United States Department of Agriculture

Ecological Management

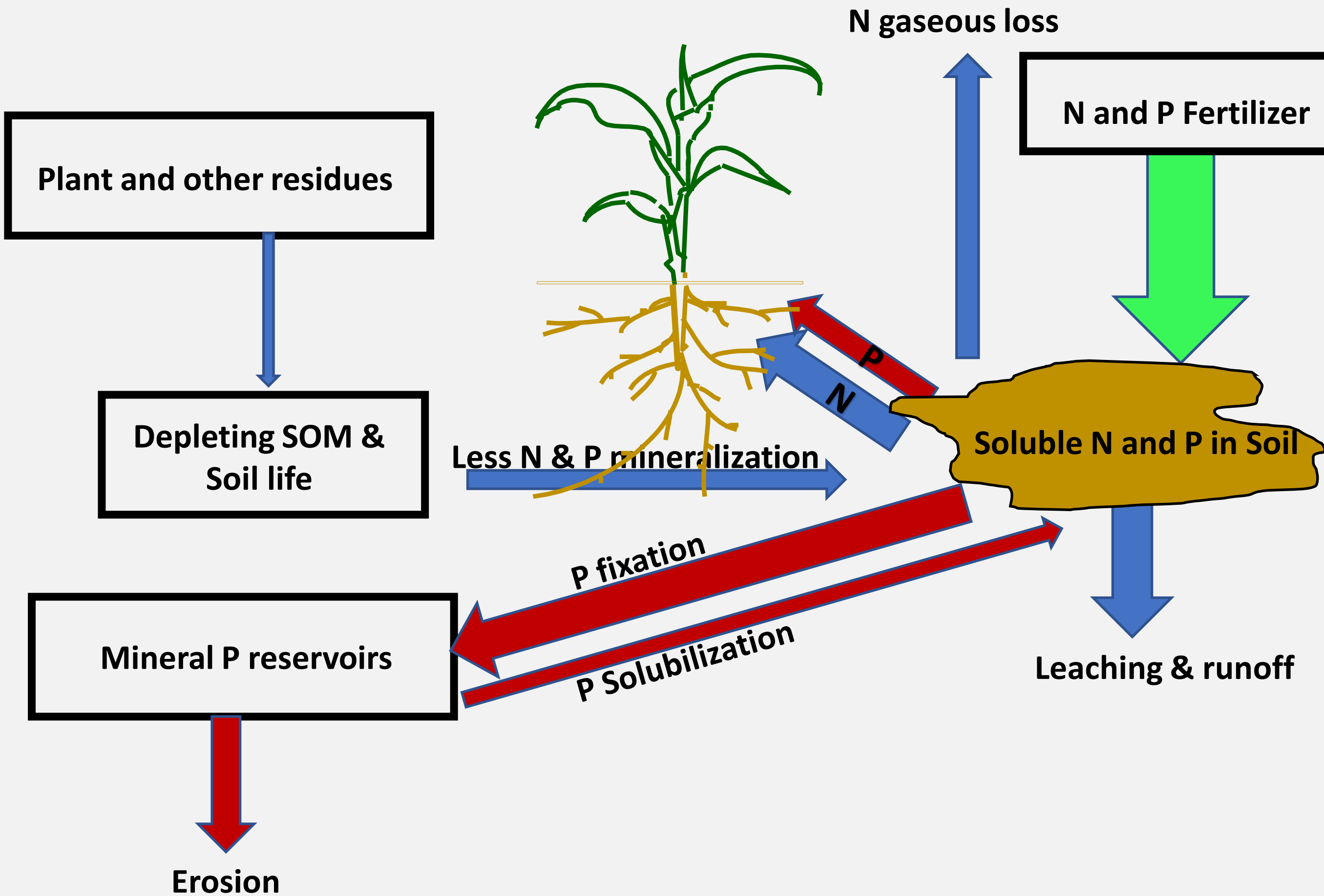
Andy Gaver - District Conservationist Butler County

USDA United States Department of Agriculture

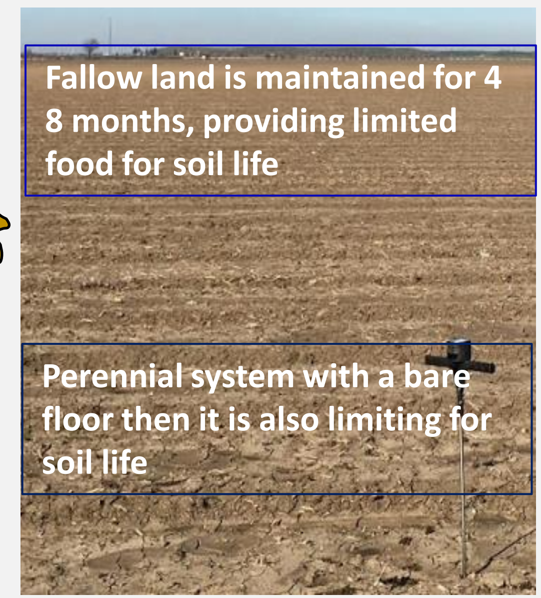
Objectives

- Summarize how a soil health management system impacts:
  - Nutrient management (e.g. mineralization/immobilization [C:N ratio], N and P cycling)
  - Carbon/organic matter management (pools/fluxes)
  - Water management/water cycle
  - Pest management (insect, disease and weeds)

Dominant Nutrient Management Strategy



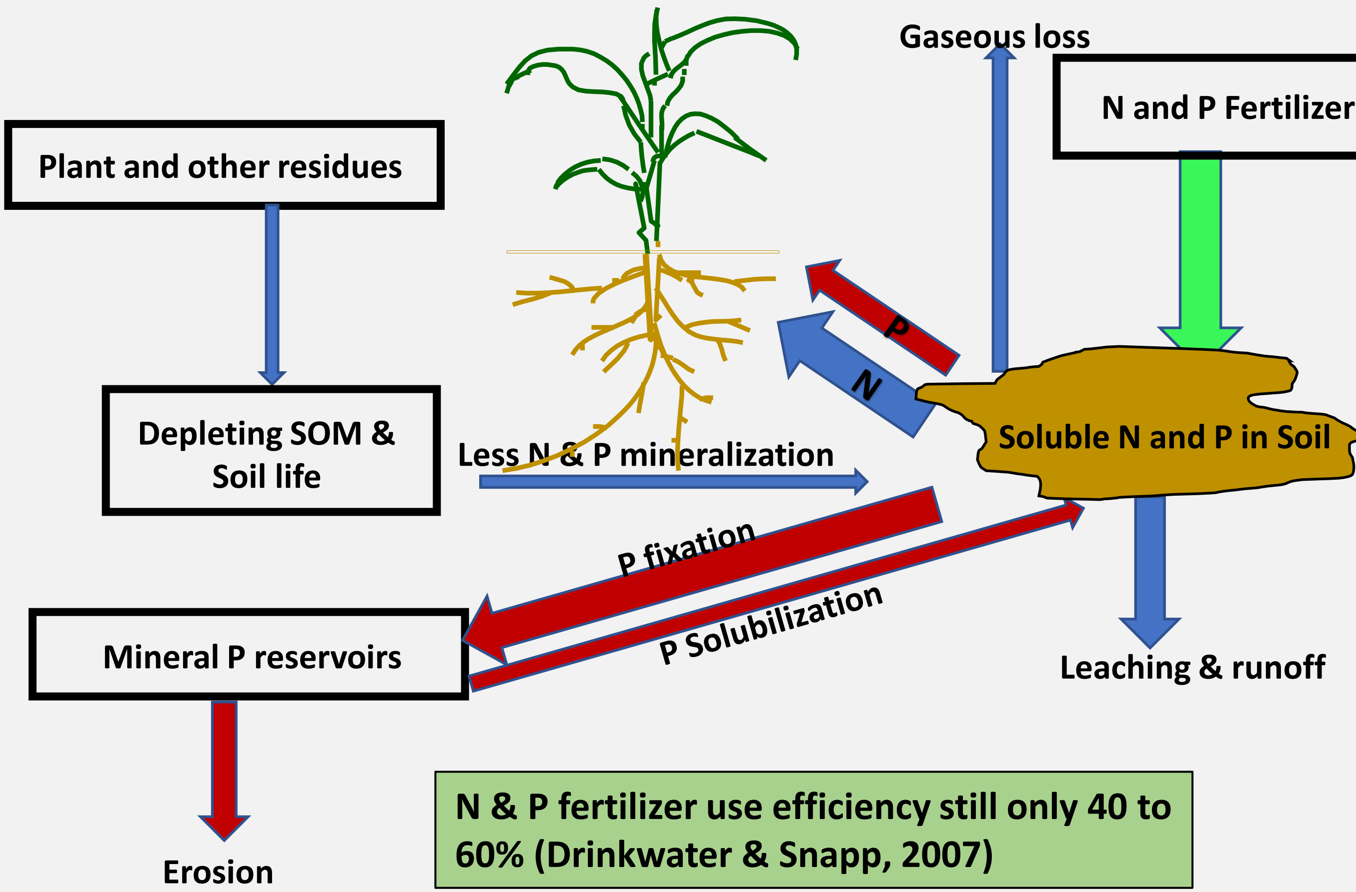
Plenty N & P are added to meet the yield goal. Soil with excess fertilizers is leaky



Adapted from Drinkwater & Snapp, 2007

USDA United States Department of Agriculture

The 4R Nutrient Management Strategy



N & P fertilizer use efficiency still only 40 to 60% (Drinkwater & Snapp, 2007)

Side dressing, banding, fertigation, split application & nitrification inhibitors etc. increase the efficiency but do not eliminate nutrient losses

Fallow land is maintained for 4-8 months providing limiting food for soil life

Perennial system with a bare floor is also providing limiting food for soil life

Losses of Nutrients

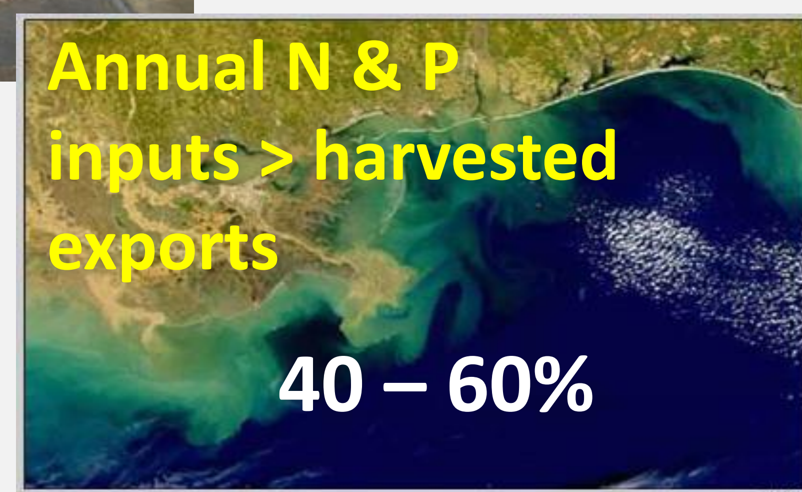
Chemical paradigm

↓

Simplified cropping system

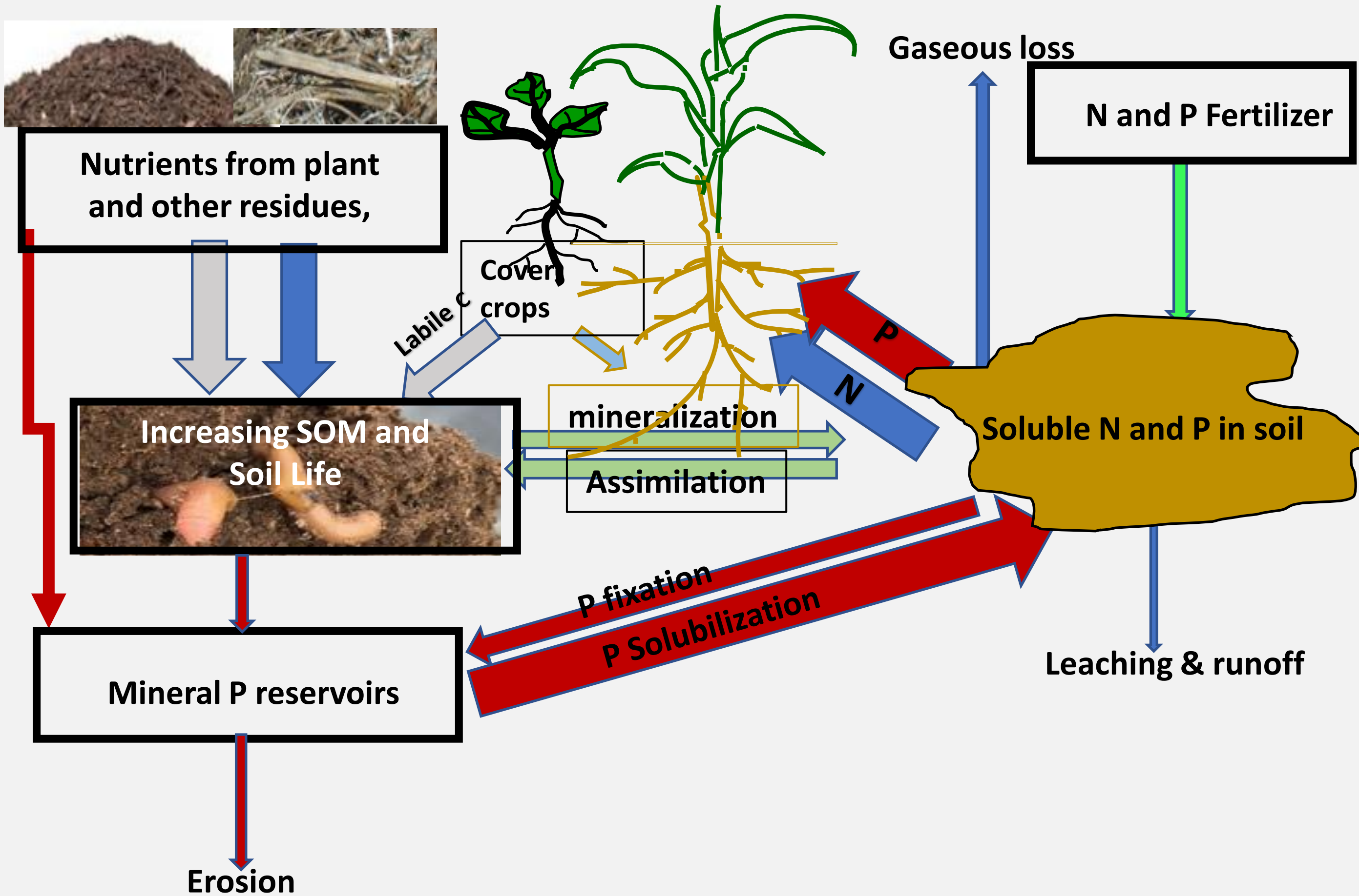
↓

Maximize nutrient concentration in space & time →



USDA United States Department of Agriculture

Ecological Nutrient Management



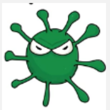
- Achieves high yields, minimizes fertilizer use, and reduces environment pollution
- Soil reservoirs increase and are made more available by diverse inputs
- Diverse inputs are residues, cover crops, compost, crop rotation, and slow release N
- Minimize tillage to preserve residues & protect soil life that recycle nutrients
- Measure all pools of N & P and apply 4R strategy to maximize the nutrient efficiency

Adapted from Drinkwater & Snapp, 2007

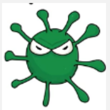
To summarize

Mineralization Vs. Immobilization

Mineralization:

Organic N +  → NH_4/NO_3

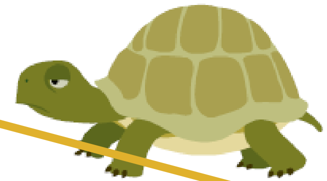
Immobilization is the reverse of mineralization.

NH_4/NO_3 +  → Organic N

Johnson et al. 2005, Cornell University

C:N ratio in Cover Crops (Nutrients Availability & Decomposition Rate)

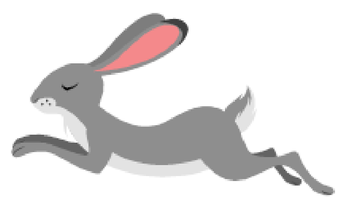
Material	C:N Ratio
rye straw	82:1
wheat straw	80:1
oat straw	70:1
corn stover	57:1
rye cover crop (anthesis)	37:1
pea straw	29:1
rye cover crop (vegetative)	26:1
mature alfalfa hay	25:1
Ideal Microbial Diet	**24:1**
rotted barnyard manure	20:1
legume hay	17:1
beef manure	17:1
young alfalfa hay	13:1
hairy vetch cover crop	11:1
soil microbes (average)	8:1



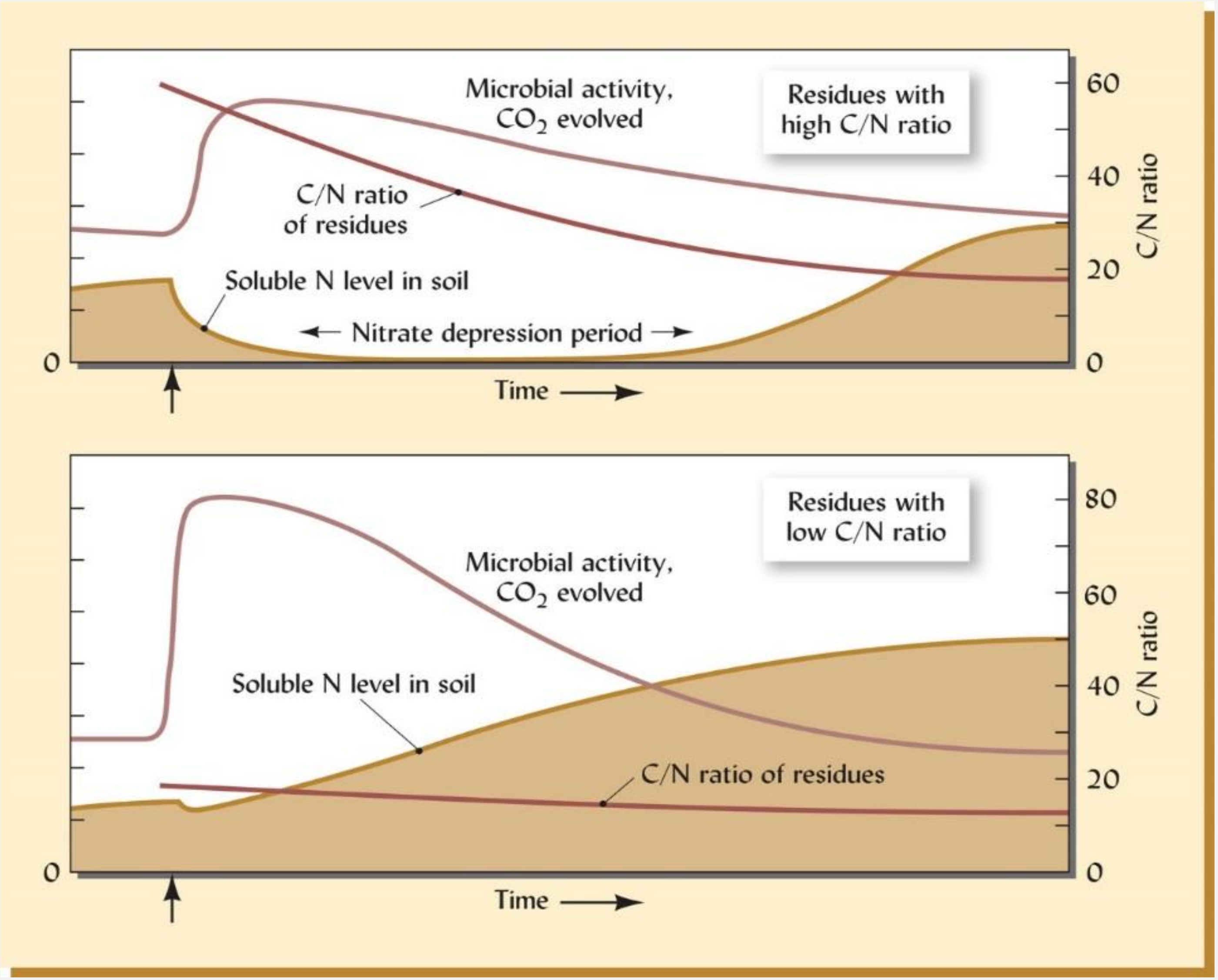
slower

Relative Decomposition Rate

faster



How C:N is Impacted by Microbes

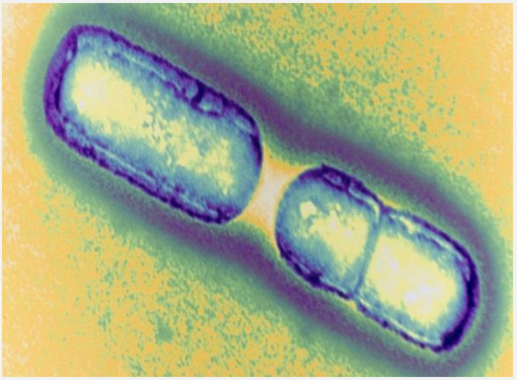


Weil and Brady, The Nature and Properties of Soils, 15e

Nitrogen Mineralization

Bacteria

C:N ratio about 5:1



5:1

Bacteria Feeding Nematode

C:N ratio about 10:1

10:1

Nitrogen Mineralization

Bacteria

C:N ratio about 5:1

Bacteria Feeding Nematode

C:N ratio about 10:1

Consume two bacteria to get enough carbon for function and reproduction

Nitrogen Mineralization

Bacteria

C:N ratio about 5:1

Bacteria Feeding Nematode

C:N ratio about 10:1

Consume two bacteria to get enough carbon for function and reproduction

Only Needs 1 part N

Nitrogen Mineralization

Bacteria

C:N ratio about 5:1

Bacteria Feeding Nematode

C:N ratio about 10:1

Consume two bacteria to get enough carbon for function and reproduction

Only Needs 1 part N

Excrete 1 part N to soil solution as Plant Available N

Reduce N Losses

- Nitrate mineralized from crop residues and soil OM Is highly soluble through the winter.
- Nitrogen leaching can be significant even without fall N applications.

Residue Mgt for N Retention

NRCS | SHD | Ecological Management | v2.2

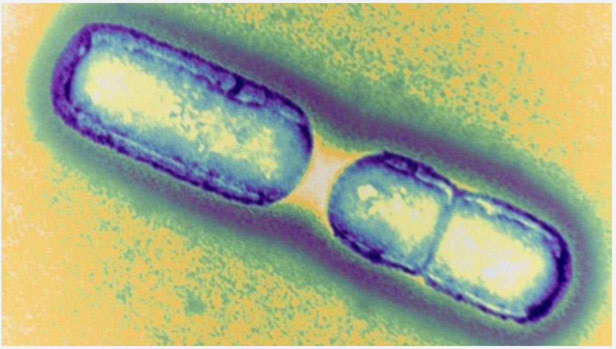
Nitrogen Immobilization

Cover Crop

C:N ratio about 40:1

Bacteria

C:N ratio about 5:1



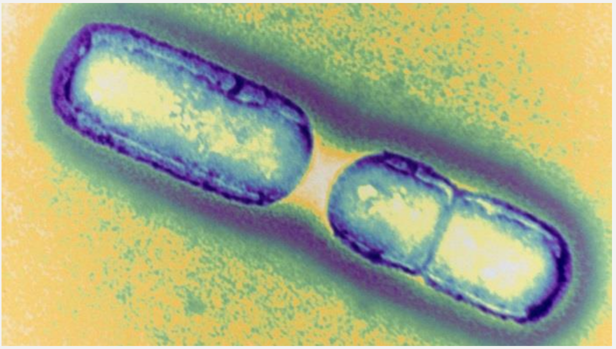
Nitrogen Immobilization

Cover Crop

C:N ratio about 40:1

Bacteria

C:N ratio about 5:1

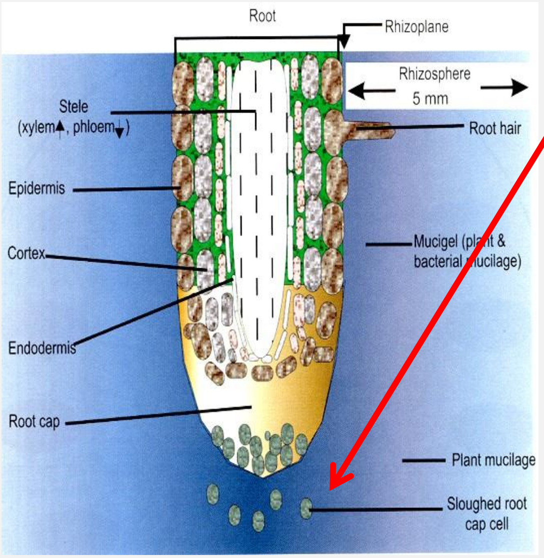


Consume enough carbon from the rye for respiration & body structure

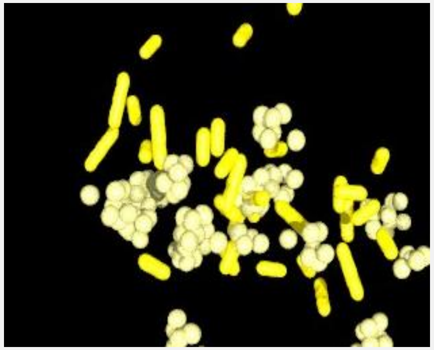
Knowledge Check: Poll Question

Is a dead cover crop with a C:N Ratio of 50 considered a high or low C:N ratio?

Plant Roots Attract Microbes



Exudates: carbohydrates and proteins secreted by roots; attract bacteria which nematodes & protozoa consume, which mineralize nutrients for plants.



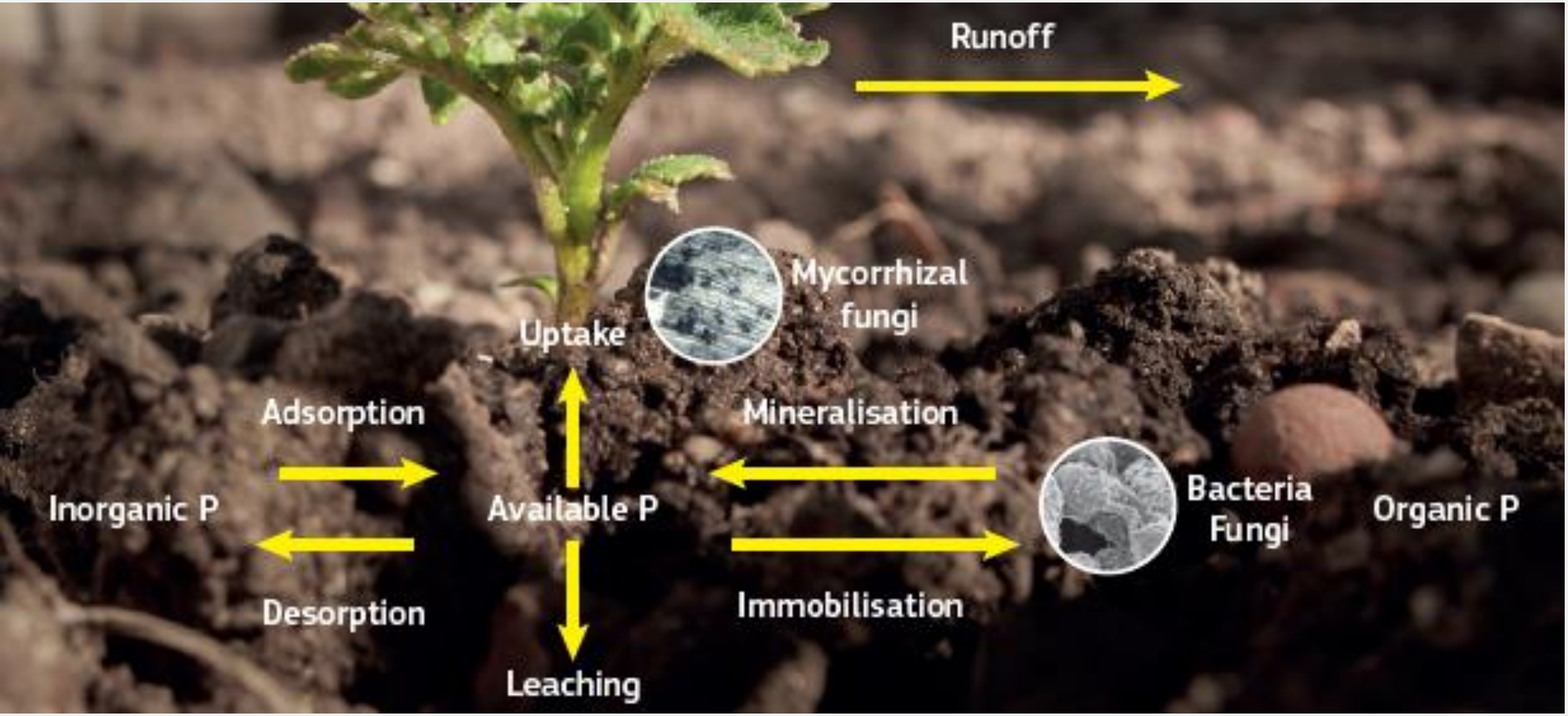

Bacteria and fungi are like little fertilizer bags


Nematodes and protozoa consume microbes and excrete plant available nutrients

United States Department of Agriculture

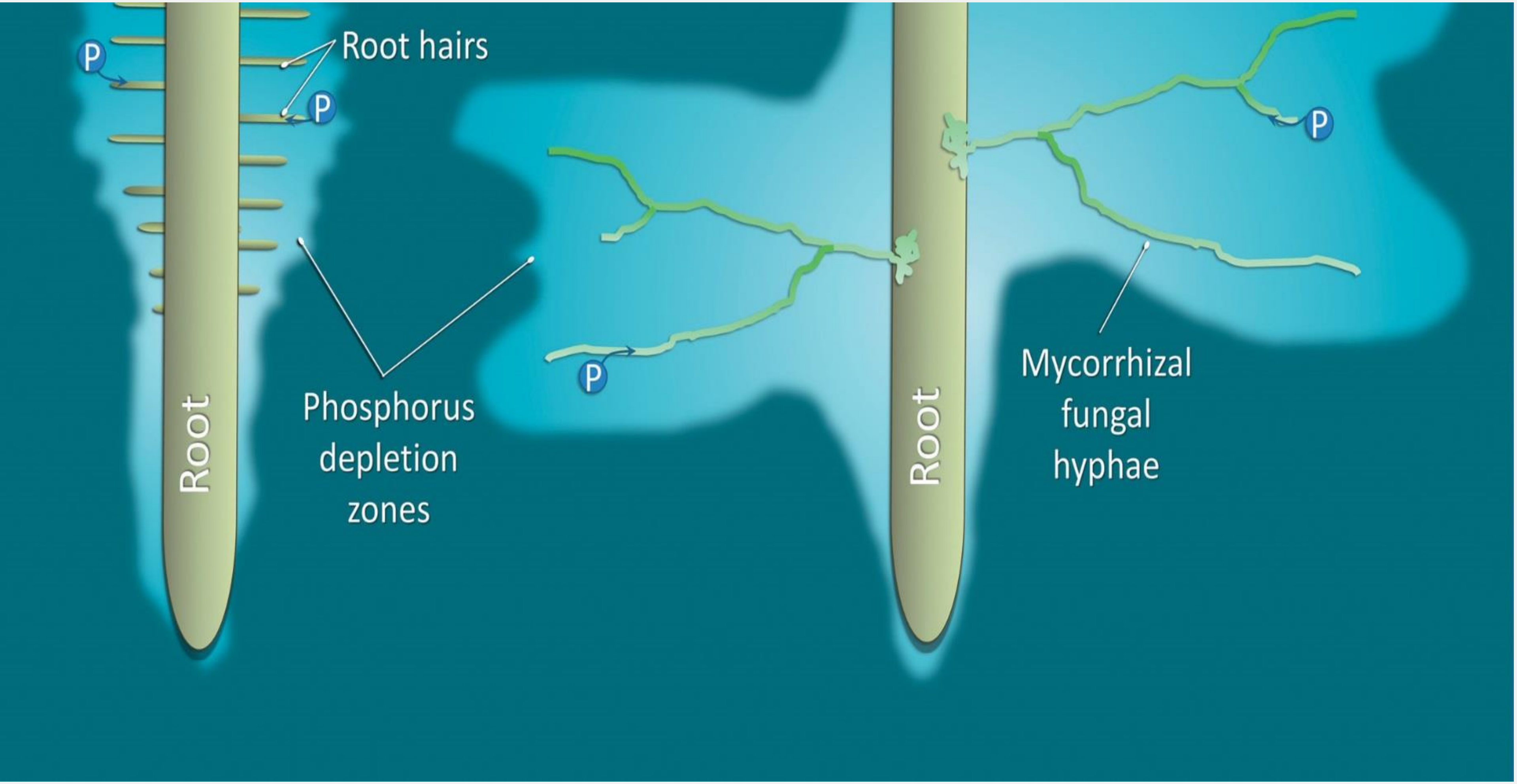
Biology and the Phosphorus Cycle:

What factors affect P movement/availability?

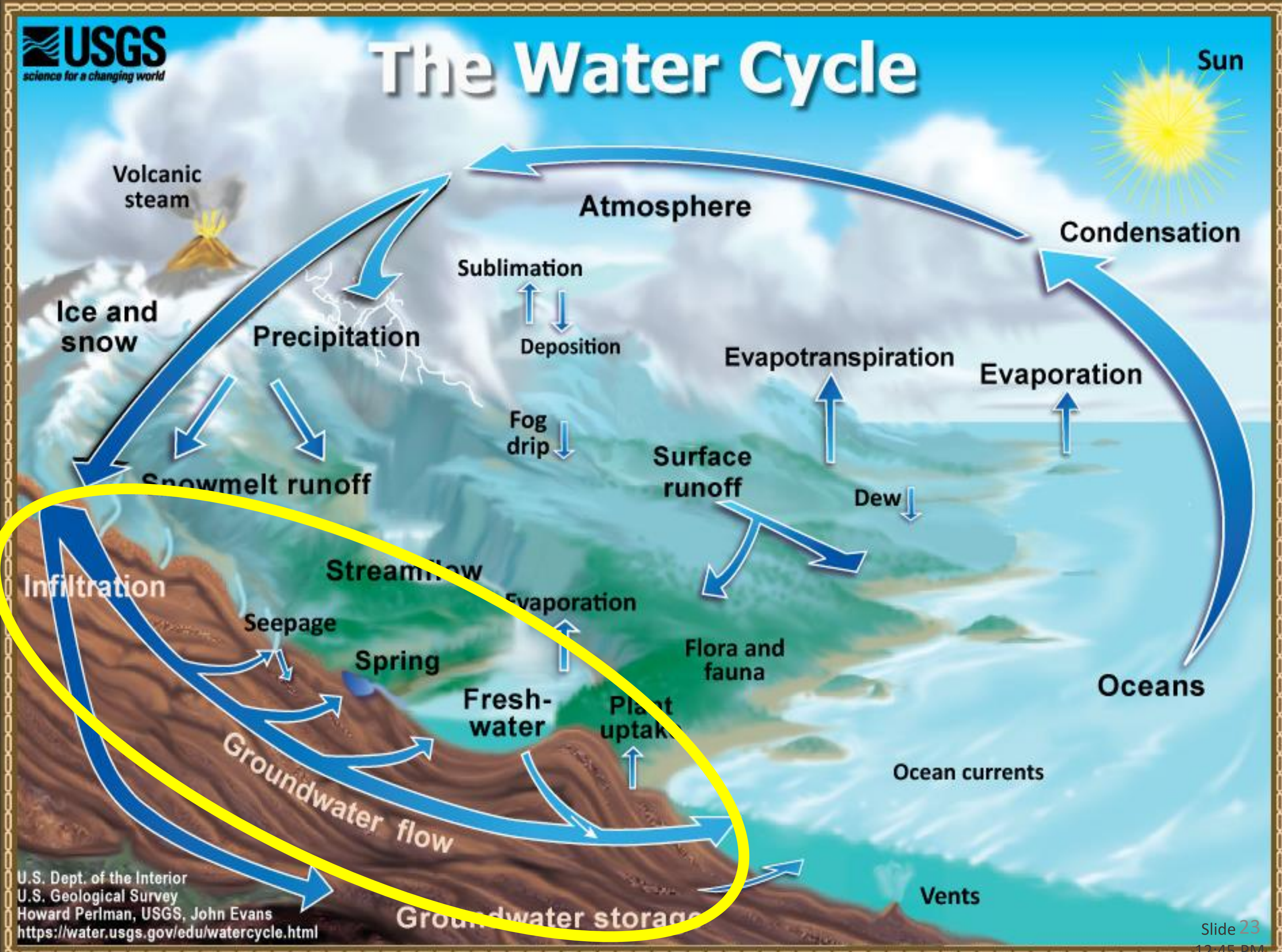


Top: Global Soil Biodiversity Atlas, p.105: Simplified phosphorus (P) cycle in the soil. The regulation of soil P cycling is influenced by microorganisms (e.g. bacteria and fungi). (DG, JRC)

Benefits of AM Association

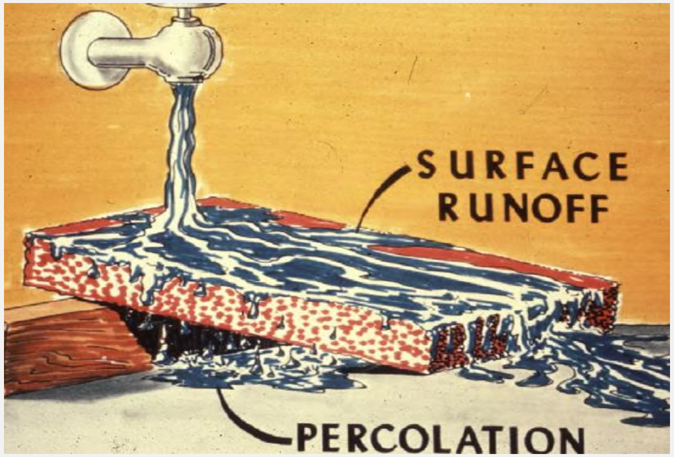


Weil and Brady, The Nature and Properties of Soils, 15th ed.

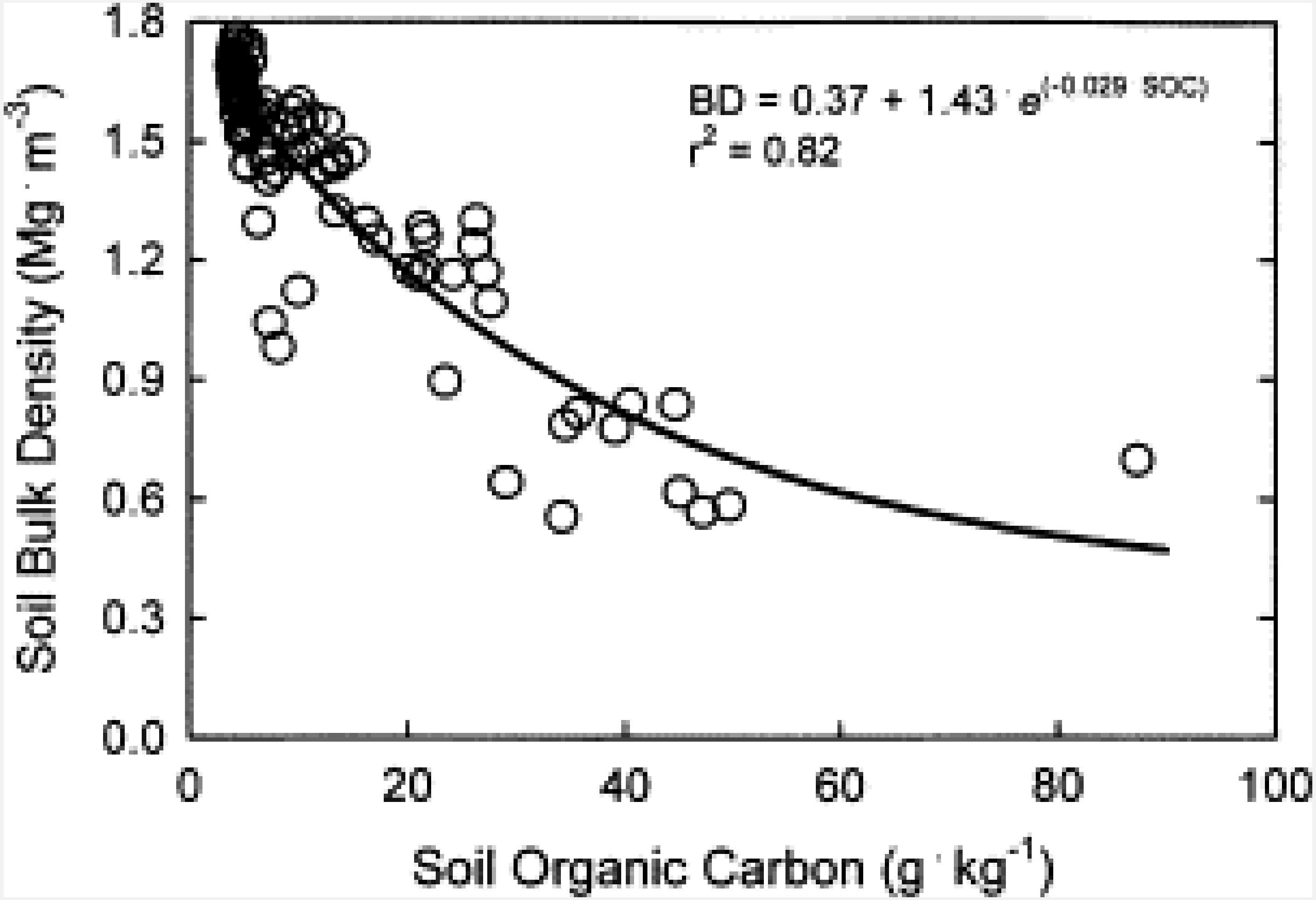

USGS
science for a changing world
The Water Cycle
Sun
Volcanic steam
Atmosphere
Condensation
Sublimation
Deposition
Ice and snow
Precipitation
Evapotranspiration
Evaporation
Fog drip
Surface runoff
Dew
Snowmelt runoff
Streamflow
Infiltration
Evaporation
Seepage
Spring
Flora and fauna
Fresh-water
Plant uptake
Oceans
Groundwater flow
Ocean currents
Vents
Groundwater storage
U.S. Dept. of the Interior
U.S. Geological Survey
Howard Perlman, USGS, John Evans
https://water.usgs.gov/edu/watercycle.html

Aggregate stability & Water Cycling

- Soil-atmosphere interface controls infiltration, one of the most critical moments in the water cycle.
- Soil aggregate instability leads to soil pore plugging, ponding, runoff and water quality problems.
- Soil aggregate stability supports infiltration, and soil profile storage and groundwater recharge.

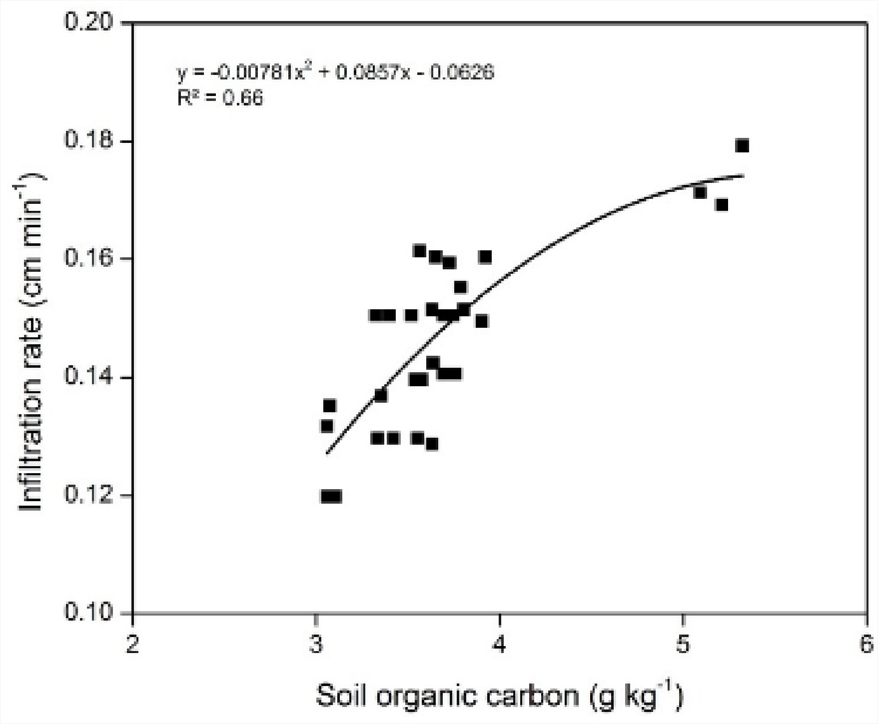


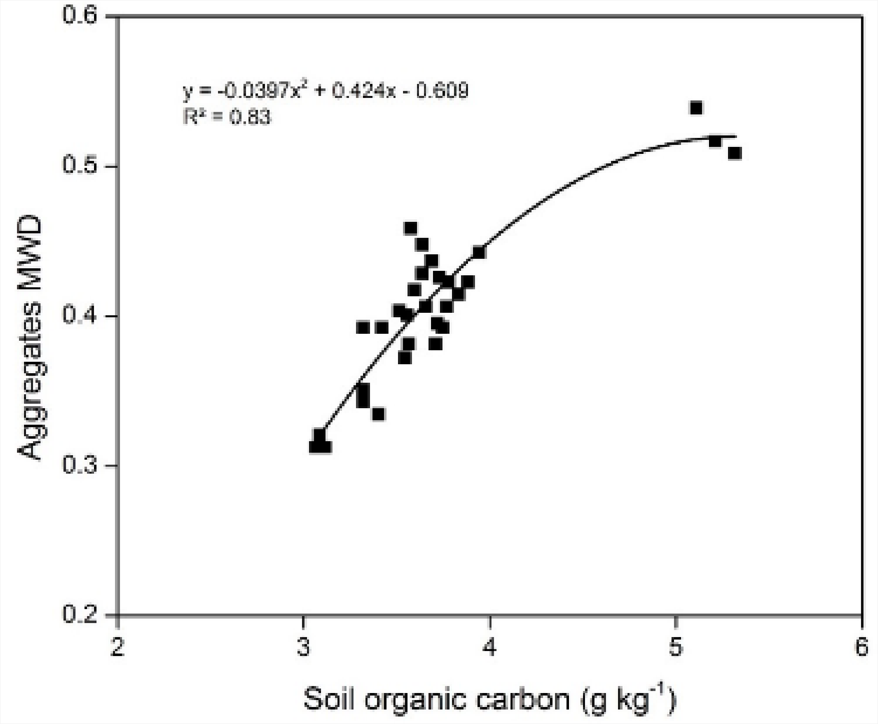
Soil Organic Carbon and Bulk Density



Franzluebbers, 2002, Soil & Tillage Res.

Carbon, aggregates and infiltration



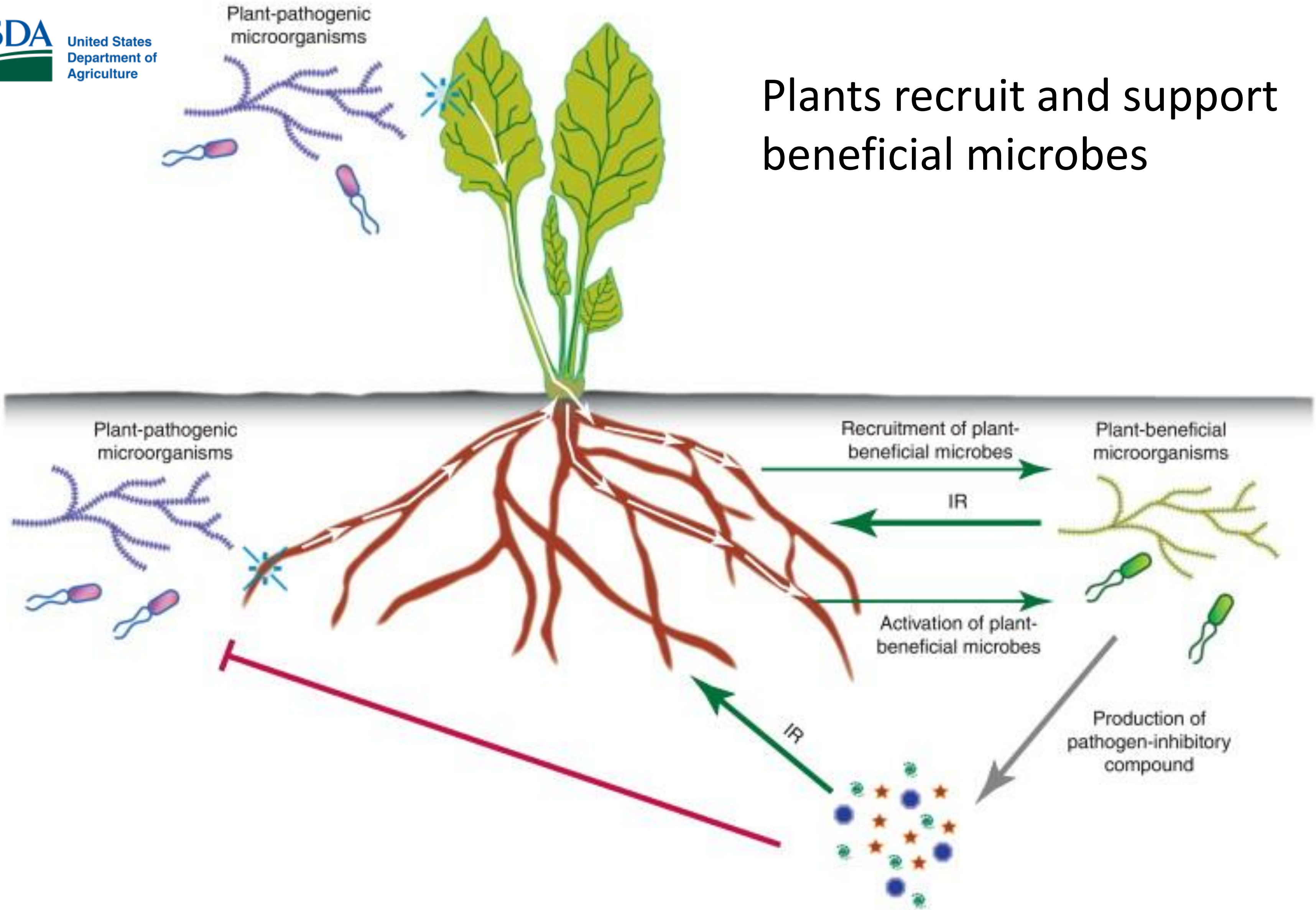


Brar, et al. 2015. *Agronomy* (5)

Knowledge Check: Poll Question

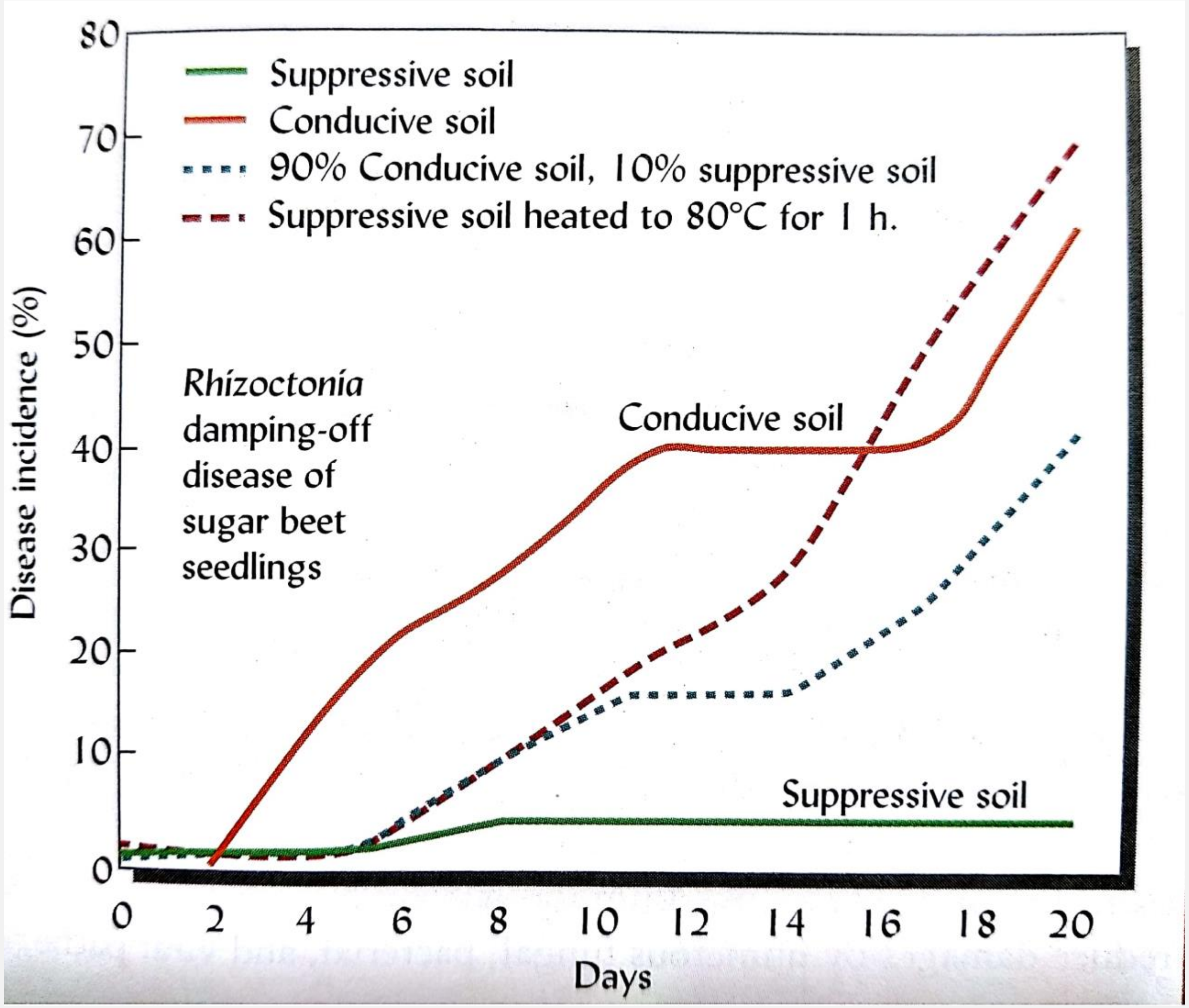
Eco: Why is greater soil organic carbon related to lower bulk density?

Plants recruit and support beneficial microbes



Berendsen, et al., 2012. Trends in Plant Science. 17(8)

Plants benefit from microbes



Soil microbes suppress crop pathogens!

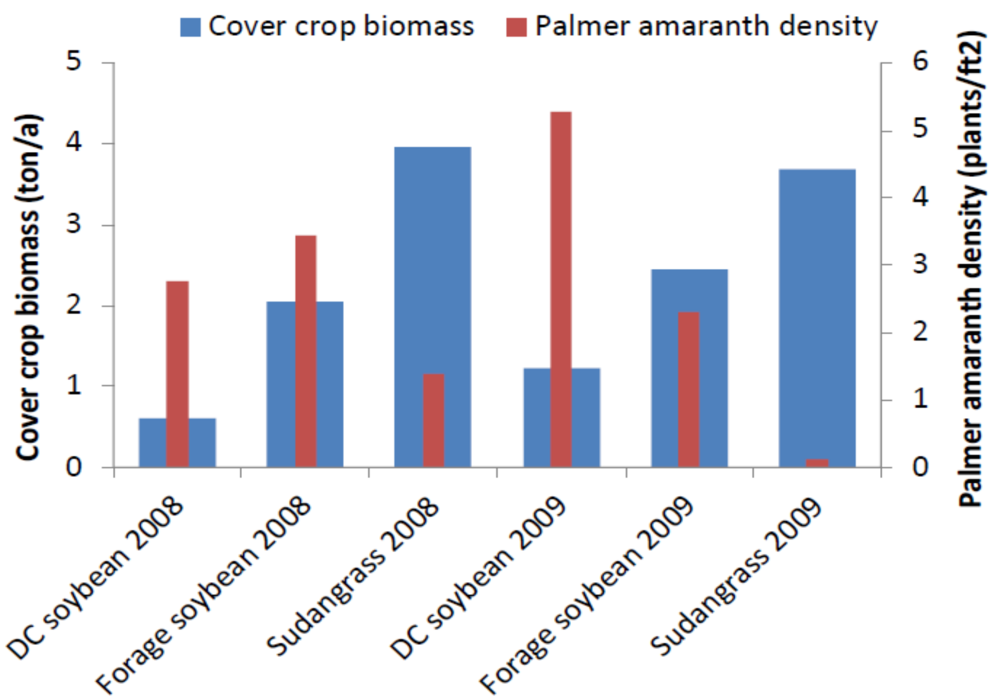
Weil & Brady, The Nature and Properties of Soils, 15th edition. From data of R. Mendes et al. 2011

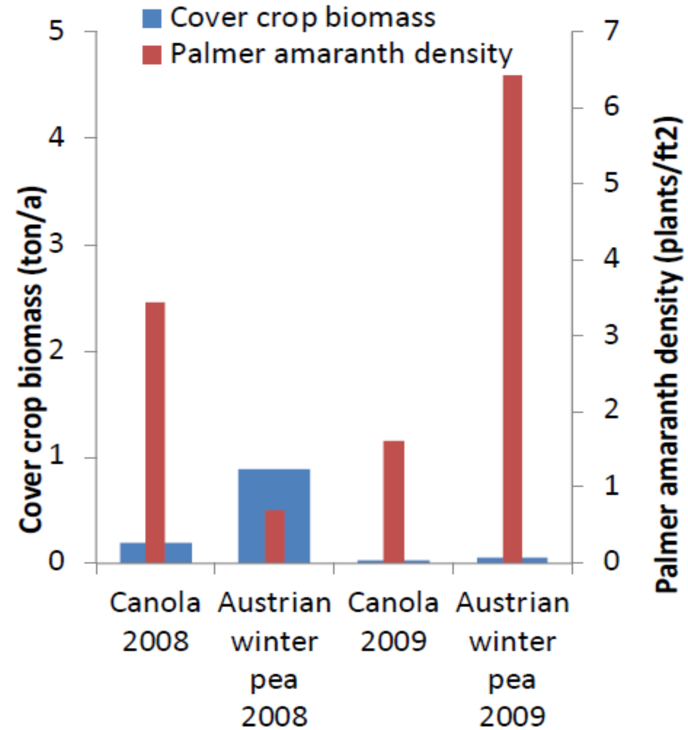
Covers and Pest Management

- Reduce sunlight reaching soil surface
- Alter micro-environment during weed seed germination
- Release of chemicals from roots or decaying residue to inhibit weed seed germination (allelopathy)
- Improve overall soil health to enhance crop vigor
- Physical barrier to pathogens

Residue Effect on Palmer Amaranth

- **Cover crops in wheat stubble, before grain sorghum**
- **Every 900 lb/ac increase in cover crop biomass reduced Palmer amaranth biomass by 4% (Petrosino, 2010)**





United States Department of Agriculture

This information is provided as a public service and constitutes no endorsement by the United States Department of Agriculture or the Natural Resources Conservation Service of any service, supply, or equipment listed.

While an effort has been made to provide a complete and accurate listing of services, supplies, and equipment, omissions or other errors may occur and, therefore, other available sources of information should be consulted

The USDA is an equal opportunity provider and employer.

Meeh, NRCS