



Healthy Food Comes
From Healthy Soils,
But How to Diagnose
Soil Health?

Dr. Debankur Sanyal

Assistant Professor & Soil Health Specialist

Dept. of Environmental Science

The University of Arizona

What is *Soil Health*?

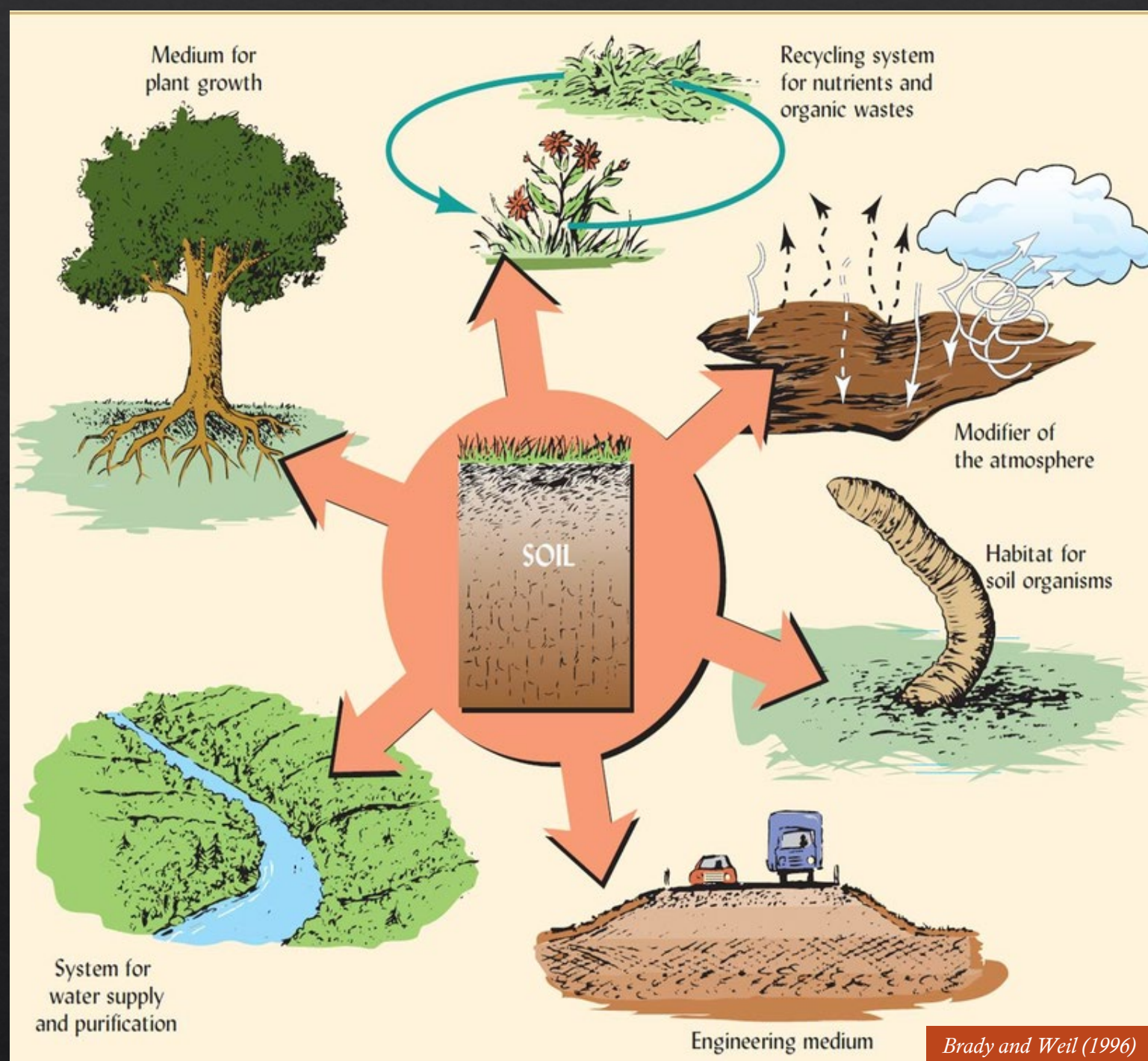
The continued *capacity* of soil to **function** as a vital **living system**, within ecosystem and land-use boundaries, to **sustain** biological productivity, promote the *quality* of air and water environments, and maintain *plant, animal, and human health*.

(Doran and Zeiss, 2000)

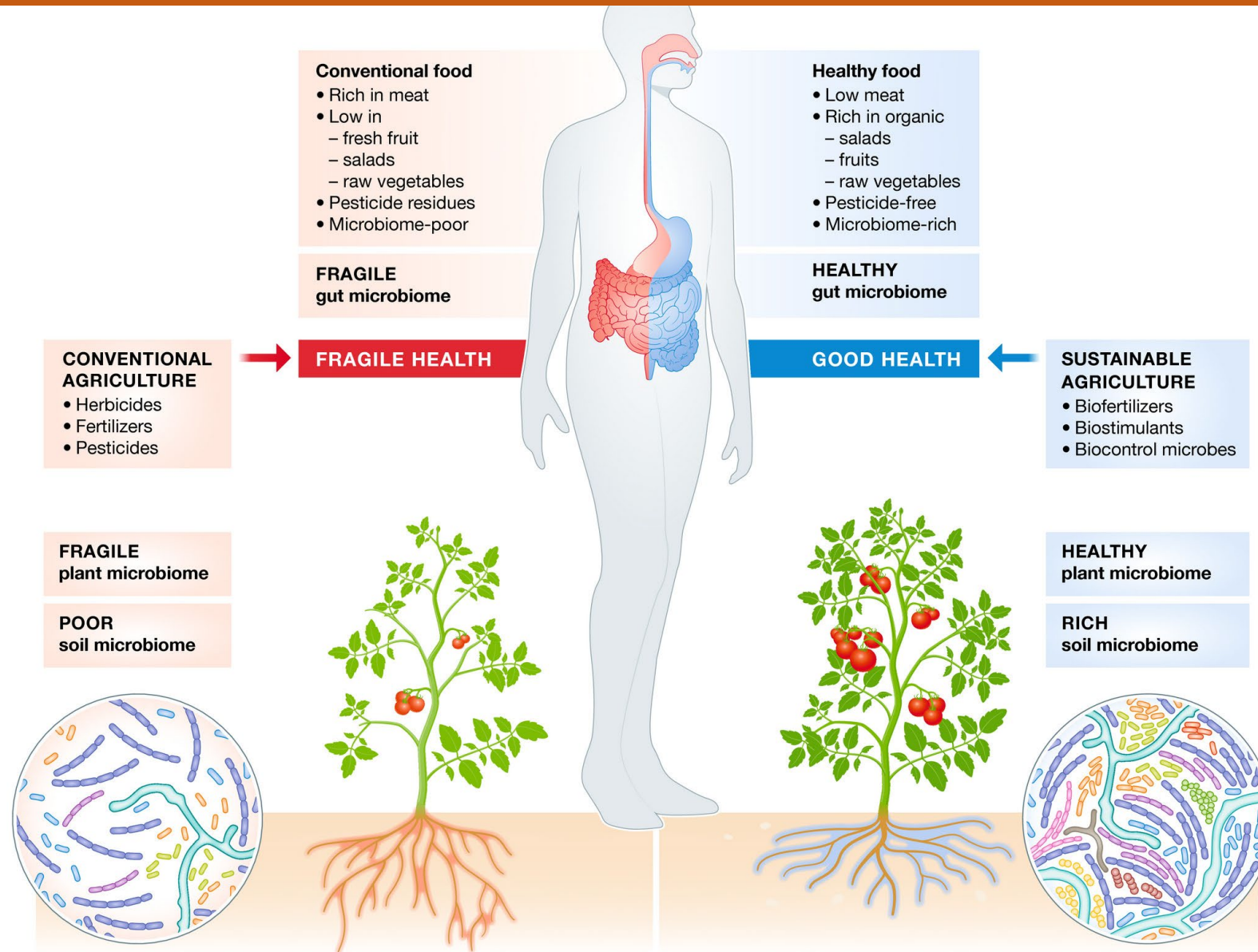


Soil *Functions*

- ◆ Element **ycling**
- ◆ Store Carbon and **Water**
- ◆ Shelter **Biology**
- ◆ Gaseous exchange
- ◆ **Healthy Environment**



Healthy Soils = Healthy Food = Healthy Life



Soil Health Principles

Soil Armor



Maintain Living Roots



Ecosystem Diversity



Boost Biology

Integrate Livestock



Minimize Soil Disturbance



Soil Health Benefits



BASIS FOR HEALTHY
FOOD PRODUCTION



HOME TO A QUARTER
OF OUR PLANET'S
BIODIVERSITY



HELPS FIGHT AGAINST
CLIMATE CHANGE



HELPS IN THE STORAGE
AND PURIFICATION
OF WATER



AIDS IN HUMAN
HEALTH



HPLC 2020

The planet survives only thanks to a **few cm** of **healthy soil** that grows **95%** of **our food**



Food and Agriculture
Organization of the
United Nations



GLOBAL SOIL
PARTNERSHIP

Soil Health Parameters

Organic Matter



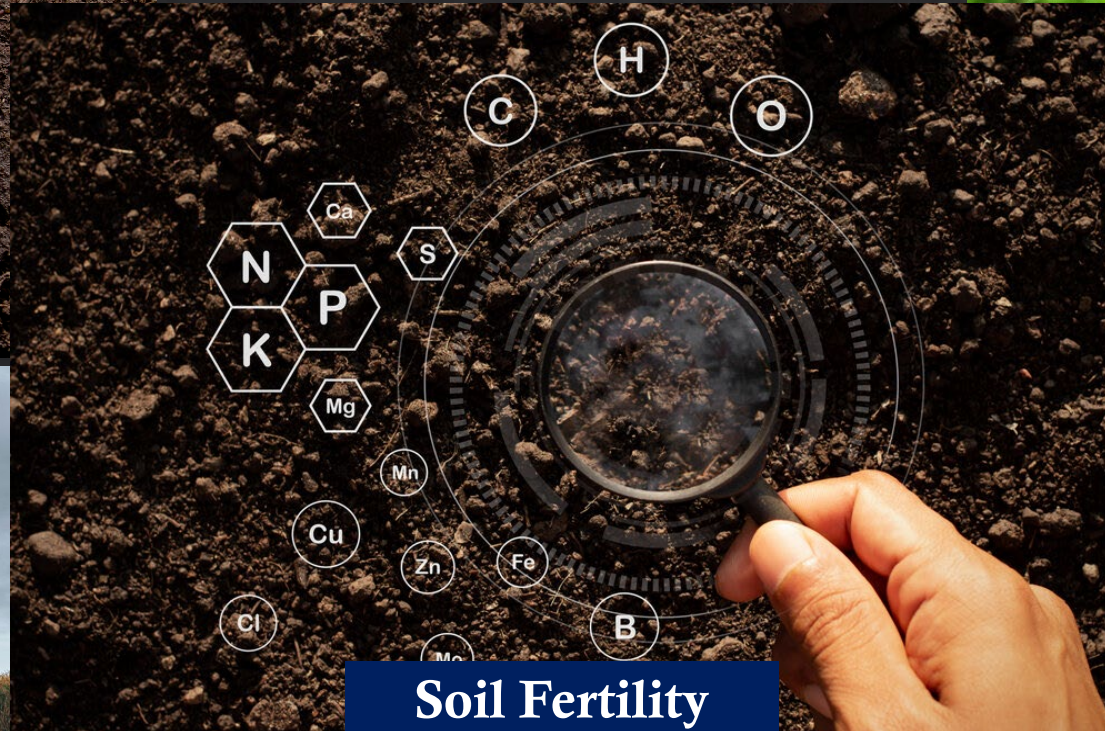
Biology



Water Movement



Soil Fertility



Soil Structure





Improve soil structure



Water infiltration & storage



Boost soil biology

Soil Carbon



Store & release nutrients



Sustainable farm and food

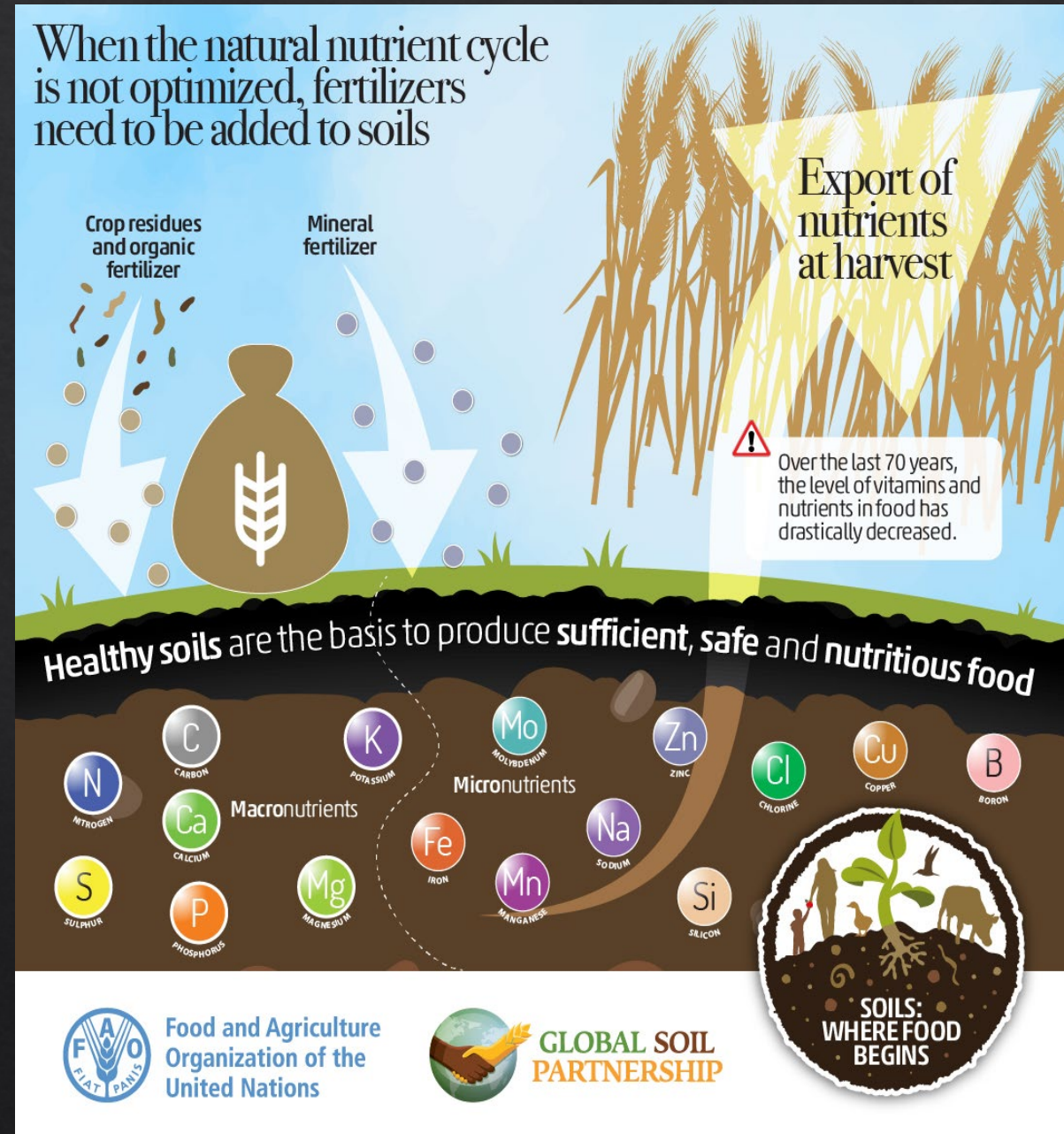


Build *healthy soils*

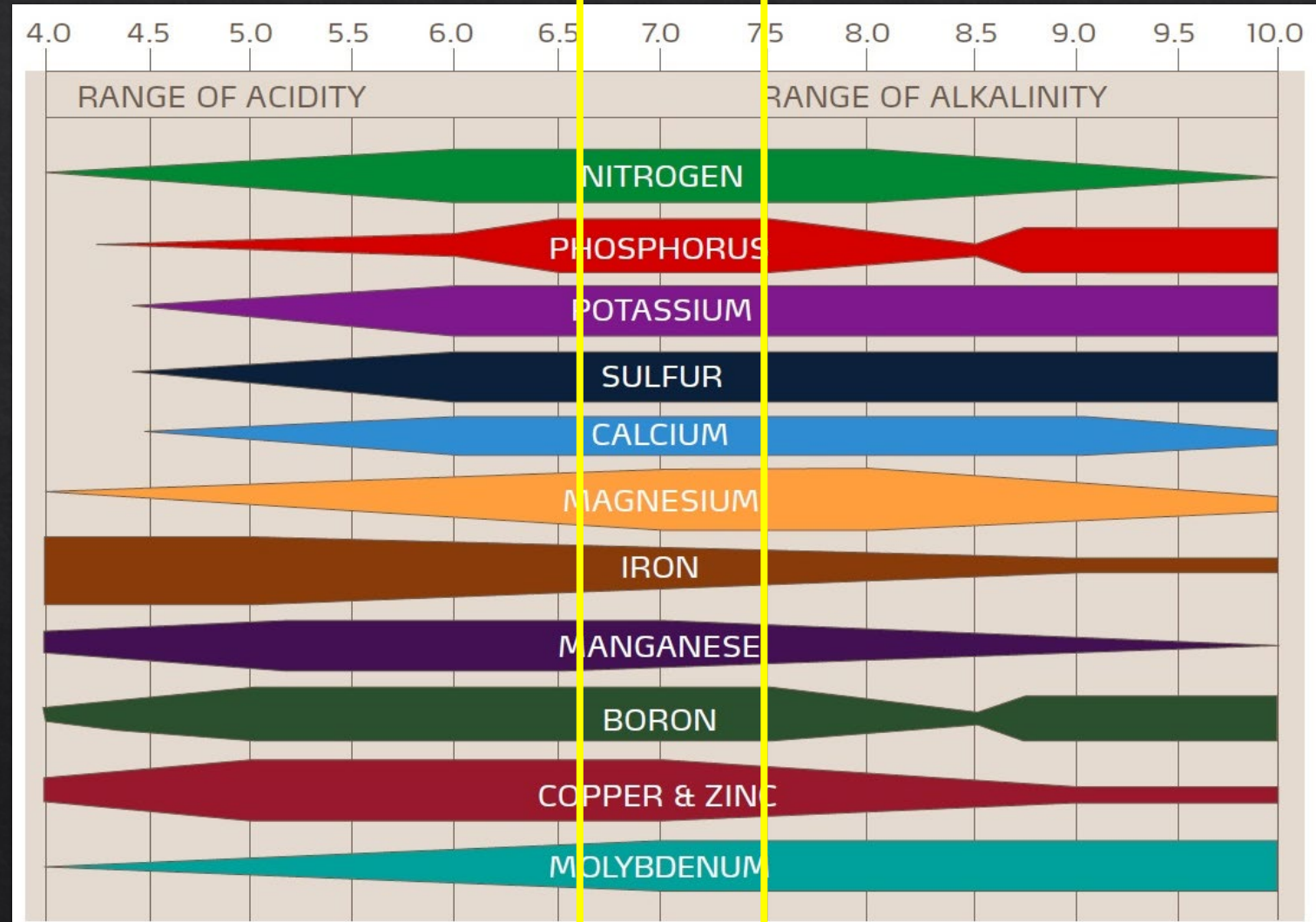
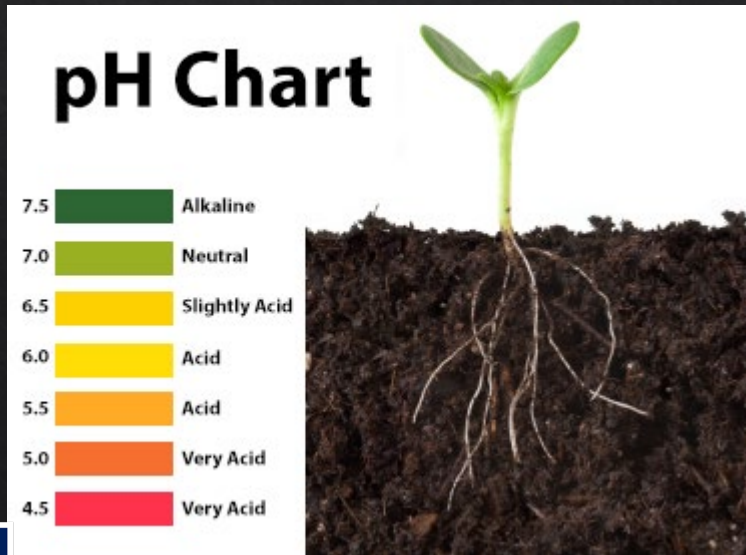
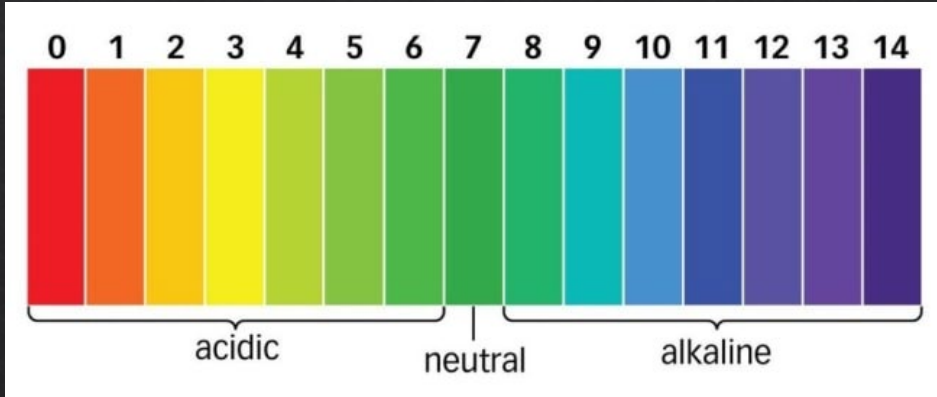


Soil Health and Soil Fertility

- ◆ Healthy soils **provide** optimum plant nutrition
 - ❖ *Nutrient cycling and storage*
 - ❖ *Water and air movement*
- ◆ Require less chemical input
- ◆ Produce nutritious food
- ◆ Less pollution; Sustainable

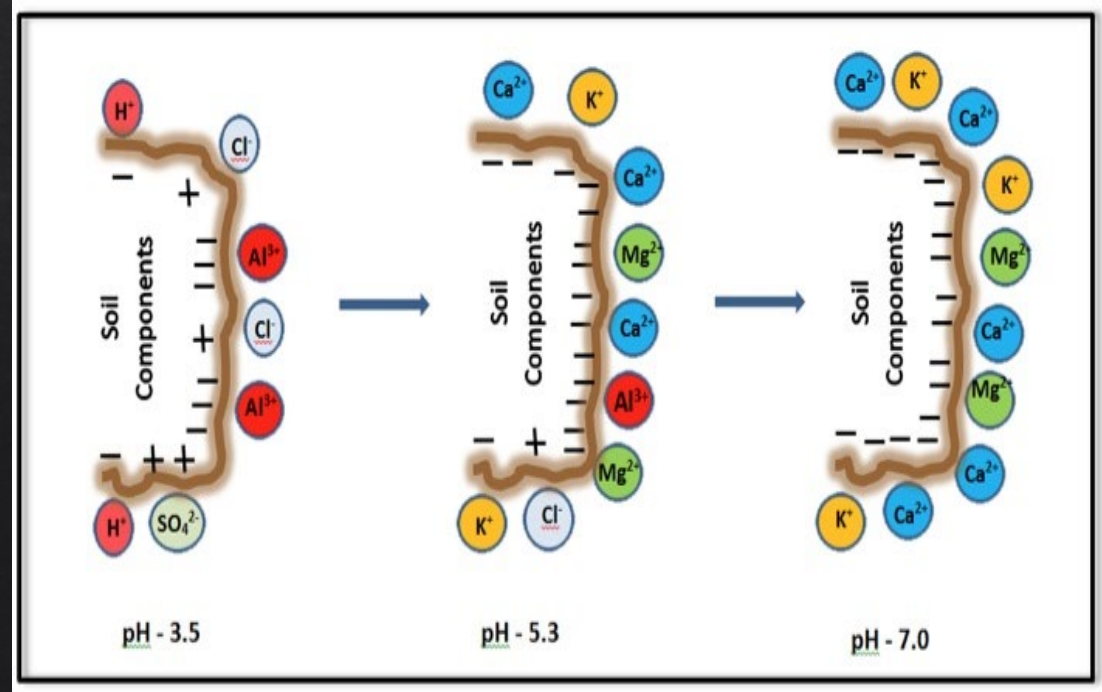
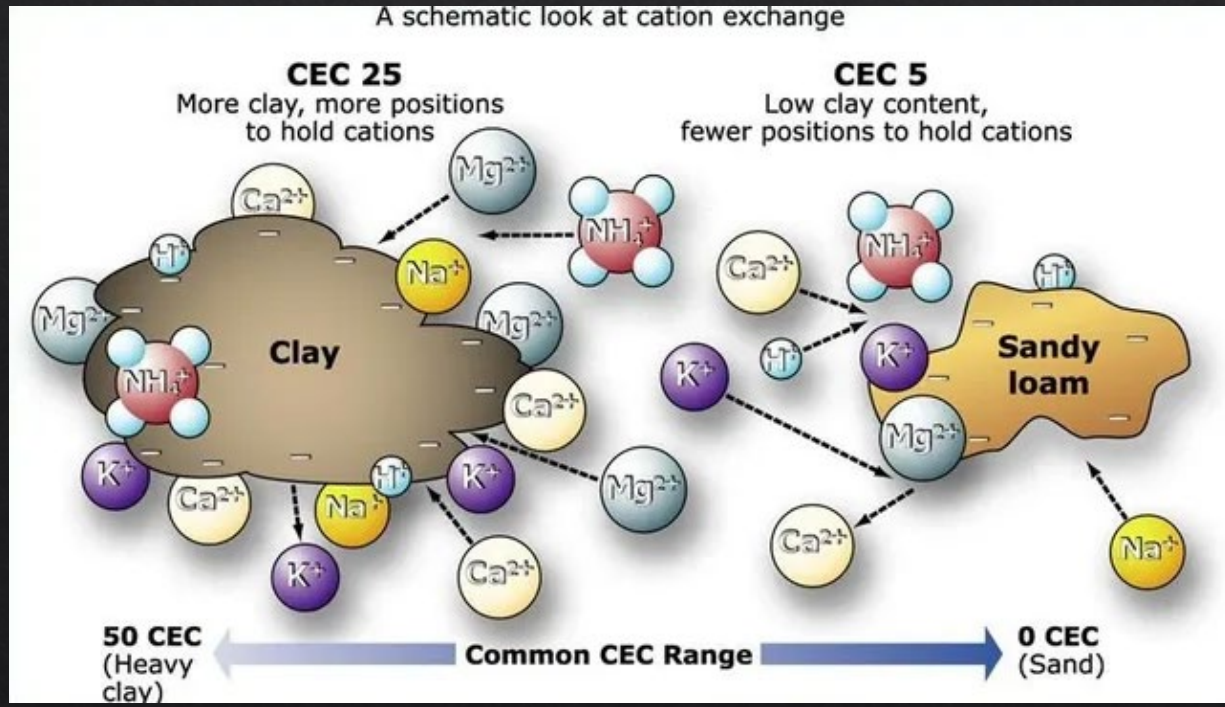


pH and Nutrient Availability



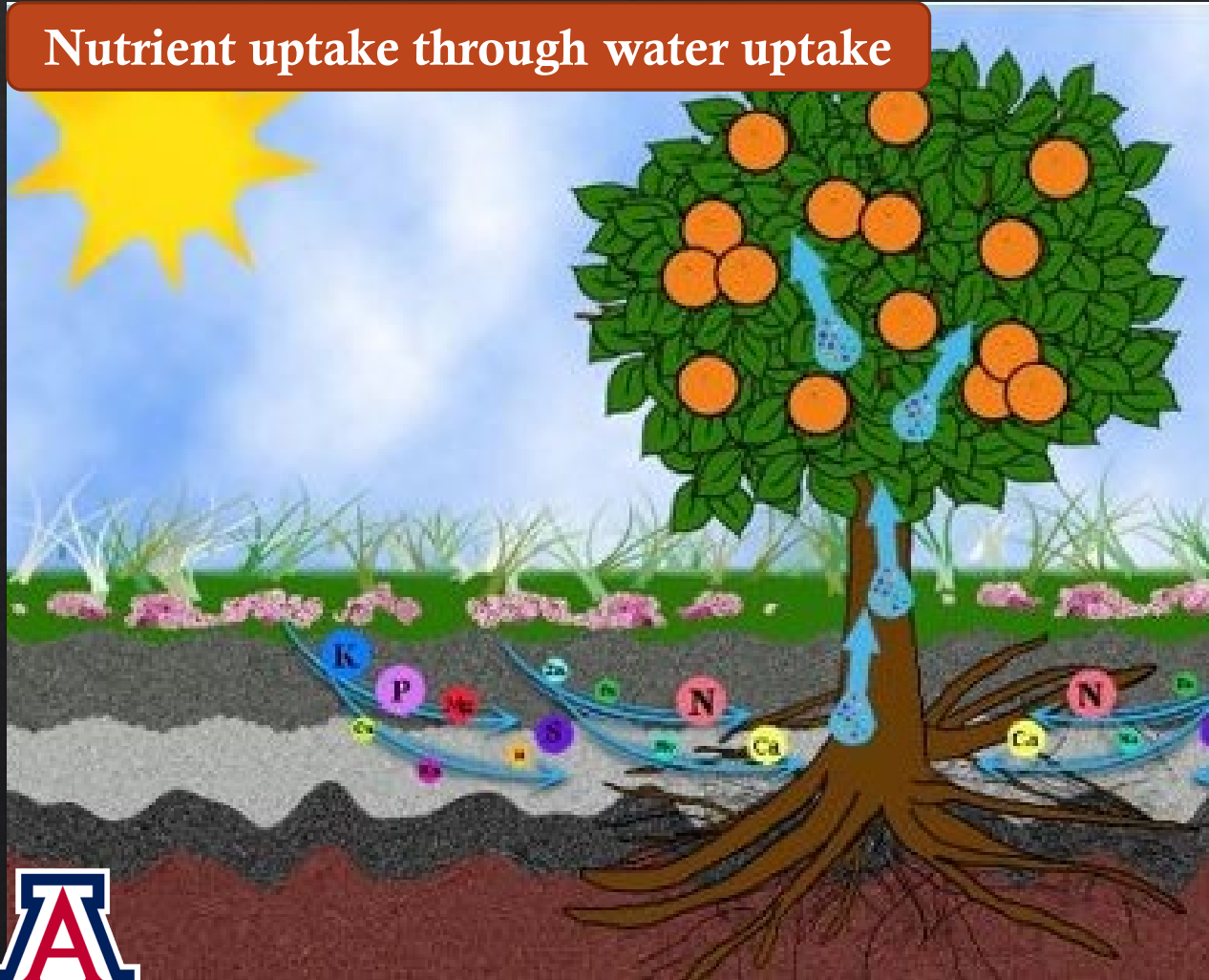
Cation Exchange Capacity (CEC)

- ◆ A measure of the total negative charges within the soil
- ◆ Soil's ability to supply important plant nutrients

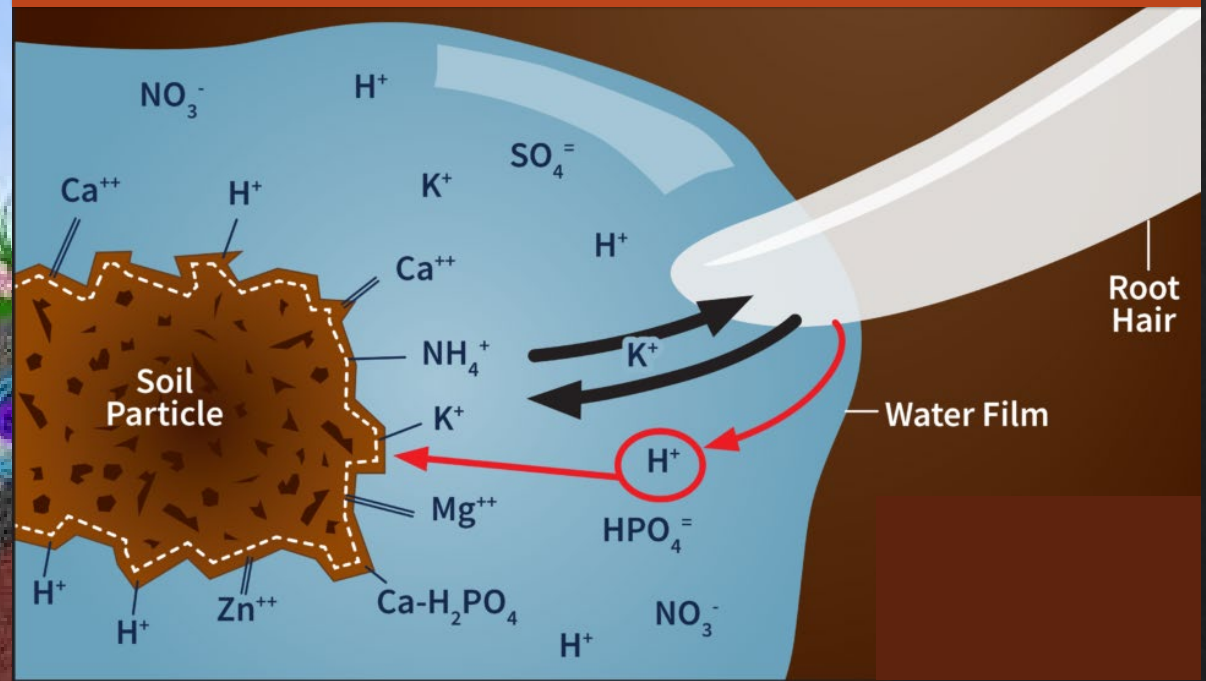


Nutrient Uptake

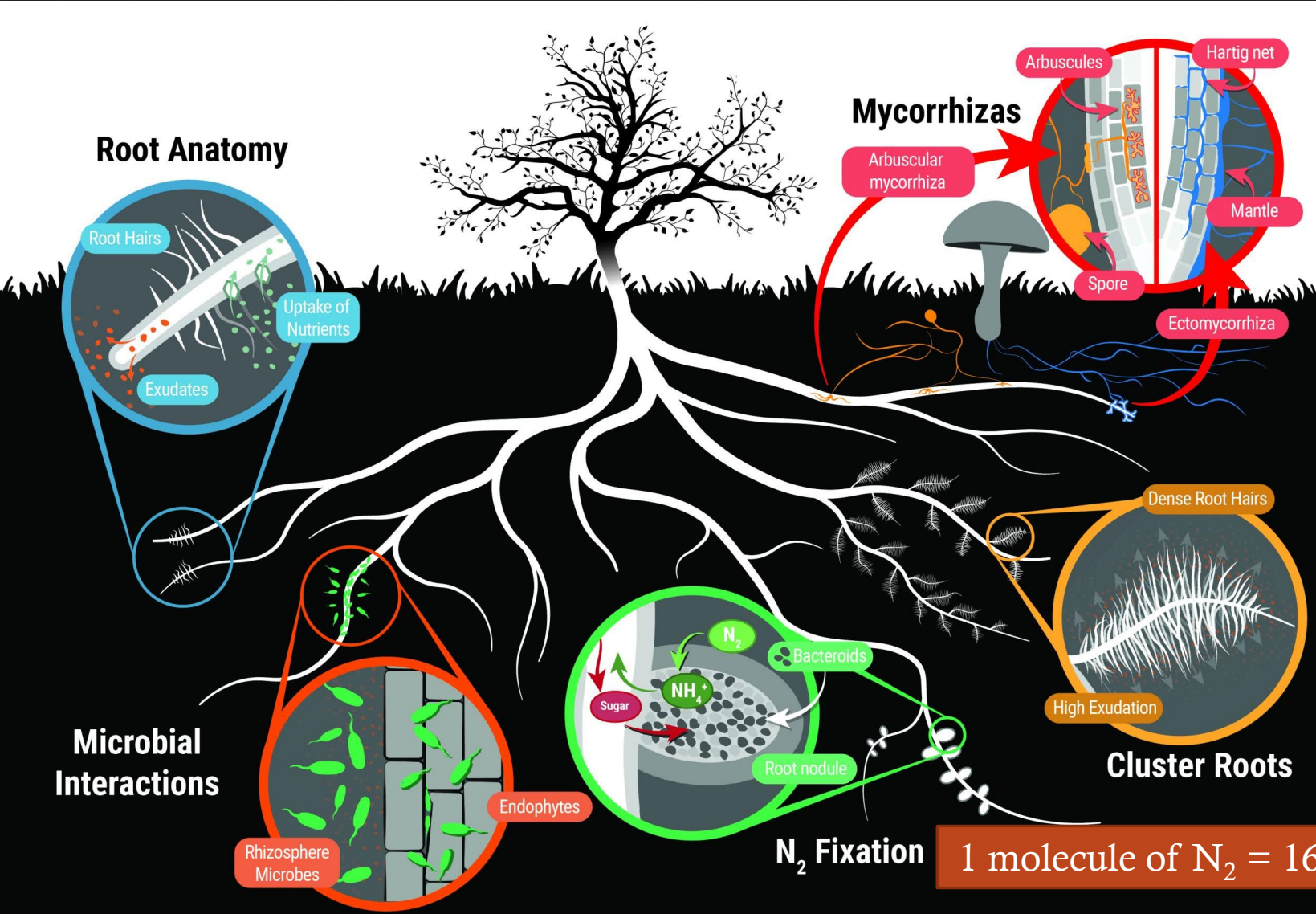
Nutrient uptake through water uptake



- ❖ Plants can only uptake **water-soluble ionic** forms.
- ❖ Therefore, insoluble forms should be transformed into soluble forms.

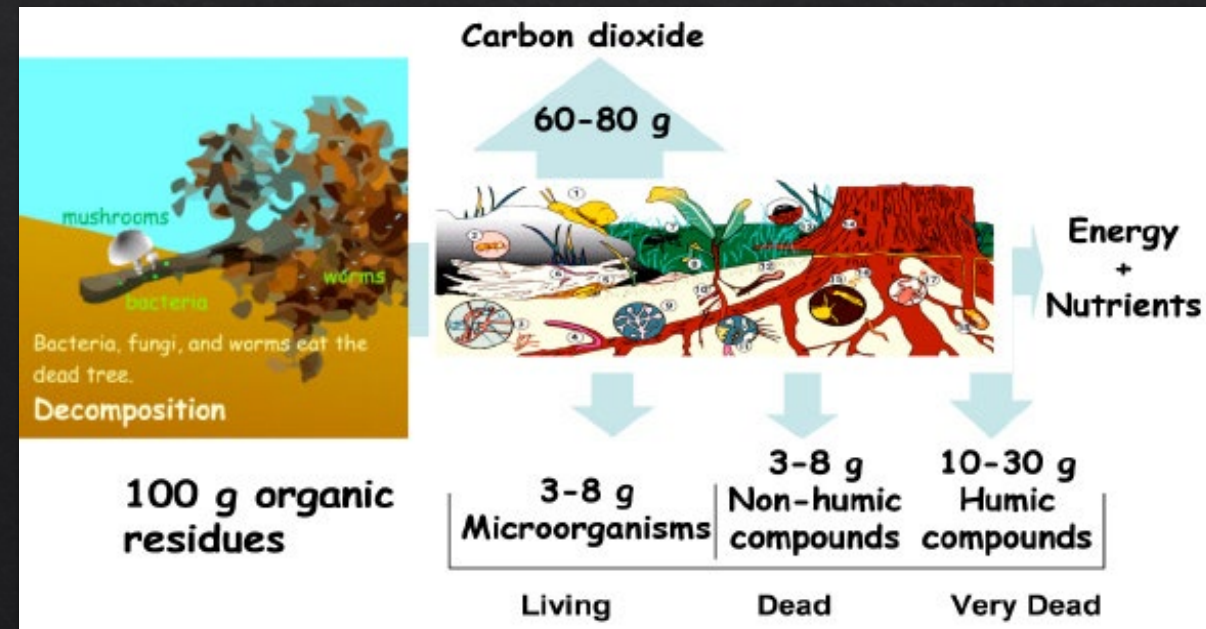
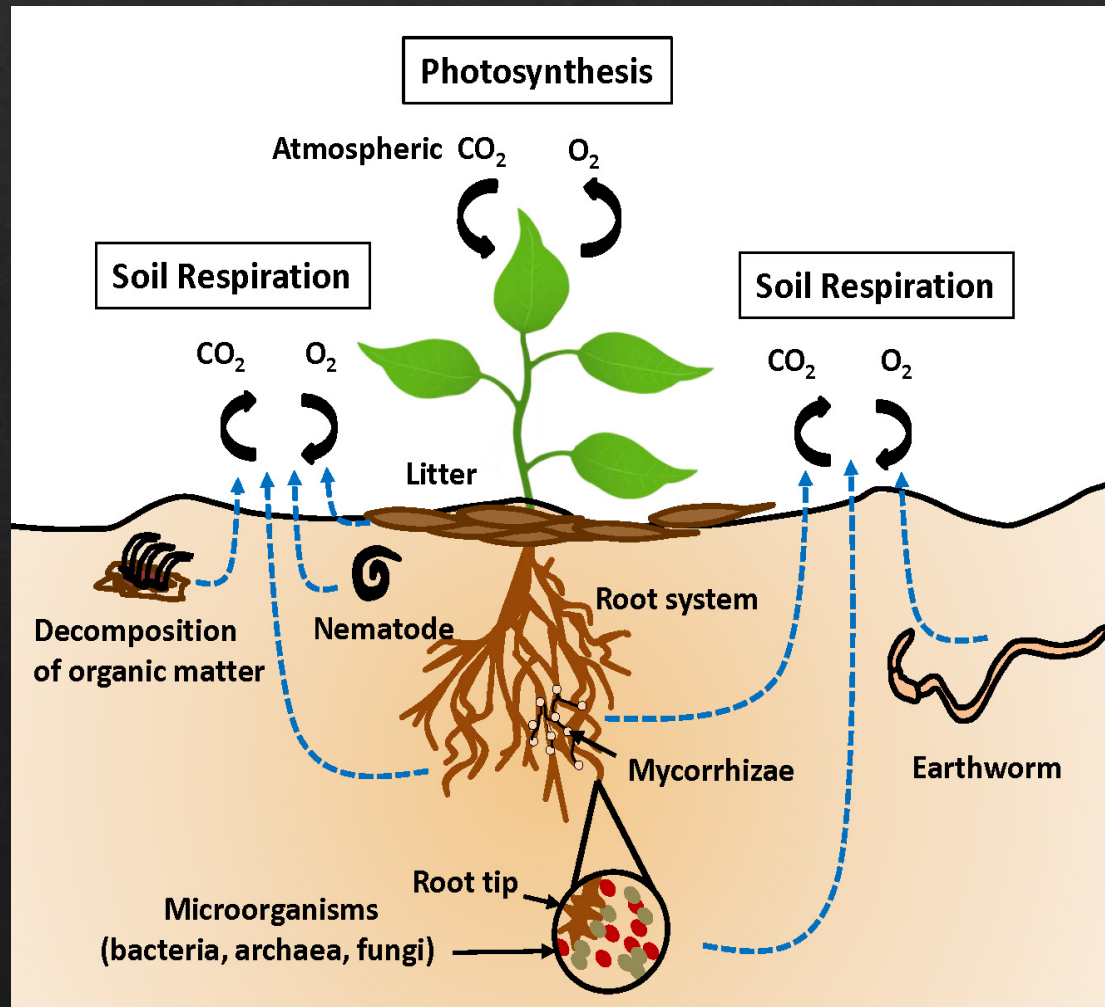


Communicating with Soil Biology

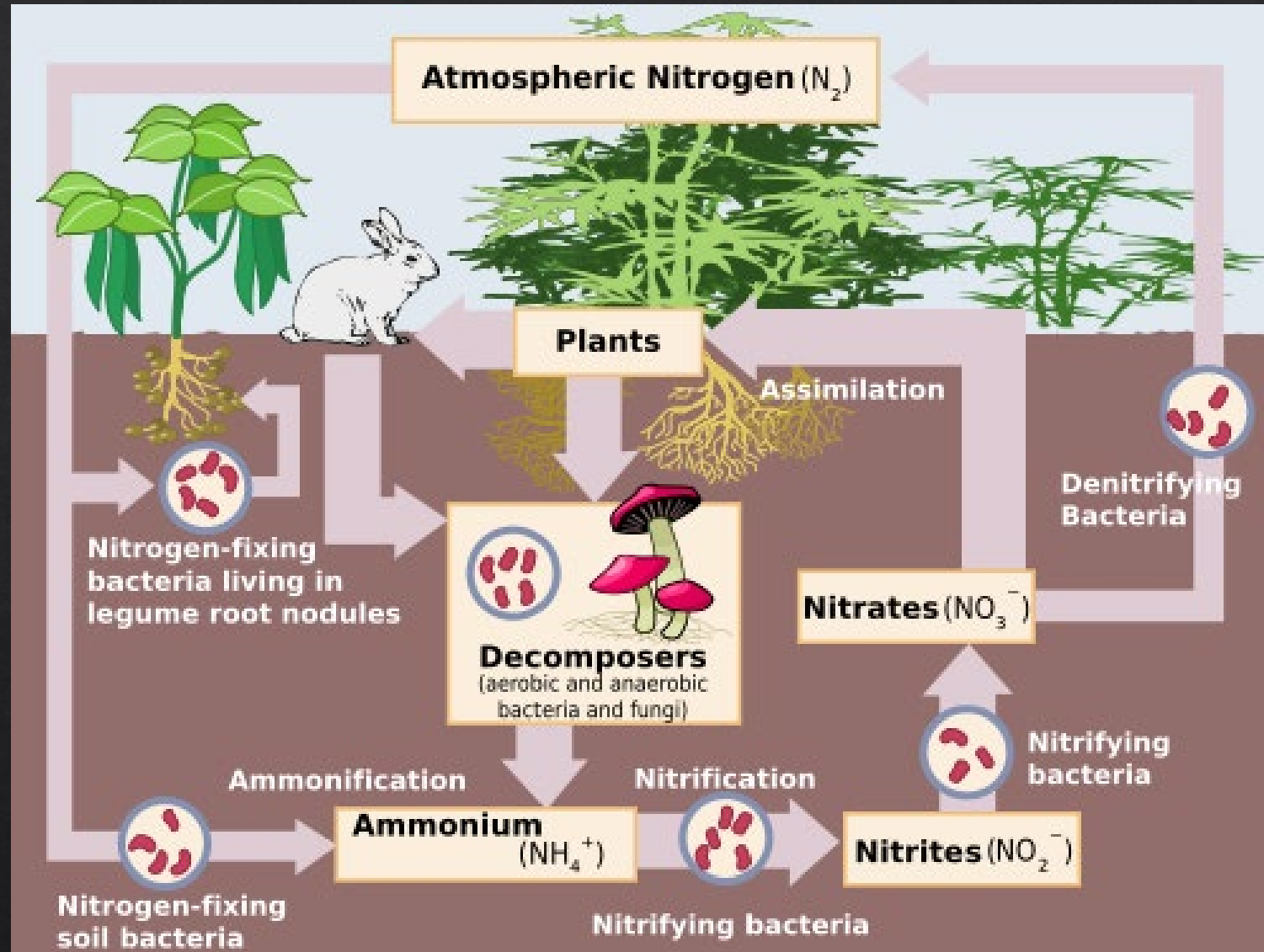


Nutrient cycling: SOM decomposition

SOM is the reservoir of nutrients and **carbon**; releases nutrients through microbial decomposition



Nitrogen cycle



Nutrient Deficiency Symptoms: Nitrogen



Lower/Older leaves are first affected; Yellowing/ Burning



Nutrient Deficiency Symptoms: Phosphorus



Purple leaves; Bronzing



Nutrient Deficiency Symptoms: Potassium



Yellowing/ Burning starts at the leaf margin



Nutrient Deficiency Symptoms: Magnesium



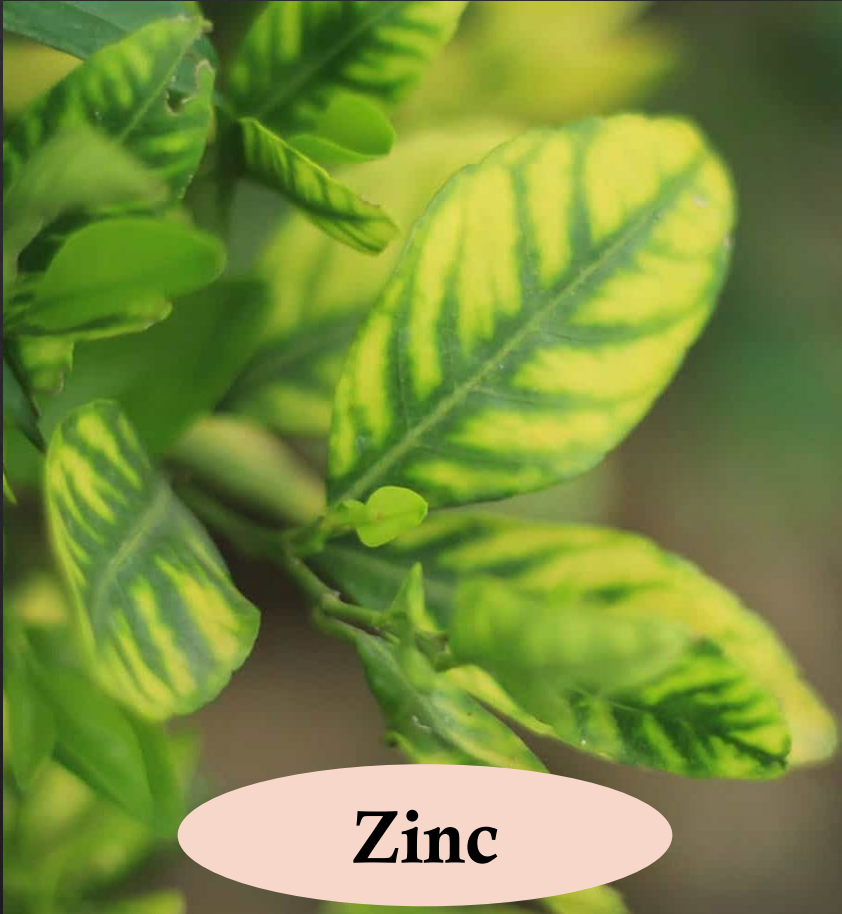
Yellowing between veins; older leaves first affected



Other Nutrient Deficiency Symptoms



Boron



Zinc



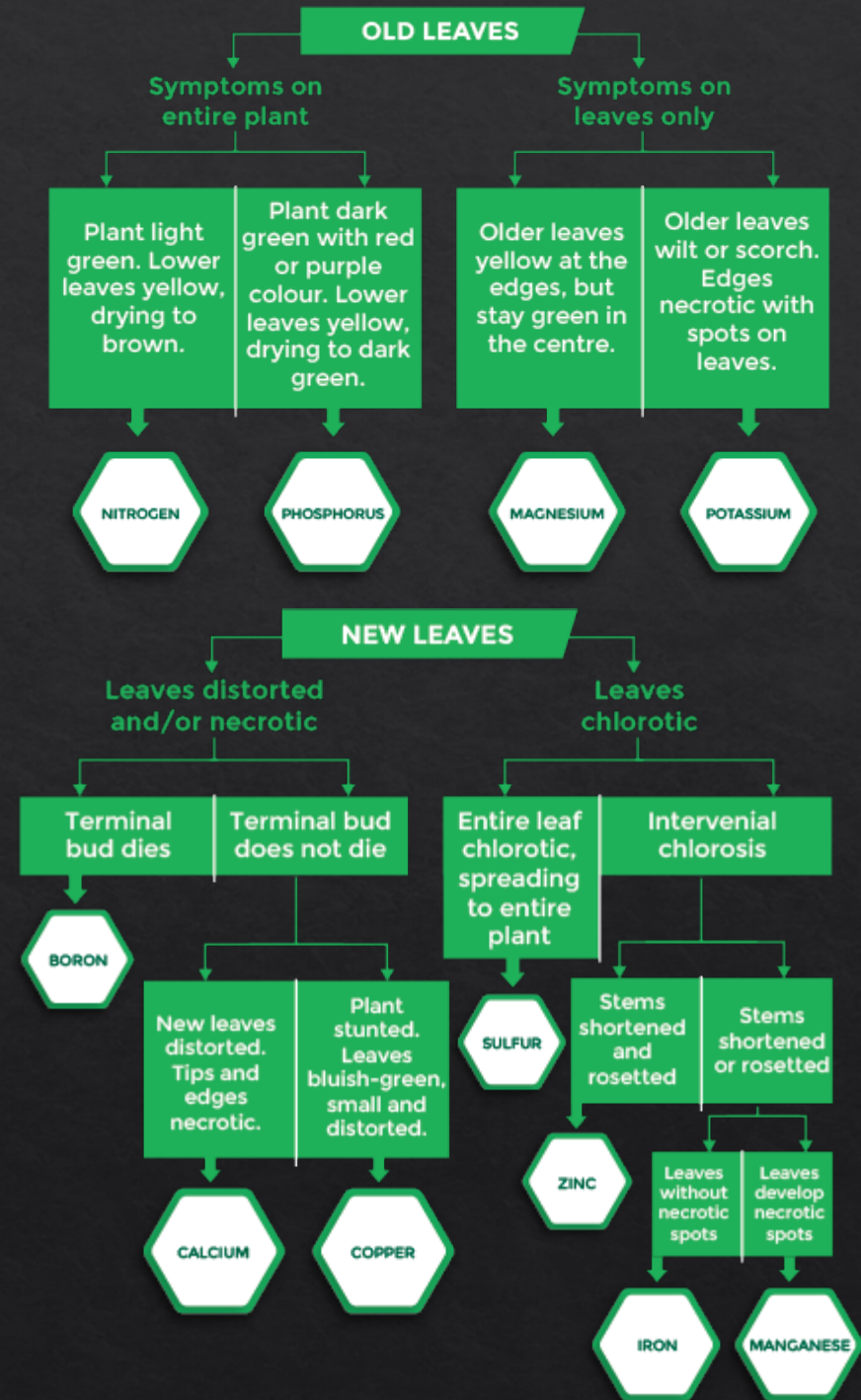
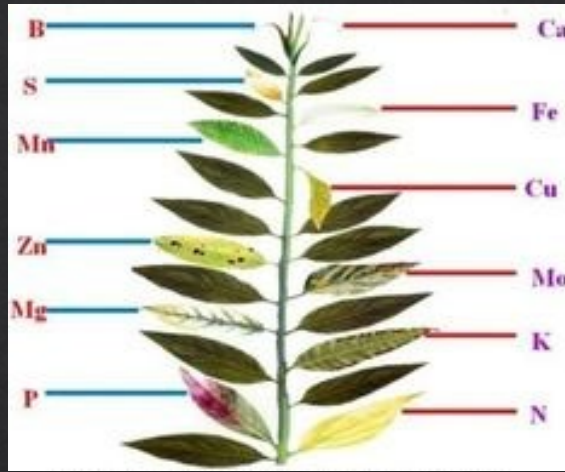
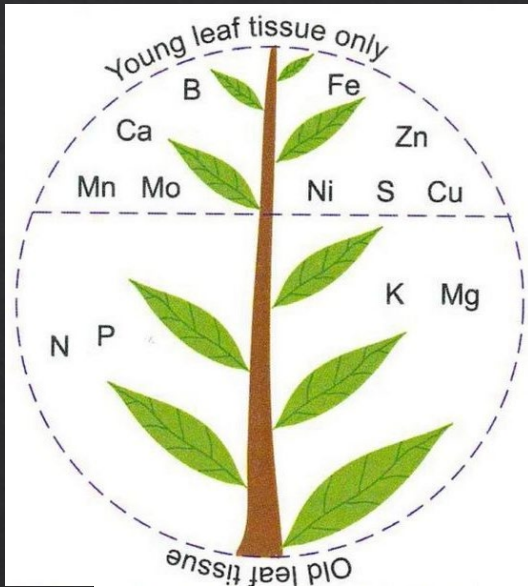
Iron

Dead spots

Interveinal Yellowing/ Burning/Chlorosis

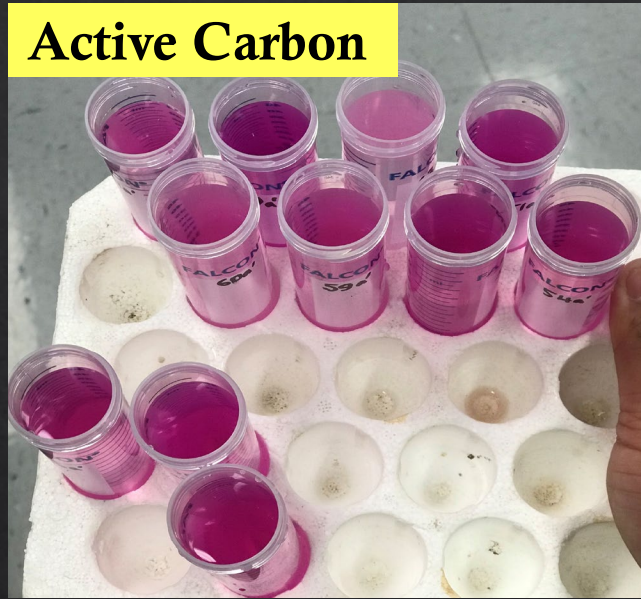


DIAGNOSIS



Judging Soils: Soil Health Assessment

Active Carbon



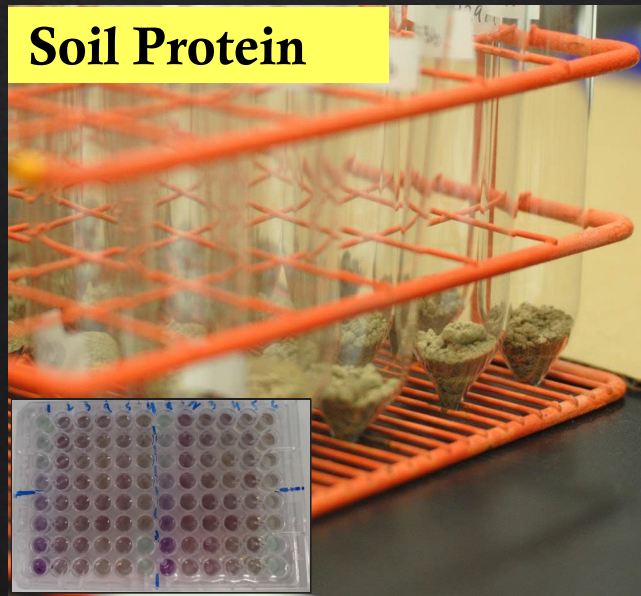
Mineralizable N



Soil Respiration



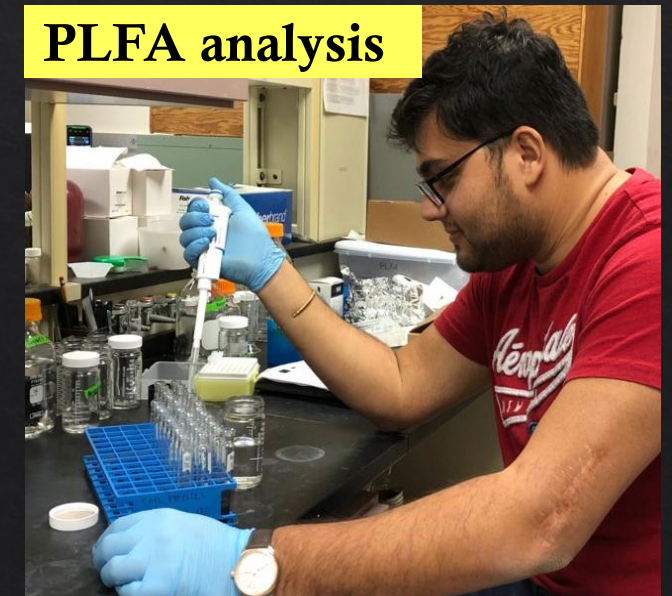
Soil Protein



Soil Enzymes



PLFA analysis



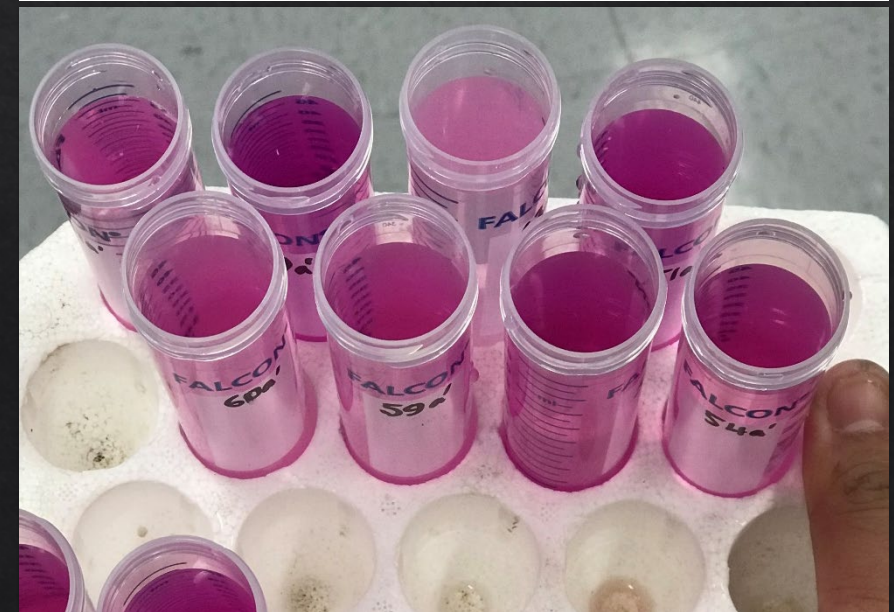
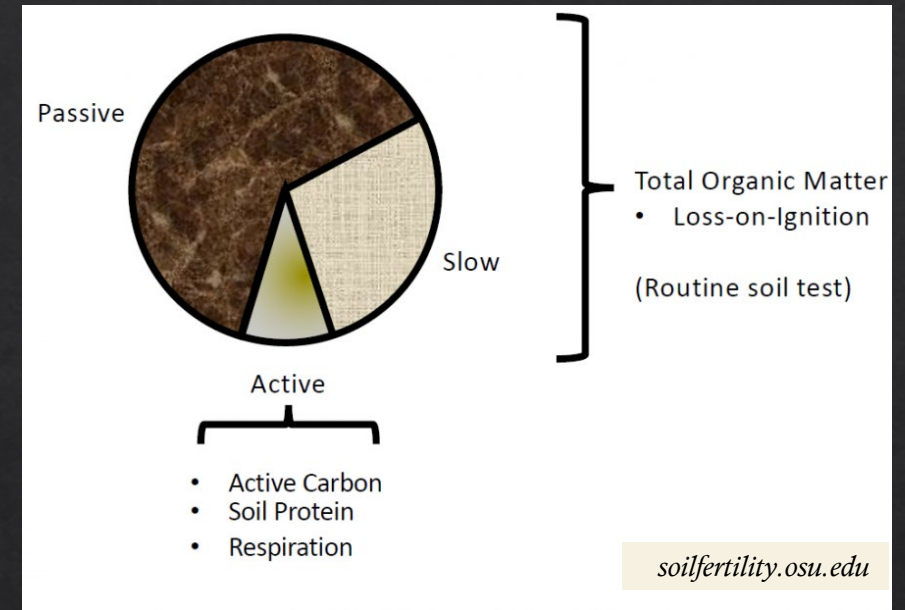
Potentially Mineralizable Nitrogen

- ◆ Indicator of N mineralization capacity
- ◆ Mineralization: ammonium-N to nitrate-N
- ◆ **Incubation** study: Measures ammonium
- ◆ N cycling: organic N \longleftrightarrow inorganic N



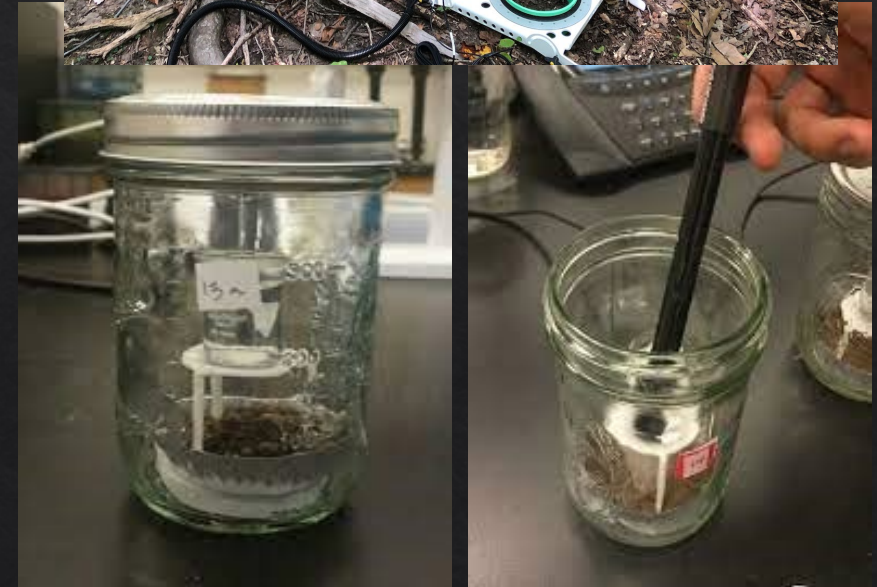
Active Carbon (POXC)

- Permanganate Oxidizable Carbon (POXC)
- 1 - 4% of total organic carbon
- Available to microbes as **energy source**
- Responds to changes in soil management



Soil Respiration (CO₂ burst)

- ◇ CO₂ released by soil biota (microbes, roots)
- ◇ Indicator of potentially *active* soil lives
- ◇ Direct or indirect measurement
- ◇ Dependent on *moisture* and temperature



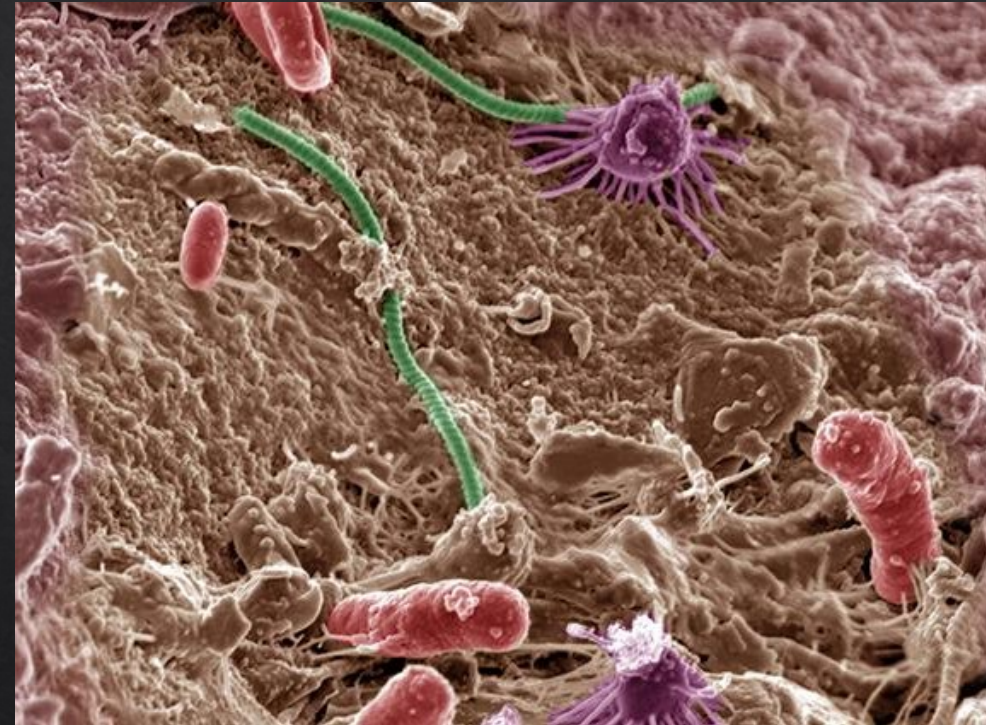
Soil Protein or ACE Protein

- ◆ Autoclaved Citrate Extractable (ACE)
- ◆ Indicate a pool of organic N in SOM
- ◆ Microbial activity
- ◆ Robust alternative to PMN



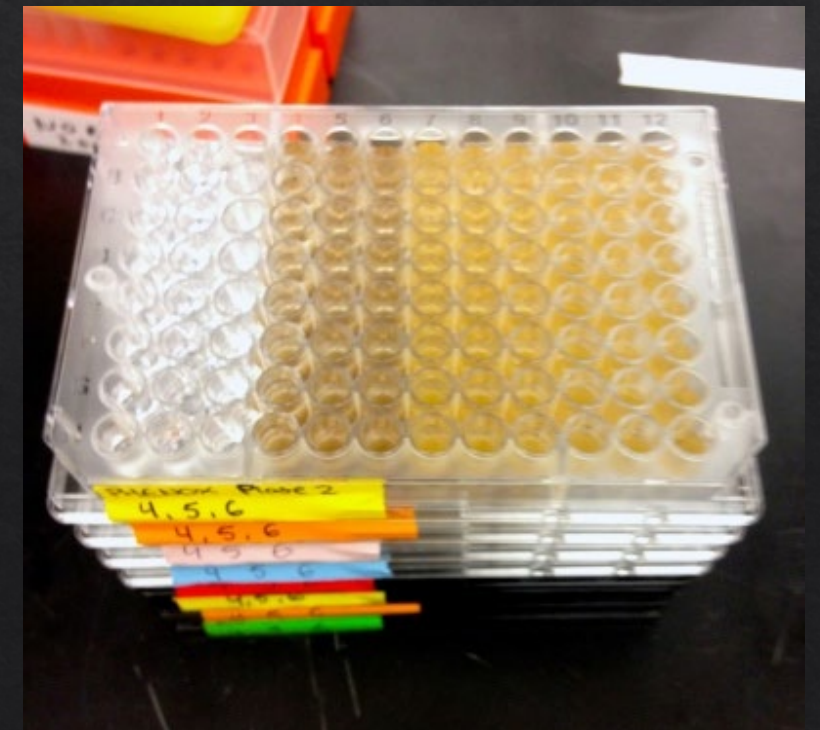
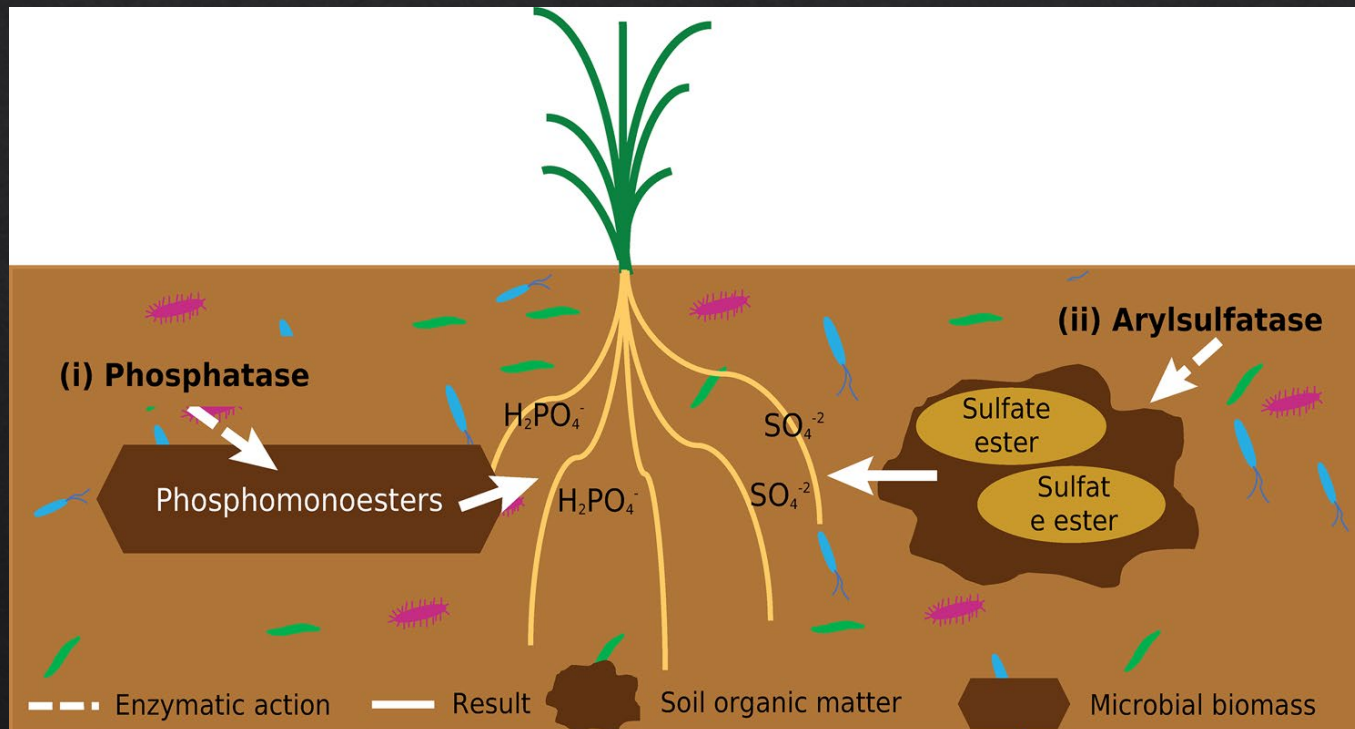
Soil Microbial Community

- ◆ Life of soil
- ◆ Ecological and physiological functions
- ◆ Nutrient cycling and availability
- ◆ Provides resiliency against weather



Soil Enzymes

- ◆ Enzymes decompose organic matters
- ◆ Influenced by moisture, temperature and pH



Phospholipid Fatty Acid (PLFA)

- ◆ Chemotaxonomic *markers* of microbes
- ◆ Phospholipids: component of cell membrane
- ◆ Phospholipid *saponified* to fatty acids
- ◆ Soil sampling method is crucial
- ◆ *Microbial Biomass* is calculated
- ◆ An expensive test, both cost and time



Soil Health *Practices*

Conservation Tillage



Cover Crops



Crop Diversification



Manure



Livestock



Legumes




Catering Industry Needs: Which Cover Crop to Use?



**Soil Health & Cover Crops:
A Study from South Dakota**

Debankur Sanyal, Ph.D.
Post Doc Research Associate
Dept. of Agronomy, Horticulture and Plant Science
South Dakota State University

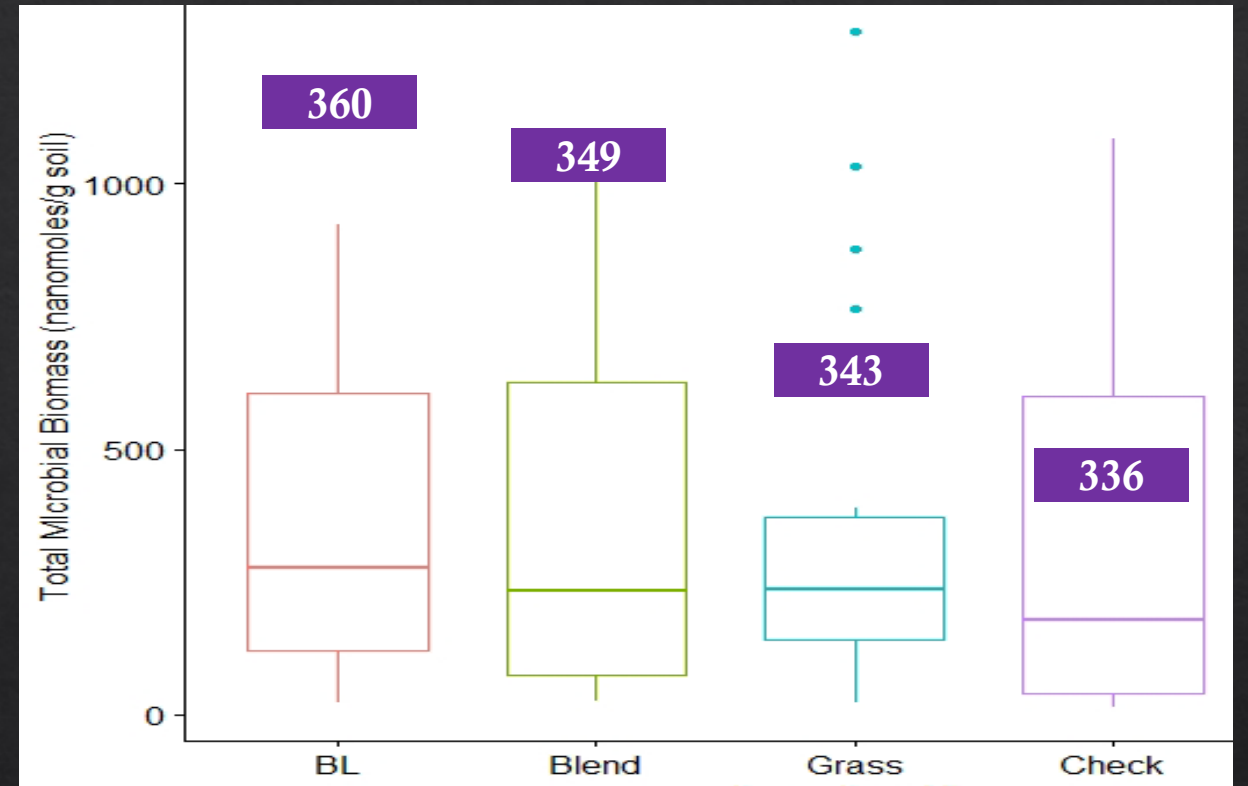
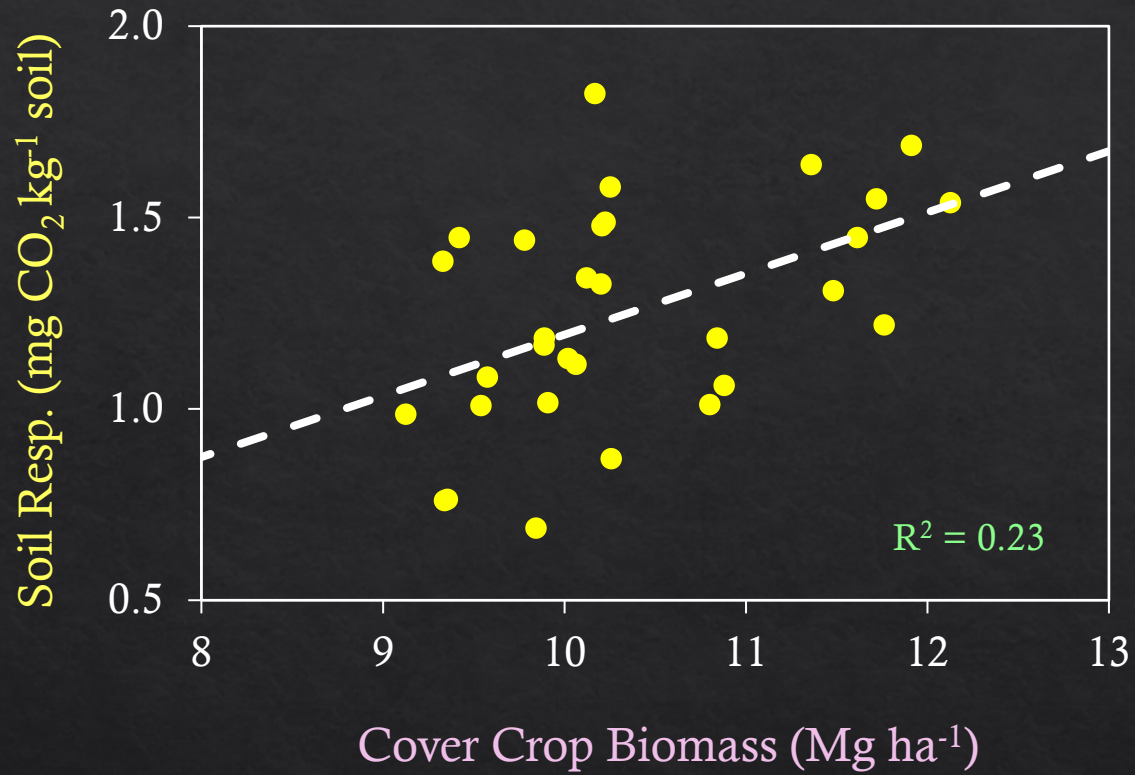


Which cover crops to choose for specific **crop rotation**

Measuring nutrient *catch and release* and **soil health**

Presented and *published* research outcomes



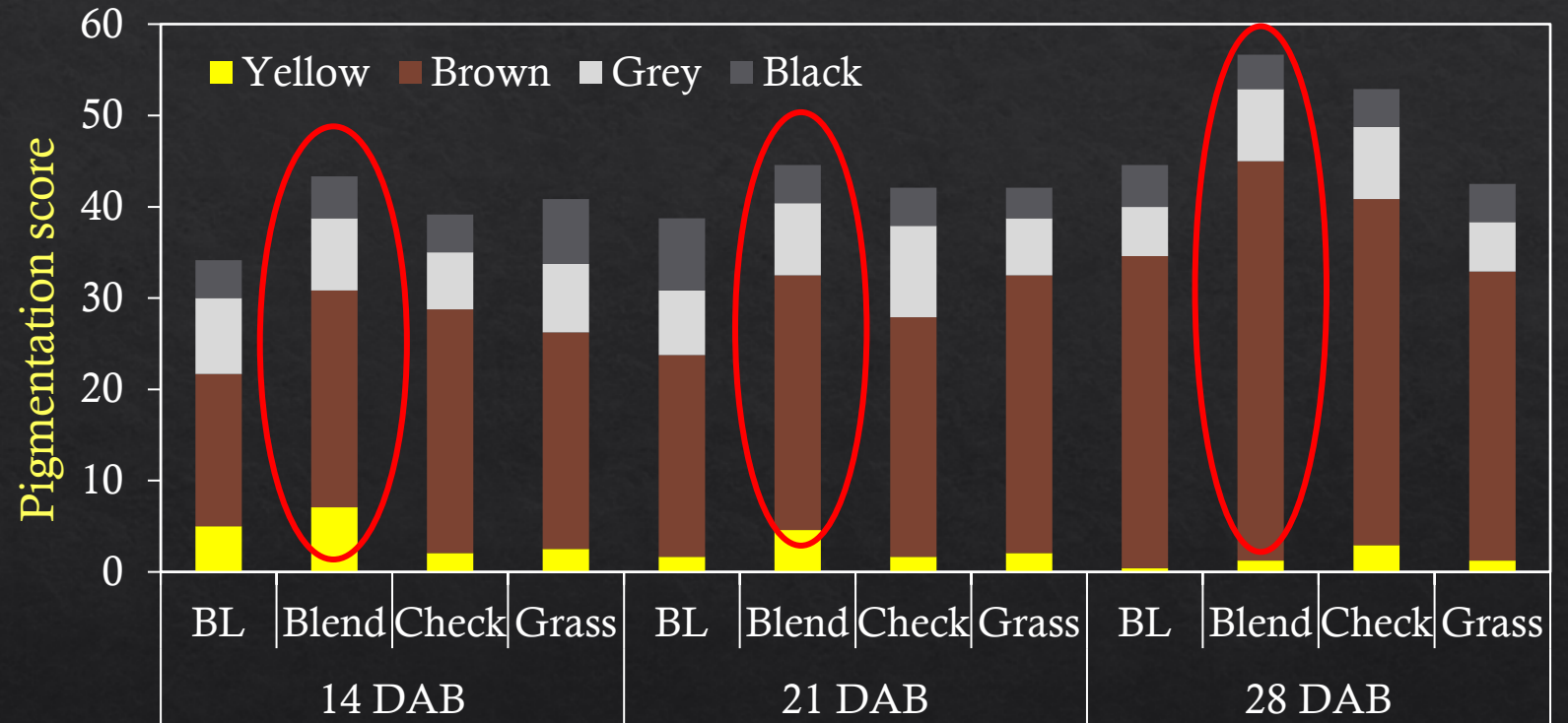


**Numbers depict mean values

Cover Crops influence microbial biomass and microbial activity



Cotton Strips for *in-situ* Microbial Activity

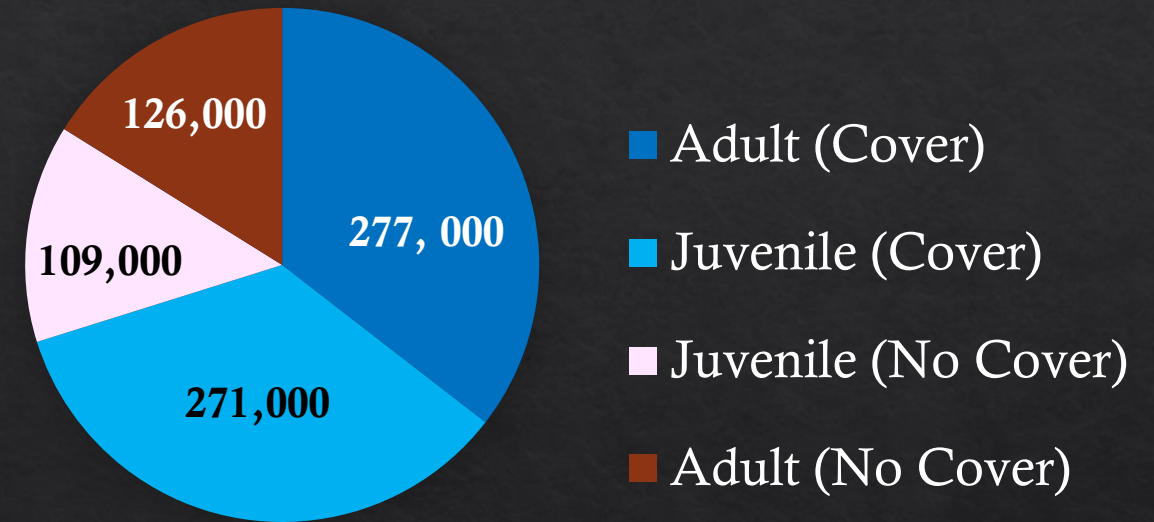


Effects Cover Crop Mixes at Different Days After Burial (DAB)

Blend treatment had higher microbial activity



Earthworm Population in Soil



**Numbers depict earthworm population per hectare

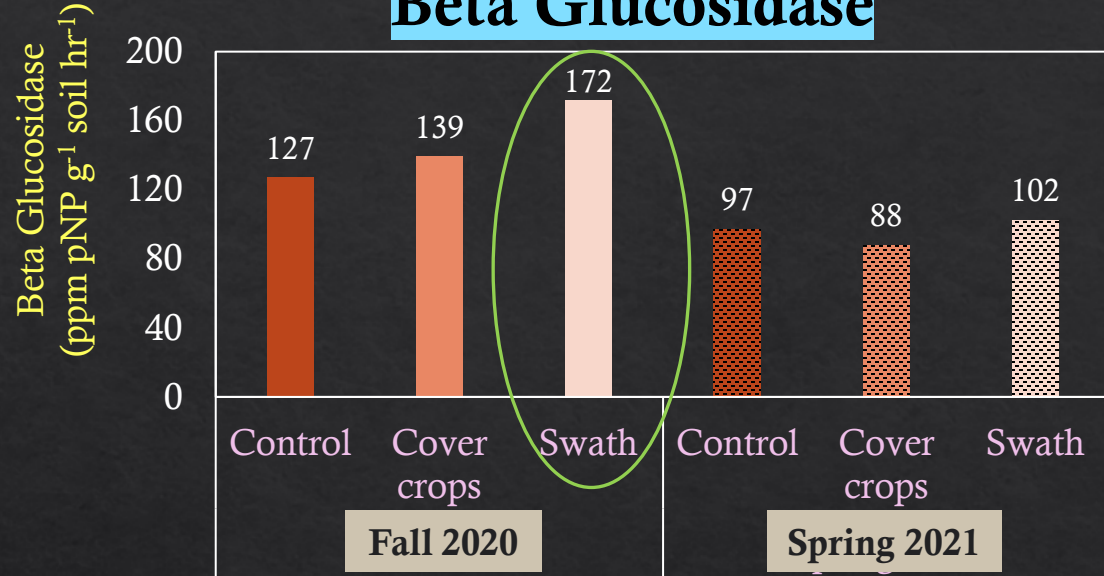


Innovative Grazing & Soil Health

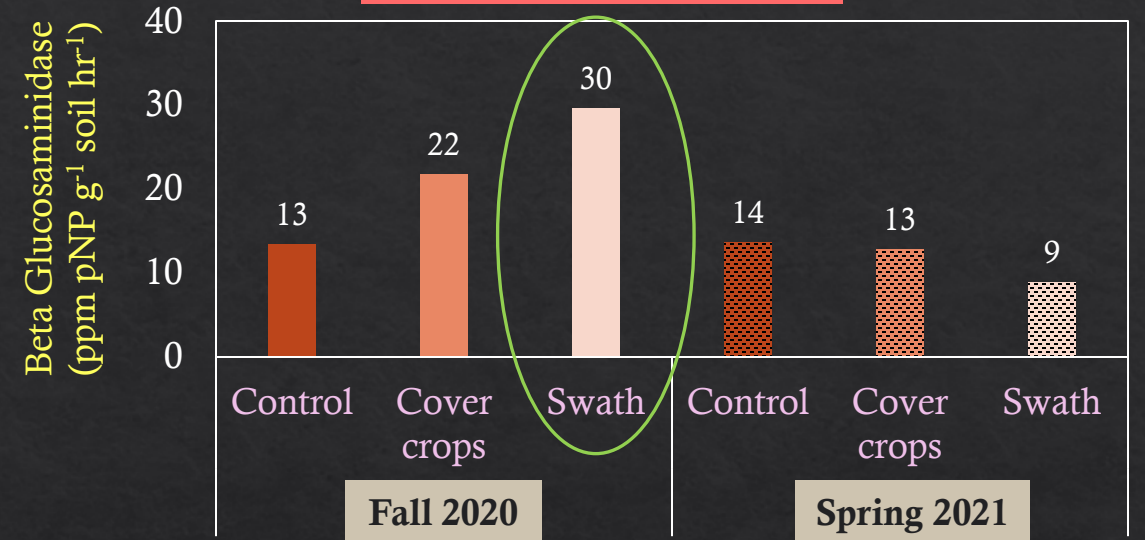
- 3-Year project (2020-2022)
- Treatments
 - Swath Grazed CC
 - *Freely Grazed CC*
 - Ungrazed CC
 - Sorghum×Sudan (Control)
- Grazing Period: 14-16 days in the fall
- West River Ag Farm, SDSU at Sturgis, SD
- Cash Crops: Spring Wheat and Field Peas
- Parameters:
 - Soil nutrients
 - Soil health assays: protein, enzymes, active C



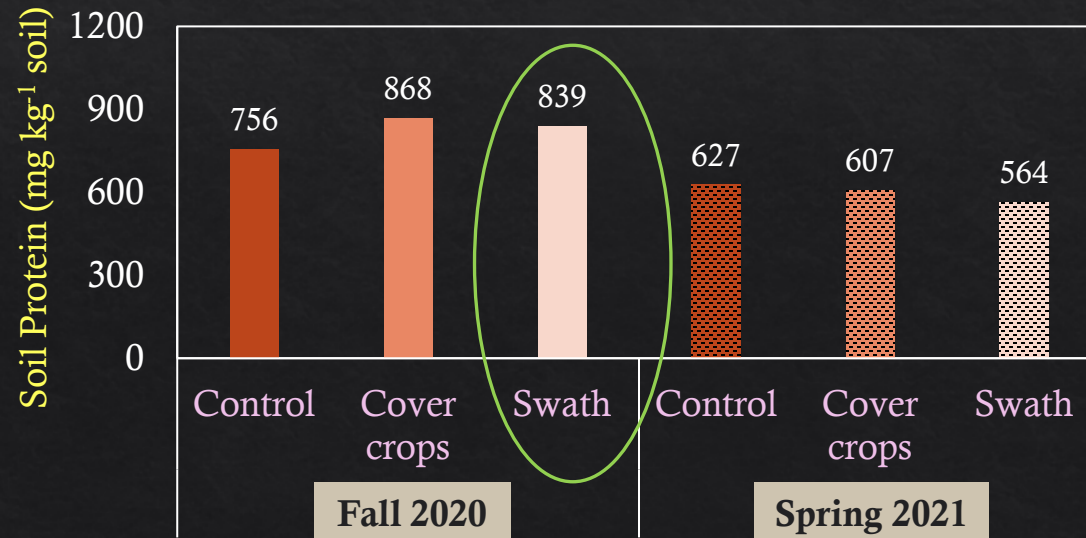
Beta Glucosidase



Glucosaminidase

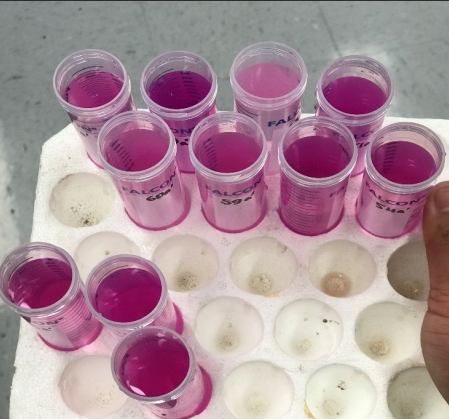


Soil Protein

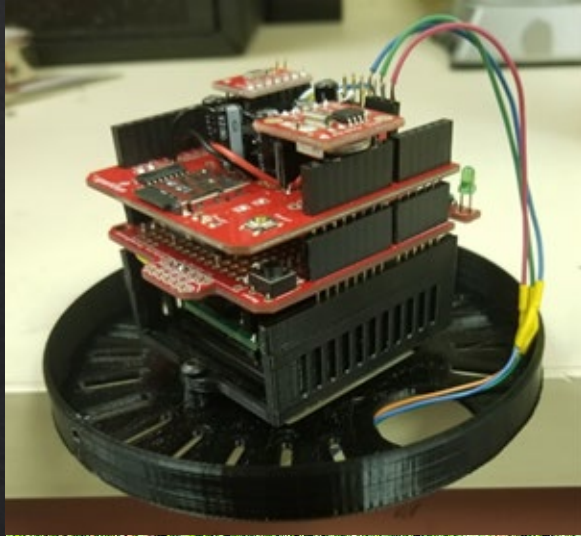


Top 0-7.5 cm

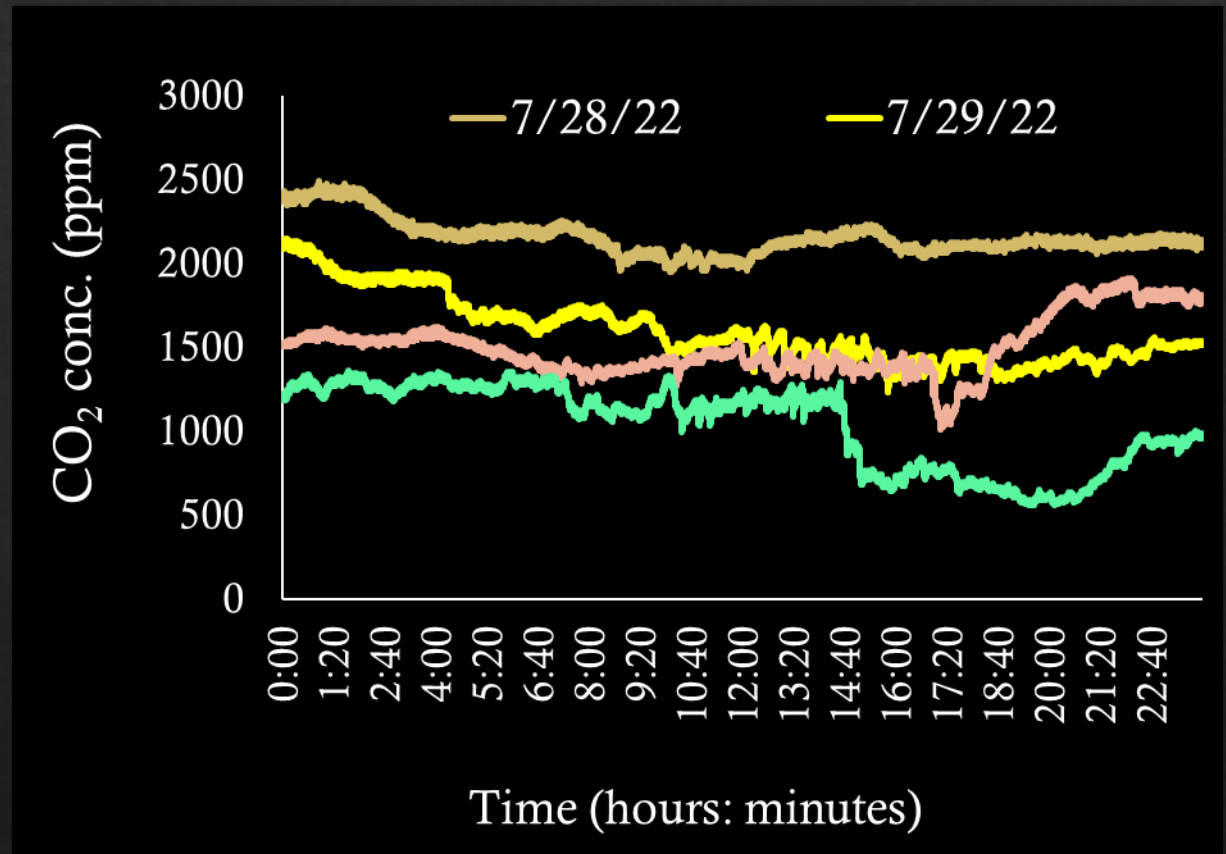
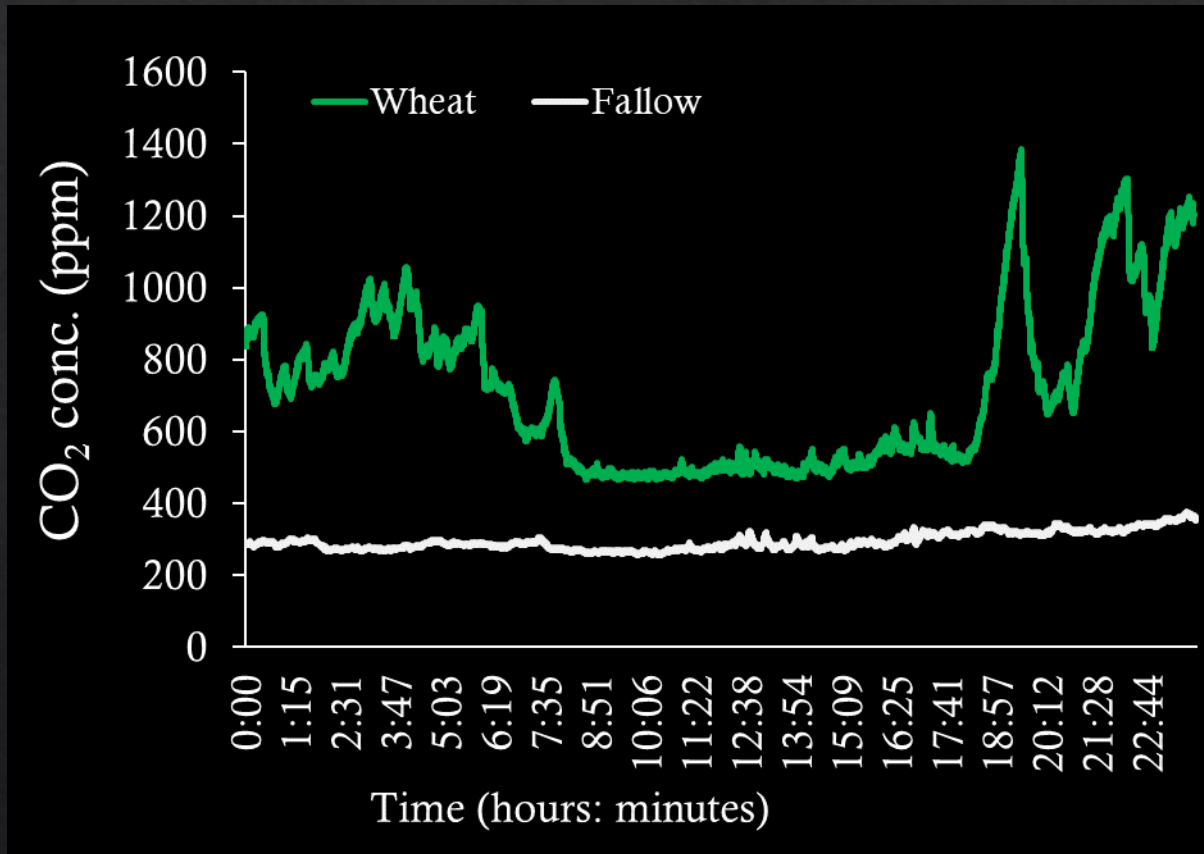
Soil Health Survey



Low-cost Soil Respiration Device



Soil Respiration *in-situ* Data

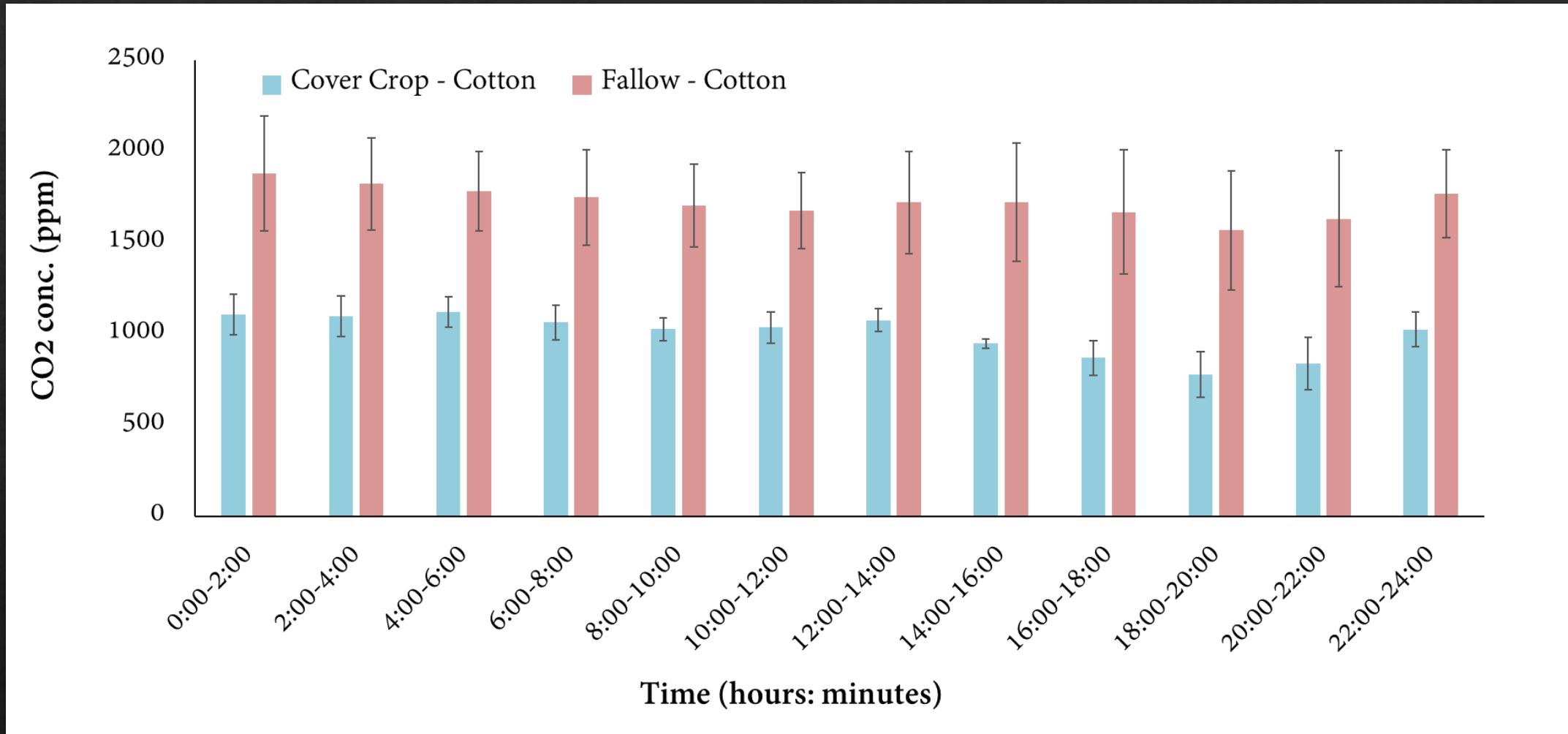


CO₂ emissions from a commercial wheat field and a fallow ground

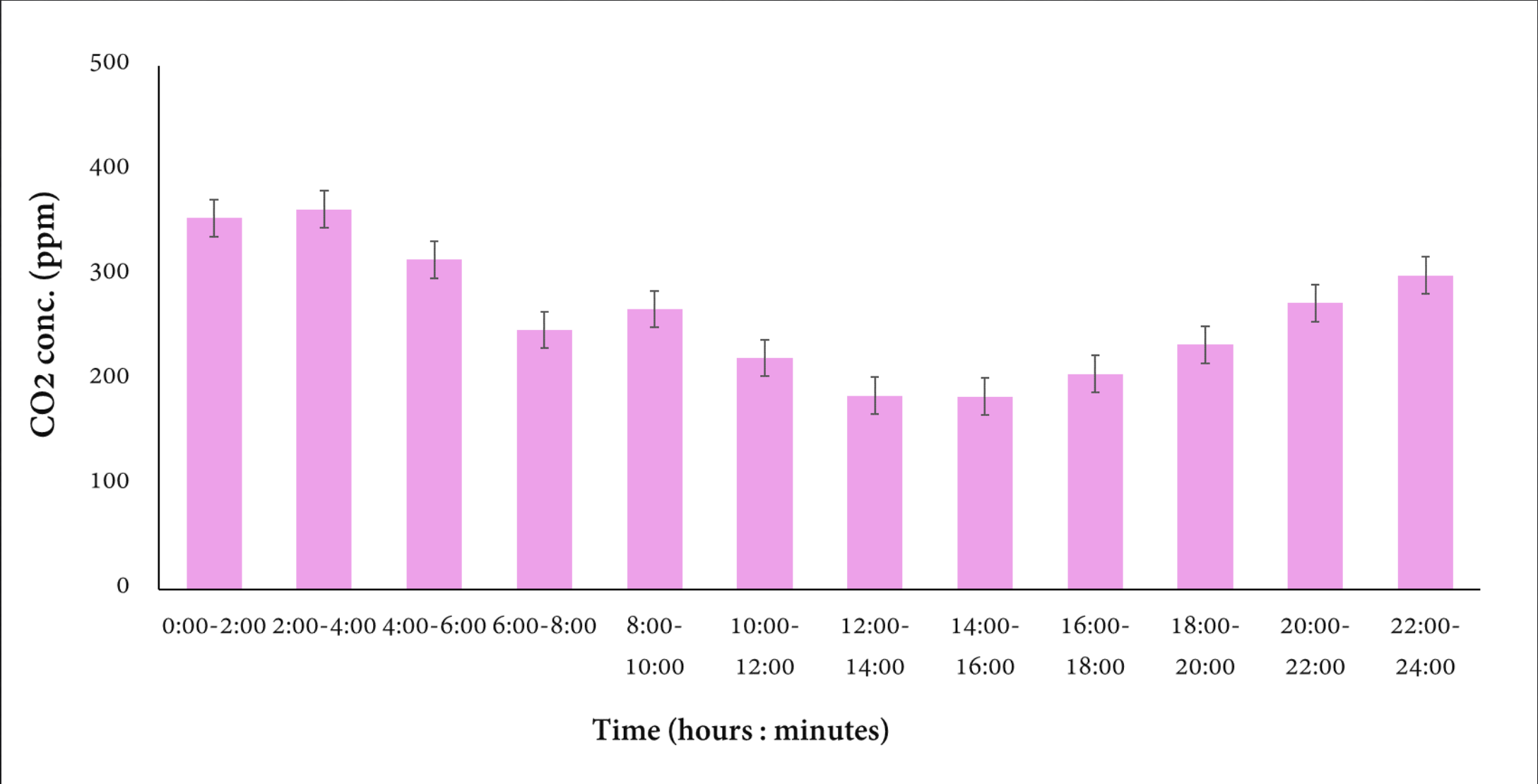
Daily variation of CO₂ emission in a wheat field



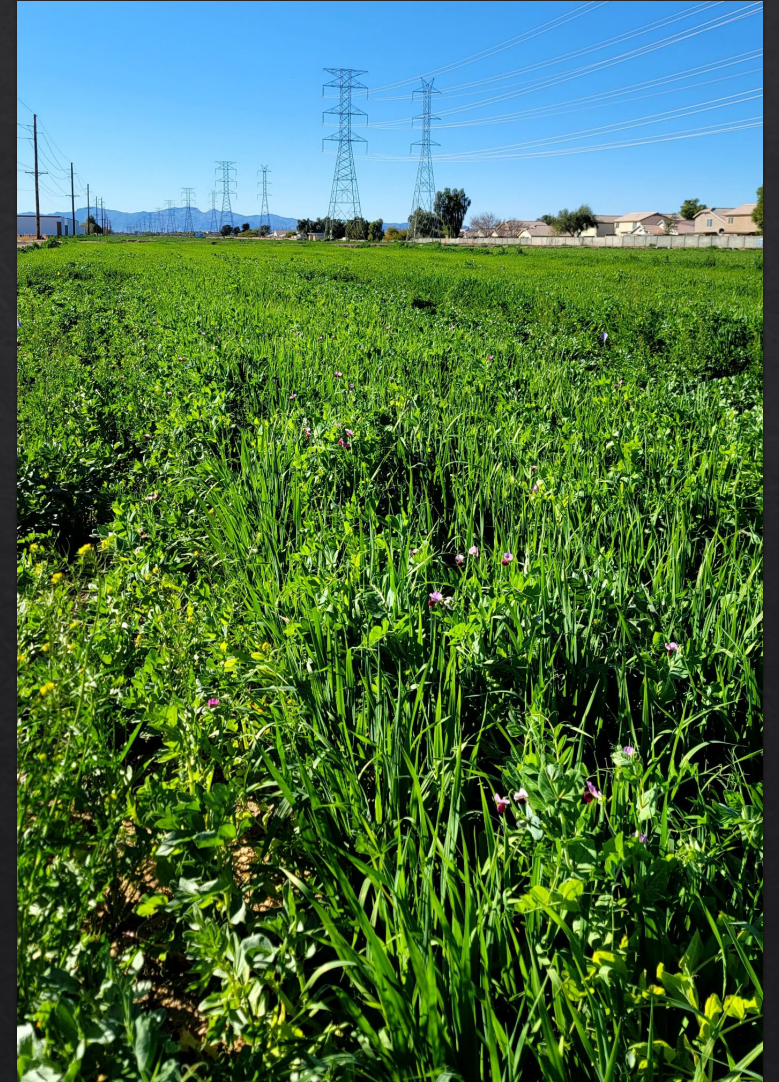
CO₂ Emissions from Two Cotton Rotations



Potential Soil Respiration (PSR) in Wheat



Testing Cover Crop Mixes



Water Sanitizers and Soil Health



Building New Farmlands



Thank you!

- Dr. Chris Graham
- Mr. Anthony Bly
- Dr. Robert J. Goos
- Dr. Bob Brueggeman
- Mr. Chaz Stackpole
- Dr. Channah Rock
- Dr. Joey Blankinship
- Dr. Charles Sanchez
- Dr. Jeff Silvertooth
- Dr. Diaa Elshikha
- Dr. Pedro Andrade

- Dr. Biswanath Dari
- Dr. Arnab Bhowmik
- Dr. Debalin Sarangi
- Dr. Peter Sexton
- Dr. Howard Woodard
- Dr. Babu S. Brar
- Dr. Navreet Mahal
- Dr. David Karki
- Dr. Shyam Solanki
- Dr. Gazala Ameen
- Ms. Pallavi Sharma

