STERLING VALLEY
AGRONOMY

Michael Nestor, CCA

Regenerative Ag Agronomist

Where Fungi's and Seeds Get Together!!!

Double P Ranch

Douglas Poole, Regenerative Farmer

Double P Ranch

- Sandy Loam soil in a 6”-9” annual rainfall zone
- Dryland fallow small grains system including winter and spring canola, winter and spring wheat, oats, sunflowers, winter and spring triticale, millet and hemp
- Cattle integration utilizing cover cropped ag fields and native range
- Implementing a fallow elimination plan

60 & 10

60 & 10

Paradigm Shift

Fertilizer Inputs


RESEARC

Introduction

- **N** is a major, if not the single largest, factor in profitable wheat production in the PNW

YIELD x Mkt Price

REVENUE - **COSTS** = **PROFIT**

short-term economics

Average **nitrogen supply requirements**

- Unit N supply (*soil+fertilizer*) requirement for different market classes of wheat
  - Soft white winter and spring: 2.7 lb N/bushel
  - Hard red winter: 3.0 lb N/bushel
  - Hard red spring: 3.6 lb N/bushel
  - Hard white winter/spring: 3.2 lb N/bushel

Where does the nitrogen go?

- 2.7 lbs nitrogen supply per bushel soft white
- At 10% grain protein, grain contains 1 lb N/bu
- 2.7 – 1 = <u>1.7 lb N/bushel left in field</u>
  - Straw = ~0.40 lb N/bu → organic matter
  - Remainder (~50%, or 1.3 lb N/bu) → future residual N in the soil test and available to subsequent crop
  - Loss?

Post-harvest yield and protein assessment

- Low yield, low protein
  - Low N available; severe under-fertilization or N loss
- Low yield, high protein (low test weight)
  - Stress, over-fertilization; high residual N left in soil
- High yield, low protein
  - Target met for soft white; under-fertilized for hard wheat protein goal?
- High yield, high protein
  - Over-fertilized soft white wheat?; target met for hard wheat

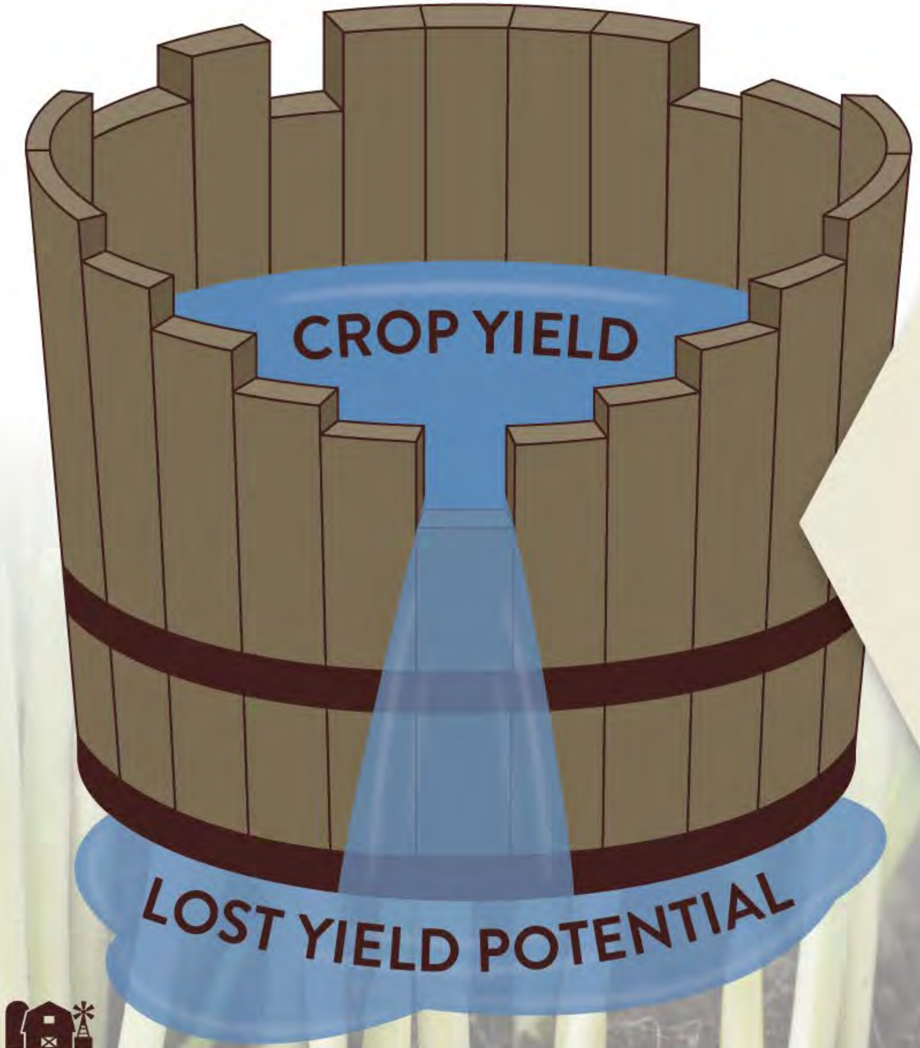
Critical Nutrient Levels for Wheat Tissue Test (Whole Plant, Seedling before Jointing)

Nutrient	Critical Range (% Nutrient in Dry Matter)
N	4-5%
P	0.2-0.5%
K	2.5-5.0%
Ca	0.2-1.0%
Mg	0.14-1.0%
S	0.15-0.65%
Fe	0.003-0.02% (30-200ppm)
Mn	0.002-0.015% (20-150ppm)
Zn	0.0018-0.007% (18-70ppm)
Cu	0.00045-0.0015% (4.5-15ppm)
B	0.00015-0.0004% (1.5-4ppm)
Mo	0.00001-0.0002% (0.1-2.0ppm)

Source: Sampling Plant tissue for Nutrient Analysis, G.J. Schwab, G.D. Lee, and R. Pearce, University of Kentucky Cooperative Extension

THE LAW OF THE MINIMUM: *Liebig's Barrel Metaphor*

A plant's potential is limited if even 1 growth factor is deficient or missing



BARREL STAVES = Individual growth factors that plants need

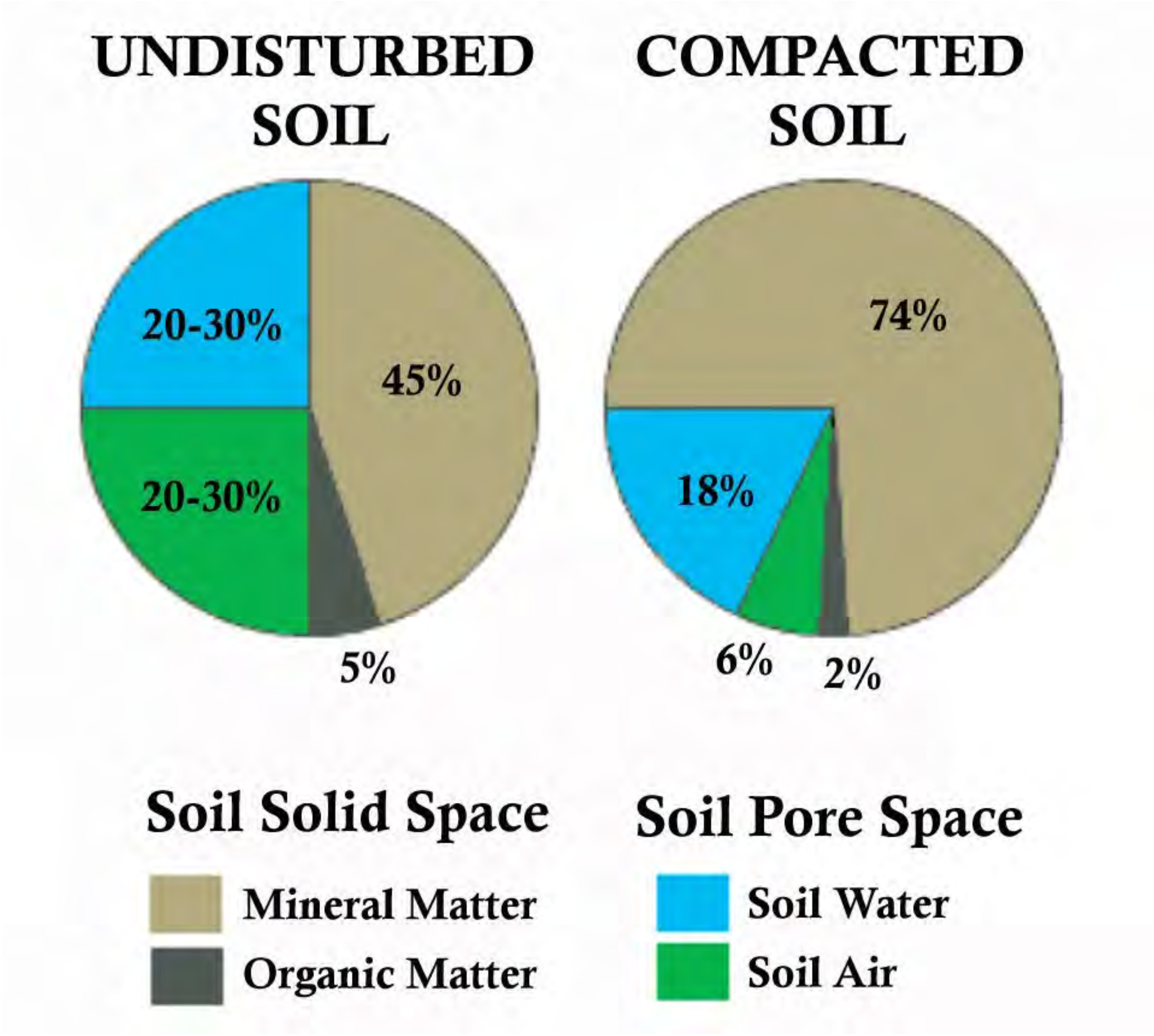
PLANTS NEED THE CORRECT:

- Nutrition
- Light
- Water/ Humidity
- Soil Conditions
- Temperature

Macro-nutrients		
7 N NITROGEN	19 K POTASSIUM	16 S SULFUR
15 P PHOSPHORUS	20 Ca CALCIUM	12 Mg MAGNESIUM

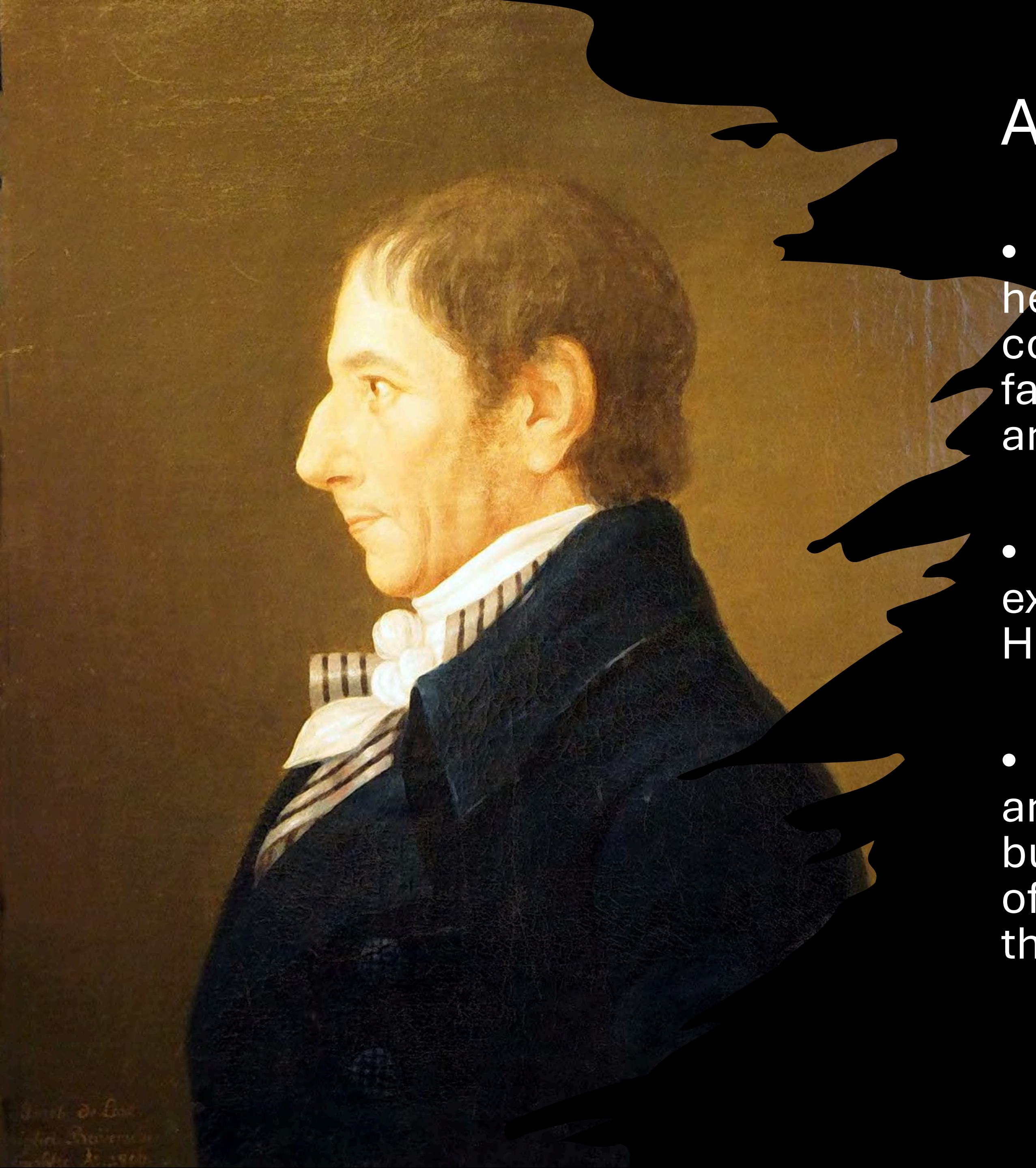
Micro-nutrients			
17 Cl CHLORINE	5 B BORON	25 Mn MANGANESE	28 Ni NICKEL
26 Fe IRON	29 Cu COPPER	30 Zn ZINC	42 Mo MOLYBDENUM

REDMOND


UNDISTURBED SOIL
COMPACTED SOIL
20-30%
45%
20-30%
5%
74%
18%
6%
2%
Soil Solid Space
Mineral Matter
Organic Matter
Soil Pore Space
Soil Water
Soil Air

Fertilizer Inputs

Old Ways



Albrecht Daniel Thaer (1752-1828)

- Albrecht Thaer 1809-1812 was Sprengel's mentor, he published 4 books on the Humus theory. He collected data from one of the first known research farms dedicated to manure usage, crop rotation, and humus.

- Humus theory states plants live on Humus extracts containing simple water compounds of C, H, O, and N (Si and K too)

- The theory claims fertilizer substances like salt and lime were considered useful for plant growth, but only because they promoted the decomposition of humus and the consumption of organic matter in the soil solution.

Carl Sprengel (1787-1859)

Sprengel- Focused on humus. The opinion at that time dating back to Aristotle, was that humus is the immediate source of plant food. And that it was assimilated by means of the mysterious.

Sprengel 1826-1828- Concluded that the increase of plant growth, which is often observed when humus is applied to a soil. Does not result from the humus itself but from the mineral elements that are either present in it or are taken up from the soil as a consequence of the presence of the humus.

Carl Sprengel (1787-1859)

1826 Disproved humus theory in Agronomy

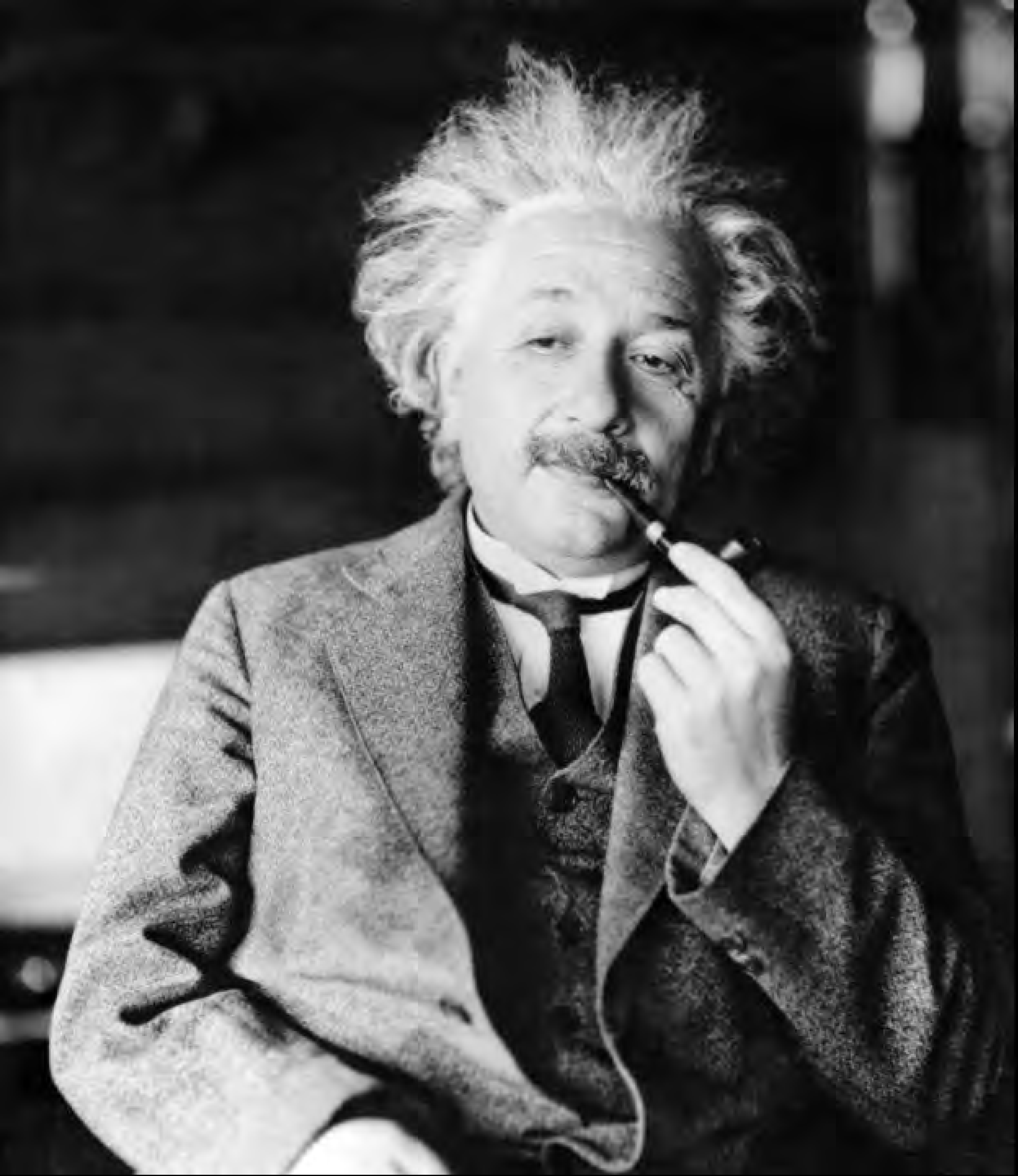
1828 Published theory of the Minimum and 20 elements that are considered plant nutrients

Sprengel and Liebig were colleagues

1840 Justus Von Liebig published the law of the minimum

Liebig used Sprengel’s doctrines to publish the law of the minimum. Not Friends

The International Community of Agronomists created Sprengel-Liebig Medal



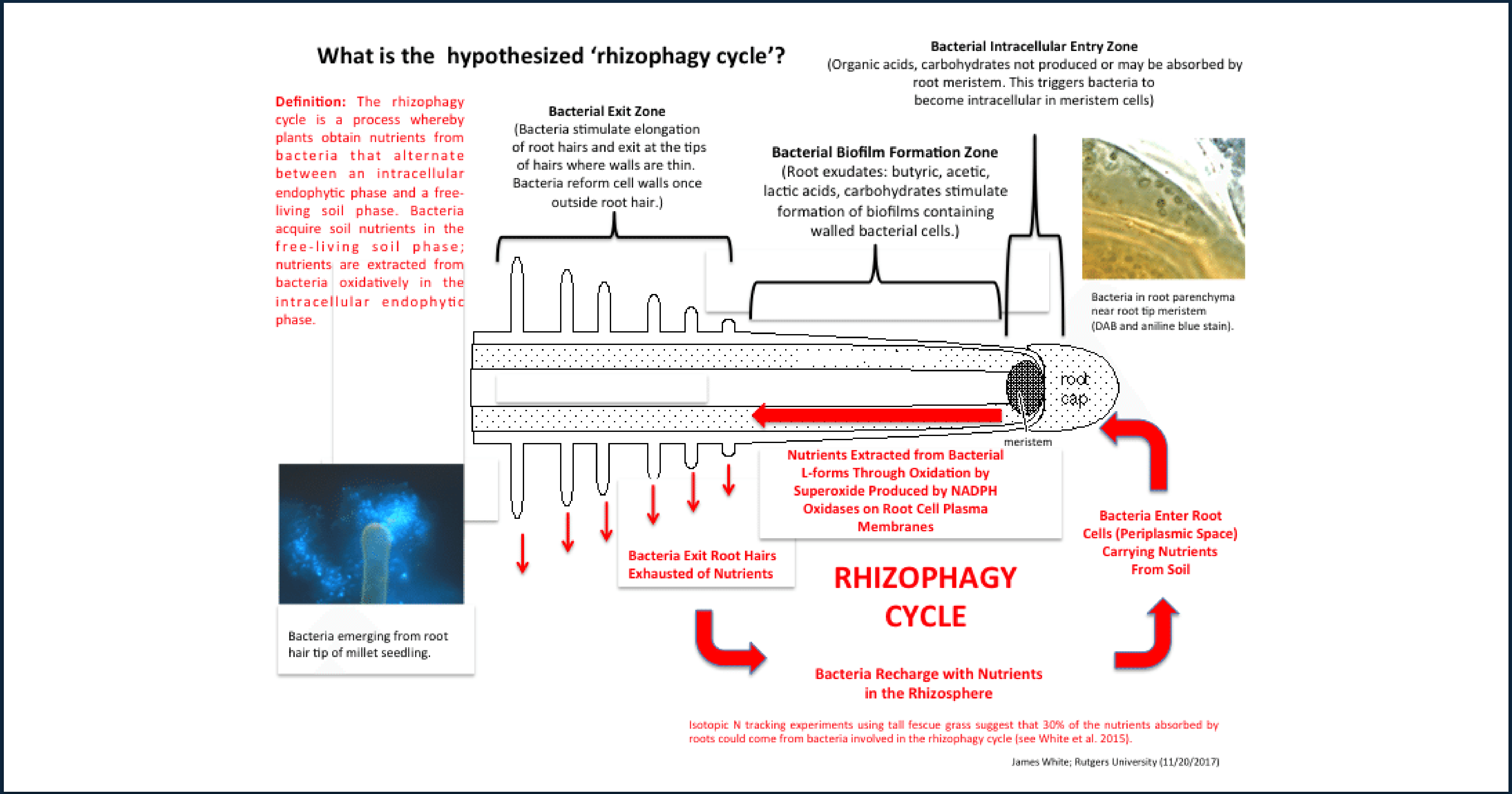
"If you can't explain it simply, you don't understand it well enough."

Albert Einstein

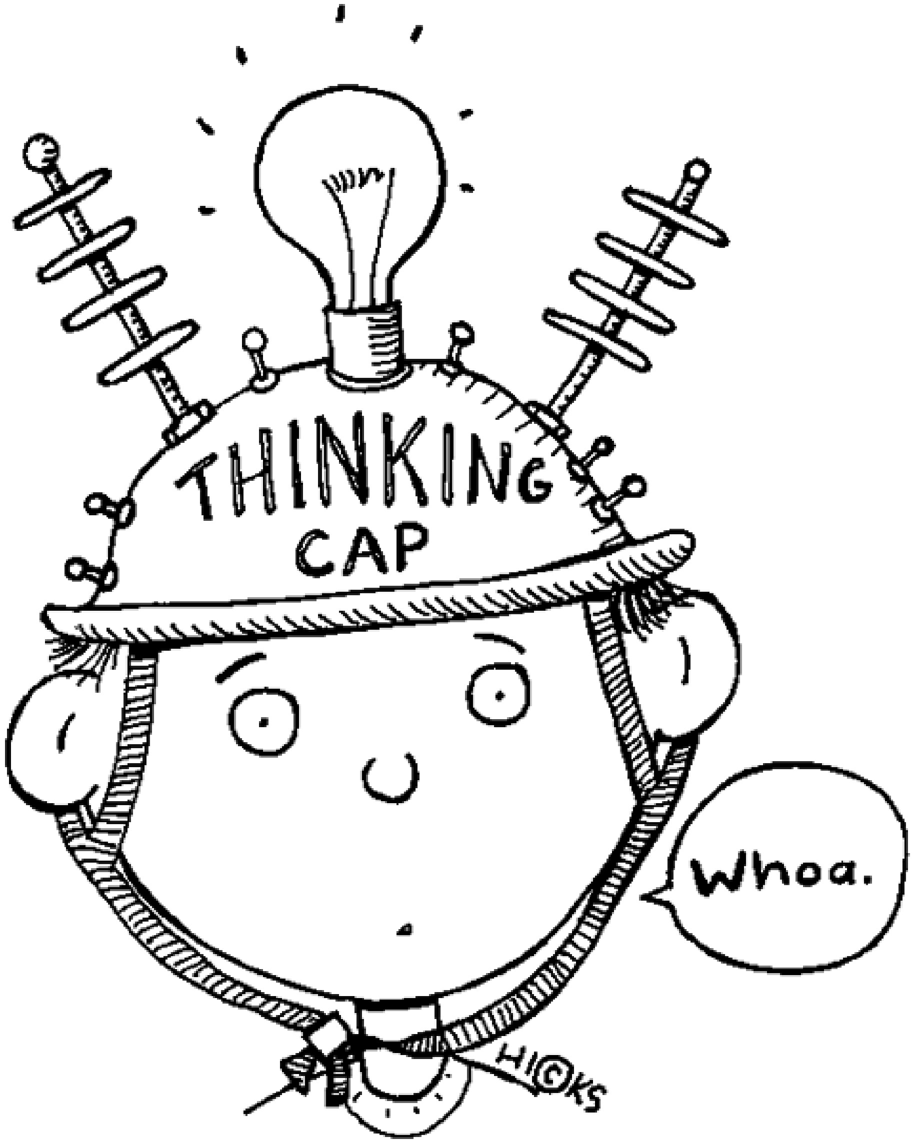
Fertilizer Inputs

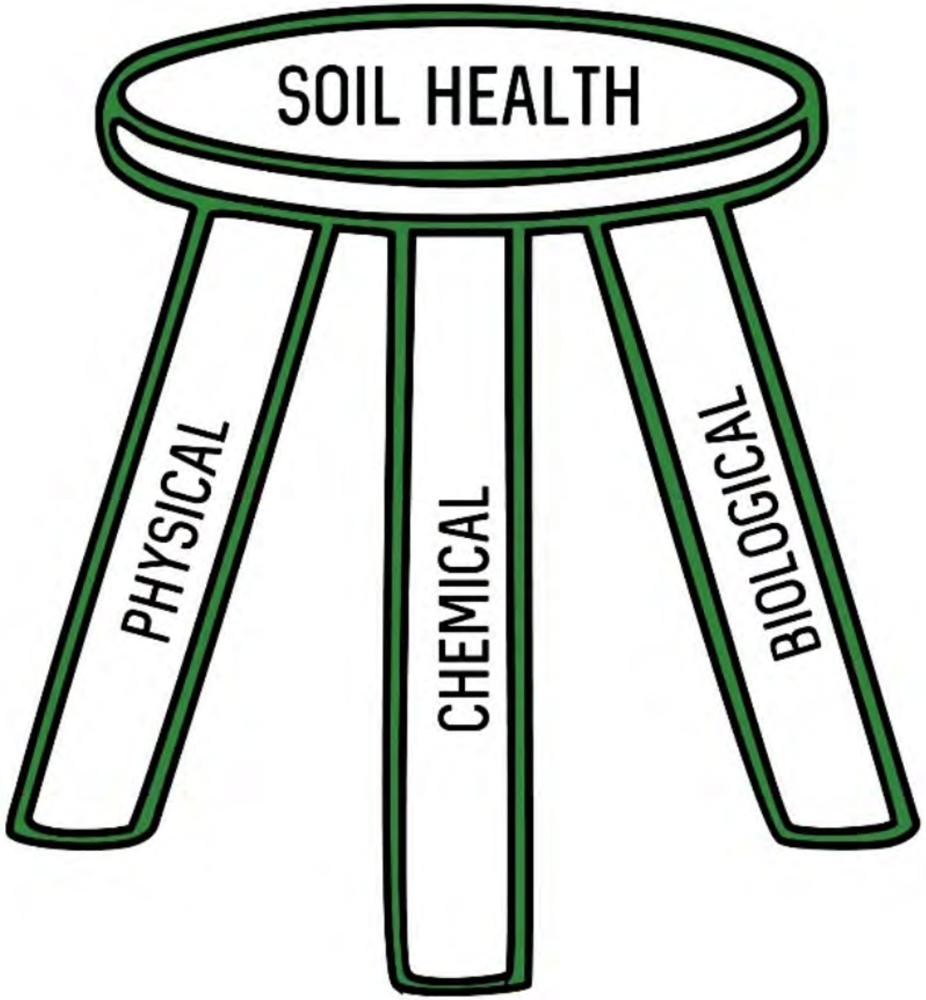

EXIT


WSU
DAD
SPEAKER
THE NORTH FACE



What is the hypothesized 'rhizophagy cycle'?
Definition: The rhizophagy cycle is a process whereby plants obtain nutrients from bacteria that alternate between an intracellular endophytic phase and a free-living soil phase. Bacteria acquire soil nutrients in the free-living soil phase; nutrients are extracted from bacteria oxidatively in the intracellular endophytic phase.
Bacterial Exit Zone
(Bacteria stimulate elongation of root hairs and exit at the tips of hairs where walls are thin. Bacteria reform cell walls once outside root hair.)
Bacterial Biofilm Formation Zone
(Root exudates: butyric, acetic, lactic acids, carbohydrates stimulate formation of biofilms containing walled bacterial cells.)
Bacterial Intracellular Entry Zone
(Organic acids, carbohydrates not produced or may be absorbed by root meristem. This triggers bacteria to become intracellular in meristem cells)
Bacteria in root parenchyma near root tip meristem (DAB and aniline blue stain).
root cap
meristem
Nutrients Extracted from Bacterial L-forms Through Oxidation by Superoxide Produced by NADPH Oxidases on Root Cell Plasma Membranes
Bacteria Exit Root Hairs Exhausted of Nutrients
Bacteria Enter Root Cells (Periplasmic Space) Carrying Nutrients From Soil
Bacteria emerging from root hair tip of millet seedling.
RHIZOPHAGY CYCLE
Bacteria Recharge with Nutrients in the Rhizosphere
Isotopic N tracking experiments using tall fescue grass suggest that 30% of the nutrients absorbed by roots could come from bacteria involved in the rhizophagy cycle (see White et al. 2015).
James White; Rutgers University (11/20/2017)


THINKING
CAP
Whoa.
HICKS


SOIL HEALTH
PHYSICAL
CHEMICAL
BIOLOGICAL

Nutrient Efficiency From Soil Application

Nitrogen	40-50%
Phosphorous	10-20%
Potassium	40%

Ballinger and Bennett,1986; Richardson, 2008; Chen et al, 2008

Foliar vs. Soil Comparison…

Foliar nutrient Rate		Soil applied rate equivalent
Nitrogen	1#/ac	10-15#'s
Phosphate	1#/ac	20#'s
Potassium	1#/ac	27#'s
Calcium	1#/ac	35-40#'s
Magnesium	1#/ac	28#'s
Sulfur	1#/ac	5-7#'s
Zinc	1#/ac	12#'s
Boron	1#/ac	30#'s
Manganese	1#/ac	20-25#'s
Iron	1#/ac	25-100#'s
Copper	1#/ac	35-38#'s

Information provided by Dr. Carl Spiva. A & L Laboratories. Modesto, California

Reducing Synthetic Fertilizers for the Microbes!

Weaning off nitrogen fertilizer

Year 1: reduce by	**20%**
Year 2: reduce by another	**30%**
Year 3: reduce by another	**50%**

Example 100#....80#....50#....25#

Maintenance of 25#/ac soil, foliar, or split app

Test, Test, Test....make adjustments when Needed

Nitrogen reduction journey

2013
began variable rate/zone nutrient applications

2015
began transitioning applied nutrients from in furrow to stream jet application

2015
Began reducing applied Nitrogen by 10-20% year (earn the privilege to foliar)

2020
Eliminated ALL synthetic in furrow applications, replaced by humic, molasses, chicken litter, calcium and other biologicals

2021
Transitioned from stream jet applications to foliar. All foliar's split applied with one application in the fall and one in the spring

Timings and Rates: Winter Wheat and Winter Canola

- Seeding Dates:
  - Canola late August
  - Wheat Early September
- First Foliar: Pre-Winter Antifreeze
  - Canola - Mid to late October 4-6 leaf stage. 2-5lbs. N/acre
  - Wheat - Mid to late October (Feeks 3-4) 2-5lbs. N/acre
- Second Foliar: Spring
  - Canola – Mid April (prebolting). 5-10lbs. N/acre
  - Wheat – Mid April (Feeks 4-7). 5-10lbs. N/acre


Biology

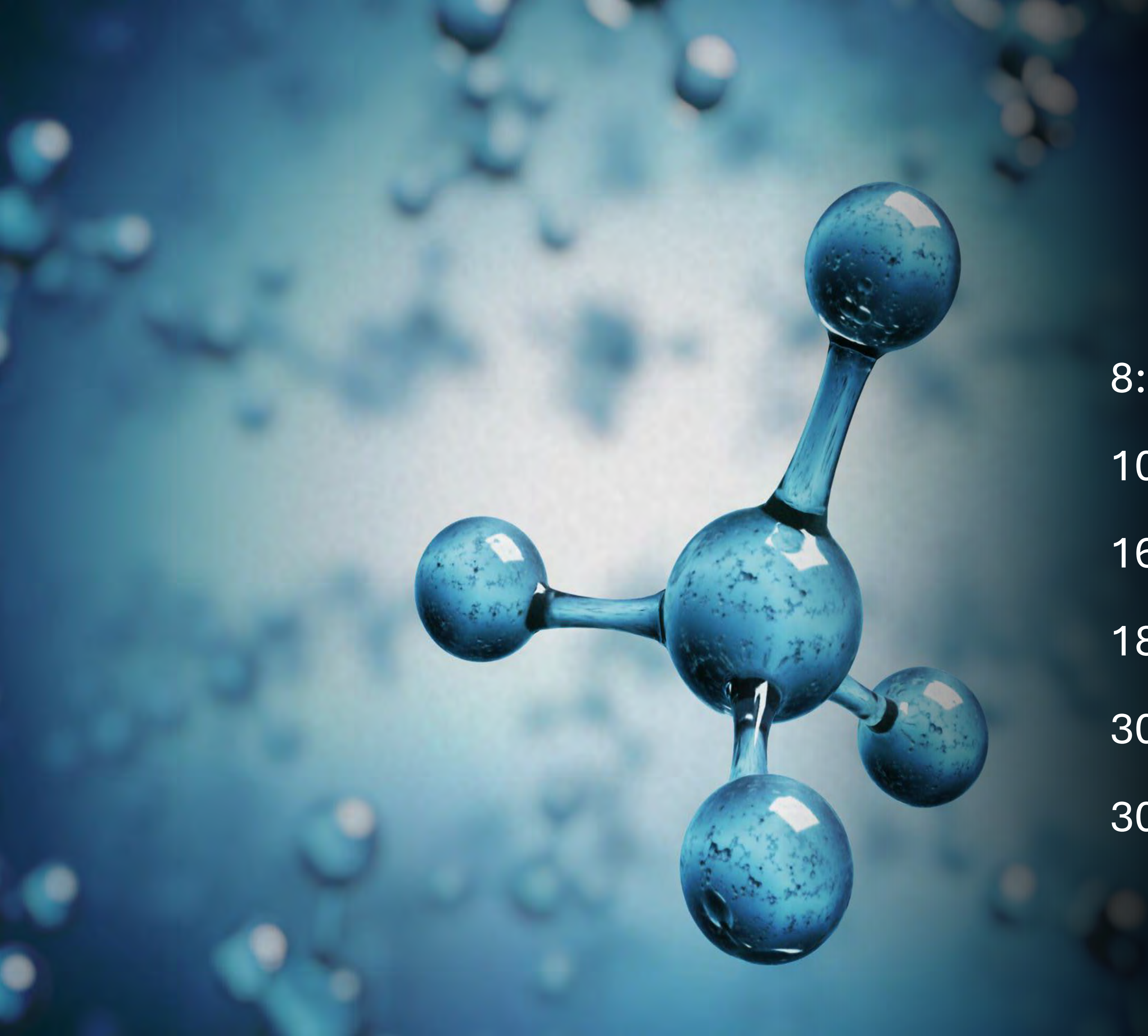
TOTAL NUTRIENT DIGESTION ANALYSIS REPORT

Lab # 4475

	Nutrient Results		Nutrients, Lbs/A	Fertilizer Equivalent, lbs of Fert*	
Nutrient	**Value**	**Units**	**Value**	**Value**	**Reference Fertilizer**
Carbon	0.65	% C	11736	19560	60% C
Nitrogen	0.081	% N	1458	3170	46-0-0
Phosphorus	0.060	% P	1071	4719	11-52-0 at 22.7% P
Potassium	0.250	% K	4503	8727	0-0-60 at 51.6% K
Calcium	0.465	% Ca	8364	38017	Gypsum-22% Ca
Magnesium	0.396	% Mg	7135	67951	K-Mag-10.5% Mg
Sulfur	0.007	% S	128	533	AMS-24% S
Zinc	49.35	ppm Zn	88.8	254	ZnSO4-35% Zn
Iron	20354.92	ppm Fe	36639	183194	FeSO4-20% Fe
Manganese	443.57	ppm Mn	798	2576	MnSO4-31% Mn
Copper	23.81	ppm Cu	42.9	171	CuSO4-25% Cu
Boron	12.16	ppm B	21.9	199	Borax-11% B
Sodium	0.025	% Na	450		
Molybdenum	0.04	ppm Mo	0.1	0.2	NaMoO4-39% Mo
Aluminum	11835.56	ppm Al	21304		
C:N Ratio	8.0				

Reviewer Comments

**Lbs of fertilizer needed to be equal to Lbs of soil nutrient/A*



C:N Ratio- Effect on soil Microbes.....

8:1 = Not Much Going On

10:1 = Barely Functioning

16:1 = Microbes Start to Reproduce

18:1 = Mycorrhizal Activity Starts

30:1 = Compost – Worm Castings

30:1 = Humans - Animals

Double P Ranch

Rawlins

PLFA Test

PLFA Soil Microbial Community Analysis

Functional Group Biomass & Diversity

Total Living Microbial Biomass, Phospholipid Fatty Acid (PLFA) ng/g	**923.35**
Functional Group Diversity Index	**0.605**

Total Biomass	Diversity	Rating
< 500	< 1.0	Very Poor
500+ - 1000	1.0+ - 1.1	Poor
1000+ - 1500	1.1+ - 1.2	Slightly Below Average
1500+ - 2500	1.2+ - 1.3	Average
2500+ - 3000	1.3+ - 1.4	Slightly Above Average
3000+ - 3500	1.4+ - 1.5	Good
3500+ - 4000	1.5+ - 1.6	Very Good
> 4000	> 1.6	Excellent

Functional Group	Biomass, PLFA ng/g	% of Total Biomass
Total Bacteria	**222.64**	**24.11**
Gram (+)	**222.64**	**24.11**
Actinomycetes	65.34	7.08
Gram (-)	**0.00**	**0.00**
Rhizobia	0.00	0.00
Total Fungi	**0.00**	**0.00**
Arbuscular Mycorrhizal	**0.00**	**0.00**
Saprophytes	**0.00**	**0.00**
Protozoa	**0.00**	**0.00**
Undifferentiated	**700.71**	**75.89**

Infinity I-4 Microscope

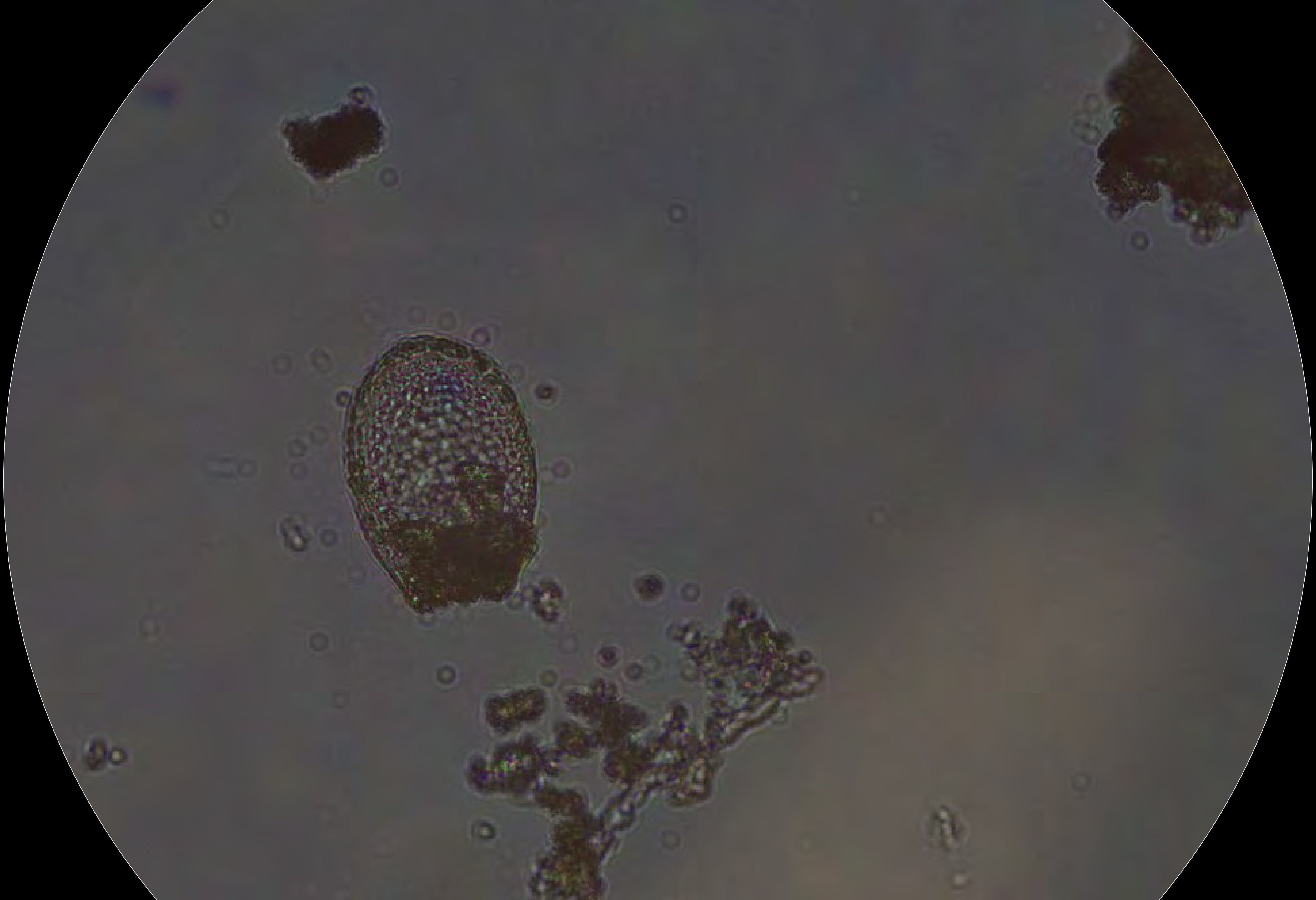
4k Digital Camera

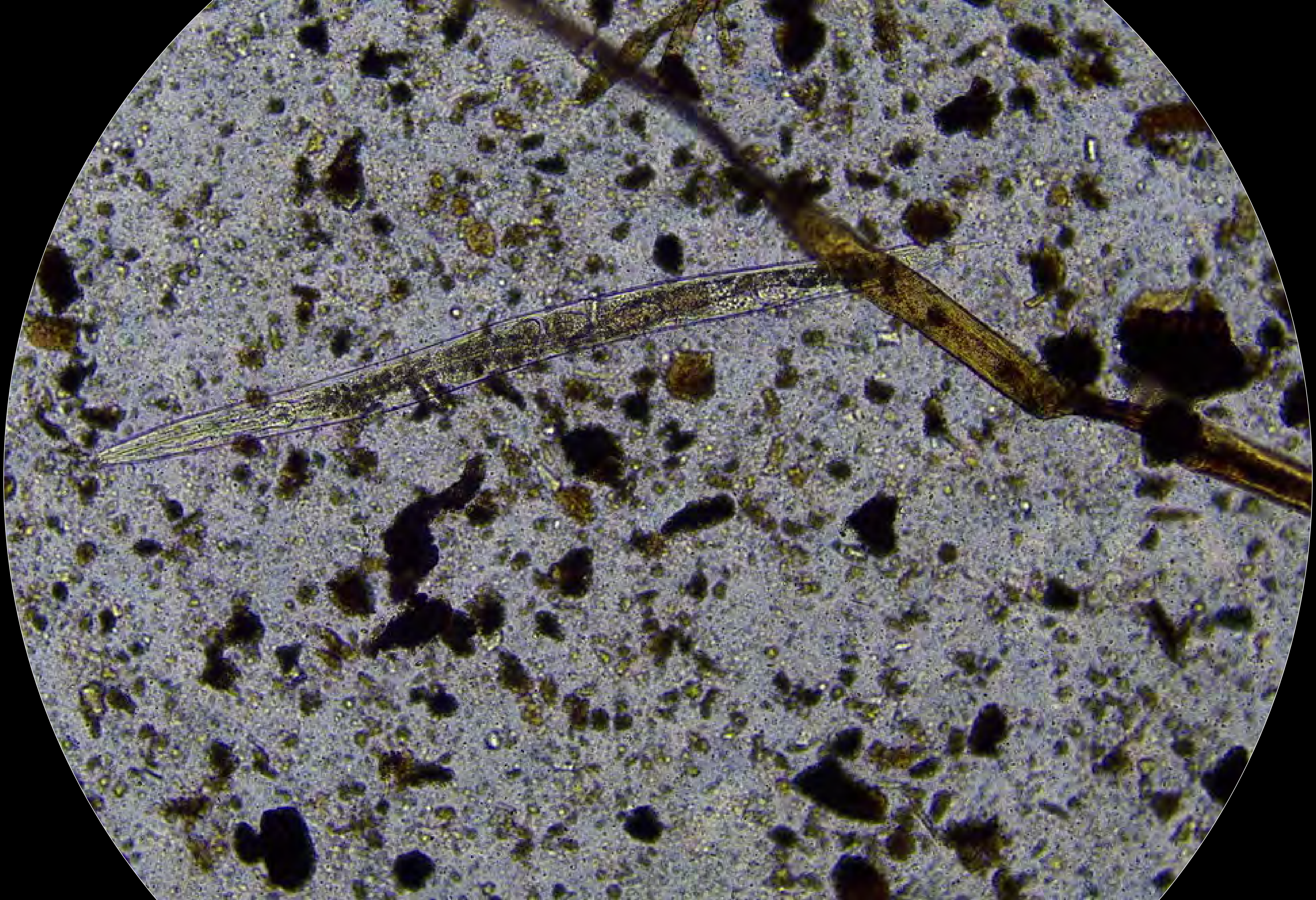
Epi-Fluorescence Module

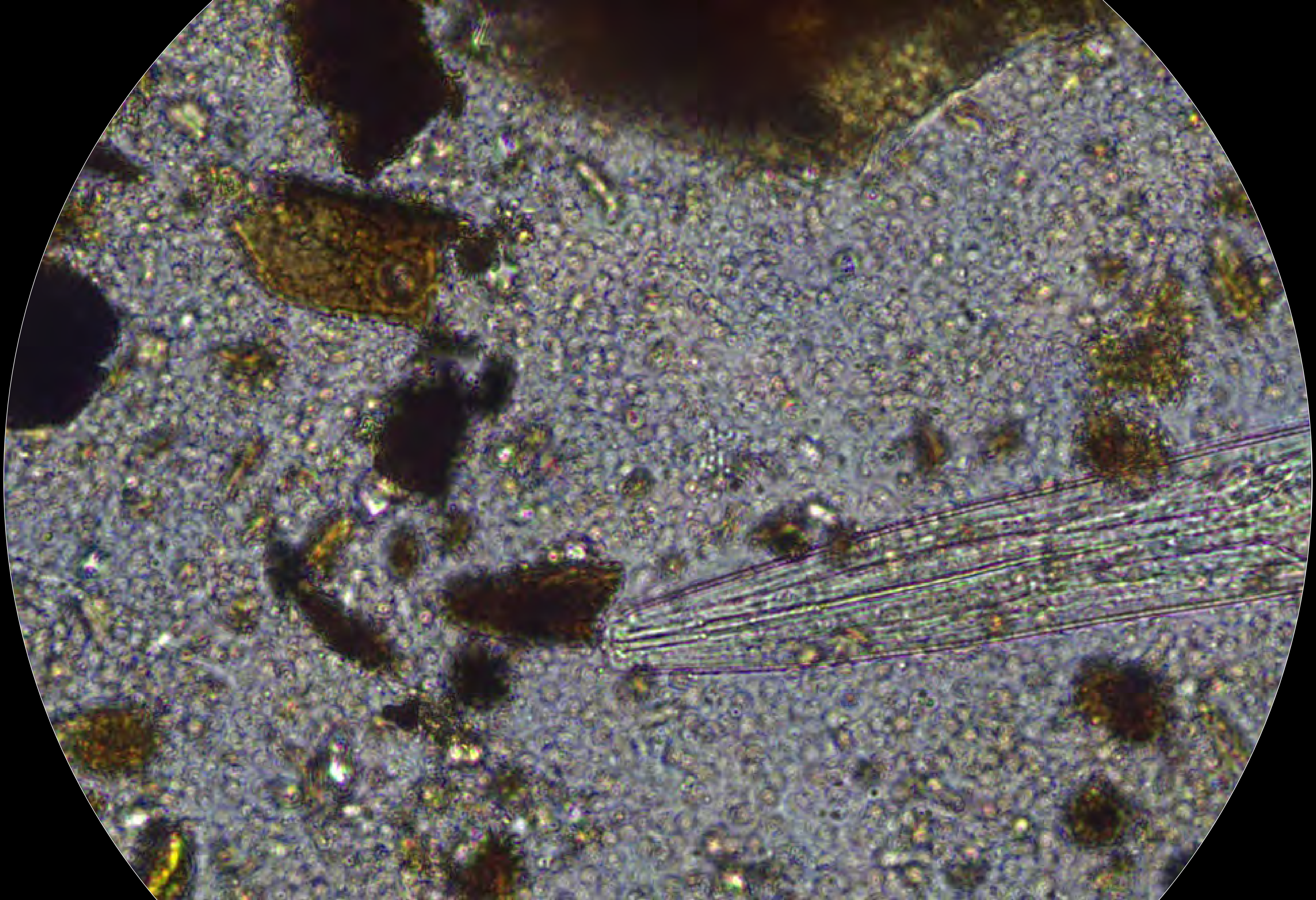
Soil Food Web

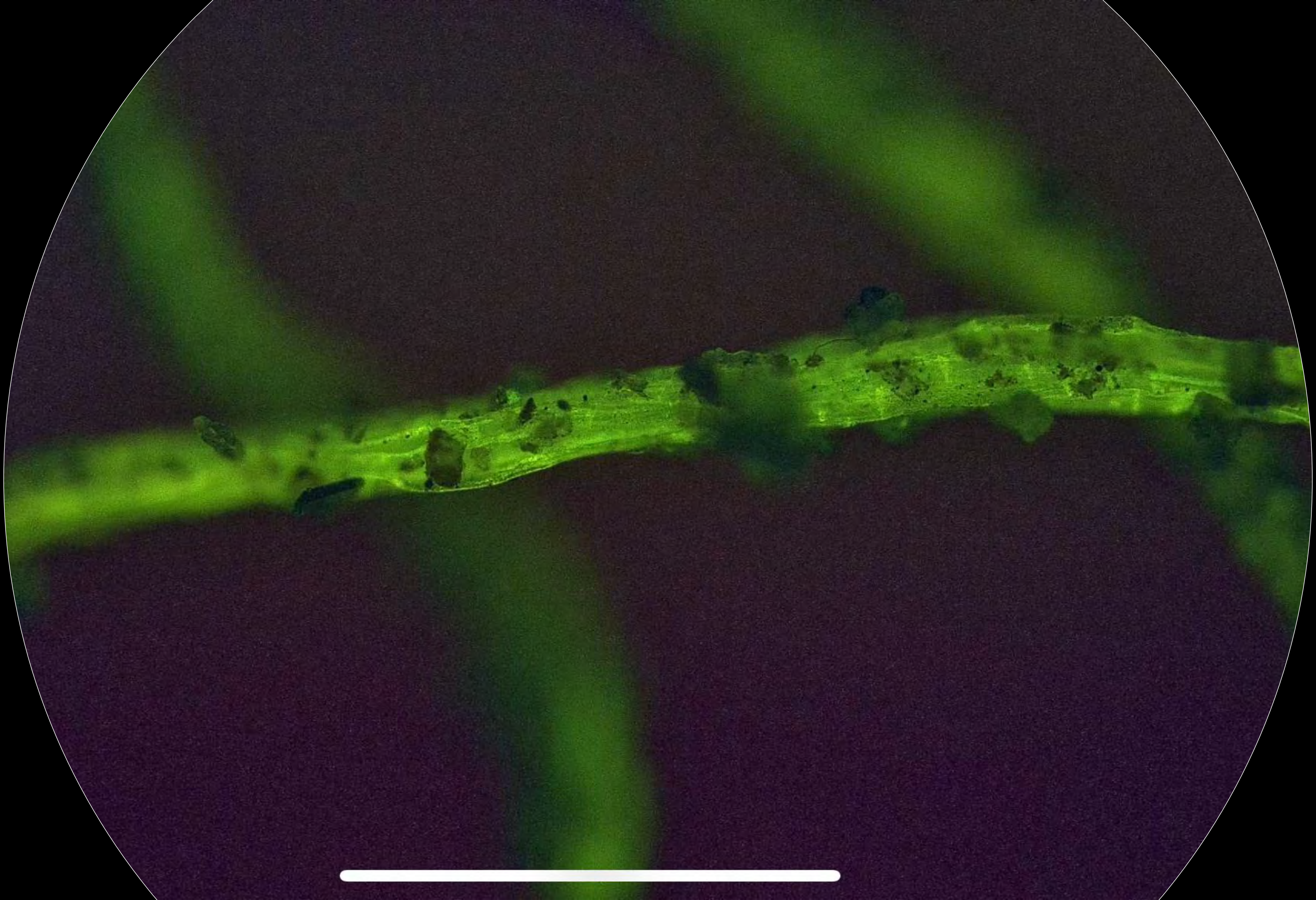
Carbon to Nitrogen Ratio

Bacteria	5:1
Fungi	20:1
Protozoa	30:1
Nematodes	100:1
Humans	30:1
Lettuce	30:1
Wood	500:1









Soil Balancing Methods....

Plant Biochemical Sequences

1. Boron-which activates
2. Silcon, which carries all other nutrients, starting with

3. Calcium, which binds

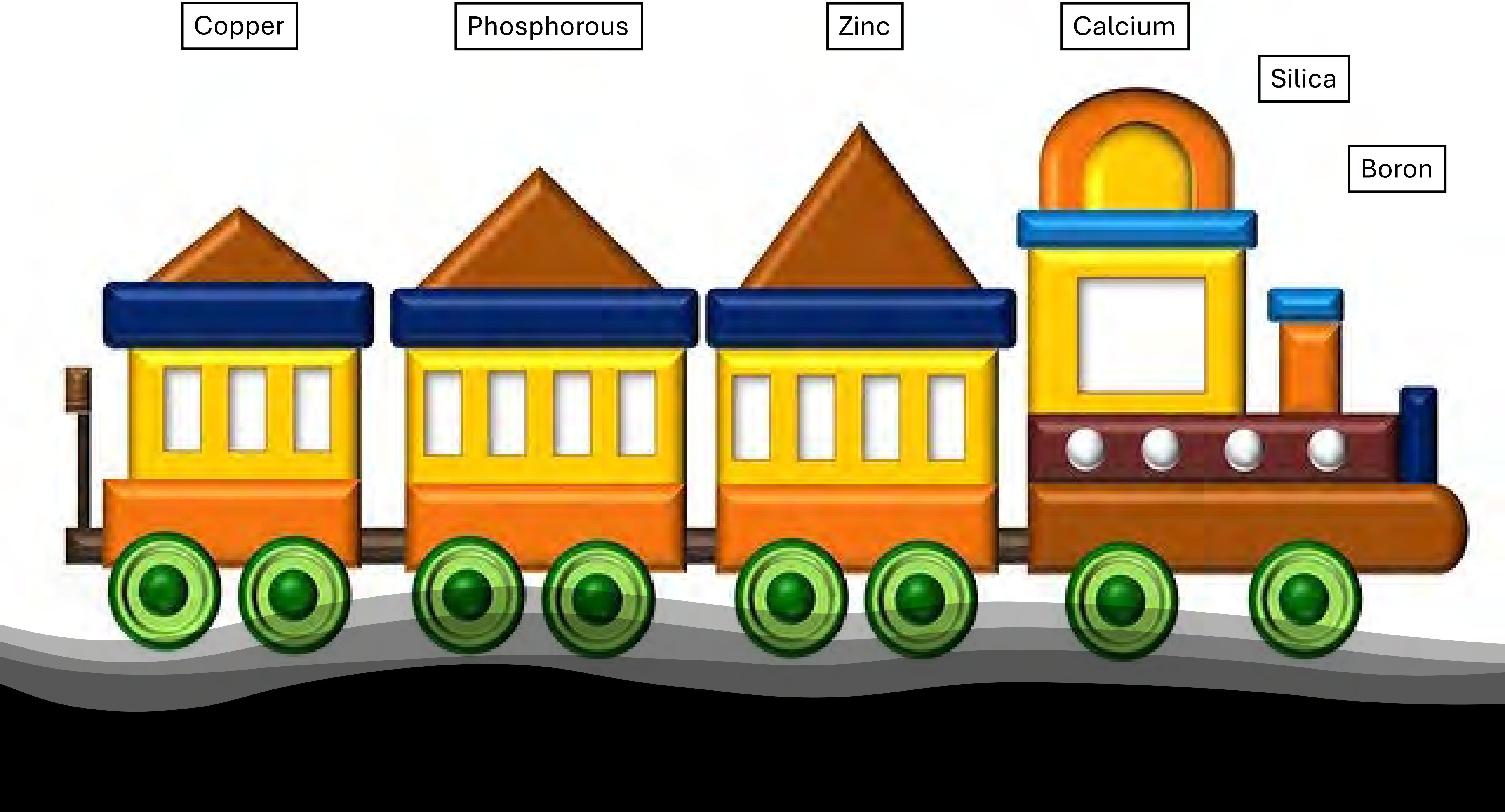
4. Nitrogen to form amino acids, DNA and cell division. Amino acids form proteins such as chlorophyll and tag trace elements, especially

5. Magnesium, which transfers energy via

6. Phosphorus to

7. Carbon to form sugars which to were

8. Potassium carries them. This is the basis of plant growth


Copper
Phosphorous
Zinc
Calcium
Silica
Boron

Let's Talk Brix....

10% Brix in Plants is an Indicator of
50% less Nitrogen is Required

Because the
Carbon, Oxygen, and Hydrogen are Present

Weeds get Smaller and
Compete Less Against Cash Crop

After You Dry Plant Biomass- 80% Water- H_2O

The Remaining

20% is.....

Glucose- C_6-H_{12}-O_6

47% Carbon

43% Oxygen

4% Hydrogen

3% Nitrogen

3% Soil Minerals

Sucrose- C_{12}-H_{22}-O_{11}

Fructose- C_6-H_{12}-O_6


C
(42.0%–47.0%)
H
(6.0%)
N
(1.0%–5.0%)
Ca
(0.3% – 5.0%)
O
(40.0%–44.0%)
P
(0.05%–0.8%)
Fe
(0.005%–0.1%)
Zn
(0.001%–0.01%)
K
(0.3%–5.0%)
Si
(0.05% –3.0%)
B
(0.005%–0.01%)
Mg
(0.05%–1.0%)
S
(0.05%–0.8%)
Na
(0.02%–0.5%)
Cl
(0.02%–1.0%)
Mn
(0.002%–0.03%)

Critical Nutrient Levels for Wheat Tissue Test (Whole Plant, Seedling before Jointing)

Nutrient	Critical Range (% Nutrient in Dry Matter)	
N	4-5%	40,00-50,000ppm
P	0.2-0.5%	2,000-5,000ppm
K	2.5-5.0%	25,000-50,000ppm
Ca	0.2-1.0%	2,000-10,000ppm
Mg	0.14-1.0%	1,400-10,000ppm
S	0.15-0.65%	1,500-6,500ppm
Fe	0.003-0.02% (30-200ppm)	
Mn	0.002-0.015% (20-150ppm)	
Zn	0.0018-0.007% (18-70ppm)	
Cu	0.00045-0.0015% (4.5-15ppm)	
B	0.00015-0.0004% (1.5-4ppm)	
Mo	0.00001-0.0002% (0.1-2.0ppm)	

Source: Sampling Plant tissue for Nutrient Analysis, C.J. Schwab, G.D. Lee, and R. Pearce, University of Kentucky Cooperative Extension

Winter Wheat

PPM Requirements

Potassium	230,000-280,000ppm
Calcium	80,000-86,000ppm
Magnesium	20,000-24,000ppm
Sodium	750-800ppm
Ammonium Nitrogen	20,000-25,000ppm
Nitrate Nitrogen	45,000-50,000ppm
Chloride	90,000-110,000ppm
Sulfur	20,000-25,000ppm
Phosphorous	40,000-45,000ppm

Winter Canola

PPM Requirements

Potassium	290,000-320,000ppm
Calcium	140,000-150,000ppm
Magnesium	25,000-30,000ppm
Sodium	3,000-3,500ppm
Ammonium Nitrogen	30,000-35,000ppm
Nitrate Nitrogen	77,000-85,000ppm
Chloride	60,000-65,000ppm
Sulfur	55,000-60,000ppm
Phosphorous	50,000-70,000ppm

Observations and results

- Yields:
  - All fields exceeded farm average by at least 15%
    - Two canola fields (600 acres) and 6 wheat fields (1,500 acres) exceeded farm average by 35%
- Inputs:
  - Overall nutrition costs reduced by 15%
- Anecdotal observations:
  - Crop vigor in the fall exceeded previous years
  - Weed and pest pressures were significantly lower
  - Brix readings usually several points higher than neighboring fields

Naked Seed Trial

Hartline Spring Wheat

Hard White 12% Protein

Worm Casting Faster Emergence- May 9th

Terraxa Seed Treatment

Plus Expensive Phos Starter

Worm Casting Extract

Naked Seed Trial

Hartline Spring Wheat

Hard White 12% Protein

Worm Casting Faster Emergence- May 9th

Sap Sampling -June 1st

Terraxa Seed Treatment

Plus Expensive Phos Starter

Worm Casting Extract

Naked Seed Trial

Hartline Spring Wheat

Hard White 12% Protein

Worm Casting Faster Emergence- May 9th

Sap Sampling -June 1st

Regular Tissue Testing- June 30th

Terraxa Seed Treatment

Plus Expensive Phos Starter

Worm Casting Extract

Naked Seed Trial

Hartline Spring Wheat

Hard White 12% Protein

Worm Casting Faster Emergence- May 9th

Sap Sampling -June 1st

Regular Tissue Testing- June 30th

Regular Tissue Testing –July 14th

Terraxa Seed Treatment

Plus Expensive Phos Starter

Worm Casting Extract

Naked Seed Trial

Hartline Spring Wheat

Hard White 12% Protein

Worm Casting Faster Emergence- May 9th

Sap Sampling -June 1st

Regular Tissue Testing- June 30th

Regular Tissue Testing –July 14th

Terraxa Seed Treatment

Plus Expensive Phos Starter

Field #02

129 bu/ac

16% Protein

57# Test Weight

221 Falling Numbers

160 #'s of Nitrogen

Applied

Worm Casting Extract

Side by Side

2 Bushels Better

Field #11

123 bu/ac

12.53% Protein

57# Test Weight

280 Falling Numbers

5#'s of Nitrogen

Applied + Micro's

Questions?

Thank you!