information on cropping/grazing system management, yield data, etc.

ARS Role

- Assign lab ID for each sample, **sample results will be kept confidential**
- SHNT will be used to evaluate current soil health conditions and make fertilizer and management recommendation
- Provide copies of the results to farmer participants and NRCS state office
- Conducted training webinars on Soil Health Nutrient Tool

Soil Sampling Protocol

- Samples need to be pulled from the same field, 15 to 20 cores per sample
- Soil samples should be pulled:
  - Cropland: 2-4 weeks prior to planting the cash crop and/or cover crop on cropland
  - Pasture/Range: Annually before grazing event
- Soil samples:
  - Sample depth 0-6 inches; take 10-15 samples per field, mix together in a one-quart zip-lock bag.
  - Label them clearly with a name and a number such as Smith 1, 2, 3, and so on.
  - Include an email address.
  - Do not dry, freeze or chill them, just send them, ARS will dry them

2014 Enrollment

- 40 States participating
- 1330 Samples submitted
  - 1110 cropland
  - 220 pasture/range
- Cutting off registration September 30th
- Second crop year samples being submitted

Data Collection

- Fine line between too much and not enough
- Need data to evaluate:
  - Nutrient
  - Soil Health Rating
  - Cover Crop Recommendation
- Soil Health Nutrient Tool Share Point Site

Soil Health Nutrient Tool Share Point Site

https://ems-team.usda.gov/sites/NRCS_ST/ENTSC/Lists/Soil%20Health%20Nutrie

Soil Health Nutrient Tool - ...

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- Plant Data Team
- Soil Health and Sustainability Team
  - Soil Health Nutrient Tool Registration
  - Soil Health Nutrient Tool - Crop
  - Soil Health Nutrient

Soil Health Nutrient Tool - Crop

Instructions

This list is used by NRCS States to input management information for the "Soil Health Nutrient Tool - Crop" project. Before creating a new record, look up the "Lab ID-C" for the field sample at Soil Healt

NOTE: This form uses required entries to save the record (*). Enter 0 or NA to bypass entries that are not applicable for the management of the field.

Only the creator of the entry can edit/delete it.

Data entry forms (pdf) and supporting documents are available here.

Contact David.Lamm@gnb.usda.gov for project/management assistance and to submit SharePoint access requests. If you experience problems with SharePoint after you have access, contact Holli.Kuyke

New | Actions | Settings

All Items | Find an item

Title	Lab ID-C	Last	First	State	County	Tract	Field	Field Ac	Texture	2013 Crop	Dbl Crop	2014 Crop	2014 Mgmt	2014 Plant Date	SHNT	ST Yr	P Test
View/Edit																	
View/Edit																	
View/Edit	ARS Entry	Enger	Steve	ND	Traill	3893	4250	20	Clay loam	Wheat, Winter	Other	Soybean	No-till (STIR =< 20) - no full width tillage	5/10/2014	No	2011	Bray
View/Edit	ARS Entry	Enger	Steve	ND	Traill	3893	4250	60	Silt loam	Soybean	NA	Soybean	No-till (STIR =< 20) - no full width tillage	6/21/2014	Yes	2012	Bray
View/Edit	ARS	Enger	Steve	ND	Steele	353	142	60	Silt	Soybean	NA	Wheat,	No-till (STIR	10/18/2013	Yes	2012	Bray

125%

Data Collected – Cropland

- 2013 crop
- 2014 crop
- Planting Date
- Management Info (STIR value)
- Soil Test Info (P, K, OM)
- Nutrients (timing, method, material)
- Manure
- Cover Crop used (grass, legume, other)
- CC Termination & estimated height
- Rainfall
- Irrigation

Soil Health Nutrient Tool - Crop - View/Edit

VIEW

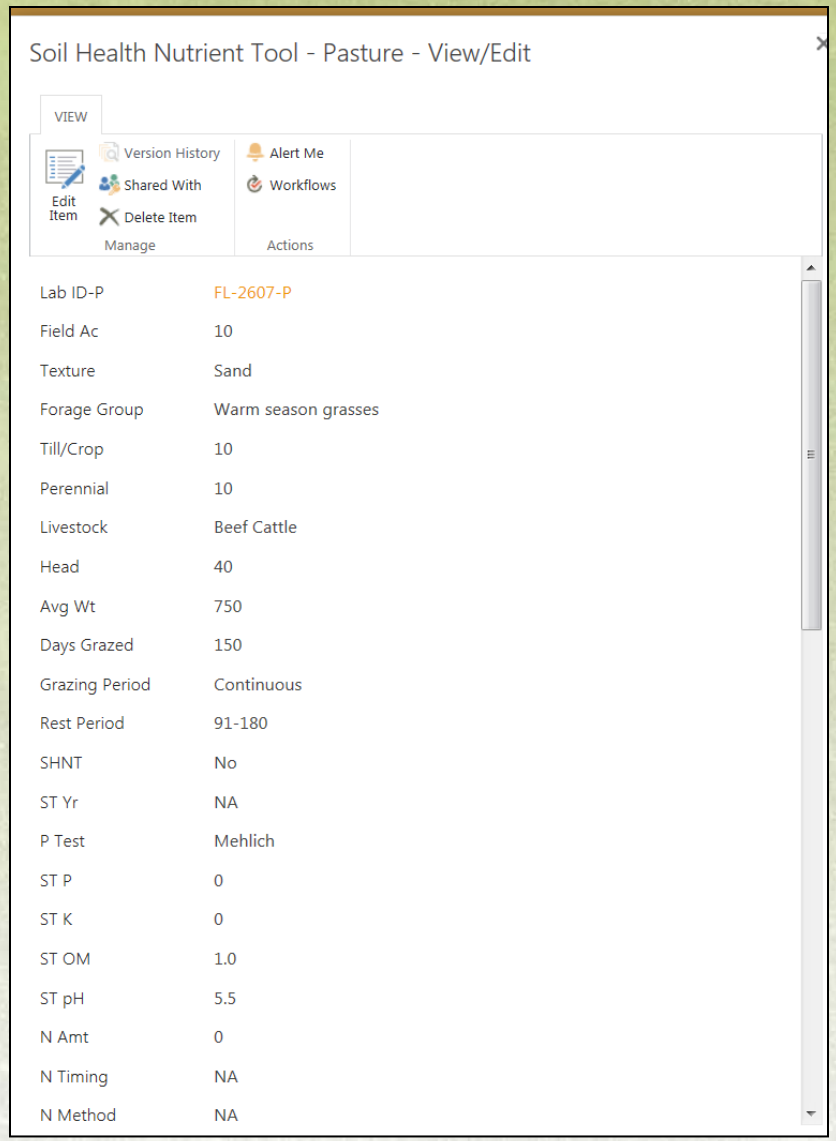
Edit Item | Version History | Shared With | Delete Item | Alert Me | Workflows

Manage | Actions

Lab ID-C	ARS Entry
Field Ac	16
Texture	Silty clay loam
2013 Crop	Vegetables, All
Dbl Crop	Other
2014 Crop	Vegetables, All
2014 Plant Date	7/14/2014
2014 Mgmt	Conventional (STIR > 80) - inverted tillage, heavy disking
SHNT	No
ST Yr	2011
P Test	Olson
ST P	33
ST K	273
ST OM	1.9
ST pH	7.6
N Amt	35
N Timing	At planting
N Method	Banding
N Material	UAN
P Amt	28
P Timing	At planting
P Method	Banding

Data Collected- Grazing Systems

- Soil texture
- Forage Group (Warm season, cool season, legume mix)
- Years since fields been tilled
- Years fields been in perennial cover
- Livestock type
- Number of Head
- Average weight
- Total days grazed
- Grazing system
- Soil Test
- Nutrients (timing, method, material)
- Manure
- Rainfall
- Irrigation



Lab ID-P	FL-2607-P
Field Ac	10
Texture	Sand
Forage Group	Warm season grasses
Till/Crop	10
Perennial	10
Livestock	Beef Cattle
Head	40
Avg Wt	750
Days Grazed	150
Grazing Period	Continuous
Rest Period	91-180
SHNT	No
ST Yr	NA
P Test	Mehlich
ST P	0
ST K	0
ST OM	1.0
ST pH	5.5
N Amt	0
N Timing	NA
N Method	NA

Contact Info

USDA - NRCS

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