Soil quality and health: microscopic warriors of vegetable production system

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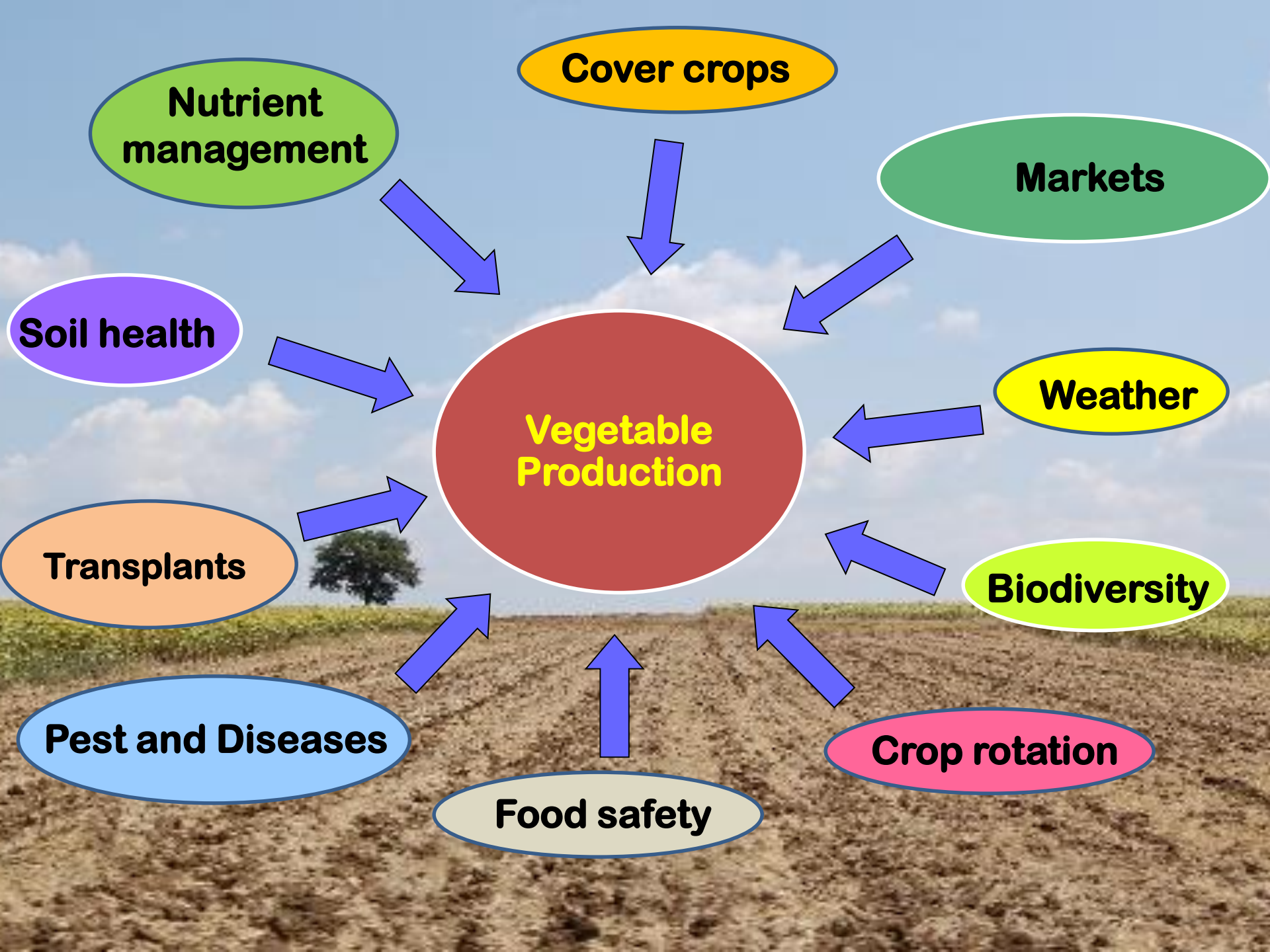
- **Hogs outnumber humans five to one in Iowa**
- **Largest truck stop in North America on Interstate 80**
- **Red delicious apple was developed in Iowa in 1880**


STOP
2290

Not too long ago, and pretty close by . . . .


Cover crops
Nutrient management
Markets
Soil health
Vegetable Production
Weather
Transplants
Biodiversity
Pest and Diseases
Crop rotation
Food safety

What is "Soil Quality and Health"?

- Soil Health is a state of a soil meeting its range of ecosystem functions as appropriate to its environment. *USDA NRCS (2013)*
- Soil Health and Soil Quality are often used interchangeably
  - Health refers to the internal state of an entity
  - Quality refers that entities "fitness for purpose"
- The term health implies a capacity to sustain function… not merely a particular function, but the full range of function.

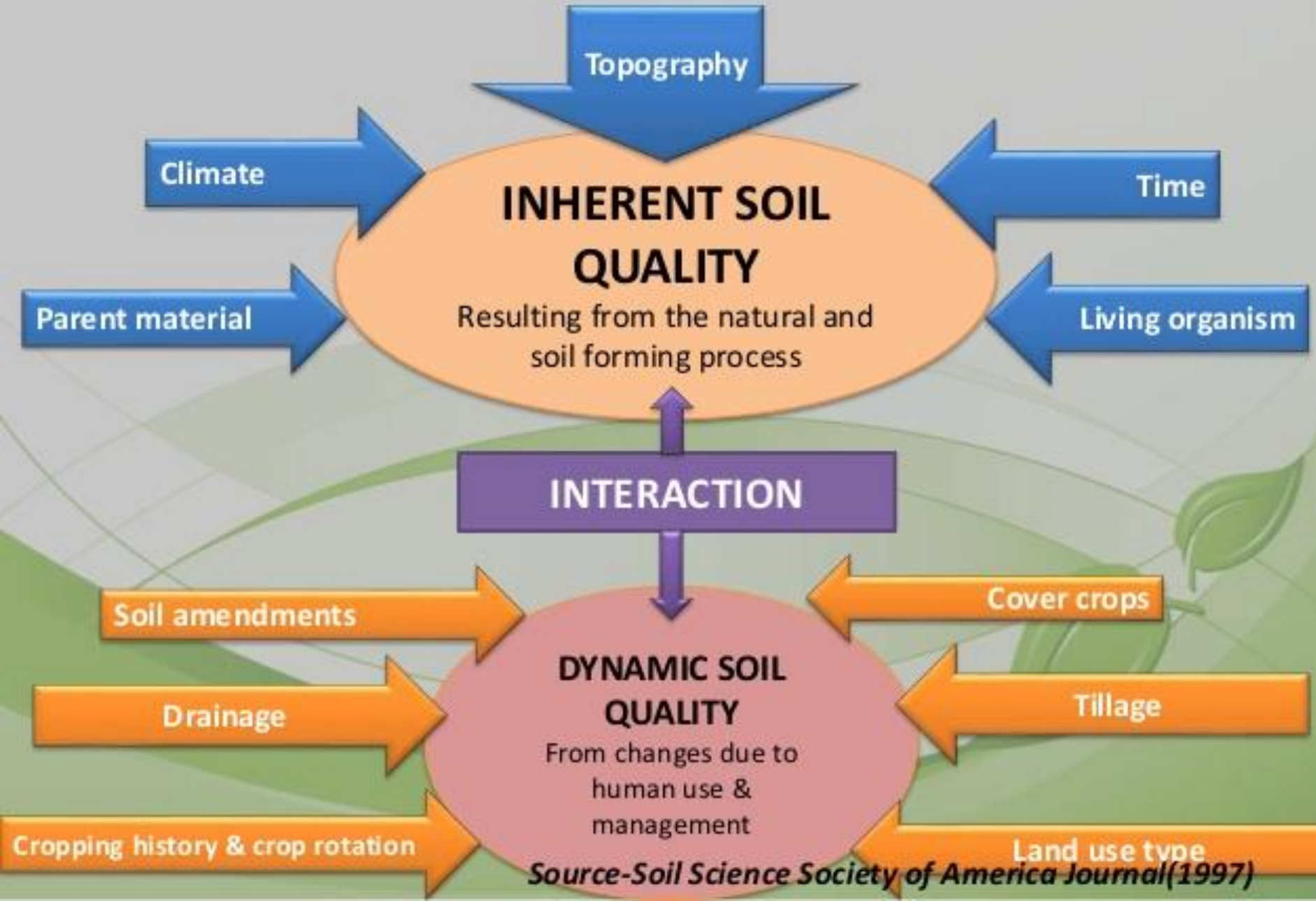
Characteristics of healthy soil

- Good tilth
- Sufficient depth
- Good water storage and drainage
- Less compaction

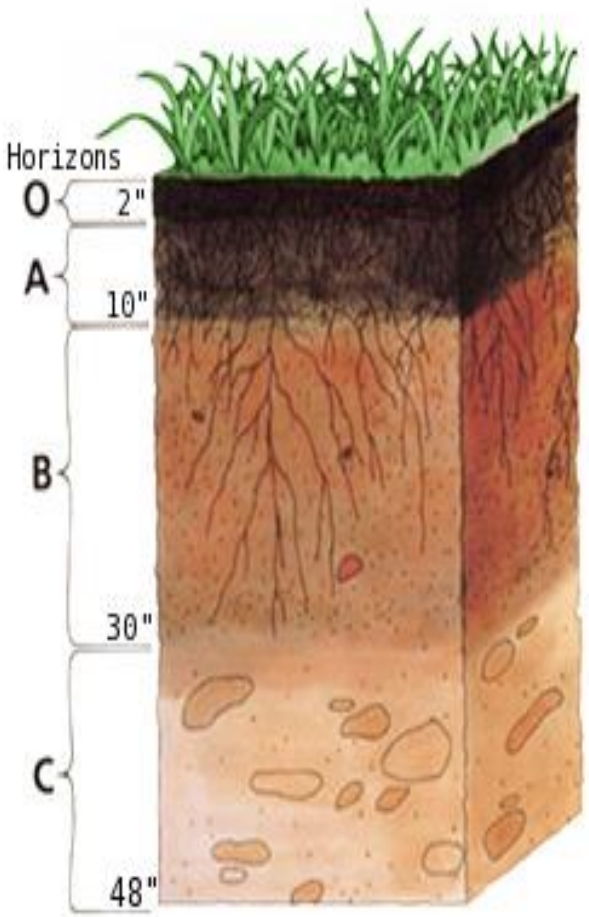
- Sufficient supply, but not excess of nutrients
- Proper balance of nutrients
- Optimum pH, EC
- Low weed pressure

- Organic matter
- Biologically active soil
- Diversity of soil microorganisms

Factors effecting soil quality



Soil Profile



O=Organic material

A=Topsoil

Biology

B=Subsoil

C=Weathered or decomposed rock

R=Parent rock


I think I got it right
Is it O or A horizon?
Is it time for lunch?

Soil is alive…

For example, in 1g of soil:

>100,000,000 bacterial cells

>11,000 species of bacteria

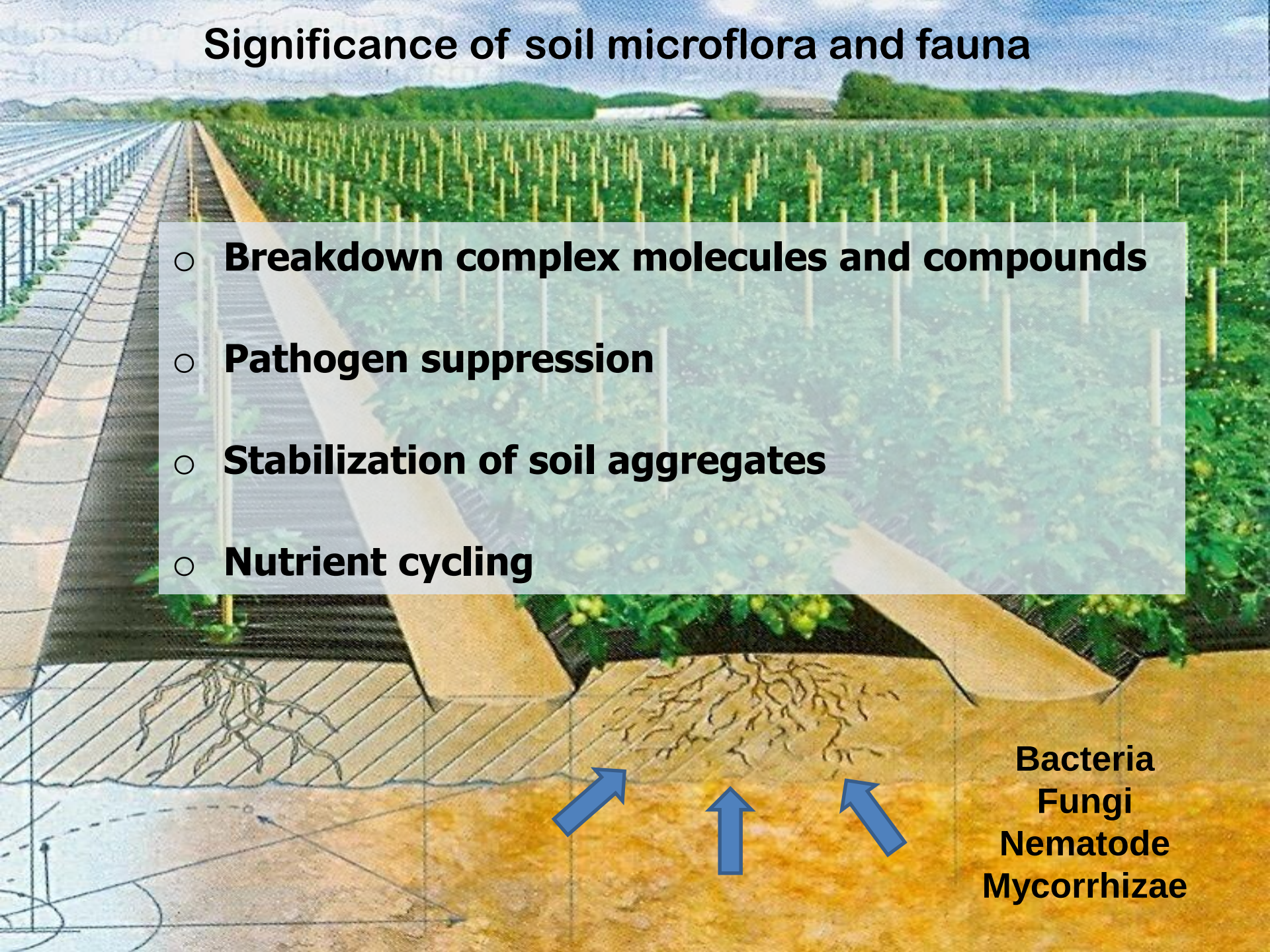
Also fungi and larger animals

Why soil quality and health is important for vegetable cropping systems?

- Soil harbours most of the world's biodiversity
- Responsible for many key ecosystem functions
- Annual crops need timely supply of nutrients
- Pest and disease interactions
- Cycling of energy and nutrients intimately associated with the soil food web

Significance of soil microflora and fauna

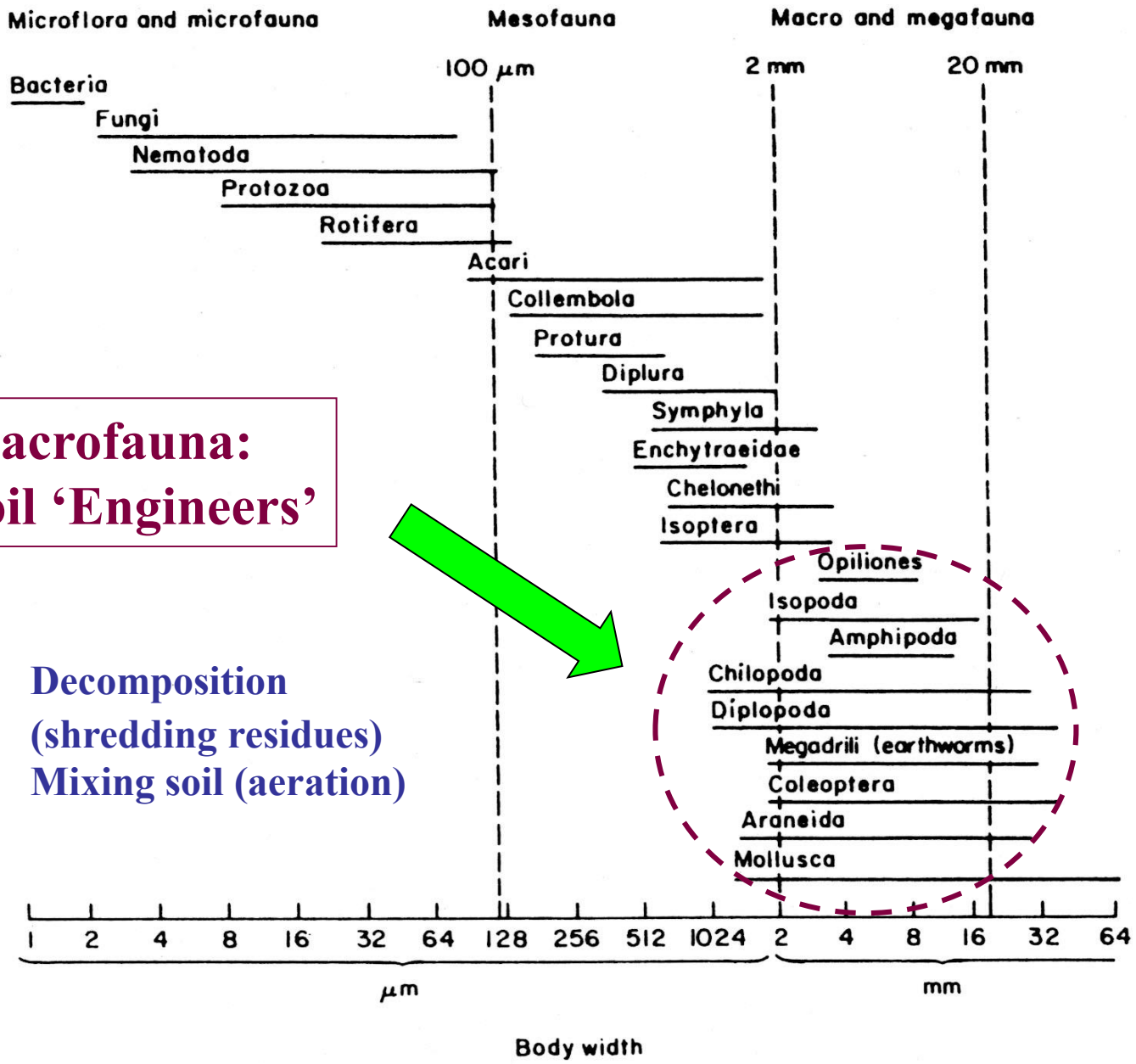
- Breakdown complex molecules and compounds
- Pathogen suppression
- Stabilization of soil aggregates
- Nutrient cycling



In order to understand how biology affects our soils - we need to understand a little about the organisms who live there

Macrofauna: Soil 'Engineers'

1. Decomposition (shredding residues)
2. Mixing soil (aeration)



Adapted from Swift et al. 1979

Macrofauna


Termite


Pseudoscorpion

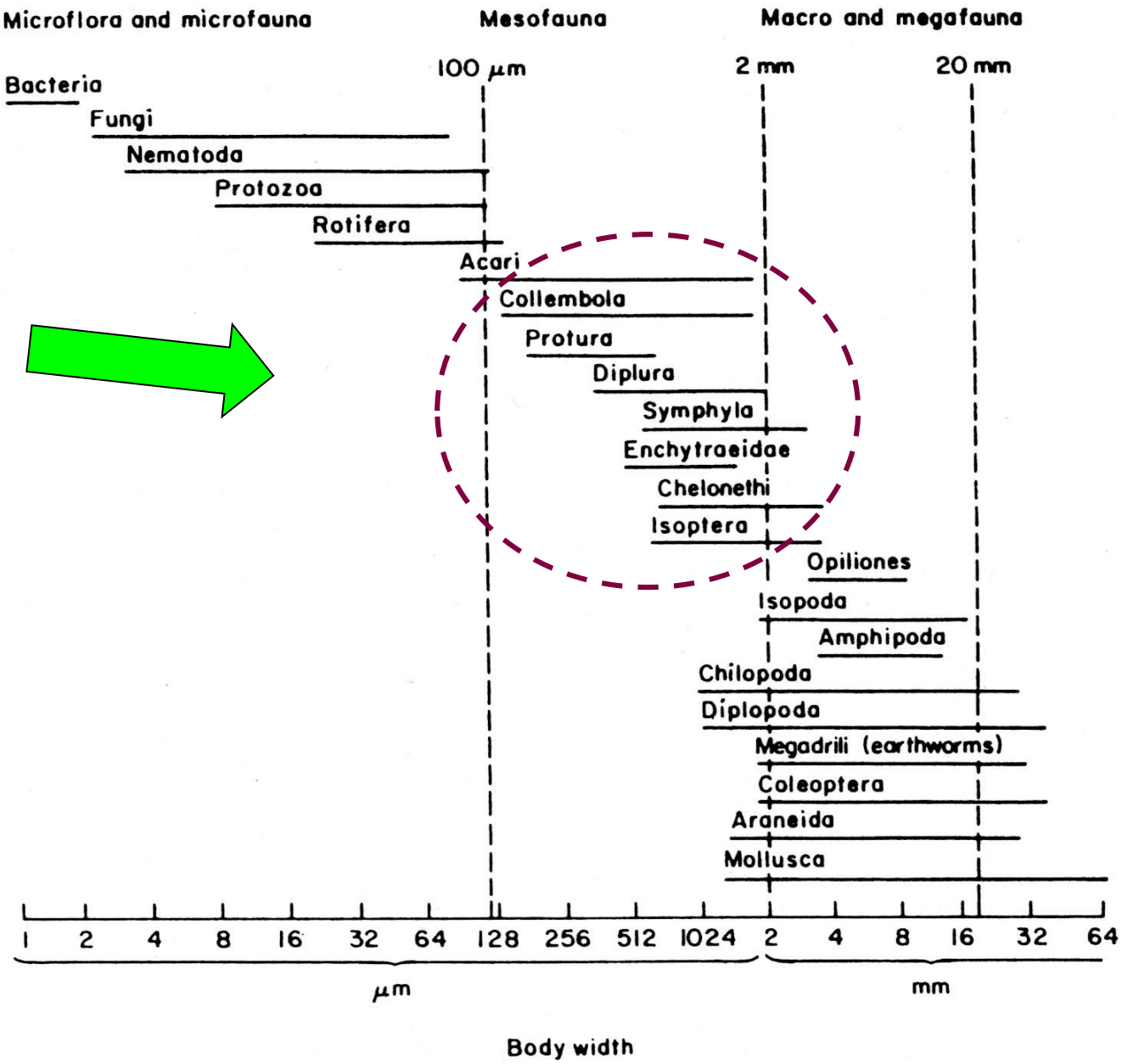

Earthworm


Centipede


ail
Corbis.com


Vole

Mesofauna:
Soil predators, pathogens, herbivores



Adapted from Swift et al. 1979

Soil mesofauna

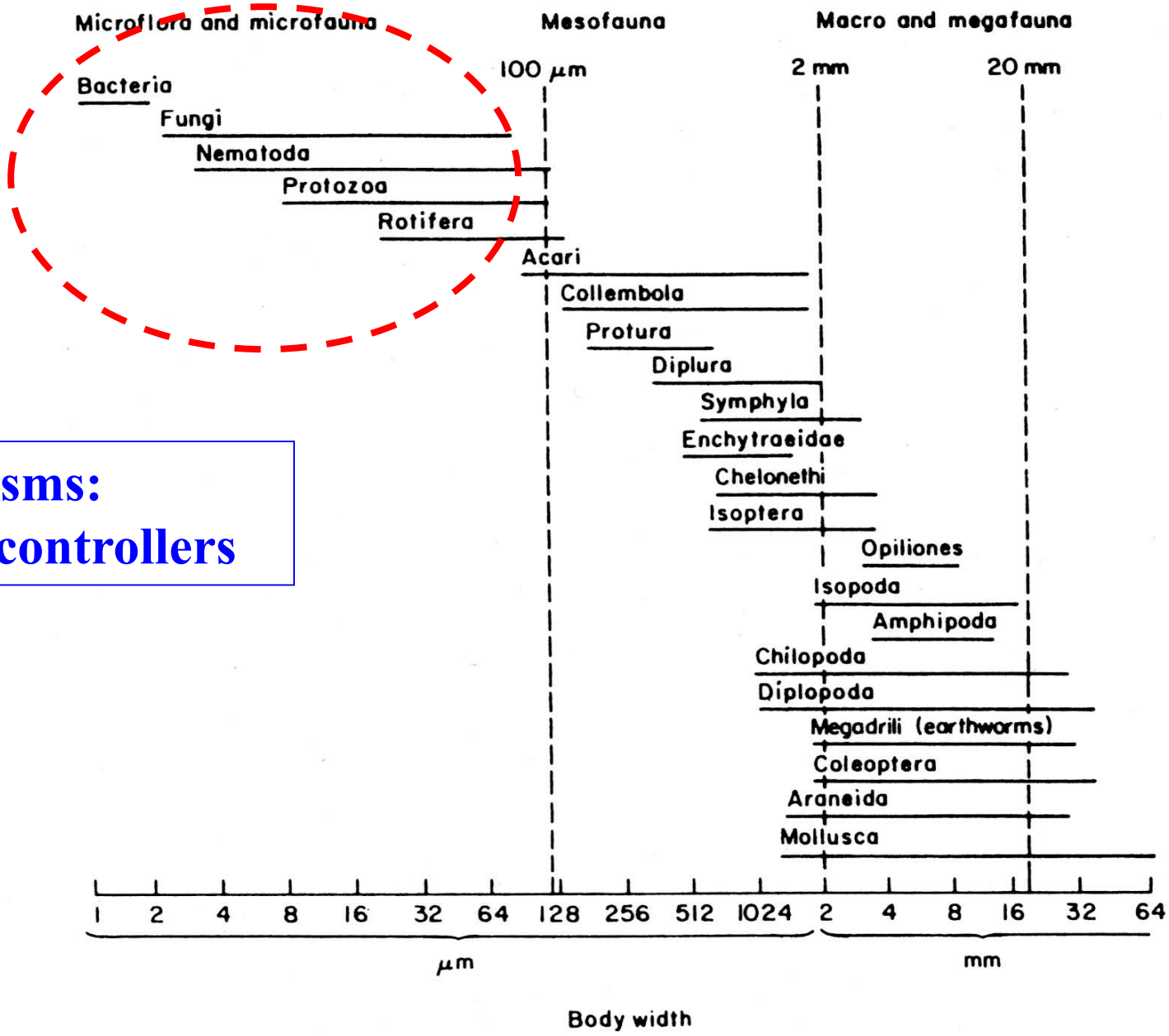
Diplura

Symphyla

Soil mesofauna are important for

1. Residue decomposition
2. Predation
3. Pathogenesis

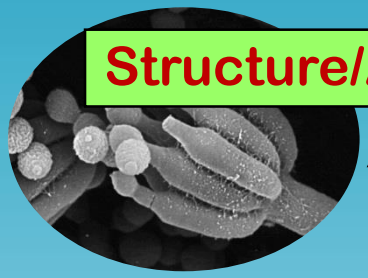
Microorganisms: Soil process controllers



Adapted from Swift et al. 1979

Process Controllers

Happy bacteria



Funny fungi

Structure/Aggregation

Nomadic nematode

Pristine Protozoans

Humification

Organic matter

Nitrate Leaching

Nutrient cycling

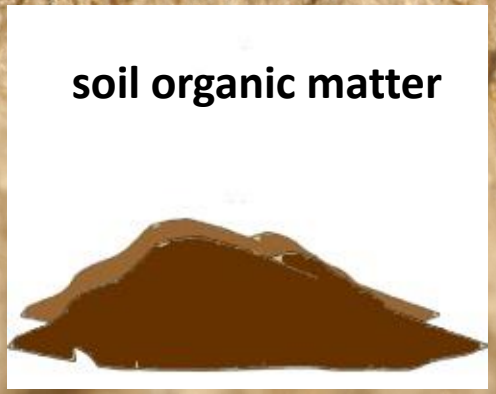
Decomposition

Soil organisms are involved in nearly every aspect of soil quality

Soil Biology is important for nutrient cycling

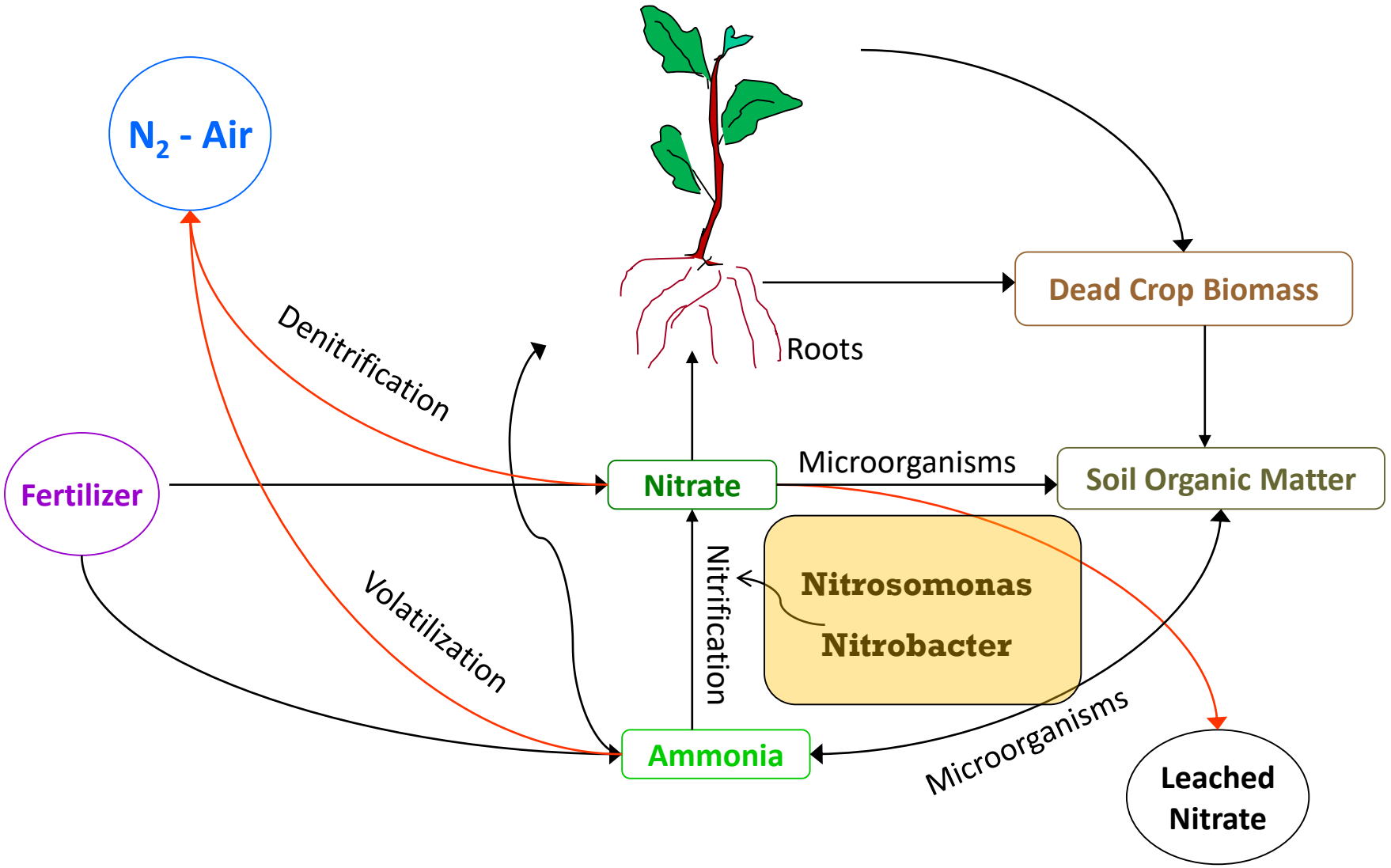
Soil organisms continually transform nutrients among many organic and inorganic forms

Decomposition



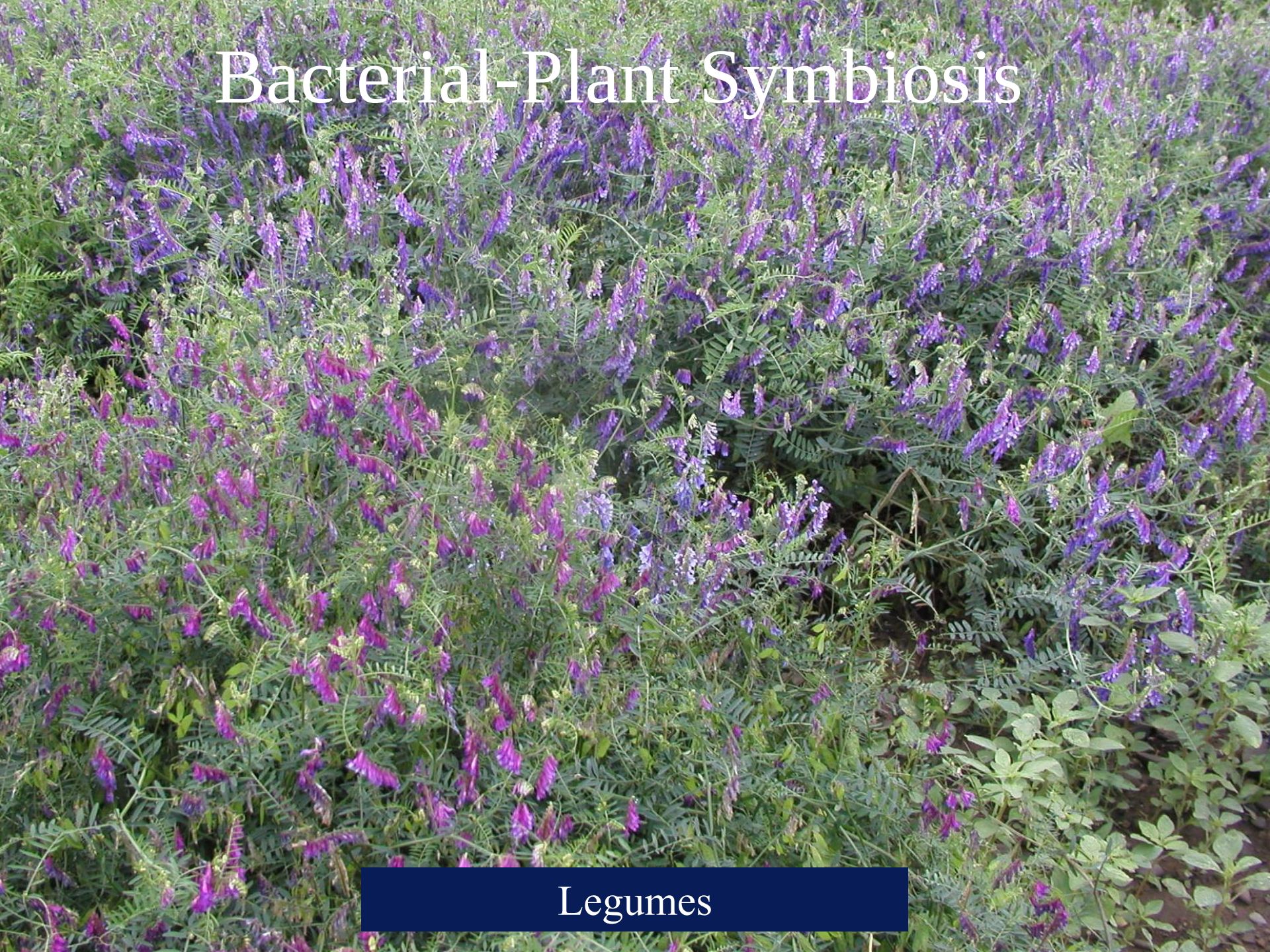
N P K

Microbial Nitrogen Cycling



Microorganism-Plant Relationships

Bacterial-Plant Symbiosis



Legumes

Nitrogen Fixation

* Symbiotic relation between bacteria and plants:

  -e.g., legumes + *Rhizobium*

  - bacteria require plant for growth; plant gains ‘free’ source of available N

* Grasses-*Azospirillum/Azobactor*

Rhizobia are host specific

GENUS	SPECIES	PLANT
Rhizobium	*meliloti*	Alfalfa (Medicago, Melilotus)
Rhizobium	*leguminosarum*	Peas (*Pisum*)
Rhizobium	*leguminosarum*	Vetches (*Vicia)*
Rhizobium	*leguminosarum*	Clover (*Trifolium)*
Rhizobium	*leguminosarum*	Beans (*Phaseolus)*
Rhizobium	*loti*	Trefoil (*Lotus)*
Rhizobium	*fredii*	Soyabean (*Glycine)*
Bradyrhizobium	*japonicum*	Soyabeans, Tropical legumes (*Arachis, Leucaena*)
Azorhizobium	*caulinodans*	Stem nodules (Sesbania)
		Non-legumes (Parasponia)

Treatment	Cover crop biomass[a] (lb/A)	N %	C :N ratio	N contribution (lb/A)
Cover crop				
Crimson clover	4,096 A	1.74 B	22 A	72 B
Red clover	4,985 A	2.18 A	15 C	104 A
Yellow clover	2,797 A	2.00 B	18 B	57 B
Inoculation				
Inoculated	4,751 a	2.02 NS	18.5 NS	93 a
Non-inoculated	3,167 b	1.93	18.1	62 b

[a] Mean separation within columns for cover crop (uppercase) and inoculation (lowercase); means followed by same letter(s) are not significantly different ($P \leq 0.05$)

NS Non-significant at $P \leq 0.05$

Non-inoculated

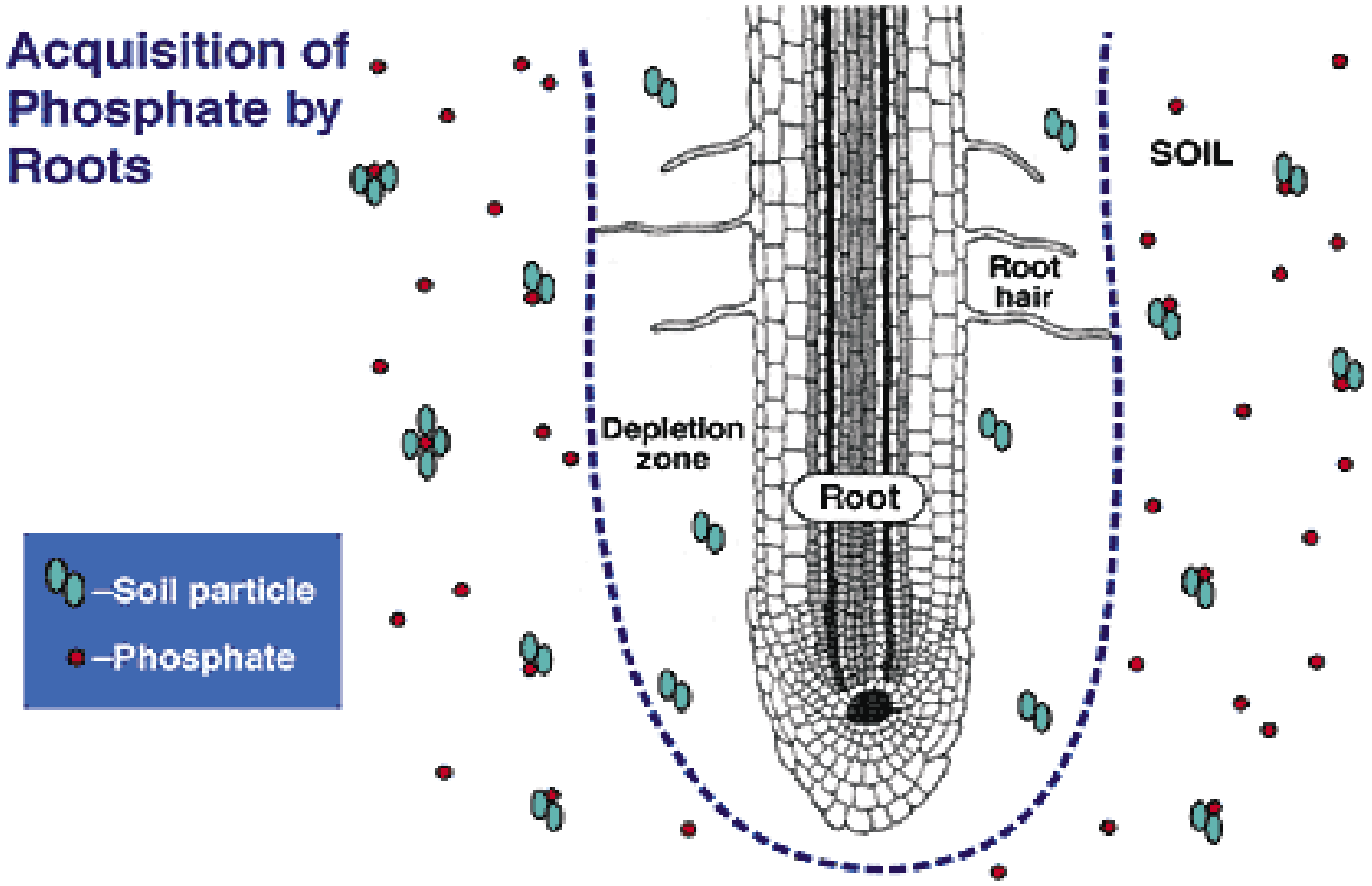
Inoculated

Fungi-Plant Interaction

Mycorrhizae
(root fungus)

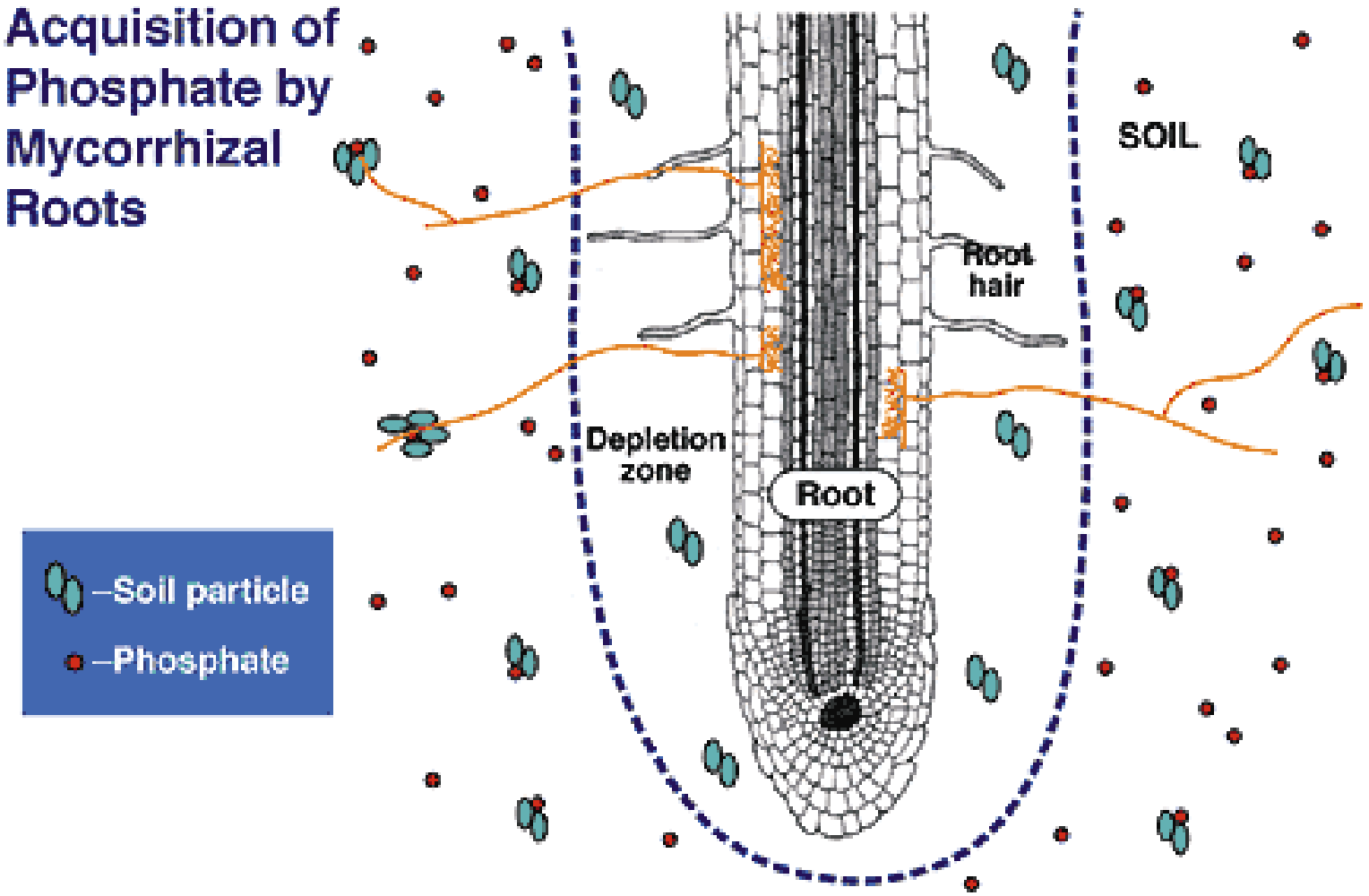
- Extension of root system
- Fungus enhances nutrient and water intake
- Plants provide carbon source

Nearly 90% of native plants have mycorrhizae association



Roots without mycorrhizae

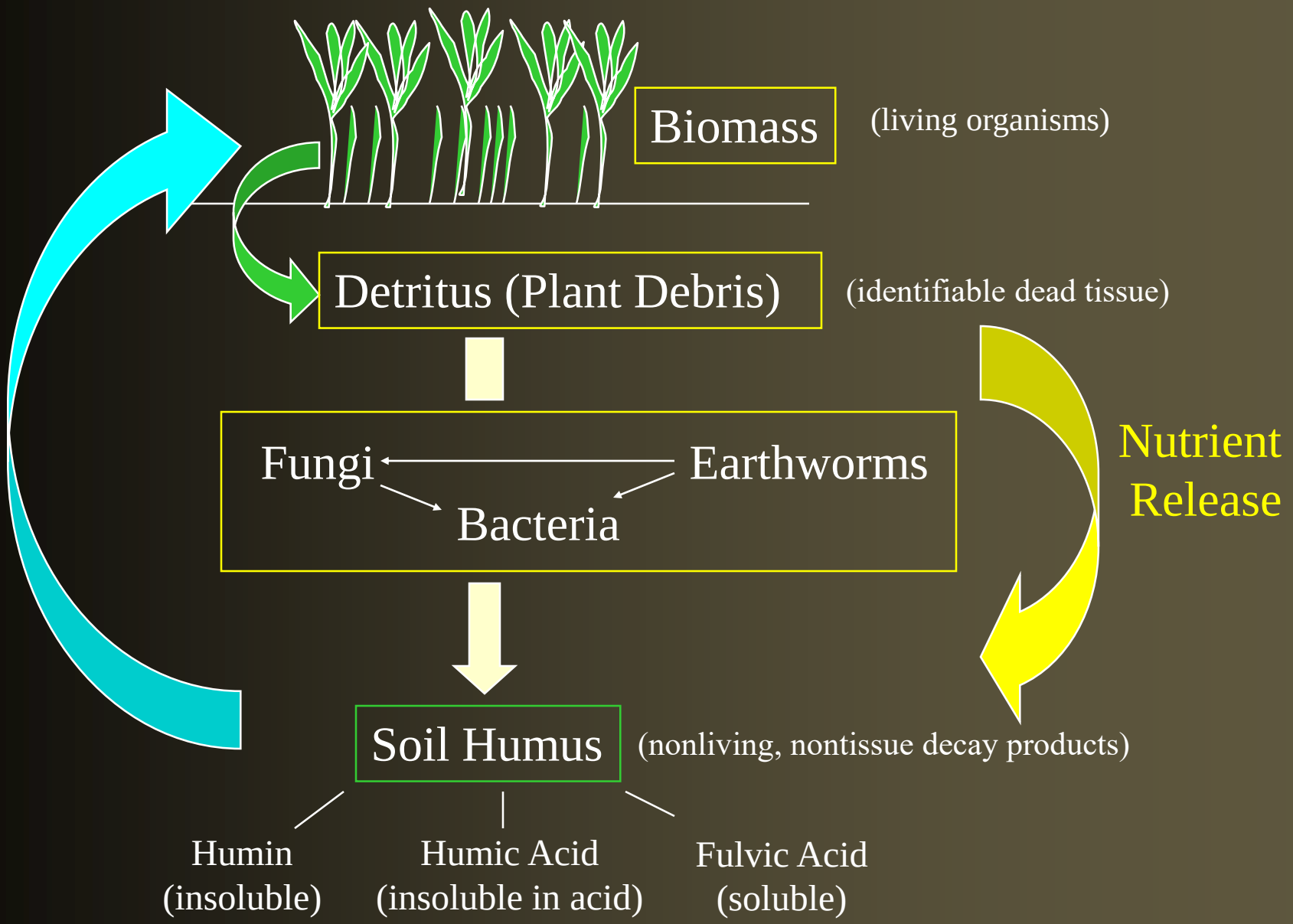
Source: Harrison et al. 1999



Roots with mycorrhizae

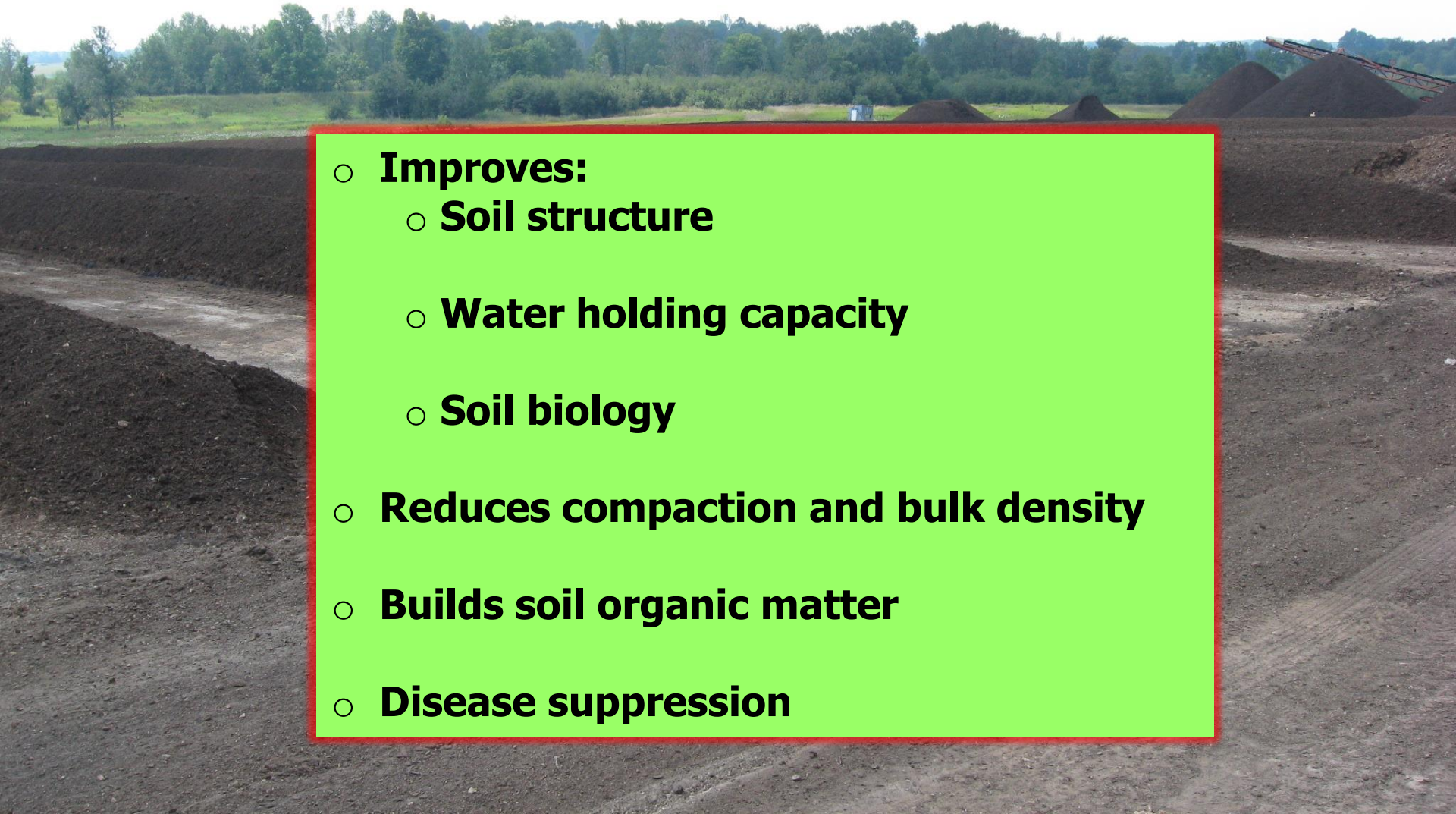
Source: Harrison et al 1999

Organic Matter



Compost: an excellent soil amendment

Do not view compost as N, P, and K



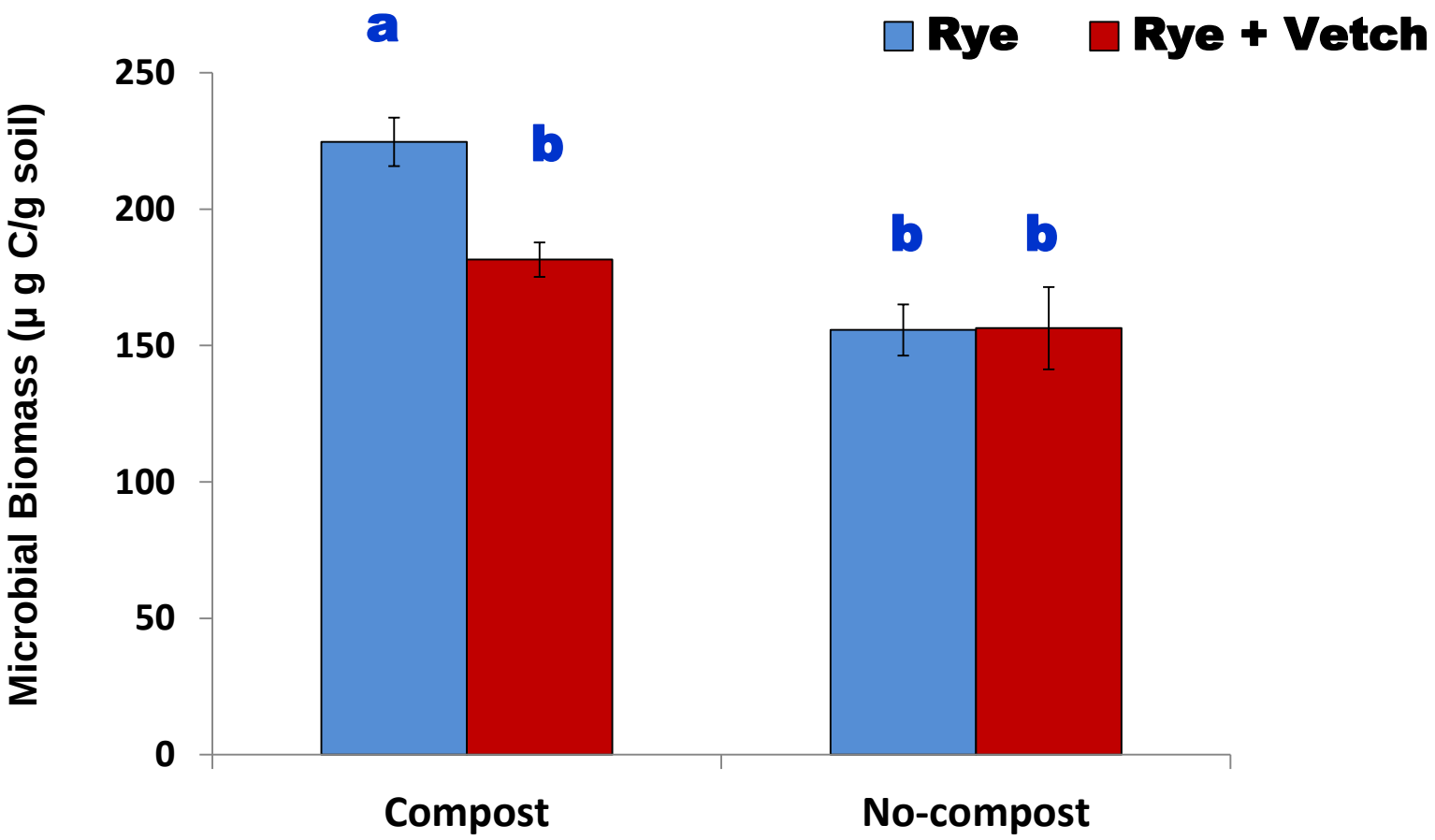
- Improves:
  - Soil structure
  - Water holding capacity
  - Soil biology
- Reduces compaction and bulk density
- Builds soil organic matter
- Disease suppression

Cover crop and compost effects on tomato and cucumber production

Soil chemical and physical properties

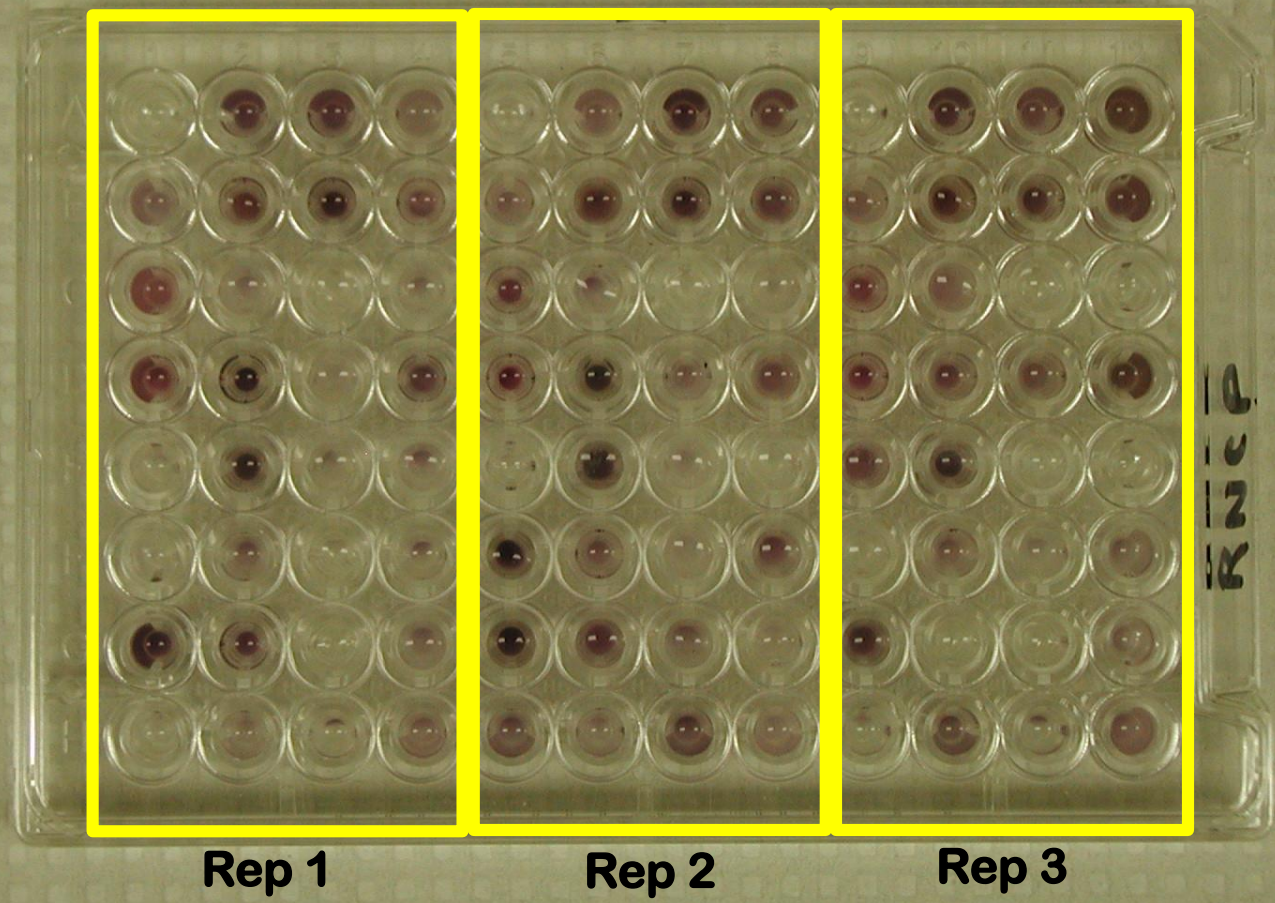
Cropping system	pH	EC ($dS.m^{-1}$)	Water holding capacity ($g.g^{-1}$)	NO_3-N (kg ha^{-1})	NH_4-N (kg ha^{-1})	Cations (mg kg^{-1})		
						Ca	Mg	K
	2007							
Monocrop (C)	ND	0.44 a	0.23^{NS}	31.4^{NS}	4.5 b	2228.8^{NS}	406.5^{NS}	161.8 ab
Monocrop (NC)	ND	0.35 b	0.20	29.0	6.8 a	2018.5	385.0	100.5 c
Intercrop (C)	ND	0.34 bc	0.21	34.7	6.5 ab	2086.0	413.8	195.5 a
Intercrop (NC)	ND	0.28 c	0.22	31.5	7.4 a	2097.8	408.0	135.3 bc
	2008							
Monocrop (C)	7.1^{NS}	0.57 a	0.22^{NS}	54.2 a	7.5^{NS}	2017.0^{NS}	433.8^{NS}	199.5 b
Monocrop (NC)	7.3	0.31 c	0.23	37.7 b	7.6	2076.8	417.8	120.5 c
Intercrop (C)	7.2	0.52 ab	0.22	56.8 a	8.3	2291.8	452.8	240.0 a
Intercrop (NC)	7.3	0.39 bc	0.25	40.9 b	7.7	2156.0	426.3	133.0 c
	2009							
Monocrop (C)	7.4 ab	0.42 a	0.36 a	9.3^{NS}	1.9^{NS}	2137.0 b	434.0 b	171.2 b
Monocrop (NC)	7.6 a	0.23 b	0.28 b	5.4	2.4	2149.5 b	420.0 b	114.2 c
Intercrop (C)	7.4 ab	0.36 a	0.37 a	10.2	2.3	2518.8 a	527.5 a	234.0 a
Intercrop (NC)	7.1 b	0.22 b	0.27 b	10.0	2.8	2197.3 b	427.2 b	118.0 c

Effect on soil microbial biomass

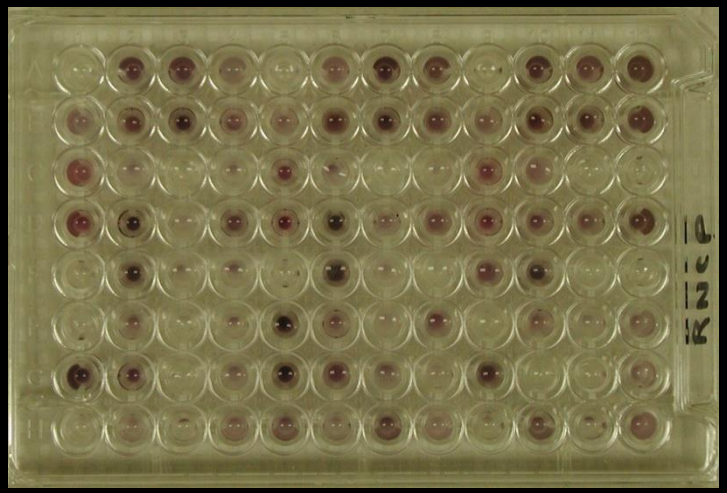


Community level physiological profile

Patterns of potential C source utilization

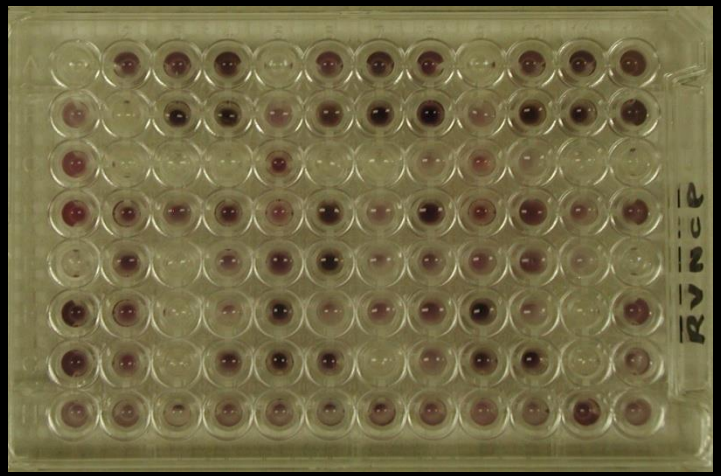


- 31 carbon substrates

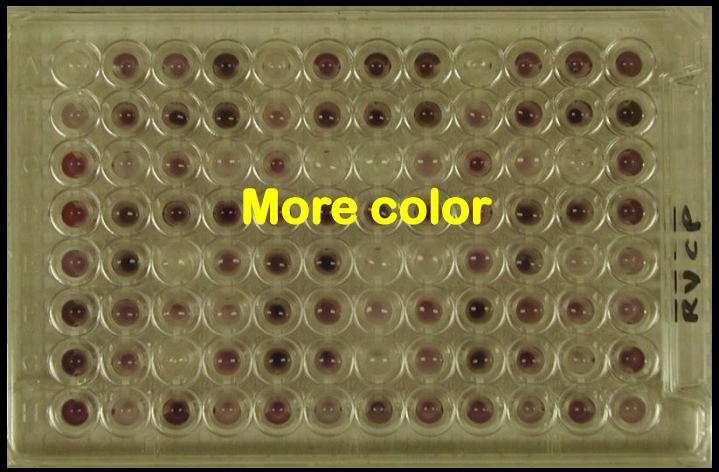


Rye – No Compost

Rye - Compost

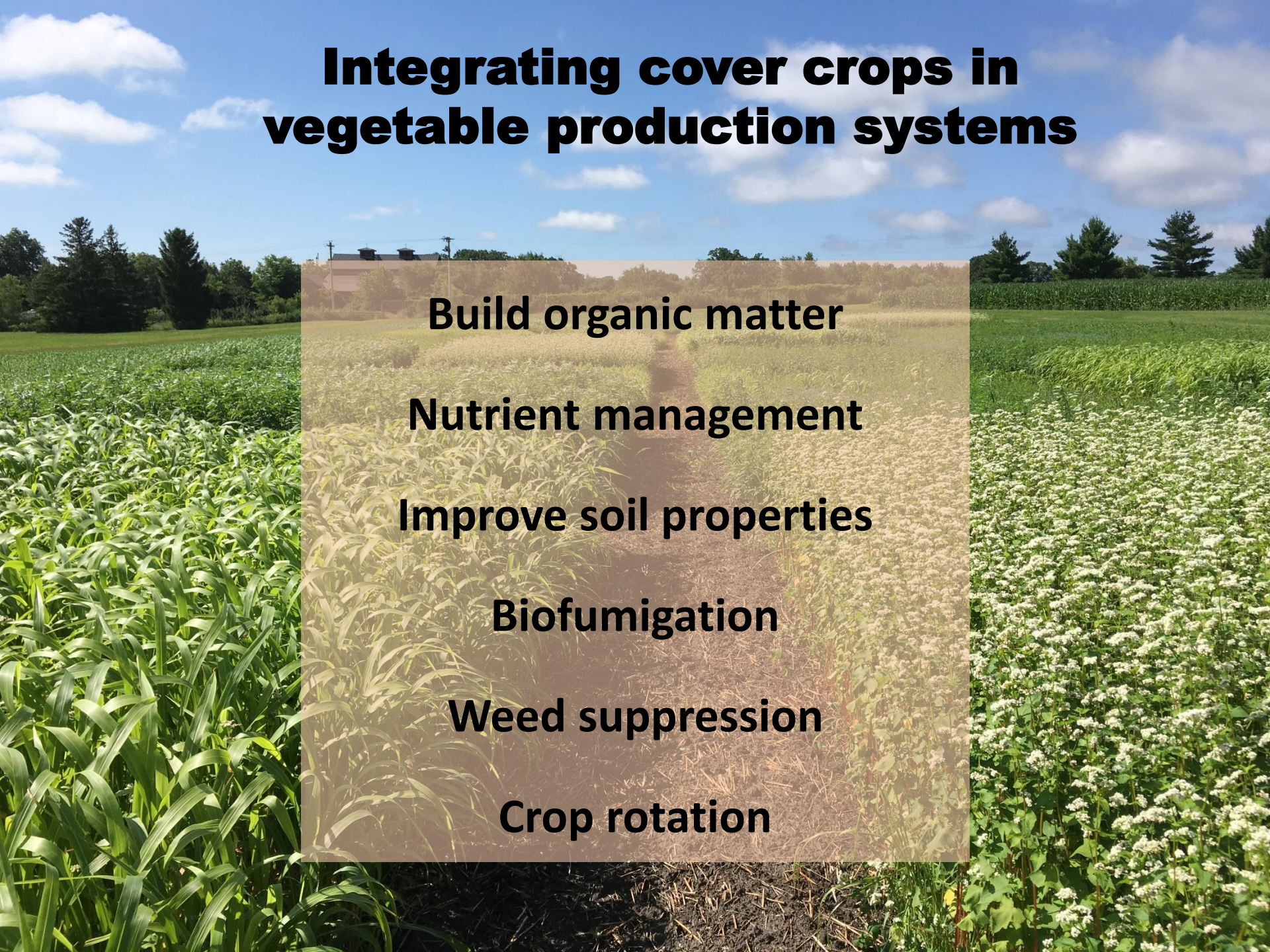


Rye Vetch – No Compost



Rye Vetch - Compost

Integrating cover crops in vegetable production systems



Build organic matter

Nutrient management

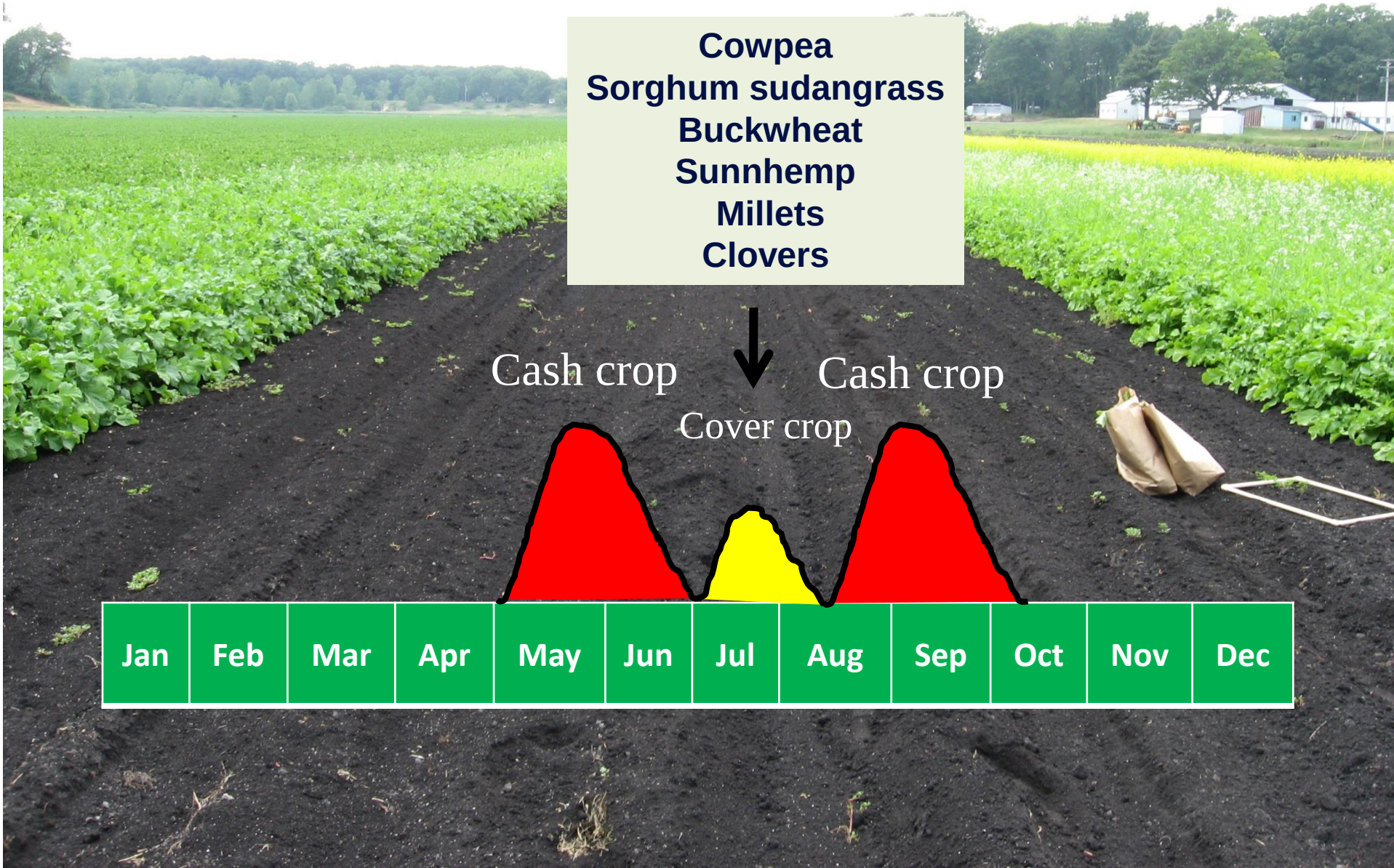
Improve soil properties

Biofumigation

Weed suppression

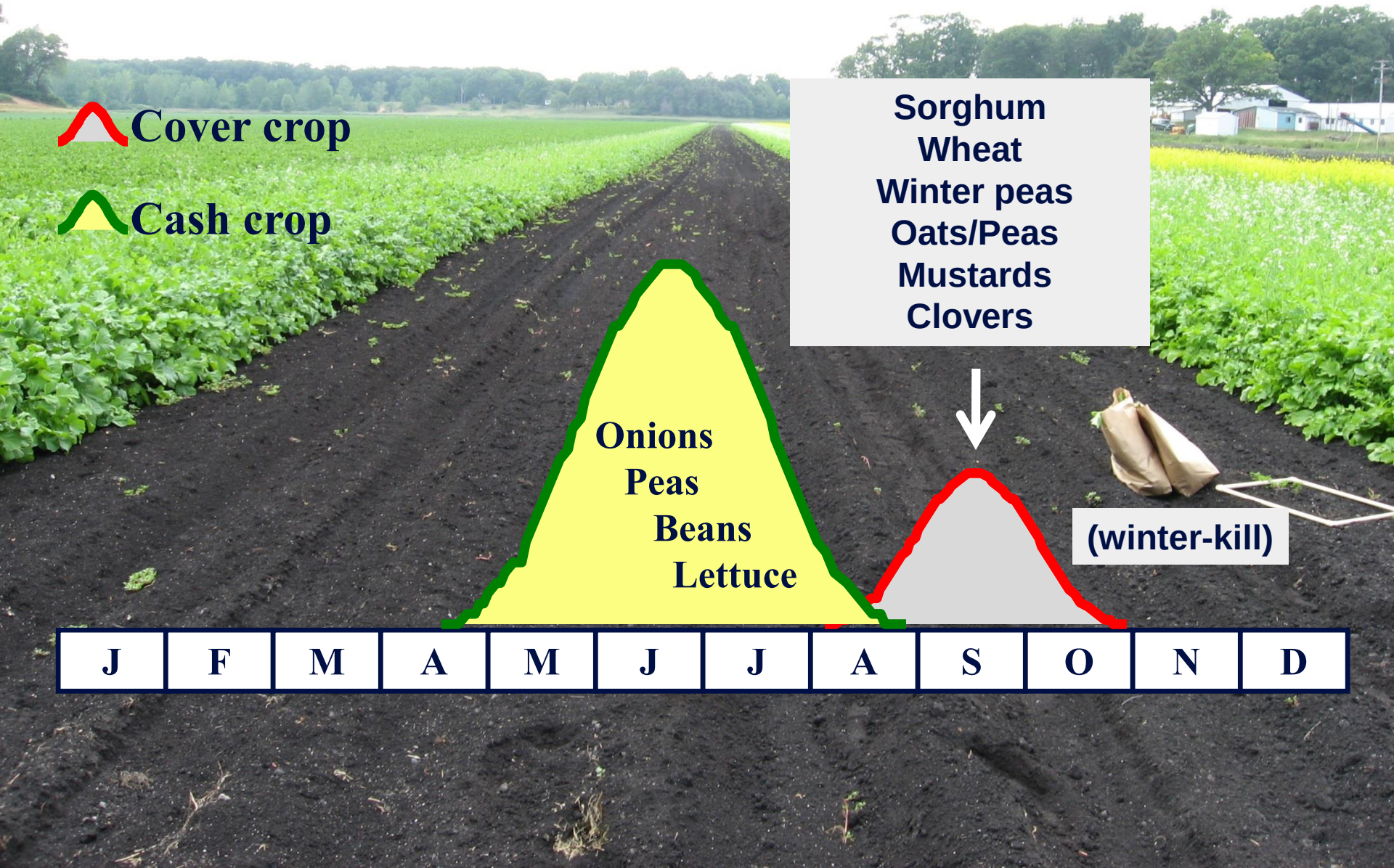
Crop rotation

Cover cropping window: summer



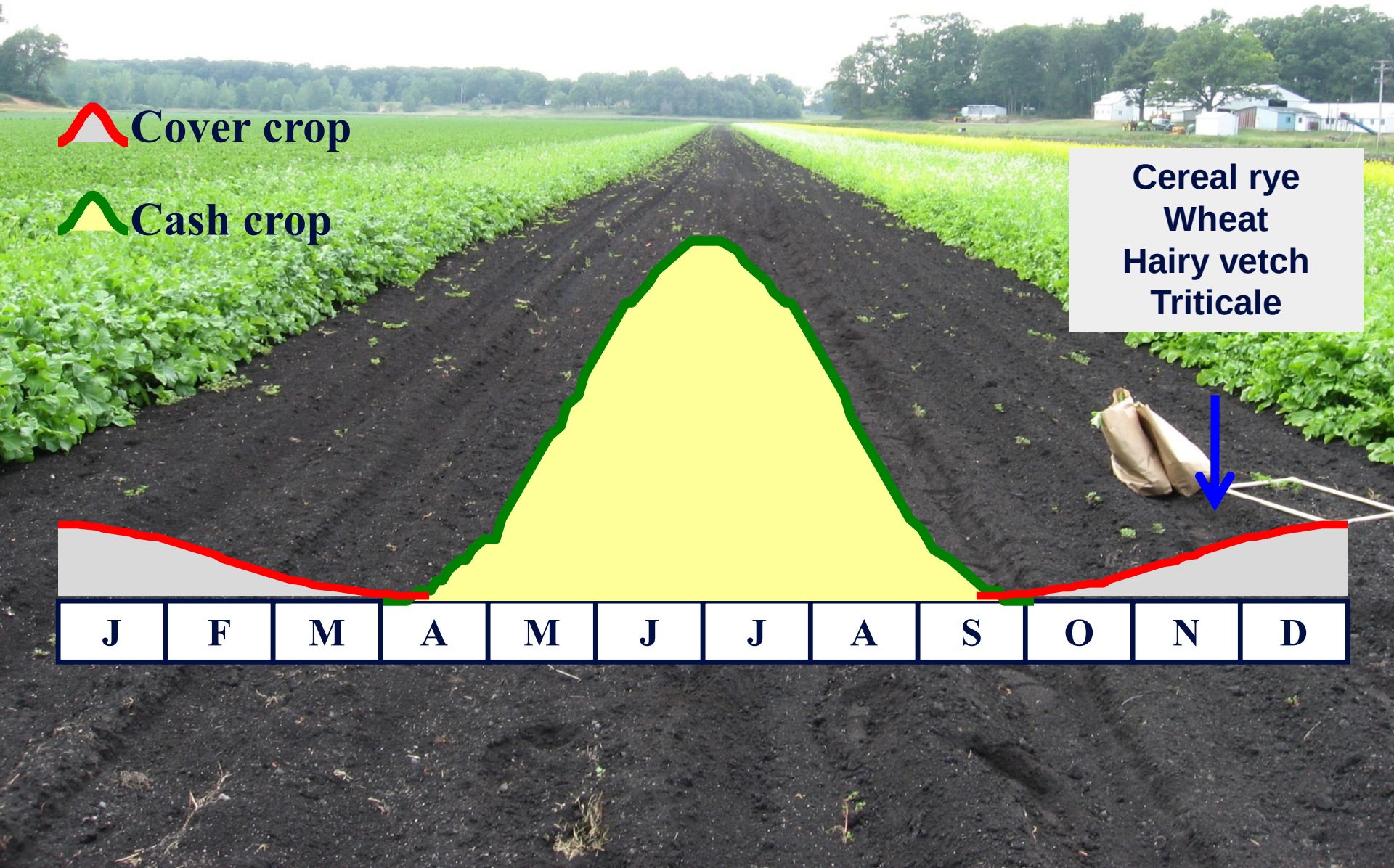
Cover crop windows: Summer or Fall

After early harvested vegetables

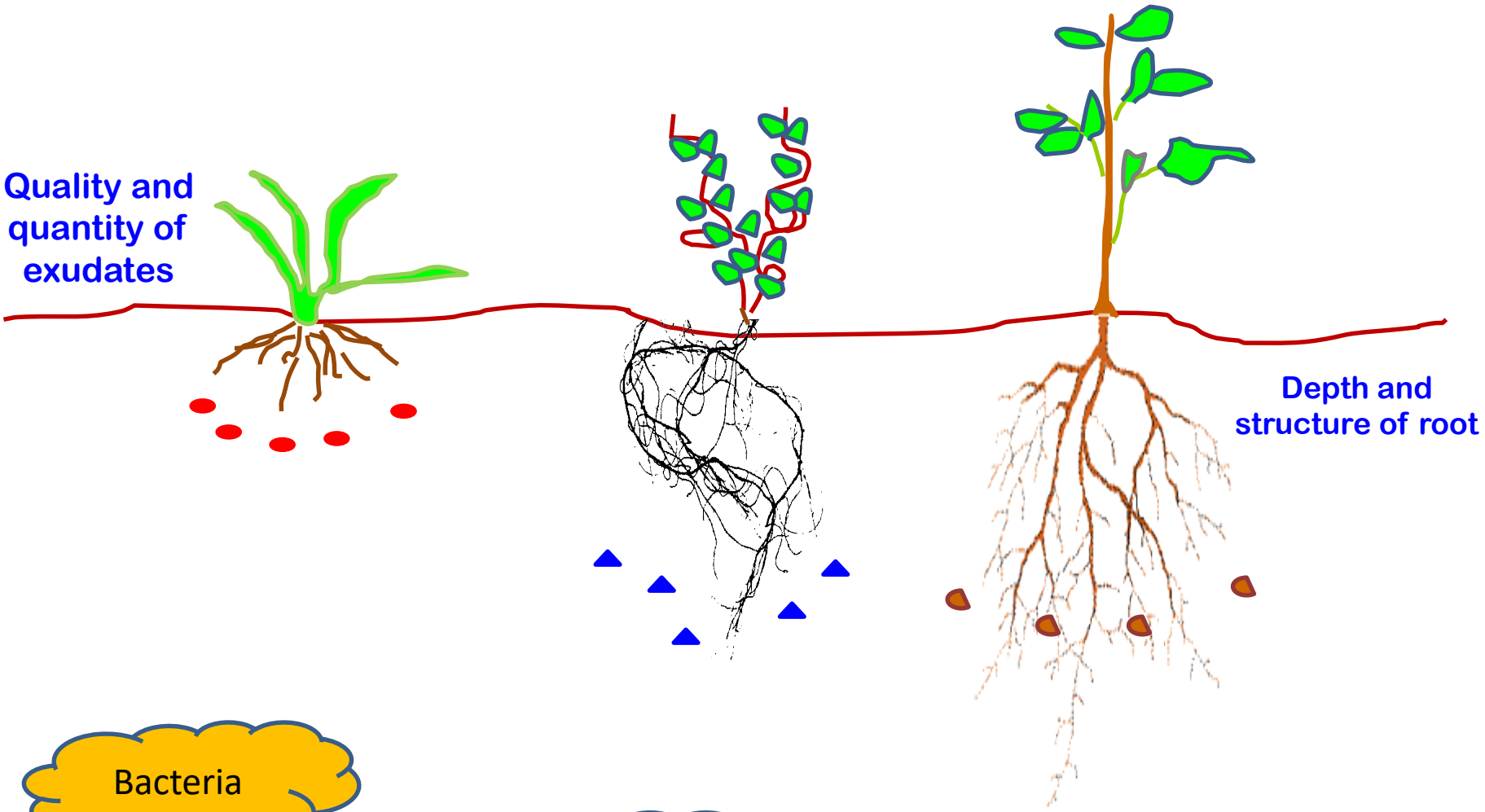


Cover crop windows: Winter

Off-season



Crop diversity can influence soil biology



Nematode Classification

Herbivore **Fungivore** **Bacteriovore**

Tylenchs

Lesion

Aphylenchs

Spiral

Dorylaims

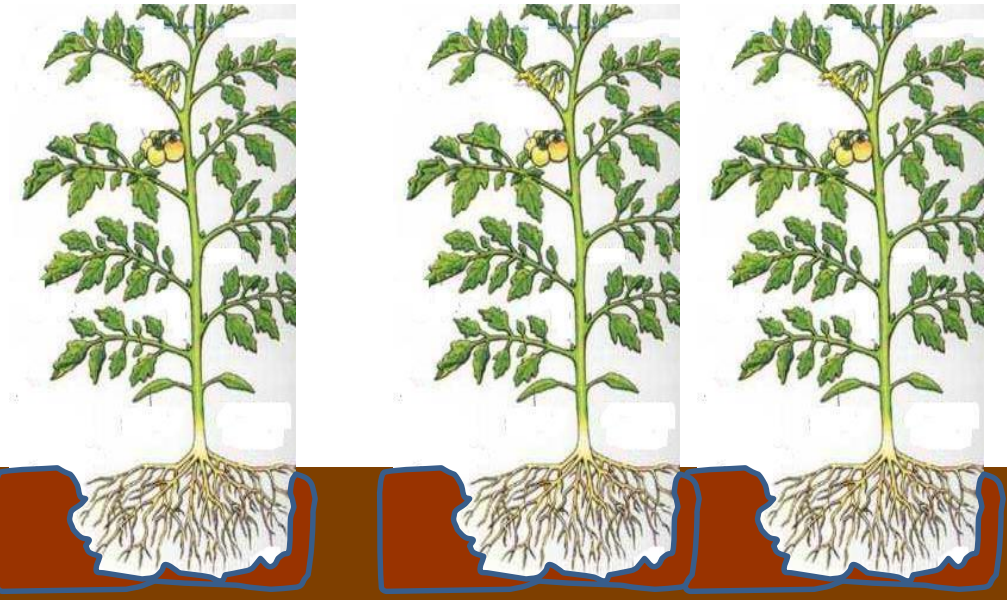
Stunt

Bacteriovore

Pin

What do nematodes do in the soil ?

Nutrient Cycling



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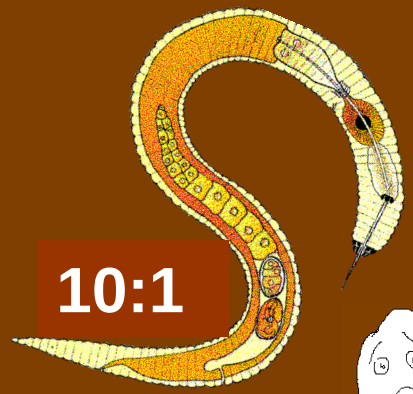


10:1

Happy bacteria

C:N 5:1

C:N 5:1

C:N 5:1

C:N 5:1

C:N 5:1

Impact of cover crops on Nematode community

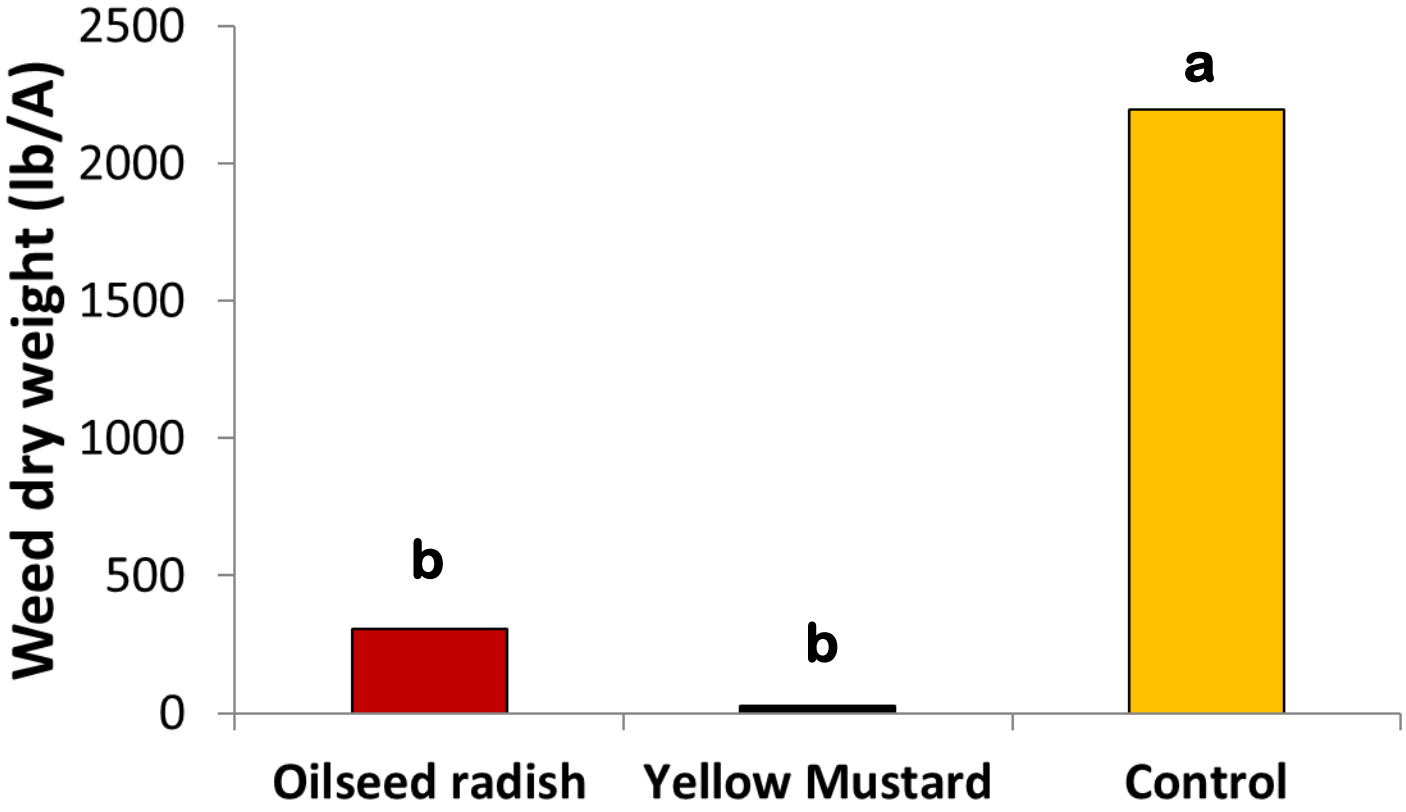
Cover Crop	Plant parasitic nematodes	Bacterial feeders
Control	178 a	383 b
Cereal Rye	97 ab	498 ab
Yellow Mustard	114 ab	533 ab
Oriental Mustard	102 ab	683 ab
Oilseed Radish	79 b	1382 a

Cover crops in high tunnels

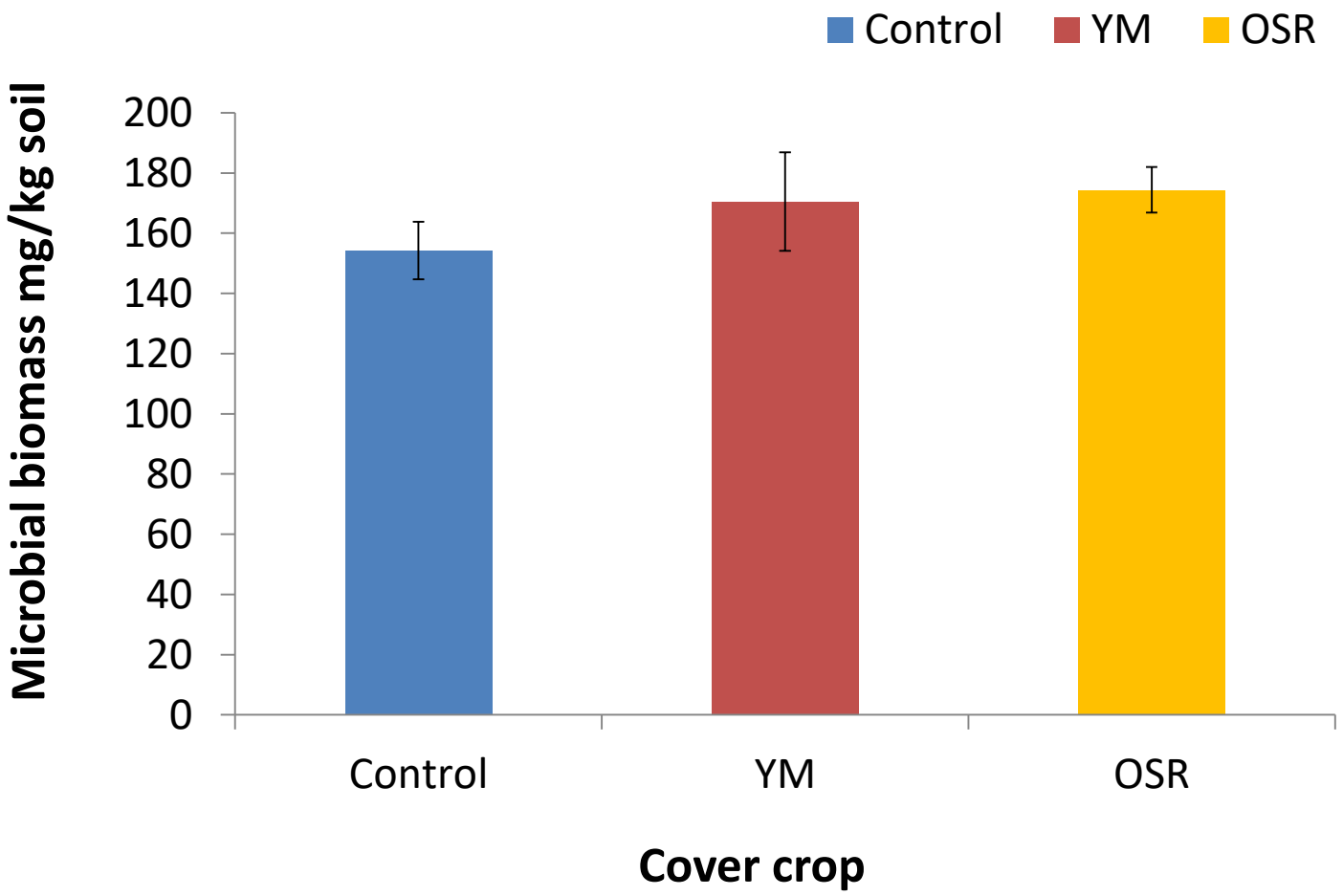

High Weed pressure
Control plots (no cover crop)


Very low weed pressure
Yellow Mustard

Weed Biomass



Microbial Biomass Carbon




Kroul Farms, Mt.
Vernon, IA
HANES
ELECTRIC
Solon, IA


BUCKWHEAT
Seeded: 3rd June
Harvested: 16th July


No Cover crop plot


Reduced tillage
cover crop systems
to improve soil
quality and health

Soil Building Processes

Cover Crops

Compost

Crop rotation

No-Till

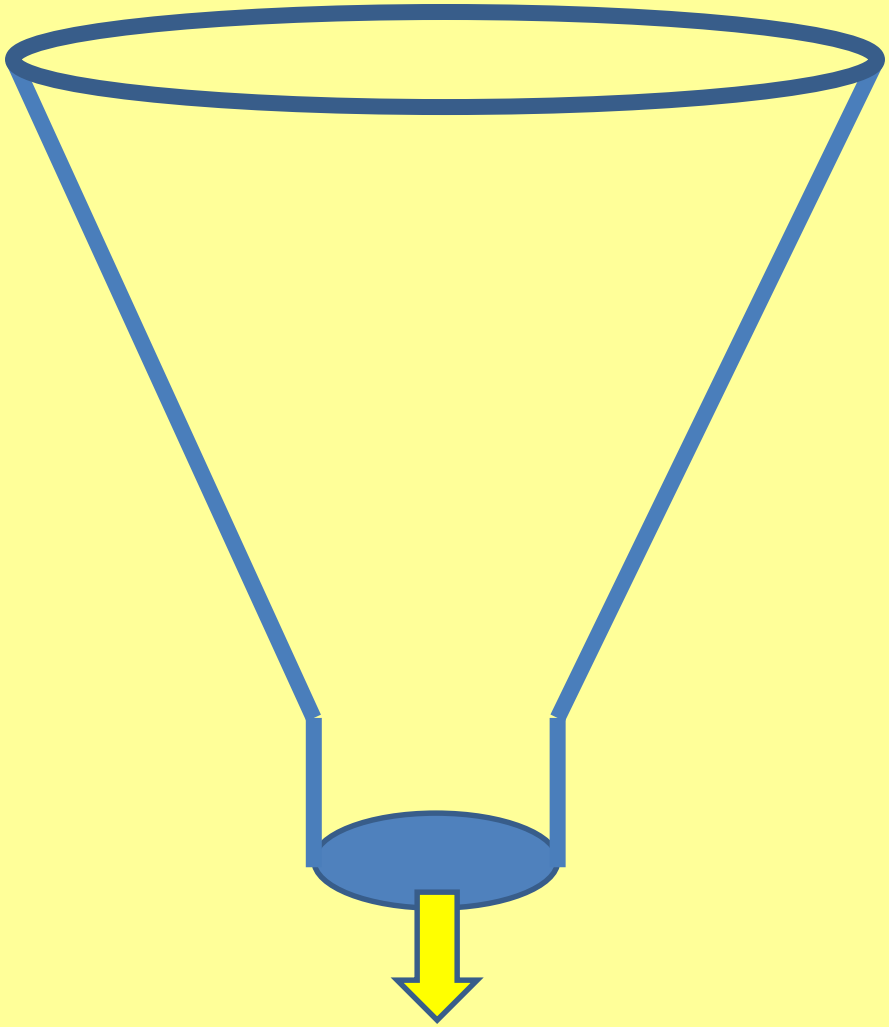
Irrigation

Nutrient Management

Strip-Till

Why biologically acive ?

- *Initiate decomposition reactions*
- *Release of nutrients for plant uptake*
- *Development of humus and other growth promoting substances*
- *Improvement in soil structure and physical propeties*
- *Suppress soil-borne pathogens by occupying the niche*
- *Drive nature's C and N cycles*



Biologically Active Soil

Funding agencies

USDA NIFA

IFVGA Iowa Fruit & Vegetable Growers Assn.

Practical Farmers of Iowa

IOWA DEPARTMENT OF AGRICULTURE AND LAND STEWARDSHIP

NORTH CENTRAL SARE Sustainable Agriculture Research & Education

LEOPOLD CENTER FOR SUSTAINABLE AGRICULTURE


Dedication
It's a balancing act !
SMART TRIPS

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