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Ecological Management

Module 5

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MN Office for Soil Health
June 6, 2019

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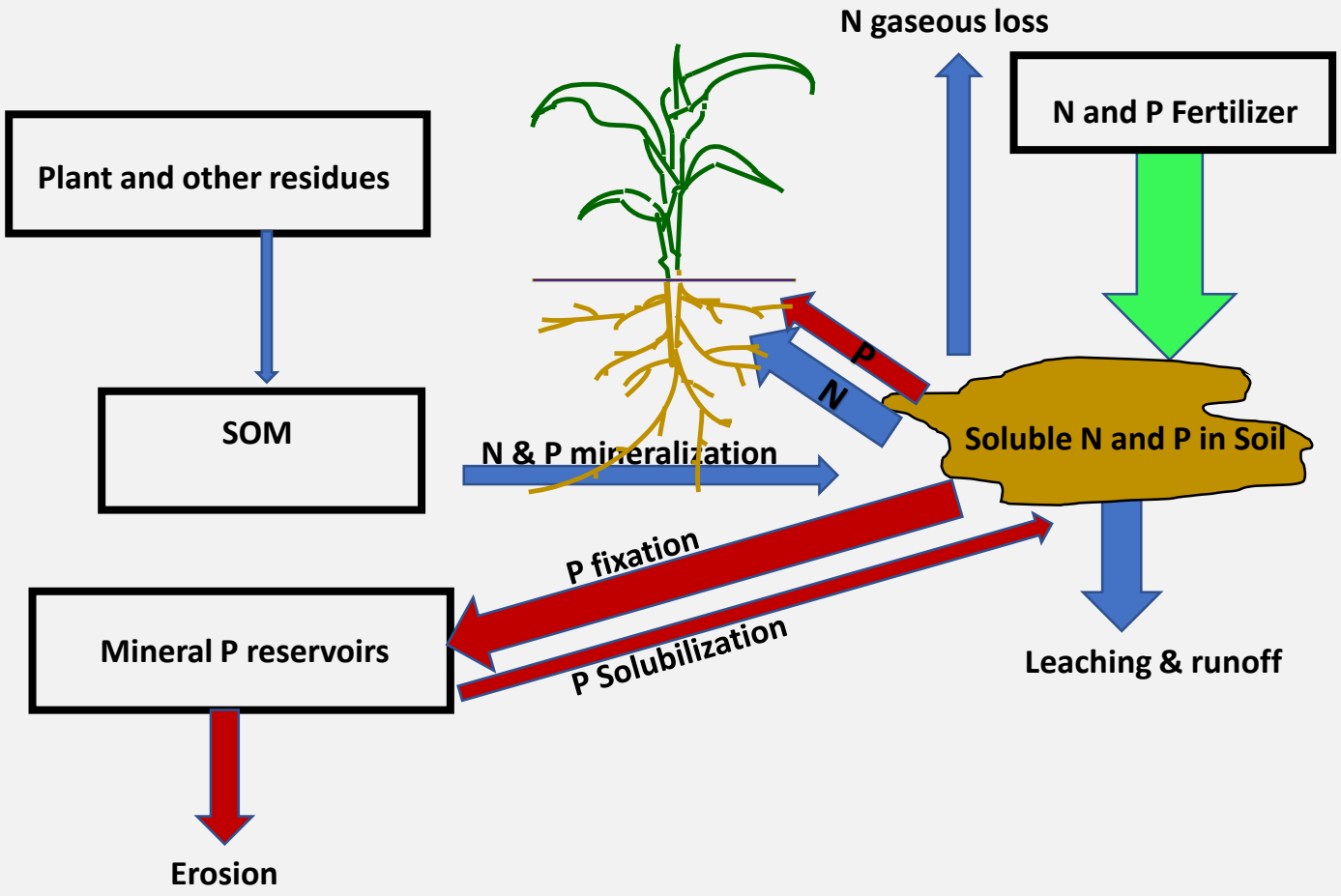
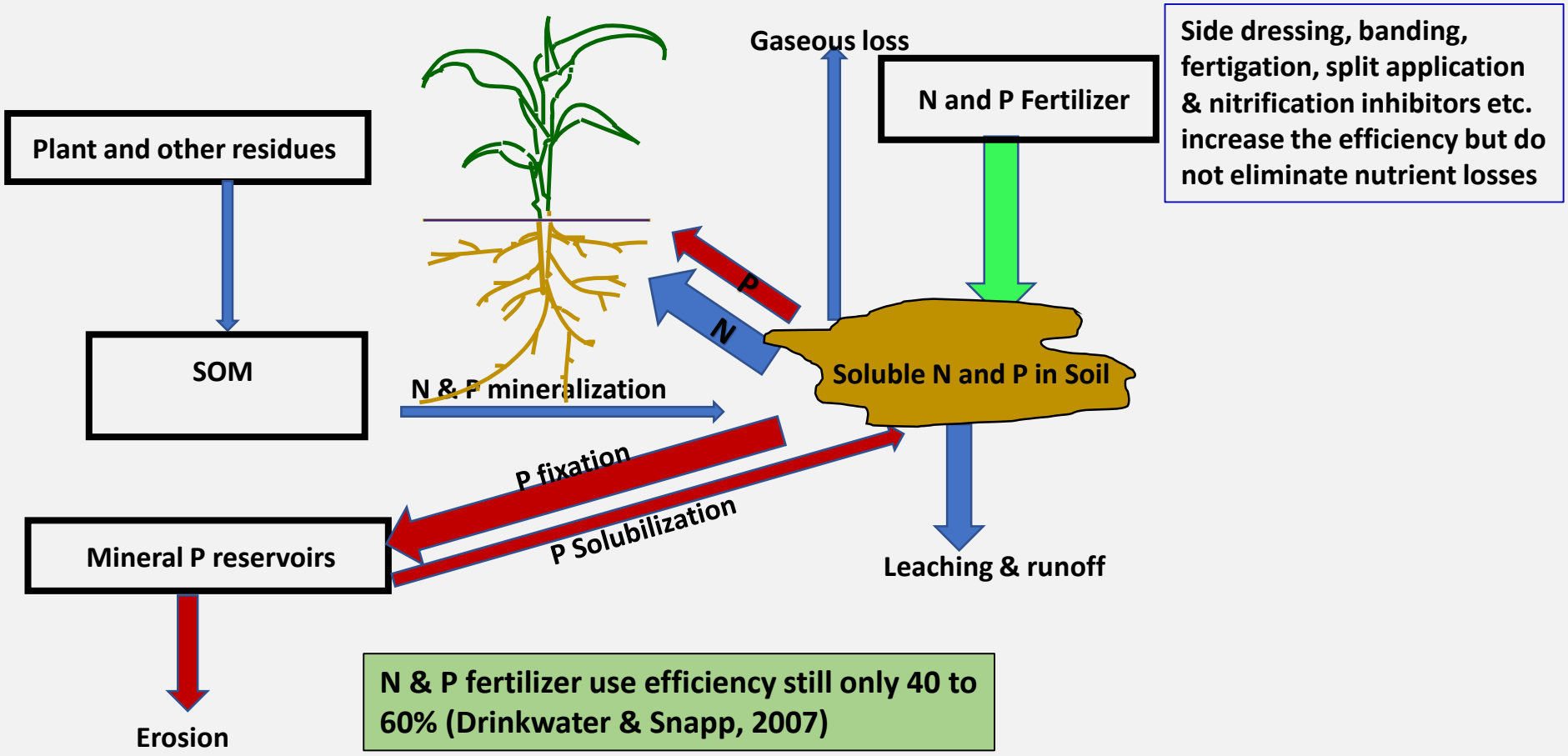
Dominant Nutrient Management Strategy



Adapted from Drinkwater & Snapp, 2007

The 4R Nutrient Management Strategy



Losses of Nutrients

Chemical paradigm

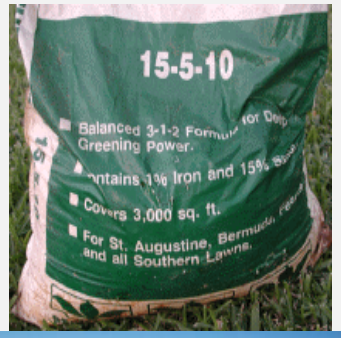
↓

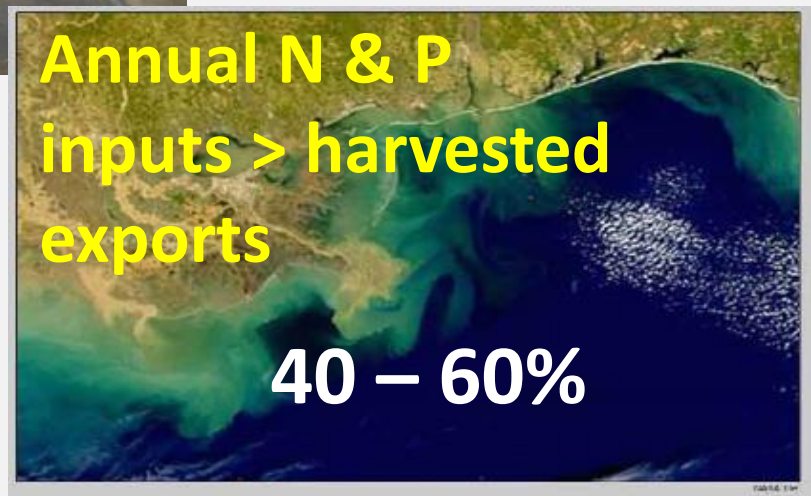
Annual cropping system

↓

Maximize nutrient concentration in space & time

→





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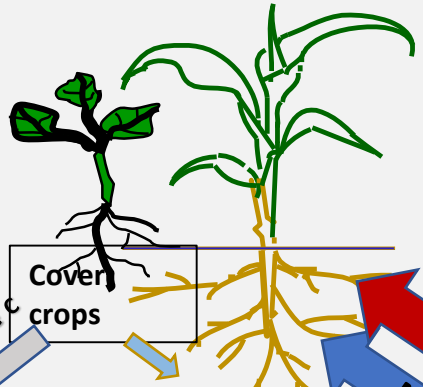
Ecological Nutrient Management

Nutrients from plant and other residues,



Gaseous loss

N and P Fertilizer

Reduce inorganic fertilizer

More diverse C inputs

Minimize tillage

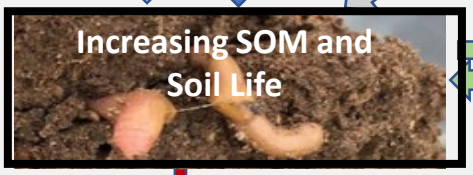
Cover crops

Labile C

P

N

Soluble N and P in soil



Increasing SOM and Soil Life

mineralization

Assimilation

P fixation

P Solubilization

Mineral P reservoirs

Leaching & runoff

Erosion

Adapted from Drinkwater & Snapp, 2007

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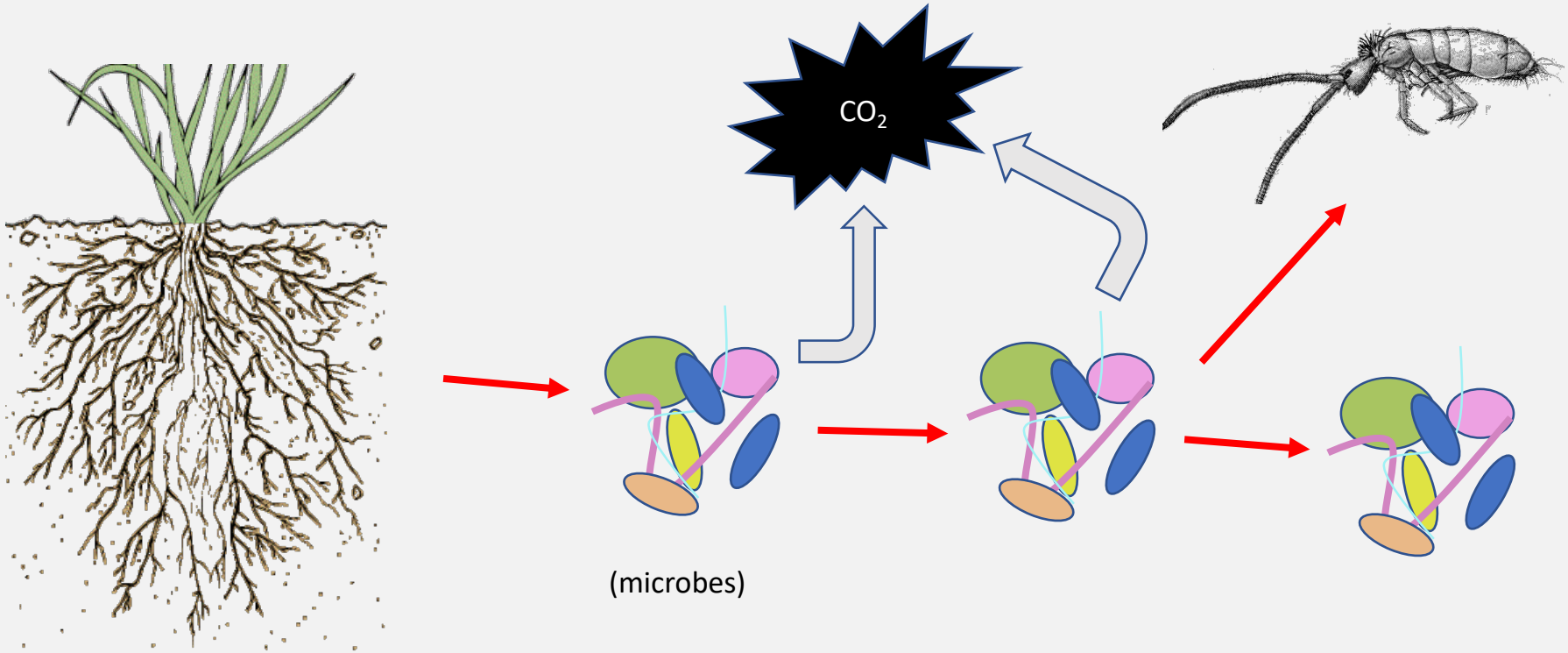
How does plant residue become SOM?



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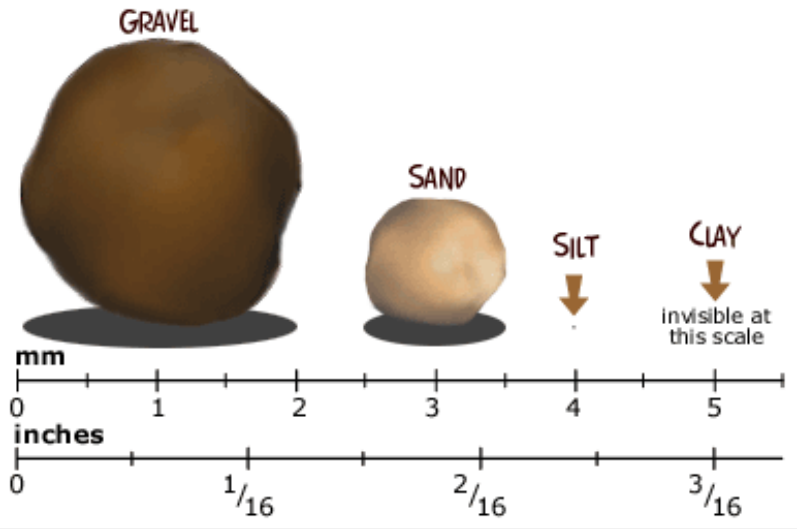
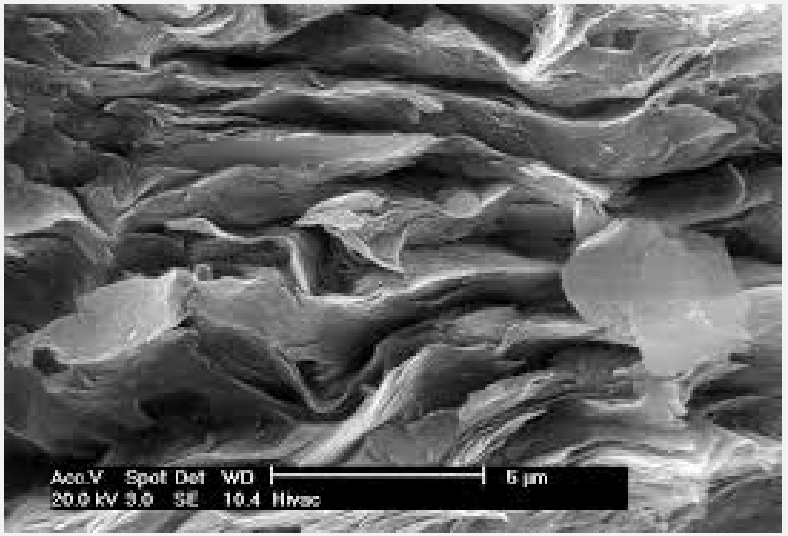
Soil carbon pools: aggregate and clay



civilblog.org



Claysandminerals.com

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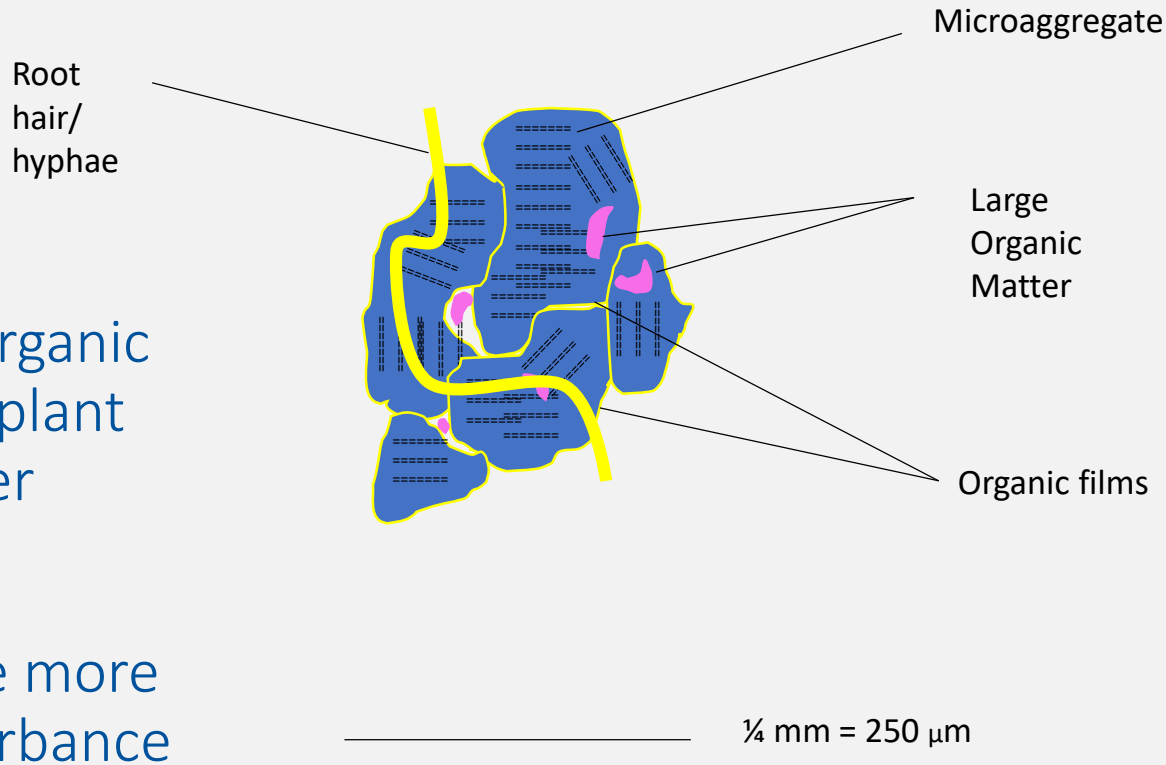
How do soil aggregates work?



Aggregates are held together by soil organic matter, including plant and microbial litter

Macroaggregates are more vulnerable to disturbance than microaggregates

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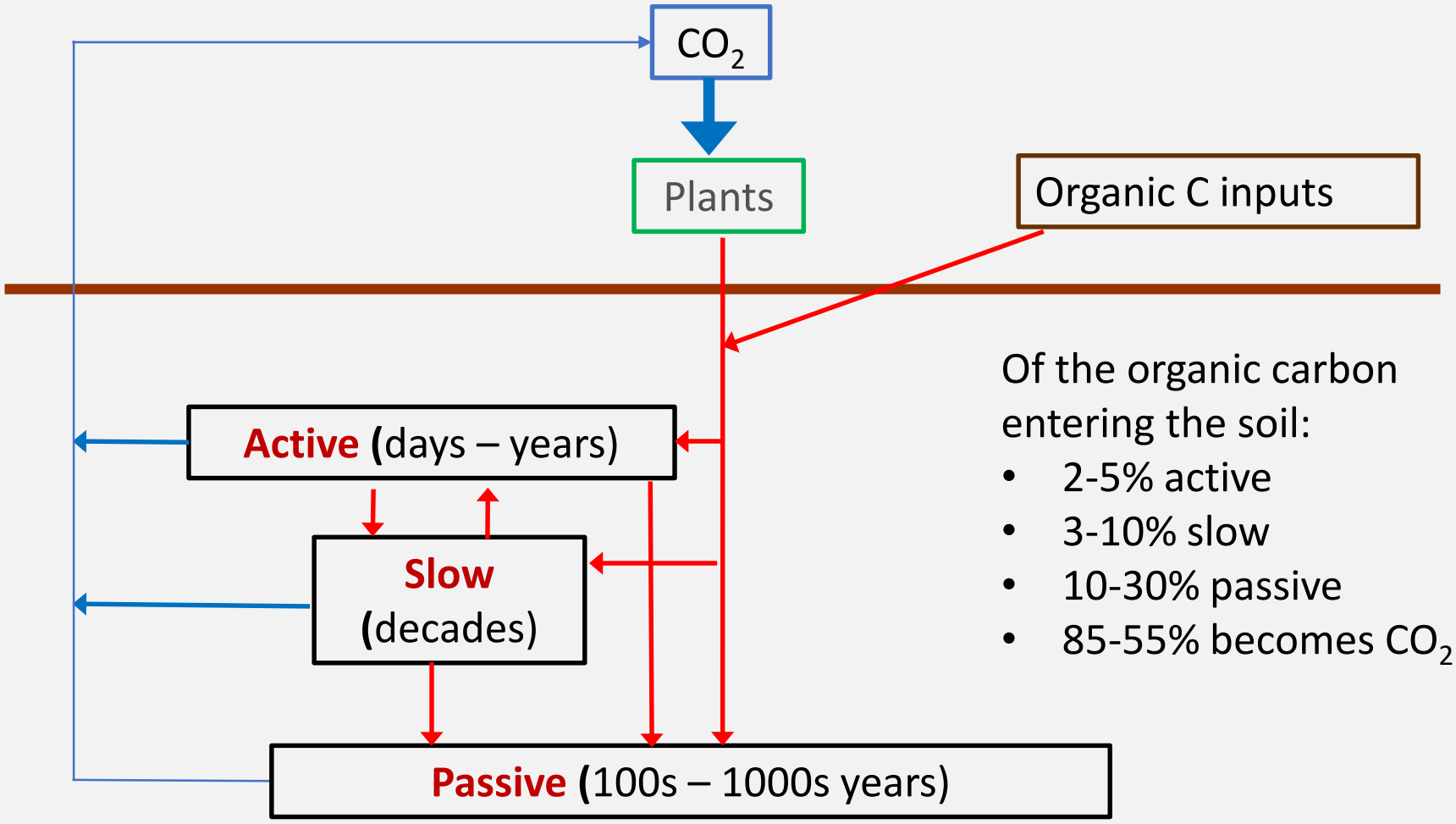
Soil carbon pools: turnover time



Of the organic carbon entering the soil:

- 2-5% active
- 3-10% slow
- 10-30% passive
- 85-55% becomes CO_2

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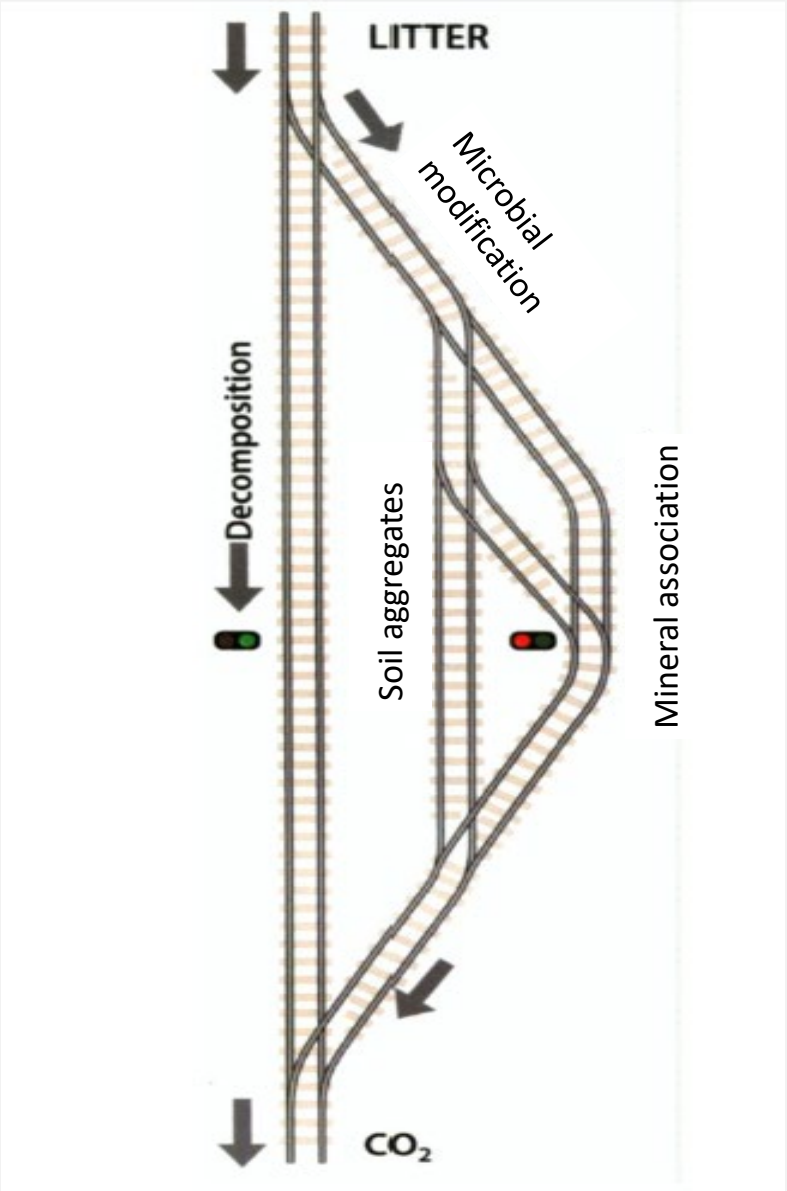
How do we slow soil carbon turnover?



Modified from Prescott 2010

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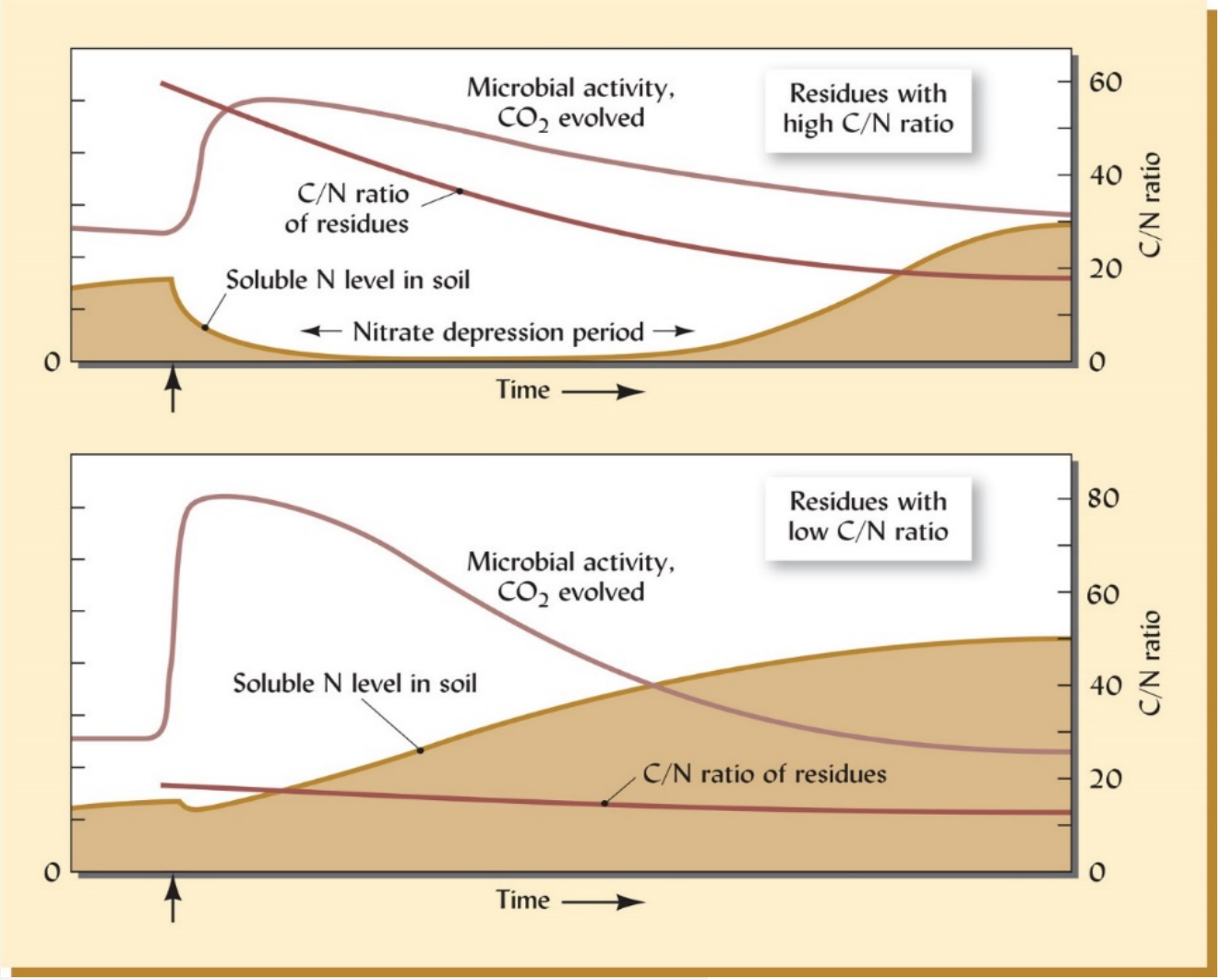
What is a mechanism to retain C in soil?

a) Microbial transformation
b) Protection in aggregates
c) Mineral association
d) All of the above

Microbes prefer low C/N ratio residue



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

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Nitrogen Mineralization

Bacteria

C:N ratio about 5:1

Consume two bacteria to get enough carbon for function and reproduction
Total C:N of 10:2

Only Needs 1 part N

Bacteria Feeding Nematode

C:N ratio about 10:1

Excrete 1 part N to soil solution- Available N

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Residue Mgt for N Retention

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Nitrogen Immobilization

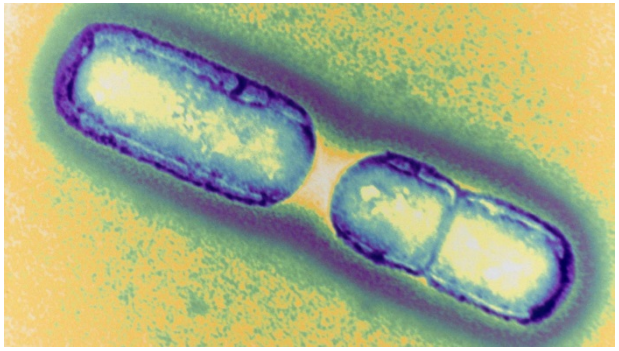
Cover Crop

C:N ratio about 40:1

NCCCCC

Bacteria

C:N ratio about 5:1



NCCCCC

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Nitrogen Immobilization

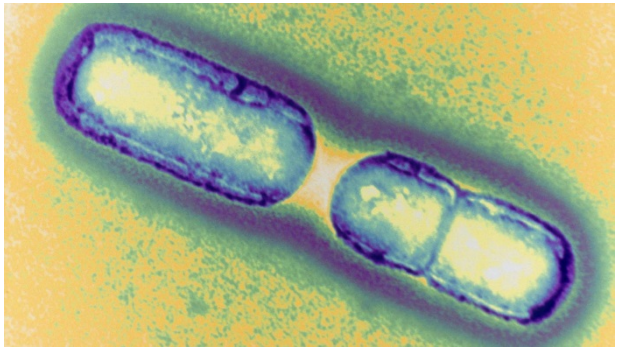
Cover Crop

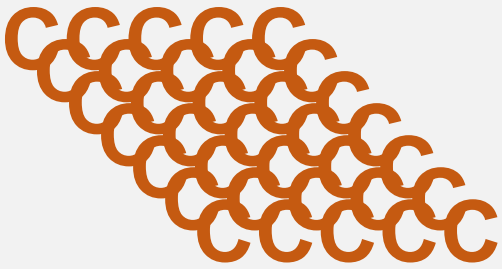
C:N ratio about 40:1

Consume enough carbon from the rye for respiration & body structure

Bacteria

C:N ratio about 5:1





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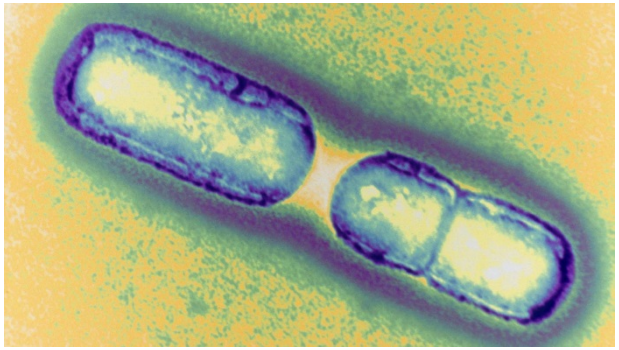

NCCCCC
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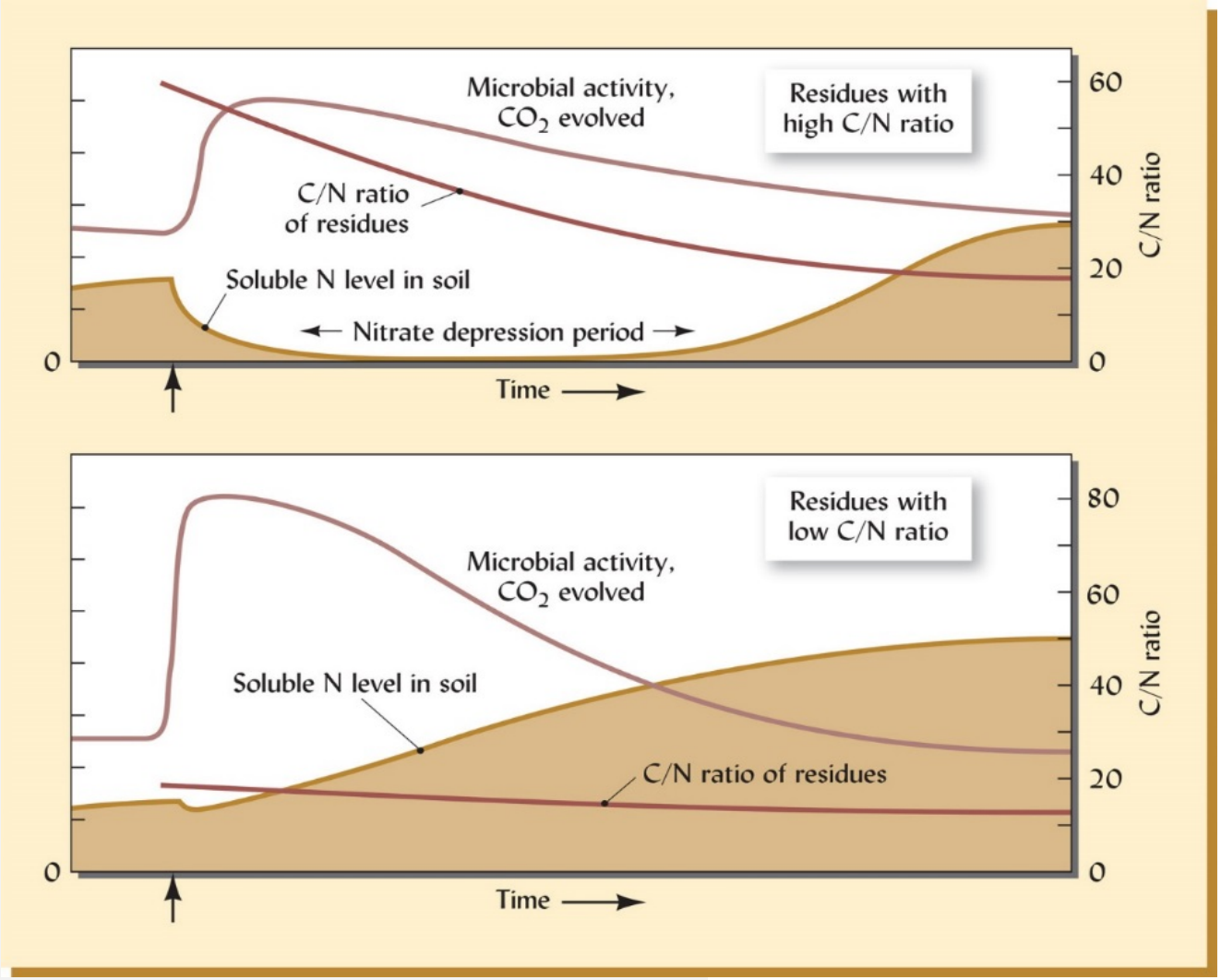
Microbes prefer low C/N ratio residue



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

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Nitrogen Immobilization

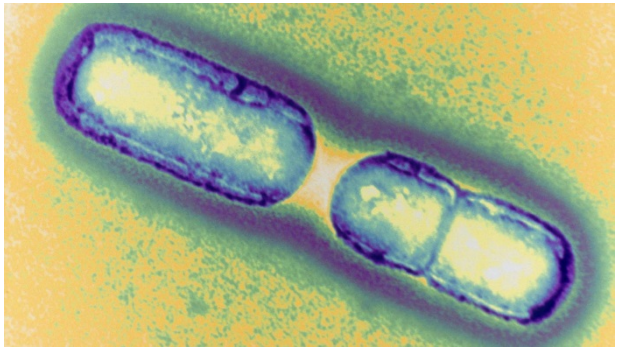
Rye Cover Crop (Flowering) 37:1
Rye Cover Crop (Vegetative) 26:1
Rye Straw 82:1
Pea Straw: 29:1

Corn Stover: 57:1

Mature Alfalfa Hay 25:1
Beef Manure 17:1

Hairy Vetch Cover Crop: 11:1

Bacteria
C:N ratio about 5:1



NCCCCC

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Immobilization is temporary

Bacteria

C:N ratio about 5:1

Consume two bacteria to get enough carbon for function and reproduction
Total C:N of 10:2

Only Needs 1 part N

Bacteria Feeding Nematode

C:N ratio about 10:1

Excrete 1 part N to soil solution- Available N

If a bacteria with C:N ratio 5:1 consumes residue with C:N ratio 50:1, how much N will need to be mined from the soil for the bacteria to incorporate all that C?

a) 6
b) 50
c) 9
d) 15

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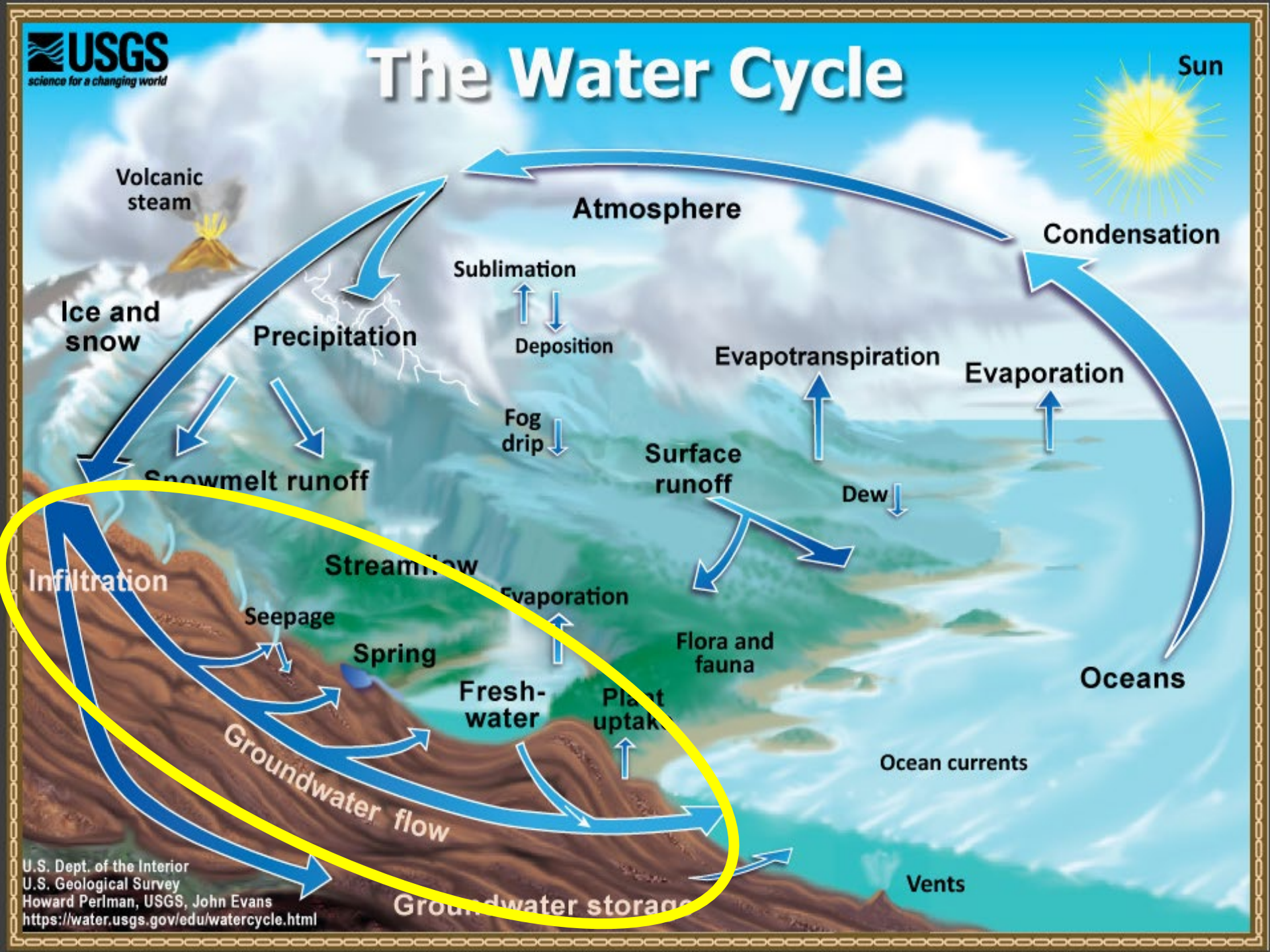
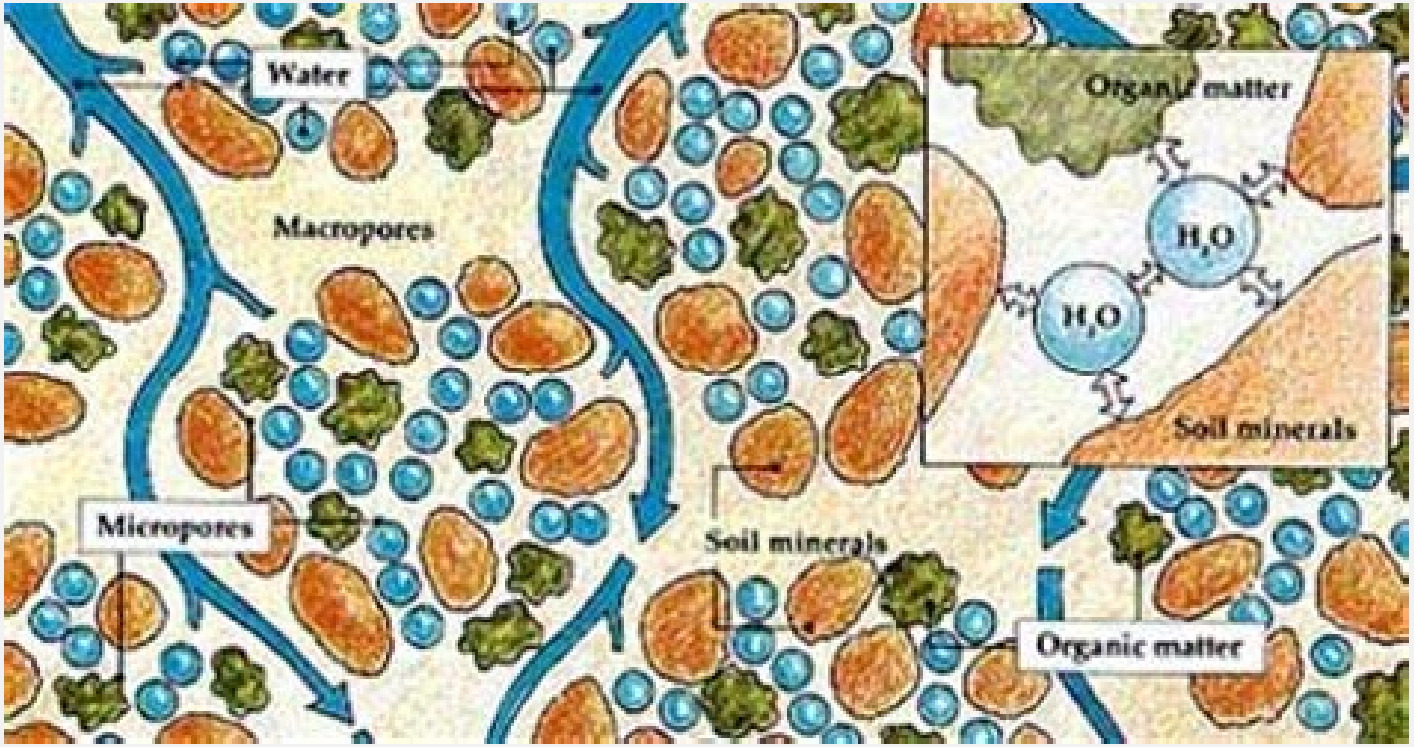
Reduce N Losses

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


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
Infiltration
Stream flow
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

How do we keep water in the soil?

- Infiltration – water enters
- Permeability- water flows through
- Storage- water-holding capacity



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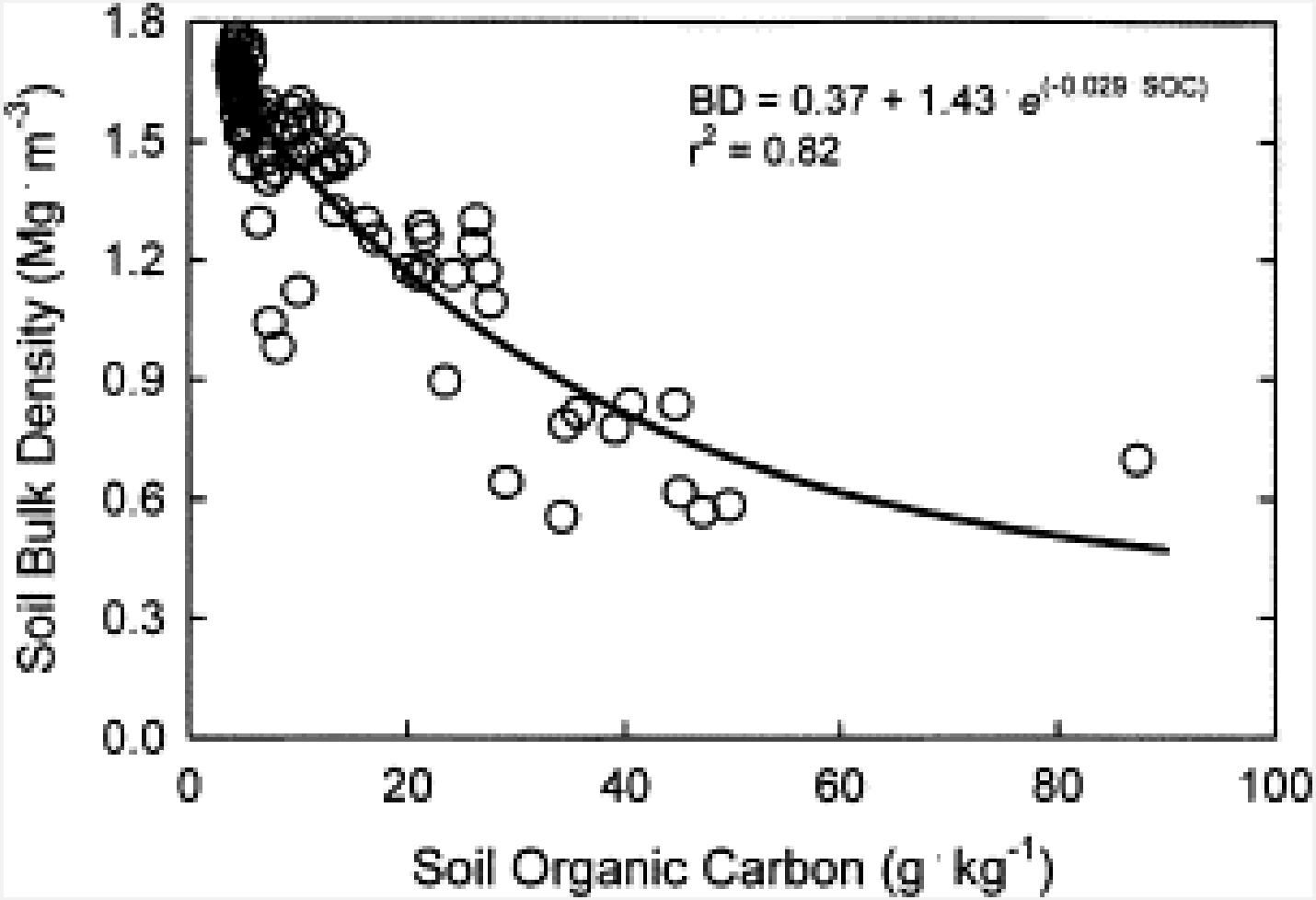
Soil Organic Carbon and Bulk Density



Franzluebbers, 2002, Soil & Tillage Res.

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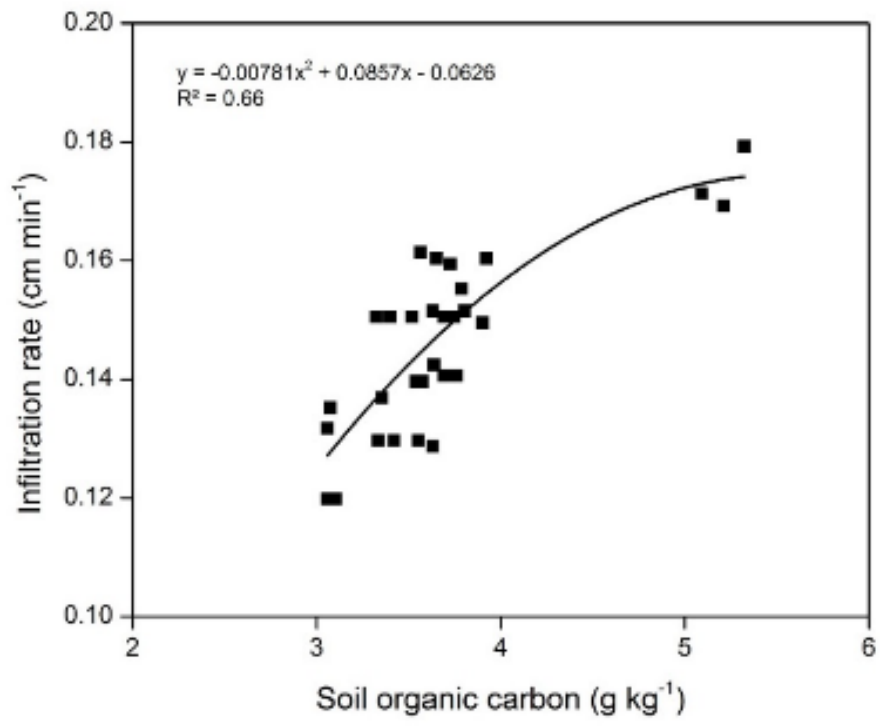
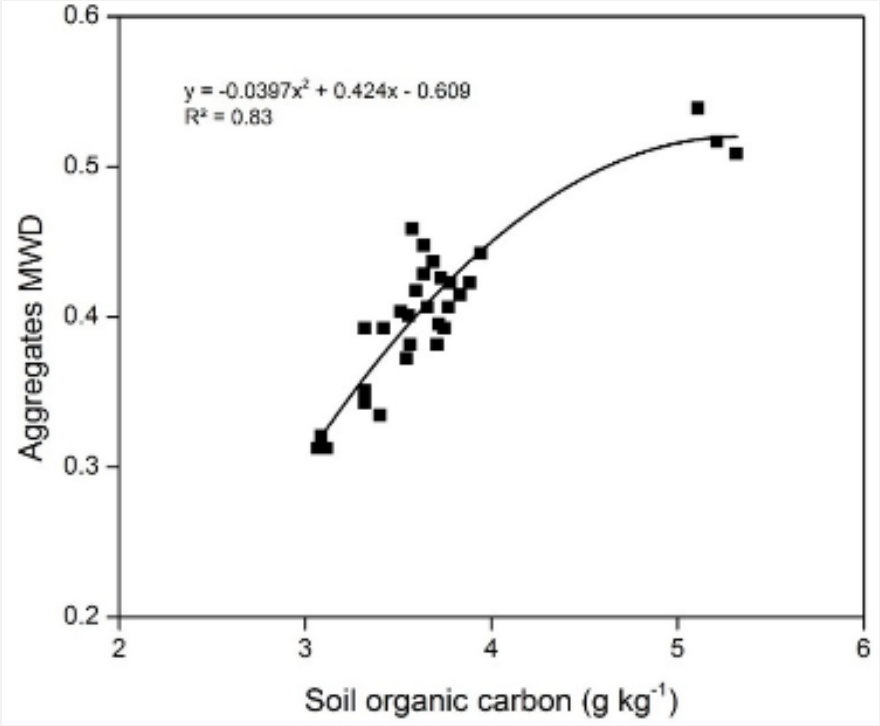
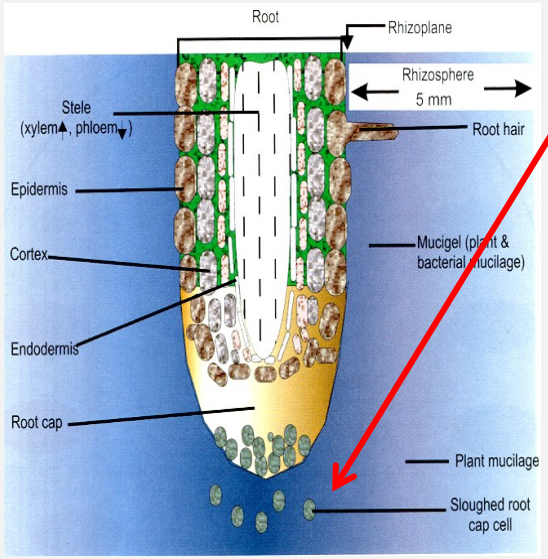
Carbon, aggregates and infiltration



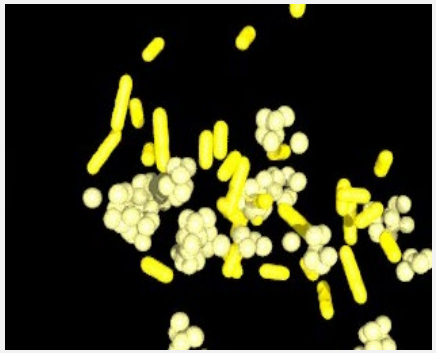


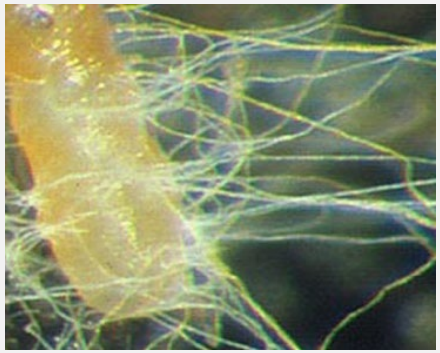
Brar, et al. 2015. *Agronomy* (5)

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

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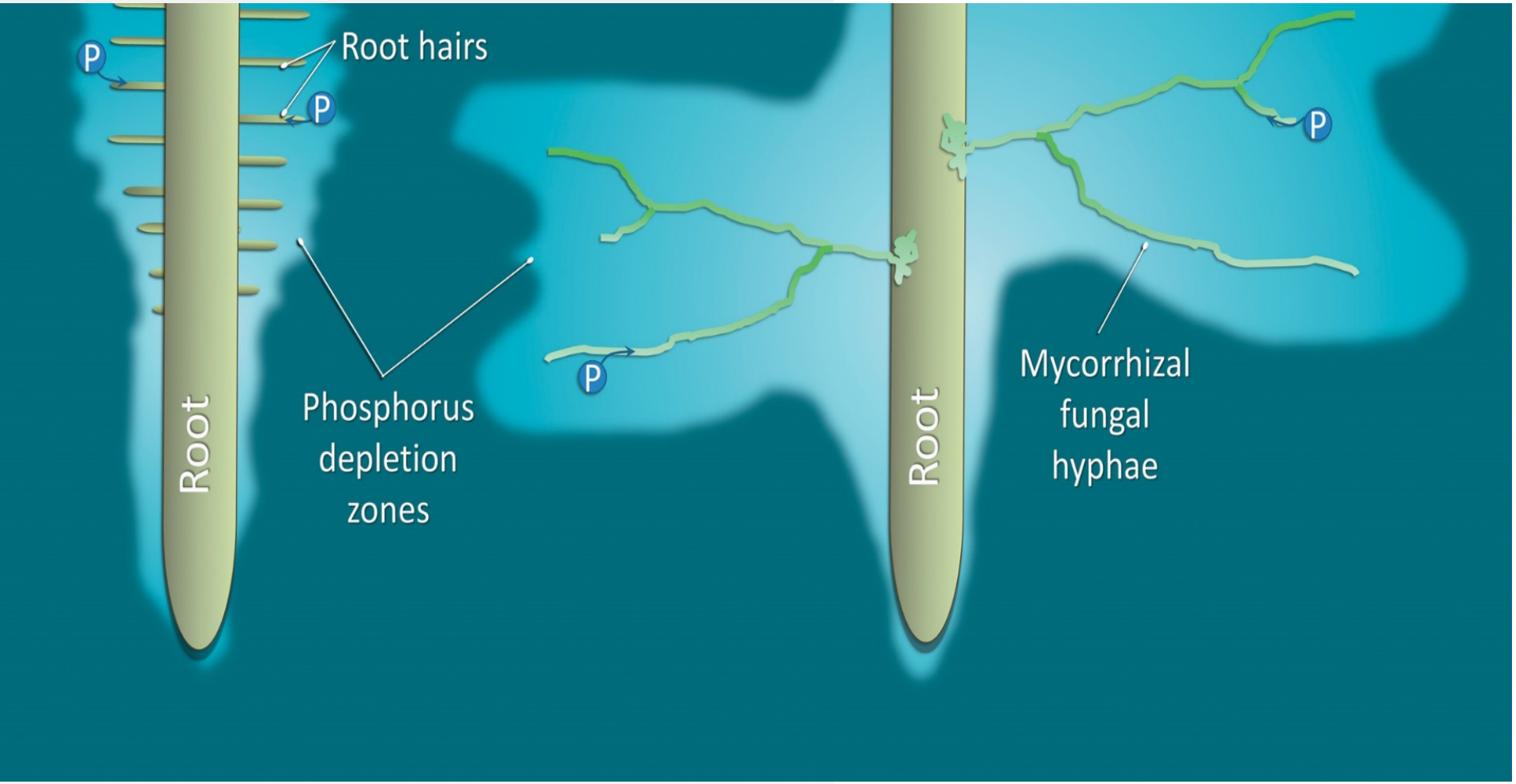
Benefits of AM Association



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

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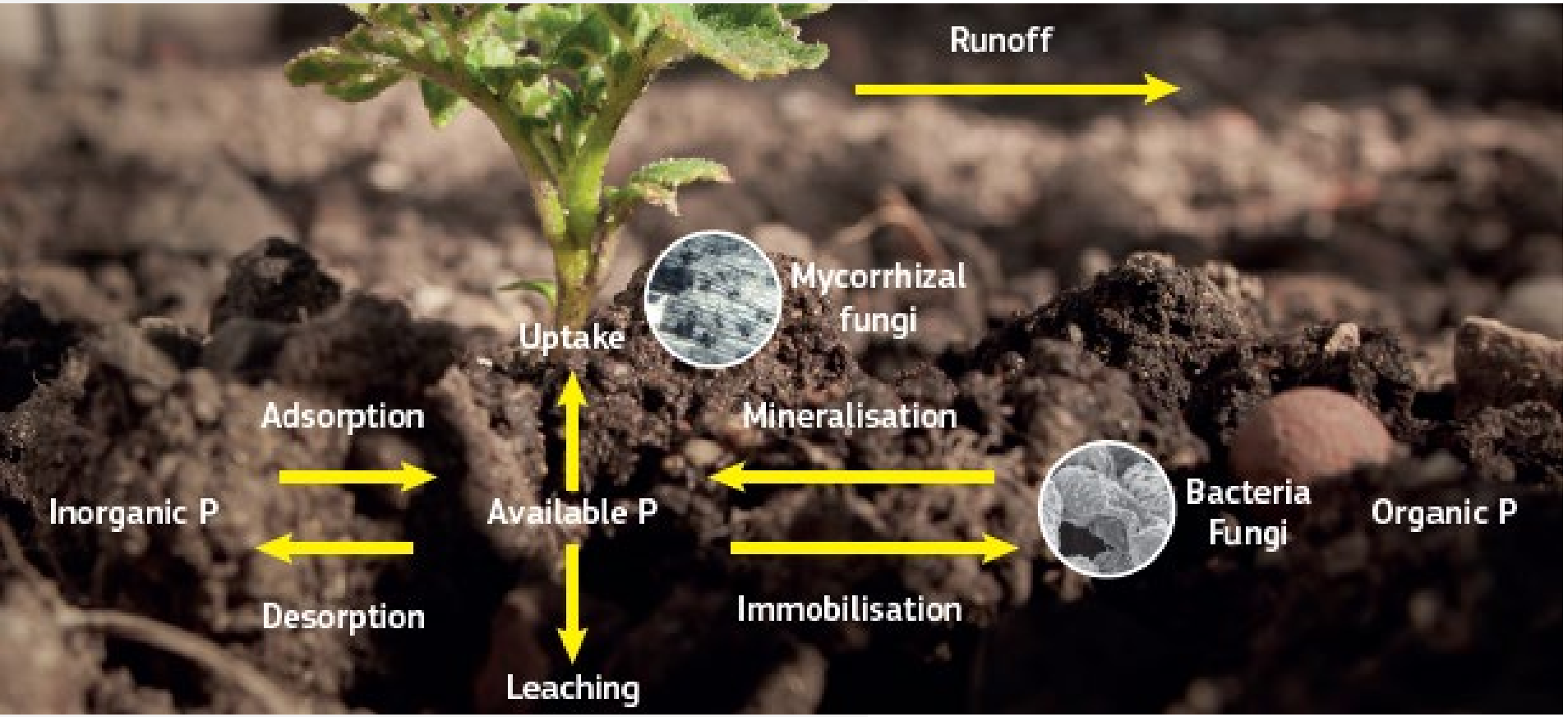
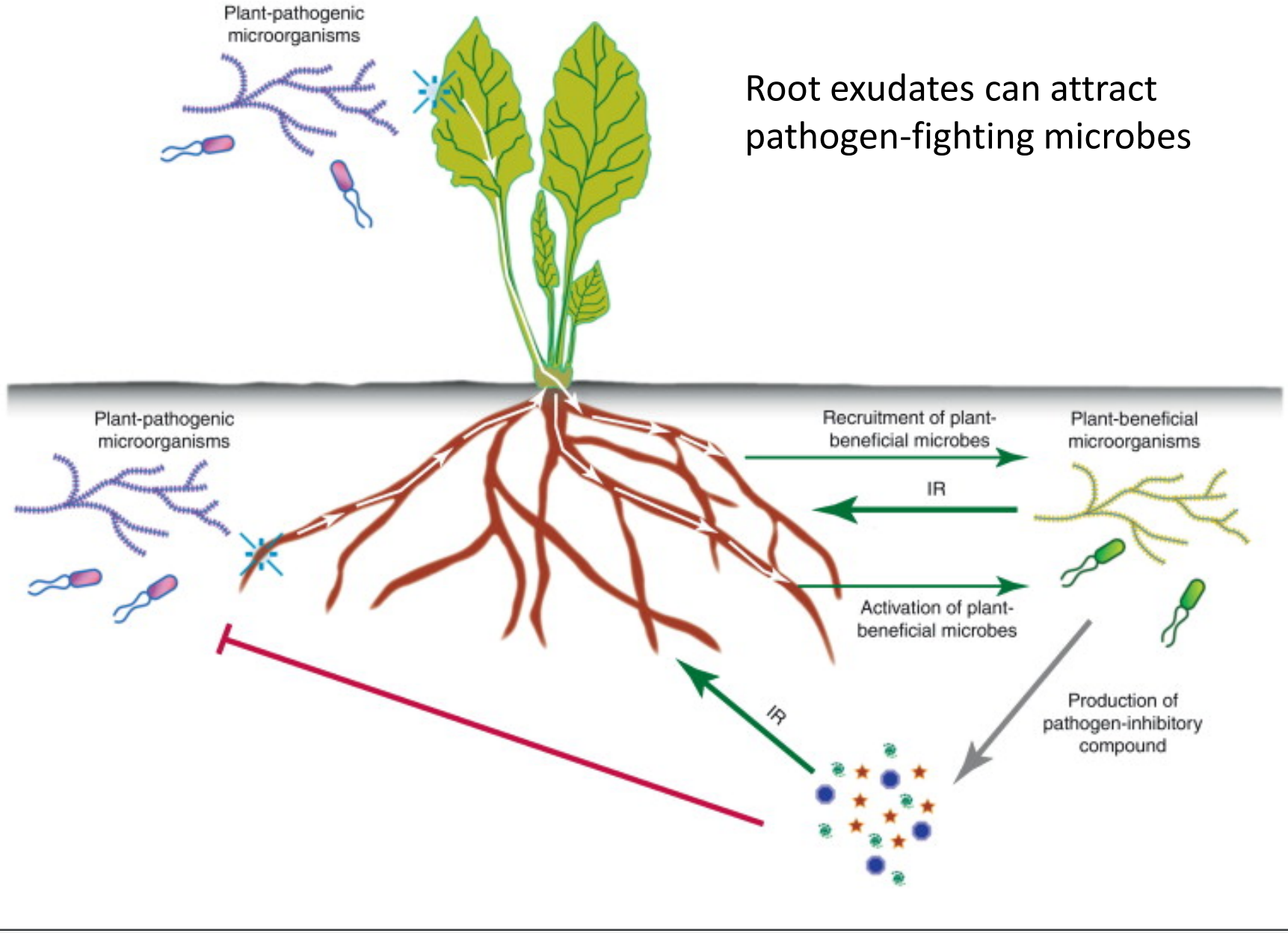
Biology and the Phosphorus Cycle



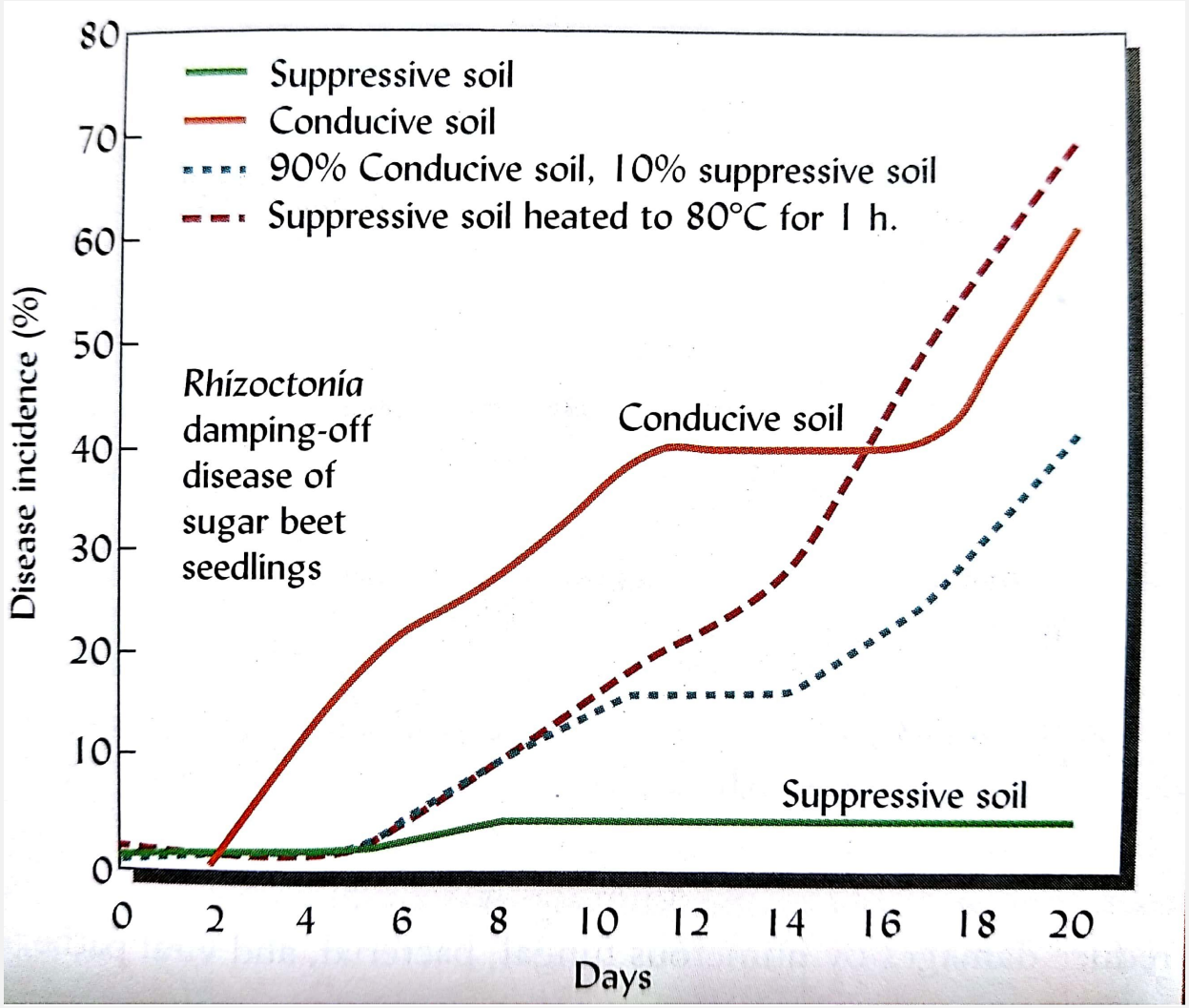
Top: Global Soil Biodiversity Atlas: Simplified phosphorus (P) cycle in the soil. The regulation of soil P cycling is influenced by microorganisms (e.g. bacteria and fungi). (DG, JRC)
Bottom: http://www.plantphysiol.org/content/156/3/989/F1.expansion.html

Root exudates can attract pathogen-fighting 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

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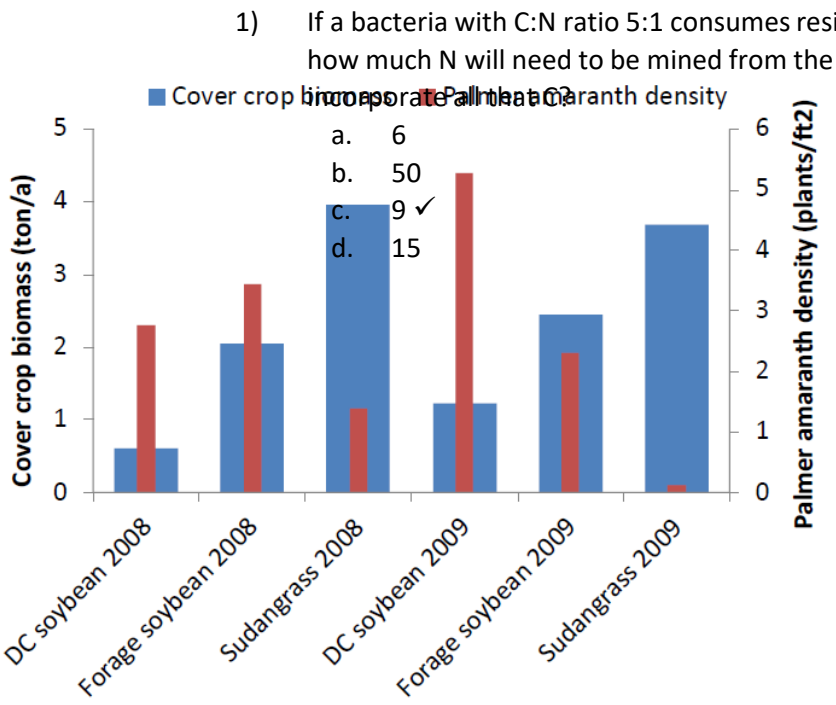
Covers and Weed Management

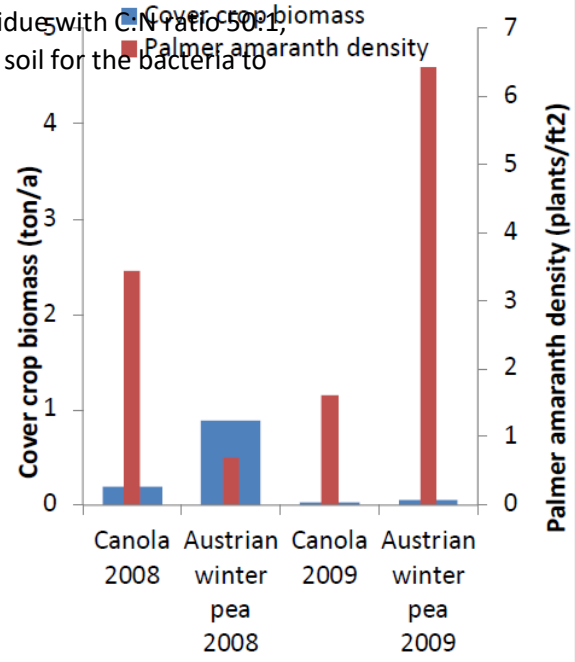
- Reduce sunlight reaching soil surface
- Alter micro-environment during weed seed germination
- Release of chemicals from roots or decaying residue to inhibit weed seed germination (allelopathy)
- Improve overall soil health to enhance crop vigor

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)**

1) If a bacteria with C:N ratio 5:1 consumes residue with C:N ratio 50:1, how much N will need to be mined from the soil for the bacteria to incorporate all that C?
   a. 6
   b. 50
   c. 9 ✓
   d. 15





How do microbes contribute to plant success?

a) AMF increase plant P uptake
b) Hyphae stabilize soil aggregates for improved water holding capacity
c) Suppression of some diseases
d) All of the above