33rd Annual NATIONAL NO-TILLAGE CONFERENCE

January 7-10, 2025 • Louisville, Ky.

Understanding Biologicals

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Instructions

- ***Send your presentation to Joseph Kuenzle @ jkuenzle@lessitermedia.com prior to December** 30th.*

If your presentation is too large to submit via email, please upload your presentation to Google Drive.

- ***We will have your presentation loaded on the computer and ready for you when you arrive. We will also arrange for printouts.***

- ***NTF* will provide the computer and projector. Plan on giving your presentation from the podium on the laptop computer**

Should you have any questions on how to use this template or upload your files, contact Joseph Kuenzle at 262-782-4480, ext. 434 or jkuenzle@lessitermedia.com

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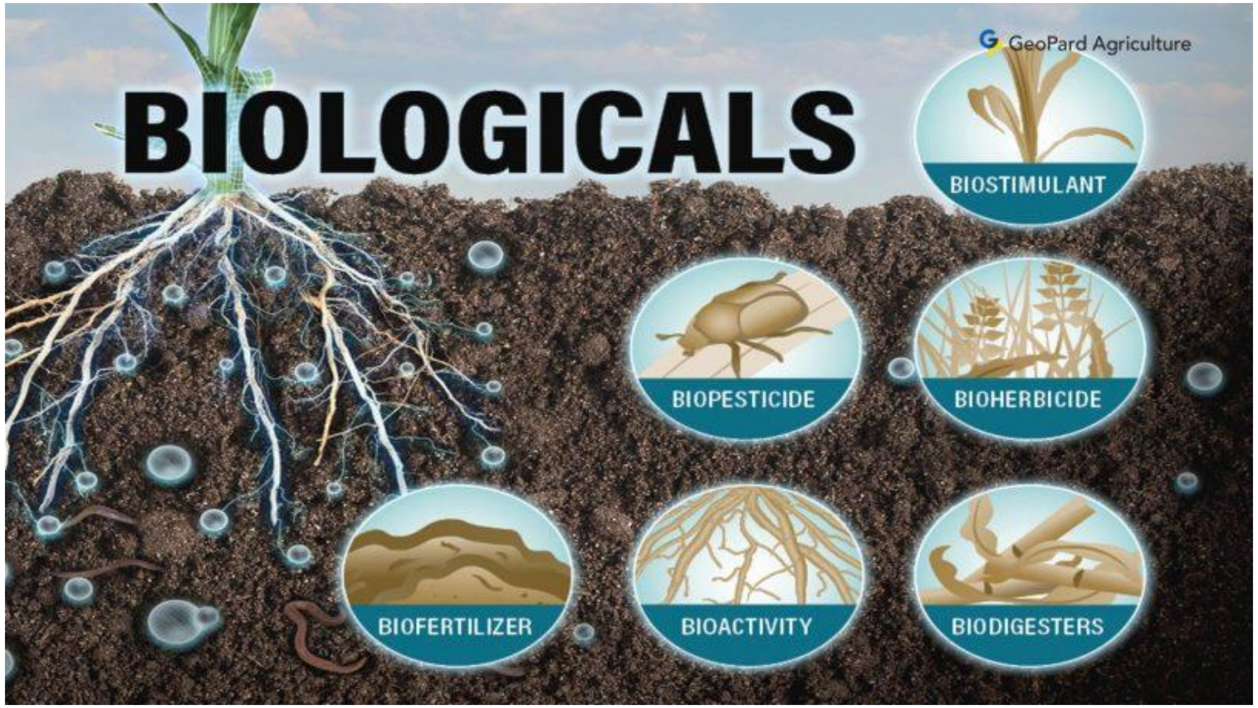
Biologicals

Dr. Connor Sible, University of Illinois estimates that by 2032, farmers will spend $32 billion/year on biological products.

Currently, biologicals enhanced seed growth (25%), fertility (25%), pest management (25% on insect, disease, weed control) and another 25% are specialty products.



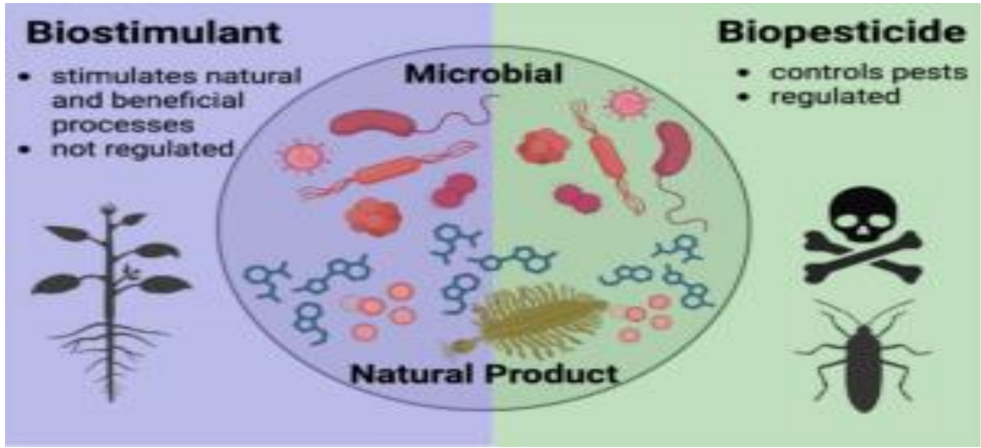
What Are Biologicals?

Biologicals: Both living organisms (microbes, others) and nonliving byproducts of the living or other substance that improve plant growth.

Living Organisms:

Biofertilizers: (microbes that improve plant nutrition);

Biopesticides: (microbes that control or kill pathogens, insects, other pests);



Growth hormones: Help plants survive environmental stresses (drought, temperature, soil pH, wet soils) etc. (drought, temperature, soil pH, wet soils) etc.

What Are Biologicals?

Non-Living

Byproducts of Living Organisms: Peptides, Amino Acids, Enzymes.

Humates: Fulvic Acid (FA), Humic Acid (HA)

Marine Extracts: Seaweed, Kelp

Sugars: Sugars (Simple to complex)

Six Major Types of Living Organisms

Fungi: (Arbuscular Mycorrhizae Fungi, Saprophytic Fungus or Decomposers)

Bacteria:

a) Nitrogen Fixers: Rhizobium, Free Living Bacteria
b) Phosphorus Solubilizers
c) Rhizophagy Bacteria (*Pseudomonas*)

Micro-fauna: Protozoa & Nematodes

Macrofauna: Small Arthropods (springtails, mites, sow bugs, etc that help with decomposers)

Biopesticides: BT bacteria

Bio-controllers: Metarhizium Fungi (Consume soft body insect larva).

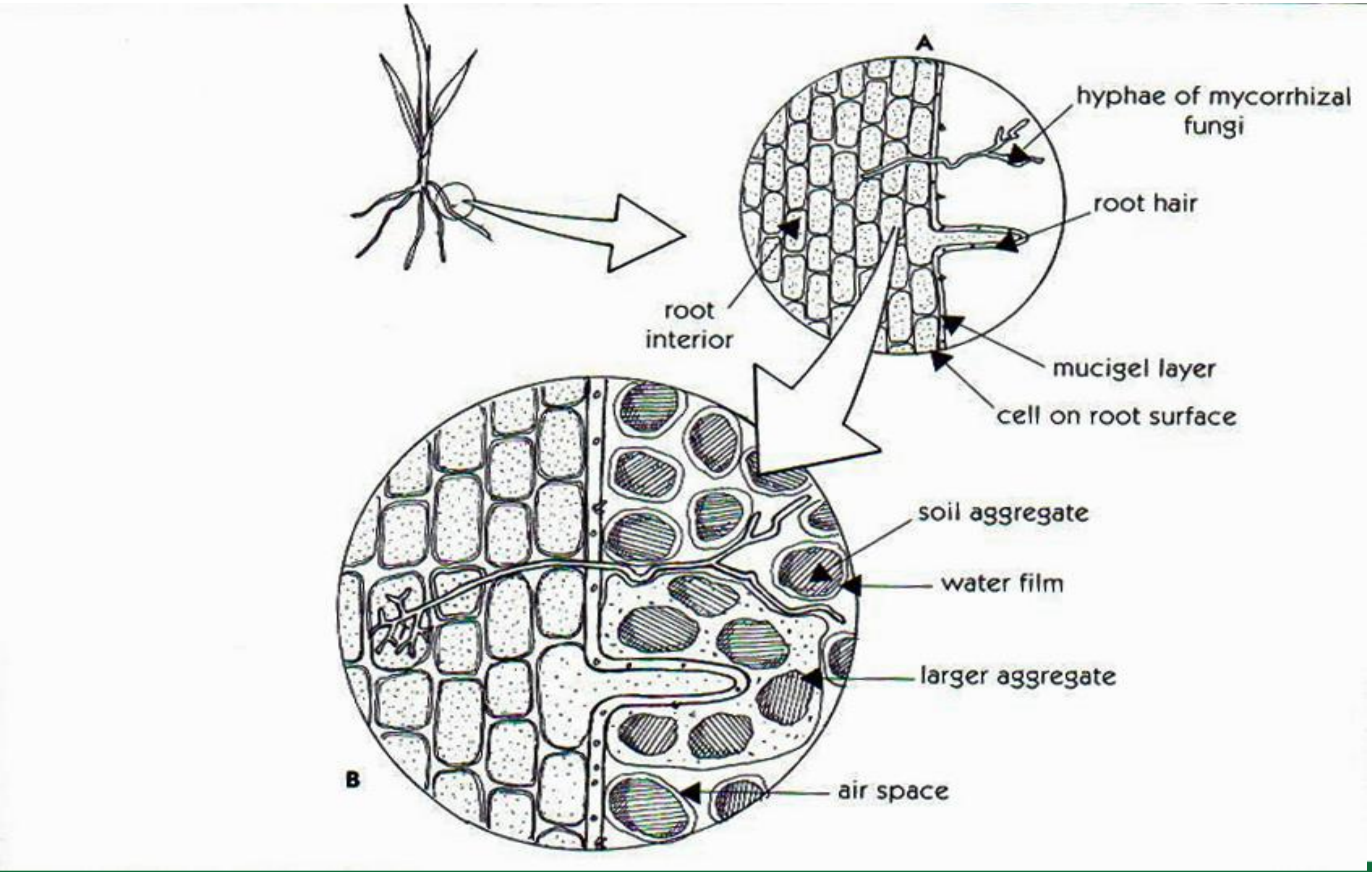
Mycorrhizae Definition

What are Mycorrhizae?

- The word **Mycorrhizae** was first used by german researcher A.B Frank in 1885 and originates from the Greek mycos, meaning "fungus" and "rhiza" meaning "root".
- Mycorrhizae is a symbiotic **mutualistic relationship** between special soil fungi and fine plant roots: it is neither the fungus nor the root but rather the structures from these two partners.

AMF started plant relationships 350 to 450 million years ago, when plants had few roots!
Davide Moore
World of Fungus

Mycorrhizae (AMF) Fungus



Source: Better Soils for Better Crops

Mycorrhizae Associations with Plants

90% of all plant families associate with mycorrhizae.

60% of fungi have host specific plants & about 150-250 AMF species (Amaranthus & Simpson, 2011)

Oats, sorghum, Sudan, sorghum-Sudan, flax, sunflower, and red clover (most legumes) build fungal populations and increase AMF diversity.

Wendy Taheri, TerraNimbus – found some new wheat varieties are not colonized by AMF.

Sixteen Reasons to Care about AMF

1. Increased Soil Fertility
2. Build soil structure & increase soil water holding capacity
3. Produce a more nutritious food for humans and livestock
4. Replace/reduce harmful chemicals
5. Eliminate nutrient runoff & leaching
6. Increased plant nutrient use efficiency particularly phosphorus
7. Increased essential oil production

Sixteen Reasons to Care about AMF

8. Protection from Nematodes
9. Protection from Fungal & Bacterial Plant Diseases
10. Drought Tolerance
11. Salinity Resistance
12. Earlier Flowering
13. More Flowers and More Fruit
14. More Biomass = Increased Yields
15. Sequester Carbon in the Soil
16. Pollinators Prefer Mycorrhizal Plants

Problems with AMF?

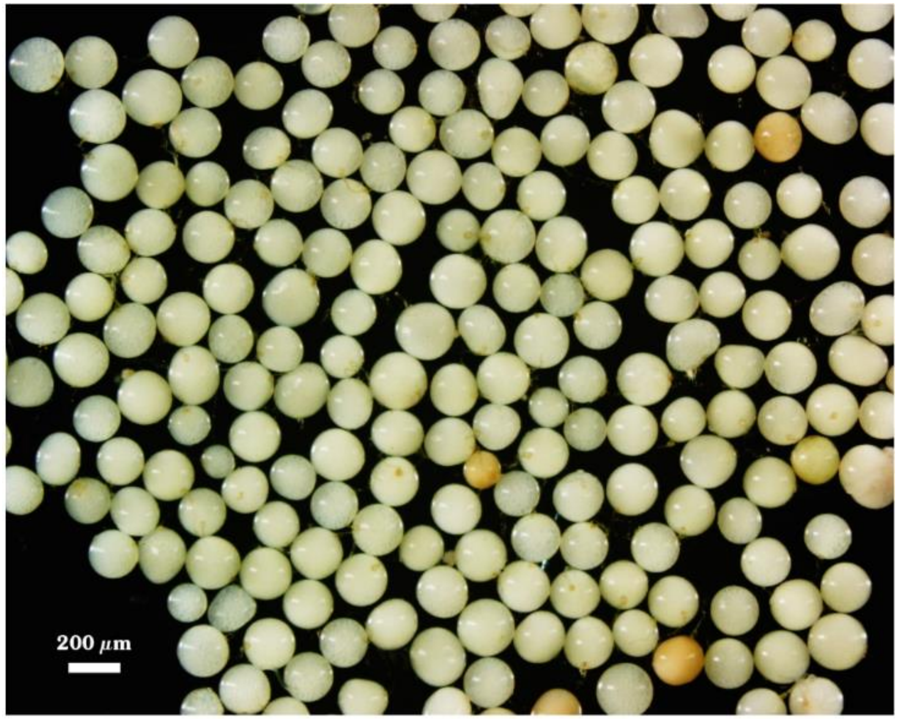
What Species do you Need?

What Species do you Have?? It costs at least $5K to $10K to find out.

What is the Distribution in your Soil?? Like soil testing, it varies across the field based on soil type, management history, environmental conditions.

How do you get them if you do not have them?
Need right soil conditions: No-till, cover crops, living roots.

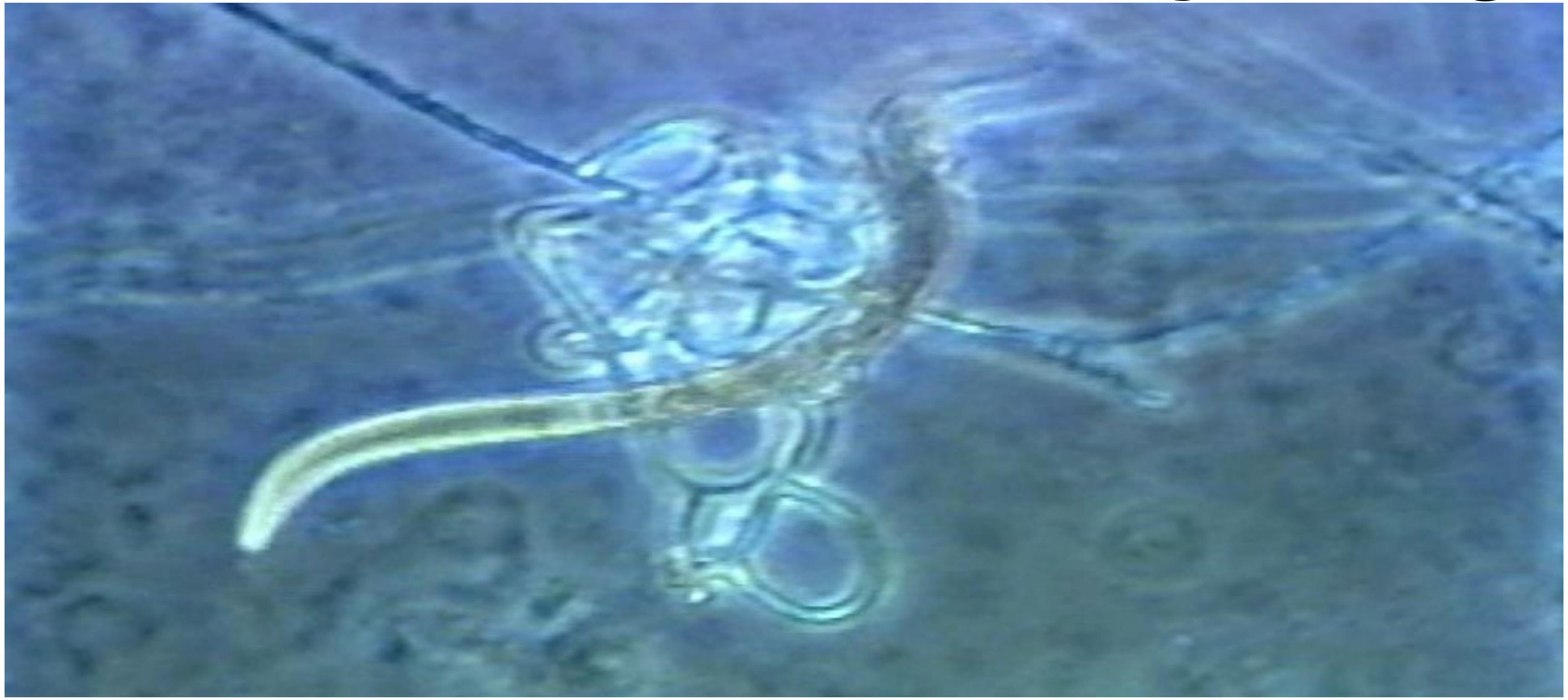
AMF Genera in Corn



Glomeraceae (15 species)
Gigasporaceae (18 species)
Diversisphoraceae (3 species)
Acaulosporaceae (13 species)
Clariodeoglomereceae (4 species)
Paraglomaceae (2 species)
Archacosporaceae (1 species)
Ambisporaceae (3 species)

Estimated Total Corn AMF species (58 AMF, could be many more)

Trichoderma: Predatory Fungi



**Trichoderma Fungi produce both cellulase and chitinase.
Feed on organic matter, nematodes, and protozoa.**

Trichoderma: Predatory Fungi

Beneficial Fungi: biocontrol pathogens
Aggressively colonize the rhizosphere
Compete with pathogens for root space
Digest nutrients efficiently for plant uptake
Prey on other fungi species (mycoparasitism)
Secrete >100 biologically active compounds

a) Enzyme that breaks down pathogen cell wall
b) Antibodies

Secondary nutrients: enhance root environment for more Trichoderma to grow
Improve plant growth & disease resistance
Produce stimulant for increased plant root growth

Trichoderma Environment

Beneficial Environment

Things they "Like"

High C:N ratio, High carbon and high cellulose

straw, corn stalks, cereal rye

Humic Acid or Fulvic Acid on Leaf surfaces

Seaweed

Fish hydrolase

Do NOT Like Fungicides

Key Point: Add Humic acid or Fulvic Acid to fungicides to protect Trichoderma species.

Fungi Decomposers

Saprotrophic Fungi: Form soil networks and rely on decomposing crop residue for nutrients. AMF & saprotrophic fungi decompose lignin.

Examples:

Trichoderma, Penicillium digitatum, Aspergillus flavus, Actinomucor elegans, Podospora bulbillosa,+ AMF*.* *All produce* PGPF (growth hormones) + seed germination +chlorophyll.

How to Increase Decomposition

1) Soil Temperature (>50^0F)
2) Moisture (50% for best decomposition)
3) No-till, cover crops, good soil health (Good microbial diversity).
4) Plant early, harvest early.
5) Reduce Pesticides Usage (Insecticides, Fungicides, miticides)
6) Increase Macrofauna and small insects.

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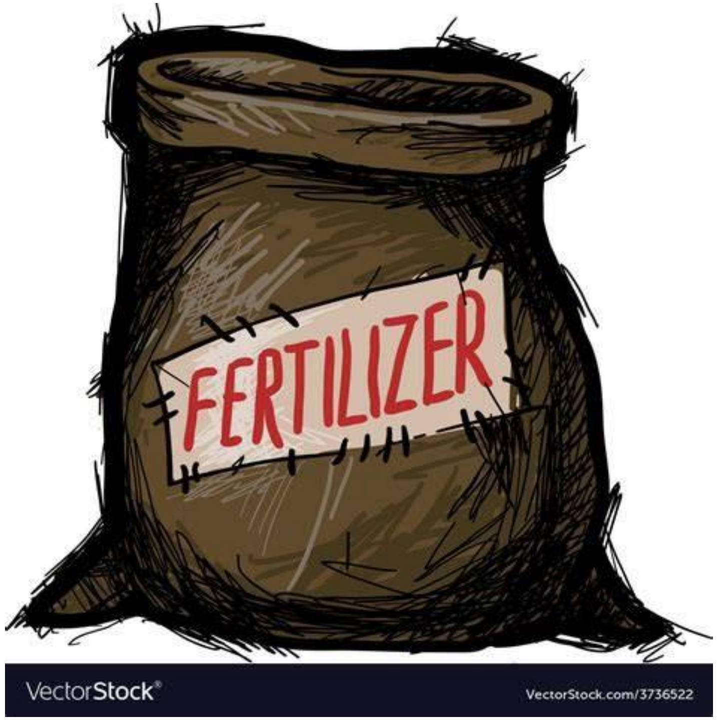
Types of Bacteria



Soil is a grave yard of dead and living bacteria.
Each bacteria cell is a soluble bag of fertilizer!

Classified by Shape (rod, sphere, spiral); by oxygen demand (Aerobic vs Anaerobic), Gram negative/positive.

Gram negative (G-) are smallest and most sensitive to changes in soil environment, Gram positive (G+) larger, thicker cells.

Oxidizers vs Reducers: Oxidizers live in well aerated soils, Reducers in saturated soils. Oxidizers improve soil structure. Reducers make nutrients plant available

Reducers also tend to cause and increase disease.

Soil Redox Conditions

Soil Oxidizing Conditions: Dry soil, Aerobic soils, Lots of available oxygen.

.

Soil Reducing Conditions: Wet saturated soil, anerobic soils, compacted, and poor soil structure lead to highly reduced soils and leaching of plant available nutrients.

Can roots grow in highly reduced soils? No Too Wet!

Can dry (droughty soils release adequate plant available nutrients?) Not likely!

Soil Redox Conditions

Solution: Million-dollar rain **(Goldilocks condition).**

Oscillating wet and dry soil conditions in microenvironment. Moist areas allow reduction of nutrients and drier areas allow good root growth and roots close enough to absorb reduced elements and oxygen for root absorption and respiration. Respiration releases energy. Respiration allows a plant to grow and for plant maintenance. Shows Importance of Soil Health!

Important Bacteria Species

What Bacteria Species are important in Ag?

a) *W*idespread in nature, soil, and all around and within plants.

b) *Bacillus* are gram positive (G+) bacteria found in C-S-W that help with plant nutrient acquisition (especially zinc), provide plant hormones for increased growth, decrease plant pathogens, and decrease plant stress.

c) *Pseudomonas (P)* bacteria are gram positive (G+) and help control fungus while promoting above and below ground growth. **There are at least 191 *P.* species, including *P. syringae* which increases the freezing point of water and also cause it to rain!** Many solubilize phosphorus and help plants avoid many stresses (drought, climate change, pathogens).

Other Bacteria Species

What Bacteria Species are important in Ag?

Endobacterium (E.) and *Agrobacterium(A.)* bacteria.

E. species improve soil porosity, some fix N and solubilize phosphorus, protect from pathogens, live in plant seeds, and increase plant growth. Seed treatments may cause some bacteria to die. Bacteria in seeds increase germination and seedling survival.

A. species are G-, are free living N fixers (20-100 # N), promote plant growth, but also transfer DNA to plant cells. May cause disease when soil conditions get tough and become pathogens.

Corn Bacteria Species

Corn (C) has at least 7 additional beneficial bacteria genera: *Achomobacter, Curtobacterium, Herbaspirillum, Microbacterium, Micrococcus, Paenibacillus, Serratia.*

Yield increases of 16-32%
in good soils, better plant growth.

Some rare soil bacteria may
create huge benefits and require
only small amounts of carbon (sugars).

Soybean and Wheat Bacteria Species

Soybeans (S) benefits from an additional 4 bacteria genera: *Rhizobium, Klebsiella, Agrobacterium, and Pantoea.*

Wheat (W) benefits also from *Azospirillum, Herbaspirillum, Klebsiella, and Micrococcus*.

For tomato growers: *Pseudomonas* and *Escherichia*, strawberries: *Bacillus* and *Sphingopyxis,* potatoes (all the corn bacteria species plus *Acinetobacter, Comamonas*, and *Methylobacterium*).

These are general bacteria groups called genera; in many cases you will be buying individual bacteria species.

Bacteria Decomposers

N fixers for Legumes (Soybeans) and Clovers: *Rhizobium Bacteria* Rhizophagy: Where about 40-60% of plant N comes from:
Pseudomonas Bacteria. Free Living Bacteria: *Azotobacter, Bacillus, Clostridium, Klebsiella* for 20-100# of free N.

Takes 4-5# N/soybean bushel, about 1# N/corn bushel. 300-bu corn needs 7# N/acre for 3 weeks. Plants need adequate potassium to enhance corn N uptake and adequate water.

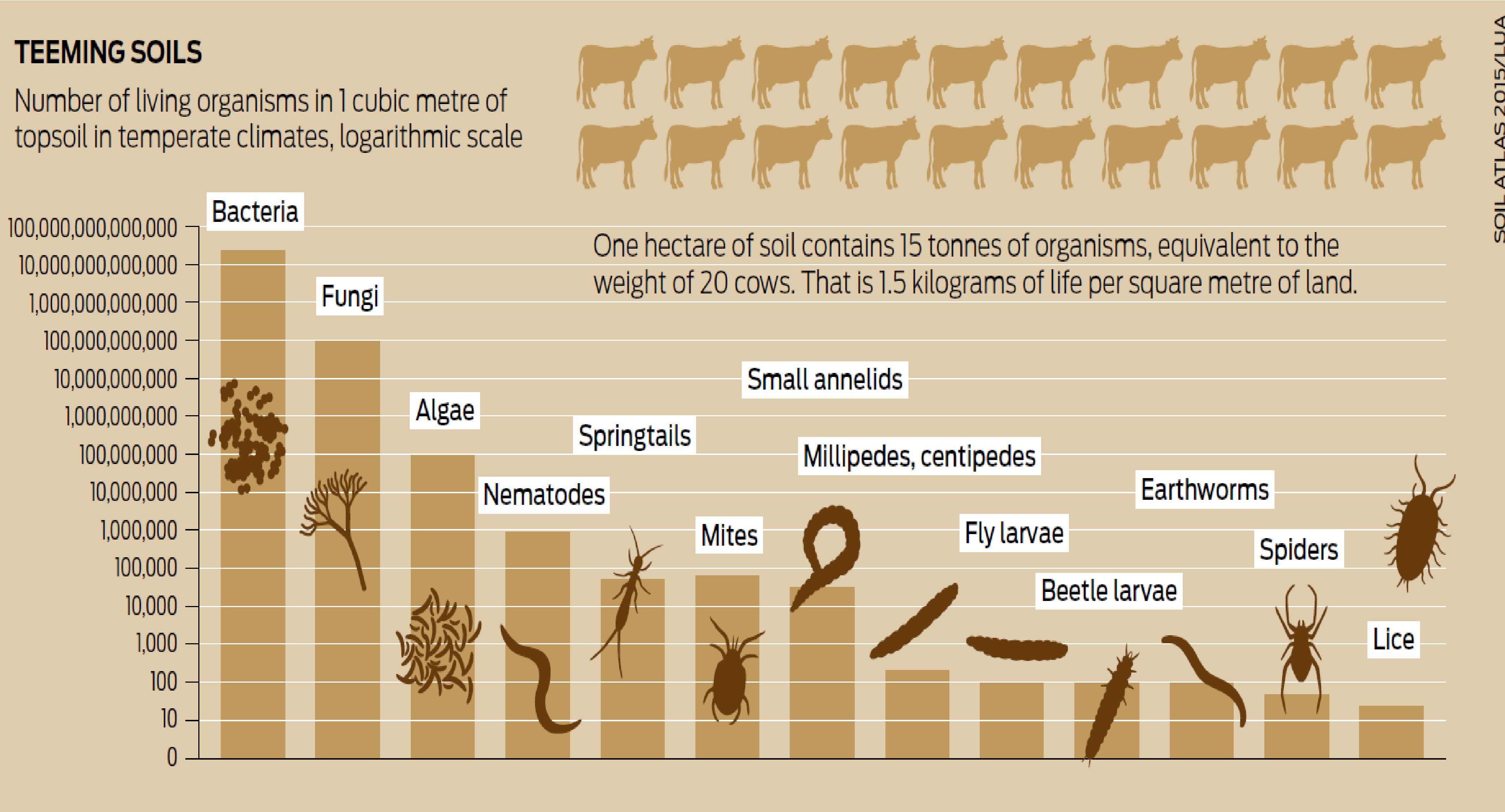
Phosphorus Solubilizers (biofertilizers): *Pseudomonas, Bacillus, Micrococcus, Flavobacterium, Aspergillus, Penicillium, Fusarium, Sclerotium*

Bacteria Decomposers

Bacteria: Decompose sugars and easy to digest nutrients. Help keep N in the root zone so it is not leached away. Red worms and compost are a great source of decomposing bacteria. Redworms have 10,000 species of beneficial bacteria in gut.

Bacillus subtillis, Pseudomonas fluorescens, Aspergillus niger and A. terreus, Penicillium polonicum, Gluconacebacter rhaeticusi, Janthinobacterium lividum to name a few!

Soil Food Web



Source: http://globalsoilweek.org/soilatlas-2015

Microfauna

Protozoa: Live in all soils. Predominate in conventional tilled soils. Three Types: flagellates, amoebas, cilliates

Nematodes: like small worms. Predominate in no-till and healthy soils.

Feed on bacteria and fungi and make the nutrients especially N plant available. Play a vital role in nutrient recycling. Live in the small pore spaces and water films around roots. Improve soil aggregation and soil porosity.

One protozoa can consume 10,000 bacteria per day. Major regulators of the microbial community.

Macrofauna

Larger soil organisms that help degrade crop residue.

Earthworms, mites, spring tails (collembola, 3600 species), centipedes, millipedes, beetles, sow bugs, ants, flies, spider.

Factors that increase residue decomposition

a) Temperatures above 50^{0}F plus adequate moisture
b) Adequate Fungus, Bacteria, Protozoa, Nematodes
c) Macrofauna
d) Live plants (cover crops), Undisturbed soil (no-till)
e) Plenty of nutrients (manure, compost)
f) Avoid insecticides, fungicides, late harvest, tillage

Earthworms

Incorporate 10 tons topsoil/yr
*** Live up to 9-12 years in soil**
*** Lay eggs in moist soil. Sexual maturity based on size.**
*** Move up to 30 feet/year**
*** Create "macro-pores" to aid in water movement and soil root exploration.**

Earthworms Casts

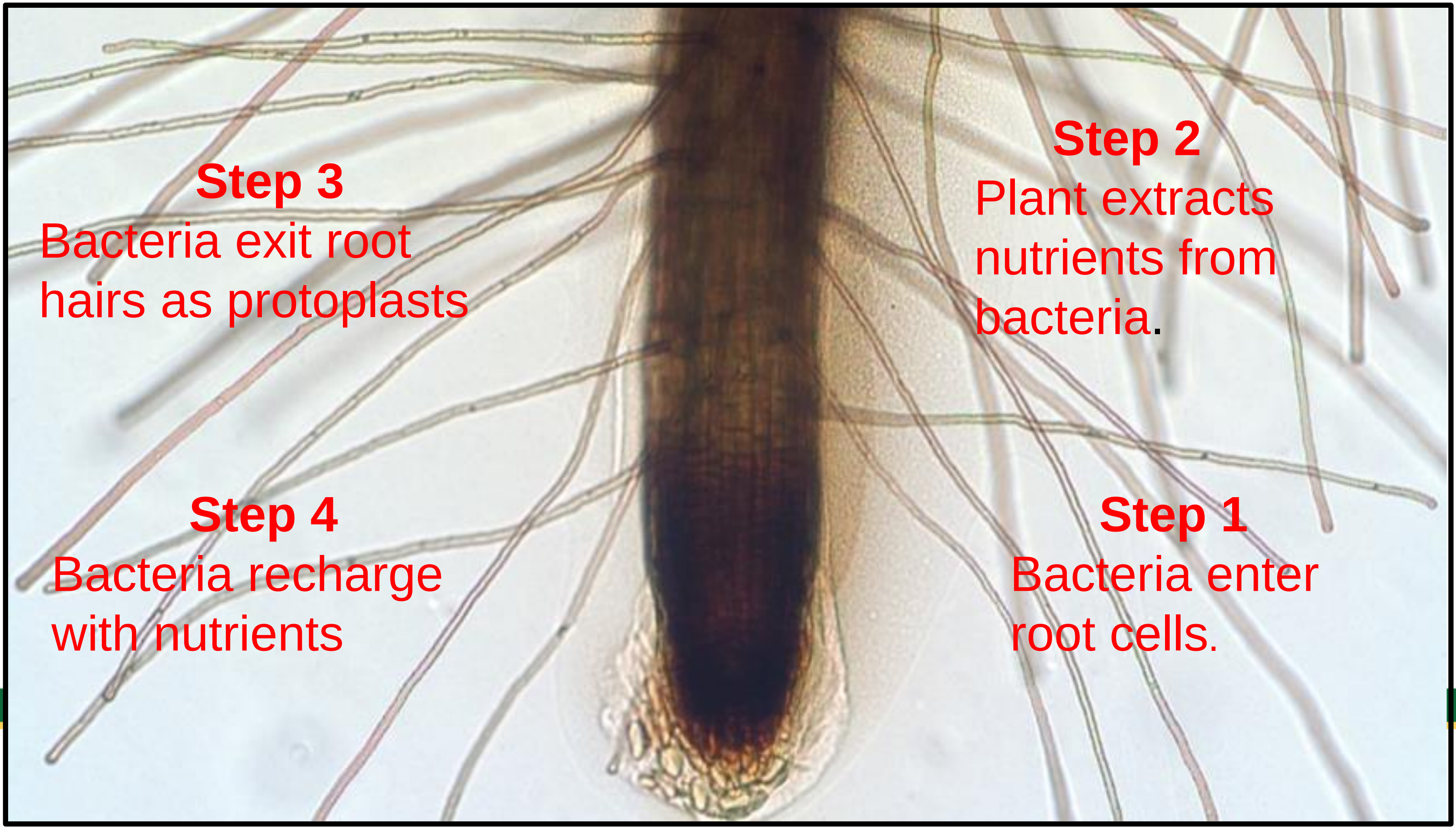
Soil aggregates of mineral soil and shredded organic matter.

Higher in bacteria, SOM and nutrients than bulk soil.

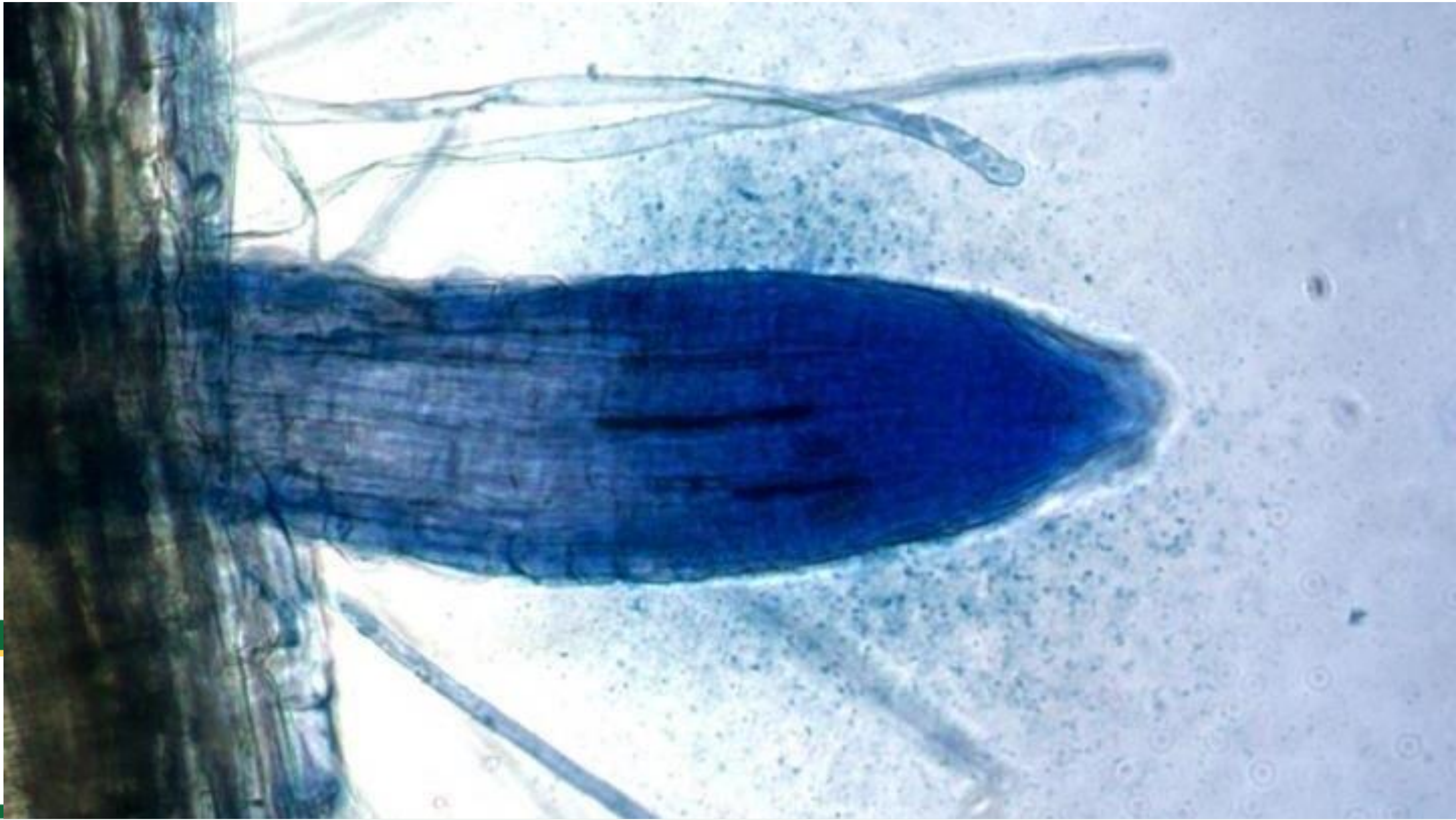
Inoculate soil with microbes

	Casts	Bulk Soil
Silt & Clay (%)	38.8	22.2
Structural Stability	849.0	65.0
CEC	13.8	3.5
Exchangeable Ca^{++}	8.9	2.0
Exchangeable K^{+}	0.6	0.2
Soluble P (PPM)	17.8	6.1
Total N (%)	0.33	0.12

Rhizophagy: Roots Eating Bacteria



Rhizophagy



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Metarhizuum fungi

13 M. Species: Prefer No-till
1) M. spores are parasite to 200 insect species: eggs, larva, Adult insects
2) M. Hyphae enhance N uptake in plants
3) Lipase enzyme in M. fungus us convert soybeans into soybean diesel

Metarhizium anisopliae* var. *acridum

Green Muscle®

- Very high specificity against grasshoppers
- Commercially produced by CABI (U.K.)
- Awaiting EPA permit to use the South African isolate for field trials in collaboration with USDA-ARS (most probably, in 2008)

Insect Species controlled by Metarhizium Fungi

- Metarhizium species are known to attack a wide range of arthropods: greater than 200 species in over 50 families.
- Ticks and beetles; root weevils, flies, gnats, thrips, locusts and grasshoppers
- Metarhizium species have been developed in other countries for use against cockchafers, spittlebugs, grubs, borers, and for control of mosquitoes that vector malaria.
- 47 commercial M. Fungi products worldwide

Figure 1. Wax moth larvae killed by Metarhizium infection. Metarhizium spores contact, germinate, infect, and ultimately kill insect pests. Photo credit: Nick Sloff, Penn State Department of Entomology

Soil Organic Matter (SOM)
SOM = MOM

SOM is Like Your MOM!

*Buffers pH (makes nutrients plant available)
*Buffers soil temperature (blanket, hot/cold)
*Buffers nutrients (feeds the plants),
* ↑ water holding capacity (water plants)
* ↑ water infiltration (less ponding water)

* ↓ water & nutrient runoff

SOM chelates (claw) macro/micro nutrients

Humic Substances

Humic Substances: Organic heterogenous compounds Yellow to black, includes Fulvic (FA) and Humic Acid (HA), contains 90% of all soil N.

Mystery: Impossible to define chemically.

Over 100,000 compounds in plant tissue and residues that are digested and transformed by microbes into humus.

Humus: Includes Humic (FA + HA) and non humic compounds.

Non-humic compounds: Amino acids, peptides, carbohydrates, fats, proteins, pigments, resins, waxes

Medium.com

Humic Substances

Fulvic Acid (FA): Low weight (open structure) molecular organic biologically active substances. Contain more oxygen and hydrogen for reactivity. Ties up many micronutrients (Ca, Mg, Fe, Zn, Cu, Mn, positive charges) but also contains S & low pH. FA has open carbon chains, many different compounds

Humic Acid (HA): High weight molecular organic substances. Large molecules that are dense and store many nutrients especially N-P-S-Ca. Has more carbon, N and less oxygen than FA. Formed more in reducing environments where oxygen is lacking. Many compounds, longer carbon chains but higher density.

Healthjade.net

Rhizosheaths

Dr. Christine Jones

Fulvic Acid (FA) Functions

1) **Improve seed germination and growth**
2) **Increased root and shoot growth (cell growth)**
3) **Increased root and stem branching**
4) Enhance cell division and elongation (**increased yield**)
5) Complex and chelate metals, improve nutrient physiology
6) Stimulate plant metabolism, faster fruiting, more flavor
7) **Enhance nutrient uptake (Especially Fe and Mn)**
8) **Improved Chlorophyll synthesis (Iron uptake)**
9) **Increased plant permeability for nutrients**
10) Increased protein and enzyme metabolism
11) **Positive impact on RNA and DNA.**
12) **Catalyst in improved plant respiration**
13) **Ties up Free Radicals**
14) Resist fungal attacks, Increase beneficial microbes
15) Change microbial communities, increase pseudomonas
16) May be source of energy to some microbes

Fulvic Acid (FA) Functions

1) **Buffers pH and creates <u>SOIL BALANCE</u>!**
2) **Chemical weathering of clays and rocks**
3) **Creates Fertile Soils, Restores worn out soils**
4) **Synthesis of new minerals from clay and rock**
5) Decomposes silicates in clay particles with hydron ions
6) **Releases and restores essential soil nutrients**
7) Better drought and heat resistance
8) Assists in microbial denitrification
9) Scavenges for heavy metals (2-6X more than HA)
10) **Detoxifies toxic chemicals (pesticides, heavy metals)**
11) FA is like mini-battery charger, stimulating electrical processes for optimal potential. Light Electrical Stimulation = Increased Biological Stimulation (20 milli volts (mV)).
12) Increased protein and enzyme metabolism
13) **Increases Plant Growth and Yield!**

Fulvic Acids

Fulvic acid (FA): Many different compounds. FA are very similar but some differences depending upon soil type, soil texture, vegetation, climate, soil parent material. FA is a component of biological materials and microbial decomposition, FA's are similar everywhere in the world. FA chelates 2X-6X more nutrients than HA! FA is 45-85% liquid (very fluid, flexible).

Types of Fulvic Acid:

1) Formic Acid
2) Acetic Acid
3) Propionic Acid
4) Aspartic Acid
5) Succinic Acid
6) Lactic Acid
7) Ethanol Acid
8) Absorbic Acid
9) Tannic Acid
10) Pyruvic Acid
11) Butyric Acid
12) Oxalic Acid
13) Fumaric Acid
14) Salicylic Acid or Aspirin

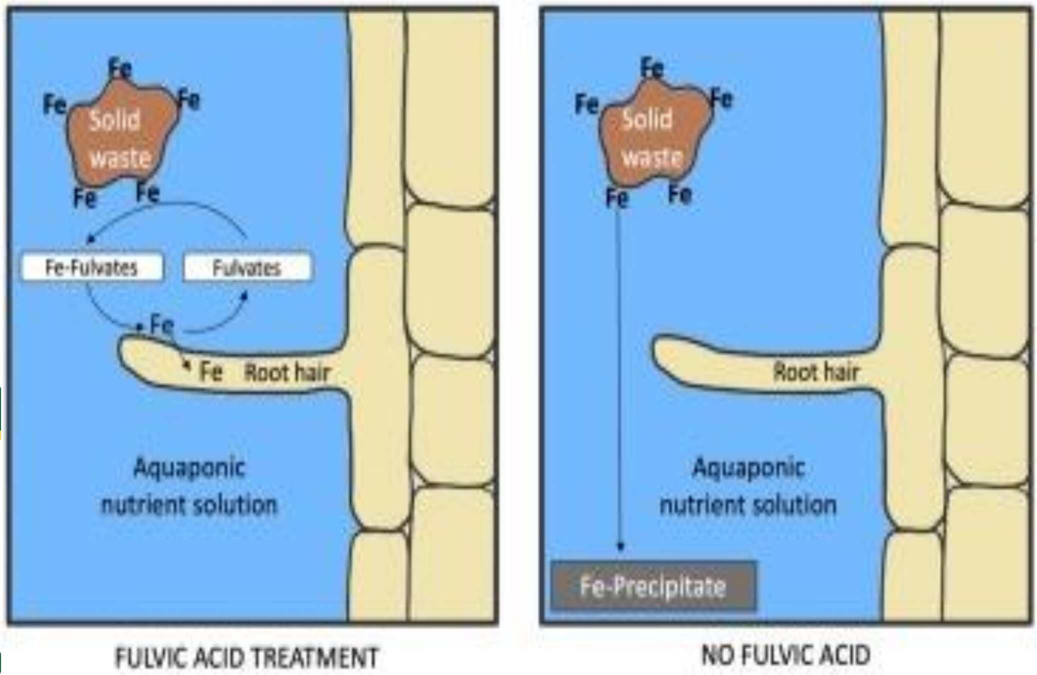
FA has 2X the acidity of HA (more H ions).

Walmart.com

Fulvic Acids:
Iron & Chlorophyll

Enhance nutrient uptake (Especially Fe and Mg)
Fulvic acid (FA): **Increases the plant iron content 3-10X by chelating oxidized iron (ferric iron)!** The ferric iron (Fe3+) is reduced to ferrous iron (Fe2+), an essential nutrient to increase to enzyme that produces chlorophyll for greener plants and complete photosynthesis. **Iron is highly reactive and immobile without FA!**

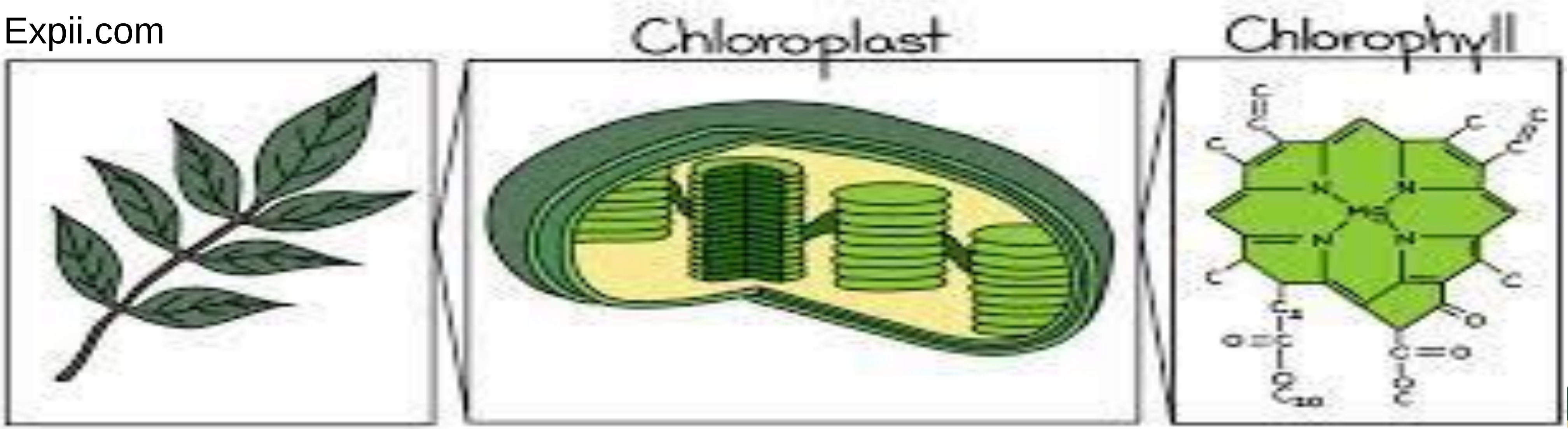
FA has a high affinity for uptake of Fe!



Fulvic Acids:
Magnesium & Chlorophyll

FA also increases magnesium (Mg) in plant cells. Mg is needed because it is the central element in the chlorophyll molecule. The dark green color of healthy plants is due to chlorophyll which produces plant energy from photosynthesis.

Expii.com



Which molecule in Humans looks and acts like Chlorophyll??

Humic Acid

<u>Physical Effects:</u>

1) **Improve soil structure, more aeration, higher water holding capacity, improved drainage, higher nutrient exchange, better plant growth**
2) Higher heat absorption due to HA black color
3) **pH buffering**, smaller changes in soil pH, HA accepts or donates H ions.
4) Reduced water and nutrient runoff, reduced nutrient leaching, less soil erosion
5) Reduce soil compaction

<u>Mechanical Effects:</u>

1) **Higher population of beneficial microbes**
2) **Favorable soil medium for root growth, reduces fertilizer needs**

Humic Acid

Soil Chemical Activity:

1) Active rock disintegration, releases essential plant nutrients
2) ***Makes phosphorus and iron plant available, reduces P* lockup by clay particles, slowly release (spoon feed) fertilizer nutrients to the plant.**
3) Liberates carbon and carbon dioxide from soil.
4) **High ion exchange (High CEC and AEC), High nutrient storage capacity**
5) **High N-P-K-S-Ca**
6) **High microbial energy source (5,000 calories/gram of energy)**
7) Reduces pathogens and harmful microbes
8) Chelates and makes nutrients plant available, FA>HA
9) Neutralizes toxic pollutants and toxic plant compounds

Humic Acid

Biochemical Effects:

1) **Stimulates plant cellular growth and division (Auxin-like affect), increased seed germination**
2) Effective development of plant circulatory system
3) **Increases plant respiration and transpiration (more energy, more nutrients)**
4) Decreases plant stress

Interesting Note: Soil HA is 9X higher than HA in living organisms! HA tends to accumulate deeper in soil and marine sediments (anaerobic, less oxygen)

Humic Acid

<u>Pragmatic Results:</u>

1) **Increased plant growth**
2) Improved seed germination
3) Great fibrous roots
4) Increased nodules in legumes
5) Insect resistance, less Disease
6) Plant resistance to drought
7) Less frost damage
8) Improved ability to withstand low and high temperature changes
9) **Improved Yields (HA has many cytokinin hormone precursors).**
10) **Improved seed & fruit quality, higher nutrient density, higher protein content**
11) **Less storage loss due to rotting, longer storage life**

12) Promotes Greener, thicker, healthier plants

Fulvic and Humic Acid

Leonardites or soft coal-like substance are a good source of FA + HA. Found in North Dakota on shallow outcropping. Derived from bogs, swamps and peat where semi aerobic to anaerobic conditions exist. Leonardite is just organic material from past plant generations.

Tomato plants biomass increased 40% when coal based humates were added to hydroponic solutions at concentrations of 10 to 10,000 PPM for six weeks.

FA is the less dense and less processed plant material that may have come from plankton.

HA is more processed and denser material. Many FA's eventually become HA. HA becomes plant toxic above 10,000 PPM due to high acidity while Leonardite is not toxic at 10,000 PPM.

Amino Acids

Peptides and Amino Acids convert to proteins which then may convert to enzymes. Amino Acid and all proteins are high in N!

There are 20 amino acids to build proteins and then some convert to enzymes.

Amino Acids: Alanine, Arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, valine

Key Amino Acids (AA) in Agriculture??

What Amino Acid is needed to allow roots to be infected with endophytes?

Endophytes are microbes in the interior of a plant?

Example on soybeans, which AA allows Rhizobium bacteria to enter the root to form nodules?

Which AA allows AMF to infect the root?

Which AA allow Pseudomonas bacteria to infect the root and cell to perform Rhizophagy? **(Arginine!!)**

Some Key Enzymes

- Enzymes speed up biological process by 10X-100X-1000X even 10K to 100K times faster.

- P solubilizing Enzymes: Phosphatase (Acid & Akaline)

- N enzymes: Urease (Ammonia recycling), Protease (N recycling).

- S enzymes: Arylsulfatase (Sulphur recycling).

Key Phytohormones

Growth and Yield Stimulators

- Auxins: Plant root and shoot growth, Cell elongation of stems and roots, cell division
- Cytokinins: Plant growth and Yield, Shoot growth, increases chloroplasts, delays plant death,
- Gibberellins: Promote longer growth (stay green), stem elongation, breaks seed dormancy, helps seeds germinate, overall regulator of auxin and cytokinins.

Growth Regulators

- Abscisic Acid: Induces seed dormancy, controls closing the stomata, inhibits plant growth and development.
- Ethylene: Speeds up plant maturity, seed ripening. Involved in seed dormancy and seed germination.

New Phytohormone: Stigolactones, plant and microbial growth, possibly by regulating (turning on and off genes)

Crop Nutrients that Enhance Hormones

- **<u>Growth Hormones</u>: Auxin in leaf tips: NO_3^-, K^+, Cl^-**
- **<u>Yield Nutrients</u>: Cytokinin in Root tips, delay plant maturity, Key nutrients: NH_4^+, P, Mn^{2+}**
- **<u>Growth and Yield Nutrients</u>: Gibberellin, Ca^{2+}**

- Apply gypsum (calcium sulfate, mined) at 200-300 pounds/A 30-40 days before blooming or tasseling.
- 90% of calcium is taken up at pollination and grain fill.
- Cobalt needed for N fixation in legumes and soybeans.
- Add compost or manures which are high in micronutrients to optimize yield.

Marine Extracts

- Kelp, Seaweed, etc.
- Contain key micro nutrients that enhance plant growth: Iodine, Chromium, Selenium, Cobalt, Sodium etc.
- Also contain some plant growth hormones and other enzymes.
- Low levels of other macro- and micro-nutrients.
- Marine extracts usually come from aquatic systems and are often a complex blend of sugars, hormones, enzymes, and micronutrients.

Sugars

From simple to complex sugars, plants and soil microbes respond to sugar applications.

There are Four major types of sugar:

- Simple sugars like glucose and fructose are called monosaccharides. React quickly in the soil. Quick burst of microbial energy. Decrease diseases.
- Disaccharides (Two mono's) sucrose (glucose + fructose). Slower breakdown in soil, longer lasting.
- Polysaccharides (several mono's like glucose which forms starch). Molasses is long lasting sugar, sticky, hard to apply, stimulates long-term plant health.

- Galactose is lactose or natural milk sugar is a mono.

Application of Biologicals

- a. Application of biologicals varies by product, follow directions!
- b. Avoid direct sunlight, apply on a cloudy day. Keep cool, store refrigerator, generally around 50^0F. Hot temperatures and sunlight (UV rays) kill many bacteria.
- c. Need adequate moisture to survive, apply water after application.
- d. Compost, humus and manure are good food and beneficial bacteria sources (as are red worms).
- e. Some biologicals are applied to seeds with a nutrient coating.
- f. Others applied at the base of the plants to the roots, some foliar applied to leaves.
- g. Watch soil pH, most beneficial bacteria can survive a 6.5-7.0 pH, but that varies by species.

Understanding Biologicals

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